AMERICAN PRACTICE OF SURGERY

A COMPLETE SYSTEM OF THE SCIENCE AND ART OF SURGERY, BY REPRESENTATIVE SURGEONS OF THE UNITED STATES AND CANADA

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OF NEW YORK CITY

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PART XVI.

REGIONAL SURGERY.

(Continued.)

SURGICAL DISEASES AND WOUNDS OF THE PELVIC AND GLUTEAL REGIONS.

By CHARLES H. PECK, M.D., New York City.

As fractures and dislocations of the pelvic bones, injuries and diseases involving the pelvic viscera, and gunshot wounds are fully treated in other articles, the present description will include only such injuries and surgical diseases as are peculiar to this region.

Deformities of the Bony Pelvis.—Pelvic deformities may be congenital, or acquired as a result of injuries or diseases—*e.g.*, fractures, dislocations, inflammations of bones or joints, osteomalacia, echinococci, tumors, etc.

Among the numerous types of deformity recognized, the following may be briefly enumerated:—

Variations in Type of Purely Obstetrical Interest.—These are: the simple flat pelvis, with conjugate diameters all shortened; the rachitic flat pelvis, with shortened conjugate, increased transverse diameter and jutting promontory; the obliquely narrowed rachitic pelvis due to scoliosis; the infantile type of pelvis; the masculine type of pelvis in the female; the justo-minor and dwarf types of pelvis; and the pelvis with abnormal inclination, either too great or too little, causing dystocia.

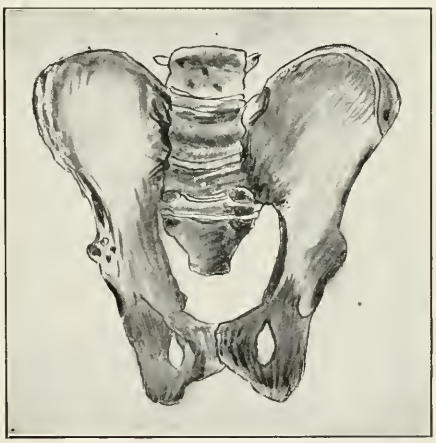


Fig. 1.—Bilateral Ankylosis of Sacro-Iliac Synchondroses, with transverse narrowing of the pelvis—so-called "Roberts pelvis." (From Waldeyer's "Das Becken.")

In addition, one recognizes the following kinds of pelvis:—

Spondylolisthetic pelvis, in which the lower lumbar vertebræ project forward into the inlet of the pelvis. This form is usually congenital, but may follow injury or (when rachitis is present at the same time) overloading.

Kyphotic pelvis—a funnel-shaped pelvis approaching the infantile type, and associated with kyphosis.

Osteomalacic pelvis—a form of pelvis which is caused by the weight of the superimposed body in combination with the counter-pressure of the limbs. The distortion is often extreme and the deformity complex.

Transversely Narrowed Ankylotic Pelvis. (Roberts.)—This form of pelvis is due to bilateral ankylosis of the sacro-iliac joints and defective development of the upper part of the sacrum. (Fig. 1.) All transverse diameters are greatly

narrowed, and the sacrum is abnormally deep and shows convex instead of concave transverse diameter.

Obliquely narrowed pelvis—a form of pelvis which is due to defective development of one wing of the sacrum or to unilateral ankylosis, either congenital or secondary to sacro-iliac disease. (Fig. 2.) The true conjugate diameter is longer, but all other diameters, and especially that of the exit, are shorter. Scoliosis of the spine is usually present as an effect of the pelvic deformity.

Coxalgic pelvis—a form of pelvis which is due chiefly to tuberculous coxitis. (Fig. 3.) The pelvic half of the affected side becomes atrophied and is more inclined than its fellow. The condition produced is much like the preceding.

Fig. 2.

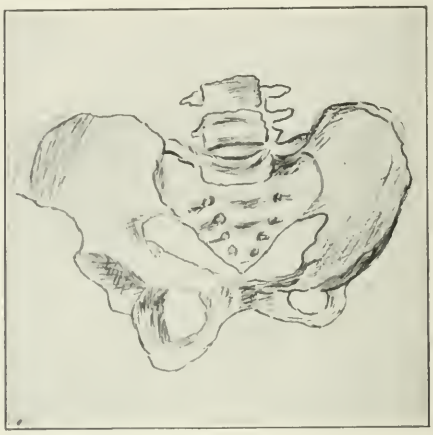


Fig. 3.

Fig. 2.—Obliquely Contracted Pelvis from Arrested Development Affecting the Left Half of the Pelvis, with Ankylosis of the Left Sacro-Iliac Synchondrosis. (From Waldeyer's "Das Becken.")

Fig. 3.—Coxalgic Pelvis; Defective Development of Left Half of Pelvis, associated with Tuberculous Coxitis. (Tillmanns.)

Split pelvis—a deformity which is due to congenital absence of the symphysis or to diastasis of the same. In high degrees the deformity may be associated with ectopia vesicæ. In some cases the pelvis is otherwise normal.

Double Promontory.—This abnormal condition is commoner in the male than in the female. The second promontory is located between the first and second sacral joints, below the true promontory. The deformity is of obstetrical interest.

Acute Osteomyelitis and Periostitis of the Pelvic Bones.—Acute osteomyelitis and acute periostitis of the bones of the pelvis are of comparatively infrequent occurrence. They occur especially in adolescents, generally in the second decade, occasionally in younger children, and rarely after the age of twenty-five years. The parts most commonly involved are the epiphyses, where spongy bone tissue is most abundant, the region of the acetabulum, the sacro-iliac synchondroses, the spines or the crest of the ilium, the lateral masses of the sacrum, etc. Of these, the ilium is most frequently affected, the sacrum less commonly, and the pubic arch or the ischium very rarely.

The disease may be primary in the pelvic bones, or it may be associated with osteomyelitis of other bones of the body; the foci may be single or multiple. Not infrequently the source of infection may be traced to a suppurative focus in some other part of the body, or to some infectious disease—as, for example, a furuncle or an abscess of the soft parts, one of the exanthemata, typhoid fever, a severe cold, etc.; or it may be one of the manifestations of a general septicæmia or pyæmia. A preceding trauma may be of etiological significance. The infecting organism is most frequently the Staphylococcus pyogenes aureus, less frequently some other form of the Staphylococcus (albus or citreus) or the Streptococcus pyogenes. Rarely, the typhoid bacillus is responsible for the process, and, still less frequently, some other organism—as, *e.g.*, the Bacillus pyocyaneus, the B. pyogenes fœtidus, the B. coli communis, etc.

The local and constitutional effects vary greatly according to the type and virulence of the infecting organism and the power of resistance of the patient, as happens in osteomyelitis in other parts of the body. The staphylococci produce the greatest amount of local suppuration and necrosis, the streptococcus the more severe and fatal constitutional symptoms, and the typhoid bacillus the chronic, slow-forming abscesses or inflammatory areas.

Pathology.—The pathological changes in acute osteomyelitis of the pelvic bones are exactly the same as those which occur in osteomyelitis elsewhere. (See Vol. III., Part xii.) The process may remain localized, the mildest types producing non-suppurative periostitis or osteitis, or later a sclerosing osteitis without necrosis. In the more severe cases there may be localized abscesses, with more or less necrosis, or the suppuration may involve a wider area, causing separation of the periosteum and extensive death of bone. In streptococcic infections the general toxæmia may be so great that death occurs before local destruction is marked; on the other hand, typhoid infections are so chronic and indolent as to simulate tuberculosis. If the process begins in the region of the acetabulum the pus is prone to break through into the hip-joint, causing a suppurative arthritis. Statistics from the Tuebingen clinic show that this occurred in eighty-six out of one hundred and six cases in which the disease developed in this region. Spontaneous dislocation of the hip takes place in many of the patients who recover. The sacro-iliac synchondrosis may be affected if the disease originates in the adjacent spongy bone of either the ilium or the sacrum. Abscesses may form in the pelvic cellular tissue or may perforate into the pelvic organs; they may also form primarily beneath the gluteal muscles, or the pus may accumulate there after burrowing through the sacro-sciatic foramina. Pus may follow the muscular planes of the thigh or may collect extraperitoneally in the iliac fossa. It is only rarely that the disease originates in the sacrum, but instances of this have been observed by von Bruns, Chipault, Gross, and others. This event is most apt to occur in younger children, and the prognosis is grave, ten out of sixteen cases collected by Gross having proved fatal.

Marked deformities from destruction of epiphyses and interference with growth are apt to follow recovery from osteomyelitis of the pelvic bones. In cases resulting in ankylosis of the sacro-iliac or the hip joint the affected side of

the pelvis becomes much contracted and narrowed—the obliquely contracted pelvis. (See Fig. 4.) If sacro-iliac ankylosis is bilateral, both sides are narrowed, causing a general diminution of the transverse diamater—the so-called Roberts pelvis. (See Fig. 1.) Some of the deformities observed owe their origin to the pressure exerted by the weight of the body upon bones which, by reason of their being softened by disease, bend under the pressure.

Symptoms.—The symptoms, character of the onset, and course of the disease vary with the site of the primary focus and with the severity of the process. In general, the onset is sudden, the attack beginning with a chill, high fever, and deep-seated pain over the affected bone. If the region of the acetabulum is affected the pain is increased by pressure over the great trochanter or on the sole of the foot. The slightest motion of the hip-joint is painful and the patient is confined to bed from the onset. In tuberculous disease, from which the present affection must be differentiated, the onset is more gradual, the patients usually being able to go about limping for months before they are finally bedridden. Tenderness on pressure over the affected site is an early and constant sign; swelling and boggy œdema appear later, when the inflammation extends to the periosteum and the adjacent soft parts. The constitutional symptoms may be mild or of any grade of severity up to the violent types of streptococcic infection in which death occurs from the general toxæmia before local symptoms have declared themselves. Abscesses or suppurating sinuses leading directly, or more often deviously, to necrosed bone are often present when the patient first seeks surgical relief. Among the changes which are observed may be mentioned irregular thickening of the bones, especially the ilium, loose sequestra, and bone that is denuded but not yet ready to separate. Small encapsulated foci of infection may remain dormant for varying lengths of time and then break out afresh, as happens in osteomyelitis elsewhere. Abscesses may form in the pelvis and break into pelvic organs, or they may break outwardly, leaving fistulous tracts behind. There are on record cases where sharp sequestra have ulcerated through into the bladder and have formed the nuclei of calculi. Careful examination by rectum or vagina should always be made, especial care being taken to explore the region of the acetabulum and of the sacro-iliac synchondrosis. It is possible in this way to distinguish localized tendernesses, boggy swelling, or the presence of abscesses or fistulous tracts.

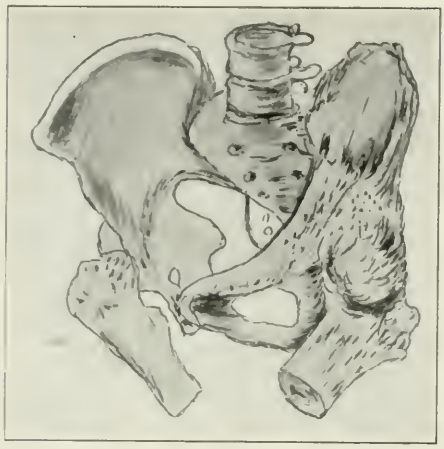


Fig. 4.—Healed Osteomyelitis of the Left Ilium. (From Albert and Kolisko.)

Diagnosis.—The diagnosis is made by a careful consideration of the symptoms and signs above pictured. The suddenness of the onset, with a chill, fever, and deep-seated boring pain, which is increased by pressure, and which at first is not

accompanied by swelling of the overlying soft parts; the history of a preceding trauma, of a severe cold, of furunculosis or of some infectious disease; the information obtained by careful palpation of the pelvis both externally and internally *per rectum* and *per vaginam*, will usually suffice to exclude other lesions with which the osteomyelitis might be confused.

Prognosis.—The prognosis of acute osteomyelitis of the pelvic bones is in general not good, especially where the site of the primary focus is near the acetabulum or the sacro-iliac synchondrosis. Osteomyelitis of the sacrum has proved especially fatal. Death may be caused by acute septicæmia or pyæmia or by the exhaustion of chronic sepsis. Extension of the inflammation to the membranes of the cord has been observed; abscesses may break into the urinary tract; and, in the non-fatal cases, there may be left various troublesome conditions—intractable suppurating sinuses, marked pelvic deformities which have resulted from arrest of development, ankylosis of pelvic joints, or distortions that have been produced by pressure. There was a mortality of 24.5 per cent in the series of one hundred and six cases which were collected from the records of the Tuebingen clinic,—cases in which the acetabular region was involved.

Treatment.—The treatment of acute osteomyelitis of the pelvic bones consists in early incision down to the affected site as soon as the diagnosis is established. Resection of large areas of affected bone has been advised, especially by A. von Bergmann, who advocates, in certain cases, excision of the entire ilium, with the acetabular cavity. This is accomplished by a deep transverse incision (down to the bone) below the iliac crest, separation of the periosteum, and chiseling through the bone in its entire length, the attachment of the muscles of the back and abdomen to the crest being left intact. Then, by means of a raspatory, the bone is freed from periosteum on its inner and outer aspects, and its connections with the sacrum behind, the pubes in front, and the ischium below, are divided, the head of the femur being left free in the wound. Bone regeneration and restoration of function may, it is said, be confidently looked for if the broad periosteal surfaces are preserved. An operation as extensive as this would rarely be justified. In the more chronic stages, when there are sinuses leading down to bone, the suppurating tracts must be laid freely open, all sequestra removed, and any areas of necrosis that may be discovered curetted and freely drained. It is quite possible that, with the increasing use of Bier's hyperæmic treatment by means of suitable suction cups, a more perfect control of the inflammatory process in pelvic osteomyelitis may be obtained, and that in consequence, as has happened in the case of inflammatory lesions elsewhere, the destruction of tissue will be less and the need for extensive incisions done away with altogether. In general, however, early incision with osteotomy and thorough drainage of the focus of disease, especially when the site is such that an adjacent joint is endangered, must be our main reliance.

Tuberculosis of the Pelvic Bones.—Tuberculosis of the pelvic bones occurs most frequently before the age of thirty, and generally originates at or near the centres of ossification—*e.g.*, in the ilium near the acetabulum or sacro-iliac synchondrosis; in the lateral masses of the sacrum; and near the symphysis pubis.

Tuberculosis of the ischium is very rare. In later life the secondary centres, as the crest or spines of the ilium, are occasionally involved. Except in cases in which the disease is confined to the peripheral portions of the ilium (as the spines or the crest), tuberculosis of the pelvic bones is of surgical interest chiefly as it occurs in three important locations, viz., (1) in the region of the acetabulum; (2) at the sacro-iliac synchondrosis; (3) at the symphysis pubis.

Although the disease is of fairly frequent occurrence in the first of these locations and is certainly of great importance, it is, nevertheless, so intimately associated with and so frequently causes tuberculosis of the hip-joint that a detailed description would be out of place in this article. (See Vol. III., p. 558.)

Fig. 5.—Right Sacro-Iliac Disease, with Lumbar and Gluteal Cold Abscesses, in a Girl nine years of age. (Original.)

The treatment of acetabular tuberculosis by the very radical methods that were practised by H. Schmid, Bardenheuer, and others in former years, would rarely if ever be considered justifiable at the present time, when such brilliant results are being obtained by early and conservative orthopedic treatment.

Tuberculosis of the Sacro-iliac Synchondrosis.—Tuberculosis of the sacro-iliac synchondrosis is most common in adolescents and young adults. It is rarely seen in children and not often after twenty-five years of age. It sometimes follows trauma and has been observed as a complication of lumbar spondylitis (Ridlon), being then probably secondary to the spondylitis; but in the great majority of cases no cause can be traced.

Pathology.—The changes are similar to those observed in tuberculous arthritis elsewhere. The primary focus, as a rule, is located in some part of the adjacent ilium or sacrum, the disease involving the joint proper and the synovial membrane (in the rare instances in which it is present) later. The type may be that of a dry arthritis (caries sicca), but more commonly there are an exudate (with the formation of a cold abscess later), perforation of the capsule, and burrowing of pus in various directions. Perforation most frequently occurs anteriorly where the ligaments are weakest, the abscess forming in the pelvis, or it may burrow behind the pelvic fascia along the course of the sacral nerves or the pyriformis muscle and appear in the gluteal region after escaping through the greater or the lesser sacro-sciatic foramen. (Fig. 5.) This is the most common

site, the pus following this route in about one-half of the cases. Gravitation abscesses may follow the curve of the sacrum behind the pelvic fascia into the ischio-rectal fossa and come to the surface in the perineum; they may follow the psoas muscle and appear in the thigh or above Poupart's ligament; or they may perforate into the bladder or the rectum. Occasionally the perforation takes place posteriorly or in an upward direction, the abscess pointing superficially near the joint or higher up in the lumbar region. As the destruction of joint surfaces, bone, and ligaments progresses, the joint becomes loosened and disability increases. Rarely, both joints are involved, either simultaneously or one very soon after the other; in such cases the sacrum may be almost entirely destroyed by caries.

Symptoms.—The onset is usually very gradual, the first symptom being pain, either in the region of the joint itself or in the distribution of the sacral plexus, the sciatic, or the anterior crural nerves. Pain in the early stages is often mistaken for sciatica, but is not so constant in position. It may be over the sacro-iliac joint, in the region of the anterior superior spine of the ilium, in that of the flexors of the thigh, along the anterior surface of the thigh, or in the gluteal region. It should also be borne in mind that the pain which accompanies early involvement of the joint is increased by walking, standing, prolonged sitting, or any movement causing strain upon the joint. Direct pressure over the joint or lateral compression of the iliac crests elicits pain, as does palpation of the anterior aspect of the joint *per rectum* or *per vaginam*. It is in this latter site that tenderness, swelling, or abscess formation is often first detected. With the onset of the pain there are characteristic attitudes or changes in gait; the weight is borne on the healthy side; the affected side of the pelvis is tilted downward and slightly forward, giving rise to apparent lengthening of the limb on that side with compensatory scoliosis. Rarely, tilting in the reverse direction, with apparent shortening, has been observed. The scoliosis and apparent lengthening or shortening disappear on lying down. The gait is somewhat waddling; bending forward and straightening up are painful movements; and the weight of the body cannot be supported on the foot of the affected side for any length of time. Patients therefore find it difficult to put on their shoes and stockings; when in bed they lie preferably on the sound side. The pain may continue for several months, or even for as long a period as two years, before the local swelling and the tenderness elicited by direct pressure over the joint posteriorly, or by palpation of its anterior aspect *per rectum*, indicate the presence of an abscess. Compression of the iliac crests causes pain, and, while hip-joint motion is not limited, flexion and outward rotation of the thigh are sometimes painful. Fixation of the hip or lumbar spine may be due to a gravitation abscess following the course of the psoas, but actual tuberculous involvement of these structures should always be suspected and excluded. Pain may diminish with the formation and rupture of an abscess. Some atrophy of the buttock and thigh on the affected side is commonly present. When abscesses have burrowed and burst spontaneously, fistulous tracts, usually tortuous, lead by roundabout ways to the joint. Spread of the disease to the spinal cord or its membranes is rare, but may occur. Constitutional symptoms persist for a long time, and are due to the continued pain and the prolonged suppuration. Secondary infection,

accompanied by more active sepsis, or the presence of tuberculous disease in some other part of the body, may hasten a fatal issue.

Diagnosis.—In the early stages the diagnosis is not always easy, the pain being frequently mistaken for neuralgia—for sciatica or for lumbago, for example. Later, when an abscess has formed, it must be differentiated from spondylitis, hip disease, acute osteomyelitis of one of the pelvic bones, or one of the various pelvic suppurative processes, especially of the female generative organs. If suppurating sinuses are present, they must—unless they can be traced directly to the joint—be differentiated from those which are due to osteomyelitis or which owe their origin to intrapelvic suppuration. Careful consideration of the accompanying symptoms—viz., the peculiar gait; the tilting downward of the pelvis; the apparent lengthening of the limb on the affected side; the tenderness on direct pressure over the joint posteriorly, on palpation of its anterior aspect *per rectum*, and on transverse pressure on the iliac crests; the presence of a cold abscess in one of the characteristic locations; the slow course of the disease, and the fact that the patient's age coincides with that at which the disease occurs oftenest—will usually result in a correct diagnosis being made. An *x*-ray examination should not be omitted, as it may give valuable information when the bone involvement is well marked. Primary sarcoma of the sacrum or the ilium in the region of the synchondrosis is a possibility, but it is extremely rare to find a sarcoma in either of these localities.

Prognosis.—The prognosis has been considered very grave, many surgeons taking an extremely gloomy view of the outlook. Patients with sinuses which have existed for a long time, who are weakened by prolonged suppuration, or who are septic from secondary infections, may succumb to a septicæmia or a pyæmia, to an amyloid degeneration of the various organs, or to disseminated tuberculosis. In those cases in which the patient comes under observation early, where proper fixation apparatus is employed, and where a suitable climatic, hygienic, and dietetic régime is put in force, good results may be obtained without radical operative procedures.

The unfavorable character of many of the statistics published is probably due to the fact that most of the cases reported were complicated by secondary infections and burrowing abscesses.

Treatment.—In the early stages immobilization with orthopedic apparatus, such as a double Thomas hip brace (Whitman), a strong pelvic girdle attached to a spinal brace (Ridlon and Jones), or a plaster spica, may be employed. Extension by weight and pulley at night when the patient is in bed may be used in connection with the ambulatory treatment. (Young.)

If, in the course of the fixation treatment, an abscess forms, it may be aspirated alone, or first aspirated and then treated with iodoform emulsion. Incision and drainage should be employed with caution, owing to the great danger of secondary infection. As a rule, such interference should be avoided, except when a thorough radical operation is attempted.

If, despite the conservative measures employed, the disease continues to make headway, a radical operation may be performed. The joint is exposed by free

posterior incisions, the diseased bone is thoroughly removed, and all tuberculous granulation tissue is excised or removed by means of the curette. If a cold abscess is present its contents should be evacuated, its walls should be thoroughly excised or curetted, and, if possible, the entire wound should be closed without drainage. It is safer, as a rule, to take the chance of having to do a secondary operation for some overlooked or recurring tuberculous focus than it is to run the risk of secondary infection in a drained wound. If the operation is done subperiosteally, it is practicable, in advanced cases, to remove quite extensive portions of bone and yet have regeneration of the excised tissue and restoration of the functional power of the bone as a whole take place. Bardenheuer has, in a number of cases, resected practically the entire half of the pelvis, from the sacro-iliac synchondrosis, behind, to the symphysis pubis, in front, removing the head of femur at the same time. Operative procedures as radical as this would rarely if ever be justified. Extensive tuberculosis of the sacrum renders thorough removal of the disease very difficult if not impossible; but, where the lateral portion is involved to only a moderate degree, it is sometimes possible to reach and remove the diseased portions during the excision of the joint. Intrapelvic abscesses, which are so often present, may require removal of a considerable portion of the ilium before it becomes possible properly to expose and treat the disease.

Tuberculosis of the Symphysis Pubis.—Tuberculosis is of comparatively infrequent occurrence at the symphysis pubis, the age of predilection being adolescence and early adult life. Among the cases reported both sexes appear to have been equally often affected.

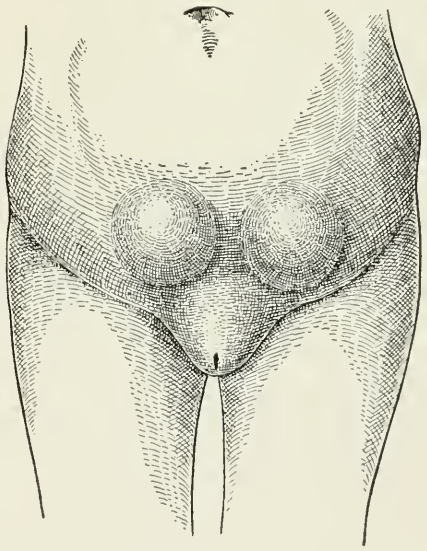


Fig. 6.—Tuberculosis of the Symphysis Pubis, with two typically placed supra-symphyseal abscesses, in a woman fifty-seven years of age. (Von Bungner.)

The process may originate in the bone, or in the fibro-cartilage of the symphysis. The pathology of the process and the variations in type are the same as when tuberculosis affects other parts of the pelvis. When abscesses form they are usually located above and behind the pubis, spreading laterally toward the inguinal regions, seldom downward toward the perineum or inner aspect of the thigh. The abscesses, as a rule, lie in the suprapubic pre-fascial space, between the muscles and the transversalis fascia, and not behind the transversalis fascia in the space of Retzius. The mid-region above the pubis is usually free from swelling, presenting rather a depression between two lateral swellings, owing to the fact that the abscess lies behind the insertions of the powerful recti muscles. (Fig. 6.) There have been reported cases in which an abscess has been mistaken for an inguinal hernia and a truss has been worn. Rarely, through involvement of the descending ramus, an abscess may spread downward to the perineum.

Spontaneous rupture, with the formation of a sinus, is most apt to occur in the inguinal region, less frequently in the perineum or the inner aspect of the thigh. The bone is most frequently involved on its upper and posterior aspect.

Symptoms.—In the early stage the symptoms are: pain over the symphysis or in the inguinal region; a tendency to stoop forward in walking, in order to relax the recti muscles and so to relieve the strain upon the symphysis. At first, the local signs may be slight, but, upon careful examination, tenderness will usually be elicited on direct pressure over the symphysis or on palpation of its deep surface *per rectum* or *per vaginam;* or there will be pain over the symphysis when the iliac crests are compressed. The course of the disease is slow and chronic, and, after the lapse of a certain length of time, the appearance of a swelling at the site already mentioned announces the formation of an abscess. Through carious destruction of bone the symphysis may become so loosened that mobility can be detected; but this is often obscured by the fact that in front the pubis is covered by strong muscles and fascia, and behind by the thickened transversalis fascia and by tuberculous tissue. As a rule, the differential diagnosis is not difficult. It is important to remember the possibility of neuralgic conditions in the early stages of the disease, and of inguinal hernia when an abscess forms on one side of the pubis. An *x*-ray examination should not be neglected, and careful palpation of the pubic arch, both externally and *per rectum* or *per vaginam*, is important. Tuberculous lesions in the lungs or other parts of the body should also be carefully searched for.

Treatment.—Tuberculosis of the symphysis pubis should be treated by radical operation as soon as the diagnosis is made. The upper and posterior surfaces, where the disease is usually located, are easily accessible and are favorably situated for thorough removal of the disease. The affected bone, even if the disease should involve the entire horizontal ramus and parts of the descending rami, should be resected subperiosteally through a transverse incision. In the case of a cold abscess the contents should be evacuated, all granulation tissue should be thoroughly removed, and, if possible, the wound should be closed without drainage. If drainage is employed, the greatest care must be taken to avoid secondary infection. When it is found necessary to resect large portions of bone a strong pelvic girdle or some suitable pelvic support should be worn for some time or until bone regeneration has taken place.

Syphilis of the Pelvic Bones.—Syphilis very rarely affects the pelvic bones.

Localized periostitis or osteitis, associated, in the earlier stages, with manifestations of syphilis elsewhere, is occasionally seen, and in such cases the diagnosis is not difficult.

In the later stages gummata may develop, or there may be a sclerosing osteitis, associated with thickening of the bone or with the formation of osteophytes, which, when they occur in the region of the foramina, may press upon nerves and thus give rise to distressing neuralgias.

Rarely, necrosis may take place and an abscess form—conditions which may easily be mistaken for lesions of tuberculous disease.

The treatment consists in general antisyphilitic medication. Local inter-

ference is contra-indicated, as a rule, unless necrosis, with abscess formation, shall have taken place; and these conditions should then be treated on general surgical principles.

Echinococcus of the Pelvic Bones.—The rarity of this disease may be judged from the fact that only twenty-odd cases have been recorded in the literature. The course of the disease is slow, and the extent to which the bony structures may be destroyed is at times very great. Thus, for example, in a case reported by Fischer and Viertel, the entire half of the pelvis, together with the head of the femur, was destroyed.

The diagnosis and treatment are based upon the same principles as those which govern the diagnosis and treatment of echinococcus disease in other parts of the body.

Tumors of the Pelvic Bones.—*Chondroma and Osteoma, Including Exostoses.*—The chondromata consist, as a rule, of hyaline cartilage with the admixture of some connective tissue. They are of either the large-cell or the small-cell variety, and they arise ordinarily from normal cartilage, but they may also spring from any portion of the osseous tissue. Although they are essentially benign in character, they sometimes form metastases. All sorts of retrogressive changes may be witnessed in chondromata, and they sometimes become converted into sarcomata.

Osteomata consist either of pure bone or of a mixture of tissues, cartilage being quite frequently present.

Exostoses (enostoses), which are also known by other names, grow from the surface of a bony structure. At times they consist partly or wholly of cartilage (enchondroma; ecchondroma). The strictly osseous exostosis may be either ivory-like in density or of a spongy nature, containing perhaps true bone marrow.

The types of tumor mentioned above show great variation in size; the growth may even attain so great a bulk as nearly to fill the pelvic cavity.

On the whole, osseous tumors do not often develop in the pelvis, only about one hundred cases having been reported in the literature. In the majority of these cases the ilium or the sacrum was the part affected; the pubis and the ischium being very rarely involved.

If the tumor is accessible and if it gives rise to symptoms, it should be extirpated. Some thirty successful operations have been reported. (Tillmanns.)

Fibroma.—A fibroma may arise from the periosteum of one of the pelvic bones. It occurs in several transitional forms—as, for example, in that of a cystic fibroma, a calcifying fibroma, an osteo-fibroma, etc. While a fibroma often occurs as a tumor of the bone, arising from periosteum or from the point of insertion of a muscle, it is more often encountered as a tumor of the soft parts. The fibroma grows slowly and is benign in character; the symptoms to which it gives rise being mainly those which result from pressure.

In accordance with general surgical principles the proper treatment is extirpation.

Sarcoma.—Sarcoma occurs in the pelvic bones in a variety of forms. When it originates in the bone marrow it may be highly vascular and may even pulsate.

The mixed-cell myelogenous form is the most common; melano-sarcoma is rare. The ilium is the most common seat of the growth, the sacrum coming next in order. Of all the sarcomata which occur in the pelvis, a large percentage originate in bone, comparatively few in the soft parts (11 in 127 cases, according to Tillmanns).

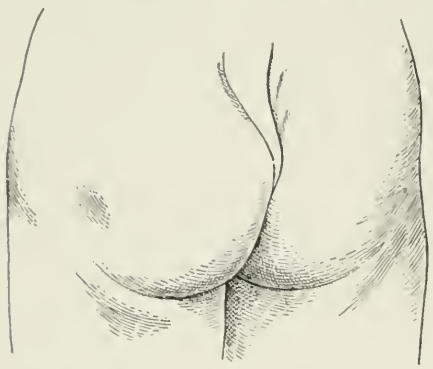


Fig. 7.—Rudimentary Tail-Formation in a Five-months-old Boy. (From Bartels and Werner.)

The diagnosis must be made on general principles. The intrapelvic growths, it must be borne in mind, may easily be confused with tumors of the pelvic viscera. The treatment is early extirpation, when such a measure is possible; and the prognosis is unfavorable.

Carcinoma.—The primary occurrence of a carcinoma in the pelvic bones is something unknown, but secondary growths have been observed.

Endotheliomata and other rare tumors may occur here as in other parts of the body, but they require no special description.

Congenital Deformities of the Sacro-Coccygeal Region.—*Rudimentary Tail-Formation.*—The question of the formation of a tail in human beings is one of the oldest in medical literature, and in ancient times many authors gave credit to the most exaggerated accounts of tailed human beings and of entire tribes of people with tails, such stories being most frequently brought by travellers and travelling merchants from Africa, Asia, India, and the islands of the Indian Ocean. When critically examined, these stories were found to originate in the fact that certain barbarous or semi-civilized tribes in Africa, Java, Sumatra, etc., wore, at religious ceremonies, fêtes, etc., costumes of animal skins with tails—*i.e.*, costume tails. During the Middle Ages, these exaggerated reports were given even greater credence, but recently the careful researches of several investigators, notably M. Bartels, have finally placed our knowledge of the occasional occurrence of rudimentary tail-formation in human beings on a scientific basis. That such formations do at times occur is a well-established fact, and the explanation is reached through a study of the development of the caudal end of the embryo. Normally, from the first to the third month of fœtal life, there is a distinct tail-like projection, beyond a line drawn from the thirtieth vertebral segment to the membrana analis. The number of rudimentary vertebral segments in this projection is normally four or five, representing the coccygeal segments; but as many as nine of these segments have been observed.

Between the third and fourth fœtal months the projection becomes a triangular hummock covered by skin, and this in turn disappears as the gluteal masses develop and the coccyx (toward the ninth month) takes its normal curve or bend forward. Bartels makes several groups of the authenticated cases of persistence of the tail-formation, but essentially there are only two varieties—those which contain bone and those which are composed entirely of soft parts.

First Variety.—The tails which contain bone are: first, those which have an actual increase in the number of vertebral segments, as in normal vertebrate animals; second, those in which the projection contains the normal number of coccygeal vertebræ, which, by abnormal growth of vertebral bodies and discs, are increased in length.

Second Variety. — The tails composed wholly of soft parts are: first, the persistence of the normal coccygeal, triangular hummock ("Steishöcker") of the third to fourth month of fœtal life; second, the conical projections of skin and soft parts into which the bone does not extend; third, the pedunculated lipomata, fibromata, etc., which occur in this region and form pseudo-tails.

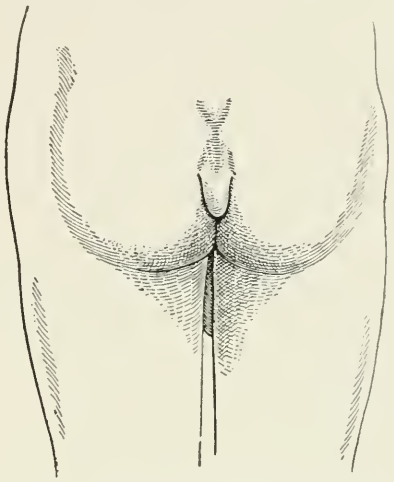


Fig. 8.—Human Tail, in a Greek Recruit, twenty-six years of age. (From Ornstein, of Athens.)

There have been recorded several cases of three-sided, skin-covered elevations in the sacro-coccygeal region — elevations which were limited by distinct lateral grooves and which terminated in a point in the region of the anus, but which, at the base or upper part, merged with the skin of the back without distinct boundary line. These are the so-called "angewachsene" or adherent tails of Bartels, and they represent persistence of the normal fœtal coccygeal hummock of the third to fourth month—the "Steishöcker." No part of this elevation forms a free or tail-like projection from the body.

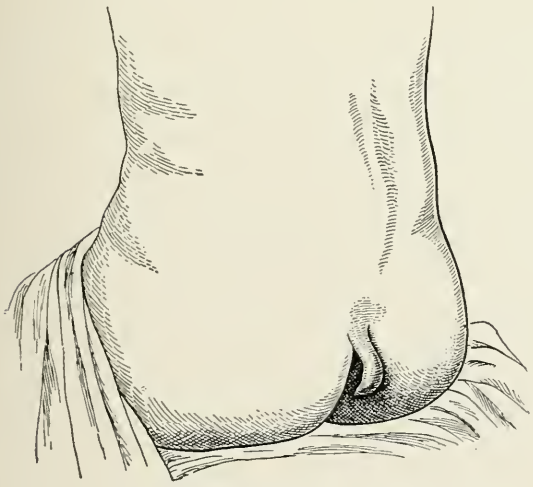


Fig. 9.—Pseudo-Tail or Pendulous Lipoma in an eighteen-year-old Boy. (From Bartels.)

The position of the elevation is in the median line, but it may be to one or the other side of this line, as in the case of Bartels and Werner. (Fig. 7.) Many authenticated cases of free-hanging or projecting tail-like formations have been observed and recorded, some of them containing coccygeal vertebral segments, as in the case of Braun in which the last three coccygeal vertebræ could be felt, or in that of Ornstein (Fig. 8) in which slight mobility of the coccygeal vertebræ, both in the projection itself and in the two vertebræ located above its base, could be felt beneath the skin.

Finally, one meets with the pseudo-tails or pendulous tumors (lipoma, fibroma,

etc.), in the coccygeal region—tumors which in no sense represent defective or abnormal development of the caudal structures. (Fig. 9.)

This entire group of cases possesses scientific rather than surgical interest, and, for a careful or thorough study of the subject, the reader is referred to Bartels' exhaustive researches in the *Archives of Anthropology*, Bd. 15.

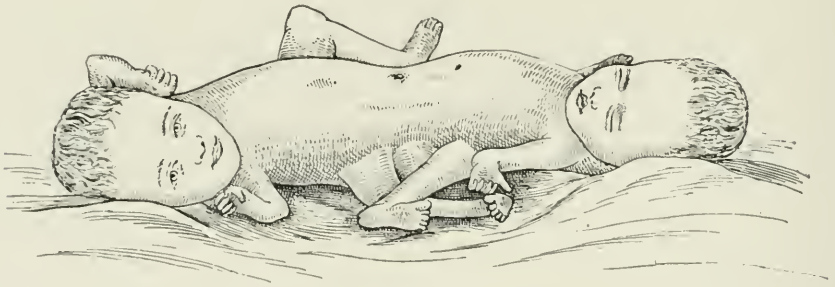


Fig. 10.—Jones Twins, born in Tipton Co., Indiana, on June 24th, 1889; died on Feb. 19th and 20th, 1891. (From Gould and Pyle.)

Double or Bigerminal Teratomata (Double Monsters).—Double or bigerminal teratomata or monsters are formed by the joining together of two separate embryos or individuals during the very early stages of embryonic life, which joining can assume many different forms. Well-authenticated cases of joined twins, with symmetrical development of the two individuals, have been observed and reported in the literature a number of times, as have also cases in which one individual has developed more or less perfectly while the second is simply an attached parasite, or fœtal inclusion. The caudal end of the body is especially apt to be affected, although many different types have been illustrated in the reported cases. The entire subject is fully dealt with by Ahlfeld, whose Atlas contains illustrations of the majority of the authenticated cases on record. In the classification of the congenital sacral tumors, some of those which contain rudimentary organs, limbs, maxillary bones, etc., must be considered as true fœtal inclusions. Besides these, there are tumors which contain only tissues or organs normally present in the sacro-coccygeal region, which have probably developed from detached islands or rests of embryonic tissue that have gone on to abnormal growth, and are strictly monogerminal in character.

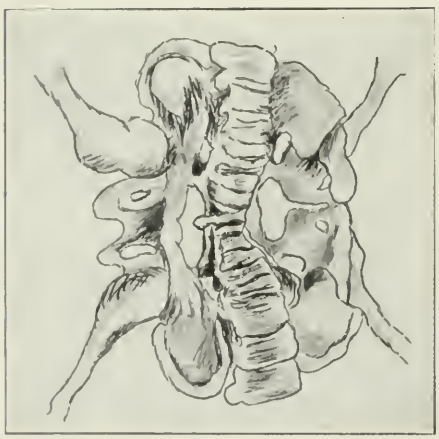


Fig. 11.—Pelvis of a Case of Joined Twins, similar to that of the Jones Twins (Fig. 10). (Case of Levey, quoted by Tillmanns.)

In the well-known case of Geoffrey St. Hilaire, the joined twins Helena and

Judith were born October 26th, 1701, and lived to the age of twenty-two years; they died within three minutes of each other, on Feb. 8th, 1723. The autopsy showed that, from the second sacral vertebra downward, the sacrum and coccyx were single. Both vaginæ terminated in a single vulvar orifice, and there was a single anal orifice for the two rectums. Millie and Christine, the negro sisters born in Columbus Co., North Carolina, in 1851, were observed and reported by many different authors, and are said to have lived to be twenty-three years of age.

The Jones twins, who were born in Tipton Co., Indiana, on June 24th, 1889, and who died on Feb. 20th, 1891 (Fig. 10), represent another type of symmetrical development. In this type the umbilicus is single, the anterior body surface presents no distinct division, and the lower extremities are undeveloped and lie at the side. Fig. 11 represents the pelvis of a similar case, reported by Levey. An example of bigerminal deformity of the parasitic type is seen in the case of Joan Baptista dos Santos, who was born on Sept. 5th, 1845. This case was reported by Acton in 1846, and a picture of the monstrosity (at the age of twenty years) was first published in Ahlfeld's Atlas. A complete lower extremity, containing two joined thigh bones and provided with a double foot, was attached to the body in the coccygeal region. (Fig. 12.) There were two well-formed, functionating penes, each with its urethra; the scrotum was single.

Fig. 12.—Accessory Lower Extremity; Joan Baptista dos Santos, nine months of age, born Sept. 5th, 1845. (From Acton and Ahlfeld.)

Congenital Sacro-Coccygeal Tumors and Cysts; Mixed Teratomata.—Congenital tumors of the sacro-coccygeal region are divisible into two great classes: those of bigerminal origin, or true fœtal inclusions; and those of monogerminal origin, or defects of development in the caudal end of the body. The latter class may contain tissues that represent organs of the pelvic region,—*e.g.*, post-anal gut, spinal cord, etc.,—but never organs of distant parts of the body, as for example, portions of an upper extremity, maxillæ, etc.; such findings always represent a bigerminal origin of the tumor. The differentiation between very imperfectly developed true fœtal inclusions and teratomata of monogerminal origin, containing a variety of tissues all normally present at the caudal end of the body, may at times be very difficult or impossible. It is thought by many investigators that developmental anomalies, in the shape of nests of embryonal tissue, derived from some of the various structures at the caudal end of the fœtus,

are responsible for a large number of the congenital sacral tumors, which have been described as true fœtal inclusions.

In many cases, however, the evidences of a bigerminal origin seem conclusive. The well-known case of the Schliewener child (Fig. 13), born in 1864 and reported by Virchow and von Langenbeck, is an interesting example of a tumor containing muscle fibres, cartilage, and bone, and having a kind of contractile motility. A similar case of a girl, two and a half years old, was reported by Stolper. (Fig. 14.) In this case the tumor had a contractile movement, but was partly cystic, a clear fluid having been drawn by puncture.

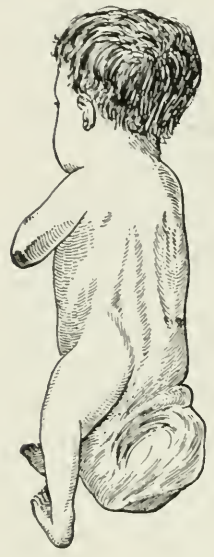


Fig. 13.—Schliewener Child; Contractile Teratoma of Sacro-Coccygeal Region. (After Virchow.)

In some of the cases the tumor undoubtedly arises from the remains of the neurenteric canal or of the post-anal gut.

The successful removal of these tumors has occasionally been accomplished, but care must be exercised in separating the deep attachments, which may be in direct continuation with important structures, especially the spinal canal.

Post-rectal Dermoids.—The mode of origin of this group of tumors, as in the externally placed dermoids of the sacro-coccygeal region, is somewhat in doubt. They may arise from infoldings of the cuticle of the perineum during fœtal development, but it is more probable that they arise in the remains of the ectodermal portion of the Wolffian body or duct, possibly sometimes from the post-anal gut or from the neurenteric canal. They differ from ovarian dermoids which originate as aberrant growths in ova, either fecundated or non-fecundated, and from true teratomata, although they have been found in close relation with tumors of the latter type from which a distinct pedicle leading to the spinal column has been traced. They may also be associated with the type of congenital tumors which are due to superfœtation, or fœtal inclusions, but, as previously stated, they usually occur as simple dermoids. Nearly all of the cases thus far observed have been in females. Of thirty-two cases collected from

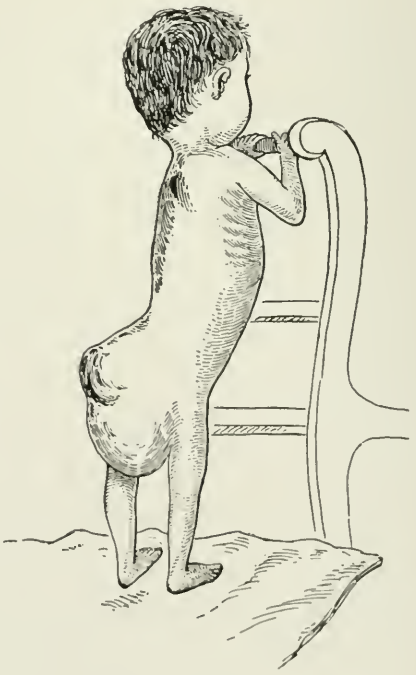


Fig. 14.—Sacro-Coccygeal Tumor, the Size of a Child's Head, in a Child two and a half years old, otherwise healthy. (After Stolper.)

literature by Tillmanns, only three were in males. As they are of very slow growth, as a rule, varying in size when first discovered from that of a pigeon's or hen's egg to that of a man's fist, being rarely as large as a child's head, they have been usually first detected in adult life, either from interference with childbirth or from suppuration of their contents. If suppuration occurs and is followed by spontaneous rupture, the dermoid may discharge into the rectum, the bladder, or the vagina, or through the skin of the perineum. The position of this variety of tumor is between the sacrum and the coccyx, behind, and the rectum in front, either in the median line or to one side of it, most often to the left. The rectum and bladder are pushed forward, the latter often upward against the symphysis, in such a manner as to cause interference with urination and defecation. The vagina is flattened and pushed forward and its lumen may be so diminished that a digital examination is impossible. The perineum itself bulges downward.

Pathology.—The cysts may be single or multiple. There have been reported instances in which three or more lay in a chain in the hollow of the sacrum. They are comparatively immovable, and seldom rise above the brim of the pelvis, differing in this respect from ovarian dermoids. They are usually situated above the levator ani, but may be below it. Their walls consist of firm connective tissue lined usually with pavement epithelium, sometimes with cylindrical epithelium. Glandular structures are seldom found in the walls. The contents of the cysts are a grumous material and a yellowish-brown, gruel-like fluid, with bundles or balls of hair. Under the microscope there will be found fat, epithelial detritus, hair, etc.

Symptoms and Diagnosis.—The symptoms vary according to the size and position of the cysts; they may be attributed to pressure upon and displacement of pelvic organs, with consequent disturbance of function, or to the occurrence of suppuration, with or without spontaneous rupture. The perineum bulges downward and the bladder and rectum are pushed forward and upward.

The consistence of the tumor is doughy; it pits on pressure and sometimes there is a peculiar feeling of crepitation, due to the character of the contents (hair mixed with grumous material).

Differentiation from ovarian dermoids is seldom difficult, and is made by noting the bulging downward of the perineum, and the immobility and the displacement forward of the rectum. As before stated, the tumors are rarely recognized until attention is called to them through interference with childbirth or by the occurrence of suppuration in them.

Treatment.—Treatment consists in the removal of the tumor through a perineal incision, the position and extent of which depend largely on the site, size, and degree of bulging of the tumor. The choice lies between a lateral or median perineal incision, a para-sacral incision, and a transverse retro-anal incision.

Removal of the coccyx may be of advantage in obtaining sufficient exposure. Complete enucleation of the cyst wall should be done, if possible, but, if this is impracticable on account of adhesions following suppuration or for other reasons, as much of the lining membrane as possible should be destroyed and the remain-

der of the cavity packed, with the idea of obtaining healing by granulation. Occasionally, in large tumors, the abdominal route, either extraperitoneal or transperitoneal, may be necessary, or the abdominal and perineal methods may be combined.

Pilo-nidal Sinus.—Synonyms: Foveæ Sacrales; Sacro-coccygeal Dimples or Foveæ, Sinuses, or Cysts.

Description.—From twenty per cent to thirty per cent of all infants examined at birth present, in the sacro-coccygeal region, either a distinct dimple or depression of the skin or an actual orifice which may vary in size from a pin-point to an opening large enough to be mistaken for the anus. Of a large number of adults examined, between four per cent and five per cent presented a similar condition. This condition is always congenital and, as a simple fovea or de-

Fig. 15.—Photograph of a Sacro-Coccygeal Fovea of the Groove Type, in a child fourteen months of age. It occurred in connection with spina bifida. (Original.)

pression, possesses no surgical interest. But when the infolding of the skin is of a sufficient depth to form a sinus, or when the deeper portion becomes sequestrated and forms a cyst-like cavity filled with epithelial detritus, hair, etc., infection is prone to occur in it, and there is then produced a condition which necessitates surgical intervention.

The foveæ or sinuses may be associated with other congenital deformities (Figs. 15 and 16), but, as a rule, they occur in individuals who are otherwise normal.

Pathology.—During the process of development, in early fœtal life, the intestinal and neural canals are continuous around the end of the notochord, the U-shaped portion which winds over the end of the coccyx being termed the neurenteric canal. At about the end of the third month of fœtal life the structure, beginning at the apex of the curve, undergoes a process of obliteration, the posterior portion becoming the filum terminale of the cord, and the anterior limb

of the U being represented for a time by the fœtal structure known as the post-anal gut, which in turn disappears soon after the union of the proctodeum with the rectum proper,—a change which completes the anal portion of the lower bowel. Some observers believe that the foveæ and sinuses represent unobliterated portions of some part of the neurenteric canal; others attribute their formation to a simple infolding of the skin at the point where the filum terminale is adherent to its deep surface, and in individuals in whom the mesoblastic tissue is late in forming and scanty in amount. Still others believe that it is simply an evidence of imperfect closure of the medullary groove. In any event, the structure of the sinuses and cysts, and the character of their lining membrane and of the contents, would seem to indicate that an epidermoid infolding is the basis of

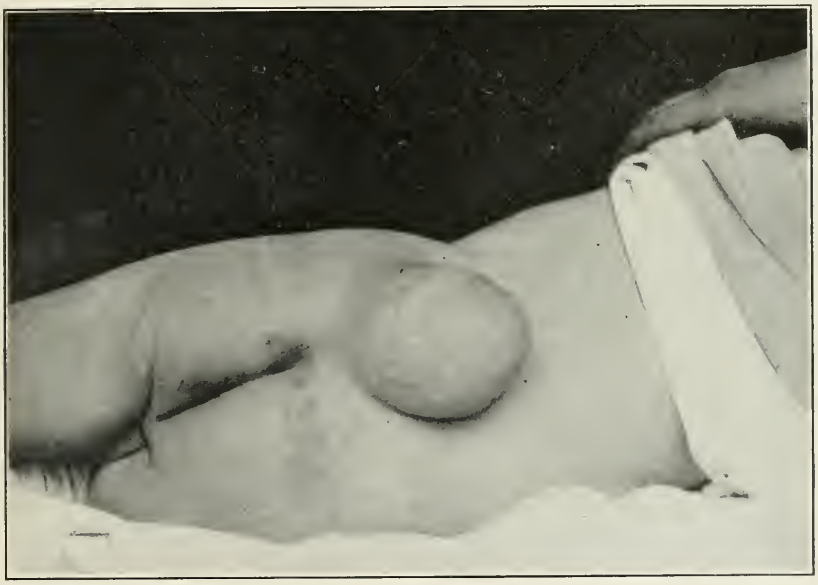


Fig. 16.—Photograph of a Sacro-Coccygeal Dimple or Fovea, Occurring, in Connection with a Spina Bifida, in a Male Child sixteen months of age. (Original.)

the pathological process, rather than a development in the neurenteric canal or the deeper structures. Careful examination of sections made through the sinus wall will almost always demonstrate the presence of the pavement epithelium of the cuticle at some point, though it is usually impossible to find sebaceous or sweat glands. The contents of the cysts consist of a cheesy or grumous material which frequently contains bundles or balls of hair more or less mixed with the grumous mass. Under the microscope, epithelial detritus, fat droplets, and fat crystals are seen. Infection, which is prone to occur, converts the tract or cyst into a suppurating sinus or abscess. The sinuses lead down to the posterior surface of the lower part of the sacrum, and, if a cyst-like dilatation has occurred, the deep portion of the cyst wall will be found intimately adherent to the periosteum of the sacrum. The cysts should not be confused with the true teratomata, as they never contain bone, cartilage, rudimentary members, or

organs: they are of an entirely different origin. There is usually one opening in the skin, exactly in the median line, and from one and a half to three inches posteriorly to the anus—*i.e.*, about at the sacro-coccygeal junction. There may, however, be two openings (Fig. 18) or even several openings (Fig. 19), or the original opening may have closed and a new one have formed as a result of suppuration, in which case it is often located to one side or the other of the median line (Figs. 20 and 21).

Fig. 17.—Sacro-Coccygeal Cyst in a Man, twenty-nine years of age. (Original; drawn from life.) Note the shining, pearly, epithelial lining of the sac, closely adherent to the periosteum of the sacrum.

Suppuration occurred in the third week of a severe attack of typhoid fever. The swelling was incised under cocaine anæsthesia, and the opening was allowed to heal by granulation.

One must distinguish several degrees of the process: namely, the simple groove or depression (Figs. 15 and 16); the deeper tract or sinus lined by pavement epithelium derived from the cuticle; the sinus leading into a dilated sac, similarly lined, which still communicates with the surface (Figs. 17 and 18); and the completely sequestrated sac, which does not communicate with the surface depression.

Borst, Tillmanns, and others distinguish between true dermoids, the lining of which shows the true structure of the cuticle (*i.e.*, hair follicles, sebaceous and sweat glands), and epidermoid cysts, the walls of which consist simply of connective tissue lined with pavement epithelium.

Symptoms.—There are no symptoms, except the presence of a fovea or a sinus opening, until the retained epithelial detritus, etc., form a cyst or tumor, or, more commonly, become infected and form an acute abscess. If this is allowed to burst spontaneously, as is frequently the case, a sinus persists, or the opening heals and a secondary abscess forms. This process may be repeated a number of times before the patient seeks surgical relief.

Diagnosis.—When the opening of the suppurating sinus lies to one side of the median line, and the site of the original fovea is closed or indistinct, the condition may be mistaken for necrosis of the sacrum or coccyx; or, if the opening is situated low down, it may even be mistaken for a fistula in ano. Tuberculosis

or syphilis may be suspected, and in certain cases of decubitus, with a small area of necrosis in this region and a large infected retrosacral subcutaneous bursa, one may confuse the condition with an infected congenital sinus or cyst. In the case shown in Figs. 17 and 18 the reverse error in diagnosis was at first made, the extremely low, typhoidal state of the patient suggesting an ordinary bedsore.

Necrosis of the sacrum or coccyx is easily excluded by the absence of bare bone, as well as by the usual appearance of the openings which are clean cut, and into which the epithelium of the skin seems to dip. (Fig. 18.) Where the opening is an aberrant one, as it is apt to be after the bursting of an abscess (Fig. 20) or after a previous incision for abscess (Fig. 21), the original median depression or dimple in the usual site may often be found.

Fig. 18.—Sacro-Coccygeal Sinuses. Note two distinct openings in the skin, and their position about two and a half inches above the margin of the anus. (Photograph of the case shown in Fig. 17, before the incision was made.)

Tuberculosis and syphilis are excluded by the usual methods, and by the fact that a single lesion at this site, unless due to diseased bone, is rarely observed.

Fistula in ano is easily excluded by the non-fetid character of the discharge, by the direction followed by the sinus, and by the fact that it never terminates just beneath the rectal wall as a blind external fistula does.

In bedsores that occur in this region, in patients suffering from some protracted and exhausting disease, it is well to bear in mind the possibility of a pre-existing cyst or sinus which has become infected. The clean-cut character of the opening and the firm, well-defined wall of the sac or sinus are features which contrast strongly with the flabby, necrotic subcutaneous fat and undermined skin of a bedsore.

Treatment.—Thorough excision of the wall of the sinus or cyst should be done to prevent recurrence. Simple as this treatment is, it is surprising how many cases are inefficiently treated by incision and drainage, the peculiar character of the lining membrane of the sinus or cyst causing recurrence of abscesses or a persistent suppurating tract.

An elliptical excision should be made around all sinus openings and the dissection should be carried through the normal subcutaneous fat, well outside the lining membrane of the sinus. In its deeper parts this lining membrane lies in

close contact with, and is usually adherent to, the periosteum of the lower part of the sacrum, and care should be taken to make its removal complete. The wound may then be closed by suture, with or without a small rubber-tissue drain inserted at the lower angle. It is important that ample gauze pads should be placed over the wound and secured by broad strips of adhesive plaster, in order to obliterate dead spaces and prevent sliding or lifting of the flaps.

Even in suppurative cases it is often possible to obtain healing by primary union, if the pus is evacuated and the cavity thoroughly swabbed first with pure carbolic acid and then with alcohol or peroxide of hydrogen, before the dissection of the sac wall is undertaken. If, for any reason, complete excision of the sac wall is found to be impracticable, the cavity should be laid widely open, curetted, swabbed with pure carbolic acid and alcohol to insure destruction of the sac wall, and then packed with sterile gauze. Recurrence does not take place if the plan of completely excising the sac or the sinus wall, or of destroying it thoroughly, is strictly followed.

Fig. 19.—Several Sacro-Coccygeal Sinuses in a Man thirty-two years of age. The drawing, which is a copy of a photograph, shows four distinct openings, all leading to one suppurating tract. This tract was excised in its entirety under ether anæsthesia. (Original.)

Incised Wounds.—Incised wounds of the pelvic and gluteal regions differ in no way, as regards symptoms and treatment, from those of other parts of the body, except when they involve viscera, vessels, or nerves—*e.g.*, wounds penetrating into the pelvis through the sacro-sciatic or obturator foramina or alongside the rectum in the ischio-rectal region.

The things of chief importance are these: Examine carefully in order to ascertain whether any injury has been inflicted upon the rectum, the bladder, or one of the important blood-vessels or nerves; observe strict asepsis; and provide very free drainage, especially where there is danger of infection in the intrapelvic connective-tissue planes. Injury to the gluteal artery, with resulting hæmatoma or a traumatic aneurism, is of special moment, and will be more fully described.

Injuries and Diseases of the Iliac Vessels.—Injuries and aneurisms of the common, external, and internal iliac vessels, although of great importance, need not be considered here, as they will be fully described in the special article on "Wounds and Diseases of the Heart and Blood-vessels." We shall therefore consider here only those branches which supply chiefly the pelvic and gluteal regions.

Injuries of the Gluteal Artery.—Injuries of the gluteal artery are of comparatively infrequent occurrence, owing to its deep situation, but they are of great

practical importance on account of the serious consequences which frequently follow. The artery leaves the pelvis through the great sacro-sciatic foramen, above the pyriformis muscle, immediately after its origin from the posterior division of the internal iliac. Sometimes its inferior branch lies below the pyriformis in the foramen, but more frequently its division occurs after the vessel has emerged above the muscle.

Among the different causes of injury may be mentioned: stab wounds, gunshot wounds, fracture of the pelvis, and subcutaneous rupture from a severe fall, from a blow, or from the kick of a horse or man, without fracture.

Fig. 20.

Fig. 21.

Fig. 20.—Sacro-Coccygeal Sinus in a Man twenty-four years of age. The drawing, which is a copy of a photograph, shows the healed opening of the original sinus in the median line, and to the right, but somewhat higher up, the opening of a still suppurating sinus. (Original.)

Fig. 21.—Sacro-Coccygeal Sinus in the Case of a Man fifty-two years of age. The drawing, which is a copy of a photograph, shows the external opening through which the abscess discharged its contents; the site of the original fovea cannot be recognized. The entire fistulous tract was excised under cocaine analgesia. (Original.)

Traumatic Aneurism of the Gluteal Artery.—Of the cases reported in the literature, about two-thirds have resulted in late traumatic aneurism, or in an immediate false aneurism with diffuse hæmatoma beneath the gluteal muscles. The hæmatoma may become very large, causing swelling of the thigh, pressure on the sciatic nerve with its associated pain, and interference with locomotion. Pulsation and a thrill or murmur may be present. The patient may actually bleed to death in this way, if prompt and effectual ligation of the wounded vessel is neglected; or he may die from sepsis if the hæmatoma ruptures and the cavity becomes infected. False aneurism has been mistaken for simple abscess, and an incision made with the expectation of evacuating pus has been followed by

severe hemorrhage. Punctured wounds of the artery may be followed by apparent healing, and then, after weeks or months, a true traumatic aneurism develops. Fatal secondary hemorrhage may occur from such an aneurism.

If both artery and vein are wounded an arterio-venous aneurism may develop.

Erosion of the artery in the wall of a tuberculous abscess, with severe bleeding on evacuation of the abscess, has been observed.

Diagnosis.—In the case of a wound in the region of the great sacro-sciatic foramen, injury of the gluteal artery should be suspected whenever there is severe bleeding, or when, at some later date, secondary hemorrhages develop. Such an injury should also be suspected if, after a kick, a fall, or a contusion, a swelling makes its appearance in the buttock and upper part of the thigh, whether pulsation, a thrill or a murmur can be detected in the swelling or not. If the case is seen for the first time after the swelling has developed and after the suspicion of an abscess has already arisen, it is well not to overlook the possibility of a hæmatoma or a false aneurism, the result of an injury inflicted upon the gluteal artery. The sudden enlargement of a cold abscess in this region is also significant of the possible erosion of the artery, or of one of its branches, with hemorrhage into the abscess.

Treatment.—When the injuries are of recent date and a suspicion has arisen that the gluteal artery is damaged, the wound should be freely enlarged by an incision along a line drawn from the posterior superior iliac spine to the trochanter. The fibres of the gluteus maximus should then be separated and strongly retracted, and the artery should be exposed to view as it emerges from the foramen. A double ligature of catgut should be placed around the vessel on each side of the bleeding point; or, if this is impossible, clamps may be applied and left in place for forty-eight hours or longer. The introduction of a sterile gauze tampon may be found necessary if the patient is in poor condition, if the bleeding is profuse, and if the bleeding point cannot be easily identified. A short incision, which extended into the peritoneal cavity, has been made through the rectus muscle, and digital compression has been successfully applied to the common iliac or the aorta as an aid to the ligation. Exceptionally, it may be necessary to perform transperitoneal ligation of the internal iliac itself, especially in cases where a large hæmatoma or a false aneurism has been incised inadvertently, and when identification of the bleeding point in the wound is impossible. Under these circumstances a temporary tamponade is employed while the iliac vessel is being secured.

Spontaneous Aneurism of the Gluteal Artery.—Spontaneous aneurism of the gluteal artery is also of rare occurrence, but some thirty or more cases have been collected from the literature. It is probable that many of these cases are really traumatic, and that a subcutaneous injury from a blow, a fall, or a kick is the real cause. In other cases the cause is undoubtedly disease of the arterial walls, as in spontaneous aneurism elsewhere.

Symptoms.—The symptoms and signs of gluteal aneurism are the appearance of a fluctuating, pulsating swelling in the gluteal region, with sometimes a thrill

or murmur; pain localized over the swelling or radiating down the sciatic nerve; and interference with the function of the limb.

Diagnosis.—Differentiation must be made from an abscess, a cyst, or a soft pulsating sarcoma. Pulsation, murmur, and thrill may all be absent in aneurism, if it is of small size, if it has very thick walls, or if the overlying soft parts are very thick; and fluctuation may be simulated by the thick gluteal muscles and overlying fat. The aneurism, especially if it be of the spontaneous form, may project some distance into the pelvis, through the foramen.

Prognosis.—As in aneurism elsewhere, a spontaneous cure occasionally takes place; or the aneurism may remain stationary in size or may increase very slowly. Often, however, the increase in size continues until rupture, with severe hemorrhage, occurs. The false aneurism or the hæmatoma may run a rapidly fatal course in the absence of proper surgical intervention.

Treatment.—The treatment of gluteal aneurism consists in exposure of the sac and the ligation (both proximal and distal) of the main artery, if possible, and of any branches that enter the sac. Or the sac may be laid freely open and the clot evacuated under compression of the aorta or the common iliac through an opening in the peritoneum; after which the vessels should either be ligated or closed by suture according to the method of Matas. If, for any reason, it be found impossible to expose the gluteal artery, or if the examination *per rectum* or *per vaginam* shows that the aneurism extends into the pelvis, it may be necessary to proceed directly to extra-peritoneal or transperitoneal ligation of the internal iliac. This operation, however, has been attended by a considerable mortality (about forty per cent of published cases) and should be avoided if possible.

Technique of the Operation of Ligating the Gluteal Artery.—The patient lies on the face or well over on one side, the thigh being rotated inward. An incision, from 12 to 15 cm. in length, is then made on a line drawn from the posterior superior spine of the ilium to the upper border of the trochanter major, the centre of the incision being at the junction of the upper and middle thirds of this line. After the skin and the superficial fascia have been divided, the gluteus maximus is split in the line of its fibres and strongly retracted, thus exposing the pyriformis and gluteus medius muscles and also, in most cases, large crural branches of the artery. The pyriformis and gluteus medius are separated, and the gluteal artery is thus brought into view as it emerges from the great sacro-sciatic foramen above the pyriformis. It is ligated as near the foramen as possible, as it sometimes divides into its two branches (superficial and deep) close to the point of exit or even inside the pelvis. Care should be taken to avoid including the superior gluteal nerve in the ligature. The ligation may be greatly facilitated by transperitoneal compression of the common iliac.

Injury or Traumatic Aneurism of the Sciatic Artery.—Injuries or traumatic aneurisms of the sciatic artery are less frequent than those of the gluteal. The artery arises from the anterior branch of the internal iliac and emerges from the great sacro-sciatic foramen below the pyriformis muscle. According to Fischer, aneurism of the gluteal artery is three and a half times more frequent than an-

eurism of the sciatic artery. In some cases it has been impossible to tell which vessel was affected, and in others both have been involved in the same aneurism. The symptoms, diagnosis, and prognosis are practically the same as for the gluteal artery.

The treatment consists in ligation through a gluteal incision. The details are as follows:—

Technique of Ligating the Sciatic Artery.—A line is drawn from the posterior superior spine of the ilium to the outer part of the tuberosity of the ischium. The point of exit of the artery is at the junction of the lower and middle thirds of this line. An incision from 10 to 12 cm. in length is made parallel to the fibres of the gluteus maximus, its centre being at the above-mentioned point. The fibres of the gluteus maximus are strongly retracted, the spine of the ischium and the lower border of the pyriformis are identified, and the artery is found lying posteriorly and externally to the internal pudic, as it emerges from the great sacro-sciatic foramen below the pyriformis muscle in company with the bundle of sciatic nerves. The nerves must be carefully avoided in placing the ligatures. Ligation of the internal or common iliac may be found necessary.

Injuries or Traumatic Aneurism of the Internal Pudic Artery.—Injuries of this artery are of comparatively rare occurrence; they are produced by the same causes as those which are responsible for the injuries to the gluteal and sciatic arteries. Fractures of the ischium or its ramus are among the more frequent causes. So far as the peripheral part of the artery is concerned it is apt to be injured when the perineum is wounded.

When the artery is injured in the region of the great sacro-sciatic foramen, the symptoms and treatment are practically the same as when the sciatic artery is the part injured, and the operation for the exposure of the latter artery is the same as that which is required for the exposure of the internal pudic. The important point is to remember the course of this artery after it emerges from the great sacro-sciatic foramen. It passes below the pyriformis muscle, crosses the spine of the ischium, and re-enters the pelvis through the lesser sacro-sciatic foramen.

If the wound or the aneurism is in the peripheral part, where the artery passes forward, in close proximity to the ramus of the ischium, to the perineum, it is best approached through a perineal incision along the ramus, with the patient in the lithotomy position. (Vide Vol. IV., p. 512.)

Injuries or Traumatic Aneurism of the Obturator Artery.—The obturator artery may be injured by fractures of the pelvis, especially those involving the horizontal ramus of the pubis and the margin of the obturator foramen; by stab or gunshot wounds, especially those which affect the artery after its exit from the pelvis; and by wounds accidentally inflicted in the course of surgical operations—those, for example, for obturator hernia.

Aneurism of the obturator artery, either traumatic or spontaneous, is of rare occurrence. A significant symptom is obturator neuralgia, due to pressure on the nerve.

The vessel may be exposed for ligature, at its exit from the pelvis, by an

incision which extends from the inner third of Poupart's ligament in a downward direction, and divides skin, fascia lata, and the sheath of the pectineus. The operator should be careful to avoid wounding the internal saphenous and femoral veins. To get them out of harm's way they should be pulled outward. The obturator externus muscle is exposed to view when the pectineus is retracted inward. To expose to view the obturator vessels and nerve in their groove at the upper margin of the obturator foramen it is necessary to divide the sheath of the obturator externus and to retract its upper border downward. To expose the artery in its course in the pelvis, the extraperitoneal or the transperitoneal incisions employed in exposing the iliac vessels, will have to be made. (Vide Vol. IV., p. 507.)

Abscess of the Gluteal Region.—Abscesses of the gluteal region may arise from many different sources, both extrapelvic and intrapelvic.

Furunculosis is common in this region and particularly distressing; but it presents no other features that call for special comment here.

Cellulitis and lymphangitis occur in most cases as extensions from ischio-rectal infections, but they may also develop from a variety of other sources.

Deep-seated gluteal abscesses may be due to osteomyelitis, to sacro-iliac disease, to intrapelvic suppuration which has extended through one or the other of the sacro-sciatic foramina, to pyæmia, etc. Careful rectal or vaginal examination, for the purpose of determining the possibility of intrapelvic disease, should not be omitted. The *x*-ray is of use in detecting or excluding disease of the bone.

Cold abscess in the gluteal region is very common and is frequently due to sacro-iliac disease, but may arise from disease of the spine, hip, sacrum, or ilium.

The treatment is that of the cause, if it can be located, and of abscess in general. A word of caution against the possibility of mistaking traumatic aneurism of the gluteal artery for abscess is perhaps not amiss at this point.

Diseases of the Pelvic Bursæ.—The bursæ of the pelvic and gluteal regions, especially the subcutaneous group, vary both as regards their number and as regards their size; the occupation of the individual appearing, in many instances, to exert an influence—as in the case of the bursa subcutanea trochanterica in hand-organ players, in that of the bursa subcutanea sacralis in chimney sweeps, in that of the bursa spinæ iliacæ in weavers, etc. The principal sites in which these inconstant subcutaneous bursæ occur, are:—

(1) Over the lower sacral and coccygeal region. (According to Luschka, the bursa in this locality has a diameter of from 1.5 cm. to 2.5 cm.)

(2) Over the great trochanter. (Waldeyer.)

(3) Over the anterior iliac spine.

(4) Occasionally subcutaneous bursæ are found over the tuber ischii.

The writer has seen a large subcutaneous sacral bursa become infected and slough in a case of prolonged decubitus from chronic rheumatism.

The superficial bursæ mentioned above are of surgical importance only if, as a result of an irritation of some kind, they become the seat of an acute or

chronic bursitis, or if, in consequence of a contusion, a hæmatoma forms in the sac.

Of the deeper bursæ, that between the gluteus maximus and the trochanter major is one of the largest in the human body. The most common affection of this bursa is a chronic hygroma (*e.g.*, occupation bursitis, as in organ grinders). The swelling is sometimes very large, cases having been reported in which it reached downward to the middle of the thigh, or upward to the iliac crest. (Chassaignac.) Tuberculous bursitis in this site is rare, but has been observed. (Wieting.) Another bursa lies between the gluteus maximus and the tuber ischii. To enumerate by name all of the deep bursæ which lie between muscles, tendons, ligaments, and bony surfaces, would require much space, as the list is a formidable one. Special mention, however, should be made of the bursa subiliaca, which lies between the ilio-psoas tendon, the hip-joint, and the horizontal ramus of the pubes. This bursa extends down as far as the trochanter minor, and usually communicates with the hip joint. Many cases of bursitis subiliaca have been reported. They vary much in type: simple acute bursitis (hygroma), chronic bursitis (hygroma), gonorrhœal bursitis, tuberculous bursitis, syphilitic bursitis, etc. On account of the fact that the bursa subiliaca frequently communicates with the hip-joint, the treatment of inflammation of this bursa is of special importance, and every precaution against secondary infection of the joint must be observed. In general, the bursæ are liable to the following diseases:—

Acute bursitis, inflammation with serous effusion (hygroma); chronic inflammation, or chronic hygroma; tuberculous inflammation; syphilitic inflammation; gonorrhœal inflammation; suppurative inflammation; hæmatoma.

The tuberculous, syphilitic, and gonorrhœal forms of bursitis are quite rare. Hæmatoma is caused by bleeding into the bursal sac, the result of a contusion or of some other injury. Suppurative bursitis (or acute abscess) may arise from infection of the sac in the course of any of the above types of inflammation.

Treatment.—Inflammation of the bursa subiliaca may be effectively treated in the following manner:—

A vertical incision is made from Poupart's ligament in a downward direction, between the femoral artery and the anterior crural nerve. Then the ilio-psoas muscle is pulled to one side or its fibres are split apart until the sac is exposed to view. The sac wall should be completely excised, if possible, and then the wound should be closed. If this is not feasible, the sac wall should be destroyed by other means (*e.g.*, by curetting, or by the use of carbolic acid and alcohol) and ample provision for drainage should be supplied.

Bursitis trochanterica may involve one or more of several different bursæ—*e.g.*, the subcutaneous, subfascial, the anterior or posterior bursæ of the gluteus medius, etc. The type is most often that of an acute or a chronic hygroma, and many cases have been reported.

The treatment of this form of bursitis, as well as the bursal inflammations in the region of the tuber ischii and other sites, is the same as that already described for inflammation of the subiliac bursa.

Tumors of the Gluteal Region.—Except for the congenital forms which have already been described, tumors of the soft parts of the pelvic and gluteal regions differ very little from those found in other parts of the body. Nearly all of the various forms of benign and malignant growths are occasionally met with.

Lipomata and fibro-lipomata of the pendulous type occasionally spring from the buttock and they sometimes attain an enormous size; but in other respects they have the same characteristics as the lipomata encountered elsewhere in the body.

Lymphangioma and angioma are occasionally seen in the gluteal region; they extend upward from the lower limb.

Elephantiasis may affect the gluteal region.

Sarcoma rarely originates in the soft parts of the gluteal region. Out of one hundred and twenty-seven cases collected by Tillmanns there were only eleven in which this occurred; in the remainder the disease originated in bone.

Carcinoma or epithelioma occurs very rarely or not at all in the gluteal region except as a secondary growth.

Other forms of tumor may occur in this region, but they call for no detailed description.

Neuralgias of the Pelvic and Gluteal Regions.—Pain in the area of distribution of the nerves of the pelvic and gluteal regions may be traced to many causes. It may be due to a wound or contusion or other trauma of the sacral plexus or its branches, or to pressure exerted by a tumor, an aneurism, a callus, a misplaced fragment of bone, or an inflammatory exudate. It may be secondary to an inflammation of one of the pelvic bones or one of the joints, or to some affection of the male or female generative organs; it may also result from one of the various constitutional conditions, as anæmia, malaria, rheumatism, syphilis, arteriosclerosis, diabetes, a severe cold, habitual constipation, etc. Venous hyperæmia, producing pressure on nerves that pass through osseous or fibro-osseous canals or foramina, is one of those causes of neuralgia in general to which many observers attach great importance. Such venous congestion of the pelvic and gluteal regions is of very common occurrence, for many different reasons, and may be of considerable importance as an etiological factor in the neuralgias of this region.

Coccygodynia.—Coccygodynia is the term applied to a painful neurosis that affects the ano-coccygeal branches of the coccygeal plexus. Such a neurosis may be caused by an injury or by disease involving the coccyx or the neighboring ligaments or soft parts; it may develop secondarily to disease of the rectum or the female generative organs; or it may occur as a pure neurosis. It occurs most frequently in women, especially after injuries associated with child-birth. Trauma —as, for example, difficult labor, a fall on the buttocks, an injury inflicted by horseback riding, the passage of hardened fæces, etc.—is the most frequent cause. The injury done to the bone may be an actual fracture or it may be simply a contusion; one of the sacro-coccygeal or intercoccygeal joints may be dislocated; or there may be tearing, laceration, or contusion of the adjacent ligaments or

soft parts. In falls upon the coccyx the force is applied from behind, and the bone is forced forward or the posterior ligaments are injured, while in difficult labor the opposite is true. Fracture or luxation may be followed by union of the parts while in a faulty position, the lower fragment sometimes projecting forward almost at right angles toward the rectum, in which case defecation is especially painful; or the displacement may be backward, so that, when ankylosis occurs, the rigid coccyx projects directly downward from the sacrum, and the patient then feels as though sitting on a nail. Again, healing may be accompanied by abnormal mobility, or a false joint may be formed; in which case the pain will be due to this rather than to ankylosis.

In many cases of traumatic origin, in which the neuralgia is decidedly severe, no injury to the bone or joints can be detected. Under these circumstances we are forced to assume that the injury was originally inflicted upon the ligaments or other soft parts, and that these injured places have imperfectly healed or are still the seats of painful cicatrices.

Pain simulating coccygodynia may be secondary to an inflammation either of the coccyx itself (caries or necrosis) or of some neighboring structure (such, for example, as a fissure or an abscess of the rectum, inflamed hemorrhoids, inflammation of the uterus or adnexa, etc.). In these cases the cause can usually be discovered by careful examination and the symptoms relieved by appropriate treatment of the primary condition.

There are many cases, however, in which no history of trauma or other cause can be found, and which must therefore be looked upon as true neuroses. Thus, Simpson has reported a case in which the pain followed exposure to cold from prolonged sitting on damp ground; and there can be no reasonable doubt that rheumatic changes in the coccyx or its joints is a possible explanation of the pain in some of these cases. Again, in the so-called idiopathic cases the pain may be the result of slight unnoticed trauma, especially when the person affected is a hypersensitive woman of neurotic tendency. (Tillmanns.) Cases have been reported in which there existed an abnormal mobility between the first and the second coccygeal vertebræ, and a subsequent examination showed that the intervertebral disc was thickened and displaced; and yet the patient gave no history of either childbirth or trauma. (Hirst.) After due allowance is made for all those possible lesions there still remain a considerable number of cases which must be regarded as pure neuroses, and in which the most careful examination reveals no cause for the persistent pain.

Symptoms.—The chief symptom is pain, which is especially felt on sitting down, on rising from the sitting posture, and on defecation. To avoid strain on the coccygeal muscles and ligaments, patients, when they rise, place their hands on the chair or seat, and, in a stooping posture, they push themselves up.

Sleep may be disturbed by pain caused by some movement which throws a strain upon the coccygeal ligaments. Defecation may be painful and difficult and the after-pain severe. The pain may be increased at the time of the menstrual period and be slight or absent in the interval. It may disappear for a

period of several months and then reappear with increased severity. The course is chronic, the pain often persisting in varying degree for months or years.

Diagnosis.—The diagnosis, as a rule, is not difficult. Palpation, with a finger in the rectum and the thumb making counter-pressure on the outside, enables one thoroughly to examine the coccyx and to detect an ununited fracture or union in malposition; an unreduced dislocation; abnormal mobility; inflammatory swelling, or simply tenderness on pressure without other changes. Careful examination of the rectum itself and of the pelvic organs must not be neglected.

Prognosis.—The prognosis is good. The milder cases often recover spontaneously in a few weeks or months, while in other cases recovery takes place only after the proper treatment has been employed or after the removal of some discoverable cause. Finally, the most obstinate cases rarely fail to be cured by extirpation of the coccyx.

Treatment.—The first and most important thing needed is to treat properly, or to remove radically, any condition to which the coccygodynia may be due, as, for example: a fissure in ano, a perirectal inflammatory process, an existing disease of one of the female generative organs, etc. Constitutional treatment for anæmia, lues, or neurasthenia, or psychic treatment for hysteria, may be indicated.

Local antiphlogistics, rectal irrigations, and antineuralgic or sedative medication, if carefully employed, may prove of benefit. Electricity and massage applied, both externally and *per rectum*, have effected cures. In the early stages, conservative treatment should be given a fair trial, unless the pain is especially severe or unless there is demonstrable injury to the bone or the joints.

Excision of the coccyx was first performed by Nott, of Mobile, Ala., in 1832. Later, it was taken up by Simpson, whose careful studies of the disease are well known, and afterward by many other surgeons; and at the present time it is recognized as the best method of treatment for all obstinate cases.

Technique of the Operation.—A median incision is made over the coccyx, from tip to base, and is carried down to the bone. The soft parts are freed on all sides with scalpel or periosteal elevator, especial care being taken, on the anterior aspect, not to injure the rectum, and disarticulation is effected at the sacro-coccygeal joint. The wound is closed by sutures, with or without a small drain at the lower angle; or, if necrosis or suppuration be present, it is allowed to heal by granulation. A cure is practically certain after this procedure. Either general or local anæsthesia may be used.

Subcutaneous division of the muscles and ligaments attached to the coccyx laterally has been practised by several surgeons, but the procedure is neither so safe nor so surely effective as the open operation. The formation of an extensive hæmatoma and failure to cure the pain have both been observed after this procedure.

Sciatica.—The most common of the neuralgias of the branches of the sacral or lumbar plexuses, with the possible exception of lumbago, is sciatica or pain in the great sciatic nerve and its distribution.

Etiology.—Sciatic pain may be traced to a great variety of causes. Among them may be mentioned the following:—trauma, with direct lesion of, or pressure upon, the nerve either in its peripheral distribution or in its course through the vertebral canal, an inflammatory process in some neighboring structure (*e.g.*, one of the pelvic bones, the sacro-iliac joint, or one of the pelvic organs); pressure from a tumor, an aneurism, a callus, the gravid uterus, uterine fibroids, impacted fæces, etc.; some constitutional disease, such as rheumatism, syphilis, diabetes, influenza, etc. As examples of infrequent etiological conditions there have been reported cases where the cause proved to be a hæmatoma which was located within the vertebral canal and which pressed on the cauda equina. In still other cases it was found that the sciatica was caused by a tuberculous pachymeningitis in the region of the cauda, the inflammation having developed secondarily to sacro-iliac disease. The neuralgia may be due to general neurasthenia or to hysteria, or it may be a symptom of a lesion of the central nervous system. The writer has observed a case in which pain in the distribution of both sciatic nerves, without other symptoms, persisted for months, finally proving to be due to a metastatic tumor of the brain, secondary to carcinoma of the breast. After all of these possible etiological factors have been excluded, there still remain a considerable percentage of cases in which no cause can be found, and in which the affection must be considered a pure neuralgia.

Symptoms.—The chief symptom is pain in the distribution of the sciatic nerve,—a pain which varies in severity and constancy, and which is sometimes combined with disturbances of sensation—*e.g.*, paræsthesiæ, such as a feeling of cold, prickling, numbness, etc. The pain is usually increased by moving the limb. The characteristic points of tenderness on pressure are: (1) at the exit of the nerve from the great sacro-sciatic foramen; (2) at the lower border of the gluteus maximus; (3) in the popliteal space; (4) behind the head of the fibula; and (5) at the external malleolus. In cases of long duration, in which the affected limb becomes weakened, various other changes may be observed: there is usually muscular atrophy; contractures may develop, with limitation of motion; and there may be lateral scoliosis due to the effort to favor the affected limb. The character of the scoliosis varies, the curvature being sometimes toward, sometimes away from, the affected limb.

Diagnosis.—The diagnosis is made from the localization of the pain, from the characteristic painful pressure points, and by excluding the various conditions, already mentioned, which may cause pain in the sciatic distribution—*i.e.*, by examining for disease of the pelvic bones or joints, for tumors, for inflammatory exudates, etc., which may cause pressure upon the nerve, and also for processes within the vertebral canal, especially those affecting the cauda equina. Hip disease and spondylitis must also be borne in mind.

A diagnostic sign of some value is that known as "Lasègue's phenomenon." The test is made in the following manner: When the knee is flexed, motion in the hip-joint is painless, but if the knee is extended and the thigh is strongly flexed, so as to put the nerve on the stretch, severe pain is caused along its course and especially at its exit from the great sacro-sciatic notch. Another test, which

is known as the "crossed sciatic phenomenon," or the Fajersztajns sign, is to lift the sound limb (*i.e.*, the limb on the side opposite to that on which the sciatica exists), with knee extended, high in the air; by which procedure pain is produced over the exit of the sciatic nerve on the opposite or affected side. This phenomenon is explained by the fact that traction of the nerve on the sound side exerts a pull, through the dura of the cord, on the roots of the affected nerve.

A differential diagnosis is to be made from hip disease, from hip-joint neuroses, from ilio-sacral disease, from spondylitis, from psoas abscess, from muscular rheumatism, and from pain due to the pressure of a tumor, an aneurism, or an inflammatory exudate. A careful rectal or vaginal examination should always be made, by digital manipulation, to exclude anything abnormal in the pelvis, either in the vicinity of the roots of the nerve or in other parts.

Sometimes sciatica is very accurately simulated by malingerers, even to the typical tender pressure-points. A careful examination, as indicated above, together with electric muscle tests and measurements for atrophy (which is almost invariably present in prolonged cases), will generally make it possible to reach a correct conclusion.

Treatment.—The treatment of sciatica is at first medical. Constitutional affections such as rheumatism, syphilis, and malaria must be relieved, constipation must be overcome, and general supporting and hygienic treatment should be employed. Absolute rest in bed, combined with the use of warm baths, hot packs, and the local application of heat by poultices, by hot-water bags, or by electric heating pads, is often beneficial. Mud baths, sun baths, and, in the later stages, electricity and massage may be tried. Baking in hot-air apparatus has sometimes proved very effective. Antineuralgic medication, especially by means of the salicylates, aspirin, or the antipyrin group of coal-tar products, is sometimes effective. Hypodermic injections of antipyrin, and, more recently, of alcohol (seventy to eighty per cent), into the trunk of the nerve, have been tried with varying results.

Bloodless stretching of the nerve by flexion of the thigh with the knee extended has been used with good effect, either alone or combined with some of the measures already mentioned.

Intraspinal injections of cocaine have been claimed by several writers to effect a permanent cure, or at least to afford temporary relief, of the pain. High-frequency electrical currents and the violet rays may be used as in other neuralgias. The galvanic current, interrupted at stated intervals by the method of Le Duc, is also advised.* If medical and non-operative measures fail to give relief, open operation and nerve-stretching should be resorted to.

The technique of stretching the nerve is as follows:—The patient is turned on his face or well over on one side, and a vertical incision, about 10 cm. in length, is made midway between the tuberosity of the ischium and the great trochanter, with its centre at the gluteal fold. After the skin and fascia have been incised, the lower border of the gluteus maximus is retracted upward, and the nerve is found lying along the outer border of the biceps and slightly beneath it. It

*See Le Duc's article in La Presse Médicale, 1907, xv., 129.

should be grasped between the thumb and forefinger and stretched by pulling in both directions, peripherally and centrally, until it drops back distinctly relaxed. It is estimated that the nerve can safely bear a pull of thirty pounds. To the stretching may be added direct injection of various remedial solutions (from seventy to eighty per cent of alcohol, one per cent cocaine solution, five per cent antipyrin solution, or a one-half per cent to two per cent solution of osmic acid) into the trunk of the nerve.

In certain intractable cases exposure of the nerve at its exit from the great sacro-sciatic foramen is advised. The steps of this procedure are as follows:—An oblique incision is made from the posterior inferior iliac spine to the posterior margin of the great trochanter; and the fibres of the gluteus maximus are separated in the line of the incision, thus exposing the pyriformis muscle as it emerges from the great sacro-sciatic foramen. The nerve lies at the lower border of this muscle, resting on the sacro-sciatic ligaments. Traction is made upon it at this point and the finger is swept around it at its point of exit from the pelvis, to make sure that there is no pressure and that no adhesions exist at that point. Then, by passing the finger on through the foramen, palpation of the sacral nerve roots can be made nearly or quite as far up as their point of exit from the anterior sacral foramina. The more radical procedure of opening the sacral portion of the vertebral canal for direct examination of the sacral nerve roots has been done, but it should be reserved for cases in which there is direct evidence of an intraspinal lesion.

Obturator Neuralgia.—Neuralgia in the upper and inner part of the thigh, in the distribution of the obturator nerve, is usually due to pressure on the nerve at or near the obturator foramen. It is of especial importance as a symptom of obturator hernia, but may also be caused by a fracture, by a tumor, by an aneurism of the obturator artery, by an inflammatory exudate, or by disease of one of the neighboring bones. It rarely occurs as a pure neuralgia, and its treatment consists chiefly in the search for, and relief of, the primary cause.

Neuralgia of the Symphysis Pubis.—This form of neuralgia, in which the pain radiates out toward the inguinal regions, is occasionally observed, but is usually due to actual disease, injury, or abnormal mobility of the symphysis itself or of the adjoining bones.

Neuralgia of the Internal Pudic Nerve.—This variety of neuralgia is observed, in women, chiefly in connection with displacements or disease of the generative organs, while in men it is associated with disease of the bladder, the prostate, or the seminal vesicles. Its treatment is that of the exciting cause. Division of the internal pudic nerve has been advised in intractable cases.

SURGICAL DISEASES OF THE EXTREMITIES.*

By CHARLES A. PORTER, M.D., and WILLIAM C. QUINBY, M.D., of Boston, Massachusetts.

Ischæmic Myositis, or Volkmann's Contracture.—This serious condition is seen usually following a fracture, most often at the elbow or forearm. Because of the use of too tight bandages for the reduction of the fracture, or by reason of a rupture or thrombosis of the blood-vessels occurring at the time of injury or exposure to cold, the blood-supply of the flexor muscles of the forearm is impeded to such a degree that there results a profound ischæmia of these structures. This leads to their marked shortening, with flexion of the carpus and fingers and with some hyperextension at the metacarpo-phalangeal joints. In many cases the nerves are involved as well, either primarily or secondarily. This causes motor and trophic changes, such as temperature disturbances and ulcerations on fingers and hand. A majority of the cases have occurred in children or youths.

Once established, this condition is extremely hard to remedy. The methods of treatment advised are of two sorts: (1) mechanical, and (2) operative. In the first method the muscles are gradually stretched by specially fitted and adjusted splints of tin, which are applied first at the fingers and are then gradually extended above the wrist to the elbow. The extended position thus gained is maintained until all tendency to contract has disappeared. This procedure should be combined with massage, electricity, and Zander exercises. The second method, which calls for an operation at the seat of the contracture, aims at freeing and separating the muscles, and pays special attention to freeing all nerves involved. If possible, these nerves should be displaced to some smooth fascial space or plane. Other operators, finding it impossible, in the more severe cases, to overcome the deformity by these means, have resected a sufficient portion of the forearm bones to allow extension of the wrist and hand.

Whatever method be used the outlook is only relatively good. Function may be somewhat improved, but only in the milder cases can any approach to a complete restoration of it be hoped for. It is therefore of the greatest importance to insist that in all injuries to the extremities, especially fractures,

* The purpose of the present article is not, as one might infer from the title adopted, to furnish a comprehensive discussion of all the surgical diseases and injuries to which the upper and lower extremities are liable, but simply to treat of those minor disorders which do not fall under any of the headings which have been adopted in the previous volumes of this series, or to which only a casual reference has been made by the writers of the different articles.—THE EDITORS.

the first dressing should never interfere with the circulation. Careful watch should be kept, and, upon the appearance of any evidence of blueness in the fingers (for instance, after the application of apparatus for a fracture of the elbow), the dressings should immediately be loosened. After the first dressing good circulation should be maintained by frequent massage and passive motion.

Ossifying Myositis.—There are three types of this disease: (1) myositis ossificans progressiva; (2) ossification due to constant irritation, such as the "cavalry-man's thigh"; and (3) myositis ossificans traumatica.

In the first type the process is an inflammatory one involving whole muscles, and taking origin in the connective tissue. The process may stop in the fibrous stage, but, as a rule, calcification and ossification take place. Apparently the heteroplastic bone formation is a product of the connective tissue, the muscle being involved only secondarily. The etiology is unknown, and the disease is quite rare.

Fig. 22. Radiograph of Ossified Area in the Tendon of the Brachialis Anticus Muscle. Complete recovery followed operative removal. (Patient of Dr. C. C. Simmons.)

The second and third types are of greater interest to surgeons. Here the process is a localized one, and always of traumatic origin. The biceps and brachialis anticus of the arm, and the quadriceps and adductors of the thigh, are the most common sites of the bony growths. In the arm the commonest cause is a previous backward dislocation at the elbow. (Fig. 22.)

There is still considerable discussion as to the origin of the new-formed bone. In a recent article* Simmons states that the most generally accepted methods of origin are: (1) that a bit of periosteum is torn off at the time of the injury, and, becoming misplaced, continues to form bone; or (2) that, also as a result of trauma, the fibrous connective tissue, or even the muscle fibres themselves, undergo retrograde changes which result in bone-like formation. This last method depends on the now known pathological fact that, when the necrotic tissue of an inflammatory focus is not absorbed, it usually becomes calcified, and this deposit of calcium favors the formation of osteoid tissue.

* Simmons, C. C.: "Myositis Ossificans of the Brachialis Anticus," in Boston Med. and Surg. Jour., 1909, p. 548.

When symptoms exist they are those of mechanical disability, or of pressure on nerves.

Knowing the possibility of such a condition, the surgeon will find it easy to make the diagnosis with the aid of the *x*-ray.

The treatment, in those cases which show disabling symptoms, is excision. In other instances, even when a bone tumor may be shown to be present, delay should be the rule, for such deposits have been known subsequently to become absorbed. In any event, operation should be delayed for a reasonable time or until the tumor has ceased to grow: if the symptoms demand early operation, a sufficient margin of healthy tissue should also be excised in order to prevent recurrence by extension. With these precautions, operation will be followed by relief of the condition.

Chronic X-Ray Dermatitis; X-Ray Burns and X-Ray Carcinoma.—A very important as well as unfortunate result of the use of the *x*-ray is the occurrence of dermatitis in those parts of the body which are exposed to its action. This is not at all infrequent among those working constantly with the rays, and in many instances it causes great disfigurement of the hands as well as great discomfort. Moreover, this process may go on to the formation of ulcerated areas which are exceedingly painful, and which, if allowed to persist, may become the seat of epithelial cancer.

The clinical appearance of these chronic *x*-ray dermatoses suggests a premature and extreme senility of the skin. Microscopic examination also shows the most extraordinary changes, always of a degenerative character, unequalled in their severity and chronicity by the effects of any other agent. The skin, usually over the backs of the hands, forehead, etc., becomes dry, eczematous, and atrophic, and is frequently accompanied by the formation of telangiectases and by atrophy of the sweat glands. (Figs. 23 and 24.) Among the other changes noted may be mentioned the appearance of keratoses, warts, and fissures. The nails are atrophied, dry, irregular, and striated in a longitudinal direction, or they are sometimes lost. Sooner or later, often as a result of some slight trauma, though not necessarily so, there occurs an ulcer which is exceedingly painful. In some cases there appears to be an almost complete vasomotor paralysis, the tissues becoming remarkably vascular. Frequently small hemorrhages occur in the skin, and these are often the starting points of subsequent ulcerations.

Treatment.—For the atrophic conditions of the skin and the telangiectases, nothing can be done. Hypertrophic changes, keratoses, and warts may be safely treated in the usual manner. Quite recently there have been several instances of the successful use of liquid air for these lesions. If such treatment fails, excision, with or without skin grafting, will probably relieve the pain and result in a cure.

Too much emphasis cannot be laid on the great danger of all persistent *x*-ray ulcerations, especially those which have followed, after a few years' interval, the chronic skin lesions of the early operators. In a paper published in the *Annals of Surgery* for November, 1907, attention is called to the not

infrequent occurrence of epidermoid cancer in such persistent ulcerated areas. In a more recent collection * there are gathered the records of forty-seven cases of undoubted carcinoma, of which nine (twenty-five per cent) have been already fatal. In all of these, except two, death was clearly due either to a failure to recognize, sufficiently early, the malignant nature of the ulceration, or to refusal on the part of the patient to permit adequate operation. In two of them—multiple epitheliomata of the body—it is hard to say whether proper treatment would have brought about a cure. In view of these fatal cases, and of the success which has attended early operation and skin-grafting, we think such treatment should be unhesitatingly employed at an early stage of all persistent *x*-ray ulcerations.

Technique of Excision and Skin-Grafting.—Before the ulcer is excised a tourniquet should be applied, if possible, because much of the work must be

FIG. 23. Hand of *X*-ray Operator Showing Telangiectases and Keratoses, with Marked Senility of the Skin. The results of several amputations and skin graftings for areas which had become cancerous are well illustrated. (Original.)

done with great care, especially when dealing with a suspicious ulceration over an aponeurosis or tendon sheath. After the lesion has been excised, firm pressure should be made for ten minutes by means of gauze applied to the raw surface, and the hand should then be exposed to the air and held aloft. No grafts should be applied until all bleeding has ceased. So far as possible, an attempt should be made to bevel the edges of the wound, after the granulations have been shaved off, in order to get a smooth surface. The base of the wound is next examined for vascularity, as upon this depends, in some measure, the thickness of the graft which should be used. While a thick graft, if it attaches itself successfully, is most desirable, healing may undoubtedly be jeopardized by attempting to place a thick graft upon a very small spot or upon one where the tissues are as comparatively bloodless as on the backs of the fingers. Under such conditions, therefore, thinner grafts should be used. In operating on the hand, the whole forearm should be fixed by adhesive plaster to a

* "The Surgical Treatment of *X*-Ray Carcinoma and Other Severe *X*-Ray Lesions," by C. A. Porter. Journal of Med. Research, vol. xxi., No. 3, p. 357; October, 1909.

well-padded palmar splint, before any of the grafts are applied. If this plan is adopted, it will not be possible for a sudden movement of the patient or of the assistant to brush off grafts newly laid on. They should be so cut and arranged that they do not overlap either the edges of the wound or each other. If the spot where the grafts are applied is on the back of the hand, they should be covered with a piece of rubber protective tissue which extends not more than one-eighth of an inch beyond their edges; if it is located on the fingers, narrow strips of this tissue, arranged in an imbricated fashion, should encircle two-thirds of the finger. A small pad of absorbent gauze is then placed over the protective, and direct downward pressure is applied by means of a piece of gauze or bandage, tied in a surgeon's knot on the palmar side of the splint.

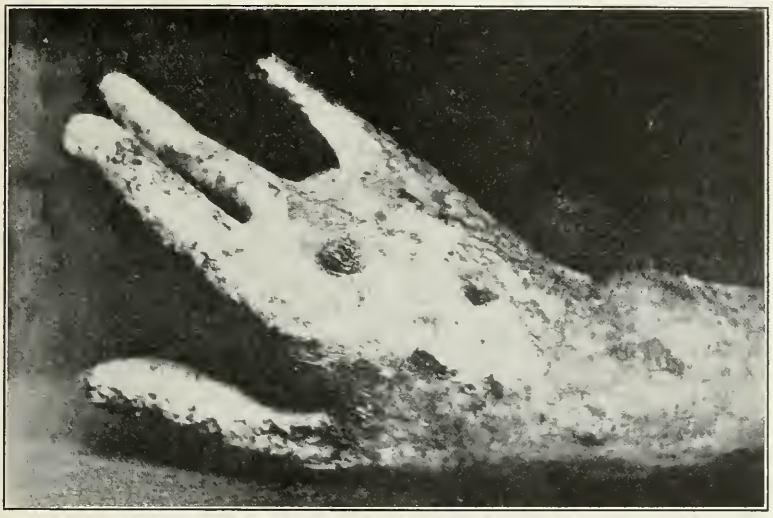


Fig. 24.—Later View of the Hand Shown in Fig. 23; the Photograph was Taken a few Months Later. Note the fact that the area at the base of the middle finger, which in Fig. 23 was suspicious, has now become definitely epitheliomatous. (Original.)

This obviates the possibility of carrying the smaller grafts from left to right during the ordinary application of a bandage. Owing to the amount of exudation which occurs immediately after operation, the grafts should not be exposed at once to the air, as is customary in skin grafting under normal conditions. At the end of twenty-four hours, the hand having been kept continuously elevated on a pillow, the rubber protective should be carefully removed. Longer delay than this will usually be followed by maceration of the grafts. At the first dressing any blebs present should be snipped open with the scissors and their contents gently expressed. Any lateral movement of the grafts must be avoided. All the edges of the individual graft should then be greased with lanolin or with the following ointment, which has been found less macerating:

Benzoinated lard	175 parts
Lanolin	25 "
Ichthyol	4 "
Silver citrate	1 part

The grafts should then be covered by a cage made either of wire screen or of tin and allowed to dry exposed to the air. Whenever possible, this plan of treating the grafts should be continued during the ensuing week. Often, however, the sensitiveness and pain, after a half-hour's exposure, become so great that the whole surface must be covered with ointment. Almost without exception, the pain of these ulcerated areas has ceased from the time of operation.

Treatment of Burns Following Exposure to the *x*-Rays.—In the acute and subacute stage it is advisable to delay interference until the end result appears to have been attained; the only indication for early operation is extreme pain. In general, too early operation—*i.e.*, operation at the end of two or three weeks—is apt to result in the excision of too much tissue, whereas delay for five or six weeks may leave a wound in the edges of which subsequent necrosis may occur. At the end of three months, if the pain can be borne for this length of time, excision, with a margin of tissue extending an inch beyond the periphery of the lesion, will be found satisfactory. Immediate grafting may be done, or one may wait until granulation has established itself and then resort to the application of a Thiersch graft.

Splinters and Nails in the Feet or Palms of the Hands; Blank-Cartridge Wounds.—In deciding upon a proper course of treatment for these common injuries we are influenced, first, by the danger of tetanus, and, second, by that of ordinary pyogenic infection. Until within the past ten years, the danger of tetanus from blank cartridges was not recognized, but recently, owing in a great measure to the agitation of the *Journal of the American Medical Association*, even the laity have come to realize the extraordinary fatality of such apparently trivial injuries. For several years past, at the larger hospitals, all of these patients have been etherized and thoroughly operated upon. The same holds true, to a certain degree, in the suburban towns in which there happen to be active surgeons, but there still occur many accidents the victims of which are either treated at home or at an apothecary shop. There can now be no doubt that the best established surgical principle is that, in blank-cartridge wounds, the patient should be etherized, a tourniquet applied, and all discolored tissue thoroughly excised. If a tendon sheath is opened, it should be drained, and, if the tendon is mangled, the injured portion should be excised and sutured. All of the crannies of the wound are to be thoroughly disinfected with pure carbolic acid followed by alcohol, and packed wide open with gauze and rubber protective; the latter to be in contact with the tendon or its sheath. Where possible, cultures should be taken. If these prove to be negative for tetanus bacilli, and if ordinary infection is not present, the wound may be allowed to close quickly. On the other hand, if cultures are positive, the wound should be kept open and prophylactic injections of anti-tetanic serum made. Many cases of this character have been treated at the Massachusetts General Hospital within the last ten years, and, although in two instances cultures have been positive and no serum has been given, not a single case of tetanus has developed after thorough surgical cleaning. The question as to whether serum should be given at the outset in blank-cartridge wounds

must be determined by experience. Certainly it would be safer to use it thus and at suitable intervals thereafter for a couple of days.

In regard to wounds from rusty nails which have penetrated deeply into the hand or the sole of the foot, much the same treatment applies, although, as the tissues are less damaged, the excision should be less wide, and the packing smaller in amount.

In relation to splinters, the treatment must depend somewhat upon surrounding conditions; also upon one's capacity to do a clean operation and not divide important anatomical structures. In view of the frequently innocent nature of this accident, it is hardly wise to use anti-tetanic serum except in special instances of possible infection, and probably, if the sliver is small and if it has not penetrated too deeply, conservative treatment, until infection has developed, will be adequate. If, however, a nail or splinter has penetrated deeply into the foot or into the hand, the writers are convinced that, after removal of the infecting agent, vertical incisions and the introduction of rubber-dam drainage *down to the bottom*, facilitated by retraction of the borders of the wound, will prove conservative treatment in the long run. In no other way can the risk of burrowing infection, with subsequent remedial mutilation of the hand or foot, be avoided. The pads of fat in the palm of the hand and in the sole of the foot rapidly fill up the wound, and a puncture through the palmar or plantar fascia quickly heals, leaving the infection pent-up and ready to burrow in various directions and possibly without producing easily recognized signs. The number of bad cases of infection in the hand and foot from this cause, which go rapidly from bad to worse, is sufficient evidence of oversight and the undervalued significance of these wounds.

Ingrowing Toe-Nail.—The appearance of this common affection of the nail is so well known as hardly to need description. The disability brought about by it is great and, when the condition is neglected, the amount of suffering is very considerable and out of all proportion to the simple character of the lesion. The treatment is of a threefold character—protective, palliative, and radical. On careful inquiry, it will be found that, in general, ingrowing toe-nails result from the attempt made, when the pain is first felt, to cut away the side of the nail in order to prevent pressure. The cutting is repeated and each time it is done farther and farther back, until the sharp edge impinges upon the granulation tissue.

In chiropody it should be the rule always to cut the big toe-nail straight across. Owing to tight shoes or to the natural formation of the big toe, plus local irritation, there frequently develops exuberant flesh, especially at its outer side. Then follow, in succession, infection, maceration, and, finally, granulation tissue.

Palliative Treatment.—The palliative treatment consists in the adoption of suitable foot-wear, in cleanliness, and in antisepsis. The application of alcohol and careful packing of absorbent cotton to push aside the tender skin, until the nail has had sufficient time to grow away from the infected part, is admirable treatment. Exuberant granulations may be removed with curette

or by cauterization. Adhesive plaster, if properly applied, will tend to keep the pulp of the nail on the plantar side.

Operative Treatment.—In the acute forms, in which marked infection is present, the least radical operation is evulsion of the nail, which may readily be done under cocaine; the nail to be split in the middle with straight, sharp scissors, and the two halves separately evulsed. The raw pulp is covered with a piece of rubber protective tissue, and, in a few days, the patient will be able to walk with some degree of comfort; and if, in the mean time, the toe is firmly bandaged, there may be no trouble upon subsequent growth of the nail. If, however, it is obvious that there is excess of tissue on the side of the nail, the following operation can be highly recommended. It consists in carrying an incision upward on the affected side, through the skin on the dorsum, almost to the joint. (Fig. 25.) From a quarter to a third of the nail bed is extirpated, the nail having first been divided parallel to its long axis, and evulsed. A wedge-shaped piece of tissue is then removed and the lateral flap sutured with a few horse-hair sutures. A piece of protective is placed between the flap and the nail bed. (Fig. 26.) This is done under a tourniquet, and a dressing, with firm pressure, should be applied before the rubber tube is removed. If the patient is confined to bed or lounge for a few days, healing will be very satisfactory and a recurrence of the condition rare. If the patient, however, persists in walking about, healing may be slow, occupying from two to three weeks.

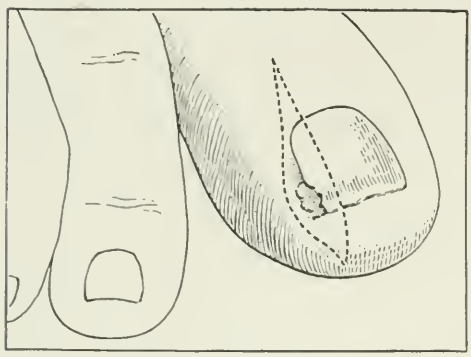


Fig. 25.—Incision through Nail and Nailbed. The matrix included between incisions is to be thoroughly extirpated, and the redundant tissue on the inner side is to be removed by a wedge-shaped excision carried down to the bone.

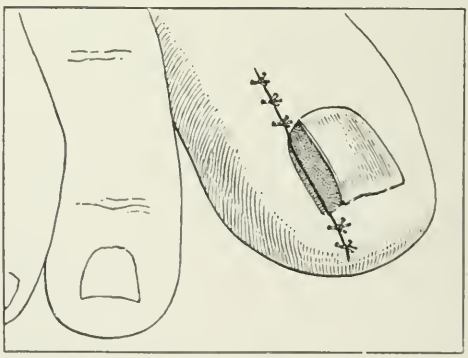


Fig. 26.—Upper and Lower Incisions loosely Secured with Horse-hair. Shaded portion represents small piece of rubber tissue (placed for drainage) between nail and inner flap and extending down to bottom.

Bursitis Subacromialis, or Periarthritis of the Shoulder-Joint.—Under this heading, Codman has described * a most important lesion of the shoulder, one which has been but little considered. It is from his admirable papers on the subject that the following description is taken.

Anatomy.—The subdeltoid bursa and the subacromial bursa are usually one and the same thing. Subacromial bursa is really the better name, for, with

* Boston Medical and Surgical Journal, May 3d, 1906.

the arm in abduction, the whole bursa is subacromial. The subdeltoid portion is that part which, in abduction, lies beyond the edge of the acromion under the fibres of the deltoid. The base of the bursa is firmly attached to the top of the tuberosity and the tendinous expansion of the supraspinatus, while its roof is firmly attached to the under side of the acromion and the coraco-acromial ligament. (Figs. 27 and 28.)

Motions of the Humerus.—External rotation is tested by rotating the forearm outward while the elbow is flexed and held to the side. Normally, the axis of the forearm will stand in the sagittal plane. Internal rotation is tested in the same way, but with the hand placed behind the back. Abduction is accomplished by raising the arm from the side of the body in the sagittal plane. Because of the shape of the head of the humerus, abduction in internal rotation cannot be carried within a considerable number of degrees as high as it can in external rotation. The supraspinatus and the deltoid act together to accomplish abduction, the power of the supraspinatus furnishing a fulcrum for the power of the deltoid. As the lines of force of the two muscles approach one another, the deltoid is able to obtain a fulcrum on the glenoid. In normal action, the glenoid bears all the weight, and the power of the supraspinatus keeps the tuberosity from seeking a fulcrum on the acromion and coraco-acromial ligament. The function of the bursa is to prevent friction at this point. Soreness in the region of the bursa or in that of the tendinous insertion of the supraspinatus, throws the latter out of action, and the deltoid alone cannot perform abduction. (Figs. 29 and 30.)

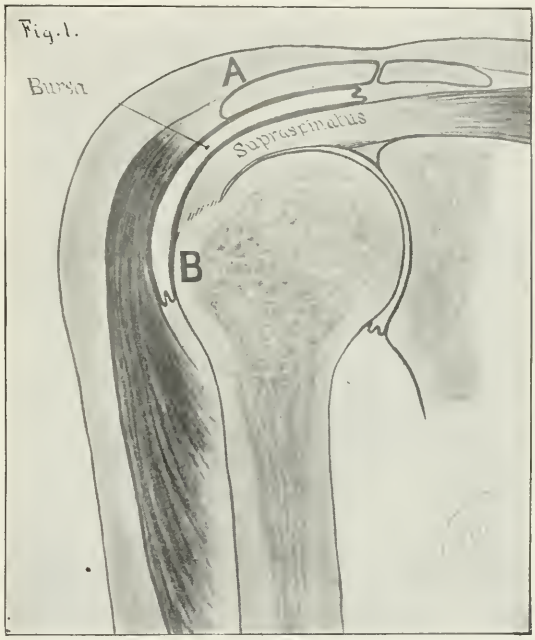


Fig. 27.—Diagram from a Frozen Section. (Dr. E. A. Codman.) Notice the deltoid and its origin from the edge of the acromion. Notice also the subdeltoid or subacromial bursa with its roof made by the under surface of the acromion and by the fascia beneath the upper portion of the deltoid. Its base is on the greater tuberosity and the tendon of the supraspinatus, which separates it like an interarticular fibrocartilage from the true joint. If the surfaces of the bursa between the points *A* and *B* were adherent, it would be impossible for the joint to pass into the position shown in Fig. 28.

Pathology.—The important point in the pathology of this affection is that the spot on the greater tuberosity where the tendon of the supraspinatus is usually found damaged, is the point which acts as a fulcrum on the acromion, when the supraspinatus is not doing its work. Partial rupture at the insertion of this tendon may occur from muscular violence alone, during the period of abduction when the burden of overcoming inertia is suddenly thrown on the

supraspinatus. Unless this muscle is on the *qui vive*, the powerful contraction of the deltoid tends to force the tuberosity to gain a fulcrum on the acromion, and this jams the tendinous expansion of the supraspinatus between the two bones. (Figs. 31, 32, and 33.)

Symptoms.—The clinical picture may fall under one of the following three types: (1) Acute or spasmodic type; (2) Subacute or adherent type; (3) Chronic or non-adherent type.

First Type.—The symptoms of the first or spasmodic form are:—(1) Localized tenderness on the point of the shoulder, just below the acromion process, and to the outer side of the bicipital groove. (2) In a small portion of the cases, this tender point being on the base of the bursa, it will disappear beneath the acromion when the arm is abducted. When it occurs, this sign is almost pathognomonic. (3) When attempts at abduction or external rotation are made, the scapula is locked by spasm after a certain point, and moves with the humerus. About ten degrees of motion can always be obtained without moving the scapula. In mild cases, the spasm may be momentary and occur only just as the tender point disappears beneath the acromion, or just as it reappears from beneath it in the descent of the abducted arm. (4) In certain mild, early cases in which there is but little spasm, the patient alleges that he cannot, unaided, raise the arm to an abducted position, but will allow passive motion. Oftentimes this is not a real inability to abduct, and the patient merely means that he cannot raise the arm without pain. This pain is probably caused by the unwillingness—if we may use such a term—of the supraspinatus to start the pull on its sensitive tendon. (5) Pain is felt in the region of the point of the shoulder or down the outer side of the arm, even extending into the hand. Pain at the insertion of the deltoid may be the only symptom. At night discomfort and pain are particularly annoying, and the patient cannot sleep on the side of the lesion. (6) Occasionally effusion in the bursa is demonstrable, and frequently puffiness is felt upon palpation.

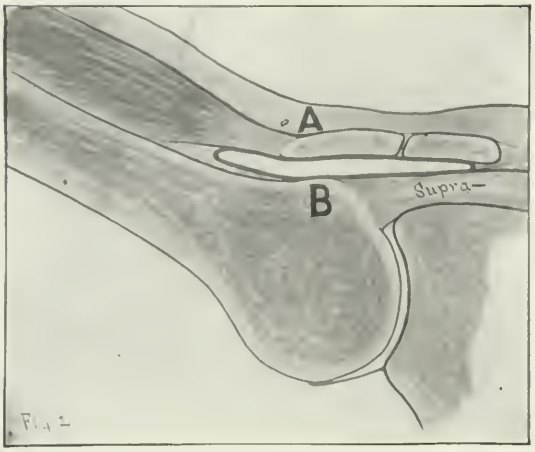
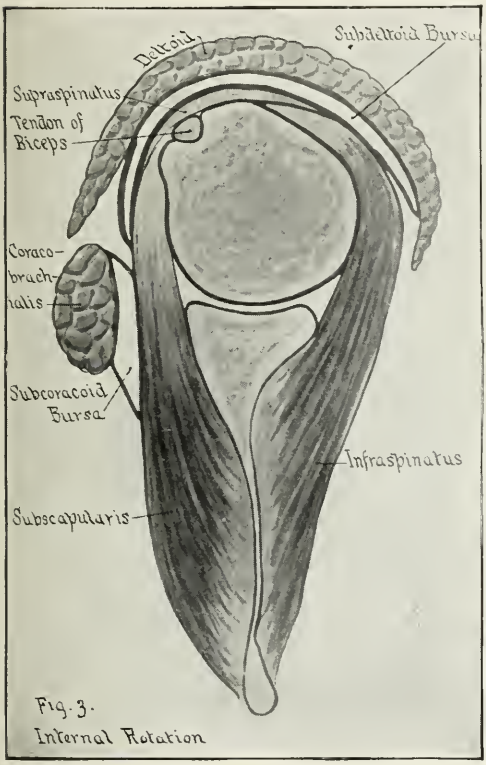


FIG. 28.—The Figure Illustrates the Condition Found in Abduction, the Tuberosity having Passed under the Acromion and the Point *B* having Passed the Point *A*. The elastic deltoid has taken up the slack at one end, and the supraspinatus at the other. It is obvious that the floor of the bursa, as it lies on the tendon of the supraspinatus and the tuberosity, must be a smooth, even, rounded surface. (From Dr. E. A. Codman.)

Second Type.—In the second type, adhesions exist between the roof and the floor of the bursa, and there is an absolute mechanical limitation to abduction and external rotation. There may or may not be active inflammation as well. (1) Localized tenderness may or may not be present, according to the

degree of existing inflammation. In recent cases it is usually present; in old, quiescent cases it is absent. (2) Since the tuberosity cannot be made to pass under the acromion, the point of slipping tenderness is not found. (3) Abduction and external rotation of the humerus are limited to a greater or less extent, usually so much so that the tuberosity will not pass beneath the acromion. The ten degrees of free motion in which the function of the bursa is not called into play, persist; if they do not, the true joint is involved. (4) Beyond an arc of about ten degrees the scapula accompanies the humerus in



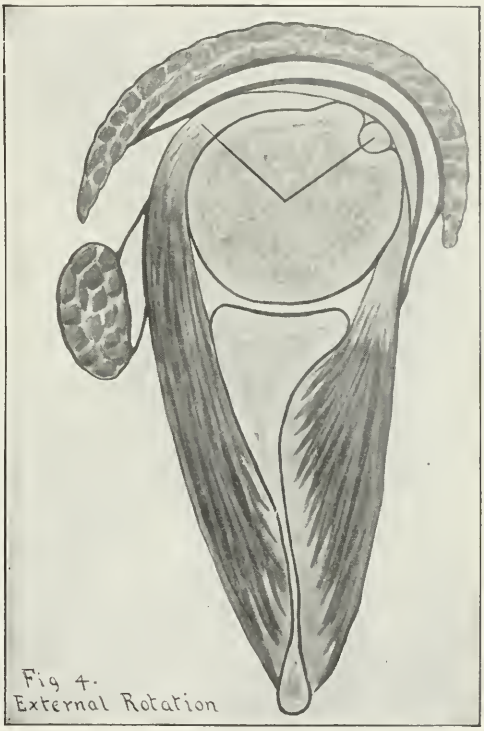


FIG. 29. FIG. 30.

FIGS. 29 and 30.—Diagrammatic Sketch of a Horizontal Section through the Head of the Humerus, to Indicate the Lateral Extent of the Bursa, and the Necessity for its Existence to Allow the Greater Tuberosity to Rotate Beneath the Deltoid. Notice also how (Fig. 29) the tendon of the infraspinatus is stretched around the head of the bone in the internal rotation, and how the tendon of the subscapularis is stretched around the head in the opposite direction in external rotation. (Fig. 30.) This stretching occurs, not in the tendons themselves, which are very short, but in the muscles, which by their construction take up the slack of the capsule of the joint. It can be easily imagined how a simultaneous spasm of these muscles would lock the joint. (From Dr. E. A. Codman.)

all its motions, whether active or passive. (5) The pain is often in the same distribution as in the first type, and frequently occurs in the neck also. In the severe cases it closely resembles the pain of brachial neuritis. In some cases it may prevent sleep. In other cases there may be no pain whatever. (6) In severe cases there is sometimes inability completely to extend the elbow.

Third Type.—The essential characteristic of the third form is painful motion, but the full arc of motion persists. The trouble is due to slight irregularities

in the contour of the base of the bursa, usually at the external side of the bicipital groove, so that the motion, instead of being smooth and free, is interrupted in its course as the irregular point passes beneath the acromion. (1) Local tenderness may or may not be present; it is often absent. (2) If local tenderness is present, the point of slipping tenderness is also found, for this can pass beneath the acromion. (3) Abduction and external rotation are but little if at all limited, but at some point in abduction acute tenderness is experienced, which disappears as soon as the tuberosity is safely beneath the acromion. In lowering the arm, this sensation is again experienced. (4) The scapula does not accompany the motions of the humerus; the motions may be jerky and uneven. (5) There may be considerable pain, especially after use.

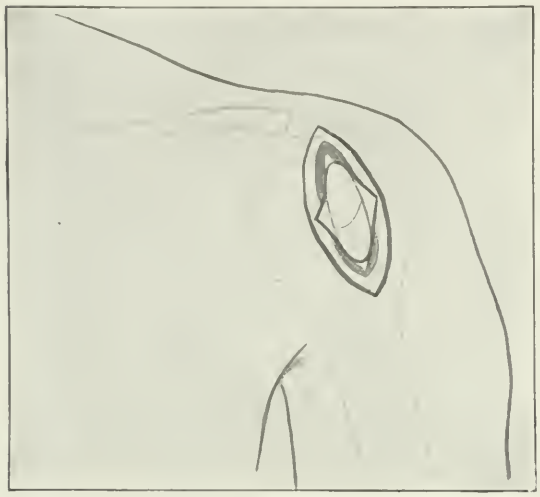


Fig. 31.—Diagram Showing Incision Used for Demonstration of the Bursa. For enlargement of the same see Fig. 32. (From Dr. E. A. Codman.)

Differential Diagnosis.—The following are the only pathological conditions with which this affection is likely to be confused: tuberculosis of the head of the humerus; fractures of the tuberosity and of the anatomical and surgical neck of this bone; deep-seated axillary abscess; acromio-clavicular arthritis; paralysis of the circumflex nerve; and inflammation of the sheath of the biceps tendon.

Tuberculosis of the head of the humerus is best differentiated by the use of the *x*-ray. Besides, the atrophy of the muscles and the fixation are more pronounced, and the ten degrees throughout which motion is always free in subacromial bursitis are sometimes, though not always, lost in tuberculosis.

Fractures of the tuberosity and of the anatomical and surgical neck might be mistaken for this affection, but here also the *x*-ray gives a crucial test.

When deep axillary abscesses are small and are situated high up under the pectoralis major, their most marked symptom is fixation of the shoulder-joint. Careful examination will show, however, that the point of maximum tenderness is under the pectoralis major instead of at the point of the shoulder, and an examination high up in the axilla reveals induration.

Acromio-clavicular arthritis is differentiated by a decided thickening about the articulation of the acromion with the clavicle, and by localized tenderness at this point, but not at the point of the shoulder.

Paralysis of the circumflex nerve is quite rare. If present it is made evident by absence of contraction of the fibres of the deltoid, when the effort to raise the arm is made.

Inflammation of the sheath of the biceps tendon may be confused with a

subacromial bursitis, but accurate localization of the point of tenderness, and the fact that, when the tendon sheath is involved, the ten degrees of painless motion are lost, will usually be sufficient for the differentiation.

Prognosis.—In the first class, that of the acute cases, the prognosis is very favorable if the course of the disorder is not interfered with by misdirected treatment. A middle course between fixation and exercise will usually result in a cure of the condition in a few weeks. Too long fixation or too violent exercise are both to be avoided. The prognosis in the adherent type of cases is the most serious, but it is fair to say that even without treatment the disability seldom lasts over two years. The prognosis in the chronic type of cases is, on the whole, good. The symptoms may abate or may disappear at intervals, to return again after several months. Some cases have the same elusive quality that is exhibited by cases of fringes in the knee-joint. At times there is no trouble, and again a synovitis of a subacute character starts up and the symptoms reappear.

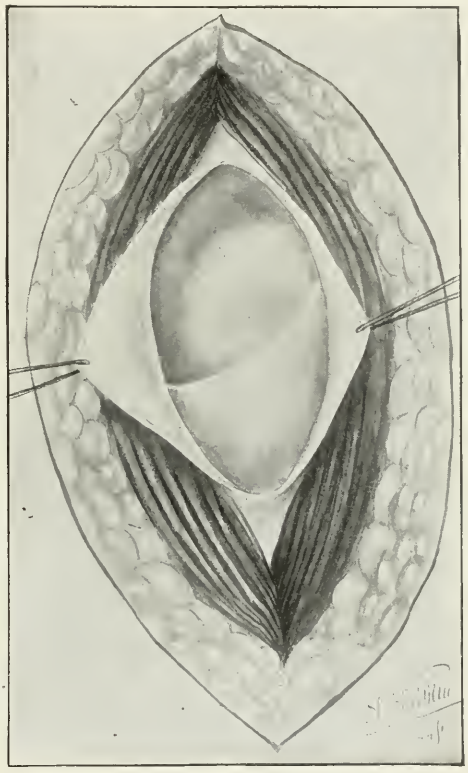


Fig. 32.—This Figure Shows the Appearance of an Incision into the Normal Bursa. The extremely thin superior layer of the bursa is caught with sutures and the smooth shining base is seen in the middle. The base can be moved by rotation of the arm without moving the superior layer. In the lower portion of the wound is seen one of the "nictitating folds." (From Dr. E. A. Codman.)

Treatment.—In treating the acute cases there are two indications: the patient's comfort and the prevention of adhesions. The position of the arm is of importance. The patient may be seated beside a table and the arm laid in abduction on a pillow on the table. This position relaxes the short rotators and deltoid, and allows the tender point at the base of the bursa to avoid contact with the tip of the acromion. At night the arm is supported on a pillow placed with its long axis at right angles to the patient's body as he lies on his back. When the patient has to be about, a sling may be used with the utmost caution. He should be instructed occasionally to take his arm out of the sling, and let it swing by his side, or, when possible, to let it rest on the table or on the arm of his chair. A Velpeau bandage should never be used for more than a day or two. Massage, applied not to the region of the bursa, but to the surrounding muscles, is of value. Counter-irritants are of little avail.

What has been said in regard to the treatment of the first class of cases applies also to the more acute cases of the second class—so long, at least, as the

adhesions are still more or less plastic. When they have become organized and firm we have to deal with an actual mechanical impediment to motion, instead of spasm of the neighboring muscles. Frequently both factors are met; sometimes one predominating, sometimes the other. In the severe cases treatment falls under one of the following three general plans:—

A. Gradual stretching.
   (1) Leaving improvement to natural use.
   (2) Massage, passive and active exercises.
   (3) Manipulations by physician without anæsthetic.
   (4) Zander exercises.
   (5) Baking, electric-light baths, etc.

B. Rupture under an anæsthetic.
   (1) Manipulation under an anæsthetic without incision.
   (2) Manipulation followed by fixation in abduction.

C. Division.
   (1) Incision into the bursa and direct division of adhesions.
   (2) Excision of the subdeltoid portion of the bursa.

The first group of methods, while sometimes adequate, more often is only palliative and at best merely shortens somewhat the duration of the disability.

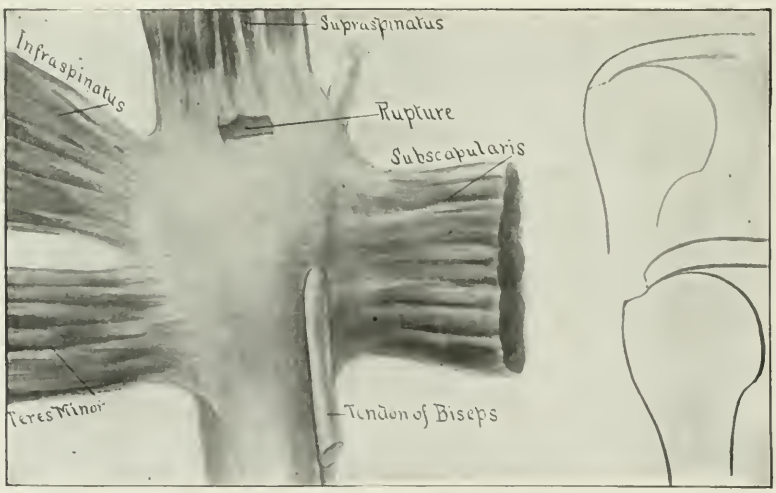


FIG. 33.—The Figure Illustrates the Condition Found when the Tendon of the Supraspinatus is Torn. The head of the humerus is seen from the outer side with the tendons and portions of the muscular bellies of the short rotators still attached to it. There is a small tear in the tendon of the supraspinatus near its insertion on the greater tuberosity. The rupture is not complete because the Y-shaped expansion of the tendon still holds it in fair position. As explained in the text, this lesion is at the point where the shoulder is most prominent.

In the outline drawings (on the right) are shown, above, the smooth contour made by the tuberosity and the overlying tendon when the condition is normal, and, below, the irregular contour found where the tendon has been ruptured. (From Dr. E. A. Codman.)

In some cases rupture of the adhesions under an anæsthetic undoubtedly shortens the period of convalescence by many months. There are two main objections to it: it may tear the normal joint structures more easily than the dense adhesions in the bursa, and thus rupture the atrophied and stiffened

supraspinatus or the other short rotators; or, in those cases in which the adhesions alone are ruptured, there is a tendency for them to form again, since the soreness incident to manipulation starts scapulo-humeral spasm once more and leaves the raw surfaces in contact.

The third form of treatment—that of open division of the adhesions—is carried out as follows:—With the elbow flexed to a right angle, and the humerus at the side in a position midway between internal and external rotation, a vertical incision two or three inches in length is made over the external lip of the bicipital groove. Separate the fibres of the deltoid till the underlying cellular tissue is clearly exposed. Lift up this tissue and incise between forceps, in the same manner as on entering the peritoneal cavity. Enlarge the incision and clamp the edges of the serous lining on each side. Holding these clamps as retractors, have the assistant rotate the humerus so as to make the base of the bursa pass to and fro beneath the incision. Then pull down hard on the arm so that air may fill the subacromial portion. A finger may then be introduced into the cavity of the bursa between the tuberosity and the acromion. All adhesions should be freed either with the finger or with scissors and forceps. Exostoses and roughened projections should be removed with rongeurs. Drainage should be provided for by suturing the skin incision only. The patient should then be placed in bed with the arm held in abduction by strapping a forearm splint to the head of the bed. Passive motions should be begun early.

Codman feels that, when the pain is great, such an operation will afford decided relief; but that, where there is no pain and where the disability does not interfere with the patient's occupation, the cure may be left to time, assisted by massage, exercises, and manipulations by the physician. He sums up the subject as follows:—

(1) The subacromial bursa and the supraspinatus muscle are of essential value in abduction of the arm.

(2) Lesions of the subacromial bursa and of the tendon of the supraspinatus are the common causes of stiff and painful shoulders.

(3) Many cases which pass under the diagnosis of contusion of the shoulder, neuritis, periarthritis, circumflex paralysis, and muscular rheumatism, are in reality due to lesions of these structures.

(4) The final prognosis of these cases is good, but when pain is severe or disability is great, relief may be obtained by a simple operation of little danger.

Ilio-Psoas or Subiliac Bursitis.—The ilio-psoas bursa is situated beneath the combined tendon of the psoas magnus and iliacus muscles, and in close proximity to the anterior crural nerve and femoral artery and vein. (Fig. 34.) It often extends a short but variable distance above the pelvic brim superiorly, while inferiorly it not infrequently communicates with the hip-joint. Inflammation of this bursa is therefore of special surgical importance.

It may be involved in osteoarthritic processes and in suppurative or gonorrhœal infections. It may become secondarily involved in diseases of the hip-joint.

Symptoms and Diagnosis.—A single or double swelling may be present at the

top of the thigh anteriorly. When double it is due to an enlargement on both sides of the psoas tendon, and fluid can be pressed from one side to the other. Fluctuation is usually present, but this may not appear when the walls are too thick or the tension within the bursal sac is too great. Pain, radiating to the knee, is often severe, the close relationship of the bursa to the anterior crural nerve explaining how this can occur with only a moderate amount of swelling. The thigh is held in a position in which there is the least pressure on the tumor. This is usually that of moderate flexion, abduction, and external rotation. The corresponding muscles are in contraction, so that movements of the hip are possible only to a limited extent.

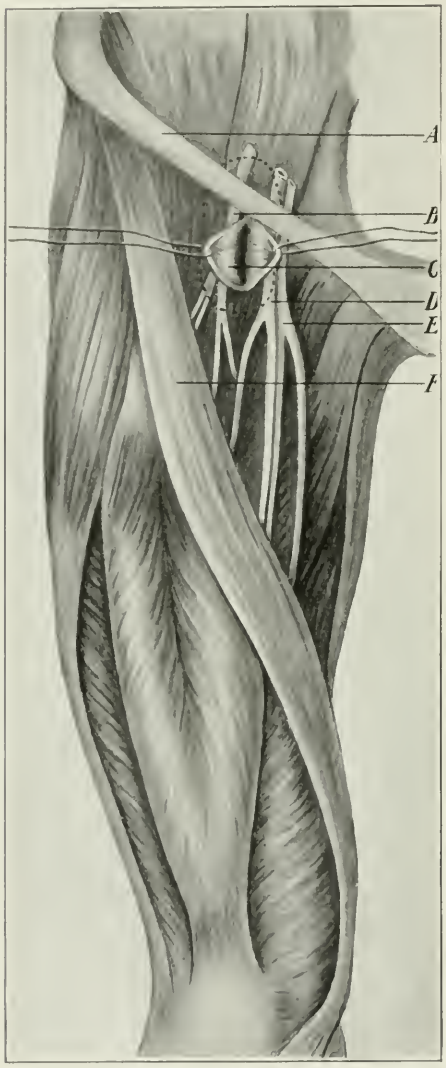


FIG. 31.—The Anatomy of the Ilio-Psoas Bursa. (From Dr. F. B. Lund.) *A*, Poupart's ligament; *B*, anterior crural nerve; *C*, ilio-psoas bursa; *D*, femoral artery; *E*, femoral vein; *F*, sartorius muscle.

By keeping in mind the accurate location of the bursa as well as the relations of the greater trochanter to Nélaton's line, one may usually exclude such conditions as femoral hernia and hip disease, with dislocation. Since the bursa often communicates with the joint cavity (in about sixteen per cent of the cases, according to Lund), the possibility of coincident involvement of bursa and joint in disease of either should be borne in mind.

Treatment.—In a valuable paper on this subject Lund* has described his experience in three cases. In all instances incision and drainage gave immediate relief. He advises a vertical incision just below Poupart's ligament, the point of the knife passing between the anterior crural nerve and the femoral artery. The ilio-psoas muscle may be drawn inward, or its fibres may be separated by blunt dissection in the line of incision.

Post-operative Treatment.—Such simple drainage of the bursa until its cavity has become obliterated will suffice for a cure in uncomplicated cases. In cases where the infection involves the hip-joint as well, extension of the leg and other well-recognized orthopedic measures should supplement the drainage.

* F. B. Lund: "The Ilio-Psoas Bursa. Its Surgical Importance, and the Treatment of Its Inflammatory Conditions," in the Boston Med. and Surg. Jour., Sept. 25th, 1902.

Infections of the Fingers and Hands.—Though the mortality due to infectious processes starting in the hand—more commonly referred to as septic hands—is not very great, the morbidity due to crippling of fingers or hands, or to the loss of either, is, however, exceedingly large. Such infections occur most frequently among the middle classes—that is, in those who are dependent in the largest measure for their livelihood upon the use of their hands. This high morbidity is not by any means always due to the fact that the patient goes to the surgeon too late in the disease to get the best result of his treatment, for bad results are also seen with unfortunate frequency in those who apply early for treatment. Could the harm resulting from ignorance, or from the present general use of poultices, ointments, antiphlogistine, and the like, be done away with, and the rule generally adopted that all hand infections demand immediate operation, with the exception of some mild forms of pustules, etc., the hands thus annually saved from partial or complete disability would do the work of a city. In no domain of surgery is the interdependence of operation and after-treatment more marked than in the instance of septic hands. No amount of subsequent care can overcome the ill effects of an improper or an inadequate operation, and a good operation may easily be rendered useless by careless and poor after-treatment.

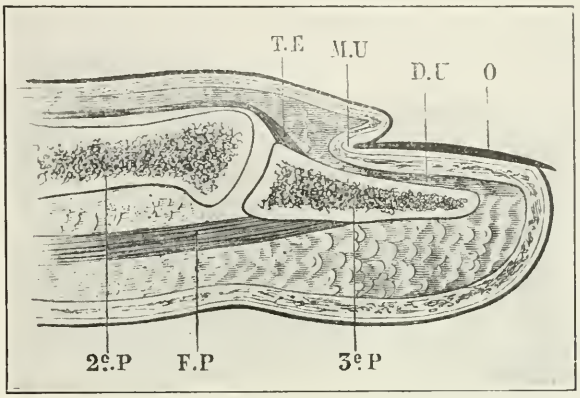


Fig. 35.—Diagrammatic View of the Anatomical Relations at the End of the Finger. (From Tillaux.) Note the close relationship between the matrix of the nail and the terminal phalanx; also the relative proximity of the joint cavity, the capsule of which is derived from the extensor and flexor tendons.

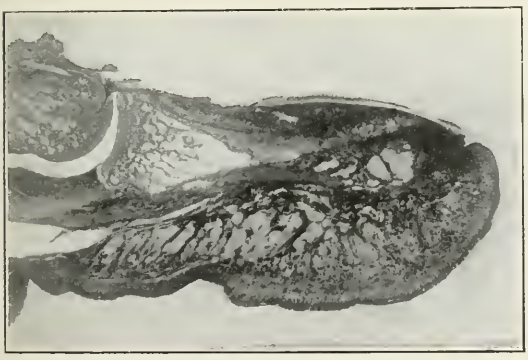


Fig. 36.—Longitudinal Section of Terminal Phalanx. (From Kanavel.) Note the direction of the fibres in the pulp and the intimate manner in which this is connected with the bone.

Anatomy.—In addition to the general anatomy of the hand, there are several important features which have so direct an influence on the outcome of septic processes, that they must be reviewed here.

The bones and joints of the wrist and hand offer nothing of special note with the exception of the terminal phalanges. These differ markedly from the others in being intimately associated with the finger nail on the dorsum, while

the bony structure on their palmar aspect is rough and spongy, and closely united by Sharpey fibres with the periosteum and connective tissue of the pulp of the finger. (Figs. 35 and 36.) As will be shown later, these two characteristics have an important bearing on infections of the ends of the digits.

Tendons.—The tendons of the flexor muscles of the forearm, after passing under the annular ligament, are inserted into the fingers in the following manner: the tendons of the superficial flexor split at the beginning of the proximal phalanx and are finally inserted, in the form of an aponeurosis, along the sides of the second phalanx. The tendons of the deep flexor pierce the superficial one, and pass on to be inserted at the base of the terminal phalanx. The vascularity of these tendons is notably slight, the blood-supply required for their nourishment being minimal, and, if this be destroyed, the tendon inevitably sloughs. From the muscles at the proximal end, the tendons receive some few blood-vessels, as also from the tissues about their insertion. In their course through the hand and fingers, however, the sole blood-supply is through small irregular vessels running in the delicate meso-tendon — the so-called vinculæ. These are prolongations of the parietal synovial sheaths of the tendon over it as a visceral layer. These small vessels enter the tendon on its dorsal surface, and if, by œdema, thrombosis, or operation, they are destroyed, the tendon over the area supplied by them must perish. (Fig. 39.)

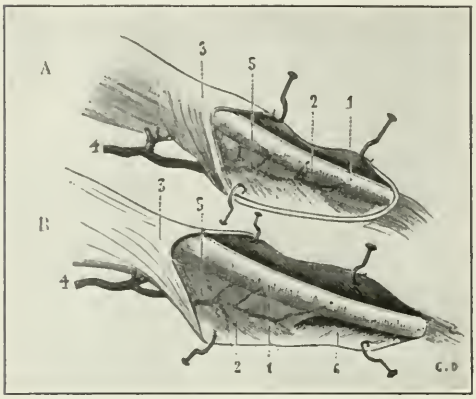


Fig. 37. — Diagram Showing the Meso-tendon Carrying the Arteries to the Tendon Proper. 1, Flexor tendon; 2, meso-tendon or vincula; 3, tendon sheath opened on its dorsal aspect. (From Tillaux.)

Tendon Sheaths.—The flexor tendons are surrounded by synovial sheaths in two places on their way to the phalanges: *a*, in the lower part of the forearm and hand; *b*, over the fingers. At the fingers, each pair of tendons is enclosed in a sheath which begins 1 to 1.5 cm. proximal to the corresponding metacarpo-phalangeal joint, and ends at the base of the terminal phalanx. In the palm and at the wrist, the tendons of the long flexors lie in two large synovial sheaths —a radial and an ulnar, often called carpal or palmar bursæ. The radial bursa encloses the long flexor of the thumb and begins 2 to 3 cm. above a line uniting radial and ulnar styloid processes. At its lower end this bursa is continuous, in the large majority of cases, with the sheath of the thumb tendon by a more or less narrow portion, just above the metacarpo-phalangeal joint. The ulnar bursa covering the flexor tendons of the fingers corresponds to the cubital portion of the palm and wrist, and, like the radial, extends a greater or less distance up the forearm. In many instances, it communicates with the tendon sheath of the little finger. Corresponding to the movements of a larger number of tendons this bursa has a larger extent than the radial bursa, which has but one

tendon. In the ulnar bursa the tendons lie in two layers—a superficial and a deep; so the synovial sheath sends a process between these layers. The bursa is thus unilocular in the ulnar portion, while in its radial portion it forms three chambers. In a large number of cases these two bursæ, the radial and the ulnar, communicate definitely, or at least potentially, at a point where the flexor tendon of the thumb closely approximates the deep flexor tendon of the index finger, just distal to the lower border of the annular ligament. (Figs. 35 and 36.)

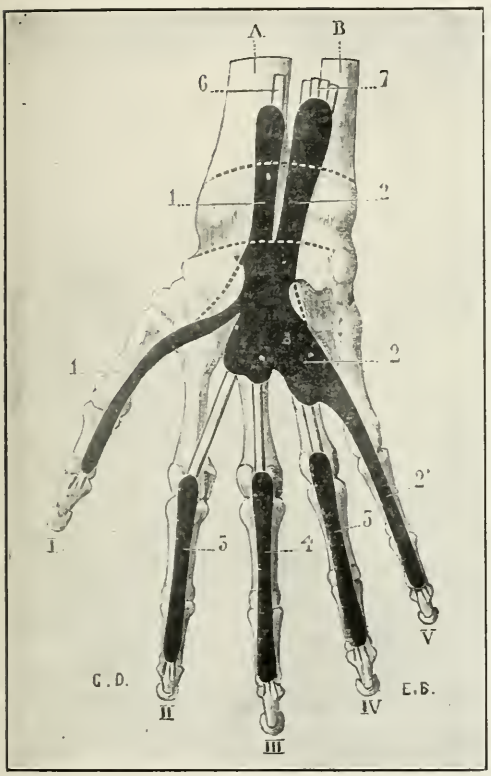


Fig. 38.

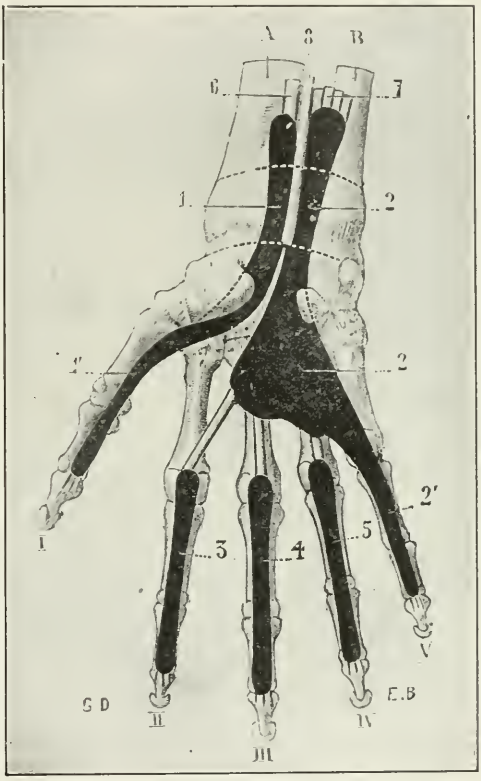


Fig. 39.

Fig. 38.—Diagram Showing the Usual Arrangement of the Sheaths of the Flexor Tendons in the Fingers and Palm. Notice the communication between the sheaths of the thumb and little finger at the wrist; also the distance to which these sheaths extend above the annular ligament. (From Tillaux.)

Fig. 39.—Diagram Showing a Rather Less Usual Arrangement than that Pictured in Fig. 38. (From Tillaux.)

No detailed description of the numerous anatomical variations of these bursæ need be made. It is sufficient for our purpose to remember that pus starting in the sheath of the litt'e finger can spread to the tip of the thumb, or vice versa; and that pus starting in either the little finger or the thumb sheath can easily infect the palmar bursæ, and thus extend into the forearm.

Palmar Fascia.—The importance of this dense fascia is marked in that it prevents the occurrence of the usual signs of infection, such as swelling and redness, from appearing on the palm, though the infection be located there. Instead, swelling of the back of the hand occurs very quickly after the onset

of deep suppuration, the œdema spreading diffusely over the whole dorsum. This is a very common occurrence in all acute infections which lie beneath this fascia, and should lead to no mistake in diagnosis, because this dorsal œdema is nowhere sensitive to pressure.

Fascial Spaces.—The excellent work of Kanavel has called attention to the importance of these loose connective-tissue spaces in influencing the spread of infection in the hand, when it lies outside of the synovial sheaths. They are described by him as follows:—1. The dorsal subcutaneous space, which represents an extensive area of loose tissue without definite boundaries, allowing pus to spread over the entire dorsum of the hand. 2. The dorsal subaponeurotic space, which is limited on its subcutaneous side by the dense tendinous aponeurosis of the extensor tendons, and upon the deep side by the metacarpal bones. It has the shape of a truncated cone, with the smaller end at the wrist and the broader at the knuckle. Laterally, the aponeurotic sheet shades off into the subcutaneous tissue. 3. The hypothenar space, which is a distinctly localized one, lying in front of the hand beneath these muscles. 4. The thenar space, which occupies approximately the area of the thenar eminence, as far as to the flexion and adduction crease of the thumb, but not extending to the ulnar side of the middle metacarpal. It lies deep in the palm just above the adductor transversus muscle. 5. The middle palmar space, which, with its three diverticula below, extends along the lumbrical muscles. It is limited by the middle metacarpal bone upon the radial side, is overlapped by the ulnar bursa upon the ulnar side, and is separated from the thenar space by a partition which is very firm everywhere except at the proximal end, where it is rather thin. A small isthmus can be found leading from the proximal end of this space under the tendons and ulnar bursa at the wrist, up into the forearm. Infection of these spaces, though important, is not nearly so grave an event as when it involves the tendon sheaths and bursæ.

Fig. 40.—Photograph Showing Exuberant Granulations and Septic Blister Following Paronychia in which Nail has not been Removed. (Original.)

Nerves.—It is always important to remember the position of the lateral digital nerves, in order that cocaine may be properly applied to them in operations on the ends of the fingers done under local anæsthesia.

The motor branch of the median nerve, which supplies the muscles of the thenar eminence, should also be borne in mind. This branch supplies the abductor, opponens, and the outer head of the flexor brevis pollicis, and is given off from the main trunk just after this has passed the annular ligament. It should always be avoided in opening the palmar bursæ.

Etiology and Types of Infection.

The infecting organism is usually a staphylococcus or occasionally a streptococcus. One should always bear in mind, however, the possibility of such rare infections as anthrax, glanders, chancre, chancroid, and diphtheria. Infection of the hand may develop subsequently to trauma (cuts, slivers, punctured wounds), and on the back of the hand it may find an entrance by way of the hair follicles. The largest number of cases, however, occur without any external evidence of infection.

Infections of the Ends of Fingers and Dorsum of Fingers and Hand.

Since any infection spreading through delay and neglect may cause an acute phlegmon of the hand or arm, we naturally find all grades of extension and of severity; one form gradually merging into another of a more severe type. The classification of the different forms is therefore somewhat difficult. Such terms as "whitlow," "paronychia," and "felon" can scarcely be defined with absolute accuracy. In general, the terms whitlow and paronychia are used to describe an infection about the side or base of the nail, while felon designates an infection located deeper in the pulp of the finger. The first form is called a "run around." This may start just under the nail fold of the skin, and the pus held by the adhesion of the nail is pent up and burrows laterally to the sides or round the base of the nail, under the lunule. Such infections are prone to become chronic under faulty treatment, with the formation of exuberant granulation tissue and subsequent loss of the nail. (Figs. 40 and 41.) Usually the nail grows again, unless the matrix has been destroyed. In a felon, the infection may be either in the fatty pad of the finger tip, in the tendon sheath, or under the periosteum, or it may take the form of an osteomyelitis of the terminal phalanx. Occasionally the process appears to start primarily as an arthritis. The tendon sheath is frequently involved, either

Fig. 41.—Photograph Showing Paronychia with Granulations. The proximal portion of the nail over the lunula has been removed by a transverse incision, thus affording adequate drainage. (Original.)

primarily or secondarily, and, the infection spreading upward, there develops one form of deep palmar abscess.

Infection of the hair follicles on the back of the hands or first phalanx is common. Here, with the usual signs and symptoms of a furuncle, there occurs a small or large greenish-yellow slough, very painful and frequently accompanied by definite lines of lymphangitis running up the arm. (Fig. 42.)

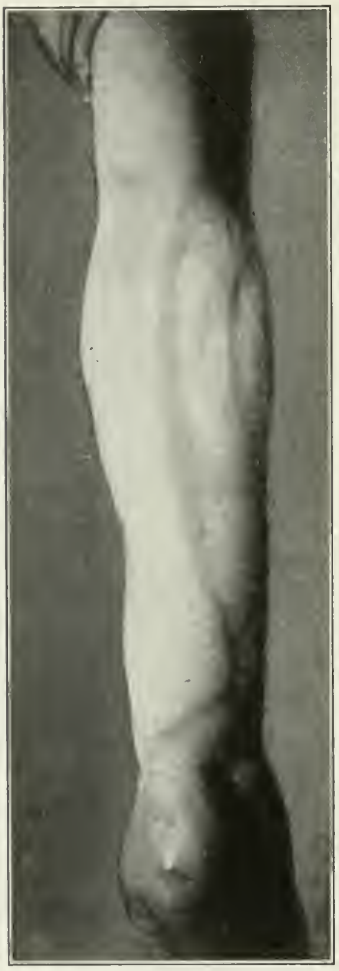


Fig. 42.—Photograph Showing Line of Lymphangitis Running from Furuncle on Dorsum of Thumb to Epitrochlear Lymph Node. (Original.)

Subcutaneous infections caused by trauma or arising idiopathically may develop anywhere upon the dorsum of the hand or fingers, but, owing to the absence of definite tendon sheaths, they are not so liable to extend as are infections in the palm. (Fig. 43.)

Particular attention is called to a not uncommon lesion caused by a blow of the closed fist against a man's teeth. This naturally occurs over the knuckles and almost always results in infection of the joint, with a complete or partial severing of the extensor tendon. Spread of the infection to the palmar side of the joint is not rare. As the majority of these accidents occur on Saturday night, and are not seen until Monday morning, infection is well under way at the time of the first observation. The whole hand is puffed and extremely sore, the finger cannot be extended, and the wound is usually gangrenous.

Treatment.—After considerable experience we have come to consider these cases as most serious. They should be radically treated at once. The gangrenous area should be excised, the wound well laid open, and thorough drainage of the joint instituted on both sides of the tendon, with rubber dam inserted into either side of the joint. Only by thorough drainage can palmar infection be prevented. With the hand immobilized on a palmar splint, the joint may be washed out once or twice daily, and occasionally healing will thus occur without necrosis of the cartilage. If divided, the tendon can only be united by secondary suture. In these cases, when seen immediately, no attempt should be made to secure primary union. It should always be borne in mind that an occasional complication of such an injury is the development of a chancre.

The treatment of a paronychia in its early stages should be by passing, on the flat, a thin-bladed knife between the nail fold and the nail proper. This

will usually evacuate a drop or two of pus, and, under a moist dressing or the application of some bland ointment to favor discharge, healing rapidly occurs. If there is any tendency to backing up of pus, a narrow strip of gutta-percha tissue, inserted into the cavity, will allow free drainage and prevent all pain. These infections, if untreated for two or three days, involve the matrix of the nail, and extend under the nail itself, as can be seen by the yellow discoloration of the lunule and by the fluctuation elicited by pressure on the base of the nail. In such cases the treatment consists in freeing the nail from the nail fold entirely, by evulsion; or, in some cases, a transverse incision, separating and removing the proximal from the distal portions of the nail, may be made. (Fig. 41.) When once the nail has been separated from its bed by infection, another nail

Fig. 43.—Photograph Showing Sepsis of Middle Finger Resulting in Infection of the Sheath of its Flexor Tendon and Subsequent Palmar Abscess. The photograph also shows well the characteristic flexion of the fingers and œdema of the dorsum of the hand. (Original.)

must form, and palliation is usually unsatisfactory, most often resulting in prolonged suppuration and the formation of exuberant granulations. The only objection to complete removal of the nail is that the matrix thus exposed is rather sensitive to pressure. Pain can be prevented, however, in a large part, by covering the nail bed with a piece of rubber tissue. Where a portion of the old nail has been left, the new nail appears to grow less well, having to push the former nail downward.

In the treatment of hair-follicle infections, the skin should first be disinfected and a longitudinal incision made, under cocaine, through the base of the slough. This may then be removed with a curette or with forceps and scissors. The resulting cavity should be cauterized with carbolic acid. If this latter precaution is not taken, there will not infrequently follow an ascending infection through the lymphatics to the epitrochlear or axillary lymph nodes, from a lesion which before operation was entirely local. Occasionally abscesses of

these nodes are seen developing a surprisingly long time after the primary infection.

Septic blisters occurring on the dorsum or under the thickened skin of the palm, should have their covering completely removed, when they may be dressed with ointment or dry gauze. Careful examination should always be made for a possible pin-point communication with a deeper process.

More Severe Hand Infections; Deep Palmar Abscess.

A characteristic picture of finger or hand infection is the following:—The finger is swollen and tense and shows reddening of varying intensity. Though the swelling occurs throughout its whole circumference, it is more marked on the dorsum; the finger is held in a markedly flexed position in both the phalangeal and metacarpo-phalangeal joints; both active and passive motions are painful, and along the anterior surface of the finger sensitiveness to pressure is very marked. Further than this, there are the usual general symptoms of infection, such as fever and increase of pain when the hand is in a dependent position. (Fig. 43.) In general, redness and swelling are of little significance in localizing the infection. The most important sign is pain on palpation. The flexed position of the finger does not necessarily mean involvement of the

Fig. 44.—Case of Palmar Abscess. The photograph shows incisions necessary for adequate drainage. The annular ligament has not been cut through. (Original.)

tendon sheath, for it also occurs when infection is only around this. Such a process is often seen to have started as a felon, or it may be at times rather difficult to detect the central focus of infection. The most reliable method of determining this is by touching the finger with a probe in various places, care being taken to keep in mind always the anatomical points which have been mentioned above. In such cases as this, operation should be resorted to immediately. (Fig. 44.)

Occasionally, however, the story is somewhat different. Starting with a prick or small wound, or possibly without evidence of such, there may develop a superficial streptococcus lymphangitis, which involves the hand, or possibly

the hand and arm. Such an infection may terminate in recovery, or it may change to the phlegmonous variety with the formation of pus. Such cases should be treated for from twenty-four to thirty-six hours by the application of hot poultices and by immobilization and elevation of the hand. A most successful form of treating them is that devised by Gamgee, which depends for its success on graduated tight pressure beginning at the finger tips, and extending as far as the elbow. The dressing is applied over a palmar splint, and is most satisfactorily made of oakum laid over dry gauze. After several layers of oakum have been applied, tight pressure, greatest over the fingers and gradually diminishing upward, is made by bandaging. The arm is put in a sling, and the patient kept quiet. It is often surprising to see what such a dressing as this will accomplish in twenty-four hours, both in the relief of pain and in the removal of clinical evidences of infection. However, should the condition persist longer than thirty-six hours at the most, operation (consisting of incisions over the most suspicious areas) should be undertaken.

The treatment of all other conditions than those already mentioned should always be by operation, under general anæsthesia. It is impossible to overemphasize the importance of a tourniquet in such operations. This apparatus should always be used, so that the field may be free from capillary oozing, which, when present, makes an intelligent dissection absolutely impossible. In operating on a felon, for instance, with the patient under ether and a tourniquet applied, the surgeon should make an incision over the distal phalanx, on its side. Median incisions are objectionable, and should not be used unless unavoidable. If the infection is found to be in the fat only, the slough should be removed, and the wound treated with carbolic acid and a rubber-tissue drain. If there be a question as to whether the infection is subperiosteal or within the tendon sheath, these membranes should be opened, provided adequate cause for the symptoms has not already been discovered. If adequate cause has been discovered, however, and there be no tenderness at all in the palm or over the tendon sheath, the wound should be loosely packed and its behavior observed until the following day; because more harm would probably result from incising an uninfected sheath through this septic area, than from mere delay. If, however, the sheath appears distended with fluid, it should be opened up to the interphalangeal joint, either laterally or in the middle line. Its edges should then be retracted gently by an assistant, and downward pressure made on the palm of the hand and over the proximal phalanx in order to determine the presence or absence of turbid serum. In cases where the serum is merely turbid —*i.e.*, in the early stages of an infection,—a second incision should be made over and through the upper part of the sheath in the palm of the hand. Through this opening in the sheath salt solution should be injected downward, and a rubber-tissue drain should be inserted at either end of the wound. But if the infection has persisted for two days or more, or if the contents of the sheath be found definitely purulent, drainage should be more free—either by two lateral incisions along the finger and one in the palm, or, less preferably, by three median incisions made in such a manner as to avoid the points of flexure. Since,

as mentioned in the anatomical remarks, the integrity of the tendon depends upon its rather precarious blood-supply, great care should be taken during operation that no instruments or drains be passed between the tendon and its posterior sheath. In like manner a single long median incision, with the finger in a flexed position, allows the tendons gradually to draw away from their posterior attachment and to assume the position which the string bears to a bow. This point is of vital importance in the management of these tendon-sheath infections; in other words, *never interfere with the blood-supply.*

The next process to be considered is where the infection has reached an advanced stage, one in which pus has reached either or both deep palmar bursæ, or in which, as in cases that have been still more neglected, it may have passed upward above the annular ligament and then, after rupturing the bursa, have forced its way among the muscle planes of the forearm. In operating upon such extensive infections as this, the point of attack is best made in the region last, and therefore least, infected. In the presence of swelling, redness, and tenderness above the wrist, an incision should be first made just above the annular ligament. This should open the bursa, which should then be washed out from this point as thoroughly as possible. Next, the palm of the hand should be opened; and here, in accordance with the evidence already gained, the incision should be made either along the inner side of the thenar eminence, or, if the infection has spread from the little finger, just beyond the median side of the hypothenar eminence. (Fig. 44.) It has never seemed necessary to the writers to split the annular ligament, as is advocated by Forssell; sufficient drainage can usually be obtained by the use of a small fenestrated rubber tube. In such severe cases as the one under consideration, all possible pockets should be thoroughly cleaned by washing, and then drained with gutta-percha tissue. The length or multiplicity of incisions is of small importance as compared with the crippling after-effects of sloughing tendons. Of course, in making these incisions, the surgeon should keep constantly in mind the anatomical points already mentioned. In such operations as these, particular stress should be laid upon the importance of following the infection as far as, or even a little beyond, the infected area, as the tendency is widespread to stop somewhat short of the necessary point, thereby not only allowing, but inviting, an extension of the infective process. Cases are constantly seen in which a neglected finger or hand has been incised several times, the operator each time failing to grasp the real extent of the infection, or in some respects falling short of the necessary radical operation. (See Plate C.)

The use of the hyperæmia method of Bier has been of value in the hands of the writers only in partially preventing the general absorption (with high fever and chills) which occurs in the severe type of cases. Its effect on the area below the bandage is bad, since it makes the tissues œdematous and boggy, thereby obscuring the picture, so that new foci may be overlooked, and lowers local resistance. Under no circumstances should this treatment take the place of operation, and in general, except in the intermittent use for the purpose mentioned above, it is to be condemned.

SUPPURATIVE TENOSYNOVITIS

Operation Delayed until Tendon had become Gangrenous

(Case of Dr. Charles A. Porter)

After-treatment.—In the after-treatment of these extensive infections it is very important that the general health should receive attention. Further, since in the beginning the parts must be dressed at least once daily, if not twice daily, pain should be avoided in every way possible. Drainage by rubber dam, with the copious use of some ointment such as boracic ointment, is much preferable to the use of gauze, which should be reserved until the wounds have begun to granulate, or used only in the more superficial parts of fresh wounds. Following an adequate operation, prolonged hot soaks in antiseptic solutions are unnecessary, or even bad, because they obscure the field. Each dressing should be undertaken only in the most methodical manner and with the aid of an assistant. Instruments and hands should be sterile. The patient's hand should lie on a table, beside the bed, and, after removal of the previously moistened dressings, the wounds should be washed out with salt solution, or wiped *very gently* with dry gauze pledgets, while their edges are carefully retracted by the assistant. Pressure from the periphery toward the centre will demonstrate the presence or absence of any extension of the process. Fresh rubber tissue and dry gauze should supplant the old. Continuous immobilization on the splint is important, and care should be taken, as soon as possible, to extend the fingers and oppose the thumb, as one not infrequently sees cases of prolonged suppuration in which the fingers are permanently flexed, the hand flattened, and the thumb approximated to the forefinger in the same plane. Since the flexors are much stronger than the extensors, adhesions in extension are much more readily overcome later, than are those which occur in flexion. After three or four days, it is wise to bend the fingers passively at each dressing, as adhesions rapidly form, not only in the tendon sheaths, but in the joints as well. Wounds at the wrist, owing to the swelling of the tissues, will be found to separate widely. These may be closed by secondary suture during the granulating stage.

When such a hand is healed, the after-treatment is by no means completed. Neglect at this point not infrequently leads to permanent disability. Active and passive motions, massage, hot and cold douches, must be pushed; tendencies to contract must be corrected by the use of extension apparatus. Painstaking thoroughness in this respect often makes the difference between an impaired and a perfectly useful hand.

Sloughing Tendon and Bone Necrosis.

Two prime causes of failure of these wounds to heal kindly are sloughing tendon and bone necrosis, the latter being quite frequently overlooked. The length of time required for the complete disintegration of a tendon once thoroughly infected is often surprising, and, if the process is left to nature, many weeks may elapse before the wound becomes finally clean. The practice of conservatism in dealing with these tendons, in the hope that some portion of them will remain functional, has probably been carried to an extreme. As a rule, little is to be expected of a tendon once thoroughly infected. The dead, yellowish-white appearance of a sloughing tendon is sufficiently characteristic

to be promptly recognized. When this condition has resulted, nothing is to be expected as regards future usefulness of the part. It is then a great saving of time to the patient to remove the dead portion of the tendon *in toto,* care

FIG. 45.—Photograph Showing Suppurative Arthritis Following Neglected Felon. The joint cartilage was found free, surrounded by fungous granulations. (Original.)

being taken not to encroach on the uninfected portion, which can usually be distinguished by a fairly sharp line of demarcation. Even when this has been done, a sinus will frequently persist at the two ends of the wound, where the

FIG. 46.—Bone Sinus after Old Infection of Joint of Middle Finger, the Persistency being Due to the Sloughing Articular Cartilage. (Original.)

remains of the tendon are still present and the sloughing is going on. Something may here be done by cautious paring of the end to hasten the process of permanent healing.

Where bone necrosis has taken place, the conditions are somewhat similar. The necrosis is commonly observed in the terminal phalanx after the typical more or less neglected felon. If the periosteum has been destroyed, permanent repair is impossible. When, therefore, a doubt exists as to the extent of the damage to the bone, it is generally wise to cocainize the part and explore the region carefully. The phalanx will often be found quite detached, as a sequestrum, when it should of course be removed. Where only a portion of the bone is bare of periosteum, radical measures should not be taken, as these portions may heal either by the separation of a thin sequestrum from the surface or by the ingrowth of a new periosteum generated from the edges. These pieces of necrotic bone are frequently covered by a mass of easily bleeding, exuberant

FIG. 47.—*X*-ray Photograph Showing Reformation of Terminal Phalanx in Thumb after Subperiosteal Resection for Osteomyelitis Following a Neglected Felon. (Original.)

This patient had an osteomyelitis following a felon of the terminal phalanx of the thumb. As he was to be a dentist, the wound was thoroughly drained for six weeks, then the whole of the necrotic terminal phalanx was removed subperiosteally, and the thumb was placed in a position of slight flexion. Ankylosis of the adjacent joint took place, but there was sufficient reproduction of bone to make a useful thumb tip. As operation was performed through lateral incisions, there was no painful skin over the ball of the thumb.

granulations which may appear sufficiently healed on the surface to give rise to the belief that the parts beneath have healed. Investigation with a probe, however, will reveal the real condition. In many cases, especially among the lower classes, the element of time is of considerable importance to the patient, and over-prolonged delay in removing these causes of chronic suppuration is a distinct waste of time. The tendency, on the whole, has been to delay too long, and we are inclined to advise careful watching of these wounds for the occurrence of these complications, so that, by the early removal of necrotic bone and sloughing tendon, convalescence may be greatly shortened. If the terminal phalanx be at fault, and its entire removal becomes necessary, a very

useful and not very unsightly finger may be obtained without doing an amputation. If the sequestrum be removed on the palmar surface or by a lateral incision without disturbing the nail, the shape of the finger will be partially preserved, though the tendency to the formation of a "parrot-nail" is marked. An amputation should not be done immediately for necrosis of the terminal phalanx, but healing should be allowed to occur, and, if then the deformity is great or the scar sensitive, a subsequent amputation can be done at any time. True conservatism in dealing with infected fingers lies in the prompt and complete treatment of the infection without removing any uninvolved tissue.

The points of special importance, in the treatment of hand infections, may be briefly summed up as follows:—A thorough knowledge of anatomy; complete operation as early as possible; care in avoiding injury to the blood-supply of the tendons; adequate drainage by rubber tissue; complete immobilization; the use of retractors in dressing the wound and gentle manipulation; avoidance of all possible pain; active and passive motion persisted in most faithfully; and, finally, observance of the maxim that, in hand infection, palliative treatment with antiphlogistine and poultices should always be condemned.

Infections in the Wrist-joint.—Pyogenic infections (gonococcus excluded) of the wrist-joint are always serious, from a point of view of future disability, and they are sometimes dangerous to life. Judgment as to the proper treatment is extremely difficult, owing to the number of compartments into which the wrist-joint is divided and to the danger of bringing about a secondary infection of either the dorsal or the palmar tendon in making drainage. This matter is, of course, less difficult to decide upon when the wrist-joint infection is secondary to that of tendon sheaths or to a deep palmar abscess. By searching with care for points of greatest tenderness, an attempt should be made to decide whether the infection is located between the ulna and the carpus, between the radius and the carpus, or among the intercarpal bones. Ulnar infection is best drained toward the outer side of the forearm; infection between the radius and the carpus, posteriorly, a little to the ulnar side of the extensors of the thumb, or, in deep palmar abscess, in the median line, on the radial side of the median nerve. If disorganization of the joint is sufficient to require through-and-through drainage, rubber dam will be found to be far superior to tubes or gauze. The wrist should be slightly flexed and immobilized upon a splint which extends up over the shoulder.

Axillary Adenitis; Axillary Abscess (from sepitc hands).—Pyogenic infections of the axilla are either primary, or secondary to suppuration in the breast, the thoracic parietes, or any part of the upper extremity. Primary infections are superficial, starting about the hair follicles and leading to a superficial abscess. Unless they are properly treated, there are apt to be, in the proximity of the primary infection, multiple foci similar to a crop of furuncles.

The axilla should be shaved and then washed several times a day with corrosive sublimate and alcohol (1 : 3,000), the frequency depending upon the severity of the furuncle or abscess, which should be opened and drained and then covered with dry dressings. The deeper variety of infections underneath

the axillary fascia are often overlooked in their early stages, and may result in large and even dangerous abscesses. The patient often complains of simple stiffness in the shoulder, and if, as frequently happens, the original source of infection upon the fingers has healed, little attention is paid to the axilla. There may be in the beginning palpably tender lymph nodes, or, owing to the stiffness of the shoulder, all that can be felt is a vague sense of resistance with slight tenderness on deep pressure. There may be fever and leucocytosis, or both may be absent. If the disease is allowed to progress, the arm-pit becomes tense and swollen, motion at the shoulder in any direction is painful, the pectoral fossa is distended, and, if the collection of pus is large, it may burrow between the pectoral muscles, and even upward into the supraclavicular fossa. The pain may be severe, depending upon the purulent infiltration about the brachial plexus. When a brawny condition exists, early operation is clearly indicated, even long before fluctuation can be made out. The arm being placed in a position at right angles with the body the axilla should be opened either by a vertical incision or by one carried along the posterior border of the pectoralis major muscle. A regular dissection, with a broad base above, should be made downward, and, as soon as pus is found, an effort should be made to break up all of the lateral openings, the finger being used for this purpose with care, in order to avoid tearing the vessels. If the abscess is chronic, bleeding from the granulating surface may be free, even alarming if a vein is torn. Thorough antiseptic douching, and, for the first day or two, light gauze packing are the measures required. If the inexperienced surgeon is tempted to make a small opening into which he inserts a drainage tube, convalescence will probably be slow; the better plan is to make a triangular opening with the apex at the top of the axilla.

Axillary adenitis secondary to severe infections of the arm or forearm.—Under these conditions, if no enlarged and tender lymph nodes are discoverable, and particularly if the infective agent is the streptococcus, some surgeons advocate a clean dissection of the axilla. With this teaching I am not in accord, for I feel that the lymph nodes are valuable, not only as sieves, but as germicidal agents; and it seems to me that it is especially in streptococcus infections that the opening up of large lymph spaces is inadvisable. Such infections in the axillary lymph nodes, before pus has formed, should be treated conservatively, with rest in bed and quiet, the chief attention being paid to the source of the infection.

Carcinoma of the Ends of Stumps.—As a result of continuous irritation by the artificial leg, or more frequently as a result of irritation from too tight a cicatrix, carcinoma occasionally develops in amputation stumps. This may show itself as a continuous open, granulating wound, with or without pain, and clinically the condition can be determined only by the chronicity of the sore or by the unusual induration of the edges. Occasionally the ulceration may be seen to progress, involving parts where there is no tension. In such instances the diagnosis is easier. The two illustrations (Figs. 48 and 49) show, in one, the first type, in which the diagnosis except by microscopical

examination would be difficult; in the other, the second type, in which it would be easy. Microscopically, the characteristic squamous-cell epithelioma is found, and, in general, this type of carcinoma, like that in Marjolic's ulceration, is relatively benign. In this development of malignant disease we have an additional argument for amputation or a plastic operation at a sufficiently high level to remove any tension of the soft parts over the bone.

Brachial Paralyses.—In spite of all warnings, the temptation to place a rubber tourniquet about the middle of the arm, in operations on the forearm or hand, seems insurmountable. In many clinics there occur, every year, a few examples of this easily avoided accident. One finds frequently that an attempt to avoid injury is made by covering the arm with a towel or sheet wadding before the tourniquet is applied. The real cause is not to be found on the out-

Fig. 48.—Epithelioma Developing in Unhealed Amputation Stump Three Years after Operation (Original.)

side, but should be attributed to pressure of the musculospiral nerve against the bone, for it is the musculospiral nerve which is far more frequently involved than the others. In a case in which the tourniquet had remained in position for an hour, there was complete paralysis of all nerves (musculospiral, median, and ulnar), which persisted for a year. Inasmuch as the operation was an excision of the elbow, the flail-joint, plus the absolute paralysis, was nothing less than a calamity. In another instance in which a tourniquet had remained in position for only three-quarters of an hour, in an operation for Dupuytren's contraction of the ring finger, it was six months before the paralysis had disappeared. Some surgeons, for this reason, have refused to use a tourniquet on the upper arm. The rule should be, never to apply a tourniquet about the middle of the arm, but always to place it in the axilla, with a pad over the clavicle, and then to carry the tube in figure-of-8 fashion around the opposite axilla. If the tourniquet is held away from the root of the neck by the hand of an assistant, no paralysis will ever occur. In operations upon the hand, a tourniquet may be placed at the junction of the lower and middle thirds of the forearm, without danger, if it is not tied too tightly.

Injuries to the Brachial Plexus.—Injuries to the brachial plexus may result from direct or indirect violence and from pressure and traction, or such definite crushing or severing trauma as occurs in gunshot wounds, fractures of the clavicle, and knife wounds. There are several varieties of post-anæsthetic paralyses or pareses which develop as a result of pressure of either the clavicle or the head of the humerus upon the plexus. As these almost invariably recover, without operation, they are merely mentioned here. Although birth paralyses in their etiology are the same as those which result from traction in adults, they will be considered later. (See page 71.)

Fig. 49.—Amputation; Sloughing of Flaps; Healing by Epidermization; Subsequent Development of Epithelial Carcinoma. (Original.)

For the pareses or sensory disturbances, which may be produced by a cervical rib, the reader is referred to the article on "Surgical Diseases and Wounds of the Neck," in Vol. VI.

According to Sherren, lesions of the brachial plexus may be divided into supraclavicular and infraclavicular, the causation and prognosis differing in each variety. The supraclavicular injuries, for example, come from indirect violence—that is, traction,—while the infraclavicular are almost always produced by direct violence or by pressure of the dislocated head of the humerus.

Traction injuries may affect either the roots, the cords, or the trunks of the anterior divisions of the lower cervical and upper dorsal nerves. The commonest injury is due to extreme lateral extension of the head, with the shoulder fixed, or more commonly to violent depression of the upper extremity—as may happen, for example, from a fall on the shoulder while coasting. In these cases, the brunt of the violence falls first upon the upper cords or trunks of the fifth or sixth cervical, or upon the whole plexus. In a rarer form, illustrated by a case of my own, in which the upper extremity was caught in a revolving shaft, the traction was applied upward, and the lower two trunks only were torn, though the upper ones were intrinsically injured. While an actual tearing

asunder of the nerves can be demonstrated in some cases, the lesion, in the majority of instances, consists of over-stretching and laceration of certain parts of the nerves, with hemorrhage into their substance. The subsequent development of scar tissue forms a knot of fusiform enlargement and destroys the continuity of the axis cylinders. Rarely, one finds that the whole plexus consists of a mass of cicatricial tissue in which the separate trunks and cords are indistinguishable. Occasionally the lesion is found entirely within the nerve sheaths, but usually there is marked perineuritis binding the surrounding tissues to the plexus. In many cases, there is immediate total paralysis of the whole plexus. In the course of time the functional power returns to a greater or less degree; complete recovery taking place in some cases, while in others there is persistence of the motor, and, to a less extent, of the sensory paralysis. In traction injuries, especially, there is found involvement of the sympathetic cord in the neck, as shown by slight pseudo-ptosis and enophthalmos. The pupil is smaller and does not dilate when shaded, and the cilio-spinal reflex is absent. The affected side of the face and of the upper extremity often does not sweat. If the sympathetic is injured, the result is almost always permanent and irremediable. In general, coexisting sympathetic changes mean injury of or near the nerve roots, and give an unfavorable prognosis for operative repair. Symptomatically, the commoner traction injuries result in complete paralysis of the whole plexus, of the Erb-Duchenne or upper-arm type, or of the Klempke lower-arm type. The muscles involved and the sensory anæsthesia may be determined by the usual methods. Especial attention, however, should be directed to the presence or absence of paralysis in the muscles supplied by the supraclavicular nerve.

Non-operative Treatment.—Immediately after the injury a careful neurological examination should be made, tests being applied to the muscles and areas of epicritic and protopathic sensibility. The paralyzed arm should be placed in a sling, and, as soon as pain and tenderness have disappeared, massage, douching, etc., should be employed. At the end of two or three weeks the muscles should be carefully tested for the reaction of degeneration.

Operative Treatment.—While it is true that the earlier the operation, the better the prognosis, the exact time at which to interfere is difficult to decide. Sherren advises operation if the reaction of degeneration is present at the end of fourteen days. He states that no case of perfect recovery, after late suture of the whole plexus, has been recorded, nor do I know of a completely successful case, even after early suture. In gunshot and cutting injuries, immediate operation is clearly indicated, and an endeavor should be made to restore the plexus to its original condition.

Exploration at an early date after the injury is not dangerous, and if, at operation, an actual tearing apart of trunks, cords, or roots can be demonstrated, immediate suture is clearly demanded; but if no definite solution of continuity of the nerves can be made out, it would seem more conservative surgery to close the wound and wait until time has determined what portions of the plexus are permanently damaged. Excision of one or two inches of trunks

or cords of the brachial plexus, with the usually resulting tension, seems unjustifiable, unless it is certain that no natural repair can take place. In a number of the cases which have been operated upon at periods varying from four months to two years after injury, absolute paralysis existed from the beginning, and the whole plexus was found to be so inextricably fused with the surrounding structures, through the medium of tough connective tissue, that amputation at the shoulder seemed the only proper course to pursue, and this operation was accordingly performed. If only a part of the cords or trunks are injured, the decision in favor of excision or lateral anastomosis to sound nerves must depend upon the conditions found in the individual case. From the time of the accident to that of operation, and for years afterward, it is of vital importance that the nutrition of the muscles should be maintained by regular treatment with massage and electricity. In a case of my own, improvement is still taking place three and a half years after operation; none could be demonstrated until after a year had elapsed.

I wish to advocate exploratory operation and suture of obviously torn nerves, at the end of three weeks. In case nerve stretching, with hemorrhagic infiltration, is the only demonstrable lesion, the wound should be closed and operation postponed till a future date.

Brachial Birth-palsy.—While for many years the exact explanation of this not uncommon condition remained in doubt, it now seems quite clear that in the great majority of these cases the paralysis is due to tension and laceration or rupture of the nerves, exactly as happens in the traction paralyses which have just been considered. This subject has been exhaustively discussed in a very valuable paper by Clark, Taylor, and Prout, published in the *American Journal of the Medical Sciences*, 1905, page 670. Obstetrical paralysis seems to be due, in brief, to two causes: the damage done by direct pressure upon the brachial plexus by the forceps or fingers, and that produced by traction. The former occurs less often and is much less severe than the latter. Traction injuries occur in both breech and vertex presentations, in which, during confinement, the shoulder is depressed when the head is hyperextended to the other side. Rotation of the chin away from the lesion increases the tension. In the paper quoted above, which has a complete bibliography, the various questions in etiology are thoroughly discussed, and the authors seem to prove convincingly that tension is the cause of almost all of the severe and permanent obstetrical paralyses. In their anatomical investigations, and in seven cases operated upon, the authors found that the lesions consisted of two sorts: actual rupture of trunks or cords (infrequent), and rupture of the perineurium, with hemorrhage into and beneath the perineural sheaths and infiltration of blood between the strands of nerve fibres. The results of actual rupture are self-evident, but organization of these hemorrhages and partial disruption of the nerves result in subsequent cicatricial contraction and the development of neurofibromata which permanently interfere with the function of the nerves. These birth-palsies differ in one important respect from those which, in adults, are caused by injuries inflicted upon the brachial plexus: if untreated, they are

followed by more or less lack of development of the limb, with contractures in after years. Unless proper treatment is carried out, so much degeneration of the nerves and muscles takes place that a cure becomes impossible. Under proper orthopedic treatment, however, and by the breaking up of adhesions, the reduction of the frequent backward dislocation, and the employment of electricity and massage, considerable and even great improvement may now and then be brought about. Almost always, the chief injury is located at the junction of the fifth and sixth roots, though lower nerves may be involved. There may be temporary complete paralysis of the upper arm, which sooner or later improves, or entirely recovers, but in the severer cases there are left permanent lesions in the muscles supplied from these two roots.

The question of treatment is partly dependent upon the danger of operating in young infants. Clark, Taylor, and Prout do not advise operation earlier than at the age of one year; others advise it as early as at the end of three or four months. The danger of operating naturally depends upon the extent of the lesion. If only the upper two cords are injured, the operation is less severe than when, in order to gain proper exposure of the whole plexus, the clavicle must be divided. So long as tenderness over the plexus shows the existence of a traumatic neuritis, all treatment should be limited to passive motions, slight massage, and the protection afforded by a sling. When this tenderness subsides, more active treatment, of which electricity forms the most important part, may be instituted. The muscles may be satisfactorily examined after three months for their electrical responsiveness. If, at the end of ten months or a year, there is evidence of a persistent lesion, an exploratory operation should unquestionably be done. Actual rupture of nerve trunks requires excision of both ends and nerve suturing. If a definite knot of fibrous tissue is felt anywhere in the plexus, this must be excised until normal nerve bundles appear at both ends of the excised part. Suturing should be done, if possible, with fine catgut, which should be passed only through the sheaths. If the extent of the damage is so great that end-to-end suturing is not possible, either lateral anastomosis or *suture à distance* is necessary. The nerves should be wrapped with Cargile membrane; or some form of temporary splint, such as decalcified bone, should be employed; or a nerve graft may be used. The suprascapular nerve, which supplies the external rotators of the shoulder, must be sought for with great care and connected by suture with the main trunks. Sherren states that spontaneous recovery has taken place at the end of three months in about seventy per cent of the cases under his observation.

All that has been said about persistent and thorough after-treatment of brachial-plexus injuries applies with even more force to brachial birth-paralysis.

Baseball Fingers.—Owing to the frequency with which the game of baseball is played in America, the resulting injuries to the fingers are extremely common, and, as a rule, they end in a permanent deformity, which sometimes amounts almost to a distortion. The reason for this is obvious: treatment is carried out for only a few days, and then, as soon as the early tenderness has ceased, the patient resumes ball-playing. The injuries are of two sorts: a back-

ward blow on the palmar surface of the finger which results in a dislocation with some laceration of the ligaments; or, more commonly, a blow on the end of the finger, the force being transmitted to one of the three joints, usually the second or first interphalangeal. *X*-rays have shown that fissures in the bone are much more common than would be expected. There result swelling, tenderness on flexion, and pain, and in a few days a fusiform enlargement develops about the joint, with, occasionally, lateral displacement or rotation from laceration of the ligaments. If the force has caused flexion, not infrequently the entensor of the finger is ruptured at its insertion into the terminal phalanx.*

Aside from the question of the advisability of stopping play, the surgical treatment of the injury consists in reducing the deformity, in making slight dorsal hyperextension, and in applying a grooved palmar splint, which reaches up to the wrist. The finger should be immobilized for a week or ten days, when soaking it in hot water will be found valuable. Massage tends to irritate the periosteum, and results in increased bone formation. After a couple of weeks, a piece of rubber dam about one inch wide is wound around the finger, from the tip to the knuckle. The moderate pressure thus continuously exerted causes absorption of the exudate. After a certain length of time, motion may be allowed,—first passive, then active,—and, when all tenderness has disappeared, massage will be found invaluable. In all baseball fingers an *x*-ray photograph should be taken for the purpose of determining to what extent the bone has been injured. But, even if a negative result be thus obtained, the surgeon should never forget that the deformity results more from periosteal bone formation than from even a fissured fracture.

Hæmatoma of Quadriceps Extensor Femoris (**"Poop"**).—While this very characteristic injury may result from other causes, it occurs most frequently in the modern game of football; much more frequently in the past, when the thighs were unprotected by guards, than at present.

The rupture of portions of this muscle may occasionally be due to tension, such as kicking the ball, but most commonly it results from direct violence applied to the front of the thigh, either from a kick or from a low tackle in which the shoulder is forced against the thigh. Only the second variety will be considered. Naturally, there are all grades of severity, from a slight bruising of the muscle to almost complete laceration of its fibres, or even tearing of the fascia lata. In the severer cases there is at once marked extravasation of blood, which sometimes may fill and make tense the whole fascia, the circumference of the leg being from three to three and a half inches larger than that of its fellow. As a rule, there is little pain when the muscle is at rest, but there are great stiffness and disability. Running faster than a "dog trot" is impossible. Within two or three days, there is almost invariably some effusion into the knee-joint.

The pathological condition is a crush of the muscle and fascia between the

* Baseball players are subject to two other lesions which are designated by them as "Glass-arm" (an overstrain of the arm experienced by pitchers) and "Charley-horse" or "Charley-bone" (knee-joint trouble).

femur and the striking body. Now and then, immediately after the injury, a definite hollow can be felt where the muscle strands have been parted. This is soon filled up with blood clot. Occasionally hemorrhage takes place underneath the periosteum and causes extreme pain for a few days. A football player who receives such an injury early in the season should be considered unfit to take part in the game for the rest of that season, or for at least a month.

Treatment.—In my experience, massage is injurious. The patient should be kept at rest in bed for the first few days, and baking and moderate bandaging should be employed. Both active and passive motion may do some good, but not until the acute soreness has disappeared should massage be used, and then it should be begun with care and gentleness. The effusion in the knee is a secondary phenomenon and is due either to settling of blood or to lymphstasis, and does not require active treatment. As the swelling subsides, there can be felt more and more clearly a muscle callus, which may or may not be attached to the bone. One or two cases have been operated upon in the fear that a sarcoma had developed, and at operation it was found that there had been some proliferation in the bone from the irritated periosteum, and that a small cyst had formed. The swelling requires months for its subsidence and not infrequently leaves behind a permanent callus, with some atrophy of the surrounding muscles.

SURGICAL DISEASES AND WOUNDS OF THE ABDOMINAL WALL.

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I. ANATOMICAL AND EMBRYOLOGICAL CONSIDERATIONS.

In the transformation of the primitive into the completed abdominal wall the protovertebral masses or segments, situated on both sides of the dorsal cord, give rise to the two muscular plaques which penetrate forward toward the central line of the abdominal wall and eventually unite to form the linea alba. Thus, it may be said that the contents of the abdomen are completely enveloped by a muscular pouch, in which at first there is normally only one point where the wall of the pouch remains open, viz., the umbilicus, through which pass the umbilical vessels—the hypogastric arteries and the large umbilical vein. After birth this space between the recti muscles is closed by a sphincter-like band of circular fibres the contraction of which causes the integument to be drawn inward. At a still later period the ring becomes obliterated, partly through cicatrization.

The large umbilical vein, which occupies the upper segment of the umbilical opening, afterward becomes the round hepatic ligament; it is feebly united to the scar and frequently adipose tissue intervenes. At this point the peritoneum, which rests upon a layer of fibrous tissue (Richet's umbilical fascia), not unlike the transversalis fascia of the inguinal region, is doubled upon itself. Between the fascia just mentioned and the posterior surface of the linea alba there exists a space. The cutaneous investment of the umbilical scar is attenuated; it contains no hair follicles. From an anatomical standpoint the navel must be regarded as a defectively organized area in the abdominal wall—one which is more liable than any other part of this wall to give way under a strain. Fortunately, its position is such that it is measurably protected against the effects of the force of gravity.

Dr. W. J. Mayo advises strongly against removal of the umbilicus in abdominal operations. The importance of adopting this practice, it may be stated, was learned through the serious objections which the Scandinavians, Bohemians, and Poles made to the removal of this structure.

Lymphatics.—The lymphatics are divided naturally into superficial and deep, or cutaneous and muscular. The superficial are divided into anterior and posterior. The anterior vessels of the superficial group converge, as a rule, toward the inguinal lymph nodes. Those, however, which arise from the

costal margins and upper epigastric space discharge into the axillary nodes. The posterior vessels take their rise in the lumbar regions, converge to a line just above the crest of the ilium, and, uniting with the anterior ones, empty into the superficial inguinal nodes. (See Plate XVIII, in Vol. II.)

The deep lymphatics, which arise principally from the fleshy portion of the muscles of the abdominal wall and from the aponeuroses, are arranged in several distinct groups. One of these groups accompanies the deep epigastric artery and terminates in the retrocrural lymph nodes; another accompanies the deep circumflex iliac and terminates in much the same manner as do those which accompany the deep epigastric artery; a third group, known as the lumbar lymph channels, follows the lumbar arteries and empties into the juxta-aortic lymph nodes; and, finally, a fourth group terminates in the internal mammary lymph nodes.

The lymphatics of the umbilical region possess considerable practical importance. According to Poirier and Cunéo they are divided into the cutaneous lymphatics, the lymphatics of the fibrous nucleus, and those of the aponeurotic ring.

The cutaneous lymphatics in the adult come from the skin which covers the fibrous nucleus of the umbilicus. From this rather close network, as a starting-point, four or five trunks pass outward and downward toward the inguinal region. These lymphatics lie in a more superficial plane than the cutaneous lymphatics of the abdominal wall and terminate in the superficial inguinal nodes. It is well to remember that none of the lymphatics at the level of the umbilicus terminate in the axillary nodes.

The lymphatics of the fibrous nucleus of the umbilicus, three or four of which are found on each side, penetrate directly the sheath of the rectus, following the ramifications of the deep epigastric artery, and appear under the fold of Douglas, where they are united with the lymphatics which arise from the deeper wall of the sheath of the recti muscles.

The lymphatics of the aponeurotic ring are in two sets—anterior and posterior. Those of the anterior set originate from the entire circumference of the umbilicus and pass over the sheath of the recti muscles. Some of these traverse the sheath of the recti muscles and unite with the lymphatics of the fibrous nucleus, while others penetrate the internal and external oblique muscles and terminate in the external iliac and retrocrural nodes. The lymphatics of the posterior set seem to have their origin in a peri-umbilical network on the posterior surface of the sheath of the recti muscles. Some of these perforate the transversalis and follow the course of the deep circumflex iliac artery, or they accompany the lumbar artery, passing into the juxta-aortic lymph nodes; while others run downward with the ramifications of the deep epigastric artery and terminate in the retrocrural internal nodes. A certain number of small lymph nodes are found in the abdominal wall, scattered along the course of these posterior lymphatics.

Gerota has found, in two cases, that a small lymph node is located in the subperitoneal retro-umbilical cellular tissue, at a distance of from 2 to 4 cm.

from the umbilicus. He calls attention to this anatomical fact because this little node may serve as a focus from which suppurative processes in this region spread and ultimately give rise to a condition to which the term "phlegmon of Heurtaux" has been applied. It must be remembered that the lymphatics of the umbilicus communicate in early life with those of the bladder by way of a network which surrounds the urachus; and that they also communicate with those of the liver by the network which surrounds the umbilical vesicle. A knowledge of these facts enables us to understand how, in a case of a malignant growth of one of the abdominal organs, secondary deposits of this growth may be found in the umbilicus or abdominal wall.

General Nerve Supply.—The abdominal wall is supplied by the thoracic nerves, from the sixth to the twelfth, and by the first lumbar. The sixth and seventh thoracic supply the epigastric region; the eighth the tract between the epigastric and the umbilical regions; the ninth and tenth the umbilical region proper; and the eleventh and twelfth thoracic and the first lumbar the inguinal region. When there is rigidity of some of the abdominal muscles the lower intercostal muscles are also often similarly affected, owing to the fact that both sets of muscles have the same nerve supply. The splanchnic nerves, which supply the abdominal viscera, take their origin from the sympathetic ganglia opposite to, and in connection with, the sixth spinal nerve. These pierce the diaphragm and join the semilunar ganglia of the solar plexus. On account of the internal anastomosis it is easily seen how grave symptoms may follow any injury of the abdominal wall. (See also Dr. Mastin's statement [p. 112] with regard to the nerve supply of the anterior abdominal wall.)

II. SURGICAL DISEASES.

Phlegmon.—Phlegmons of the abdominal wall may naturally be divided into two groups—antero-lateral phlegmons and posterior phlegmons. Those belonging to the first group—*phlegmons of the antero-lateral abdominal wall*—may have either an internal or an external origin, and they may be located just beneath the skin, in the substance of the muscular tissue, or immediately beneath the peritoneum. The superficial phlegmons owe their origin to an external wound which affords entrance to infection and from which develops a lymphangitis. Such a wound may be inflicted by a cutting or piercing instrument (as, for example, a needle), or by the chafing of a bandage, and the impurities collected in the folds of the skin and especially in the navel furnish a prolific source of infectious material. Superficial phlegmons may also owe their origin to an infection which has come from within, as from a diseased abdominal viscus (the intestine and the uterus, for example) in the immediate vicinity, or even to an infection of more remote origin—a local manifestation of a general infection. The same etiology holds good for the intramuscular phlegmons; and in this connection it is well to call special attention to the great danger attending the "through-and-through" abdominal wall stitch in certain instances.

There have been reported cases of subperitoneal abscess, of typhoid origin, with no premonitory local lesion. More common and more interesting are cases dependent on diseases of the abdominal viscera, especially the intestines.

Such a thing as an idiopathic phlegmon of the abdominal wall does not exist, although it is often impossible to ascertain the cause or causes which have given rise to such an abscess. Aimé Gumard, in his treatise on surgery, has shown that, in typhoid fever, for example, the absence of the deep layer of the rectal fascia, in its lower part below the fold of Douglas, may open the way for the development of an abscess in the substance of the rectus abdominis muscle.

Among the circumstances which, in certain cases, favor the development of an abscess or phlegmon in the rectus muscle, may be mentioned the fact that this muscle is liable to undergo fatty degeneration and that consequently, under the provocation of a slight strain or injury, the muscle fibres rupture, blood escapes from the torn vessels, and there is produced a hæmatoma—*i.e.*, a condition favorable for the development of an abscess.

The intestine and uterus have already been mentioned as neighboring abdominal organs from which may come the infective material that gives rise to the abscess in the abdominal wall. To these should be added the stomach, the liver, the gall-bladder, the prostate and the seminal vesicles, all of which organs may, when diseased, furnish the infective material necessary for the development of an abscess in the abdominal wall. Instances corroborative of the correctness of this statement have come under the writer's observation.

Abscesses in the periumbilical region or in the umbilical cicatrix have their peculiarities. For example, the pus of which they are composed usually contains sebaceous material of a cheesy consistence and sometimes débris consisting of shreds of linen or flannel, hair, etc. These abscesses, as a rule, show no tendency to spread to the peritoneum; occasionally, however, there is danger that secondary abscesses may develop in the liver, the infection spreading by way of the lymphatics in the round ligament of that organ, or that, from involvement of the lymph node of Gerota, a deep-seated abscess may form, as in the case of the phlegmon of Heurtaux referred to on a previous page.

Abscesses of the recti muscles occur both to the right and to the left of the median line and, on account of the lineæ transversæ, they appear in pouches. Like what is observed in abscesses of any other part of the abdominal wall, they may contain typhoid bacilli, these organisms having found their way from some broken-down Peyer's patch, the ulceration of which has caused the corresponding part of the intestine to become adherent to the abdominal wall.

In abscesses of the space of Retzius the contents vary with the cause to which they owe their origin. In a general way we may say: all of these abscesses, when they are of internal origin, contain a fetid pus characteristic of paraintestinal suppuration.

Phlegmons of the posterior abdominal wall owe their origin to superficial posterior lesions, such as skin erosions, the abrasions caused by the wearing of a truss, subcutaneous bursæ produced by pressure, etc., all of which lesions may serve as starting points for infection, lymphangitis, and suppuration. Fortunately, all

such cases possess one characteristic in common: the abscess is separated from the abdominal cavity by the transversalis fascia, which almost invariably compels it to open outwardly upon the surface of the body.

As the deep-seated posterior phlegmons owe their origin to some disease of the kidney, the psoas muscle, or the spinal column, we will refer the reader for information regarding them to the appropriate articles in other parts of the work.

A few words with regard to the *symptomatology* will find a suitable place here. In acute phlegmon we have three stages: first, that of the onset of the disease; second, the stage of phlegmonous inflammation; and, third, the abscess period.

In the first stage the symptoms are those of the primary disease, *i.e.*, the disease of the liver, the intestinal canal (typhoid fever), the stomach, etc.

The second stage is the period of phlegmon. Induration appears after the seventh or eighth day; it is saucer-like in form, smooth, and resistant. If the mass is located in the subumbilical region, involving the recti, it will terminate below in a curve the concavity of which is directed upward; this characteristic being caused by the fold of Douglas. If the phlegmon involves the space of Retzius the characteristic just noted will be lacking; the inflammation will appear to be continuous with the pubis. The general symptoms will be at their maximum at this period, *i.e.*, there will be a marked chill, a sharp rise of temperature, an accelerated pulse, marked thirst, and a dry tongue—in brief, the evidences of acute septic infection, with marked leucocytosis. With the formation of pus an abatement, more or less marked, of these symptoms takes place.

In the third or abscess period spontaneous openings may occur in the skin. The umbilical abscess may open internally. When the abscess is located in the space of Retzius there is danger that the pus will break through into the peritoneal cavity, into the large intestine, into the bladder, or into the rectum. Thus, in the latter instances, a most intractable fistula may be formed, especially if the skin is perforated at the same time.

In the chronic form the symptoms are frequently very slight, so much so that the patient may go on indefinitely without consulting a surgeon. Under these circumstances the abscess wall and the contained pus seem to be innocuous.

So far as the *diagnosis* is concerned, no difficulty is presented; the nature of the trouble is in most cases apparent. In the case of a deep abscess or phlegmon, however, it is easily possible, upon a mere physical examination, to confound the condition with an intra-abdominal tumor. But, if the preceding history is taken into consideration, there should be no difficulty in clearing up the diagnosis.

A free incision, combined with the usual cleansing measures and dressings, constitutes the only rational plan of *treatment*. After the abscess cavity has been thoroughly cleansed it should be packed lightly with antiseptic gauze, which should be changed as often as circumstances may require. If the abscess be deep-seated, care should be taken in cleansing it not to perforate the peritoneum. Should there be a communication with the intestinal canal, it is always advisable to allow the condition to become chronic before attempting the

necessary means of repair. (Consult also the article on Abscesses, in Volume II.)

Ulceration.—Ulceration of the abdominal wall usually results from infection introduced by scratching with dirty finger nails or by an abrasion caused by the clothing in an individual who neglects to keep the skin or clothing properly clean, especially in the region of the umbilicus. It is apt to develop in rum-drinkers, who are affected with cirrhosis of the liver, whose veins are enlarged and tortuous, and whose skin and subcutaneous tissues are overcharged with blood. The scratching of a pimple under these circumstances—*i.e.*, in a person whose powers of resistance are below par—may give rise not only to a simple ulcer, but eventually to one of a phagedenic character. Under ordinary circumstances, however, the ulceration, in this part of the body, is usually of an indolent character, with thickened edges. Ulcers of the abdominal wall may be the result of venereal infection—chancre, chancroid, or gonorrhœa.

In general, the *diagnosis* presents no special difficulties.

So far as the *treatment* is concerned, cleanliness constitutes the most important element. When the ulcer and the surrounding parts have been thoroughly cleansed, antiseptic dressings should be applied. In ordinary cases this is all that is required; but in a case of chancroidal ulcer or in one of a phagedenic character it will be necessary first to cauterize it thoroughly with nitric acid and then to apply an aqueous solution of sodium bicarbonate, or else to apply first pure carbolic acid, for from two to five minutes, and afterward alcohol.

Cysts of the Urachus.—These tumors, which represent a collection of fluid in a patent urachus, are found in the anterior abdominal wall. The urachus, which represents what remains of the allantois after the embryo has reached a certain stage of development, is still patent at the second month of intra-uterine life. It stretches from the bladder to the umbilicus. As pointed out by Dr. J. F. Binnie in his article on "Formation of the Urachus," this strip of tubular tissue, in the early stages of development, is, like the bladder, completely surrounded by peritoneum except where a meson attaches it to the ventral wall. This meson, as Binnie mentions, sometimes becomes lengthened at points, thus giving rise to a sacculated condition of the tube; and, as a further result of this normal obliteration in certain parts of the tube, there are produced cysts which are provided each one with a long meson pedicle and are surrounded by peritoneum. Should this cord continue to remain pervious in even a very slight degree, permitting communication with the bladder, it becomes possible for a urachal cyst to develop, and this is especially likely to occur if any interference with the expulsive function of the bladder should arise. The urachus is well supplied with blood-vessels.

There are two general forms of cysts of the urachus: first, the pedunculated variety; and, second, those which are more or less embedded in the anterior abdominal wall, but which have their posterior surface covered by peritoneum.

Urachal cysts usually appear in middle life, and they are more common in females. Vesico-umbilical fistulæ, on the other hand, are more frequent in males.

The *symptomatology* of cysts of the urachus varies considerably. In the

form in which the urachus is described as "presenting the appearance as if it were knotted or had excrescences" there may be no subjective signs whatever; the abdominal condition is discovered accidentally, as in making an examination for some intra-abdominal trouble. But, under the influence of a traumatism, these small cysts may become inflamed and may cause not a little trouble. In the majority of these cases the history is that of an acute illness, with the rather sudden development of an abdominal tumor. (Douglas.) Generally, the attack is preceded by an acute or chronic form of disease of the bladder or urethra, in the course of which there is likely to have been retention of urine. The patient runs down rather rapidly; there is marked pain, usually dull and heavy, and accompanied, as a rule, by pressure downward in the lower abdomen; there are nausea and vomiting, with decided prostration; constipation is present; and the urine, which is passed with some difficulty, is diminished in quantity and is usually loaded with mucus and pus. Examination reveals the presence of a tumor below the umbilicus. If the abdominal walls are relaxed, it is very easy to demonstrate that this is a mural tumor, asymmetrical in shape, immovable, soft, and fluctuating; and if it be of considerable size it will be found that its upper surface is flat and that it bulges laterally. Douglas speaks of the percussion sound as being of a dull character, fading gradually from below upward to the limit of the tumor. He attributes this to the fact that the expansion of the tumor forces the intestines out of the pelvis. Should the tumor push downward into the pelvis, distention of the bladder can be demonstrated by the catheter or by the cystoscope. A microscopic examination of the fluid withdrawn from the cyst will, as a rule, settle the diagnosis, by demonstrating the presence of polygonal epithelium. Stones have been found in these cysts. The pathological conditions for which the latter may be mistaken are the following: intra-abdominal growths, parovarian tumors, encysted tuberculous peritonitis, and hydronephrosis.

Dr. W. J. Mayo reports two cases of cysts of the urachus, in one of which the cyst was as large as a fœtus at nine months. Death from gangrene of the peritoneum followed operation. Tate reports two cases of death from operation on a cyst of the urachus in which the sac was dissected out.

Treatment.—Incision of the tumor and evacuation of its contents are the measures first required. Afterward, the cyst cavity should be washed out with normal salt solution, and then a weak solution of iodine, of about the color of sherry wine, should be applied, due care being taken to provide thoroughly for drainage.

Endothelioma of the Urachus.—Dr. W. J. Mayo reports a single instance of this disease, which is of rare occurrence. Removal of the growth was soon followed by a recurrence which caused the patient's death. The diagnosis of such an endothelioma rests upon the results of an examination with the microscope and upon the rapidity of growth of the tumor.

Patent Urachus.—This condition has been found in four different forms:—(1) It may remain open throughout its entire length, the urine escaping from the umbilicus (as in the author's case); (2) it may terminate in a blind extremity

at the navel, the bladder end of the duct remaining open in varying degrees; (3) it may be closed at the navel and for some distance from this point in the direction of the bladder, but after that the duct is patent and communicates with the bladder; (4) it may be closed at both navel and bladder ends, the intermediate portion forming an elongated cyst. Several cases have been reported in which there was no constriction between the bladder and the urachus; instead, the bladder presented a funnel-shaped extension which terminated in a blind cul-de-sac at the navel. According to Vaughan there are on record quite a number of instances of patent urachus of the blind internal variety which later became converted into the complete variety by a rupture through the navel or by the opening of an abscess at or near the umbilicus. In the great majority of cases, in which the diagnosis was correctly made, the condition was that of a completely patent urachus that had existed from the time of birth. Walter and Wutz, as the result of a large number of autopsies, have arrived at the conclusion that the majority of persons have a urachus which is patent throughout a varying length of its course, but which at the navel is closed permanently, while at the bladder the communication is shut off by means of a valve (Wutz) located in the dome of that organ. Any obstruction to the egress of urine from the bladder may be the cause of an acquired patent urachus and possibly also of the extension of infection from the bladder to the duct. There are on record cases in which, after prolonged retention, urine has suddenly burst forth from the umbilicus. The majority of cases occur in males.

Symptoms.—If the case should be one in which the urachus has a concealed outlet externally, there will be a constant discharge of muco-pus from the navel, and the careful introduction of a sterile probe through the small opening, concealed more or less by the folds of the umbilicus, will demonstrate the existence of a fistulous tract that extends downward in the linea alba toward the bladder. Not infrequently a plugging of the small opening in the umbilicus by foreign matters gives rise to the formation, in the navel, of a small abscess, and the patient, when he applies to the surgeon for relief, is in complete ignorance that he has a congenital deformity. On two occasions the author has found concretions—the so-called umbilical stones—in this blind external fistula; the nucleus being formed, in each instance, of some extraneous material.

In those cases in which the navel end of the urachus is closed, or in those in which the bladder end of the duct is represented only by a diverticulum from half an inch to an inch in depth (as was demonstrated to be the case in the majority of cadavers examined by Binnie), there is no apparent reason why the individual in whom either of these conditions exists might not easily pass through life without a subjective symptom. But if, on the other hand, the bladder end of the urachus is patent for a distance of two inches or more, and if, at the same time, the Wutz valve maintains only partially its function, the development of any obstruction of the outlet of the bladder will be likely to cause the formation of a mural tumor representing a dilatation of the lower part of the urachus. Furthermore, the contents of this tumor, being composed, as they are, of retained urine, may undergo decomposition; in other words, an abscess may form, and

this abscess may either empty itself into the bladder, or may dissect a way for itself in one of two directions—outward to the surface of the body by way of the space of Retzius, or downward and backward behind the bladder. In cases where the urachus is patent throughout its entire length the constant escape of urine from the urachus, by way of the navel, makes the diagnosis self-evident; but, where both the navel and the bladder ends of this duct are closed, the development of a cystic tumor will result.

Treatment.—The first step required is to search for and remove anything that may interfere with the free normal egress of urine from the bladder; and in male children one should look especially for phimosis.

W. J. Mayo's operation for the radical relief of this condition consists in thoroughly dissecting out the tube from the umbilicus to within half an inch of the bladder. At this point the duct and attached tissues are divided, and the remaining stump is turned in toward the bladder; a purse-string suture being applied to the region and a small drain being left in situ. Even when all these precautions have been taken, a discharging sinus is likely to persist for a long time.

Among the other measures which have proved more or less successful in the treatment of this condition may be mentioned the use of caustics and the actual cautery, the employment of ligatures and sutures, the slitting open of the entire tube, followed by a thorough curetting, and the application of pure carbolic acid and alcohol. It is well to remember that all operative procedures on this vestige of an embryonic condition are attended with danger to life.

Desmoid Tumors.—Desmoid tumors are comparatively rare growths. Out of nearly five thousand abdominal tumors Cabot, of Boston, found only three which were of this nature. At the clinic at Tuebingen, Germany, Pfeiffer saw forty cases during a period of forty-six years. Three cases are reported in Powers' excellent paper on this subject. These growths are more frequent in women than in men, the proportion being 7 to 1; they occur most frequently in the child-bearing period—*i.e.*, between the ages of twenty-five and thirty-five years.

Etiology and Characteristics of the Disease.—Heredity does not figure as a causal factor. No entirely satisfactory explanation of the etiology of these tumors has yet been brought forward. According to the theory of Powers the tumor represents an active proliferation of superfluous embryonal elements and of the adjacent normal connective tissue.

The most common site is below the umbilicus. The tumor, which varies in size from a hen's egg to a mass several times as large, usually springs from muscle or fascia by a more or less broad pedicle. In the majority of cases it develops in one of the recti muscles, and hence is usually located on one side, rarely in the median line. Its shape is generally rounded or oval; the long axis of the tumor corresponding to the length of the muscle, and the direction of the growth which takes place being determined by the resistance of the overlying structures. In multiparous women the tumor pouches toward the anterior surface. In women who have never borne children the location of the tumor has been diagnosed as intra-abdominal. Should strong tendinous or muscular

bands develop in the line of growth of the tumor, the mass assumes a lobular or nodulated shape or at times the so-called cuff-button form. These tumors are usually surrounded by a distinct capsule, from which the tumor may readily be shelled out, but when they attain a large size it will be found necessary to separate them from their surroundings by dissection, the sac having largely been obliterated by pressure. In about sixty-five of Pfeiffer's four hundred collected cases he found bony attachments or pedicles connecting the tumor with the ilium, the pubic bones, or the false ribs.

Course and Symptomatology.—Desmoids of the abdominal wall are usually of slow growth. Under certain circumstances, however, they may grow rather rapidly, as, for instance, during pregnancy; but, after delivery has taken place, the growth seemingly ceases.

Subjective symptoms may be altogether absent, even until the growth attains the size of an English walnut; and even then it is painful simply because it exerts mechanical pressure on sensitive nerve filaments. But, when the tumor grows more rapidly than usual, the symptom of pain is likely to be more prominent. Tenderness on pressure is not generally in evidence. Adhesions to the skin are rare.

Pathology.—(By Dr. Frank J. Hall, of Kansas City, Mo., Pathologist of the University of Kansas.)—"Desmoids of the abdominal wall were first described by Lisfranc in 1837. Sanger is the author who limited the term Desmoid to the particular tumors that are here described. Mueller had previously employed the term to designate the entire group of fibromata. There has always been more or less confusion in the classification of these tumors because of the injection of the sarcomata into the discussion. The writer wishes to exclude the sarcomata in this relation.

"Taking all reported cases one finds, as did Ledderhose, that ninety per cent occurred in women, and that about seventy-five per cent appeared in women who had borne children. This clinical fact makes it apparent that the conditions of the muscular and fascial wall of the abdomen in pregnancy are such as to predispose to the formation of these special fibromas in this part of the body. The idea has been many times advanced that the stretching and trauma associated with pregnancy and the act of delivery so tear the fibres of the fascial planes that these tumors arise much as does a keloid of the skin after a burn or other abrasion of the skin. This view would place these growths among the reparative hyperplasias and remove them from the group of true neoplasms. With this view the writer concurs. The close analogy which these growths bear to known traumatic conditions of the intramuscular structures—as, for example, the muscle callus or interstitial myositis and myositis ossificans traumatica—makes this view tenable. Indeed, there are on record several cases of calcification of desmoids. Pfeiffer has recently reported forty cases from von Bruns' clinic, and he has collected three hundred and sixty from literature, making it evident that the condition is not rare.

"Most of the tumors of this class arise from the tendinous structures in connection with the recti and follow in their growth the direction of the fibres of

the muscle. The shape of the mass is usually that of a compressed ovoid; exceptionally, it is spherical or bossated. The size and rapidity of growth are variable. Cases of desmoids as big as a child's head have been reported, but the usual size is about that of an egg or of the palm of the hand. When a suspected desmoid grows rapidly, or is not associated with the female sex of the childbearing period of life, sarcoma should be regarded as the probable condition. The growth is usually slow but progressive. The patient experiences occasional tearing pains which are likely to be more severe at the time of menstruation. One patient who came under the observation of the writer, said that at the menstrual period the tumor throbbed at each cardiac impulse and that when the finger-nail was drawn lightly across it the sensation was that of a keen, deep incision.

"The form of this class of tumors seems to depend upon the point from which they originate. If the growth springs from the fascia, it is usually encapsulated and, pushing the muscle aside, it produces a pressure atrophy and thinning of the opposing structure. Such specimens are purely fibrous in structure, feel gritty under the knife, and present the appearance of an ordinary fibroid. If the tumor begins in the sheath of the muscle it is likely to project its proliferating connective tissue between the individual muscle fibres which surround it, and to cause various degenerative changes in them. Some undergo simple atrophy, with a proliferation of the sarcolemma nuclei, while other fibres are, for a time at least, hypertrophic. (See Plate XLVIII, the figures of which show a proliferative interstitial myositis.) The surgical removal of this variety of desmoid is difficult on account of the lack of limitation and the danger of recurrent growth if a bit of the original tumor is left.

"In desmoids, the blood-vessels are numerous and are usually intimately connected with the fibrous tissue of the growth, so that they gape widely when cut. Their walls are poorly formed, and the impression is left that they are dilated granulation-tissue vessels surrounded by scar tissue. This defective structure in the vessels leads to interstitial hemorrhages that may later give rise to cysts filled with a grumous fluid. Nutrient difficulties may also result in a sort of sero-mucoid degeneration in certain areas—changes which have led to the application of the term "myxo-fibroma" to some specimens of this variety of tumor.

"When all the features of these growths are considered it is difficult to resist the belief that they are essentially inflammatory new growths and should be so treated."

Diagnosis.—The tumor, especially when small, is sharply defined, and, when it springs from the rectus muscle, it is movable from side to side. During active contraction of the muscles involved mobility of the tumor disappears. Should the growth have its origin from the superficial layer of muscle it soon becomes prominent. Those growths which project into the abdominal cavity are apt to change their position when that of the body is changed. Except when they have formed adhesions with one of the abdominal organs they are not influenced by the respiratory movements. In some cases a positive diagnosis

can be made only after an exploratory incision, as in the author's case, where the trouble was mistaken for appendicitis with adhesions. The growth, in this instance, sprang from the internal oblique muscle. It is a good plan, in investigating a suspected desmoid tumor of the abdominal wall, to seat the nude patient on a stool, with the back toward the examiner and the body bent forward, so as to relax the abdominal muscles as much as possible. When the patient is thus placed, it is easily possible, if the tumor is located in the abdominal wall, and even if it should be connected anteriorly by adhesive bands to the neighboring bone, to insinuate the fingers beneath the growth. Bimanual manipulation by way of the vagina and the rectum assists materially in differentiating such a tumor from a growth of the uterus or of one of the adnexa. Growths of the stomach, liver, or pancreas give a history of defective alimentation preceding the discovery of the tumor. Omental tumors change position whenever the body is moved.

Treatment.—There can be no medical treatment for desmoids. Rubbing and the application of irritating liniments will do harm by causing a determination of blood to the tumor and thus increasing its growth, or by changing an already perverted cell to one of a more dangerous character. Extirpation at as early a date as possible should be advised, and it should also be remembered that, in taking away a portion of the muscular structure of the abdominal wall, there will be left a weak place which may very easily become the seat of a ventral hernia. Desmoids arising from the posterior aspect of one of the recti or from the transversalis usually involve the peritoneum, and consequently this must be excised with the tumor. The line of incision should be made in the direction of the long axis of the growth. If it be found surrounded by a capsule, there will be no difficulty in shelling it out whole; but, unless this be the case, the only safe course is to carry the incisions wide of the growth, even should it be necessary afterward to transplant muscular tissue to fill in the space. Never sacrifice any skin, as, after suturing separately each plane of subcutaneous tissue, the opposite edges of skin may be brought together and sutured in the cox-comb fashion suggested by Koenig—a method which gives additional strength to the line of stitches in the skin. It is advisable for the patient to wear an abdominal bandage for several months after recovery. Recurrences take place in about forty per cent of all cases. The earlier the extirpation, the less is the liability to recurrence.

Angioma.—This species of tumor, in one of its various forms, is observed only rarely in the wall of the abdomen. It is usually of congenital origin, and does not involve the deeper tissues. Early excision is the proper treatment.

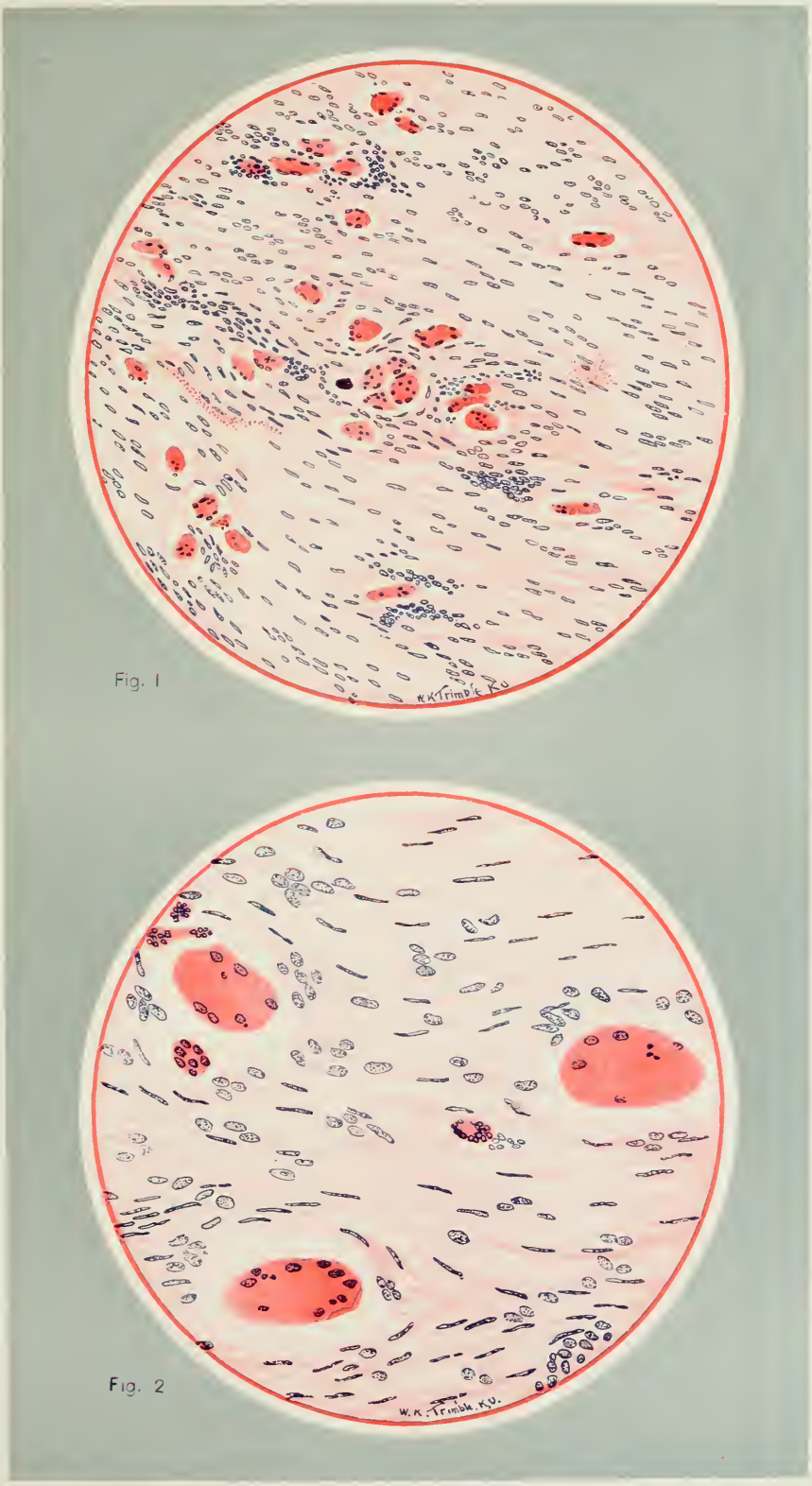
Adenoma of the Sebaceous Glands.—Tumors of this nature are very rarely found in the abdominal wall. They may readily, as stated by Dr. W. C. Clarke, be confused with tumors that arise (1) from the glands of the wall of a desmoid cyst, (2) from the epithelium of an inclusion cyst, (3) from a supernumerary mammary gland, or (4) from a sweat gland. A microscopical examination, however, soon dispels all doubt as to the nature of the tumor. The epithelial elements may undergo fatty metamorphosis or mucoid degeneration, or both, and as a result there will be developed one or more cysts containing a firm material similar to sebum or a dark-brown watery fluid. The presence of acini

EXPLANATION OF PLATE XLVIII.

DESMOIDS OF ABDOMINAL WALL.

Fig. 1.—Low-power Drawing of Intramuscular Desmoid of Rectus Abdominis Muscle. Shows the enclosed and degenerating muscle fibres surrounded by ovoid nuclei that represent the proliferated sarcolemma nuclei. In many places the fibres of connective tissue are separated and the spaces are occupied by escaped red blood cells and a serous fluid.

Fig. 2.—High-power Drawing of the Same Tumor showing three hypertrophied muscle fibres and four atrophic fibres that resemble multinucleated giant cells. Areas adjacent to this present no muscle fibres in recognizable condition, the site of the completely destroyed fibre being represented by a group of sarcolemma nuclei.



SECTIONS OF A DESMOID OF THE ABDOMINAL WALL

(DRAWN BY W. K. TRIMBLE, M. D.)

and the development of such processes as fatty metamorphosis and calcification are characteristics which belong especially to sebaceous glands; and therefore the giving of the name sebaceous adenomata to these tumors appears to be warranted. Operative interference is the only proper therapeutic procedure.

Fibroma Molluscum.—This fibrous growth of the skin may appear as an isolated tumor, or a number of such growths may develop simultaneously. They usually appear as soft pendulous masses, at times distinctly pedunculated; they are painless and they are also easily separable from all surrounding tissues. Occasionally they grow to a large size. They are distinguished from lipomata by their smooth surface and by the fact that they are rarely lobulated. Usually they are well supplied with blood-vessels.

Early removal is advisable, as these tumors, under the influence of constant irritation, sometimes assume the characteristics of a sarcoma and increase rapidly in size. In removing them, one should be careful to ligate thoroughly the vessels of the pedicle.

Sarcoma of the Skin.—This variety of tumor, fortunately, is observed only rarely in the abdominal wall. As already stated above, what was originally a simple fibroma may later become converted into a sarcoma, and it is therefore difficult at times to determine whether the tumor under observation is merely a fibroma, or whether it must be classed as a sarcoma. In still other cases the sarcoma may develop from a pigmented nævus or it may have its origin from seemingly healthy tissue. The rapidity of growth, the elasticity, and the marked painfulness of the tumor are good indicators of malignancy. Still more pronounced evidences of malignancy are furnished by the early breaking down of the tumor, which then presents the character of an offensive mass. The deeper layers of the abdominal wall soon become involved and the lymph nodes show that they are the seat of a mixed infection.

The growth should be promptly diagnosed and excised, the incision being made in such a manner as to leave a wide margin of healthy tissues outside the tumor. If this precaution be not taken, a recurrence is almost sure to follow.

Carcinoma.—Recurrent carcinoma in the abdominal wall, following operations for carcinoma of the stomach or gall-bladder, has been observed by Mayo. In several instances he has known these secondary hard nodular deposits to develop in stitch punctures; and it is now his practice to decline to undertake any intra-abdominal operative work in cases in which he finds small, hard lumps or plaques in the umbilicus.

Lipoma.—Lipomata may be subcutaneous or subserous. The *subcutaneous lipoma* may be found developing in any portion of the abdominal wall. It is usually surrounded by a thin capsule of fibrous tissue, is easily separable from the surrounding tissues, and, if it has not been subjected to constant irritation, it will not be found adherent to the overlying skin. When the tumor is compressed bimanually the irregular polygonal depressions and elevations of the enlarged fat lobules can always be distinguished. The larger fat tumors are never hard, they grow slowly, and they sometimes attain an enormous size. In the author's case of a man fifty-six years old, a lipoma (subcutaneous), with a

four-inch pedicle, and weighing forty-eight pounds, was removed from the left rectus muscle just below the umbilicus. These growths are painless and are seldom richly supplied with blood.

The treatment is extirpation. There is no danger that a hernia will follow the operation.

The *peritoneal* or *subserous lipoma* of the abdominal wall is a much more important growth, as pointed out by Lothrop, of Boston. The preperitoneal fat (usually from one-eighth to one-half of an inch in thickness), which is found more particularly along both sides of the linea alba, is attached by fibrous bands to the underlying peritoneum. The aponeurosis of the muscles covering this fat is studded here and there with small openings for blood-vessels and nerves, and these openings are more frequent along the sides of the linea alba and in the epigastrium. At one or more of these points, the abdominal wall becomes weakened and less able to withstand the increased abdominal pressure. Under such prolonged tension the tissues at the points mentioned undergo atrophy and furnish small openings through which a small portion of subperitoneal fat is forced. The process is a slow one, but, when it has once begun, it continues until the mass of fat, be it only as large as the end of the forefinger, will push itself through the external aponeurosis and will appear as a small tumor which may be felt beneath the skin. When the opening through which it has been forced is not too narrow, it may be found practicable to reduce this little tumor of fat tissue. It is easy to see, as has been pointed out by Lothrop, how the peritoneum may become attached to one of these little masses of preperitoneal fat, and then afterward be drawn by it through the opening in the aponeurosis; thus establishing a condition which favors the development of epigastric hernia.

Fatty tumors from preperitoneal fat are not very uncommon. As a rule, they do not arise from trauma, although in some cases they may originate in this manner. They may give rise to considerable disturbance, the symptoms differing only slightly from those caused by a small ventral hernia. As the filaments of the ilio-hypogastric and abdominal sympathetic nerves anastomose freely with those of the intercostal nerves, the pain which is referred to these masses may be due to pressure on nerve filaments or to muscular contractions. The patient may finally be compelled to seek professional advice, not directly because of the small tumor, but on account of the distressing gastro-intestinal symptoms, as happened in the two cases which came under the author's observation. It is important, therefore, that the surgeon should be on the lookout for possible cases of this nature and should examine the abdominal surface carefully whenever there are subjective gastric symptoms. He should examine the patient in a variety of postures—standing, lying on the back or on the abdomen, and with the abdominal muscles lax or tense. When the recti are tense it is generally an easy matter to discover the presence, in the abdominal wall, of any tumor, no matter how small it may be.

There is but one treatment and this is operation. The tumor should be excised, and afterward the edges of the wound should be brought together in such a manner as to overlap the aponeurosis, as suggested by Mayo.

Hydatid Cysts.—Several cases of hydatid cysts of the abdominal wall have been reported, and more particularly one by Basile in a girl aged seven, who, for two years previous to observation, had suffered from abdominal pains, diarrhœa, and vomiting. The tumor developed at the side of the middle line, and grew to the size of a hen's egg. Puncture yielded clear fluid, containing succinic acid and sodium chloride. A free incision confirmed the diagnosis of echinococcus. The disease, which is caused by the ingestion of the eggs of the Tænia echinococcus, occurs rarely in this part of the body. It develops slowly and is not associated with pain until the tumor, by reason of its large size, exerts pressure upon the sensitive nerve filaments.

The diagnosis cannot be made until the evacuation of the cyst reveals the presence of the characteristic hooklets.

Treatment consists of free incision and thorough drainage.

Actinomycosis.—Actinomycosis of the abdominal wall occurs only as a direct extension of the disease from the intestine. The individual affected generally suffers at the time from some intestinal disorder of a more or less severe type. Then an induration appears on the abdominal wall, at a point where the bowel, through ulcerative action, has become adherent. The swelling soon presents all the appearances of a phlegmon, and when it is incised the contained pus is found to have a distinct fecal odor and to contain the characteristic elements of the ray-fungus. After one of these abscesses has been incised and the contents evacuated, it is necessary to exercise great care in the treatment of the abscess wall, as, through the employment of caustics or the curette, one may easily enlarge the opening in the intestine. The disease, which fortunately is rare, usually pursues a chronic course. It may have, as a sequela, a troublesome intestinal fistula, which requires, for its cure, an abdominal section.

Tumors of the Umbilicus.—*Granuloma.*—Granuloma—or, as it is sometimes called, umbilical fungus—is a disease that is observed only in early infancy. It develops, as a result of uncleanliness, at the time of the falling off of the stump of the umbilical cord. If such an umbilicus is examined several weeks after the navel should have healed, there will be found, at the bottom of the umbilical hollow, a small mass of granulation tissue, the surface of which is covered with a purulent secretion. This will serve to distinguish it from entero-teratoma, which is covered with mucous membrane, while the absence of an opening will distinguish it from a vitello-intestinal fistula. (von Bergmann.)

The observance of cleanliness in the management of the umbilicus at the time of birth constitutes the only prophylactic treatment. As soon as the granulation-tissue growth has been discovered it should be removed by scissors and scalpel under the strictest antiseptic precautions. Care should be taken to ascertain that the growth is composed of nothing but granulation tissue.

Papillary Fibroma.—Papillary fibroma, the result of chronic irritation, is sometimes found in the region of the navel. The little tumor, which may attain a diameter of an inch or more, is made up of branching papillæ that spring from a peduncle which is firmly rooted in the umbilical hollow. On account of the constant irritation tumors of this nature sometimes become ulcerated, and

they may even degenerate into cancer. Early and complete removal is the only safe treatment, even though the peritoneum has to be invaded.

Gumma.—Gumma of the umbilicus is occasionally met with in children of syphilitic parents. It may simulate a malignant growth. The family history will clear up the diagnosis, and the treatment is plain. It is surprising how well so young an infant will bear increasing doses of potassium iodide, and the absorption of the growth is favored by the occasional inunction of mercury.

Fibro-sarcoma.—Fibro-sarcoma of the umbilicus occurs occasionally between the ages of fifteen and fifty, most frequently in women. These tumors are supposed to be the result (indirectly) of trauma. They are firm and have no pedicle; they grow more rapidly than desmoids; as in the case of sarcoma in other parts of the body, the veins of the skin covering the tumor are abundant and markedly dilated; and the related lymph nodes are not involved (except in cases where the surface has been abraded and mixed infection has taken place). These growths are apt to be painful, on account of the rapid growth and of the pressure exerted on sensitive nerve filaments. They should be removed by excision, the knife going wide of the diseased tissue and including the peritoneum. Where there is no ulceration, the prognosis is favorable.

Angioma.—Angioma is occasionally met with in the stump of the umbilicus. It should be completely excised, the scalpel being carried through tissues that have normal blood-vessels. Caustics should never be used.

Epithelioma.—Umbilical epithelioma may be primary, but, as already stated on a previous page, it is usually secondary to carcinoma of the liver or stomach. As a result of uncleanliness which keeps the parts in a state of constant irritation, there develops, at the bottom of the umbilical pit, a shallow epitheliomatous ulcer, the surface of which is covered with foul-smelling secretions and crusts. The disease advances slowly and is usually painless. The patient, to whom the idea of cancer does not seem to occur, is apt to let it run its course, without any interference, until there is deep and widespread involvement of the abdominal wall, with secondary involvement of the lymphatic vessels and nodes. Epithelioma here, as in other parts of the body, should be excised early, *i.e.*, before the lymph nodes become involved, as, when this has taken place, the prognosis is grave.

Papilloma.—Papilloma of the umbilicus is, under ordinary circumstances, a benign growth, but, when it is subjected to constant irritation, it sometimes forms a cauliflower-like mass—a papillary carcinoma—with a broad pedicle and a base that sends its roots through the entire thickness of the abdominal wall. The related lymphatic vessels and nodes soon become involved in the disease, especially should the mass ulcerate and break down. These growths, which are painless and of slow development, should be removed early and thoroughly, and a microscopic examination should be made to determine whether or not they are of a malignant nature.

Scirrhous Carcinoma.—Scirrhous carcinoma of the umbilicus grows slowly, does not ulcerate early, and is followed by metastatic involvement not only of the lymph vessels and nodes, but also of the mesentery. Its hard base, slowly

ulcerating surface, and raised edges are diagnostic. The pains are like needle-pricks, and there is a constant, thin, ichorous, and foul-smelling discharge.

Early and thorough excision is the only treatment that promises anything. The entire thickness of the abdominal wall and parietal peritoneum should be removed, the incision being made in such a manner as to include at least half an inch of healthy tissue around the entire circumference of the growth. All lymph nodes that can be found, especially those of the inguinal region, should be removed.

III. WOUNDS.

Contusions.—A contusion may be either superficial or deep, and may be complicated with rupture of muscles or vessels, or with an injury of one or several abdominal viscera. It may be caused by direct blows, kicks, falls, violent pinching, or forcible compression between opposing surfaces. In the superficial form there occurs at once a circumscribed extravasation of blood from a rupture of subcutaneous vessels; and on the second day there will be seen a darkened area, attended with no swelling, but with some soreness which is evidenced only by pressure, but which is not increased when firmer pressure is made. When the contusion involves the deeper structures of the wall, but without injuring a blood-vessel of some size or causing the rupture of a muscle, the evidences of extravasation may not be seen at all, and soreness may be felt over a limited area only when the body is moved or pressure is made over the seat of the injury. Bruises complicated by the escape of considerable blood among the tissues of the muscles of the abdominal wall, may involve the rupture of two important sets of vessels—the superficial and the deep. Rupture of the superficial epigastric artery may give rise to such an ecchymosis that the skin of the iliac and hypogastric regions is of a black color. The extravasated blood may pass down into the thigh or into the scrotum. When, as a result of the contusion, the deep vessels are torn, the extravasated blood pushes its way beneath the muscles in the subperitoneal tissues or penetrates into the rectus muscle, and, being retained by the fold of Douglas, it then finds its way into the space of Retzius and, as a result, gives rise to symptoms on the part of the urinary bladder. As a rule, extravasation into the rectus muscle is evidenced by a circumscribed swelling.

Among the abdominal muscles the rectus is the one most prone to rupture when the abdominal wall is contused. This accident may be due to direct or to indirect trauma. An abrupt blow upon this muscle, or even a slight stroke when it is in an attenuated or degenerated state, may easily cause a rupture. In a case reported by M. Leuez, the patient, a cavalryman, in attempting to mount without the aid of his stirrups, suddenly experienced in the hypogastric region a sharp pain resembling a knife stab. He was unable to repeat the attempt, as he was doubled up with pain and his respiration was entirely costal. It was evident that the sudden and unusual strain had caused a rupture of a muscle in the lower abdomen. When the muscle fibres, under circumstances such as

nave just been described, are ruptured, they retract, leaving an interspace which quickly fills up with blood. After the lapse of several days this gap becomes apparent, and as a result the abdominal parietes are permanently weakened and very liable to ventral hernia.

The apparently trifling character of the injury to the skin and superficial fascia does not prove that the deeper layers of the abdominal wall are not severely lacerated. Dr. D. N. Eisendrath's case shows this well:—

"A laborer of fifty was caught between the sides of two street cars passing in opposite directions and badly crushed. He was immediately admitted to the hospital and on examination there was found a swelling the size of an orange at the summit of the iliac crest and extending somewhat below it; the tumor was tympanitic and could be made to disappear with a gurgling sound into the abdomen. A diagnosis of traumatic hernia in the triangle of Petit was made; operation was immediately performed and extensive laceration of the abdominal muscles was unexpectedly found. The only structure which separated the general peritoneal cavity from the external air was the skin; all of the muscles normally attached to the crest of the ilium, as well as the transversalis fascia and peritoneum, were torn from their attachments." (*American Medicine*, August 27th, 1904.)

Symptoms.—Tenderness on pressure over the seat of injury is a constant symptom. Should the pain be sharp and attended with muscular rigidity and shock, it is almost certain that some internal organ is injured enough to demand a laparotomy. Swelling depends upon the amount of blood extravasated. The severity of the shock is dependent upon a variety of circumstances: first, upon the seriousness of the blow or injury; second, upon the contents of the region affected; third, upon the fact whether or not the bladder and the intestinal canal were empty at the time of the occurrence (the sympathetic ganglia—the abdominal brain, if we may employ this term—being more readily but less severely compressed when these hollow organs are full); and fourth, upon the degree of rigidity of the muscles which is brought about by expectancy. That a sudden hard impact in the epigastric region is competent to cause death by shock is shown by Dr. Hunter McGuire's case of the soldier who was instantly killed by the impingement of a bullet on his belt buckle. A post-mortem examination was made in this case and it was found that no injury had been done to any of the viscera. Vomiting is apt to follow a severe blow administered at any point along the linea alba, particularly after a full meal.

The most valuable symptoms in visceral laceration are progressive rigidity and immobilization of abdominal muscles. Should these symptoms persist for a time, and be accompanied by a rising temperature, increasing tenderness, a more rapid pulse, and an increasing blood count, a celiotomy is demanded; it matters but little how light the external contusion may seem to be. The policy of waiting for further symptoms to develop is likely to cost the patient his life.

Diagnosis.—It is not always possible to say at once, in a case of contusion of the abdominal wall, what is the nature of the injury inflicted upon the ab-

dominal viscera. Time and a close watch of the general symptoms are necessary. Neither shock, pain, tenderness nor ecchymosis furnishes sufficient evidence to warrant the surgeon in making at once a positive diagnosis of existing conditions. Hospital records show that about three-fifths of these patients recover with only slight or passing symptoms; that less than one-fifth have peritonitis; and that rather more than one-fifth have, as a complication, a rupture of one of the viscera.

Treatment.—Most careful and immediate attention should be paid to every injury of the abdomen. The value of rest—absolute rest—as a remedial agent cannot be overestimated; it should be enforced so long as there is the slightest pain on muscular movement or when pressure is made upon the injured part. Although Roswell Park says, "Unaccompanied by sepsis even the largest hæmatomata are rapidly absorbed and require no treatment beyond rest and cooling applications," he also states that "hemorrhage between the layers of the abdominal muscles, or between the abdominal muscles and the peritoneum, may be so extensive as to cause death, and this result has followed pricking the deep epigastric artery in the closure of abdominal wounds." It may therefore be found necessary, if the hæmatoma is increasing in size, to make an incision, remove the blood, ligate the bleeding vessel, and perhaps pack the wound with gauze.

Burns and Scalds.—Burns and scalds of the abdominal wall are often very serious lesions. In army and naval life localized burns of the abdominal wall may occur as a result of explosions of cartridge boxes, etc., and are likely to be accompanied by laceration or by contusions that may prove even worse than the scalds or burns themselves. This localization of burns or scalds is of comparatively rare occurrence in civil life; in most instances the thorax and other neighboring parts being affected at the same time.

The symptoms, prognosis, and treatment of burns of the abdominal wall are not different from those of burns in other parts of the body. When the superficial area involved is large, and when the damage done extends to a considerable depth, there is danger that the resulting inflammation may extend and set up a peritonitis. The tendency to effusion into the serous cavities of the brain, chest, or abdomen, to ulceration of the duodenum or other parts of the intestine, or to muco-enteritis, is no greater in burns of the abdominal wall than in those of a corresponding degree in other parts of the body. Death, in these cases, is usually the result of hemorrhage or of peritonitis resulting from perforation. Firm, fibrous, contracting eschars are occasionally left on the abdominal wall as a result of a burn or scald. They may, in some instances, be so extensive as to produce a bowing of the body forward or laterally and a corresponding diminution of the stature. In a case which came under the author's observation (a young girl upon whom hot embers had been thrown and whose abdominal wall had in consequence become the seat of a burn of the second degree), the eschar extended from the xiphoid process to the pubis and measured at some points six inches in width. The treatment adopted in this case was the following:

The scar tissue, which represented a relatively narrow, vertical parallelogram, was incised in such a manner as to convert it into six flaps the long axes of which ran horizontally (Fig. 50). Furthermore, the bases of these flaps were planned to occupy different sides in alternation: the base of the first flap, for example, being on the right side, while that of the second occupied the left. After these flaps had been carefully dissected up from their underlying attachments they were twisted on their bases—those on one side in an upward and those on the other in a downward direction—and sutured in their new positions

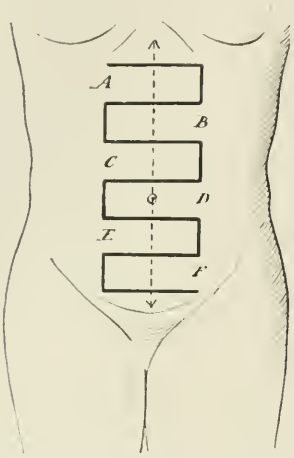


Fig. 50.

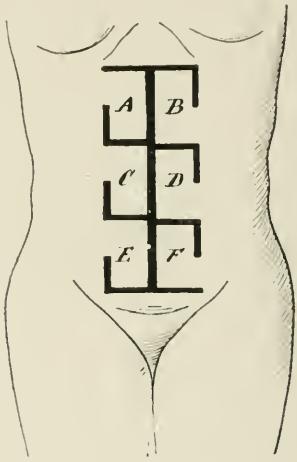


Fig. 51.

Fig. 50.—Diagram Showing Incisions Required for Making Six Skin Flaps in the Front Part of the Abdominal Wall.

Fig. 51.—The Flaps shown in Fig. 50 and designated by the letters A, B, C, etc., have here been dissected up from their attachments and turned, half of them up and the other half down, into their new positions.

partly to the edges of the neighboring abdominal wall and partly to one another (Fig. 51). The effect of this re-arrangement of the segments of the eschar was to change the direction of its component fibrillæ from one mainly vertical to one largely horizontal; in other words, the new arrangement almost completely broke up the former tendency of these fibrils to contract in a vertical direction and thus to produce a bending forward of the body. As a final result of the operation the patient gained two and one-half inches in height, her general health improved, and the abdominal pains ceased.

Incised Wounds.—The incised wounds are caused by sharp-edged or cutting bodies. As a rule, they gape more or less, the degree depending upon whether the wound is parallel with or transverse to the distribution of the muscular fibres, and also upon the degree of tension of the abdominal wall at the time of the reception of the wound. If the latter should be a transverse one in the epigastric, the umbilical, or the hypogastric region, the spreading will be more marked on account of the distribution of the fibres of the rectus abdominis muscle; and if the epigastric artery should be cut, there will be active hemorrhage, requiring ligation of both ends of the divided vessel, owing to the fact

that the branches of this vessel anastomose freely with those of the internal mammary. Should the deep epigastric be cut with a sharp instrument in the iliac region, there will be danger of extensive hemorrhage (properitoneal hæmatoma) beneath the transversalis fascia, and yet, on account of the crossing of the fibres of this fascia, there may be no bleeding externally, as happened in one of the author's cases.

In cases of incised wounds, the first thing to do, in the way of treatment, is to stop the bleeding, to remove any foreign substances that may be present, and to render the wound as aseptic as possible. If there is any doubt whether the latter object has been attained, it is safer to provide drainage. In closing the wound it is advisable to use a separate line of catgut sutures for each layer of fascia and muscle. The importance of observing great care in the manner of suturing together the opposite edges of all divided tissues is emphasized by the danger of a hernia occurring later at this point. Always satisfy yourself that the peritoneum has not been opened, even though it be necessary, for this purpose, to enlarge the already existing cut.

Punctured Wounds.—These are caused by pointed bodies, such as nails, spikes, needles, foils, splinters of wood or iron, etc. When inflicted by sharp-pointed objects, these wounds resemble those of the incised variety; when by a blunt instrument, they resemble lacerated wounds. The skin and subcutaneous tissues may be transfixed at right angles or obliquely, and the track which remains is smaller than the instrument which inflicted the wound.

In punctured, as in incised wounds, it is necessary to be sure that no dirt or foreign substance is left in the track of the wound. In other words, if any doubt exists, the best course is to open the wound freely and continue the exploration to the deepest point. Use both antiseptic and aseptic precautions, always having in mind that the instrument that caused the wound was infected or became so in passing through the clothing. Hence suppuration in these wounds is frequent. The radiograph is not infrequently necessary to a successful removal of some object imprisoned in the wound. Drainage should be thorough, and for this purpose it will often be found useful to employ small "rubber tissue rolls" or cigarette drains. When suturing is resorted to, it should be done with the idea of placing the flaps in good positions, and not with the expectation of obtaining primary union. The plan of placing over the wound numerous layers of aseptic gauze, wrung out of a mixture of equal parts of sterile glycerin and solution of thymol, and covered with rubber tissue, will ordinarily effect a prompt closure of the wound.

Gunshot Wounds.—This subject has been treated so fully in Volume II. that it will not be necessary for me to consider it in the present article.

THE DIAGNOSIS OF TUMORS OF THE ABDOMEN.

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In this chapter the word "tumor" will be used in a very broad sense, so as to cover any mass which is abnormal in form, character, or location. It will therefore include not only the new-growths, but also collections of fluid, misplaced or misshaped organs, inflammatory exudates, etc., for, from a diagnostic point of view, an hypertrophic tuberculosis of the cæcum, for instance, is as much a tumor as is a carcinoma of the same organ.

The term "abdomen" will also be used in a general rather than in a strictly anatomical sense, for many tumors which project into, or occupy largely, the abdominal cavity have their origin within the pelvis, while others may originate in the walls of the abdomen and thus be, strictly speaking, entirely outside the abdominal cavity; yet for practical reasons all of these conditions should be considered together.

The History.—The clinical history is often of considerable importance in the diagnosis of abdominal tumors. It not infrequently indicates both the particular organ or part in which the tumor is located and also the nature of this tumor and the presence or absence of complications; and it should therefore always be carefully inquired into before one proceeds with the direct examination of the patient.

The sex will, of course, at once exclude such tumors as are peculiar to the opposite sex.

The age is of importance owing to the tendency of certain tumors to appear at particular periods of life. True neoplasms of the kidney are most common in infancy and early childhood; hæmatometra and hæmatosalpinx about the age of puberty; fibromyomata of the uterus and the ovarian cystomata during the period of sexual activity; carcinomata during the fifth decennium; etc.

The rapidity of onset and the duration are of importance in differentiating the acute inflammatory swellings from the new-growths. As a rule, tumors which develop rapidly, with pain and fever, and those which follow an injury or an acute infectious disease or the puerperal state, are inflammatory in origin, while those which develop slowly and apparently spontaneously, and without pain, are usually new-growths. As a rule, malignant tumors develop more rapidly than the benign.

The symptoms connected with abdominal tumors are seldom characteristic, although they frequently point to the particular organ or part involved. They may be local or general. Local symptoms are due to disturbed functions of the organs involved or to the mechanical effect of the growth on the surrounding

parts. Thus, a tumor of the stomach obstructing the pylorus may cause vomiting, as may also a tumor of the pancreas which presses on or displaces the stomach. Obstruction of the bowel may be produced by a tumor originating in the bowel wall itself, or by one which is entirely independent of the bowel; in the latter case, the obstruction is caused by pressure from without. Menstruation may be completely suppressed, as in pregnancy, or increased in both frequency and severity, as in fibromyomata and malignant growths of the uterus. Disturbed urination may be caused by pressure on the bladder. A tumor involving the kidney may alter the quantity or quality of the urine. By pressure on the iliac vessels or the inferior vena cava œdema of one or both extremities may result, and ascites may occur from pressure on the portal vein. Jaundice will be present if the pressure occludes the common or the hepatic bile duct. Pain, either local in the tumor or referred as a result of pressure on some neighboring nerve trunk, may occur.

The general symptoms relate to the condition of the blood and to the general nutrition. Thus there may be the usual secondary anæmia, or the anæmia of splenomegaly or Banti's disease, or leukæmia.

Emaciation is quite common in malignant growths in general, but is particularly marked when the growths interfere with the taking of nourishment or with the retention of food in the stomach or with the digestion of the food through shutting off the pancreatic juice and the bile by pressure on the ducts.

The peculiar emaciation of the upper extremities and face, seen in patients with large ovarian cystomata, is not often met with at the present time, owing to the fact that these tumors are seldom allowed to become so large or to persist for so long a time as formerly. Cachexia may become marked in the late stages of malignancy, particularly when the growth has open surfaces which are the seat of infection.

Methods of Examination.—When possible, patients should be prepared for examination by having the stomach, bowels, and bladder emptied, and in obscure cases it is very desirable that the patient be placed on a spare diet and be given laxatives for a few days in order that the entire intestinal tract may be empty and free from gas. The usual position of the patient for examination is on the back, with the head and shoulders slightly elevated and the knees partly flexed. In special cases the patient may be examined while lying on the side or while resting on the hands and knees, or in the sitting or standing position. All clothing should be removed from the abdomen so that the entire region shall be clearly exposed to view. After assuming the recumbent position the patient should be permitted to rest for a few minutes in order to become composed and to permit the tumor, should one be present, to resume its "position of equilibrium." By this term is meant that location which every movable tumor tends to occupy when unrestrained, and it is often a matter of considerable diagnostic value. For instance, an enlarged and movable gall bladder, when displaced by the hand, will soon resume its normal location of equilibrium if left undisturbed, as will tumors of the pylorus and of other parts of the intestinal tract, etc.

Inspection.—Before the abdomen is palpated it should be closely inspected and its general contour observed. It should be viewed in a longitudinal as well as in a transverse direction, and from behind as well as from in front. In this way any irregularity of the surface or any bulging laterally or posteriorly may be readily recognized.

The longitudinal motion which is transmitted by the diaphragm, during respiration, to a mass within the abdomen is quickly distinguished from the perpendicular rise and fall of a tumor of the abdominal wall. The settling of the abdominal wall about a tumor, which takes place during expiration and causes the latter to rise up like a high rock out of the water, is very characteristic and is quite different from the slight expansile movement seen in ascites, or from the arrest of the abdominal wave which is observed at the edge of an inflammatory mass in the lower part of the sheath of the rectus muscles or in the prevesical space.

The enlarged epigastric veins, either unilateral or bilateral, due to obstruction to the return circulation in the iliacs or the inferior vena cava; the enlarged veins about the umbilicus in obstruction to the circulation through the portal vein; the rhythmic waves in the stomach, with obstruction at the pylorus; the peristalsis of the intestinal loops cephalad of a tumor that causes partial obstruction of the bowel lumen; the transverse fold of an excessive deposit of fat in the abdominal wall,—a fold which becomes more prominent when the patient assumes the standing posture; the redness of the surface or slight œdema of the skin sometimes noticed over an inflammatory exudate; the bulging of the umbilicus in ascites; the pigmentation of the skin in some cases of enlargement of the spleen,—all these are points which may be observed in an instant by the experienced eye.

Palpation.—Palpation is by far the most important method of examination in tumors of the abdomen, for by the sense of touch more definite knowledge can be obtained than by any other means. By palpation may be determined the size of the tumor, its shape or outline, the character of its surface, its consistency, its range of mobility, its points of fixation, its sensitiveness, the presence or absence of fluctuation or of pulsation, the peculiar "purring" sensation of an echinococcus cyst, the rhythmic contractions of the pregnant uterus, the movements of the fœtus in utero, etc. In fact, by touch alone a diagnosis can be made in a large majority of the cases of abdominal tumors; but, in order to accomplish this, the sense of touch must be cultivated. One feels understandingly only that which one has been taught to feel.

Gentleness in palpating is absolutely essential to fine differentiation, as all roughness is not only productive of pain and discomfort to the patient, but, by exciting an involuntary resistance on the part of the patient, defeats the end in view. Complete relaxation of the abdominal muscles is necessary in order to secure the best results in palpation, but occasionally a patient is seen in whom it seems almost impossible to secure relaxation when the abdomen is touched. Even in these cases much can be learned by gentleness and patience. By pressing the hand flat on the abdomen while the patient breathes deeply, and sinking

the fingers deeper and deeper with each expiration, the entire abdomen can be quite thoroughly palpated. However, in case successful palpation is impossible on account of rigidity, tenderness, nervousness, fright, or for other reasons, an anæsthetic should be employed, and this should never be neglected when necessary. When palpating the upper abdomen for masses which are affected by the movement of the diaphragm, place the palmar surface of the hand gently on the abdomen and allow it to remain while the patient breathes in and out several times. A mass moving beneath the fingers will often be recognized in this manner by a delicate touch, while, if deeper pressure is made, the mass will escape detection. Even the edges of the normal liver can be readily felt moving to and fro like a soft wave beneath the fingers. In searching for fluctuation only the finger tips should lightly touch the surface, while, with the percussion hammer or the fingers, a light, quick tapping is made on the adjacent parts. In this manner the very edge of the liquid can often be outlined. It is simply a question of delicacy of touch, and this, it is universally recognized, is a matter of training.

Bimanual palpation is of great value, not only so far as the pelvic cavity is concerned, but also in examinations of the lateral abdominal regions; in which latter case one hand is placed posteriorly in the lumbar region while with the other hand the region to be examined is systematically palpated from the front; or the patient may be placed on the opposite side with the knees slightly flexed, which relaxes this portion of the abdominal wall very well. A mass occupying this region may be palpated between the two hands, and so thoroughly can this be done that not only its shape but also the character of its surface and its consistency can be readily determined.

In the presence of ascites, if the finger tips are placed against the abdominal wall and are then made to communicate to the latter a quick, sharp stroke, there will frequently be felt, deep down in the abdomen, a mass which would escape ordinary palpation on account of being surrounded by fluid. The quick stroke suddenly displaces the fluid and the fingers then strike against the tumor. In this manner, if the tumor is movable,—as, for instance, a tumor of the omentum,—a definite sensation of ballottement may be obtained. Many intra-abdominal tumors are quite freely movable. Pagenstecher, who has made a very careful study of this subject, has shown that the degree or range of mobility of a tumor is of considerable diagnostic importance. The fact that a tumor is movable indicates that it has a pedicle. This may be quite long and narrow, and composed of a simple fold of peritoneum containing blood-vessels, etc., as in tumors of the intestines or ovary; or it may consist of a more or less constricted portion of gland tissue, as in a "schnür" lobe of the liver; or it may be short and composed of a variety of tissues, as in enlargements of the uterus or in tumors of the stomach. Be the pedicle what it may, the principle is the same, namely, that the tumor occupies the free or movable end, and the opposite end is the fixed point of attachment. If the tumor be moved now throughout its extreme range it will be found to describe, on the surface of the abdomen, an arc, or a circle, or an oval, the centre of which corresponds to the fixed end of the

pedicle. The outline thus described is more or less characteristic in each case and thus indicates the particular organ or part in which the tumor has its origin.

The degree of motion which can be imparted to an enlarged gall bladder depends upon the length of its meso-cyston or the extent to which its fundus extends beyond the free border of the liver. When either of these conditions is marked the gall bladder may be quite freely movable in a pendulum-like manner, with the concavity of the arc upward and its centre or fixed point at the edge of the liver. The outline traced in this case is quite different from that observed in a movable kidney. In the latter the pedicle consists of the renal vessels and the fixed point is near the midline in the lower epigastric region. The kidney, therefore, when moved describes an arc about this centre toward which the hilus is always directed. It should be stated here that, with the exception of the smaller variety of hydronephrosis which occurs in movable kidneys, enlargements and tumors of the kidney do not, as a rule, possess a wide range of mobility.

Tumors of the stomach and intestines are usually quite freely movable. Of the stomach tumors those of the pylorus are the most movable. They can be moved at times throughout a large circle or oval in the upper abdomen—a feature which is quite characteristic. Tumors of the greater curvature are less movable, and those of the lesser curvature the least so. Tumors of the cardiac end often cannot be felt at all, or, if palpable on deep breathing, can readily be made to disappear under the left costal arch. Tumors of the cæcum vary as to their mobility. In some cases they are quite freely movable, in others they become fixed at an early period. When they are movable the convexity of the arc is directed toward the midline and the fixed point or centre is in the lower part of the right side. Tumors of the sigmoid flexure move about the lower left quarter of the abdomen as the fixed point, and the range of motion depends upon the length of the middle portion of the meso-sigmoid. The omentum lies free in the abdominal cavity, being attached only at its superior border, and this attachment, besides, being to movable organs; consequently tumors of this structure, unless fixed by adhesions, are quite freely movable throughout the central portion of the abdomen.

Tumors of the root or fixed portions of the mesentery are but slightly movable, while those which are located in the distal portion are quite freely movable in all directions.

A movable spleen descends from beneath the left costal arch and may be moved throughout the upper and left portion of the abdomen, at times to or beyond the midline laterally and as far as the pelvic brim below. It may be distinguished from a movable left kidney by the fact that it descends in front of the colon while the kidney is retroperitoneal. A tumor of the ovary with a long pedicle may form one of the most movable of tumors and at times may actually be placed in any part of the abdominal cavity. With a shorter pedicle it may be moved from side to side and show a distinct point of attachment below, on one side or the other of the pelvis.

A subperitoneal fibroid of the uterus with a long pedicle may be freely movable in the lower half of the abdomen, but its attachment to the uterus may

be determined by bimanual examination. Another feature of interest connected with these movable tumors is their change of location under the influence of gravity, and patients may be examined in the knee-chest or knee-elbow position or on the side, or standing, etc., in order to determine this point. As noted under "Inspection," all movable tumors, however much displaced, have a tendency, when left undisturbed, with the patient at rest on the back, to return to their location of equilibrium, and this fact often indicates at once the point of origin of the growth. However valuable the mobility of a tumor may be as an aid in diagnosis, it should be remembered that it is applicable only to tumors which do not exceed a certain size, and that in the case of a tumor of larger size or in one which occupies a considerable portion of the abdominal cavity, its mobility is necessarily more or less restricted on account of limited space. It should also be remembered that every tumor which ordinarily is movable may be fixed by adhesions, and may therefore lose its mobility. Consequently, mobility is of diagnostic value only in a positive sense. In other words, the fact that a tumor is found immovable does not exclude it from belonging to the movable class.

Tumors of certain regions and organs of certain varieties are so uniformly fixed that they are classed as immovable tumors, and this fact possesses therefore some diagnostic importance. To this class belong retro-peritoneal growths, including most tumors of the kidney; inflammatory masses; aneurysms; and tumors of the pancreas. A slight displacement due to a yielding of the tissues should be distinguished from a distinct mobility or change in location of a tumor.

A great difference exists in the consistency of tumors, and by this quality alone the experienced touch will often be able to make a diagnosis.

The firm "board-like" hardness of actinomycosis readily distinguishes it from the ordinary inflammatory exudates. The sensation conveyed to the hand of the examiner by a soft myoma of the uterus is entirely different from that of a cyst of the ovary under moderate tension. A dermoid of the ovary when palpated often gives one the impression of bogginess, and at times irregular, hard, bony or cartilaginous masses may be distinguished. A fæcal mass may be recognized by the fact that it can be indented or moulded by slow pressure with the fingers. The expansile pulsation of an aneurysm is characteristic, as is also the slight œdema about an inflammatory mass.

Percussion.—In making percussion the fingers placed with the palmar surface of the distal portion flat on the surface of the part to be percussed constitute the best pleximeter, for not only are the character and quality of the sound elicited, but one is also able to feel the difference in density of the tissues beneath the fingers.

Percussion is of particular value in defining the outline or limits of organs such as the liver, spleen, etc.; in marking the level of fluid in the peritoneal cavity, and especially the changes in the level when the position of the patient is changed; in locating the colon when distended with air, and in determining its relation as well as that of other loops of intestine to tumors. The percussion

note made over a loop of bowel rises in pitch as the tension in the loop increases. This is often observed in a small area over or about an inflamed appendix in the early stages, or over a loop of small intestine strangulated by volvulus or otherwise; it is also of some importance in diagnosing or differentiating such acute conditions.

Artificial Distention of the Colon.—One of the most valuable aids in determining the particular organ or tissue from which a tumor takes its origin is the distention of the colon with air. This organ, by reason of its circuitous route through the abdomen, lies in contact with, or bears a quite definite relation to, almost every other organ, and thereby becomes the great landmark in the abdominal cavity. The meso-colons—ascending, transverse, and descending—to the free border of which the colon is attached are fixed to the posterior abdominal wall and form more or less complete septa which subdivide the abdominal cavity into four quite distinct regions, namely: the superior region lying cephalad of the transverse meso-colon; the right and left lateral regions lying respectively to the right and left of the ascending and descending meso-colons; and the central region which includes the area surrounded by the meso-colons. Each of these regions contains organs and tissues which are peculiar to the particular region; and, as a tumor which has its origin in one region cannot change its habitat to another region, however much it may encroach by displacement of the septum, it at once becomes apparent that, if the particular region in which a tumor has its origin can be definitely determined, a most important point in the diagnosis becomes established, as thereby it becomes possible to exclude from consideration all those tumors which have their origin in other regions. The septa—the meso-colons—cannot be outlined through the intact abdominal wall, but the colon which occupies their free border can practically always be accurately located, and from its situation the position of the septa may readily be determined. The best way to locate the colon is to distend it with air. This, when properly done, is a very valuable and perfectly harmless procedure. The patient should be prepared by having the colon thoroughly flushed and the stomach empty. He should lie on the back with the abdomen completely exposed. A double rubber bulb, such as is commonly used with a Paquelin cautery, is attached to a glass or metal tip which is inserted into the bowel, and the anus is surrounded by a towel to prevent the escape of gas. The rubber tube is then compressed between the bulb and the towel, while this bulb is being distended with air. On quickly releasing the pressure on the tube the air in the bulb suddenly enters the bowel and when the abdomen is closely observed it will be seen to shoot around the colon like a ball as far as the ileo-cæcal valve. When this is well done the entire course of the colon is quickly and accurately mapped out without unnecessarily distending the abdomen, and its relation to the tumor, which has been outlined previously, becomes at once apparent, and the region to which the tumor belongs is established. Thus, if the colon encircles the tumor the latter will belong to the central region, in which are found tumors of the mesentery, of the omentum, of the retro-peritoneal lymph nodes, of the great vessels, and of the pelvic organs which have risen into

the abdomen. If the tumor lies cephalad of the transverse colon it belongs to the superior region, in which are found tumors of the liver, of the stomach, of the pancreas, of the retro-peritoneal lymph nodes, of the spleen, of the large vessels, etc. In the lateral regions, on the other hand, are found tumors of the kidney and of the adrenal, cysts of lymphatic origin and cysts composed of the remains of the pronephros and of the Wolffian body, tumors growing into this region from the colon, etc. When a tumor is small there may be no difficulty in at once assigning it to its proper region, but when it is so large that it encroaches upon a considerable portion of the abdominal cavity, a careful outlining of the colon may be the only means by which its probable point of origin can be determined.

Auscultation.—Auscultation is of value chiefly in the diagnosis of pregnancy, for by means of it one may detect the sounds of the fœtal heart. When these sounds can be heard the diagnosis of pregnancy is positive, but great care should be observed in excluding pregnancy, when other symptoms suggest it, just because heart sounds cannot be heard, for, in hydramnion or when the child is very small or lies with its back directed posteriorly, it may be difficult or impossible to hear the heart sounds. The various soft-blowing sounds, which are either continuous or synchronous with the patient's pulse, and which formerly were considered to be due to the circulation in the placenta, are not diagnostic of pregnancy, as they may frequently be heard in any tumor that is rich in blood supply.

The soft murmurs should not be mistaken for the more pronounced and characteristic bruit of an aneurysm.

The numerous gurgling sounds heard in the intestine are of value in this connection only so far as they may be related to obstruction of the bowel due to the pressure of a tumor or to a tumor located in the intestinal wall.

Exploratory Puncture.—The aspirating needle as a means of diagnosis should not be used through the unopened abdominal wall. This rule applies practically to all cases in which the needle must enter or pass through the peritoneal cavity.

Rarely, in extra-peritoneal swellings (as, for instance, an enlargement which presents itself in the lumbar region posteriorly), the use of the needle may furnish information without disproportionately great risk; but these are exceptions to the rule.

The reasons why the use of the needle has been abandoned are the following:

1. The danger of the escape of infectious or irritating matter through the needle puncture into the peritoneal cavity after the withdrawal of the needle, which danger is not entirely removed even by completely emptying the cyst or abscess cavity.

2. The possibility of puncturing an overlying loop of bowel.

3. The danger of injuring large blood-vessels in the walls of the mass, with the production of severe hemorrhage.

4. The fact that the information obtained is often unsatisfactory and erroneous on account of

(*a*) the fluid being too thick to pass through the needle used;

(*b*) the obstruction of the needle by a blood clot, a piece of tissue, etc.;

(*c*) the needle entering a large vein and therefore affording escape to nothing but blood;

(*d*) the fluid withdrawn not possessing definite characteristics.

5. The possibility of implanting a malignant growth in the abdominal wall along the needle puncture.

The above-mentioned objections apply, of course, to the use of the needle through the intact abdominal wall. After the abdominal cavity has been opened, during the course of an operation, the aspirating needle may occasionally be used to advantage, as, for instance, in order to ascertain the character of the fluid in a cyst; for, if it be found to contain serum, the removal of the cyst may be immediately proceeded with, while, if it contain pus, it may be wiser simply to stitch it to the abdominal wall and open it later—in other words, to do a "two-time" operation.

Exploratory Laparotomy.—When all means of making a diagnosis have been exhausted and the nature of the trouble still remains unsolved, the question of opening the abdomen for diagnostic purposes will arise. Although the opening of the abdomen under proper precautions is practically devoid of danger, still the operation should not be lightly undertaken and should be done only with the intention of clearing up the diagnosis or of relieving or removing the trouble if possible. Whenever, therefore, an exploratory operation is undertaken, one should be prepared to conduct any operative procedures which may be deemed necessary or advisable for the relief of the patient.

ABDOMINAL SECTION.

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DEFINITION AND HISTORICAL OBSERVATIONS.

The expression "Abdominal Section," first suggested and employed by Lawson Tait, seems to be the most comprehensive and fitting term with which correctly to define the surgical procedure of cutting into the peritoneal cavity through the walls of the abdomen, and the one which is more entirely than any other in accord with the common usage of to-day. The Latin word *sectio*, from which our English "section" is derived, signifies simply "a cutting out," and, when preceded by the adjective *abdominal*, which means pertaining to or relating to the abdomen, it certainly expresses quite clearly the process of gaining surgical entrance into that great visceral cavity of the body, which meaning it is intended to convey. It should be observed, furthermore, that this application of the word section is amply sustained by precedent. Such use was in vogue for centuries,—reaching back to the traditions of the misty past,—as evidenced in its association with the act of opening the gravid uterus and removing its contents through an incision in the abdominal walls, from which procedure we get the classical operation of *Sectio Cæsarea or Agrippina*, the untimely ripping of the great Cæsar from his mother's womb. At a much later period this was made to include other operations, as *sectio alta* or suprapubic lithotomy, perineal section, vaginal section, *et cetera*, many of which terms even now occupy a recognized place in surgical nomenclature.

But the correctness of the expression "abdominal section," as well as of the various other terms which have been coined for the purpose of designating the operation of cutting into the cavity of the abdomen, has been vigorously assailed; and the question of a title which shall be accurately descriptive and at the same time satisfactory in other respects, remains an unsettled one with both lexicographers and surgeons.

Among the earlier terms which were employed for designating the operation of cutting open the abdomen we find that of "gastrotomy" widely used; and, as it was orginally suggested for the operation as performed for the purpose of removing the child from the uterus, the name at first appears to have been employed synonymously with "Cæsarean section." Blancard, of Middleburg, Zealand, published, toward the end of the seventeenth century, a dictionary in which the word "gastrotomia" is given this limited definition. With the progress of time gastrotomy (formed from the two Greek words γαστήρ, belly, and τομή,

incision) was broadened in its field of application and became more generally used in its liberal and vulgar sense of incision into the belly. Consequently, we find the offshoot term, gastrorrhaphy, in use as signifying suture of wounds of both the abdominal parietes and the intestinal tube; but the meaning of the term was finally and definitively narrowed down to indicate the closure of an opening in the stomach wall by suture. With the advent and growth of gastric surgery, however, gastrotomy was largely if not exclusively confined in significance to a simple cutting into the anatomical stomach for the extraction of extraneous bodies.

The word "laparotomy" is probably more commonly employed than any other term, and its meaning has been so enlarged as to embrace every operation of every character involving division of the abdominal parietes. It comes of Greek derivation (λαπάρα, loin, τομή, a cutting) and signifies literally surgical entrance or cutting into the abdominal cavity through the loin or flank. In the beginning of the nineteenth century it was made use of to indicate operations in the lumbar and inguinal regions, such as colotomy and herniotomy, but more precisely lumbar colotomy. This employment of the term was entirely conformable to its true and original meaning, but its general misapplication at the present time has been so obvious as to call forth decided protest from many authoritative sources.

Ventrotomy, a term which was suggested a few years ago by H. A. Reeves as an appropriate substitute for the several terms then in use, had nothing to commend it and much to condemn it, and, very properly, it failed to receive the professional sanction that was expected for it.

The next and latest term that has been added to our terminology is "cœliotomy" (κοιλία, belly), which was proposed by Dr. R. P. Harris, of Philadelphia, some two decades ago, but was erroneously accredited, by some writers, to N. Davies-Colley. This recently coined term possesses very much in its favor from an etymological point of view, but just and valid objections exist to its general application. Thus, as Dr. Frank P. Foster remarks, "with its adoption has sprung up the curious term 'abdominal cœliotomy,' an abdominal opening of the abdomen," a word alliance so improper as to border on the ludicrous. The difficulty of this and similar connections do not admit of such broad and comprehensive application as seems desirable in an expression intended to describe the operation of opening the peritoneal cavity. It is for this reason that many authorities give the preference to the term "abdominal section," and it is for the same reason that the writer has determined to employ it in this article.

The history of abdominal section is in reality the history of abdominal surgery, since division of the parietes is necessarily the first step in all abdominal operations. The phrase "abdominal section" only implies incision into the cavity of the peritoneum, so that the various structures contained therein may be exposed for proper surgical inspection and treatment. The mere cutting into the abdominal cavity can alone accomplish but little in a surgical way, and consequently as a separate operation it can scarcely be claimed to possess any individual distinctiveness. It was only after it was demonstrated that the abdo-

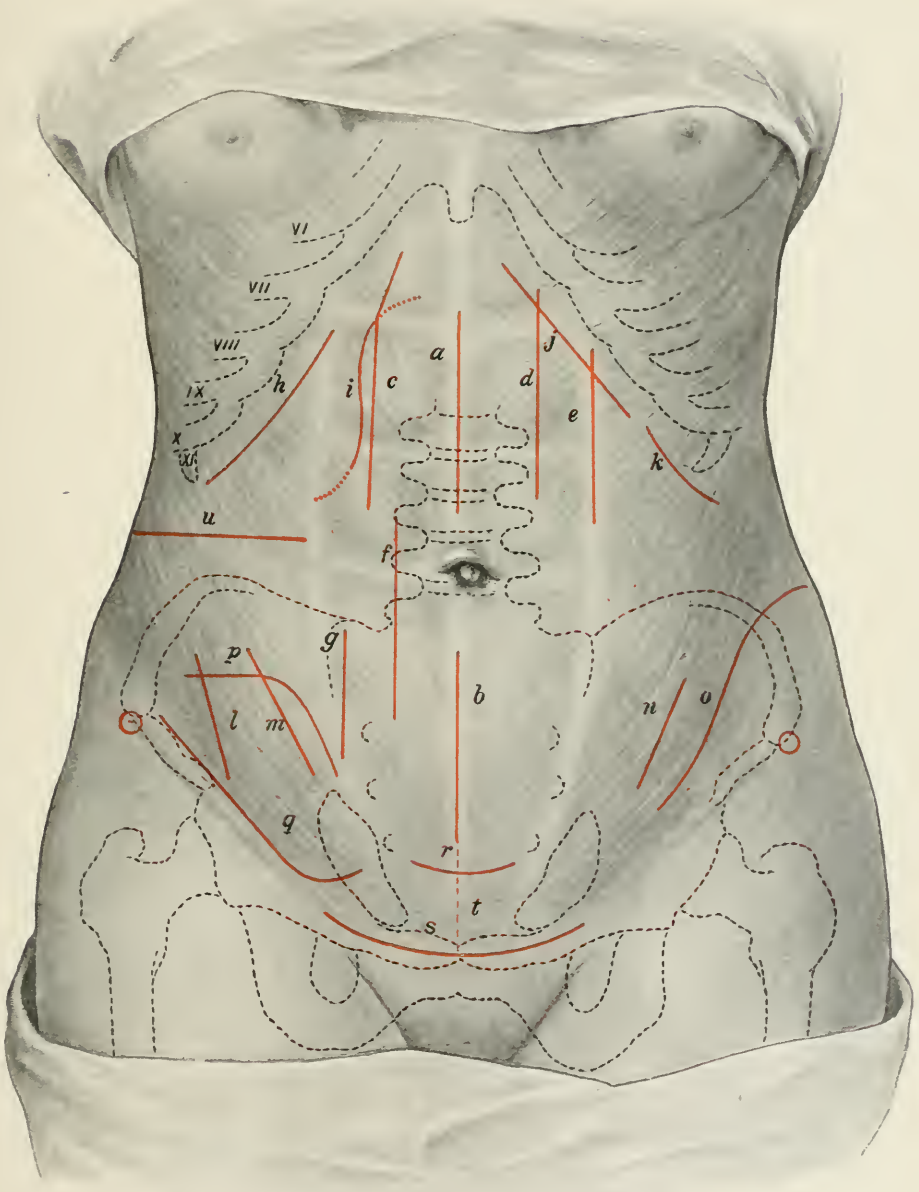
EXPLANATION OF PLATE XLIX.

DIAGRAM SHOWING THE PRINCIPAL INCISIONS EMPLOYED IN ABDOMINAL SECTION.

Vertical Incisions.—*a*, Median supra-umbilical Incision; *b*, median infra-umbilical incision; *c*, right lateral supra-umbilical incision through rectus muscle (Mayo Robson's incision); *d*, left lateral supra-umbilical incision through rectus muscle; *e*, left lateral supra-umbilical incision through linea semilunaris; *f*, the Battle-Jalaquier-Kammerer incision; *g*, right lateral infra-umbilical incision through rectus muscle; *i*, Bevan's S-incision.

Oblique and Angular Incisions.—*h*, Right oblique subcostal incision; *j*, left oblique subcostal incision; *k*, left low oblique subcostal incision; *l*, right oblique inguinal (McBurney's "Gridiron") incision; *m*, right oblique iliac incision for appendicectomy; *n*, left oblique inguinal incision; *o*, left lumbo-iliac incision; *p*, Fowler's angular incision; *q*, J. Meyer's "hockey-stick" incision.

Transverse and Curved Incisions.—*r*, Kuestner's transverse suprapubic incision; *s*, the superficial curved incision, and *t*, the deep vertical incision of Pfannenstiel's inferior abdominal section; *u*, Pean's transverse incision.



THE PRINCIPAL INCISIONS EMPLOYED IN ABDOMINAL SECTION

men could be opened and the cavity of the peritoneum invaded with comparative impunity, that abdominal surgery received that impulse which carried it on to a perfected state. And yet, although this operation should not be styled an operative entity, it constitutes the most important feature in all abdominal operations, and requires for its proper performance both manipulative skill and accurate surgical knowledge. The fact alone that the perfect closure of the abdominal wound—so that it may heal primarily and solidly—diminishes in a large measure the immediate dangers as well as future complications of the usually associated operation, entitles abdominal section to rank with procedures of the first importance.

The history of abdominal surgery, like that of all great and lasting human accomplishments, has progressed by advances and recessions. Splendid forward movements and discouraging lapses back into the darkness of forgetfulness followed, the one upon the other, until the light of true science, the light shed by antiseptic and aseptic wound treatment, placed abdominal surgery upon a pinnacle of lofty height. The name of Joseph Lister is indissolubly bound up with the history and development of this branch of the surgeon's art, as it is with modern surgery in all of its features and aspects. Lister discovered the great principle, and the numerous and ever-zealous company of surgical workers throughout the world applied it, formulated it into definite rules, and from these have been evolved the brilliant technique and marvelous achievements of abdominal surgery as we now have it.

ANATOMICAL CONSIDERATIONS.

Contour and Landmarks. (Plates XLIX and L.)—The front portion of the trunk—that portion which forms the space between the thorax and the pelvic bones—is known as the anterior abdominal wall, and is composed of several layers or planes of muscular and fibrous tissues. The contour and general appearance of the abdominal wall vary with the age and development, and to some extent with the sex, of the individual. In infants and young children the abdomen is conspicuously protuberant and of a rounded form. This degree of prominence is caused by the relatively large size of the liver, which extends over the stomach and also over the bladder and upper portion of the rectum, both of which organs, owing to the comparatively small capacity of the pelvis in early life, are as yet situated in the lower abdomen. The type of the abdomen differs but little in the two sexes until just before puberty, when the pelvis begins to assume its individual sexual character, and when, coincidently with these changes, certain differences in the shape of the abdomen take place. In the well-developed and muscular adult male, the surface of the abdomen is somewhat irregular. This irregularity is due to the fact that the tendinous intersections and muscular masses produce depressions and elevations, which, with the less evident pelvis and the shape of the thorax, materially affect the abdominal lines. In the adult female these muscular depressions and prominences are not usually visible. Furthermore,

there exist other differences, which are dependent upon the prominence and breadth of the ilia, the width of the pubic arch, and the narrowness (as compared with the same structure in the male) of the lower portion of the thorax. In a general way, however, the anterior abdominal wall resembles an irregular quadrangle, or rhomboid-shaped area, the superior sides of which are bounded by the lower end of the sternum and the costal arches, while the inferior sides are delimited by the anterior portions of the iliac crests, the line of Poupart's ligament, and the pubic bone. The four angles or corners thus formed are represented by the xiphoid cartilage, the pubis, and the right and left loins. It is chiefly through this space that the contents of the abdominal and pelvic cavities are palpated and pathological conditions recognized; and it is through an incision in its walls that the various operations upon the organs and structures within the peritoneal cavity are performed.

The anatomical and surgical landmarks of the abdomen are numerous and conspicuous. The anterior superior spinous processes of the ilia are the most prominent of the bony points of the lower lateral portions of the abdominal boundaries, and also the most frequently employed fixed bases from which measurements are taken and descriptive lines drawn upon the surface of the abdomen. The sacral promontory is located posteriorly, just opposite the centre of a transverse line crossing the abdomen between the two spines of the ilium. Rising somewhat above and continuing backward from these processes are the iliac crests, which are well outlined in thin individuals, but are frequently overlapped by a fleshy fold in those who have fat and pendulous abdomens. The costal arches are composed of the cartilages from the sixth to the tenth ribs inclusive, and they extend downward in a diverging or V-shaped direction on both sides of the upper abdomen. Both the angle of divergence and the length of the costal arches vary considerably in the two sexes and in different individuals, and are materially affected by habits of dress. At the junction of the costal arches with the sternum, and projecting downward from the lower end of that bone, is the ensiform cartilage, which corresponds to the depression known as the infrasternal fossa.

The os pubis is a prominent osseous eminence occupying the lower central angle of the abdominal space, and it constitutes a most important bony landmark. From the outer limit of the crest of the pubis projects the spine of the pubis. It is almost on a level with the upper edge of the trochanter major and is found by tracing upward the tendon of the adductor longus muscle. It affords attachment for the outer pillar of the external abdominal ring, and is a reliable guide in locating this opening.

Poupart's ligament is a tendinous cord which extends from the anterior superior process of the ilium to the spine of the pubis of the same side. It is, as a rule, readily felt by the finger, and corresponds to a line (slightly curved downward) drawn between the osseous points mentioned. It is one of the most valuable of the landmarks for surgical purposes. About half an inch (1.3 cm.) above the middle of Poupart's ligament is situated the internal abdominal ring, and, just above and external to the crest of the os pubis, is the external abdominal ring.

The surface of the abdomen is marked by several shallow furrows and depressions, which are clearly distinguishable in young and muscular subjects. The most conspicuous of these markings is the umbilicus, a circular or oval depression, which is almost centrally situated in the linea alba, from three-fourths of an inch to one inch (2 to 2.5 cm.) above a line drawn between the highest points of the iliac crests, but varying to a certain extent with the laxity of the abdomen and the obesity of the individual. It is also opposite the tip of the spinous process of the third lumbar vertebral segment, and above and slightly to the inner side of the bifurcation of the abdominal aorta. The umbilicus consists of a ring of fibrous tissue derived from the linea alba, together with the fusion of the skin, fasciæ, and peritoneum; and it represents the cicatrix resulting from the shrinking of the funis umbilicalis at birth. It is deep and broad in the female, but small and shallow in the male.

The furrows are not discernible in lax, distended, or fat abdomens, but are quite plain on well-developed muscular persons, and often outline the surface into distinct figures. The central or so-called abdominal furrow is the groove in the middle line which reaches from the infrasternal fossa to just below the umbilicus, and is best defined in its upper two-thirds. The linea alba forms the floor of this furrow. The two lateral furrows are the superficial markings of the lineæ semilunares. They are slightly curved, with the concavity directed inward, and they extend from the cartilage of the ninth rib to the pubic spine. The transverse furrows are usually three in number on each side, are situated in the upper part of the abdomen, and correspond with the lineæ transversæ of the recti muscles. In obese and corpulent persons the abdomen is crossed by two other deep transverse furrows. The upper one of these passes through the umbilicus and often conceals it; and the other, or lower one, is situated just above the pubes. Where the lower one intersects the linea alba represents the point where the trocar should enter in tapping a distended bladder. The iliac furrows are placed over the iliac crests, and are formed by the attachments of the external oblique muscles to these elevations of bone. They are best seen when the individual is in the erect posture.

Muscles and Aponeuroses.—The soft tissues composing the several layers of the antero-lateral abdominal wall differ materially in structure, and all possess, in varying degree, the common object of giving strength and support to the abdomen and its contents. The skin or outermost layer differs in character according to the locality, being thinner and finer in texture above the umbilicus and also in the lower lateral or inguinal regions. It is more adherent to the underlying tissues in the middle line than elsewhere; and it is more loosely attached to the inguinal regions on each side. Next to the skin, follow in regular succession the two layers of the superficial fascia, the connective-tissue layer, the so-called intercolumnar fascia of the external abdominal ring, the obliquus externus muscle and aponeurosis, the obliquus internus muscle and aponeurosis, the transversalis muscle and aponeurosis, the rectus muscle and sheath, the pyramidalis, the transversalis fascia, the subperitoneal areolar tissue, and the serous layer or peritoneum.

The muscular and aponeurotic layers are of particular importance to the surgeon. The external oblique—also called the external descending oblique, from the direction of its fibres—is the largest and most superficial of the flat muscles. It is situated on the anterior and lateral aspects of the abdomen, the muscular portion occupying more especially the lateral, and the aponeurosis the anterior portion of the wall.

A bundle of the aponeurotic fibres below constitutes Poupart's ligament. A line projected from the anterior superior iliac spine to a point just anterior to the ninth costal cartilage indicates the junction of the muscular and aponeurotic divisions; a transverse line drawn from the iliac crest (from a point one or two inches [2.5 to 5 cm.] behind the anterior superior spinous process of the ilium) to a corresponding point on the opposite side gives the lower limit of the belly of the muscle; and the fibres of the muscle and aponeurosis run at almost a right angle to a line extending from the anterior superior iliac spine to the umbilicus.

The internal oblique is of smaller size and thinner than the external muscle, and also covers the side and forepart of the abdomen as far as to the linea alba. The lower fibres of its aponeurosis arch downward and inward to unite with the transversalis in forming the conjoined tendon. The aponeuro-muscular limits, above, correspond to an oblique line passing from a point slightly below the tip of the twelfth rib upward and parallel with the costal arch and, inwardly, to a line drawn from the centre of Poupart's ligament upward with a slight outward inclination.

The third flat muscle, and the one which occupies the most internal position, is the transversalis, so named from the direction of its fibres. The lower fibres pass down to the pubis and blend with those of the internal oblique to form the conjoined tendon. The muscular limit of the transversalis is somewhat nearer the median line of the body at its upper and lower portions than it is at the middle.

The rectus abdominis is a long muscle, placed along the front of the abdomen. It is broader above than below, and is separated from its fellow of the opposite side by the linea alba. The tendons of the two muscles interlace below.

The pyramidalis is a small triangular-shaped muscle located at the lower part of the abdomen and in front of the rectus. It is occasionally wanting, and sometimes may be double on one side.

The quadratus lumborum is a muscular mass occupying the lumbar or lateral aspect of the abdominal walls. It concerns the surgeon only when the abdominal incision passes backward into this region and when he is called upon to treat a case of lumbar hernia.

The union or blending anteriorly of the aponeuroses of the obliquus and transversalis muscles of both sides is known as the linea alba. This forms a tendinous raphe down the midline of the abdominal wall between the inner edges of the recti muscles, from the tip of the xiphoid cartilage to the pubic symphysis. This line is broad and distinct above the umbilicus, because of the divergence of the recti muscles at this level, but becomes narrowed and less evi-

dent below it where these muscles more closely approximate each other. It is incomplete posteriorly in its lower fourth, about one inch and a quarter (3 cm.) below the umbilicus—that is, below the semilunar fold of Douglas. The linea alba is the thinnest and least vascular part of the abdominal walls, and is perforated by a number of apertures for the transmission of nerves and vessels, including the large umbilical opening. It may become of exaggerated breadth after great intra-abdominal distention, as observed in pregnancy and in cases in which large fluid accumulations exist in the peritoneal cavity.

The rectus muscle is enclosed in a sheath, the anterior wall of which is formed, in its upper part, by the union of the aponeurosis of the external oblique with the outer aponeurotic lamella of the internal oblique, and below by the blending of the aponeuroses of both oblique muscles and the transversalis. The posterior wall is formed, in its upper three-fourths, by the combining of the aponeuroses of the inner lamella of the internal oblique and the transversalis muscle, but, in its lower fourth, by a thin aponeurosis, the deep fascia, and the peritoneum, which here forms what may be called its posterior sheath. At the point where the upper portion of the posterior sheath terminates, it forms a curved fold, with the concavity directed downward, which is designated as the semilunar fold of Douglas. At the umbilicus all the layers of the abdominal coverings are fused together—that is, the linea alba is closely adherent to the underlying tissues including the peritoneum.

The linea semilunaris represents the line of separation of the abdominal aponeuroses, and corresponds to the outer border of the rectal sheath. A slightly curved line (with the concavity directed inward), drawn from a point between the seventh and ninth costal cartilages to the pubic spine, marks the direction of this tendinous line. At the umbilicus it is about three inches (6 to 7.5 cm.) from the linea alba, but, in an abdomen that has been distended by ascites or other cause, the distance is proportionately increased.

The lineæ transversæ correspond to the transverse surface lines in the upper abdomen, and are three tendinous intersections in the substance of the rectus muscle, but do not extend through the entire thickness of the muscle. The upper one is about opposite the point of the ensiform cartilage; the second or middle one is on a line with the lower part of the tenth rib; and the third is about four inches lower down on a level with the umbilicus. Sometimes there is a fourth, below the umbilicus. These lines divide the upper part of each rectus muscle into two muscular squares, those on the right being the longer. In athletic individuals these squares are quite prominent. The lineæ transversæ connect the lineæ semilunares with the linea alba. These tendinous lines serve to limit the extension of extravasations and emphysema between the abdominal layers.

The peritoneum, at the point where it is reflected upon the bladder, is not fixed, but varies with the degree of distention of the bladder and the rectum. When these organs are empty the vesical peritoneal fold is just below the superior border of the pubic symphysis; when the bladder is distended to such a degree that the highest point of the fundus is two inches (5 cm.) above the symphysis, the peritoneal reflection may be estimated to take place at a point about three-fourths

of an inch (2 cm.) above the superior border of the pubic symphysis. When the bladder and rectum are fully distended the area of prevesical space uncovered by the peritoneum widens to about three inches (7.5 cm.).

Nerve Supply.—The nerve distribution to the antero-lateral wall of the abdomen may be conveniently divided into three groups, namely: (1) the sixth, seventh, and eighth intercostal nerves, which run downward and forward and supply the upper third of the abdomen; (2) the ninth and tenth intercostal nerves, which course more horizontally inward and forward and supply the middle third; (3) the eleventh and twelfth intercostal, the ilio-hypogastric, and the ilio-inguinal nerves, which pass downward and forward to be distributed to the lower third. (The arborescent branches are shown in Plate L.)

The intercostals pass between the internal oblique and transversalis muscles, pierce the sheath of the rectus at the outer edge, penetrate and supply the rectus muscle and its anterior sheath, and are further distributed to the skin in the regions mentioned. The ilio-hypogastric nerve supplies the tissues about the internal ring and the hypogastric region. The ilio-inguinal emerges at the external ring, and sends branches to the thigh and the scrotum in the male, and the labium in the female. Besides the necessity for avoiding injury to the motor branches of the nerves supplying the abdominal walls, an exact knowledge of the relationship existing between the deep and cutaneous branches of these nerves is often of special value to the surgeon in clearing up some of the obscure problems connected with abdominal pain—as, for example, that of reflected abdominal pain associated with certain early pathological changes in the cord and the vertebral column.

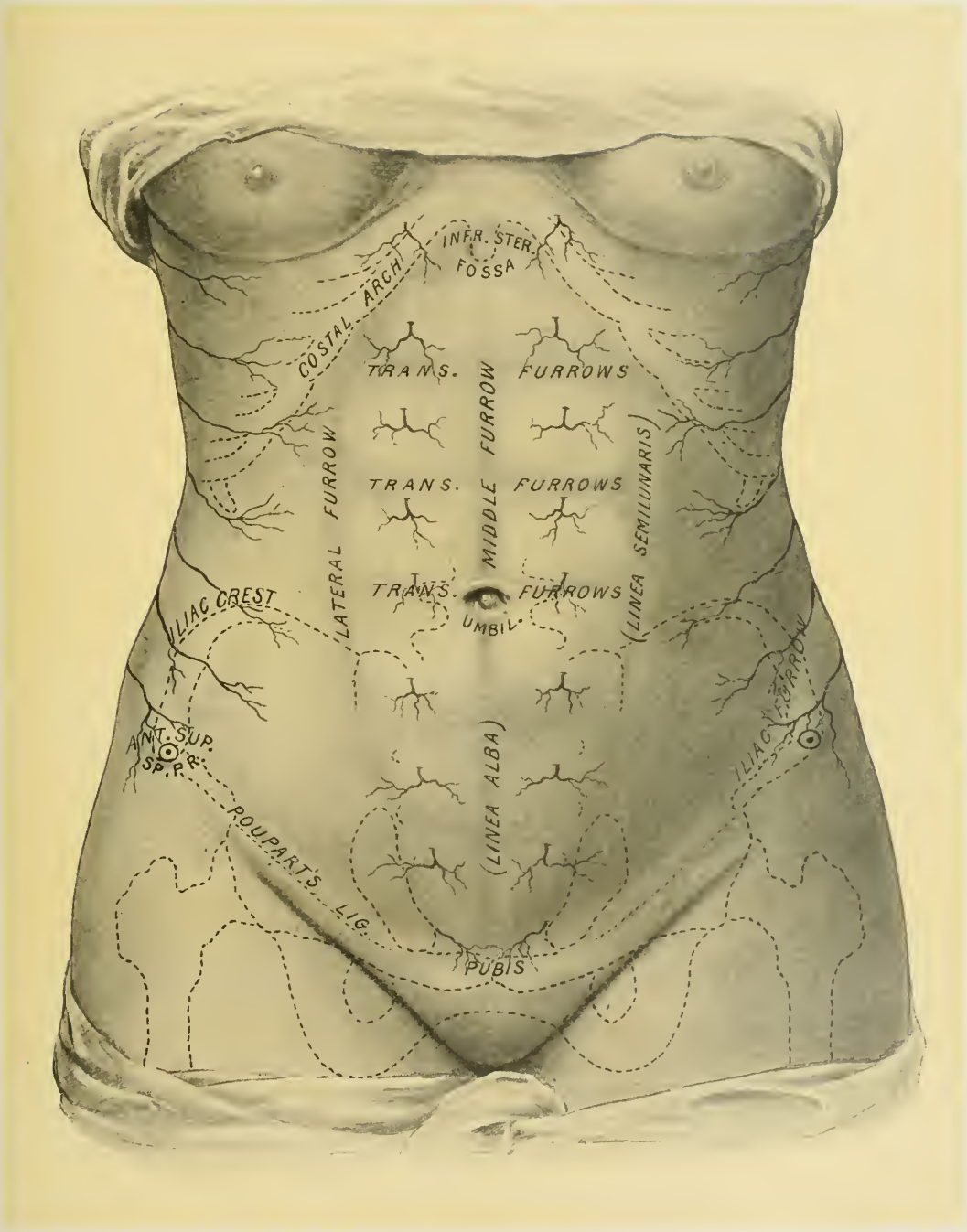
Vascular Supply.—The arteries of the antero-lateral abdominal wall are fairly numerous but of immaterial size. They are: the deep, superficial, and superior epigastries; the deep and superficial circumflex iliacs; the superficial external pudic; the lowest two intercostals; the abdominal branches of the lumbar arteries; the ilio-lumbar; and the musculo-phrenic. The larger of these are: the two epigastries; the branches of the deep circumflex iliac; the epigastric branch of the internal mammary; the last two intercostals; and the abdominal branches from the lumbar arteries. The deep epigastric runs from a point to the inner side of the middle of Poupart's ligament, between the peritoneum and the transversalis fascia, to the inner side of the internal abdominal ring, and then onward in an oblique direction to the sheath of the rectus, midway between the pubis and the navel, and, passing beneath the crescentic fold of Douglas, finally penetrates the muscle to which it is distributed. A line from the middle of Poupart's ligament to the umbilicus indicates the course of both the deep and the superficial epigastrics.

The veins of the abdominal wall correspond for the most part with the arteries, and some are in pairs. There are several veins lying over the peritoneum, in the lower third of the linea alba, and emptying into the vesical plexus at the neck of the bladder. They are termed "cœliotomy veins" by Howard Kelly. Kelly also speaks of a vessel which runs transversely in the subcutaneous areolar tissue, about three-fourths of an inch (2 cm.) above the symphysis pubis, and

EXPLANATION OF PLATE L.

THE ANATOMICAL LANDMARKS AND SURFACE MARKINGS OF THE ABDOMEN OF A WELL-DEVELOPED FEMALE.

The skeletal parts are indicated either by dotted lines or by printed words. The arborescent figures represent terminal nerve filaments.



THE ANATOMICAL LANDMARKS AND SURFACE MARKINGS OF THE ABDOMEN. (Well-developed adult Female)

from which, when divided, arterial blood appears to flow from one side and venous blood from the other.

The fatty areolar tissue lying between the fascia transversalis and the peritoneum varies in thickness in different localities, being quite thick in the upper and lower portions of the midline, but almost absent in the region of the umbilicus. It is also wanting beneath the rectus below the level of the navel, except in stout individuals.

The abdominal viscera are quite insensitive, except when inflamed, but the parietal peritoneum is normally quite sensitive, and, when inflamed, it is acutely so. However, dragging on the omentum or the mesentery, or similar peritoneal folds, may produce cardiac depression and even collapse.

SURGICAL CONSIDERATIONS.

The operation of abdominal section should never be regarded lightly, but ever recognized as a surgical procedure of importance, one that always carries with it an element of risk, and that may be, when least expected, associated with the gravest dangers. Not infrequently the operator of small experience and immature ideas, dazzled by the brilliant work performed by masters in abdominal surgery, enters the abdomen with a recklessness that is often startling. It therefore cannot be emphasized too forcibly that the operator who essays abdominal section should be thoroughly imbued with the responsibilities of the operation, both immediate and remote, and should be prepared to meet the surgical problems which he may at any moment be called upon to solve. He should appreciate that repeated and carefully conducted examinations do not always disclose the exact pathological condition which may exist within the abdomen—a condition which may demand a high degree of surgical knowledge and manipulative skill to recognize and successfully to overcome.

Exploratory Section.—The subject of exploratory section is scarcely a settled one. It is true that every abdominal section is in a certain sense exploratory, but, at the same time, no section should be merely an exploration. It was only comparatively within a few years that such an operation for diagnostic purposes was looked upon almost as criminal. Now, however, the pendulum has swung far to the opposite side, and exploratory incision seems to be resorted to with a thoughtless frequency that is to be deprecated equally with the earlier position. The facility and relative freedom from risk with which the abdomen can be opened has led to practically an utter neglect, on the part of many operators, of the honored methods of abdominal diagnosis once so carefully observed; and the indifferent, almost flippant, manner with which some surgeons of broad experience appear to regard the operation must be held as, in no small measure, responsible for the situation. It should be remembered that what is perfectly justifiable and apparently of little moment with the experienced and facile operator, is quite another thing in inexperienced and unskilled hands. And, because the skilful surgeon can invade the abdomen with so small risk, it does

not follow that even he himself is justified in resorting to the performance of this operation except for good reasons.

Exploratory section is often the one and only means by which a correct knowledge of the condition of things within the abdomen can be obtained, and thus it is not only frequently justifiable but absolutely demanded, and no conscientious man would hesitate to offer such a benefit to his patient. But, before he resorts to this step, he should make an exhaustive and painstaking examination of the case, and, in elucidating its obscurities, he should utilize every diagnostic method at his disposal.

Abdominal section for the purpose of exploration may be legitimately undertaken when it is evident that the conditions within the abdomen are such that an operation will have to be performed, although the nature of the pathological changes is obscure. It is also permissible in cases in which there is no question of doubt concerning the nature of the lesion, but in which it is not possible to say, until the abdomen is opened, whether the condition is operable or not, or even whether a chance exists that the patient may be temporarily benefited thereby.

Whilst a short exploratory incision is always preferable, there should be no hesitancy in extending it to any proper length in order to accomplish in a prompt and thorough manner the purposes for which the operation was made. Although the once prevalent belief that the degree of shock is in direct proportion to the length of the incision is no longer tenable, it should not be forgotten that long incisions always add to the degree of operative shock and correspondingly to the gravity of the case, and may prove the determining factor in a fatal issue. In this connection it is well to remark that rashness should be avoided in inflicting injury upon an intra-abdominal growth or lesion which may prove to be inoperable; for, as Tait long ago observed, it is quite easy to convert an exploratory incision into a completed operation, but often impossible to change an incomplete operation into a simple exploratory incision.

Drainage.—The employment of drainage in wounds dates back to the earliest days of medicine. Drainage of wounds was practised in the time of Hippocrates, and since then has been advocated up to the present moment. Roussetus advised draining the womb in Cæsarean section by means of "a Cannulated Pessary to be inserted in the Os Uteri"; and Laurence Heister, in 1768, recommended drainage of the abdomen for the same operation, as well as for other wounds involving this cavity, by the use of a "Cannula or Tent to discharge the Matter and other Humours," and added that the cavity should be "cleaned by repeated injections of Some Vulnerary Decoction."

In the beginning surgeons were impelled to resort to drains because the formation of pus almost invariably followed upon a wound, and they thus endeavored to prevent or limit suppuration by providing for the ready escape of the wound secretions and inflammatory products. During the first years of abdominal surgery death from post-operative peritonitis was believed to be infrequent. The lethal result was ascribed rather to the poisonous effect of the "red serum," as suggested by Keith, the absorption of which was considered the great menace to life after ovariotomy and other operations involving the peri-

toneum. As a consequence the use of drains for conveying off this toxic fluid was extensively practised, and regarded as a necessary part of the toilet of every abdominal section. With the discovery of pyogenic bacteria, and of the fact that infective inflammation was dependent upon their presence, drainage was considered equally necessary to prevent the retention of these germs in the depths of the wound. But, later, it was learned that the drain, while it undoubtedly favored the removal of germs, often became the direct avenue by which septic organisms were introduced into the peritoneal cavity. It was found, in addition, that a drain is a foreign body, the presence of which increased wound secretion; that mechanical devices were not necessary for removing the products of injured peritoneal surfaces, provided they were not largely infected; that the peritoneum is remarkably tolerant of infectious matter, and therefore much more capable of self-protection when not handicapped by the presence of a foreign substance, even in the form of a drain, which interferes with its resistive powers: and, consequently, that drainage is not nearly so important as was formerly believed, —indeed, that it is often actually harmful. Hence it can now be stated that carefully conducted asepsis renders drainage superfluous in the majority of abdominal sections, and that, even if infection exists to a limited degree, the peritoneal cavity may be closed with reasonable safety. But so much depends upon the environment and personal susceptibility of the patient to infection, upon the extent and effects on the peritoneum of operative manipulation, upon the virulence of the infection (if such exists), and upon the experience, judgment, and methods of the individual operator, that it is impossible to formulate rules that will meet the requirements of every case. Notwithstanding our increased knowledge, the problem of drainage is not yet solved. It is a problem in regard to which there is yet quite as great difference of opinion as exists with regard to any other subject connected with abdominal surgery.

Some operators have adopted the radical practice of dispensing with drains in all abdominal operations except in the presence of extensive and virulent infection and infection in the presence of extensive peritoneal impairment: whereas others adhere to the earlier method of draining in practically all cases. Between these extremes are found surgeons who drain much less frequently than before, but still resort to the practice in questionable instances of their own. The methods which they use, however, are simpler and less bulky than were those of former days.

Drainage Material.—Cannulæ or tubular drains were the earliest devices employed for favoring the escape of wound discharges. The soft-rubber tube, still in use, was introduced by Chassaignac, in 1859: and, a few years later (in 1867), Koeberle offered to the Profession his perforated tubes, with bulbous ends, for peritoneal drainage. About the same period straight glass tubes were employed by Keith and Spencer Wells. These tubes enjoyed a short but wide popularity. It was found, however, that they, as well as all hard drains, often produced damage to the intestines and other important structures through pressure necrosis,—a damage which resulted in fecal fistula in the former, and ulcerative processes in the latter, instances,—and they soon fell into disuse.

Capillary drainage was the next method to claim the attention of the surgeon. This method was effected by means of gauze, or by a combination of soft-rubber tubes with gauze wicks. The use of alternate layers of gauze and rubber tissue rolled into the shape of a pencil or cigarette, constitutes the most trustworthy method of employing drainage at the present time. Folded rubber tissue, composed of several layers which have been rolled or folded together, is also popular. The split rubber tube armed with gauze wick and the cigarette drain are the methods of choice when gauze is to be used. Both of them should be amply large. The cigarette drain is made by placing one or more layers of sterile gauze, of the desired size, on a sheet of tissue, which should be slightly wider than the gauze, and then rolled into a loose roll of the required size. Two or three sterile stitches hold the roll together. The cigarette drain is one of the best forms of capillary drain, and it possesses two important advantages: it does not adhere to the peritoneal surfaces (provided the textile fabric part does not come in contact with them), and it can be removed at any moment without disturbing protective adhesions and without causing pain.

Objections to Drainage.—The objections to drainage are manifold:—The drain keeps the wound open and delays union, and the tract occupied by the drain soon becomes infected and thereby adds a dangerous atrium for the entrance of bacteria into the peritoneal cavity. A drain is always an irritating body, interfering with the natural resistance of the peritoneum and increasing the serous flow in proportion to the extent of wounded and serous surfaces exposed to its irritating contact. The drain often fails to remove fluids, for, becoming quickly clogged, it may act as a plug and stop the drainage. The removal of the gauze drain is extremely painful, and, besides, it may break down granulations and protective adhesions, thus increasing the risk of infection or causing prolapse of the omentum or intestines and possibly inducing hemorrhage. Drainage predisposes to hernia, which is found in eight per cent of the cases, and post-operative ileus is oftener encountered in drained than in undrained cases. Drainage requires frequent change of dressings.

Again, the great objection to peritoneal drainage is that it does not usually accomplish its purpose, for the mechanical difficulties prevent this after a short time. All drains become walled-off from the general cavity in a few hours, and their function then ceases. Tubes cease to drain in about twelve hours; and in twenty-four hours the meshes of gauze fill up, the drain becomes adherent to the peritoneum, and its capillarity is lost.

Indications for Drainage.—Drainage is not indicated in uncomplicated aseptic cases. It is called for in the presence of positive infection, and also where there is much hemorrhage. It is indicated where the urinary bladder and the gall-bladder are opened, since the contents of these organs are usually infected; and immediate provision should therefore be made for draining them. Abdominal drainage should be employed also in walled-off abscesses, as, for example, in appendicitis, in extensive suppuration in the pelvis, where the pus collection cannot be reached through the vagina, and in a widespread or general peritoneal infection. A prophylactic drain should be used when the hollow viscera have

been sutured and when, in consequence, there is uncertainty as to subsequent leakage.

Drainage of the abdominal wound is indicated in abdomens with a very thick layer of subcutaneous fat. This layer, owing to the fact that it is poorly vascularized, has a tendency to break down, and this circumstance, together with the ooze of lymph and fatty matter that occurs in many cases, increases the danger of infection. In this class of cases, therefore, capillary drainage is advisable.

Gauze, in common with all drainage material, has certain disadvantages. Some of them have been referred to, but the chief objection is that it drains serum only, and does not remove pus or blood. This statement has met with denial by some observers, who maintain that, if rationally applied and in sufficient quantity, it will drain both purulent and bloody effusion from the free peritoneal cavity. (R. C. Coffey.) This deficiency, as well as the fact that gauze loses its capillarity in forty-eight hours at the farthest, should be borne in mind. Hence, when it is employed as a packing in hemorrhage, it may, after a short while, act as a dam, permitting blood and pus to accumulate beneath it, and thus cause extended infection. But, despite all these objections, gauze is the most widely used and reliable material at our command, and, when used in ample quantity and of sufficient thickness at the exit of the wound, it may be safely relied upon in most instances. Its efficiency is also greatly enhanced if the outer end is placed in a dependent position and in contact with an abundant absorbent dressing. The well-known tampon drain of Mikulicz is a convenient method of utilizing gauze in draining large cavities, especially where the wicks are to be gradually removed.

Medicated gauzes are now seldom used, and possess no advantage over the plain sterile material. The drug with which they are impregnated may inflict serious harm, and this is particularly true of iodoform, which, in my opinion, should never be introduced into the abdomen in debilitated patients or in those who are suffering from kidney lesion.

Where it is desirable to hold a drain in contact with some definite area,—as, for instance, in the neighborhood of the ureter or the common bile duct, and therefore in a position from which it is liable to be displaced by the movements of the body or through other agencies,—the tube or wick may be sutured to adjacent tissue with catgut. The gut is absorbed in a few days, and the drain is then easily removed.

All drains should be as small as is consistent with effectiveness, and should be removed as early as conditions will permit. The utmost gentleness should be observed in removing a gauze drain. Rudeness is never permissible, lest either intestinal prolapse or reinfection follow the removal. If allowed to remain for a period of from six to ten days the drain will be found loosened, and can then be readily withdrawn.

Drainage through a Stab-Wound.—A drain introduced into the abdomen through a small wound separate from the main incision, and known as the stab-wound drain, has been found of great value and a decided addition to our resources

in the application of drainage, especially in cases of extended infection. A puncture or stab with a bistoury is made through the abdominal wall at a distance from the principal incision and at a convenient point for drainage. This is then forcibly stretched by forceps which also grasp the drain from the inside and bring it out through the opening. This method lessens the risk of infecting the longer incision and the tendency to hernia.

Drainage through the Vagina and Rectum.—Drainage of the pelvic cavity through Douglas' cul-de-sac was introduced in 1864 by Peaslee in this country, and by Keith in Scotland, and for years was alternately in favor and in disrepute. It is now probably the preferred route in the majority of instances requiring drainage of the pelvis and lower abdomen.

The advantages of vaginal drainage are evident. In the first place, there is no uphill drainage, but instead there is afforded a natural gravity route which is both short and direct. The primary union of the abdominal incision is not disturbed—a result which not only renders the period of convalescence shorter and more satisfactory, but minimizes the risk of hernia. The only objection lies in the difficulty of securing vaginal asepsis. This danger, however, has been exaggerated, for, with careful attention to the details in the preparation of the parts, the risk of infection may be reduced to almost nothing.

At about the same period drainage of the pelvis through the rectum was suggested and tried, but failed of its object for reasons now well understood. Quite recently it has been again brought forward by MacLaren, who makes extraordinary claims for the method in the treatment of pelvic abscess in men.

Postural Drainage.—The important observations of Muscatello, John G. Clarke, and others, have demonstrated that there exists in the peritoneal cavity a force which conveys fluids and solid particles, present in the cavity, toward the diaphragm. These readily pass through the endothelial layer of the diaphragmatic and omental peritoneum, the area of the diaphragm manifesting a special affinity for the grosser material. This current takes place irrespective of position, although it is influenced to a certain extent by gravity. Therefore, gravity being the most important principle in all drainage, and it being a fact that absorption into the lymphatics of the upper abdomen takes place rapidly, while the pelvic peritoneum is slow in absorbing, postural drainage has come into almost universal use after abdominal operations, and particularly where widespread peritoneal sepsis exists. Postural drainage is secured by the Fowler or pelvic-low position, in which the patient is maintained in the complete or semi-sitting posture for several days after the operation, until the danger of general septic dissemination has passed. The fear of the effect of this position on circulatory failure in enfeebled patients should not be given too much weight, since the existing cardiac weakness is due to degenerative changes dependent upon the absorption of septic toxins, and would be overcome rather than aggravated by measures that lessen and retard septic absorption.

Fowler elevates the head of the bed to an angle of thirty degrees (Fig. 52), or to a point from twelve to eighteen inches above the horizontal, while the patient remains on the back. To prevent the patient from sliding down in bed a folded

pillow is placed beneath the flexed thighs, and secured in this position by a stout bandage made fast to the sides of the bed frame. Other surgeons prefer to obtain the necessary angle by raising the head and trunk by means of pillows or a back rest, with thigh slings; while still others employ retaining frames and other devices. The main object, however, is to secure the angle of elevation from the hips and not from the middle of the back or shoulders, as is so often seen.

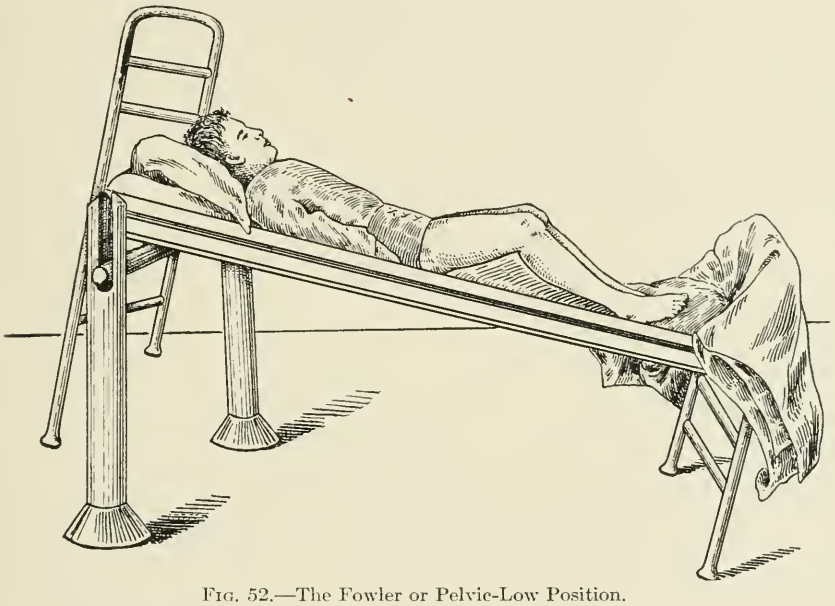


Fig. 52.—The Fowler or Pelvic-Low Position.

Recently, Dr. R. C. Coffey has shown, by some interesting experiments, that it requires an elevation of the trunk to an angle of from sixty to seventy degrees to secure drainage of the renal and iliac fossæ.

Irrigation of the Abdominal Cavity.—There is evidently a growing tendency on the part of surgeons to limit the use of irrigation of the peritoneal cavity to widely distributed infections. The more modern treatment of peritonitis by local drainage, by the exaggerated Fowler position, and by flushing the vessels through abundant colonic injections of normal salt solution, has largely superseded the older method of peritoneal irrigation.

Dr. John B. Murphy's continuous method of employing enteroclysis is a most rational one, and has given to the profession a life-saving element of the very first consequence in the treatment of septic peritonitis. Murphy has shown that the mucosa of the large intestine absorbs water with great rapidity; and that, by the rectal instillation of saline solution, as much as one pint and a half is absorbed, on an average, in from three-quarters of an hour to one hour. By this means large quantities of fluid are introduced into the circulation, thus increasing the activity of the secretions, promoting the elimination of septic material, and promptly restoring the normal blood pressure. Murphy believes that in these cases proctoclysis is second in importance only to a conservative technique. He lays particular emphasis upon the observance of the details of

the plan, and declares that the best results are obtained only when these details are carried out with precision.

We have learned that irrigation of the peritoneal cavity is often harmful, through the risk of distributing septic material to uncontaminated peritoneal areas, and that, oftener still, it is not needed; and yet irrigation is the best means, at our command, of freeing the peritoneum of septic matter, blood, and other detritus. Small circumscribed quantities of pus and blood, if promptly removed, can be sufficiently cleared away by sponge-wiping, and any little that remains may usually be safely left to the care of the peritoneum.

The normal salt solution at a temperature of about 110° F. is the only fluid to be employed for irrigation, and when used it should be confined to the contaminated area. This may be done by isolating the locality with gauze sponges and introducing the solution in small quantities, which should be poured from a pitcher or directed against the part by means of a glass irrigating tube attached to a funnel. A small quantity is introduced at a time and then soaked up by sponges, and this is repeated until the part is properly cleansed. Where blood or pus is effused in large quantity, becoming disseminated among the viscera, the entire abdominal cavity should be irrigated with thoroughness. This is facilitated by raising the pelvis and lowering it, alternately, for a number of times—a procedure which aids in conveying currents of fluid to and from the diaphragm and upper peritoneal recesses. At the same time free escape for the returning fluid should be secured by keeping the edges of the wound widely retracted. The remaining portion of fluid should be absorbed by sponges, and the pelvis and flanks well dried out. In instances of intestinal distention, especially if the bowel is much "ballooned," it is quite difficult—indeed, often impossible and therefore impracticable—to attempt to flush the peritoneal cavity.

The introduction of hot salt solution into the abdominal cavity also serves the additional purpose of furnishing prompt and valuable stimulation, so often needed in these cases.

Position of the Patient during Operation.—The dorsal decubitus, with the head and legs lying flat, is the usual position of the patient on the operating table, and is the most convenient for performing the majority of operations demanding abdominal section. Where the abdominal walls are very tense, owing to a high degree of intestinal distention, some relaxation may be gained by flexing the thighs and raising the shoulders; but this offers little advantage over the simple horizontal posture. The view of the cavity of the flank may sometimes be increased by rolling the patient toward the sound side,—a procedure which should be carried out by assistants or by the aid of mechanical appliance.

In all operations involving the pelvis and lower abdomen the *Trendelenburg or elevated pelvis position* (Fig. 53) affords such decided facility for deep work that it has become indispensable in operations upon the pelvic organs. It is probable that Bardenhauer, of Cologne, was the first surgeon to recognize the advantage of this position, but Trendelenburg popularized it, and it is generally spoken of by

his name. This position causes the intestines to be displaced upward away from the field of operation, where they are easily supported by large flat gauze sponges, or roll-packs, which permit an unobstructed view of the pelvic contents. In some favorable cases manipulation is thus facilitated to such a degree that it is almost as easily executed as when one is operating on the surface. The best results are secured by placing the patient in the desired position during the progress of the final preparation and the administration of the anæsthetic; the pelvis being elevated by gradual stages and the viscera allowed to gravitate slowly to, and become settled in, the upper abdomen. In emaciated and anæmic women this position possesses the additional advantage of lessening shock by keeping a larger volume of blood in the brain.

The degree of change in posture required differs in different cases. It may vary from an inclination of only eighteen to one of forty-five degrees, or even more,

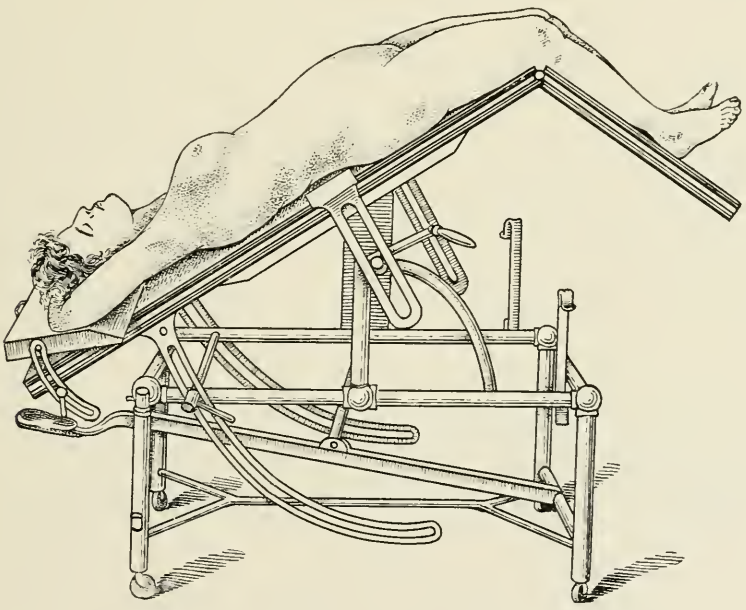


Fig. 53.—The Trendelenburg or Elevated Pelvis Position.

but an angle of thirty degrees is the average. There are certain dangers connected with this position, and the knowledge of their existence should prevent careless employment of the method. Thus, for example, keeping the trunk well bent forward produces marked strain upon the circulatory and respiratory organs through pressure on the diaphragm, and consequently, in stout and plethoric women with flabby hearts and intestines weighted down with fat, sudden and fatal cardiac and respiratory failure may occur. And yet it is in obese patients that an extreme angle of pelvic elevation is the more often necessary. Labored breathing, cyanosed face, irregular pulse, and dilated pupils are the danger signals that call for prompt restoration of the body to a normal horizontal posture. After the intestines have gravitated toward the diaphragm and the retaining packs are in place, the pelvis can be considerably lowered without dis-

turbing them. In the next place, gravity increases the danger of conveying septic matter to the upper part of the abdomen; and this, together with the lessening of bleeding, which may become dangerously active when the body is again placed horizontally, is sufficiently serious to cause some surgeons to reject this position entirely. If it is employed, it should be understood that the patient is to be kept in this position only as long as is absolutely necessary, the angle being diminished after the intestines are packed away from the pelvis, and the position of the trunk being changed to the horizontal upon the first indication of heart or respiratory embarrassment. As a precautionary measure it is well to avoid suddenly returning the patient to the horizontal position, since in feeble patients syncope may, under these circumstances, result from sudden cerebral anæmia.

All of the modern operating tables are fitted with mechanical arrangements for placing the patient in the elevated pelvic position. In some of these tables the arrangements are such that the pelvic elevation is secured by bending the trunk at the level of the lower edge of the scapulæ, the weight of the patient's body resting on the shoulders, with the neck bent forward; while in other tables the whole body is tilted by means of a plane inclined downward (Fig. 53).

The position which is generally employed in operations on the liver, gall-bladder, and gall-ducts is that in which the patient lies on the back over a cushion or sand-bag, with the shoulders slightly raised. The advantages of this position were first mentioned, about ten years ago, by Dr. J. Wheelock Elliot, who showed

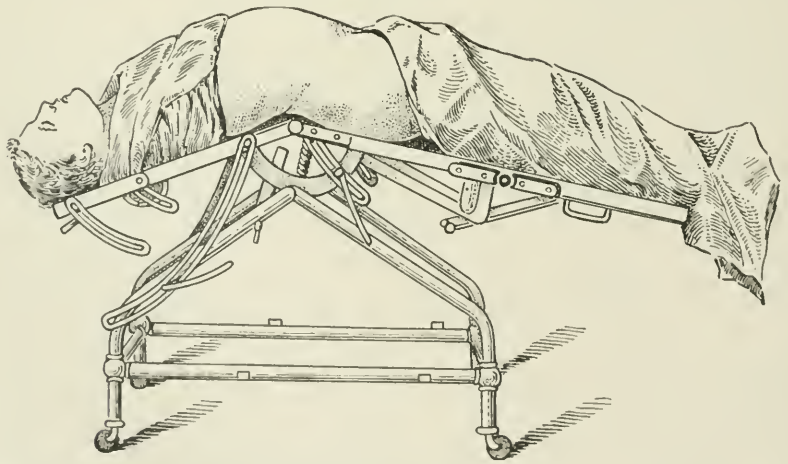


Fig. 54.—Patient in Elliot's Position on the Scanlon-Morris Table. (Elevation by Angulation.)

that, when the patient is placed on a plane inclined at an angle of forty-five degrees, with a sand-bag under the back at the level of the liver, the intestines fall away toward the lower abdomen and the liver is thrust forward; and that, as a result of these changes in the positions of the different organs, the field of operation is much enlarged, and ready access is afforded to the gall-bladder and cystic and common ducts. A pneumatic rubber cushion is preferable to the sand-bag, because it is more elastic and because the tension can be regulated by a

stop-cock attached to the cushion. Where a vertical incision is made, the position just advocated, by putting the muscles on the stretch through the pushing forward of the costal margins, renders the edges of the incision tense and difficult to retract. This does not happen in the subcostal incision or where either the Mayo Robson or the Bevan cuts are employed.

The recent operating tables, such as those provided with the Lillienthal bridge, and the Scanlon-Morris table (Fig. 54), by which the elevation is secured by angulation, are provided with arrangements for placing the patient in this position.

In operations upon the kidney and ureter the patient is placed with the sound side over a cushion, which renders the affected side prominent. This is utilized in transverse and oblique incisions across the antero-lateral abdominal walls, and materially aids the steps of the operation.

INCISIONS.

Some Principles Involved.—There are certain principles that should always govern the surgeon in performing an abdominal section—principles which make it one of the most important procedures in the broad compass of abdominal surgery. A careless indifference to these principles, and the resulting reckless sacrifice of motor nerves, muscular and aponeurotic fibres, and blood-vessels, may lead to conditions that are even worse than that for which the operation was originally required. Of the structures mentioned none should be more carefully protected than the motor nerves. A division of these nerves is often followed by muscular atrophy and hernia. This has been shown in published cases, in which the fibres of the rectus were divided or separated at the outer side without reference to the location of the related nerves; and in consequence the median side of the muscle has become atrophic and eventually hernia has developed.

The integrity of muscular tissue should be disturbed as little as possible. Muscular bellies should never be cut through, either transversely or obliquely, unless such a step is absolutely unavoidable; and then careful apposition of the edges by sutures should be made. Much less injury will be produced by opening the sheath and displacing the muscles (Fig. 55), or by the intramuscular separation of the fibres along the cleavage line (Fig. 56), and this principle should always be applied when possible. Intramuscular separation diminishes the danger of nerve injury, although, when it is done extensively, the nerve supply is always damaged to a greater or less degree. The same rigid rule should be applied to aponeurotic fibres, since it is in the aponeurosis that the strength of the parietes largely resides; although, owing to the fact that muscular tissue is the more resistant of the two structures to the development of hernia, it is safer to cut muscle than aponeurosis.

McBurney's gridiron operation for appendicectomy may be taken as a type of an intramuscular operation at other situations. In this procedure the musculo-

aponeurotic layers of the wall are separated in line with the direction of their fibres, and thereby paralysis and weakening from nerve severance and from the dividing of muscle fibres are avoided. (Fig. 57.)

Incisions that destroy muscular attachments to bone—as, for example, where the muscles along the crest of the ilium are divided—are advisable only in case of necessity.

The arteries of the abdominal wall are for the most part small, and are of secondary importance as compared with the nerves. But the blood-vessels should be spared whenever possible, and especially the deep and superior epigastric arteries.

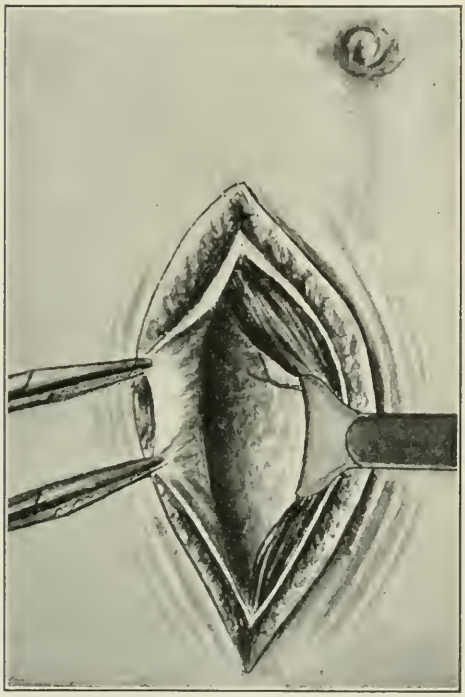


Fig. 55. — This Figure Shows the Battle-Jalaquier-Kammerer Incision. Vertical Incision, a little to one side of the median line, through the anterior sheath of the rectus; the edges of this sheath held apart by forceps; the belly of the muscle retracted toward the median line; and the posterior sheath unopened at the bottom.

The incision should be made by a free, clean cut, down to the aponeurosis, and not by a laborious division of the tissues layer by layer, as was at one time advised. In thick, fat abdomens, however, it may be necessary to incise the fatty layer by several successive cuts. The skin and subcutaneous tissue of the anterior wall are usually lax and movable, and, even when there is a considerable amount of fat, it becomes easy for the experienced operator to estimate by touch the thickness of the parietes, and to gauge practically the depth and length of the incision.

The incision should be smooth and clearly defined, without ragged or frayed edges, and it should be of the same length throughout all the layers. A funnel-shaped wound, such as results from a long skin incision and a short peritoneal opening, is, in my opinion, to be avoided. The incision can be quickly extended by a few cuts with blunt-pointed scissors or a scalpel.

Location, Direction, and Character of the Incision. (Plate XLIX.)—The abdomen should be opened by that incision which produces the least disturbance of the tissues composing its walls, and which affords a plain view of and free access to the parts to be operated upon. There is no exact rule to be followed in effecting this. A superficial or skin incision may usually be placed at any point or carried in any practical direction, but the deep incision must always be made with due respect for the anatomical structures involved.

A superficial transverse incision may be combined with a vertical division of the muscle; or a vertical median skin incision may be combined with a lateral

incision through the muscle sheath and displacement of the muscle; or a skin incision may be combined with blunt intramuscular separation. It often becomes necessary to modify the incision to meet immediate requirements. Thus, a straight incision may be converted into a curved, an angular, or an S-shaped cut. Usually, in operating upon a single organ—as, for instance, the gall-bladder, the appendix, or the stomach—a short incision is sufficient; but unexpected conditions may require it to be greatly enlarged or supplemented by a second, or possibly a third, incision. A second incision is to be preferred to the lengthening, to an inordinate degree, of the first one, which increases the injury to important structures besides adding to the general vital depression. Hence, in dealing with the biliary passages, in the course of an appendicectomy, it is better to make a second incision in the upper abdomen; or, under the same circumstances, it is better to make another opening, median or lateral, through which to attack a lesion on the opposite side, than to extend the primary incision or to use much force in retracting its edges.

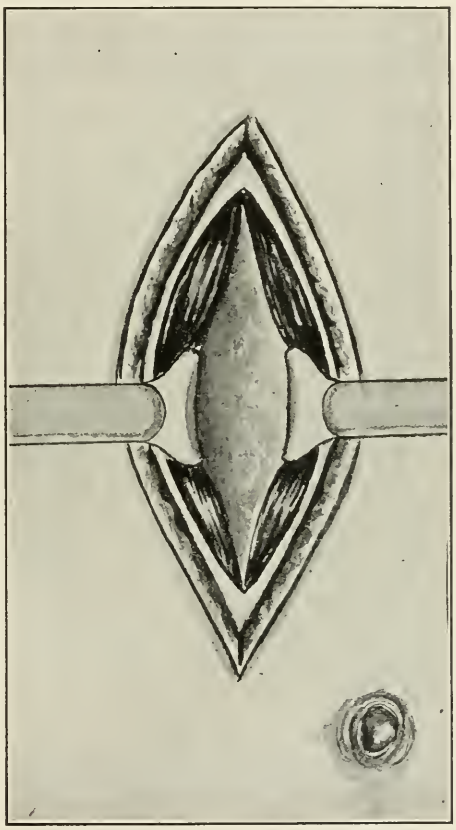


Fig. 55. — Intramuscular Vertical Incision through the Right Rectus Muscle above the Umbilicus. The fibres of the muscle are separated and held apart by retractors.

The incision may be vertical, oblique, or transverse; and it may be made in the median line or anywhere along the lateral regions of the abdominal wall. The vertical incision is oftener placed in the midline, but may be made to one side of this line. Lateral vertical incisions are usually employed in operations upon the duodenum, stomach, liver and biliary passages, colon, and spleen. All lateral vertical incisions of any length sever the terminations of one or several motor nerves. A vertical incision through the centre or outer edge of the rectus muscle is not to be advised ordinarily, since it cuts the nerves to the inner half of the muscle and may be followed by muscle atrophy and hernia. Oblique incisions are preferable in entering the abdomen in the lateral regions, especially when they are associated with muscle separation. Such incisions, inclining somewhat to a transverse direction, and extending from above downward and forward, more closely parallel the nerves (intercostals, ilio-hypogastric, ilio-inguinal) which lie between the muscular abdominal planes.

The oblique subcostal incision (which corresponds with the course of the seventh and eighth intercostal nerves) is practised in explorations of the liver and

gall-ducts, kidney, and spleen; the oblique ventral incision is used for exploring the cæcum and sigmoid, and for ligating the common iliac artery: the oblique inguinal cut may be made above or below Poupart's ligament, and is employed in herniotomy, in operations upon the cord, round ligaments, etc.; the oblique lumbo-iliac incision has in view nephrectomy, complete removal of the ureter, and extraction of a ureteral calculus; and the oblique lumbo-costal incision is the one adapted for operations on the kidney. Vischer's lumbo-iliac incision above the iliac crest, with muscle separation, has only a limited application.

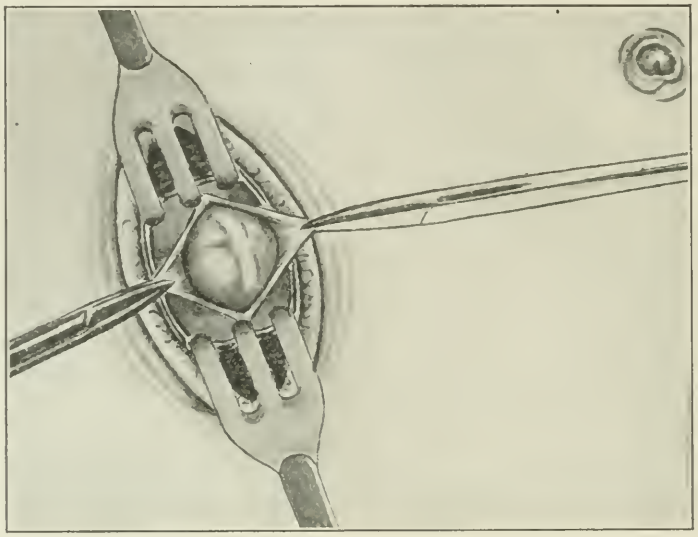


FIG. 57.—Intramuscular Oblique Inguinal Incision (McBurney's "Gridiron operation" for Appendicectomy). The skin and the muscular and aponeurotic layers are drawn apart by retractors; the peritoneum is caught with clamps; and the cæcum appears at the bottom.

Transverse incisions are occasionally resorted to by some surgeons. Those severing the rectus muscle are not desirable, although, if the muscle is sutured, as previously mentioned, hernia rarely develops. A transverse incision over the appendix, with muscle splitting, as employed by some operators (Davis and others), preserves the nerves and gives ample space. Pean's transverse incision, which extends from the outer edge of the rectus to the sacrolumbalis and is useful for kidney work, is rather more damaging to structures than a similarly located oblique cut. Pfannenstiel enters the pelvis through an inferior abdominal section; at first, he makes a curved transverse superficial cut, and then a deep vertical musculo-aponeurotic incision. Kuestner's transverse suprapubic incision is advantageously employed for the operation of suspending the uterus, and for approaching the bladder. The transverse umbilical incision (Mayo) is that of election in umbilical hernia, and offers especial advantages in fat women with lax abdomens.

An incision in the median line, rather centrally located, is chosen for the majority of abdominal sections, because it affords not only the most direct route to the abdomino-pelvic cavity, but for the reason that the linea alba is the thinnest

area, and least supplied with vessels, of the parietes. The median incision may be made anywhere in the linea alba, either above or below the navel, and in long incisions it either passes through it or around it.

Through the median supra-umbilical or epigastric incision access is gained to the liver, the stomach, the pancreas, and some portions of the intestines. In this situation the linea alba is broad and distinct, being often quite wide where intra-abdominal tension has been great, and the incision can therefore be boldly made in this locality. But care should be exercised not to carry the incision too close along the side of the ensiform cartilage, lest a low fold of the pleura be wounded or the anterior mediastinum opened. The act of respiration in the male is more abdominal than thoracic, and, consequently, the anterior abdominal wall is less steady than it is in the female, whose respiration is more thoracic. This is a circumstance of some importance in upper abdomen work. Under ordinary circumstances the abdominal parietes are quite motionless.

A median incision below the umbilicus is available in operations upon the intestines, appendix, bladder, and pelvic organs, and is the most frequently practised of all abdominal incisions. In this region the linea alba is much less sharply defined, on account of the approximation of the recti, and a median incision is apt to expose the inner border of one or both recti muscles, as well as the pyramidales, which may overlap the median line low down. If it is desirable to identify the linea alba, this can be exposed by a small oblique cut made between the edges of the recti. Care should be observed in carrying the incision too near the symphysis for fear of wounding the bladder or opening up the loose prevesical fascia. This space is one in which blood and infective material are apt to collect, and it can usually be avoided by observing the character of the fatty areolar tissue, which is granular in appearance and is provided with vessels that cross the median line in greater numbers than is observed in the preperitoneal fat elsewhere. A moderately full bladder may be its own safest landmark (J. C. Monro), and, if the relations are carefully observed, it often aids the surgeon greatly in recognizing anatomical outlines in certain pelvic operations.

In long median incisions reaching above the umbilicus, it is the usual custom to curve the incision around the left side of this depression, to avoid the suspensory ligament of the liver; but some operators cut directly through it, while others systematically follow the practice of excising it, except in young women. Where the incision is carried through the umbilicus the tissues should be split on each side so as to broaden the area and thus strengthen the suture line. In enormously fat women where the diagnosis is obscure, it has been suggested to explore the abdominal cavity through the umbilical ring, as at this spot the wall is thinnest and the liability to infection or to the occurrence of hernia is less than in other parts of the abdomen. (Howard Kelly.) If the suspensory ligament is cut, it should be sutured and all harm thus prevented. There is little or no preperitoneal fat around the umbilicus, and all the structures are united or fused together, making it difficult to distinguish the peritoneum by separation. This state of affairs may lead the inexperienced operator to believe that adhesions with the viscera exist and that perhaps he has not, after all, actually made an opening into

the peritoneal cavity. But this can be promptly determined by the ease or the difficulty with which the finger can be swept around without encountering some obstacle.

Kelly states that he has employed the median incision through the linea alba in more than two thousand cases, and has no reason to distrust it on the ground that the union is less firm and secure than where the incision is made on one side of this line.

When a secondary section is made it is better not to carry the new incision through the cicatrix of the old one, in order to avoid possible parieto-visceral adhesions that may exist at the site of the former opening.

Length of the Incision.—At one time it was regarded that the length of the incision had an important bearing upon the operative result. It is now understood that this applies only to incisions of extraordinary length, which may positively increase the shock of the operation. It is the rule, therefore, that the incision should be of adequate length for proper and easy manipulation. One is often tempted to make the incision too short and thus interfere both with rapid and with gentle work, and also with the proper inspection of the cavity. Much injury may result from forcible and rough handling through a small wound. On the other hand, a too long incision possesses these disadvantages: It allows the intestines to bulge at the upper end, to the embarrassment of the surgeon, and it adds to the risk of subsequent hernia. Long incisions through muscle or aponeurosis should always be condemned.

An incision about an inch and a half long (4 cm.) is considered short, and is sufficient for ordinary exploration. The average incision varies from three to five inches (8 to 12 cm.) in length, and, when it is more extensive, it is called long. It is usually a correct practice to make a short incision first, and then, after the introduced finger has ascertained the nature and extent of the lesion, to extend it to any length demanded. A large single ovarian cystoma may be removed through a very small wound; whereas solid growths, extensive adhesions, and thick, fat abdominal walls (conditions which render intra-abdominal work difficult) may call for a long incision—one that often extends above the umbilicus.

Longer incisions are necessary in intramuscular separation than where the muscles are divided. Long incisions of the skin and fascia are comparatively harmless, and should be made without hesitation where free exposure is required.

CLOSURE OF THE INCISION AND THE CHOICE OF SUTURE MATERIAL.

In works on surgery published during the seventeenth and eighteenth centuries there are to be found excellent and clearly described directions for closing wounds of the abdominal walls—directions which are as creditable as those given to-day. However, surgeons are not yet agreed as to what is the best manner of suturing the abdominal incision and as to what is the best material to employ

for the sutures. Every operator has his own method of approximating the edges of the incision, and, as a matter of fact, closure of the incision by a variety of methods gives equally satisfactory results, provided accuracy in their application is observed. Thus, there are in use the through-and-through or mass suture, the tier or layer suture, and a combination of the two; and these are applied either as interrupted or as continuous stitches. Both absorbable (catgut, kangaroo tendon, etc.) and non-absorbable (silk, linen, metallic threads, silkworm gut, horse hair) suture material is employed; but the present trustworthy processes for the sterilization of catgut has made possible the almost general adoption of this absorbable material together with the tier method of using it. The continuous suture may be the plain or the whip-over variety, or the chain-stitch suture (Ford's), or the figure-of-eight removable-layer suture of Fowler, and the subcuticular or intracuticular* suture (Halsted's) for the cutaneous edges. The interrupted stitches may be the plain single-loop stitch, the mattress suture, and the figure-of-eight. Different forms of metal clamps or fasteners for the skin, to obviate needle punctures, were introduced by Vidal, but the Michel clamp is the form which is more commonly used to-day.

Through-and-Through Suture.—The through-and-through interrupted suture of silkworm gut is largely relied upon, and gives excellent results in the hands of many surgeons. The advantages claimed for this suture are that it permits rapid work, that it holds firmly, that it enables the operator to avoid dead spaces, that it controls oozing, and, lastly, that it lessens sepsis. All of these are weighty points in its favor, and, when time is a factor of prime importance, this method should unquestionably be used. All sorts of material have been employed for through-and-through sutures, but chromicized catgut and silkworm gut are now more largely used, decided preference being given the latter. Silkworm gut is preferred because bacteria are less apt to adhere to its surface or to penetrate its substance.

Through-and-through sutures are introduced at a distance of from one-fourth to one-half inch from the edge of the wound, they are placed about half an inch apart, and they include the entire thickness of the abdominal wall down to, and often taking in, the peritoneum. When all the sutures are placed, the free ends are gathered together and drawn up so as to "set" them in the tissues, and care is taken to secure even apposition of the edges of the wound. After these precautions have been taken, the sutures are tied without undue tension. The tying may begin at either end of the wound. Superficial skin sutures may be placed between these deep sutures, as circumstances may require. If there is much intra-abdominal pressure from intestinal distention, it is better to tie each suture as it is placed, in order that the size of the wound may be quickly diminished. Under such circumstances, when the viscera or the protective sponge or pad is forced up against the needle point, the introduction of the bowl of a spoon to receive the needle aids materially the insertion of the sutures. If distention is marked, relaxation sutures may be added.

*The term "intercuticular" is very commonly employed by surgical writers, but "intracuticular" is evidently the more correct expression.

Tier Suture. (Fig. 58.)—The tier or layer suture for closing the abdominal wound is the one of choice. By this method the several layers of the abdominal wall are united separately, and the union of like tissues in their natural order constitutes an ideal method of procedure. Furthermore, hernia undoubtedly occurs less frequently since this manner of approximating the edges of the wound has been adopted.

The tier suture may include as many as four layers or tiers. For example, the first set of sutures—continuous or interrupted catgut sutures—include the

Fig. 58.—This Figure Shows the Manner of Closing the Wound by the Tier or Layer Method of Suturing. The peritoneum and fascia are held by a chain stitch, the muscle and its sheath by a whipover stitch. A subcuticular stitch is employed for the final closure of the wound.

edges of the peritoneum alone, or of the peritoneum and transversalis fascia combined. The second set of sutures, of the continuous or the interrupted type, and consisting of heavy chromicized gut, include the sheath of the rectus abdominis, the transversalis fascia, the subperitoneal areolar tissue, and the margin of the rectus (if cut). The chief support is furnished by this second set of sutures. The third set, the chief purpose of which is to obliterate dead spaces, consists of catgut sutures which are passed through the subcutaneous areolar tissue either

interruptedly or as a single continuous cord. The last set of sutures are composed of catgut, and they pass either through the entire thickness of the skin or merely through the subcuticular portion. A continuous glover's stitch or a lock-stitch, of either catgut or horsehair, may be substituted for the latter, or the Michel metallic skin clamps may be used instead, but none of these possesses any superiority over the method of passing the sutures through the subcuticular tissues.

The tier suture may include only three layers. First, a continuous catgut suture may be passed through the peritoneum. Second, an interrupted catgut suture may be made to include the subperitoneal tissue, the transversalis fascia, and the rectal aponeurosis (or the recti muscles). Third, an interrupted suture of silkworm gut or of silk, or a continuous catgut suture, may be passed through the subcutaneous fascia and skin.

Then, again, the sutures may be applied in only two tiers. According to this plan a continuous catgut suture is first passed through the peritoneum; and then an interrupted suture of silkworm gut includes all the remaining tissues.

Finally, the abdominal layers may be sutured separately with running removable sutures of aluminum bronze, silver wire, or silkworm gut, the free ends protruding at each angle of the incision—a plan which affords the combined advantages of the tier or layer suture and of the through-and-through suture.

Where absorbable sutures are used to unite the margins of the aponeurotic layer, and especially if the incisions are rather long, it is well to add several tension sutures of silkworm gut. These sutures, which are passed through all the tissues down to the peritoneum, furnish support against any sudden strain, such as occurs in vomiting or in coughing, and they are also desirable because the early absorption of catgut may increase the tendency to hernia.

It may be remarked, in regard to the use of catgut, that, when great tensile strength is needed, it is safer to employ doubled strands of a small size instead of a single one of the same bulk, since infection is less liable to occur in the smaller strands. It should be remembered, however, that infecting agents may be harbored between the strands.

There are certain considerations, aside from the method of suturing, which should govern the surgeon in closing the abdominal wound. For example, the several layers of the abdominal wall are not equally resistant to infection, and this fact should be given due weight in suturing the wound. The muscles and aponeuroses are the most resistant, and next in order comes the peritoneum; the fatty tissue is the least resistant, owing to its scanty vascular and nerve supply.

The peritoneum is best closed by a continuous suture of absorbable material, so applied as to bring broad surfaces in contact one with the other, to cause eversion of the edges, and not to permit a raw surface to face inward and thus favor its forming adhesions with one of the adjacent viscera. When the peritoneal edges are clean-cut and free from lacerations such adhesions do not often take place, and they are rarely of any consequence when they do occur. The continuous whip-over or the lock-stitch suture is preferable to interrupted sutures for the peritoneum, since it gives more even tension. If the peritoneum is very tense and

not very resistant, the suture is liable to tear out; and, in this event, it should be strengthened by including the layer of tissue above it in the suture, thus making one layer of the two.

Transverse or oblique cuts of the muscles should be sutured in connection with their sheaths or fasciæ. Muscles that are separated in their cleavage line do not often require suturing, but when it is found necessary it should be done with sutures of plain catgut, loosely placed so as not to favor atrophy of the muscle fibres. The sheath is then stitched separately. There is no particular advantage in causing the edges of the aponeurosis to overlap except in umbilical or ventral hernias, or when the abdomen is lax and the aponeurotic layer stretched and thinned. The repair of aponeurosis takes place as easily and as permanently at the cut edges as it does in the case of any other tendon, and overlapping is not necessary unless special firmness is desired at the line of union.

The subcutaneous fat, if thick, should be sutured by a loosely placed running suture of plain catgut. The skin should not be pierced by the needle from without inward but always from within outward. The staphylococcus epidermidis albus has its natural habitat in the deeper layers of the corium, and the passage of the needle and thread from the outside is likely to carry this germ to the subjacent tissues, producing infection and stitch abscess. When possible, it is always better to close the wound in the skin by the subcuticular suture. This suture leaves only a linear scar, and no stitch-hole scars. Strips of aseptic adhesive plaster may be used with the subcuticular suture, to lessen the tendency to stretching of the cicatrix.

In old and feeble individuals buried silk or linen sutures, or metallic threads, may be employed; they give increased strength and support to the suture line, and thus enable the patient to get up at an early period.

If drainage is used, the wound should be sutured close up to the drain, and then through-and-through provisional silkworm-gut sutures should be placed, but not tied until after the drain has been removed.

Sutures should not be drawn so tightly as to constrict the tissues, but only to the point of snugly approximating the edges of the wound. All suture knots should be drawn to one side of the line of incision. Sutures should be removed at some time between the seventh and fifteenth days.

Wound hooks or hæmostats, placed at each angle of the wound, hold the edges tense and parallel and away from the abdominal contents, and they prove convenient aids in the suturing.

POST-OPERATIVE SEQUELÆ.

Adhesions.—It may be stated broadly that local infection is the most potent cause of intraperitoneal adhesions following abdominal operations, and this result is more likely to take place when drainage, often necessary in septic cases, is employed. Drainage alone, without the presence of infection, produces adhesions through the irritation which the drain sets up in adjacent organs. These

adhesions, however, may disappear after the lapse of a moderate length of time. Wherever there are large areas throughout which the peritoneum has been destroyed, we may expect that dense adhesions will form, unless by means of sutures or by the utilization of omental grafts, obliteration of such areas can be effected. But there are certain conditions—conditions that are inseparably connected with the surgical technique—which favor the formation of adhesions. Among such favoring circumstances may be mentioned: prolonged exposure of the peritoneum to the effect of the air, rough handling or sponging, and the contact with irritating fluids. Consequently, the operator who is careful in his methods and yet at the same time expeditious, is less apt to have troublesome post-operative adhesions.

There have been suggested a number of measures which, it was believed, would prevent intraperitoneal adhesions, but none of them has met with the success hoped for. For example, the plan of covering all denuded peritoneal surfaces with Cargile membrane, a sterile absorbable animal tissue prepared from the peritoneum of the ox, seemed to be bright with promise; but the limited trial to which it has been subjected has not proved encouraging. In both the animal and the human abdomen Cargile membrane has been found to act as a foreign body, becoming enveloped in omental adhesions and producing the very conditions which it was intended to obviate. The employment of sterile oil, poured into the peritoneal cavity before the wound was closed, has been used for the purpose of counteracting adhesions, and the recent investigation of Dr. John B. Blake, of Boston, seems to offer encouragement along this line. Blake's conclusions were, that the presence of oil in the peritoneal sac is innocuous; that it remains in the peritoneum as long as fifteen days; that its presence tends to prevent early and direct adhesions of denuded and inflamed peritoneal surfaces; and, therefore, that it may be considered as moderately effective in preventing, or, at any rate, diminishing, post-operative adhesions.

The plan of introducing decinormal salt solution, or salt solution with adrenalin (Marvel), into the peritoneal cavity has not yet been tried sufficiently to warrant definite conclusions.

The stimulation of intestinal peristalsis by the internal administration of salines, and especially the plan of stimulating the outpour of peritoneal serum by the injection of large quantities of fluid into the intestinal canal by way of the rectum, are measures which may be used to advantage after operation.

Hernia.—One of the most distressing sequelæ of abdominal section is ventral hernia, and there is no technique that will positively prevent weakening of the parietes and subsequent visceral protrusion at the line of incision. Certain facts, however, have been definitely ascertained with regard to post-operative hernia, and through a knowledge of these the surgeon is now able largely to control this danger. In the first place, it is known that hernia more frequently results after incisions in the lower than after incisions in the upper part of the wall, and more frequently after incisions in the anterior than after those in the posterior and lateral aspects of the abdomen; and that an incision through the linea alba is rarely followed by hernia if it be accurately sutured and if primary healing

takes place. Fritsch states that if the incision is prolonged down to the symphysis and is permitted to divide the loose prevesical tissue, the intra-abdominal pressure against the cicatrix in this low position is frequently followed by the development of a hernia. Furthermore, long incisions are more apt than short ones to develop hernia, and yet a hernia may occur through a very short incision. Hernia may follow both transverse and oblique cuts through the oblique muscles, and it even occasionally occurs where the muscular fibres are bluntly separated along the cleavage line and afterward sutured. On the other hand, similar incisions of the rectus muscle usually heal solidly without subsequent disturbance. These results may be correctly ascribed to division of motor nerves, causing muscle atrophy and a scar which yields to intra-abdominal pressure; all of which facts have been satisfactorily demonstrated by the experiments and clinical observations made by Asmy.

Another fruitful cause of hernia is found in improper suturing of the wound. Carelessly and imperfectly placed sutures, by any method of closure, may lead to hernia, but a number of observers have shown that hernia follows closure of the wound by a single row of sutures twice as often as when suture by layers is used (or in the proportion of twenty to thirty per cent as compared with eight to nine per cent). And this percentage represents strictly aseptic union.

A drained wound directly predisposes to hernia. When this event occurs before healing is complete, an attempt should be made to close the wound by secondary suture as soon as active inflammation subsides.

In all cases, after an abdominal section, a suitable abdominal support should be worn for several weeks; and a period of several months should be allowed to pass, if possible, before heavy or straining duties are resumed. It is probable, however, that the average aseptic abdominal scar is able to withstand the ordinary habits of life after a lapse of from six to eight weeks.

PRELIMINARY TREATMENT.

Examination of the Patient.—Every patient, before he or she is subjected to an abdominal section, should be examined in a thorough and deliberate manner. The existence of albumin and casts is to be regarded as a serious matter; and, in the presence of renal changes, an elective operation should be postponed until full time has been given to bettering the condition. It has been amply demonstrated that minor kidney changes—that is, a small percentage of albumin and a few hyaline casts—exist in a large proportion of all abdominal cases, and do not contra-indicate operation; further, that such conditions are often caused by the existing lesion, and may even constitute an important indication for operation. (Kelly.) In advanced nephritis, with persistent albuminuria and epithelial casts, and especially if associated with vascular and cardiac changes (high arterial tension and cardiac hypertrophy), no serious operation should be undertaken unless imperatively called for. Again, a small quantity of al-

bumin and a few casts become of greater significance if there is a marked lessening of the urea output. The presence of pus in appreciable amount should be regarded with suspicion and closely investigated. Sugar in small quantities may be ignored; but true diabetes constitutes a positive contra-indication to a major abdominal operation. In seventy cases with saccharine urine operated upon by Noble, there was a mortality of from twenty-four to twenty-eight per cent. These facts summarized indicate that, where an anæsthetic is skilfully administered in renal disease, the danger of uræmia is not great, but that in diabetes the risk of coma is great.

The lowered vitality of these patients produces an increased tendency to shock, which the surgeon should reduce to a minimum by rapid work, by the avoidance of exposure of the viscera, by the application of bodily heat, and by submammary and colonic injections of normal salt solution.

Cardiac lesion should not deter the surgeon from operating unless there is pronounced dilatation with inadequate compensation. But in all these cases the heart muscle should be toned up by digitalis, strychnia, and strophanthus, combined with rest in bed, for some time before surgical intervention. Care should be exercised to avoid overstimulation of the heart both before and after operation.

Acute pulmonary disease is a contra-indication to the administration of an anæsthetic and to operation: but tuberculosis of the lungs may call for operation to enable the sufferer to enjoy the benefits of out-door life otherwise not attainable.

The condition of the blood requires due consideration. A transient leukæmia not infrequently constitutes an indication for operation; but a permanent leukæmic state positively forbids it. Anæmic subjects are always bad operative cases, and should receive appropriate preliminary treatment for improving the blood. Some surgeons advise against the administration of an anæsthetic when the hæmoglobin percentage is below thirty; but, in certain cases of sepsis, uterine tumor, etc., an abdominal section may be demanded even when there is a much lower registration of hæmoglobin.

In all of these conditions a great deal depends upon the anæsthetizer, and the patient should be entrusted only to one skilled in such administration.

Preparation of the Patient.—Every abdominal section should be performed in a well-equipped hospital, and, when possible, every patient upon whom it is performed should receive adequate preparation for the operation. In cases of extreme urgency—such, for example, as intra-abdominal hemorrhage, intestinal perforation, acute ileus, or appendicitis—no time should be wasted in preparation, but an immediate section should be made.

In former years no abdominal section was considered justifiable unless the patient had been given a preliminary treatment for several weeks. Now we appreciate that ordinarily this is not necessary, and that the individual condition of the patient is the proper index to the character of preparatory treatment to be instituted. Too long and too rigid dieting, together with hypercatharsis and the mental anxiety which comes with days of waiting and

anticipation, weakens the digestive and intestinal functions, begets apprehension, and defeats the purpose in view.

In emaciated, ill-nourished, overworked, and chronically ill persons, and in the feeble and aged, the preparatory treatment should, when advisable, cover a period of several weeks, and should comprise rest, nutritious food, and tonic medication. These patients manifest, also, a greater susceptibility to bacterial invasion, shock, and exhaustion, and their physical resistance should be brought up to the best possible state preliminary to operation. The very opposite condition obtains in nervous or excitable individuals, upon whom the apprehension, disturbed sleep, and other nervous disorders incident to a long preparation, are positively harmful. These subjects should be operated upon with the least delay.

In uncomplicated cases, where the patient is in good general health, the average time of preparation need not exceed three or four days; and sometimes a period of twenty-four hours is sufficient. This preparation consists principally in stimulating the secretions, and particularly in giving attention to the alimentary tract. Many of these patients, more especially women suffering from some long-standing disorder, are chronically constipated. The colon is packed with decomposing fecal masses which produce a condition of stercoræmia, and the evil is augmented by feeble peristaltic action, often associated with gaseous distention, which may even cause such extreme tympany as to forbid operation. Consequently, the bowels should be freely evacuated and regulated, but excessive catharsis is irritational and should be scrupulously avoided. A good plan of procedure is to administer, nightly, a pill composed of strychnine, aloin, and podophyllin, and to follow it in the morning by salines and copious colon flushings; and this plan should be pursued for several successive days until the intestinal inertia is largely overcome. From twelve to eighteen hours before operation a full dose of castor oil or of sulphate of magnesia should be administered, and on the morning of the day of the operation it is well to give in addition an enema composed of plain soap suds and turpentine, when not contra-indicated.

The diet should be restricted for several days to light meats, non-starchy vegetables, eggs, toast, and stale bread, and this régime may be allowed up to the evening preceding the operation. A few ounces of broth or clear soup should be given early the next morning. A liquid diet, so often employed, increases gas formation, and is not to be recommended.

The kidney function must be kept active by copious draughts of pure water, which lessens the dangerous complication of urinary suppression so frequent after the administration of an anæsthetic, and diminishes post-operative thirst.

The skin stands next in importance, and should be stimulated by baths and friction, in order that its eliminative action may be increased.

Mouth antisepsis is important, and especially so in operations involving the stomach and upper intestines. Moynihan states that focal septic conditions may be practically eliminated by the adoption of these measures, combined with a diet of sterile food and repeated gastric lavage, during a period of several days.

Disinfection of the Abdomen.—The surface of the abdomen is to be rendered as sterile as possible, but elaborate methods consisting of soap poultices, moist bichloride compresses, and like measures are unnecessary, and may so irritate the skin as to increase the danger of a septic surface.

Early in the evening of the day preceding the operation the patient is given a tub bath and the first preparation of the abdomen is made. This consists in shaving the entire abdomen well up to the ribs above and including the pubis below; scrubbing the skin with hot water and green soap, the water being changed several times; and paying especial attention to the umbilicus, pubic eminence, and inguinal creases. The abdomen is then mopped with alcohol, next with a bichloride solution (1 : 1,000), then dried, and finally covered with a plain dry sterile gauze and cotton protective pad and bandage. The scrubbing should be made with gauze sponges and not with a stiff brush, which irritates and roughens the skin. At the same time the vagina is cleansed and douched with a bichloride solution (1 : 5,000), and lightly packed with gauze. This preparation produces a sense of comfort and does not interfere with a restful night, which is of paramount importance. The same steps are repeated on the following morning. After the patient is on the operating table a third preparation is made, as follows: First, scrubbing with sponge, soap, and water; then mopping with sulphuric ether or with benzin, and afterward with alcohol and then with bichloride solution (1 : 1,000), and finally with sterile salt solution. Where the sterilization is doubtful, it is well to apply a coat of tincture of iodine to the navel, and also to the abdomen along the incision line. The iodine is subsequently washed off with alcohol. The umbilicus may be covered, also, with a collodion seal.

The patient is catheterized, or better still, allowed to void the urine, just before the operation. The wearing of a sterile canton flannel gown and leggings is a protection which should always be provided for the feeble, aged, and very young. In weak and exhausted patients, a subcutaneous, or intravenous, injection of a litre of normal salt solution may be necessary.

A hypodermic injection of morphia ($\frac{1}{8}$ to $\frac{1}{6}$ grain) and atropia ($\frac{1}{100}$ grain) a half-hour before commencing the inhalation of the ether, controls the mucous secretions from the pharynx and respiratory passages, hastens the effect of the anæsthetic, and quiets an exceedingly nervous patient.

THE ACTUAL OPERATION.

Operative Technique (Figs. 59 and 60).—With the final preparation of the field of operation completed, and the patient on the table, either prone or in the elevated pelvis position, as the nature of the operation requires, and properly protected by sterile sheets and towels, the surgeon steadies the abdominal wall with the thumb and fingers of one hand and with a medium-sized scalpel divides the skin and underlying tissues vertically, or otherwise, as required, by one bold stroke, down to the aponeurosis. If the fatty areolar layer is very thick it is better to incise it by a succession of cuts. Many surgeons now protect the

edges of the skin by some modification of Tuerck's rubber dam—which has been previously slit to correspond with the cutaneous incision—or by several thicknesses of sterile gauze. This is folded over the edges of the skin and secured on each side (as suggested by Hirst) by two or three Michel's metal skin clamps, which hold the rubber securely in place. The principle of protecting the other tissues against the incised skin is important, and should be generally adopted. In this way the white bacillus that makes its home

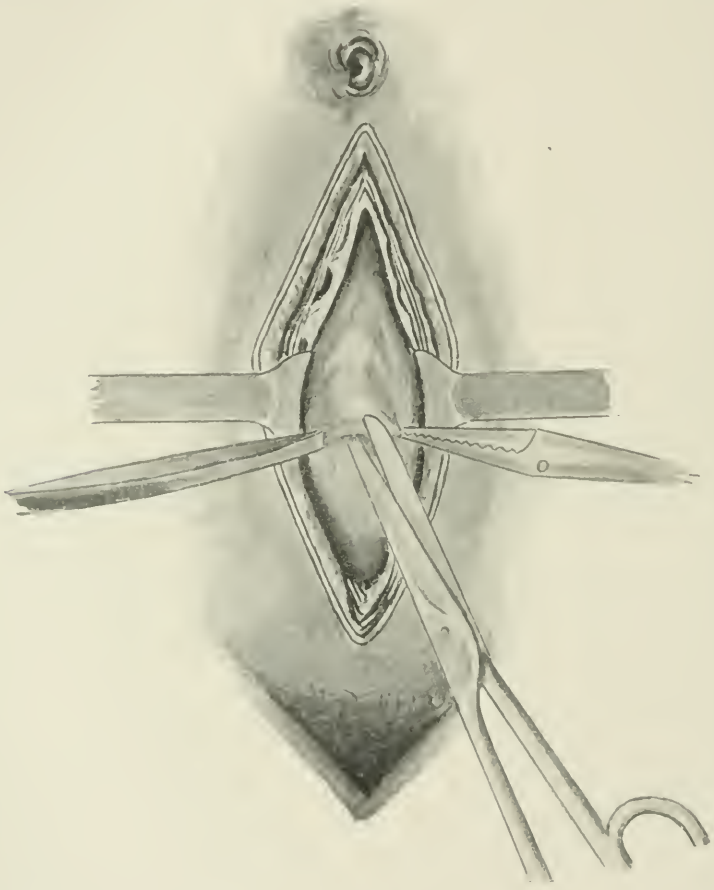


Fig. 59.—Median Abdominal Section. All the tissues have been divided down to the peritoneum, which is being opened with scissors.

in the skin is prevented from infecting either the subjacent tissues or the extruded intestines. If the incision is made in the median line, the aponeurosis is divided; but, if the incision is made on one side of the median line, the sheath of the rectus is divided instead, and the muscle is then split in its cleavage line by the handle of the scalpel or by the index fingers. In both cases the division is done with a second knife. All clamped vessels are now ligated with fine chromicized catgut, which is safer than to depend upon forcipressure and crushing. The subperitoneal layer is next cut, and then the peritoneum is caught and lifted by two dissecting or clamp forceps and in-

cised between them. This short peritoneal cut permits the introduction of one or two fingers into the cavity, and, upon these as a guide, the opening is enlarged to the full length of the incision in the skin, with which also the cut that divides all the layers should correspond. The cut edges of the peritoneum are grasped on each side with forceps, which prevent it from being pushed off from its attachments during the subsequent manipulation, and also facilitate the placing of the sutures later. Due care is observed to avoid opening the prevesical space or wounding the bladder. If it becomes necessary to prolong the incision, this is done with curved scissors or with a knife.

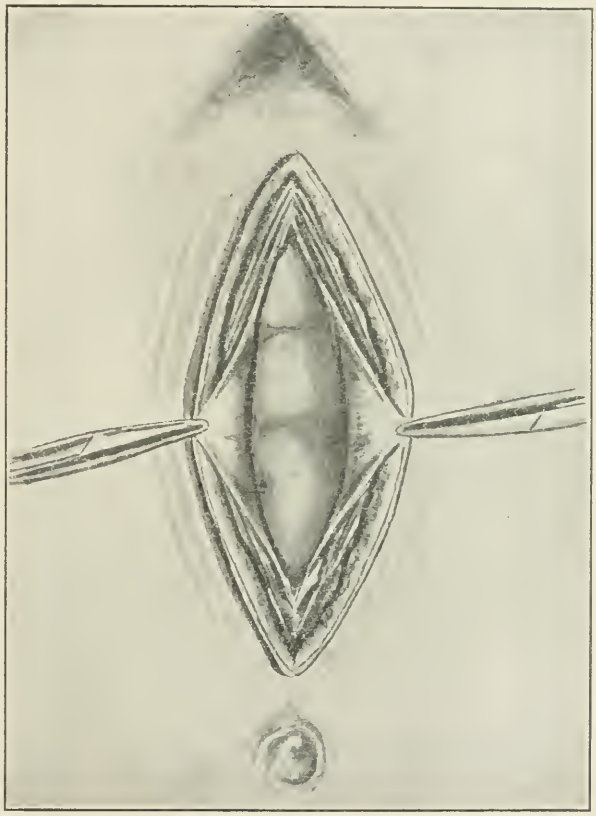


Fig. 60.—Median Abdominal Section. The peritoneum divided and the cut edges grasped with clamps.

The edges of the wound are now widely retracted, and the operator is ready to proceed with the operation which he has in view. The exposed viscera are protected by large flat gauze swabs moistened with hot normal salt solution, which are preferable to dry ones as being less likely to irritate the delicate peritoneum. The same technical steps, modified as needed, are carried out when the belly of the muscle is displaced or when intramuscular separation is the procedure adopted. When the operator is ready to close the incision, the edges of the wound are carefully cleansed of blood clots and other contamination, with sterile salt solution, and the underlying viscera are protected by a moist flat sponge or gauze pad placed within the cavity. Just before the last few peritoneal stitches are tightened this sponge or pad is removed, and at the same time the air is forced out by pressing on each side of the abdomen. The angles of the wound are now rendered taut by hooks or snap forceps, the tenseness of the tissues facilitating the introduction of the sutures, and the retracted fascia is pulled forward by clamp forceps.

The layer method of closure is always to be used when possible. The first suture, which is applied to the edges of the peritoneum, is a continuous overlap or chain stitch, of fine chromicized catgut. The second one is either an interrupted, a continuous, a mattress, or a figure-of-eight suture, of fine chromi-

cized catgut, doubled. It includes the subperitoneal tissue, the transversalis fascia, the sheath of the rectus, and possibly the intervening muscular tissue. Next comes a continuous plain catgut suture which is passed through the subcutaneous fat and which is intended to obliterate dead spaces. The last suture to be applied, one of plain catgut, passes through the subcuticular tissues. If the incision is a long one, the suture line is strengthened by two or three through-and-through interrupted silkworm-gut sutures passed down to the peritoneum; and, if drainage is employed, one or two provisional silkworm-gut sutures are inserted through the entire thickness of the walls, ready for tightening when the drain is removed.

Fig. 61.—Abdominal Binder with Perineal Straps.

Dressing the Wound.—After the wound has been closed it is carefully cleansed first with sterile water and then with a bichloride solution (1 : 1,000) or with sterilized alcohol, and finally dried. It is then covered with several squares of plain sterile gauze which extend well beyond the limits of the incision. These squares are held in place by broad strips of adhesive plaster, which also afford support and rest to the wound. Over this an abundant thickness of sterilized cotton, or a cotton and gauze pad, is laid; and the whole is held in place by a bandage consisting of the ordinary abdominal binder of canton flannel with perineal straps (Fig. 61), or by the Scultetus bandage of the same material, with the strips snugly stitched down. When these wrappings become soiled a fresh bandage is promptly applied; but, if the progress of the case is uneventful, the dressing need not be removed before the eighth or tenth day; and the sutures, if non-absorbable, may be allowed to remain undisturbed until the twelfth or fifteenth day.

Halsted and others apply next to the wound a leaf of silver foil, which acts as a protective and mildly antiseptic covering, but seems to offer no special advantage. The same statement applies to the various dusting powders of boric acid, aristol, subiodide of bismuth, etc. The so-called cocoon dressing, consisting of one or several layers of gauze pasted down with sterilized collodion, furnishes a valuable occlusive dressing, and is especially adapted to short incisions. Several layers of cotton batting are placed over this, and the whole is held in position by the usual outside bandage for abdominal support. All dressings can usually be dispensed with after the second or third week.

In persons with fat and flabby abdomens, in whom the lateral drag is positive, the abdomen should be supported by adhesive plaster and a suitable bandage for five or six weeks. This abdominal support should also be employed in cases in which a long incision has been made, and in which muscular bellies have been cut across and sutured. Post-operative abdominal support for a period of several months is not usually required; it is found necessary only in very obese women.

POST-OPERATIVE CARE.

General Considerations.—In the majority of cases, after a properly conducted aseptic abdominal section, the post-operative course is uneventful, and the patient requires simply to be let alone and allowed to recover. Every patient, with few exceptions, suffers from certain discomforts following etherization and operation, and these are sufficiently met by bodily and mental rest. This statement, however, is not intended to convey the idea that the patient should be confined rigidly to one position; on the contrary, he or she should be permitted a reasonable degree of latitude as regards bodily movements and change of position. Such movement relieves pressure, affords rest to groups of muscles, lessens nervous irritability, and, by bringing the different respiratory muscles into action, helps more especially to quicken the circulation in the finer radicles of the lungs and to clear out the smaller bronchioles. With this idea in view, Mikulicz insists that his abdominal cases shall take from ten to twenty deep inspirations daily, as a preventive against pneumonia.

Position in Bed.—When first removed from the operating table the patient should be placed on the back in a bed which has been sufficiently warmed and otherwise properly prepared, with the knees slightly flexed over a bolster. In this position the patient is allowed to remain for an hour or two until the immediate effects of the anæsthetic have somewhat subsided. The patient is then propped up to a half-sitting posture by pillows, by elevation of the head of the bed, or by similar means, and the maintenance of this position is continued for several days. This posture favors intestinal peristalsis, lessens nausea and vomiting, facilitates peritoneal drainage toward the pelvis, gives greater control over the respiratory muscles, and, consequently, diminishes the danger of post-operative pneumonia and pulmonary hypostasis, which are so much feared in the feeble and aged.

Shock.—Shock differs in degree with the severity of the abdominal operation, and its treatment also varies with the intensity of the depression. The application of warmth to the surface, perfect rest, elevation of the extremities, and rectal injections of hot saline solution to which whiskey has been added, usually suffice to restore circulatory equilibrium in slight degrees of shock. In severe cases these measures should be supplemented by the hypodermatic use of strychnine, camphorated oil, adrenalin, and atropia, and, more especially, by submammary hypodermoclysis, or by intravenous infusion of normal salt solution in sufficient quantity.

Nausea and Vomiting.—The nausea and vomiting that follow the administration of an anæsthetic in abdominal operations vary to a wide extent, being influenced by the amount of handling of the viscera, the duration of the operation, the degree of infection that has taken place, the amount of intestinal distention present, the manner of administering the anæsthetic, and the temperament of the patient. In aseptic cases, however, the agent which is more at fault than all the others is the anæsthetic, and, as a broad statement, it may be said: the less ether

the less nausea. This effect largely results from the ether-laden mucus that is swallowed, and, as a rule, as soon as the stomach empties itself of this irritant the nausea quickly ceases. It is a good plan, therefore, to wash out the stomach while the patient is still in the operating room, or, what is equally efficient, to allow the ingestion of a tumblerful of water as soon as consciousness is sufficiently regained; for, in most cases, this is promptly rejected and brings with it the irritating gastric contents. The usually short period of vomiting and coughing after the anæsthesia serves the additional purpose of causing deep respiratory efforts, which thus dislodge the accumulated mucus in the deep bronchial recesses, and thereby lessen the tendency to lung complications.

In these mild degrees of vomiting no treatment is necessary beyond rest for the stomach and otherwise general quietude. Drug treatment has but little effect, and often does harm. When vomiting persists for more than a few hours, it is usually dependent upon intestinal conditions, and these are in most cases promptly remedied by free bowel movement and by placing the patient in the Fowler position, which favors intestinal drainage. Where the vomiting results from reversed peristalsis, in either aseptic or septic intestinal paresis or in acute gastric dilatation, repeated lavage of the stomach is our chief resource and the one upon which we can depend with the greatest confidence.

Hysterical vomiting, which is occasionally encountered (it is said to occur in about one per cent of abdominal sections) may be so intense and persistent as to result in serious exhaustion and even fatal collapse. This is best overcome by full doses of morphia given subcutaneously; and at the same time careful attention should be given to the wound, so as to eliminate any possible source of reflex irritation which may exist there.

Pain and Restlessness.—For the first day or two after an abdominal section there is naturally a moderate degree of pain, but in uncomplicated cases this is not specially severe, and the patient should be urged to bear it without the aid of any of the pain-relieving drugs. Abdominal pains or tormina are usually caused by the accumulation of gas in the intestines, and they are often relieved by enema which causes the gas to escape. Pain in the back, so frequently complained of, is the result partly of the ether and partly of the muscular strain experienced by the patient while on the operating table; and change of position from side to side, with rubbing, is often sufficient to render it tolerable. If these simple measures are not sufficient, then moderate doses of aspirin (eight or ten grains), or of some similar non-depressing analgesic, will usually alleviate the pain. In other cases where intense nervousness is a decided feature, the use of opium in some form becomes imperative. Opium and its derivatives mask important symptoms, diminish intestinal peristalsis, and increase distention of the bowels, and therefore they should be avoided except in urgent cases. Under such circumstances a single dose of half a grain of phosphate of codeine, or from one-eighth to one-fourth grain of sulphate of morphia, may be given hypodermatically, but the dose should not be repeated unless urgently required.

Sleeplessness and restlessness are usual for the first night or two, and they

generally subside with a free bowel movement and the resumption of food. A full dose of one of the bromides, either alone or combined with chloral, and administered by the bowel, is often adequate to secure the needed sleep and nerve rest.

Thirst.—Thirst is one of the most distressing effects of the administration of an anæsthetic, and should be satisfied by liberal potations of water as soon as the stomach will tolerate it. Excessive thirst, however, will be materially lessened if the patient has drunk freely of water for several days prior to operation. Thirst, furthermore, is greatly diminished by the colon enemas of decinormal salt solution, which are now universally employed after abdominal section. The enemas should be commenced before the patient regains consciousness, and should be repeated every four to six hours for the first day or two, in quantities of from eight to sixteen ounces or more. The drop method should be employed for the purpose. In this method the flow of water is so regulated that absorption by the intestinal mucosa takes place about as fast as the fluid is delivered. A stop-cock device easily accomplishes this, the water being delivered, as shown by Dr. Bristowe, at the rate of about ninety drops to the minute.

Water, either hot or cold, plain or acidulated with lemon juice, should be given to drink in ample quantities, as soon as the stomach will retain it. The first cupful will probably be rejected in a few minutes. It serves to wash out the stomach. But after this it is usually retained and greatly enhances the patient's comfort. The early ingestion of water, together with the use of enemas of salt solution, fills the blood-vessels, increases peritoneal drainage, and hastens the return of both the bowel and the kidney functions to a normal standard.

Intestinal Distention.—Meteorism to a moderate extent occurs ordinarily after the operation of opening the abdomen, and, if the patient has been properly prepared and the operation aseptically performed, this symptom is of little moment beyond the pain and discomfort which it occasions. In these simple cases an enema composed of turpentine, glycerin, and salt solution, or one composed of these ingredients with asafetida added, is usually sufficient to expel the gas and quiet the pain. The procedure may be repeated, if necessary.

When the distention, however, develops rapidly and is excessive, this symptom gives occasion for serious anxiety, and often requires most active measures for its relief. Septic paralysis of the bowel, and non-septic intestinal paresis due to visceral exposure and handling, are the most frequent causes. In these conditions the expulsion of flatus is of more consequence than the passage of fecal matter, and prompt efforts should be made to re-establish peristalsis and secure evacuation of the bowels. To this end stimulating enemas of asafetida, turpentine, glycerin, Epsom salts, and castor oil, either alone or in combination, and also the use of the retained rectal tube, are the measures to be chiefly relied upon. A strong alum-water enema, an ounce to the pint, is often efficient when other measures fail. Gerster recommends with confidence the employment of a continuous enema—that is, an enema in which the fluid is delivered high up in the bowel and is kept flowing in as fast as it is expelled, the tube in the rectum not being removed. Peristalsis is further stimulated by

calomel given in one-grain doses every hour or two, and by hypodermic injections of sulphate of eserine ($\frac{1}{60}$ to $\frac{1}{30}$ grain), together with small quantities of ergot, strychnine, and atropine, to act upon the unstriped muscular fibres of the intestine. Gastric lavage is of decided benefit. If these measures prove ineffectual, and there is reason to suspect intestinal obstruction, the wound should be opened without further delay and the obstructing cause sought for and removed;—that is, if the condition of the patient will admit of such intervention. Where no mechanical cause is found to exist, an enterotomy should be performed and the bowel evacuated of its contents. This may necessitate the adoption of Monk's method—making multiple openings in the intestine, draining several loops of the intestine successively until they are sufficiently emptied, and then closing the incisions by suture. In septic cases this may be supplemented by lavage of the intestine with saline solution through the enterotomy incisions, as also advised by Monk and others. Under some circumstances it may be advisable, after the intestine has been opened, to attach it to the abdominal wall, for continued drainage.

Acute dilatation of the stomach may simulate acute intestinal tympany, but this condition is recognized by failure to secure relief notwithstanding the free discharge of flatus and bowel contents. In a case of this nature, repeated gastric lavage is our chief reliance, and it proves to be often brilliantly effective.

Bladder and Kidneys.—The patient should be urged to evacuate the bladder voluntarily, and the catheter should not be passed until all other measures have been tried. Retention is not apt to take place if the first urine excreted after operation is voided without the aid of a catheter. If, however, overflow occurs —which condition is often associated with frequent micturition of small quantities—retention probably exists, and the catheter must then be resorted to. Incomplete evacuation of the bladder is the initial step toward overdistention of the viscus, and this condition is a most positive cause of vesical paralysis and its frequent sequel—microbic invasion. Consequently, in the use of the catheter more than ordinary care should be taken to prevent infection.

Decrease in urinary excretion is of common occurrence after operation, and even urinary suppression is by no means infrequent. These conditions should be combated by repeated injections of normal salt solution, both into the bowel and subcutaneously, by sweating, by the application of dry cups over the kidneys, and by the administration of diuretics, especially theocin, and sparteine sulphate in large doses (two or three grains of the latter drug every three or four hours), as advocated by McGuire.

Bowel Movement.—The free passage of flatus and the early occurrence of a movement of the bowels, in a patient upon whom abdominal section has been performed, is always a matter of satisfaction to the surgeon, but there are often unnecessary haste and anxiety to secure these results. If the case is of an uncomplicated nature, and if the patient is doing well, with an abdomen free from distention, the bowels may be left undisturbed until they move spontaneously, or, at any rate, until three or more days have elapsed. Then some mild cathar-

tic, supplemented by an enema of glycerin and water alone—or of glycerin and water with the addition of asafetida—will usually accomplish the purpose.

In cases in which sepsis either exists or is suspected, early catharsis should be secured, and some promptly acting evacuant—such, for example, as calomel, in doses of from one-half to one grain, every hour or two, until several grains have been taken—should be commenced without delay after the operation. The administration of the calomel should be followed by the giving of sulphate of magnesia or of Rochelle salts in suitable quantity, and by stimulating enemas.

The patient's position in bed, with the trunk elevated, as now generally adopted, increases intestinal drainage and hastens the timely action of the bowels.

Nourishment.—Except in cases in which there is much exhaustion it is the custom to withhold food until there is a free downward expulsion of flatus or until the bowels move. After this takes place, it is proper, if the nausea has ceased, to allow concentrated broths, clear soups, egg albumen, and soft solids. If the irritability of the stomach continues, nutrient and stimulating enemata should be utilized. The objection to liquid food is its tendency to increase digestive disturbance, thus producing the formation of gases with intestinal distention. The return to solid food should therefore be made earlier than is now customary. The Fowler position has greatly modified feeding after abdominal operations, and permits an early return to a regular and more varied diet than formerly.

Time of Getting Up.—The average time of detention in bed after abdominal section has been much shortened during the past five years, but is still influenced by the character of the operation, the condition, and the age of the subject. If the incision is small or only of medium length, and if all goes well, the patient may be allowed to get up as early as the eighth or tenth day—the average being about fifteen days; but, if the incision is a long one, and if the operation is of a serious type, it is advisable to prolong the stay in bed through the third week, or, possibly through the fourth week. Boldt has recently urged most strongly the getting up of patients as early as from six to twelve hours after operation, even in septic cases and in major operations, and he claims extravagant advantages for the method. He supports and keeps the wound at rest by encasing the abdomen in broad bands of adhesive plaster, and gets the patient out of bed on the day of the operation, or, at latest, on the following day. The practice is radical and has gained but few advocates, and there is good reason to believe that this practice has been attended with unfortunate complications related to the insecurity of the borders of the wound. However, it is important that elderly persons be gotten up as early as circumstances will permit.

It is well to have the patient wear some form of properly adjusted elastic bandage, as a precautionary measure, for several months after abdominal section, although many surgeons regard such support as of questionable usefulness.

SURGERY OF THE PERICARDIUM, HEART, AND BLOOD-VESSELS.

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I. PERICARDIUM AND HEART.

Anatomical Considerations.

The structures which interest the surgeon who contemplates an intervention on the heart or pericardium, may be arranged, according to Terrier and Reymond,* in seven layers:—(1) The skin and subcutaneous tissue; (2) a muscular layer comprising the inner portion of the pectoralis major, the upper extremity of the rectus abdominis, and occasionally the inner edge of the pectoralis minor; (3) the ribs, costal cartilages, sternum, and intercostal structures; (4) the triangularis sterni and internal mammary vessels; (5) the pleural culs-de-sac, the cellular tissue between them (anterior mediastinum), and the insertion of the diaphragm; (6) the pericardium; and (7) the heart.

1 and 2. Layers 1 and 2 require no special comment.

3. The largest portion of this layer is occupied by the second piece of the sternum, which is about 4 cm. broad and from 5 to 7 mm. thick, its posterior face being slightly concave. The upper costal cartilages slant downward and inward, the middle ones are transverse, and the lower pass upward and inward. The length of the costal cartilages grows from above downward. Thus, the length of the first varies from 2 to 3 cm., and that of the seventh, from 12 to 15 cm. A cartilaginous bridge unites the fifth with the sixth, and a similar one the sixth with the seventh costal cartilages. The intercostal spaces diminish in width from above downward and from without inward. The fifth interspace measures, at the border of the sternum, from 2 to 3 mm. in breadth, and, at a point 7 cm. from the sternum, 15 mm. The sixth interspace, at the chondrocostal articulation, measures from 1.5 to 2 cm. in width; from this point it rapidly narrows, and throughout a distance of 9 cm., measured from the sternum, it is filled with cartilage or is represented by a mere slit. As to the intercostal structures, we need call attention only to the absence of the external intercostal muscles in this region and to the course of the intercostal vessels along the superior and inferior borders of the ribs.

4. The internal mammary vessels run downward between the costal cartilages and the triangularis sterni, from 1 to 1.5 cm. from the border of the sternum in

*"Chirurgie du cœur et du péricarde," Paris, 1898.

the three upper interspaces, and from 1 to 2 cm. from the sternum in the fourth, fifth, and sixth interspaces. (Delorme and Mignon.) The triangularis sterni arises from the posterior face of the xiphoid and the lower third of the sternum, and is inserted by digitations into the anterior extremities of the third, fourth, fifth, and sixth costal cartilages, occasionally, however, reaching the second or even the first rib.

5. According to Luschka (Fig. 62) the line of reflection for each pleural cul-de-sac begins above, behind the sternoclavicular articulation; the right line runs obliquely downward and to the left: the left line is almost vertical. At the level of the second costal cartilage these lines meet behind the sternum, at a point where the right two-thirds of the sternum joins the left one-third. From here they descend vertically very close together, being united by tissue which forms a ligament between the sternum and the pericardium, the right pleura lying beneath the right two-thirds of the sternum, and the left beneath the left one-third. On a level with the fourth cartilage the right pleura turns sharply outward, crosses the border of the sternum about 2 cm. above the base of the xiphoid cartilage, and follows the seventh costal cartilage to the osseous extremity of the eighth rib. The left pleura at the fourth costal cartilage leaves the border of the sternum in the fourth interspace and crosses beneath the fifth, sixth, and seventh costal cartilages, so that at a level with the seventh costal cartilage it lies 3.5 cm. from the border of the sternum. The pericardium thus presents two triangular areas uncovered by pleura: the superior lies behind the manubrium, with the apex at the level of the second costal cartilage, and corresponds to the situation of the thymus gland; the inferior is in direct contact with the under surface of the sternum and some of the costal cartilages. The apex of the latter is on a level with the fourth rib, and the base is situated at the upper extremity of the ensiform. For the purpose of obtaining some definite knowledge with regard to the width of this triangle, we made eleven observations on the cadaver. At a level with the fifth costal cartilage the average width was from 4 to 5 cm.; but that the space is very variable in width is shown by the measurements, it being 8 cm. in one case, and 1 cm. in another. In the case with a width of 1 cm., the edge of the left pleura just reached the border of the sternum. In two other cases, in which the widths were 3 and 4 cm., respectively, the left pleura reached nearly to the edge of the sternum. In the remain-

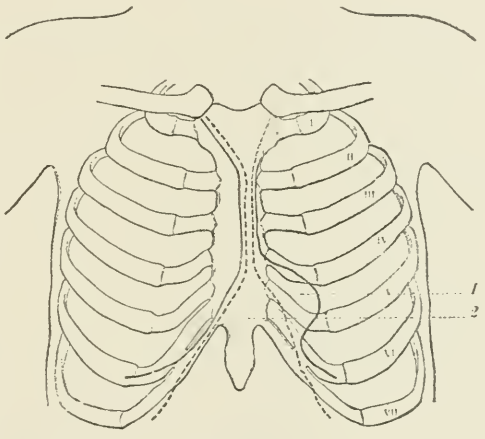

FIG. 62.—Diagram Showing Average Situation of the Pleural Culs-de-Sac and Borders of the Lungs. (1) Cardiac notch of left lung; (2) Inferior interpleural triangle. Heavy line represents outline of lung; dotted line, outline of pleura. (Terrier and Reymond, "Chirurgie du cœur et du péricarde," Paris, 1898.)

ing cases the border of the pleura was located at some distance from the sternum. The right pleura in every instance reached beneath the sternum. It is very rare that the right pleura comes from beneath the sternum above the seventh rib, and the left border of the pleura may not come from beneath the sternum until the sixth rib is reached. Therefore, a wound of the heart to the right of the sternum will almost invariably traverse the pleural cavity, while wounds near the left edge of the sternum may or may not traverse the pleura, according to the disposition of the left border of the pleura in the individual. The only wounds which will not traverse the pleura will be on the left side close to the sternal border and below the fourth interspace.

Borders of the Lungs.—The right lung follows very closely the line of the right pleura, being separated from this reflection a distance of perhaps 1 cm. during quiet breathing, but, on forced inspiration, the lung completely fills the pleural cul-de-sac. The left lung also follows the line of the left pleura to the fourth sternochondral articulation. There it curves outward and returns to join the margins of its cul-de-sac on a level with the sixth cartilage. This cardiac notch in the border of the left lung corresponds to a small portion of the fourth, the internal half of the fifth, and the inner third of the sixth costal cartilage, and the lung terminates below in a tongue-shaped process which overlies the apex of the heart.

The diaphragm arises from the posterior surface of the xiphoid by two fasciculi, and from the last six ribs by a series of processes which interdigitate with those of the transversalis abdominalis. Between the individual xiphoid fasciculi, and also between these fasciculi and the chondral insertion of the diaphragm, there exist spaces which allow the cellular tissue of the thorax to communicate with that of the abdomen. In the second of these spaces—*i.e.*, the space between the xiphoid and chondral insertions,—the peritoneum and pericardium are practically in contact.

6. The line of reflection of the pericardium is irregular and covers the ascending aorta almost to the innominate, the pulmonary artery to its bifurcation, a small part of the vena cava, and the pulmonary veins. It therefore follows that a wound of these vessels can give rise to a hæmopericardium and to compression of the heart. The outline of the pericardium projected on the anterior thoracic wall represents a truncated triangle, the apex of which corresponds to the great vessels of the base of the heart, on a level with the middle of the manubrium. The base of the triangle represents a slightly oblique line running downward and to the left. This line commences 2 cm. to the right of the sternum at the fifth costal cartilage, passes through the base of the xiphoid cartilage, and ends about 8 cm. to the left of the sternum in the fifth interspace, or at about the junction of the sixth costal cartilage with its rib. This base line is about a half a finger's breadth below that of the heart, and the space between these lines forms a cul-de-sac where pathological liquids can collect and where one can penetrate the pericardium without wounding the heart. (Delorme and Mignon.) The two sides of this truncated triangle are slightly convex outward, the right passing upward from the base line, from 1 to 2 cm. to the right of the sternum, to the second

cartilage, where it passes behind the manubrium, while the left terminates above, behind the first chondrosternal articulation. The pericardium in its upper part lies from 3 to 5 cm. behind the sternum; in its lower portion it is not more than 1 cm. distant from the posterior surface of this bone. The left border is in the neighborhood of 6 or 7 cm. from the skin, through which distance an instrument must travel before it can penetrate the sac. Between the left border and the costal cartilages the cul-de-sac of the left pleura and also the border of the lung are found.

7. The projection of the heart on the thorax forms a fairly regular quadrilateral. (Fig. 63.) The superior border is at the level of the second interspace, running from a point 2 cm. to the right to one 2 cm. to the left of the sternum. The inferior border commences on the right side at the sternal articulation of the fifth costal cartilage, slants downward toward the left, being slightly convex below, to end at the apex of the heart, *i.e.*, about 8 cm. from the median line and almost over the chondrocostal articulation of the fifth rib. The right and left borders of the quadrilateral, slightly convex outward, unite the extremities of these two lines. The greater part of the anterior surface of the heart is occupied by the right ventricle; hence the frequency with which it is wounded. The anterior surface of the heart, according to Jamain, may be divided into two regions: (1) that covered by the sternum, which comprises almost the whole of the right ventricle, the right auricle, and a large portion of the left auricle; and (2) the chondrocostal region situated to the left of the sternum. This region, which is narrower than the former and is covered by a section of the third, fourth, and fifth left costal cartilages, contains the point of the right ventricle, the lower half of the interventricular line, all of the left ventricle and part of the left auricle. It may be subdivided into two—the portion which is covered by the lung, comprising the left auricle and ventricle and the left half of the infundibulum, and that which remains free from lung covering, consisting of the apex and the inferior half of the interventricular septum. The interventricular line, in which the anterior coronary vessels are found, corresponds, according to Poirier, to a diagonal which unites the superior right angle to the inferior left angle of the quadrilateral. With reference to the spinal column the heart corresponds with the dorsal vertebræ from the fifth to the eighth inclusive; the left auricle being nearer the spinal column than any other portion of the heart.

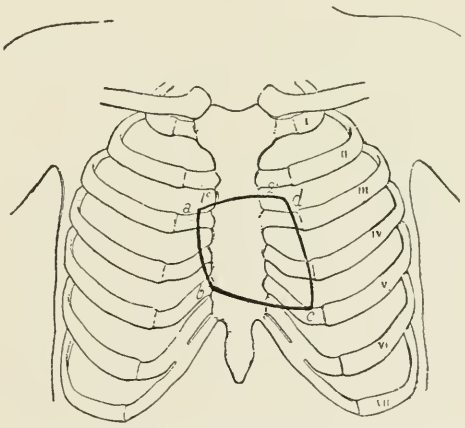

FIG. 63.—Diagram Showing Projection of the Outline of the Heart on the Anterior Thoracic Wall. (Terrier and Reymond, "Chirurgie du cœur et du péricarde," Paris, 1898.)

Finally, we must recall the fact that the position of the heart is normally modified by a change in the position of the body, by ascent and descent of the

diaphragm, and by distention of the stomach, and that it is normally higher in infants and in old age.

Pathological Conditions Modifying the Relations of the Anterior Mediastinum.

Pleural adhesions may pull either cul-de-sac farther away from the median line, thus increasing the space through which the heart may be reached without opening the pleural cavity.

A pleural effusion or a pneumothorax pushes the heart toward the opposite side, and in a double pleural effusion the heart is pushed away from the thoracic wall. The influence of pulmonary lesions (emphysema excepted) upon the interpleural space is slight. Emaciation narrows the anterior mediastinum; in sclerosis it is hidden behind the sternum and presents parallel borders. Abdominal tumors, effusions, and meteorism elevate the diaphragm and consequently the base of the anterior mediastinum. Cardiac hypertrophy widens the space between the pleuræ.

The effect of pericardial effusions on the width of the interpleural triangle has given rise to much discussion and widely divergent opinions. These opinions, we believe, can be reconciled if one takes into consideration the condition of the pleural culs-de-sac. If, for instance, the pleuræ are normal, a large effusion into the pericardium may widen, but to an inappreciable extent, the anterior mediastinum. If the pleural culs-de-sac also are distended with fluid the space may be narrowed. And, finally, if the inflammation has spread from the pericardium to the pleuræ and has obliterated the culs-de-sac, the area through which the surgeon may penetrate without causing pneumothorax is greatly enlarged. Pericardial effusions will produce different effects upon the heart, according to the degree of rapidity with which they take place. A large and rapidly occurring hemorrhage will quickly fill the pericardium, without, however, greatly increasing its capacity; and, when the effusion has attained a bulk of from 200 to 300 c.cm., the pressure will be so great as to stop the heart. In effusions which come on very gradually the pericardial sac will become distended, and it may even reach a capacity of three litres. The position which the heart may occupy in the pericardial sac also will be very variable, depending upon whether or not any adhesions are present which bind it to the pericardium. A number of authors believe that the heart, suspended at its base by the great vessels, stays in its normal position when large collections of fluid are present in the pericardium; others believe that it is pushed back from the sternum; and still others that it is crowded nearer the sternum. Voinitch has shown, in the cadaver, by injections of gelatin into the pericardium, that liquids will collect, particularly about the great vessels at the base of the heart, when the body is recumbent, but that, when the body is in a sitting posture, gravity will draw the fluid to the diaphragmatic surface about the point of the heart. The heart remains in contact with the anterior chest wall at the level of the fifth interspace and is never pushed backward by fluids: for which reason it may readily be wounded by an exploratory needle.

Wounds of the Pericardium.

Wounds of the pericardium without injury to the heart, aside from those produced by the surgeon in performing paracentesis or pericardotomy, are rare. That they do occur, however, has been conclusively proved at autopsies and by exploratory exposure in wounds of the precordium. Fischer collected 51 cases. The pericardium has been punctured by needles, lacerated by the rough ends of fractured ribs, and opened by stab- and gunshot-wounds. Eichel ("System of Surg.," von Bergmann, Bruns, Mikulicz) was able to find 27 cases of simple gunshot-wound of the pericardium in the literature, 4 of which were confirmed by autopsy and 4 by operation. In most instances the pleura also is injured.

Symptoms.—In the absence of hemorrhage and infection, wounds of the pericardium alone cause no serious symptoms. Indeed, it is probable that in a number of instances the diagnosis has not been made, owing to the absence of symptoms. Hæmopericardium may result from injury to the internal mammary or intercostal vessels, or from injury to the lung. In Tassi's case* the sac was filled with blood which came from a vessel of the pericardium itself. The immediate danger of hæmopericardium is not so much from loss of blood, which may, however, be great enough to cause death, but from compression of the heart, the symptoms of which will be detailed on a later page. Blood in the pericardium, as in other serous cavities, may be absorbed without causing any evil consequences, if the amount be not too large, or it may result in embarrassing adhesions, or become infected and give rise to pyopericardium. Infection, with or without the presence of blood in the pericardium, may manifest itself immediately after the injury or not for days or weeks. In one of our cases symptoms of pericarditis with effusion did not arise until after the wound in the pericardium had healed. von Eiselberg reports a case in which a purulent pyopericarditis developed one month after the injury. These late cases bring up the possibility of infection by way of the blood stream. Pneumopericardium has followed a wound involving the lung and pericardium. (Ewald and Happel.)

Diagnosis.—Immediately after the injury the diagnosis may be made, provided free hemorrhage occurs, by signs of increasing fluid in the pericardium and by symptoms of cardiac compression, or—if the external wound is sufficiently large—by direct palpation and perhaps by inspection. At a later period evidences of pericarditis may arise. In the absence of hemorrhage and infection the diagnosis may be impossible.

Prognosis.—Of the 51 cases collected by Fischer 22 recovered. Death is due to hemorrhage, to compression of the heart, or to infection.

Treatment.—Wounds in the precordium, not associated with general symptoms of hemorrhage or with symptoms of compression of the heart, should be disinfected superficially and closed with sutures. The patient should then be kept quiet and carefully watched. In the presence of acute anæmia or hæmopericardium exploration is mandatory. This should be done with the eye

*Terrier et Reymond, "Chirurgie du cœur et du péricarde."

and finger, and not with a probe. The external wound should be enlarged and the ribs and intercostal muscles inspected. Occasionally a knife passes through a costal cartilage without injuring the intercostal structures. If the wound penetrates the thorax it should be enlarged, with or without resection of a rib, according to circumstances, and the pericardium palpated and inspected. If the pericardium is uninjured the bleeding may proceed from the internal mammary or intercostal vessels or from the lung. The former should be ligated and the latter sutured. Two facts should be emphasized in this connection: —First, that the wound in the pericardium may be small and easily overlooked unless a careful search be made; and, secondly, that the heart may be wounded without penetration of the pericardium—an accident to which we shall have occasion to refer when discussing wounds of the heart. If, however, no opening is found in the pericardium and the pericardium is not distended with blood, the exploratory wound should be closed, provided the bleeding has been controlled, or drained if oozing still persists. In most of these cases the pleural cavity will have been injured and a hæmothorax will be present; in which event a second opening for the purpose of drainage should be made into the lower part of the pleural sac posteriorly. Should a wound in the pericardium be found this must be enlarged and the heart inspected. If the heart is not wounded the pericardial sac may be emptied of clots with the finger, dried by gentle mopping with gauze, and closed with a continuous catgut suture. Drainage, we believe, is contra-indicated if the bleeding has been controlled, because of the danger of infection and adhesions. The objects of pericardotomy immediately after the accident are to relieve symptoms of cardiac compression, to control hemorrhage, to remove foreign bodies, and to determine whether or not the heart is injured. In cases which are at first treated expectantly, but in which signs of fluid in the pericardium with embarrassed cardiac action appear after several days, an exploratory puncture should be made. (Page 154.) This, of course, applies also to those cases in which the pericardium has been explored and sutured. If the fluid is serum or blood the needle should be left in place until the flow ceases, and medical treatment for pericarditis instituted. If the fluid is bloody and small in amount, and if the symptoms are not relieved, it is probable that the heart is compressed by clots, which can be removed only by pericardotomy. If the fluid recovered is purulent, incision and drainage of the pericardium is demanded. (Page 156.)

Pericarditis.

Etiology.—Pericarditis following a wound has been referred to in the paragraphs immediately preceding. Contusions are a possible but rare cause of pericarditis. In most instances the condition is secondary to infectious diseases, such as rheumatism, pneumonia, empyema, tuberculosis, and pyæmia or septicæmia. Inflammatory affections in the neighborhood of the pericardium, either in the thorax or in the abdomen, are also responsible for a certain number of cases. Primary pericarditis is exceedingly rare.

Symptoms.—The symptoms are often obscured by the primary affection, and involvement of the pericardium is frequently overlooked. The most important symptoms are cough, fever, dyspnœa, delirium, pain and tenderness over the heart, and pain radiating down the left arm or into the epigastrium. The pulse is small and weak, and occasionally pulsus paradoxus is present. Leucocytosis is generally produced by the disease which the pericarditis complicates, but, with involvement of the pericardium, the degree of leucocytosis is usually much increased. At the onset a friction sound may be heard, but this sound disappears as the sac fills with fluid. The presence of a friction sound, however, does not exclude pericardial effusion. The most important signs of pericardial effusion are the following: increase in the area of precordial dulness, which becomes pear-shaped, with the base downward; bulging of the precordium; faint, distant, or absent cardiac sounds; occasionally aphonia and dysphagia; change in the right border of cardiac dulness, which becomes convex; alteration of the cardio-hepatic angle from a right to an obtuse angle; dulness extending up to the second interspace; absence of the apex beat or displacement of the apex beat above the lower boundary of dulness; dulness in the fifth right interspace close to the sternum (Rotch's sign); flatness, with marked resistance on percussion, over the precordium; an area of dulness with bronchial breathing near the angle of the left scapula (Bamberger's sign); and Ewart's sign, or separation of the first rib from the clavicle to such a degree that the former may be palpated throughout its entire length. The effusion may be demonstrated also by the *x*-ray. If the fluid in the pericardium is pus the fever may become intermittent and œdema of the chest wall may appear. The diagnosis may be confirmed by the introduction of an exploratory needle. The conditions which are most likely to be confused with pericardial effusion are pneumonia, pleural effusions, and dilatation of the heart, for the differential diagnosis of which we must refer the reader to a text-book on internal medicine. In cases in which the pain is referred to the abdomen, gastritis, appendicitis, cholecystitis, perforation of the bowel, and like lesions may be simulated. Only recently we were asked to see a case of pericarditis with the idea of operating for a perforated gastric ulcer.

Treatment.—The treatment of pericarditis falls within the province of the physician, and it is only when the sac becomes so distended with fluid as to cause serious symptoms that surgical intervention is indicated. Since the presence of pus cannot be positively foretold without exploratory puncture, we believe that, in the presence of a pericardial effusion, the sac should first be tapped. If the fluid is serous no further operation is required. If pus is recovered pericardotomy should be performed and drainage established.

Operations on the Pericardium.

History.—According to Terrier and Reymond, Riolan, in 1648, was the first to advise surgical intervention for pericardial effusions. From a theoretical standpoint he suggested trephining the sternum. A century later, in 1749,

Sénac advocated opening the pericardium for hydropericardium. About the same epoch Van Swieten discussed the indications for this operation. Later, Benjamin Bell, Camper, and Arnemann each proposed operative procedures, which no one put into practice, and it was not until 1798 that the first attempt to open the pericardium was made. In this year Desault opened, by an incision between the sixth and seventh ribs, what he believed to be the pericardium, but which proved to be an encysted pleurisy. Larrey, in 1829, published a somewhat similar case. As both Desault's and Larrey's patients died, pericardotomy fell into disrepute, although in neither was the pericardium opened. Romero, of Barcelona, was really the first actually to perform pericardotomy. In 1819 he published three cases operated upon for effusion, two of which were successful. The incision was made between the fifth and sixth ribs of the left side. In 1827 Jowett, and shortly afterward Skoda and Schuh, each reported a case of paracentesis of the pericardium. In 1847 Karanaeff, during an epidemic of scurvy in Cronstadt, treated the bloody extravasations into the pericardium by paracentesis, sometimes obtaining as much as two quarts of fluid, and he secured a few recoveries. From this time on, reports of cases of evacuation of the contents of the pericardium became more frequent. Thus, in 1861, Guenther collected 22 cases, and in 1876 Roberts 41 cases. Recently, Delorme and Mignon * were able to assemble 100 cases, 82 of which were punctures and 18 pericardotomies.

Paracentesis Pericardii.—Indications.—Tapping of the pericardium has been employed for serous, for hemorrhagic, and for purulent effusions.

Serous effusion is the result of inflammatory exudation or of mechanical disturbances of the circulation leading to transudation (hydropericardium). The former, or serous pericarditis, constitutes the chief indication for aspiration, which should be performed early, before the pericardium is greatly thickened and before degenerative changes in the heart occur, thus placing the membrane in the best condition for repair. It must be recalled, however, that pericarditis is generally secondary and that the primary malady greatly influences the prognosis. Chronic serous pericarditis is generally tuberculous, and little but palliation can be expected from paracentesis. Hydropericardium, or dropsy of the pericardium, is merely a symptom of kidney or cardiac disease, generally the former, and corresponds to ascites and hydrothorax, with which conditions it is generally associated. Tapping, therefore, cannot be curative, but may be employed to prolong life and render the patient more comfortable.

Hemorrhagic effusion into the pericardium, apart from wounds, may be caused by rupture of the heart or by bursting of an aneurysm, and is sometimes encountered in scurvy and in the pericarditis associated with tuberculosis, cancer, and Bright's disease. Hæmopericardium arising immediately after a wound demands exploratory pericardotomy and not paracentesis. At a later period tapping may be all that is required, although even then pericardotomy may be necessary to remove clots if the symptoms persist. Traumatic hæmopericardium has already been referred to under Wounds of the Pericardium and will again be discussed in connection with wounds of the heart. Hem-

* Rev. de chir., 1895, pp. 797 and 987; 1896, p. 56.

orrhagic effusions other than those arising from trauma and scurvy generally proceed from maladies which are inevitably fatal; hence the relief afforded by tapping is usually only temporary.

In pyopericardium pericardotomy is mandatory. Puncture should be used, as in pleural empyema, for diagnostic purposes only. The sole exceptions to this rule are certain cases of tuberculous empyema of the pericardium and cases in which the general condition of the patient is so bad that pericardotomy would not be tolerated.

Delorme and Mignon have collected 82 cases of aspiration of the pericardium, with 28 recoveries.

Technique.—Since the character, and indeed even the presence, of the effusion cannot in many instances be determined with certainty from the signs and symptoms alone, the first step is always exploratory puncture. For this purpose an ordinary hypodermic syringe, with a needle one inch and a half long, is the best instrument. Trocars of large calibre, although possessing obvious advantages, are too dangerous. Occlusion of a slender needle with a plug of muscle or other tissue practically never occurs. It is true, however, that pus may be too thick to be evacuated by a slender needle, but seldom will the needle fail to recover a few drops of even such fluid, which is all that is needed for diagnostic purposes. If the fluid is serous or bloody an aspirator may be attached to the needle; if purulent, pericardotomy is required.

The point at which the puncture should be made varies widely, according to different writers. (Fig. 64.) One should select a point at which the needle is least likely to injure the heart, pleura, lung, peritoneum, and internal mammary vessels. It may be stated at once that puncture should never be made at a point where friction sounds are heard or where the sounds of the heart are very distinct. Roteh, Wilson, and others advocate puncture to the right of the sternum. On the left, the operation has been performed in all the intercostal spaces from the third to the seventh both to the inside and to the outside of the internal mammary vessels. Roberts suggests entering the pericardium from below, by puncturing between the left edge of the xiphoid and the costal margin. From our studies in the anatomical relations of the parts beneath the precordium, a résumé of which will be found in the opening paragraphs of this article, we believe that the safest point for puncturing the pericardium is in the fifth interspace, close to the left edge of the sternum. In this position there is the smallest chance of penetrating the pleura, and the internal mammary vessels should lie well to the outer side. If no fluid is withdrawn and there is no evidence of penetration of the heart by motion imparted to the needle, the fourth interspace should be tried. If this also fails to demonstrate fluid, a point in the same inter-

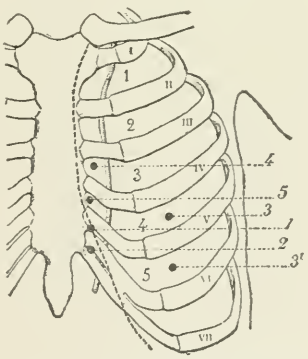

Fig. 64.—Diagram Showing Points (1, 2, 3, 3¹, 4, 5) at which Puncture of the Pericardium has been Advised. (Terrier and Reymond, "Chirurgie du cœur et du péricarde," Paris, 1898.)

space, one and one-half or two inches from the left border of the sternum, should be tried. If septic material is not found, there can be no danger of infecting the pleura even though its cavity be invaded. If pus is present in the pericardium, the overlying pleural layers are almost certain to be adherent; hence the needle may pass through them without infecting the pleural cavity. The needle should be pushed backward and slightly upward, and should be gradually withdrawn as the pericardium empties itself, in order to avoid injury to the heart. The depth to which the needle should be pushed varies with the thickness of the thoracic wall. Fluid has been obtained at depths varying from 2 to 6 cm. ($\frac{4}{5}$ in. to $2\frac{2}{5}$ inches), beyond which latter depth one should not go. We speak of puncture in the fifth interspace. As Voïnitch points out, if one penetrates to a depth of 6 cm. in the sixth interspace the needle would pass through the diaphragm and perhaps enter the liver, stomach, or colon. Terrier advises that the needle be entered cautiously to a depth of 2.5 cm. (one inch); if no fluid is obtained the patient should be raised to the sitting posture, thus permitting the fluid to accumulate in the lower portion of the pericardium.

The injection of a weak solution of iodine after tapping was suggested by Richerand for the treatment of hydropericardium. Aran, in 1855, is said to have treated successfully a case of tuberculous pericarditis in this way. Malle, Moore, and Gooch tried the same procedure without success.

Complications.—A "dry tap" may result from an occluded needle, an incorrect diagnosis, or a too superficial puncture.

Injury of the internal mammary vessels is possible, but has never been reported.

Puncture of the pleura occurs frequently; indeed, in many cases it cannot be avoided. We have already spoken of the innocuity of this accident when the puncture is made with a fine needle.

Injury to the lung is very rare, owing to the cardiac notch and the displacement of the lung by the distended pericardium.

The entrance of air into the pericardium is an extremely rare occurrence and need give no cause for alarm.

Puncture of the heart is probably more frequent than statistics lead one to believe. The right ventricle or the right auricle is the part usually injured. Generally the accident, if produced by a fine needle, causes no ill effects; indeed, in some cases, it has been followed by an amelioration of the symptoms. Occasionally, however, puncture of the heart is followed by death, either immediately or after several hours. In the former instance death is probably due to injury of Kronecker's co-ordination centre. Deaths occurring later are usually due to bleeding into the pericardium. Puncture of the auricle is more dangerous than puncture of the ventricle, puncture of the coronary artery more dangerous than either. At autopsy one may find the pericardium filled with blood and yet be unable to discover the wound in the heart.

Pericardotomy.—Indications.—In chronic serous pericarditis which fails to respond to repeated punctures pericardotomy should be considered, although we believe that it will very rarely be justifiable in such cases. Traumatic

hæmopericardium, with the exception noted above, always demands pericardotomy. In such cases the operation must be fitted to the exigencies of the case and will often be atypical. We shall take occasion to discuss the subject more fully under Wounds of the Heart. Hæmopericardium arising from causes other than trauma will rarely require pericardotomy; in these cases paracentesis is the operation of choice. The chief indication for pericardotomy is purulent effusion. Incision and drainage are as important here as in empyema of the pleura.

Whether or not pericardotomy should be preceded by resection of one or more costal cartilages depends largely on the condition of the patient. If the patient is unable to withstand a general anæsthetic, excision of the costal cartilages is contra-indicated, as such an operation cannot be done without considerable pain, and severe pain is very depressing to the heart. Incisions for exposing and opening the pericardium without resecting a portion of the thoracic wall have been made in the fourth (Hilsmann), fifth (Romero), and sixth (Desault) interspaces, and just below the seventh costal cartilage, the knife entering the mediastinum between the diaphragm and the thoracic wall. (Larrey.) We believe, as we have stated elsewhere, that "the point of election for incision is the fourth left interspace, beginning one inch from the sternal border and extending to the normal position of the apex beat of the heart, about one inch internal to the anterior mammary line. The tissues are infiltrated with Schleich's fluid and the incision is gradually deepened. When the pleura is adherent it cannot be recognized; but, if its cavity is free and if the incision has been carefully deepened, air will rush in as soon as it is penetrated and before the pericardium has been opened. When pus is reached it is allowed to flow out slowly for fear of embarrassing the heart by the sudden relief of pressure. A rubber drainage tube is inserted and an ample dressing of gauze applied. This is sufficient for the time being, and the question of flushing the pericardium or of resecting the costal cartilages may be put off until the physical signs show that the drainage is not good or that the tube is plugged with membranous lymph. Intercostal incision produces no shock. It is the simplest procedure in grave cases; it permits a more extensive operation at a later period if found inefficient; it permits the recognition of non-adherent pleural surfaces before the pericardium is opened; and, in the majority of cases, it will lead to a cure where a recovery is possible from an operative procedure. The question of the recovery of the patient is more dependent upon the cause of the pyopericardium and the pathological lesions present in other portions of the body than upon the choice of an operative procedure."

Resection of a portion of the thoracic wall for exposing the pericardium has been performed in several ways. Trephining the sternum, proposed by Riolan in 1648, and first practised by Malle in 1855, seems to have been abandoned. Ollier was the first to suggest resection of a costal cartilage. His operation, which is shown in Fig. 65, consists in making an incision from the midline of the sternum downward and outward over the fifth costal cartilage for a distance of 6 cm. The cartilage is then denuded, separated from the sternum with a knife,

raised from its bed with forceps, and its outer end severed with forceps. The operation of Delorme and Mignon (Fig. 66) is as follows: A vertical incision is made 1 cm. ($\frac{2}{5}$ in.) from and parallel to the left edge of the sternum. This incision extends from the superior border of the fourth to the inferior border of the seventh cartilage. A transverse incision 2 cm. long runs from each end of this incision toward the patient's left side. This flap is elevated and the fifth and sixth costal cartilages are separately resected, throughout a length of 4 cm., by first severing the sternal attachments, then lifting the cartilage and carefully peeling off the underlying structures, and finally by cutting or fracturing the cartilage near the outer extremity. The intercostal muscles and perichondrium are next incised in the line of the original incision until one exposes the triangularis sterni, which is then separated from the sternum, from below upward, care being taken to keep close to the bone. The finger is next passed under the sternum, at the level of the fifth cartilage, for a distance of 2 or 3 cm., and the cellular tissue covering the pericardium—together with the pleura, which is covered with fat and which should not be exposed, and the internal mammary vessels—is pushed outward. This blunt dissection with the finger is continued from within outward and from below upward until the white pericardium is exposed over the whole extent of the wound. Normally, this manœuvre is facilitated by the loose attachment of the pleura to the pericardium and by the firm connections which exist between the pleura and the triangularis sterni. The pericardium is opened with a knife at its lower part after it has been elevated with forceps, and the incision is then enlarged from below upward with scissors. If more room is needed the fourth costal cartilage may be resected.

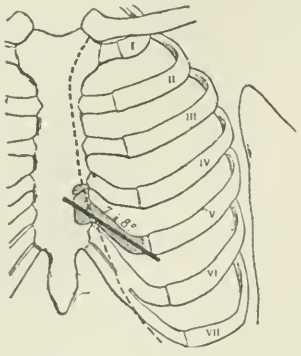

Fig. 65.—Diagram Showing Location of Ollier's Incision for Pericardotomy. (Terrier and Reymond, "Chirurgie du cœur et du péricarde," Paris, 1898.)

Durand's operation is a combination of that of Ollier and that of Delorme and Mignon. After the fifth costal cartilage has been resected, as recommended by Ollier, the internal mammary vessels are ligated at the upper and lower borders of the wound, in order that they may not be wounded during the operation or give rise to secondary hemorrhage by ulceration at a later period. The pleura is then displaced outward as in the Delorme-Mignon operation. When this is impossible, owing to inflammatory adhesions,—and such is frequently the case,—Durand gouges away a portion of the sternum.

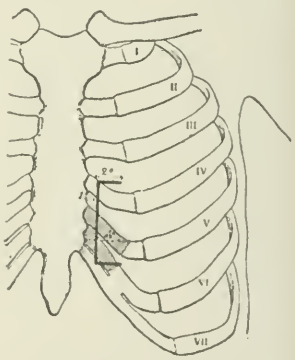

Fig. 66.—Pericardotomy according to Delorme and Mignon. (Terrier and Reymond, "Chirurgie du cœur et du péricarde," Paris, 1898.)

Voïnitch-Sianojentzky, from studies made on the cadaver, recommends three

different operations, according to the amount of fluid present. Inasmuch as the amount of fluid present can rarely be foretold before operation, we believe that it is useless to describe these operations.

If excision of a portion of the thoracic wall becomes necessary, we are inclined to think that the chondroplastic flap suggested by Roberts is better than the removal of one or two costal cartilages. The Roberts operation consists in making a trap-door out of portions of the fourth and fifth costal cartilages, the soft tissues of the third interspace being utilized as a hinge upon which the door may be turned upward. An incision is first made along the left border of the sternum, from the top of the fourth costal cartilage to the upper border of the sixth cartilage; it is then carried outward along the upper border of the sixth cartilage for a distance of 4 or 5 cm.; and finally it is extended vertically upward to the upper border of the fourth rib. With a thick-backed scalpel the fourth and fifth cartilages are divided in the plane of the vertical incisions, the line of section being beveled so as to look forward at an angle of 45 degrees. Care should be taken not to injure the pleura, which is closely attached to the costal cartilages at the outer margin of the flap. After the intercostal structures have been divided in the plane of the skin incision, the chondroplastic flap is raised from below upward, the underlying structures being cautiously separated and the triangularis sterni, which is incised close to the border of the sternum and therefore within the line of the internal mammary vessels, is exposed to view. With a finger the surgeon then pushes the muscle, vessels, and pleura outward, thus exposing the shining white surface of the pericardium. The pleura, which often has considerable fat along its edge, like the appendages of the colon, may not be seen, because it is pushed out of the way without having the overlying fatty tissue separated from it. If it is seen, its transparency or pinkish color will distinguish it from the white and more opaque pericardium. The pericardium is incised vertically or obliquely between the sternal border and the displaced vessels and pleura. The drainage tube is brought to the surface through the fifth intercostal space, and the lower portion of the flap is then properly trimmed and restored to its natural position. The beveled cartilages are sutured with catgut.

Cardiolysis.—Cardiolysis is an operation for liberating an adherent heart. It was first proposed by Brauer, an internist, and was first performed by Peterson and Simon in 1902. As the result of chronic mediastino-pericarditis the heart becomes adherent to the pericardium and the pericardium to the thoracic wall, which consequently is dragged inward with each systole, thus adding enormously to the labors of the heart and causing dyspnœa, ascites, and other symptoms of cardiac insufficiency. The chief signs of this condition are systolic retraction of the intercostal spaces, retractions of the lower lateral and lower posterior portions of the chest (Broadbent's sign), diastolic shock or rebound, absence of respiratory movements in the epigastrium, pulsus paradoxus (Kussmaul's sign), and diastolic collapse of the cervical veins (Friedreich's sign). The object of the operation is, not to destroy the adhesions after pericardotomy—a procedure suggested by Delorme,—but to resect the unyielding structures (bone and

cartilage) of that portion of the thoracic wall to which the heart is adherent, thus rendering the adhesions harmless. Generally, resection of the fourth, fifth, and sixth costal cartilages, with the corresponding ribs as far as the mammillary line, suffices to relieve the symptoms. A portion of the sternum, as in two of Brauer's cases, may be removed if found necessary. At first, great emphasis was laid upon the importance of removing all the periosteum, in order to prevent the regeneration of bone. The removal of the periosteum on the under surface of the rib, however, is difficult and tedious, and may lead to injury of the heart or may cause opening of the pleural cavity. Koenig, therefore, recommends leaving the posterior periosteum; he states that the chances of a regeneration sufficient to cause trouble are slight enough to be disregarded. In support of this view he reports a case in which, at the autopsy two and a half years after the operation, only the finest traces of new bone were in evidence. Cases suitable for operation are not frequent. The heart must still be capable of recovering after being released from its fetters. Marked systolic retraction of the chest wall, indicating a vigorous heart muscle, is an indication for operation. When advanced myocardial changes are present operation is useless. The operation has been done thirteen times and always with beneficial results. In several instances the patients, who had previously been incapacitated, were again able to earn their living.

In this connection we may mention a case of hypertrophy of the heart (Morison, *Lancet*, April 24th, 1907) in which portions of the second and third costal cartilages two inches in length, were resected, in order to give the heart more room and prevent pressure on the surrounding organs. The dyspnœa and dysphagia were relieved.

Wounds of the Heart.

History.—We have drawn the following brief account of the history of cardiac wounds from an article already published by one of us in the *American Journal of the Medical Sciences*, Sept., 1904. In olden times a wound of the heart was considered synonymous with inevitable and immediate death. Elsberg tells us that, prior to the sixteenth century, Hippocrates, Celsus, Paul of Ægina, Roland, and Lanfranc all mention heart wounds, and agree that they are invariably fatal. In the early part of the sixteenth century Fallopius studied the subject, with a view to recognizing the cavity injured, and Jacob Hollerius made the assertion that a wound of the heart was not necessarily fatal. Later in the century, bullets, arrow-heads, and other foreign bodies were found in the hearts of animals which had continued to run for some time after receiving their death wounds, and tales were told of men who, during the intoxication of battle, continued to fight after being stabbed through the heart. Toward the end of the century Ambroise Paré related the oft-quoted case of the Turin gentleman who received a rapier thrust below the left nipple during a duel, and who made several passes and pursued his slayer two hundred paces before falling to the ground a corpse.

In 1642 J. Wolf gave the first reliable account of the healing of a wound of the heart. Morgagni (1761) stated that the cause of death in many cases was compression of the heart by the effused blood, a theory which has since been converted into a fact, mainly by the observations of Rose and the experiments of Cohnheim. It is interesting in this connection to recall the fact that Morgagni died of rupture of the heart.

Sherman says that Desault laid down the rules of pericardotomy for empyema in 1798, and it took surgery ninety-eight years to pass from the pericardium to the epicardium across a space that is such only potentially.

Benjamin Bell (1783) did not believe that healing could occur. A. Richter (1786) considered the probe dangerous, and insisted upon absolute rest and free blood-letting. Larrey and Dupuytren laid down many rules for treatment. During the seventeenth and eighteenth centuries there were published, from time to time, papers which described cases in which protracted periods intervened between the injury and dissolution.

In the beginning of the nineteenth century Jamain, Zanetti, and others wrote on the viability of patients after heart wounds; but it was not until 1867, when George Fischer published his classical study of 452 human cardiac wounds, that a firm foundation was laid for the evolution of the surgery of the heart. Fischer clearly established the fact that an individual might exist for hours or even days with a wounded heart; and that, indeed, in from seven to ten per cent of the cases, the wound heals and the patient actually recovers. Loison and Ollivier collected additional cases and corroborated the findings of Fischer. Ninni states that, according to the statistics of Jamain, Fischer, Lantenelet, and Zanetti, death is instantaneous in eighteen per cent of the cases. In 729 cases collected recently by Fischer,—cases in which no operation was done,—less than sixteen per cent survived.

Up to the closing years of the nineteenth century the treatment of wounds of the heart consisted in the application of an occlusive dressing, absolute rest, ice or blisters to the precordium, and sedatives, such as veratrum viride, digitalis, and opium, and venesection. Rose advised paracentesis of the pericardium, or pericardotomy, to relieve compression of the heart. In 1881 John B. Roberts suggested the propriety of attempting to suture a wound of the heart. Later, Koenig and Delorme voiced the same opinion. The idea, however, was generally regarded as the wildest fancy of ultra-enthusiasts. Billroth declared that no surgeon who wished to preserve the respect of his colleagues would ever attempt to suture a wound of the heart. Riedinger (1884) considered the proposition beneath the dignity of mention. Tillmanns was convinced of the hopelessness of surgery when confronted with a bleeding heart. That the heart could be exposed and manipulated has been demonstrated by many experimenters. In 1894 Kronecker and Schmey discovered that this organ might be punctured with but little interference with its action, except when a spot in the interventricular septum (Kronecker's coördination centre) was touched, when immediate death ensued. In 1895 Rosenthal essayed to treat an experimental wound of the heart by direct means; he used a tampon of iodoform

gauze, and the dog survived. During the same year Del Vecchio was the first to suture the canine heart with success. In 1896 Salomoni, and in 1897 Bode, successfully closed wounds of animal hearts by suture. Since then there have been many experimental investigations into this subject. The conclusions of Elsberg, which may be taken as representative of the findings of the experimenters, are as follows:—That the heart can be grasped with the hands or forceps and gently compressed with no appreciable difference in its action, and that it can be penetrated with a needle and knife without producing more than a temporary irregularity of its action; that penetrating wounds produced during systole bleed more than those produced during diastole; that oblique wounds bleed less than perpendicular wounds; that wounds of the right ventricle are more dangerous than those of the left, because the wall of the right ventricle is thinner, and also because the blood on the right side of the heart coagulates more slowly; that, owing to the thinness of their walls, the auricles bleed more copiously when wounded than the ventricles; that wounds of the heart heal kindly and that the cicatrix is usually complete in about fourteen days; that interrupted sutures are better than continuous ones; that the tissue included in the suture always atrophies and is replaced by scar; that a smaller number of muscular fibres are included in the interrupted than in the continuous suture, thus producing less atrophy and less scar tissue; that superficial sutures are less likely to tear out than deep ones; and that the sutures should be inserted and tied during diastole, because of the danger of their tearing out if tied during systole. According to Guibal, bleeding from the auricles is continuous and steady, not being influenced by the movements of the heart. When one of the ventricles is wounded there is a continuous flow of blood from the cardiac muscle and a systolic jet from the ventricular cavity. Certain experimenters, however, have seen large wounds close during systole and bleed during diastole.

After the road had been paved by the knowledge that patients would often live long enough for operative interference, and that the heart would tolerate manipulation, two unsuccessful attempts were made in 1896 to close human cardiac wounds by suture—one by Farina and one by Cappelen, and in 1897 Rehn published the first successful cardiorrhaphy in man. Including these cases we have been able to find, up to June, 1909, 154 cases with the surprisingly high recovery rate of over forty-six per cent.

Etiology and Pathology.—Aside from spontaneous rupture of the heart, due to disease of the myocardium or coronary artery, neoplasms, gummata, echinococci, abscess, aneurysm, etc., which accident has never been subjected to surgical treatment, cardiac wounds are the result of contusion or are produced by the penetration of the vulnerating body.

In Loison's collection of 49 cases of wounds the result of contusion or of ruptures, the causes were distributed as follows: 13 followed a fall from a height; 7 resulted from the kick of a horse; 5 were caused by a fall on a projecting body; 4 followed a blow from a heavy body on the thorax; 3 were due to a blow from a wagon pole; 3 resulted from a blow from a buffer; 2 were caused by a squeeze between cars; and 1 case should be credited to each of the following causes—

being trampled under the feet of a cow, a blow from a horse's head, a blow from a man's head, a blow from a club, a blow from a fist, and a foot-ball injury.

When the chest is crushed the heart is compressed between the anterior and posterior walls of the thorax, and the blood, which cannot escape rapidly enough by the vessels, distends the walls of the heart, which gives way at the weakest portions, namely the auricles, the laceration sometimes extending into the pulmonary vein or the venæ cavæ. In these cases the chordæ tendineæ, the valves, or the septum of the heart may be torn. More often, however, the cardiac wound corresponds to the point of contusion on the wall of the chest.

Fig. 67.—Stab Wound of Right Ventricle. Heart ceased beating during operation, which was performed by Dr. Gibbon. (Pennsylvania Hospital case.)

A fragment of sternum or rib or a spent ball may push the pericardium inward and wound the heart without tearing the pericardium.

Penetrating Wounds.—According to Loison, 10.3 per cent of the penetrating wounds are needle punctures, 49.3 per cent gunshot wounds, and 40 per cent the result of puncturing and cutting instruments. Of the 154 cases of cardiorrhaphy which we have collected, in 110 the injury was a stab wound, in 21 a gunshot wound, and in 23 the cause was not stated. Excepting ruptures, punctures of the heart by swallowed foreign bodies (mostly needles), and lacerations by spicules of sternum or ribs with an intact skin, all of which are very rare, cardiac wounds are always associated with an external wound. In our collection of 154 cases the external wound was on the left side, between the second and seventh ribs and between the sternum and axillary line, in 104; in

the left midaxillary line in 2; through the sternum in 1; to the right of the sternum in 2; in the upper abdomen in 6; and in 39 the location of the external wound was not stated. In a case of stab wound below the angle of the left scapula reported by Camaggio, autopsy revealed a wound of the heart. (See Fig. 67.)

Complicating Injuries.—Among the complicating injuries wounds of the internal mammary or intercostal vessels are mentioned in several cases. In Loison's statistics injury of the pleura is noted in 45 per cent of the stab wounds, injury of the lung in almost 30 per cent, and injury of the diaphragm in about 12 per cent. Of 110 cases of gunshot wound of the heart there were 78 with injury of the pleura (70 per cent), 52 with injury of the lung (47 per cent), and 12 with perforation of the diaphragm, with or without injury of the abdominal viscera (almost 11 per cent). In our collection of cases the pleura escaped injury in 11 only (less than 8 per cent); injury of the abdominal viscera was mentioned in at least 3 cases.

The Situation of the Cardiac Wound.—The situation of the cardiac wound in our cases was as follows:—Left ventricle 64, with 33 recoveries; right ventricle 65, with 25 recoveries; right auricle 7, with 4 recoveries; left auricle 2, with no recoveries; apex 5, with 2 recoveries; left ventricle with right ventricle 1, with death; right ventricle with right auricle 1, with recovery; left auricle with right ventricle 1, with death; and 8 unknown, with 2 recoveries. The left coronary artery was injured in 4, with 1 recovery; the interventricular septum in 2, both dying; and the tricuspid valve in 1, with death.

Of 77 cases of cardiorrhaphy the wound was non-penetrating in 33, with 16 deaths, and penetrating in 44, with 27 deaths. (Tscherniachowski.) Non-penetrating wounds are never observed in the auricles, owing to the thinness of their walls. In our cases the largest wound was 7 cm. in length; in 19 there were 2 wounds, with 12 recoveries, and in 1 there were 8 wounds, with death.

Foreign Bodies in the Heart.—Guibal * gives an interesting résumé of this subject, and from it we extract the following:—

Needles, according to Loison, caused death in 60.8 per cent of the cases. They are frequently found in the hearts of mammalia, and—a long time after attempts at suicide—in the hearts of lunatics. Huppert found a needle the eye of which was encysted in the wall of the left ventricle, and which passed through the cavity of the ventricle as far as the endocardium of the opposite side. In Peeke-Richard's case, three years after its introduction, the needle, which had been well encysted, caused death by producing an ulceration of a coronary vessel, as the result of the movements of the heart. In Buchanan's case the needle perforated a bronchus and caused death by its infection. When the needle is fixed in the thoracic wall the heart may wound itself at each contraction by hurling itself upon the point of the needle. Larger foreign bodies are sometimes tolerated to an amazing degree. Dupuytren tells of a man who worked all day after having been struck in the chest during a duel. He died the following night, and at the autopsy a fragment of sword five inches long was found piercing the right auricle. Tillaux cites

* Rev. de chir., March, 1905.

the case of an alien who introduced an iron rod, 16 cm. long, in the region of the heart. A year later the autopsy showed that the rod had perforated the anterior border of the left lung and the wall of the ventricles, and had entered the right lung. Picqué reports a case in which a ball was carried in the pericardium for fifty-two years. A number of cases have been observed in which the bullet was lodged in the walls of the heart and there rested for years without giving trouble. Much rarer are the cases in which a foreign body lies free in one of the cavities of the heart. At autopsy on a man who had received a shot wound in the chest two months before, Randall and Huspell found three shots in the cavity of the right ventricle and two in the corresponding auricle. Instead of remaining in the heart such foreign bodies may be projected along the vessels as emboli, either with or against the blood-current. An example of the latter is furnished by Simmonds: a bullet, which had entered the right ventricle, was found at autopsy at the origin of the iliac vein.

Symptoms.—A wound of the heart left to itself causes death or heals spontaneously.

Death occurs immediately or not for minutes, hours, or even days or weeks.

Instantaneous Death.—Instantaneous death, contrary to the general belief of a few years ago, is extremely rare; and its cause is disputed. Injury of the centre of coördination of Kronecker and Schmey, which is situated in the anterior interventricular groove, at the junction of the middle with the inferior third, is said by these investigators to result in immediate death. The existence of the coördination centre of Kronecker and Schmey has been corroborated by Gley and Mills, but Rodet, Nicolas, Elsberg, and others were unable to cause sudden arrest of the heart by punctures or incisions at any point. "Heart block" bas been observed by several experimenters, probably as the result of injury to the bundle of His.

Guibal explains immediate death, in wounds of the heart, by reflex action, the nerve excitation being transmitted from the cardiac nerves to the bulb and thence downward as inhibitory impulses along the pneumogastric. The intracardiac ganglia come from the sympathetic and are afferent in nature, hence incapable of arresting the action of the heart. Instantaneous death is perhaps more likely to follow a severe blow over the heart or epigastrium than a penetrating wound (so-called concussion of the heart).

Cohnheim and others found that ligation of the coronary artery caused sudden death in animals. If the animal survived, the area which the ligated vessel supplied underwent granulo-fatty degeneration. Ricketts, however, demonstrated that either coronary artery may be ligated at any point without death resulting. Larrey, Klihm, and Turner have reported cases in which, at autopsy, cicatrices of wounds of the anterior coronary artery have been found. Among the cases of cardiorrhaphy the left coronary artery was injured in 4 cases. In Vince's case the patient died, on the second day, of pneumonia; in Cappelen's case, death, which was due to purulent pericarditis, also occurred on the second day; in Pagenstecher's case it occurred on the fifth day, as a result of purulent pleuro-pericarditis; and, in our case, the patient recovered.

Death after an Interval.—Death after an interval of a few minutes or hours,

aside from intracardiac lesions (valvular lacerations, rupture of the chordæ tendineæ, perforation of the septum), is the result of hemorrhage or of compression of the heart. After several days or weeks death is generally the result of sepsis (pericarditis, empyema, pneumonia, etc.), although secondary hemorrhage is responsible for a few fatalities, and clot, but not air-embolism, has been reported. Izzo reports a case of stab wound of the left ventricle which was discharged cured on the twenty-eighth day. A few hours later, the patient died while lifting a heavy body, the scar having ruptured. Cawadki lost a case from rupture of the heart fifteen days after the left ventricle had been sutured for stab wound. In Ewald's case the scar ruptured four weeks after the traumatism. In Loison's statistics there are nine cases of this nature.

It is our intention to detail here only those symptoms which immediately follow a wound of the heart in a patient who escapes instantaneous death,—*i.e.*, the symptoms of acute hemorrhage and those of compression of the heart.

When the blood escapes through the external wound or pours into the pleural cavity, the general phenomena are those of acute hemorrhage—pallor, rapid and empty pulse, subnormal temperature, dyspnœa, etc. Nervous symptoms, such as vertigo, syncope, convulsions, vomiting, and hemiplegia, are caused by the anæmia and are said to be more common in injuries of the left ventricle. Respiratory difficulties are more marked in wounds of the right ventricle, but may be due to nervous influences, pneumothorax, or compression of the heart. Hæmoptysis is rare, although the lung is frequently injured. In some cases there are precordial pain and tenderness even when the external wound is at a distance, and in several cases there has been pain referred to the abdomen. As already noted, the patient may walk or even run for a considerable distance before falling to the ground.

If the blood escapes externally it may do so in jets, but a continuous stream, accentuated by coughing, movements of the patient, and similar efforts, is more common.

When the blood flows into the pleural cavity (the pleura was injured in 143 of the 154 cases collected by us) there will be, in addition to the symptoms of anæmia, the signs of a pneumohæmothorax. Palpation may detect the apex beat; and there may be a slight increase in the cardiac dulness, or percussion over the heart may give a tympanitic note. In many cases the cardiac sounds are normal. A splashing sound indicates blood and air in the pericardium. A whizzing sound due to the presence of air in the pericardium also is described. In some cases a friction sound may be heard and in others a bruit not unlike that heard over an aneurysm.

When, owing to an obturating clot, a long oblique wound, or the fact that the pericardial sac is not perforated, the blood is confined to the pericardium, the clinical picture is that of compression of the heart. There may be a splashing sound, which disappears as the pericardium fills, at which time the area of precordial dulness will be much increased. The apex beat can neither be felt nor heard, and the pulse is exceedingly rapid and feeble or absent. The respirations are hurried and superficial, the face cyanosed, and the veins of the neck

dilated. The patient is unconscious, but may regain his senses when an exit for the blood is provided. Cohnheim demonstrated by experiments on animals that the pressure of the accumulating blood manifested itself first on the auricles and the origin of the great veins, thus producing venous stasis, cyanosis, and dyspnœa. When the pressure of the effusion exceeds that of the blood in the auricles complete obstruction to the cardiac blood-current ensues, the ventricles pump themselves dry, and the heart stops.

Spontaneous Healing.—Spontaneous healing occurred in 16 of the 121 cases collected by Jamain, in 18 of the 152 cases of Janetti, and in 17 of the 56 cases of Laforgue. Fischer gives the proportion of spontaneous recoveries as 8 per cent, while Tassi estimates that 1 per cent of penetrating wounds and 9 per cent of non-penetrating wounds will recover without operation. The wound is repaired by fibrous tissue and not by muscle (Martinotti); hence the possibility of subsequent aneurysm and rupture of the heart, and of murmurs the result of alterations of the orifices of the heart. Pericardial adhesions of greater or lesser extent probably always follow wounds of this structure, but give symptoms in only a small proportion of the cases. We shall have occasion to refer to the late results after cardiorrhaphy on a subsequent page.

Diagnosis.—It is often impossible to diagnosticate with certainty a wound of the heart. The superficial wound may be directly over the heart and associated with symptoms of profound shock, and yet the heart escape injury. Again, the wound of entrance may be in the abdomen or in the posterior aspect of the chest, the constitutional symptoms slight, and a fatal wound of the heart exist. We have in nine instances explored a wound in the precordial region. In one there was a penetrating wound of the left ventricle; in one a penetrating wound of the right ventricle; in one a contusion of the heart, a bullet being embedded in the pericardium; in one the tine of a pitchfork passed through the pericardium and lung, just grazing the heart; in three a bullet grazed the pericardium (passing downward into the abdomen in one, and backward into the posterior mediastinum in the other two); and in two, both of them stab wounds, the thorax was not penetrated. In a case in which the heart is wounded external bleeding may be profuse and there may be spurting from a wounded intercostal or internal mammary artery; then again, neither of these symptoms may be present and yet the heart be wounded in an equally serious degree. Although justified by Rehn, the use of a probe is generally condemned, because of the danger of introducing infection or disturbing an obturating clot. The statement that the blood coming from the external wound will be bright red when the left heart is injured and dark in color when coming from the right heart is not to be relied upon. The size of the wound in the heart cannot be predicted with certainty from the size of the external wound, nor can the particular cavity injured be inferred from the location of the latter. In one of our cases the cardiac wound was larger than the external wound, the knife probably having entered the heart at the beginning of systole, and the systolic swinging forward of the heart having added an incised wound to the stab. In this case also the external wound suggested a wound of the auricle rather than one of the ventricle. Hæmoperi-

cardium is not pathognomonic of a wounded heart, since it may follow wounds of this membrane alone or of the vessels at the base of the heart. The safest plan, in all cases of a wound in the neighborhood of the heart, is to make an exploration. The superficial wound may be enlarged by a transverse incision along the rib, or between the ribs, and gradually deepened for the purpose of ascertaining whether it penetrates the chest; and, if it be found that it does penetrate the chest, then the entire depth of the wound should be sufficiently enlarged to make exploration of the heart possible. Occasionally it is practicable to put a finger directly into the cardiac wound. In other cases it will be easy to resect the rib above or below, and thus obtain ample room for exploration. If, in the presence of symptoms of a wound of the heart, exploration reveals an intact pericardium, a needle should be introduced or a small opening made in this membrane to determine the presence or absence of blood, since the heart may be wounded without an opening existing in the pericardial sac. Several observers have testified that it may be impossible to detect a hæmopericardium from simple exposure of the parts. There have been several cases where the operator, having opened the pericardium and having failed to find the cardiac wound, has closed the chest without suturing the heart; and subsequently death has resulted.

Treatment.—The treatment of a wound of the heart is suture at the earliest possible moment. Of 61 cardiorrhaphies in which the time between the injury and the operation is stated, 23 were operated upon within one hour, with 10 recoveries; 5 between 1 and 2 hours, with 4 recoveries; 7 between 2 and 3 hours, with 2 recoveries; 8 between 3 and 4 hours, with 4 recoveries; 1 between 4 and 5 hours, with death; 3 between 5 and 6 hours, with 2 recoveries; 2 between 6 and 7 hours, with 2 recoveries; 2 between 8 and 9 hours, with 1 recovery; 1 between 9 and 10 hours, with recovery; 2 between 12 and 13 hours, with 1 recovery; 7 after 24 hours, with 5 recoveries. This gives a mortality of over 53 per cent for those operated upon within 4 hours, and one of $33\frac{1}{3}$ per cent for those operated upon after 4 hours. These figures cannot be construed to justify delay in operating; they demonstrate simply that an individual who survives a cardiac wound for a number of hours has a fair chance of recovering with operation, and perhaps without operation, but that, of the cases which would succumb within a few hours, many will be saved by prompt intervention.

An anæsthetic should always be employed unless the patient be unconscious, not only to relieve suffering, which in itself adds to the shock, but to prevent struggling and to facilitate the operation. We employed ether in our cases, because we believed it to be much safer than chloroform. Of 16 cases in which ether was employed, 7 died; of 36 in which chloroform was used, 18 died. Mention is made of ethyl chloride having been employed in one case and of a local anæsthetic in another, the former patient recovering, the latter dying. In 17 cases in which no anæsthetic was used, 12 died. In the remaining cases no note is made of the anæsthetic.

If the patient is unconscious from compression of the heart, not infrequently

the senses will be regained on providing an exit for the blood, and an anæsthetic will then be necessary.

Since time is an element of such great importance, some surgeons have opened the thorax without disinfecting the field of operation. Perhaps most of those who have made an attempt to adhere to the rules of aseptic surgery have done so incompletely. The results substantiate this statement. In 154 cardiorrhaphies there were 77 deaths, a mortality of a little over 52 per cent. Of these, 31 died within twenty-four hours of shock and hemorrhage, 1 on the fifth day from secondary hemorrhage from a large pulmonary vessel, and 1 on the fifteenth day from rupture of the heart. In the remaining cases the patients all died from some form of infection (pyopericardium, pyothorax, pneumonia, etc.), at periods ranging from the second day to several weeks. Of the 73 individuals who recovered, 28, or over one-third, did so in spite of infection. We believe that the most careful aseptic precautions should be taken whenever the patient's condition permits, but that in the presence of alarming symptoms one should first control the bleeding and then, by irrigation and perhaps by drainage, attempt to minimize the danger of infection.

The advice given by Rydygier, to allow a knife which may be found sticking in the chest to remain until one is ready to suture the heart, is questionable. It is easy to understand how the blade might produce further laceration of a beating heart.

The methods for exposing the heart are numerous. Almost each operator who has attempted to suture the heart has adopted a different plan. Rehn, Walcker, Parlavecchio, Pagenstecher, Fummi, and Gibbon were able to suture the heart after resecting one rib in the vicinity of the wound. Others, finding the space thus created too narrow, have removed the next rib above or below. Ramoni excised the third rib and raised an osteoplastic flap containing the fourth and fifth ribs, the base of the flap being below. Lango and Vaughan used a somewhat similar flap with the base above. Del Vecchio suggested an H-shaped incision, which was used in Nicolai's case. The horizontal portion was made at the level of the wound, in the fourth interspace, the vertical limbs corresponding to the left sternal and mammillary lines. The fourth and fifth ribs were severed, the former being turned upward, the latter downward. Loison recommends adding to the procedure of Del Vecchio a sternal flap if the auricle or right ventricle is to be reached. A horizontal incision, extending to the right margin of the sternum, is made from each end of the longitudinal incision of Del Vecchio, the sternum being severed above and below and turned toward the right.

Ninni made an incision, 10 cm. long, from a point 1.5 cm. to the left of the sternum, along the inferior border of the third rib; a second incision, 8 cm. long, began at the same distance from the sternum and followed the inferior border of the fifth rib. These incisions were carried through the entire thickness of the thoracic wall, including the pleura, but avoiding the internal mammary vessels. A vertical incision, within the nipple line, united the outer edges of these horizontal incisions. After the fourth and fifth ribs had been severed in the plane of the

vertical incision the flap was turned inward, the chondrosternal articulations luxating. This quadrangular osteoplastic flap has been modified in several ways. Either horizontal incision may be omitted, thus making the flap triangular. (Parozzani, Lastaria, Carnabel.) Rydygier advises a horizontal incision at the upper border of the third rib, extending from the right of the sternum to the left costo-chondral joint, then passing obliquely downward along the outer ends of the costal cartilages as far as the fifth interspace. The third, fourth, and fifth costo-chondral articulations and the sternum are divided and the flap turned toward the right.

Wehr suggests a V-shaped incision. Beginning at the superior border of the fourth right chondro-sternal articulation, the incision crosses the sternum, follows the superior border of the fourth left costal cartilage, curves downward, about two finger-breadths from the sternum, over the fourth, fifth, sixth, and seventh cartilages, and finally curves again below to reach the right border of the sternum at the ensiform cartilage. The sternum, costal cartilages, and ensiform cartilage are severed, down to but not including the inner periosteum, and the flap is turned to the right, the pleura being detached from the left toward the right. If the auricles are to be attacked, the incision passes above the third costal cartilage. Marion, Napalkoff, and Pagenstecher have suggested flaps resembling in general that of Wehr.

Podrez begins an incision in the second left interspace, one inch and a half from the sternum, carries it as far as the midsternum, then downward as far as the level of the seventh cartilage, and outward along this cartilage to its junction with the rib. The sternum is divided at either end of the longitudinal incision and the flap is turned to the left. The pleura is not opened. Giordano, Guidone, Fontan, and others also recommend a flap with the base directed toward the left.

To gain access to the base of the heart and the great vessels Fontan proposes a temporary resection of the sternum. An incision is made from the first to the fourth or fifth interspace, about 2 cm. from the sternum, and is then carried across the sternum and upward to the first interspace. The cartilages and the lower end of the sternum are cut and the sternum is turned upward in such a manner as to fracture at a level with the first interspace, care being taken not to injure the pleura or the internal mammary vessels.

In three cases of cardiorrhaphy the opening, owing to the situation of the wound, was made in the right chest.

Finally, Mauclaire and Villar advise exposure of the heart by incising the epigastrium and then the diaphragm.

None of the methods mentioned above is ideal. Resection of one costal cartilage gives only a small space through which to work; permanent resection of more than one leaves a breach in the thorax over the heart. Flaps with the base above or below necessitate double ligature of the intercostal vessels, thus prolonging the operation and predisposing to sloughing. A flap with the base toward the sternum is difficult to make without injuring the pleura, and does not give access to the auricles unless the sternum is included. A flap with the base directed externally allows easier separation of the pleura but does not expose

the base of the heart. Resection of the sternum exposes only a limited portion of the heart. The abdomino-diaphragmatic route is useful only for exploration when there exists an abdominal wound which passes upward through the diaphragm.

The truth is, that no definite plan can be laid down for all cases; one must be guided by the situation of the wound, the condition of the pleural cavity, and the degree of certainty in the diagnosis. If the wound is in the left chest, if there is no doubt as to the diagnosis, and if the pleural cavity is distended with air, perhaps the best plan is to make an osteoplastic flap with the base directed externally, including as many ribs as may be necessary (usually from two to four), and turning the sternum to the right, if necessary, by prolonging the horizontal incisions toward the right. If the wound is to the right of the sternum, the flap should be made in the right chest. One would not risk injuring the left pleura if there is already a right pneumothorax. When there is uncertainty as to the diagnosis, the wound should be explored as described above (page 151), and, if it be found necessary to suture the heart, as much bony tissue as circumstances demand should be resected. If the pleura is intact, every effort should be made to preserve this membrane, unless the bleeding is so violent as to demand the most hurried action. It has been suggested to employ the Sauerbruch or Brauer apparatus (see page 418) to prevent collapse of the lung during thoracotomy for a wounded heart, but the suggestion has not been put into practice.

When the lung is wounded, and it usually is, the wound as a rule ceases to bleed when the lung collapses; if it is bleeding at the time when the thorax is opened, it may be sutured after the cardiac wound has been closed.

The wound in the pericardium is enlarged in the axis of the heart by tearing or cutting, care being taken to avoid the pleura if it is not injured. When the pericardium is intact it should be opened as one opens the peritoneum, by raising it from the heart with forceps. The pericardial sac is cleared of clots with the finger and the fluid blood removed with a sponge. In the reports of several of the cases attention is called to the fact that the blood coagulated behind the heart. In experimental work Ricketts found that collapse of the lung congests the heart, and subsequent exposure causes it to dilate because of the lack of support of the pericardium and chest wall.

The bleeding from the heart may be controlled by a finger, by compression of the heart, by dislocating it forward, or by pressing it against the sternum. Rehn advises compressing the venæ cavæ, at their junction with the right auricle, between two fingers, thus making the operation bloodless. Animal experiments have proved this procedure to be harmless when of short duration—ten minutes, for example. (Haecker.) The heart may be steadied by the fingers, by forceps, or by sling sutures. In several cases the suture tore out. If the heart cease to beat during the operation it should be sutured quickly and massage performed. The use of gauze packing to control the hemorrhage will probably never be indicated; to be efficient it must be firm, and to be firm it must exert injurious compression. A round, curved intestinal needle is generally recommended. Silk was employed in 57 cases, with 30 recoveries; catgut in 23, with

14 recoveries; celluloid in 1, with recovery; and in the rest the suture material is not known. The highest number of sutures employed was 20. Silk has the advantage of being easier to manipulate and more certain to hold. It has been proved that catgut will last long enough for repair of the wound. The continuous suture is mentioned in 6 of the cases, with 3 recoveries. It may be applied more rapidly than the interrupted, and presents fewer knots on the surface of the heart. The sutures are inserted, at intervals of one-eighth of an inch, deeply into the muscle, but they must not penetrate the endocardium. In dogs Sherman found it a difficult matter to penetrate the endocardium with an ordinary curved needle. After they have been tied, the ends of the suture should be cut off one-quarter of an inch from the knot, to guard against untwisting. Diastolic suture is difficult and unnecessary. One would have to rehearse with a rapidly ticking metronome for a long time before he would be able to accomplish the feat.

After the pericardium and pleura have been cleared of fluid blood and clots the question of drainage must be decided. The advantages and disadvantages (infection and adhesions) of the drain are the same here as in other serous cavities. Most operators have drained both the pericardium and the pleura, a few have closed the pericardium and drained the pleura, and a few have closed the pleura and drained the pericardium. As far as one can judge by the statistics the results are slightly better with drainage. Of 58 cases in which the pericardium was drained, 22 died, while of 42 in which the pericardium was closed, 18 died. If the bleeding has been thoroughly controlled and the operation performed with aseptic precautions we should close the pericardium and the pleura, being prepared to open either cavity in the event of septic contamination. If oozing of blood persists, or if, owing to the patient's condition, the rules of aseptic surgery have been violated, drainage should be instituted. If one decides to drain both cavities, this should be done through separate openings—the pericardium through the wound of operation, and the pleura between the axillary lines; otherwise, infection in one cavity will inevitably be conveyed to the other. If, in the presence of pneumothorax, it is deemed better to close the pleura, an aspirator may be introduced in order to remove the air. One should remember, however, that a pneumothorax is a very efficient hæmostatic, and should hesitate to aspirate soon after operation, if the lung has been wounded.

The after-treatment is the same as for any grave hemorrhage. It is needless to add that infusion of salt solution and stimulants should not be given before the wound in the heart is closed.

All that remains to complete the history of suture of the heart is to give the end-results in those patients who survive the operation. We have notes of eighteen cases in which the patients were examined at periods ranging from a few months to several years after the operation. In one the heart ruptured on the twenty-eighth day; one has symptoms of an aneurysm of the heart; one has an irritable heart; one complains of cardiac pain; one has tachycardia, which was present before the operation; and thirteen are in good health, with no symptoms referable to the heart.

Massage of the Heart.—Massage of the heart was first proposed by Schiff, in 1874. After arresting the heart by chloroformization, he was able in some instances to reëstablish its pulsations, even after these had ceased for as long a time as 11½ minutes. He opened the thorax and compressed the heart rhythmically with the hand, being careful not to interfere with the coronary circulation. At the same time he performed artificial respiration and compressed the abdominal aorta, to force blood toward the brain. Most of the dogs, however, died after a few hours. Similar experiments were made later by Tuffier and Hallion. In 1900 Prus "killed" dogs by electrocution, by suffocation, and by the administration of chloroform. Of those in which the heart was arrested by electricity, massage was successful (in about fourteen per cent) in restoring cardiac activity, while, in the others, over seventy-five per cent were resuscitated. Prus concluded that life can be induced to return even after the heart has ceased to beat for one hour. Batelli showed in his experiments, which were subsequently confirmed by Arabian, that animals could be recalled to life six minutes after the heart had been arrested by suffocation or chloroformization. He found also that when massage produced fibrillary tremulations of the heart, it was exceedingly difficult to induce normal contractions, although he succeeded in this by applying directly to the heart an alternating current of 240 volts. Bourcart was the first to massage the heart through the diaphragm, after making an epigastric incision. One dog, in which massage was begun over eleven minutes after the heart ceased to beat, was living and in perfect health six weeks later. Hering and d'Halluin found that, after an intravenous injection of chloride of potassium (20 centigrammes to the kilogramme of animal), the fibrillary tremulations of the heart could be checked and the organ induced to beat regularly.

Although massage of the human heart was first performed by Nichaus, in 1880, the credit for the first report belongs to Tuffier, who, in 1898, published an unsuccessful attempt to restore life by this means, after death from a post-operative embolism. In 1906 Lenormant,* to whom we are indebted for the facts given above, was able to collect 25 cases, to which we may add 13 additional cases, published up to June, 1908, and one unpublished case, making 39 in all. These figures do not include so-called massage by simple pressure over the precordium.

The cause for the cardiac inhibition in these cases was chloroform in 29, ether in 1, operation without anæsthesia in 2, wounds of the heart or pericardium in 3, pulmonary embolism in 1, hanging in 1, nephritis and septicæmia in 1, and one case concerned a still-born infant.

Technique.—The heart may be approached for massage through the anterior wall of the thorax, or through the abdomen, with incision of the diaphragm (transdiaphragmatic massage) or without incising the diaphragm (subdiaphragmatic massage).

The thoracic route necessitates the resection of one or more costal cartilages, usually the third and fourth or the fourth and fifth. Osteoplastic flaps, similar to those employed to expose the heart for suture, also have been made. Most

* Revue de chir., March, 1906.

surgeons who have adopted this route have opened the pericardium, in order to act directly on the heart—a procedure which involves some risk of producing infection of this serous cavity. In four of the five cases in which the pericardium was not opened, the pleura had been torn, and massage was performed through the pleural cavity. As to the massage itself, the ventricular portion of the heart is rhythmically compressed between the thumb and fingers, about 60 times to the minute. The thoracic route has been utilized in 17 cases, with 7 complete failures, 5 failures after a few contractions had been induced in the course of one or more hours, and one complete success. The successful case belongs to Igelsrud. During a hysterectomy under chloroform the patient collapsed. After three or four minutes of suspension of cardiac activity, the fourth and fifth left costal cartilages were resected, the pericardium opened, and the heart masséed for two minutes, at the end of which time the pulsations returned.

Except in operations on the heart and lungs, in which a breach in the thoracic wall has already been made, the thoracic route will probably be abandoned, since it not only involves a risk of injuring the pleura and producing acute pneumothorax (a most serious accident at a very critical period), but also interferes with artificial respiration, which is as essential as artificial circulation.

The transdiaphragmatic route was proposed by Mauclaire. The abdomen is opened in the epigastric region, the liver depressed, and the pericardium opened through the diaphragm, a hand being introduced through the opening for the purpose of massage. This method has been employed in five cases, in each instance unsuccessfully. It avoids a pneumothorax and permits artificial respiration, but necessitates suturing of the diaphragmatic opening—an exceedingly difficult undertaking. Therefore it has given way to the subdiaphragmatic method.

The subdiaphragmatic route was first adopted by Lane. After making an epigastric incision he masséed the heart through the diaphragm without incising this structure. When, as in syncope, the diaphragm is relaxed, the heart may be seized with the hand and manipulated without difficulty, or it may be compressed against the anterior thoracic wall, which is supported with the other hand. The subdiaphragmatic method has been employed in 17 cases, with 9 failures and 8 successes. It is the quickest, least mutilating, and the most efficacious of the methods proposed.

The question as to how long one should persist in the usual methods for combating cardiac collapse before performing massage of the heart, is difficult to answer. The sooner one begins, the greater the chance of success; yet to open the abdomen without careful disinfection in a case which might survive without cardiac massage, carries with it a risk of peritonitis. If the collapse occurs during a clean abdominal operation, or an operation on the heart or lungs, we should not hesitate to begin massage as soon as the heart ceases beating. If the case is one of peritonitis confined to the lower abdomen, gloves could be drawn on the hands and a second incision made in the epigastrium. If the operation is one not involving the thorax or abdomen, we should first try rhythmical pressure over the precordial region, which we have found successful in one

case, before opening the abdomen for subdiaphragmatic massage. Lenormant advises that cardiac massage be instituted after five or six minutes, if the usual methods of resuscitation are unavailing.

The longest period elapsing between the cessation of cardiac activity and the beginning of massage, which was followed by permanent recovery, has been fifteen minutes. (De Page.) Prus, however, was able to induce cardiac contractions one hour after death, and Sick succeeded in restoring the heart to activity forty-five minutes after it had ceased beating, the patient regaining consciousness and living twenty-four hours. As in the case of artificial respiration, massage of the heart once begun should be continued with perseverance. Although, in most cases, if a successful result is to be obtained, the heart will begin to beat almost immediately after the application of massage, in others this will occur only after the lapse of several minutes—five minutes (Senecrt), six to eight minutes (Lenormant), or even forty-five minutes (Prus, Sick).

Cardiocentesis.—Cardiocentesis, or tapping of one of the cavities of the heart, was first deliberately performed by Westbrook in 1882, although previously several unintentional punctures of the heart had been made during attempts to withdraw fluid from the pericardium or the pleura. The operation was suggested for the purpose of relieving overdistention of the heart with blood, the result of some acute pulmonary affection, or with air which had been aspirated into the heart through a wound in one of the veins at the base of the neck. (See Air Embolism.) It has been proposed also for the treatment of suspended animation, the result of chloroform narcosis, of asphyxia from various causes, and of epilepsy. As the right auricle, owing to the thinness of its walls, suffers most from overdistention, Westbrook selected this cavity for puncture, entering the needle into the third intercostal space close to the right edge of the sternum and pushing it directly backward. The needle traverses the anterior edge of the right lung and the pericardium before reaching the auricle. In order to avoid the danger of hemorrhage which attends puncture of the auricle, certain surgeons have penetrated the right ventricle. Roberts advises that the needle be introduced in the fourth interspace, one or two inches to the left of the sternum. Even here one may produce copious bleeding by puncturing a vessel in the cardiac wall or pericardium, or may strike the coördination centre of Kronecker—an accident which causes sudden arrest of the heart. We, therefore, believe that the operation is one which should seldom or never be employed.

II. THROMBOSIS.

Thrombosis is the ante-mortem, intravascular, or intracardiac clotting of blood. The clot is called thrombus.

Etiology.—The causes of thrombosis, in the order of their importance, are: (1) changes in the vessel walls; (2) changes in the blood; (3) changes in the blood-current. These three factors are generally combined, and in many instances it is impossible to determine which is the primary agent in the production of thrombosis.

1. Changes in the Vessel-Walls.—Changes in the vessel-walls, with lesions of the intima, are the most prolific cause of thrombosis. Injuries, such as occur after contusions and ligations of vessels, which result in a rupture of the endothelial lining of the vessels, expose an irregular surface to the blood-current, upon which the elements necessary for coagulation are readily produced. In many of these cases the blood-channel is narrowed or a flap of the intima projects into the blood-stream, thus producing a whirling motion, or eddy, and retarding the blood-stream. In addition to these mechanical conditions favoring thrombosis, lesions of the intima are thought to encourage thrombosis by means of fibrin ferment, which is generated by disintegrating protoplasm. Aside from trauma, structural changes in the vessel-walls which may excite thrombosis are found in the last stage of acute inflammation, in the various forms of arteritis and phlebitis, in necrosis and other degenerations, and in neoplastic infiltrations.

Inflammatory changes in the vessel-walls secondary to either perivascular or intravascular infection are responsible for the vast majority of thromboses. With the progress that has been made in bacteriology, many thromboses formerly regarded as bland are now known to be infective in origin. This is particularly true of those complicating acute infective diseases and diseases accompanied by cachexia. Among the acute infective diseases which may be associated with thrombosis are typhoid fever, influenza, measles, variola, scarlatina, pneumonia, acute rheumatism, erysipelas, cholera, relapsing fever, and dysentery. Thrombosis may occur also during gonorrhœa, syphilis, gout, chlorosis and some other forms of anæmia, particularly that following hemorrhage. "In relatively few instances has the specific micro-organism of the primary disease, as the typhoid or tubercle bacillus, for example, been present in the thrombus; more frequently secondary invaders, especially streptococci and other pyogenic bacteria, have been detected: so that the thrombus is considered to be oftener the result of some secondary infection than of the primary one." (Welch.) Among the cachectic states which predispose to thrombosis may be mentioned those due to cancer, chronic gastric diseases, dysentery, and protracted suppurations, especially of bone. In these cases pyogenic organisms are most frequently found in the thrombus and the vascular walls.

"We do not possess sufficiently numerous and careful bacteriological examinations of the thrombi of infective and wasting diseases to enable us to say in what proportion of cases they contain micro-organisms. It is certain that in many instances such examinations have yielded negative results. It is quite possible that in some of these negative cases bacteria, originally present, have died out, but, although by some authors much use is made of this explanation, it is not in general a satisfactory one. Many of the examinations were of thrombi sufficiently recent to exclude this possibility. To explain these non-bacterial cases, the French writers assume the existence of a primary toxic endophlebitis, the toxins being either of bacterial origin or derived from other sources. Ponfick, many years ago, called attention to the occurrence of degenerations of the vascular endothelium in infective diseases; and there can be no doubt of the

frequency of both degenerative and inflammatory changes of the intima in toxic and infective conditions." (Welch.)

Since changes in the vascular walls induce thrombosis, and since thrombosis, particularly when of infective origin, causes an angeitis, it is often impossible to determine which of these conditions is primary and which secondary. In the time of John Hunter and Cruveilhier the thrombus was always regarded as secondary. Virchow convinced the pathologists of his day that the thrombus was generally primary. At the present time the prevailing view is that thrombosis is generally secondary to changes in the vascular wall.

Under this heading may be considered foreign bodies, such as emboli, and bodies like needles, which may enter the blood-stream, particularly the heart and the abdominal veins, and induce thrombosis. According to Freund the foreign body must have certain adhesive qualities so that the corpuscles will stick to it, the normal intima being smooth and non-adherent and so preventing coagulation. This observer has found that blood drawn from the vessels beneath a layer of oil into a receptacle coated with vaseline will not coagulate.

2. Changes in the Blood.—Coagulation of the blood is the result of the presence of fibrin ferment, which in some obscure way causes the fibrinogen and the calcium salts of the plasma to unite and form fibrin. As has already been mentioned, fibrin ferment may be liberated from the diseased or injured cells of the vessel wall. It may emanate likewise from diseased or injured blood-cells—white, red, or platelets. Any agent, therefore, which injures these cells may be responsible for the generation of fibrin ferment. That marked changes in the chemistry and morphology of the blood are caused by many diseases and that such may markedly influence the coagulability of the blood is well known. Thus, coagulation may be delayed in jaundice, scurvy, malaria, yellow fever, hæmophilia, purpura hemorrhagica, certain forms of anæmia, notably progressive pernicious anæmia and leukæmia, and by alcoholism and other toxic conditions. Decrease in the coagulability of the blood has been found after bites by poisonous snakes, poisoning by prussic acid and chloroform, and the injection of hirudin (leech extract). The inhalation of oxygen, smoking of tobacco, ingestion of acid fruit juices and ammonia, restriction of food, diminution of lime salts, and large quantities of fluid are all said to delay the clotting of blood. Normal blood, as it flows from the vessels, is incapable of coagulation when sodium oxalate, sodium fluoride, or soaps, which precipitate the calcium salts, are added to it. (Ziegler.) Intravascular coagulation has been produced by the injection of gallic acid, laky blood, solutions of hæmoglobin, defibrinated blood, emulsions of lymph cells, emulsions of leucocytes, ether, and biliary salts. Thrombosis, particularly of the capillaries, may occur in extensive burns (Silbermann), in severe frost-bites, and in poisoning with those substances which act deleteriously upon the blood-cells,—*e.g.*, aniline, arsenic, mercury, phosphorus, potassium chlorate, carbon dioxide, and illuminating-gas. During the puerperium the blood is said to be more coagulable, owing to an increase in the amount of fibrin ferment. Restriction of fluid and the administration of milk, gelatin, lime salts, magnesium carbonate, and thyroid extract render the blood more

coagulable. Weil and others inject horse or human blood serum in hæmophilia, in order to increase the coagulability of the blood. Antidiphtheritic serum has been used with the same idea.

We have already called attention to some of the infective and exhaustive diseases which may be complicated by thrombosis. As to the frequency with which thrombosis in septic and toxic conditions is due to alterations in the blood rather than to changes in the vascular wall we are unable to state. Satisfactory observations on the presence of fibrin ferment in the blood under such circumstances are lacking. (Welch.) There are, however, some observations which tend to show a relation between the number of blood platelets, which play an important rôle in thrombosis, and the formation of thrombi. The number of platelets in circulating blood has been found to be increased in such conditions as chlorosis, influenza, pneumonia, post-hemorrhagic anæmia, septic infections, and cachectic conditions, all of which may be complicated by thrombosis. This increase in the number of platelets in septic conditions is sometimes observed with leucocytosis and sometimes following leucocytosis. Diminution in the number of platelets has been observed in certain conditions in which there is a tendency to spontaneous hemorrhage—*e.g.*, pernicious anæmia, purpura hemorrhagica, malaria, and hæmophilia. These observations tend to show that the platelets are not distinct entities but rather the result of destructive processes in the blood, being derived either from the red or white cells, as some believe, or from the plate-like precipitation of globulin. (Loewit.)

3. Changes in the Blood-Current.—It was at one time thought that reduction in the velocity of the blood-stream was the most frequent cause of thrombosis. Now, however, such is regarded as a predisposing element only, and one which determines the localization of the thrombosis rather than its generation. Slowing of the blood-current alone, without either of the other factors mentioned above, will not cause thrombosis; in fact, a vessel may be ligated at two points without thrombosis taking place between the ligatures for days or weeks. To be sure, one of the other factors is generally present. Thus, in the enfeebled circulation attending fevers the blood is laden with toxic material, and degenerative changes may be found in the vascular walls. Again, slowing of the circulation may itself be responsible for nutritive changes in the walls of the vessels. It is true that, with a diminution in the velocity of the blood-stream, the elements existing in the blood undergo some alterations in arrangement, but such is generally thought to be insufficient to cause thrombosis; the white cells and platelets accumulate at the margins of the stream, but do not undergo "viscous metamorphosis," which commonly occurs if a thrombus is to form, unless there is some change in the cells lining the vessel. Of greater importance, in some instances, than mere slowing of the blood-stream are irregularities or eddies which are produced when the blood flows into a space relatively too large for it—*e.g.*, into an aneurysm or through a varicose vein. Pressure on a vessel from without predisposes to thrombosis by producing such currents, as well as by altering the nutrition of the coats of the vessel.

The Nature of the Thrombus.—The nature of the thrombus depends upon

whether it is the result of complete stasis (red thrombus) or is formed slowly from a moving current of blood (white thrombus). A white thrombus containing a considerable number of red corpuscles is called a mixed thrombus.

Red thrombi are formed quickly, and hence are composed of a mesh of fibrin in which are ensnared the red and white cells in about the same proportion as in normal blood; in other words, the coagulum is identical with that formed by extravasated blood. Such are the thrombi which seal vessels after spontaneous hæmostasis, ligation, torsion, and the like. They result also from the complete stasis which occurs in violent inflammation.

White and mixed thrombi are formed slowly from a moving current of blood, and consequently, besides fibrin, they contain chiefly those elements which begin to lag when the velocity of the blood-stream is diminished,—viz., platelets and leucocytes. Excluding the coagula which close vessels after injury, we may say that mixed thrombi constitute the vast majority of those encountered by the clinician. They are of a dirty-white or grayish color, with bright red spots or black blotches, or they consist of alternating red and white layers (laminated thrombi).

Leucocytic thrombi, consisting almost wholly of leucocytes, have been found in the small vessels in acute inflammation, and in diseases like leukæmia, in which there is a marked increase in the number of leucocytes.

Purely fibrinous thrombi are encountered in the pulmonary vessels in croupous pneumonia.

Hyaline thrombi, occasionally found in infective conditions, are probably the result of the action of toxins on the blood-cells. The modern conception of the formation of white or mixed thrombi, based largely upon animal experimentation, is as follows:—Changes in the vascular wall, associated perhaps with diminution in the velocity of the blood-stream, are followed by an accumulation of platelets at the affected spot. These platelets adhere to the vessel-wall and to each other. Leucocytes quickly augment this beginning thrombus, and with their appearance is first observed fibrillated fibrin. The color of the thrombus will depend upon the number of red cells entangled in the fibrin; the greater the irregularity of the circulation the larger the number of red cells mixed in the thrombus.

A thrombus in its inception is at first parietal or mural. Such thrombi, occurring upon the valves of the heart or a vein, are called valvular thrombi. If the thrombus continues to increase in size until it closes the lumen of the vessel it is termed an occluding, obstructing, or obturating thrombus.—The thrombus first formed, known as primary or autochthonous, may, by subsequent additions (induced thrombi), become a continued or propagated thrombus, which sometimes extends, not only along the affected vessel, but also into those vessels with which it communicates. The term "secondary" is applied to induced thrombi and to those which form about an embolus.—Ball thrombi are those which are loose in the heart; they result from the detachment of polypoid thrombi (heart polyps).—Thrombi are almost always adherent to the wall of the vessel from which they spring. They may increase in size both centrally and peripher-

ally, but generally they extend in the direction of the blood-current. The advancing end of a thrombus is usually bluntly conical, but it may be bevelled and adherent to one side of the vessel; if it projects into a collateral vessel it may be broken off and washed into the circulation as an embolus.

Changes which Thrombi Undergo.—A thrombus is at first soft and succulent. Later, it contracts and becomes more dry, compact, and granular. The leucocytes undergo fatty degeneration and the red cells are decomposed. The hæmoglobin escapes from the red cells and is dissolved or precipitated as hæmatoidin. The fibrin becomes more prominent and of a coarser texture, and hyaline material often makes its appearance. What might be styled the normal sequence is the so-called organization of a thrombus. The clot is, of course, not organized, but is simply displaced by fibrous tissue, the process being identical with that of repair elsewhere. The thrombus becomes firmly adherent to the walls of the vessel and induces inflammatory changes in these walls. The vasa vasorum dilate and leucocytes immigrate into and gradually devour the clot. At the same time the intima becomes covered with granulations, which increase in number and take the place of the clot. This granulation tissue is vascularized by new vessels springing from the vasa vasorum and is in time transformed into firm cicatricial tissue. This cicatricial tissue contracts and, in the case of an occluding thrombus, may convert the vessel into a fibrous cord. In other instances an occluding thrombus is not completely organized, but contains spaces which communicate with the blood-current above and below. Occasionally, by the absorption of the partitions between such spaces, the thrombus is canalized and the blood-current restored. The time necessary for the organization of a thrombus varies widely. In favorable cases the process, in small vessels, is well advanced within a week. Poor general health, extensive disease of the vessel-wall, and infection retard and sometimes prevent the organization of a clot.

Old thrombi are sometimes calcified. Such concretions in veins are called phleboliths, and in arteries arterioliths. The former are much more frequent, and may be loosely adherent to or wholly separate from the walls of the vessel. They are found most frequently in the broad ligaments in women, and about the prostate in men.

Softening, or liquefaction, occurs in three forms, viz., simple softening, septic or purulent softening, and putrid softening. Simple softening is seen in sterile thrombi. The interior of the thrombus, as the result of degeneration, is converted into a grayish or reddish liquid or semisolid material. This degeneration is supposed to be caused by a ferment. Septic or purulent softening is caused by bacteria; in other words, the thrombus suppurates. The organism most frequently found is the streptococcus. With septic softening, either as a cause or as a result, occurs a suppurative inflammation of the walls of the vessel; hence the terms purulent thrombo-phlebitis and purulent thrombo-arteritis. Softening of a thrombus may be produced by the bacteria of putrefaction (putrid softening) as well as by pyogenic bacteria. Softening, or liquefaction, in any of the forms mentioned above, when extending to the periphery of the thrombus, may result in the transportation of fragments of the thrombus as emboli to distant parts.

Localisation of Thrombi.—According to situation thrombi are designated cardiac, arterial, venous, and capillary.

Cardiac thrombi, although of great interest to the pathologist and internist, are of no practical value to the surgeon. In Welch's classical article on thrombosis and embolism in Allbutt's "System of Medicine," from which we have drawn rather freely in these paragraphs, the subject is considered in great detail.

Arterial thrombi are most frequent in the extremities, the lower being more often affected than the upper. Unlike the veins, the arteries are occluded as frequently on the right as on the left side. Of the visceral arteries in which thrombosis occurs, the mesenteric hold the greatest interest for the surgeon. Arterial thrombi are generally caused by injury, by localized disease of the vessel, or by the impaction of an embolus. The surgeon is perhaps most familiar with those thrombi which are the result of endoarteritis and which are found in the arteries of the lower extremity in senile and diabetic gangrene. Much more rare is the arteriothrombosis caused by an obliterating arteriosclerosis, which determines the so-called spontaneous gangrene. In those cases of gangrene which follow one of the acute infective diseases, such as typhoid, pneumonia, etc., the causative lesion is an arteriothrombus, the result of an infective endoarteritis or the lodging of an embolus. Thrombosis of the arterioles may be found in Raynaud's gangrene and in ergot gangrene. Obliteration of arteries by thrombosis, without changes in the arterial wall or other obvious cause, has been reported by Hutchinson (*Arch. of Surg.*, April, 1898), and others.

Venous thrombosis is that form of the disease which is most frequently encountered by the clinician. Injuries, pressure, phlebitis, varix, and perivascular inflammations are a prolific source of such thrombi. In addition to the thrombi which are caused by these local conditions, there are others which are due to general causes and which are most often situated in the veins. The reasons for this, according to Welch, are: "The slower mean speed of the blood in the veins than in the arteries; the low blood pressure; the flow from smaller into larger channels; the absence of pulsation; the presence of valves; the fixation of the venous wall in certain situations to fasciæ and bone; the existence, in some places, of wide sinuses and ampullar dilatation; the agency of certain subsidiary forces, such as muscular contraction and movements of the limbs, in assisting the flow in the veins; the composition of venous blood, particularly the higher content of CO_2, and perhaps the functions of the capillaries and small veins in the production and absorption of lymph." In thrombosis due to general causes the initial seat of the thrombus is often one of the valvular pockets near the root of a limb, and not the smallest veins as in localized septic processes. That thrombosis should begin in the dilated portion of a vein above a valve may be explained by the eddying motion given to the blood in this situation, but no satisfactory explanation has been offered for the preference shown for the root of a limb. Unlike arteriothrombosis, thrombosis of the veins is most frequent on the left side. The susceptibility of the left lower limb is thought to be due to the greater length and obliquity of the left common iliac vein, the current in which may be hindered by the pressure of the

right common iliac artery, under which it passes. It is crossed also by the left internal iliac artery and may possibly be pressed upon by a loaded rectum. Parmentier* calls attention to the greater length and obliquity of the left innominate vein as a factor favoring thrombosis in the left upper extremity. (See Fig. 68.)

Fig. 68.—Thrombosis of Inferior Vena Cava and Iliac Veins in Typhoid Fever. Typhoid bacilli were recovered in enormous numbers from the thrombus. (Pennsylvania Hospital case.)

Capillary thrombi are usually caused by local conditions, such as injuries, prolonged pressure, corrosive chemicals, freezing, burns, severe inflammations, etc. The capillaries are ordinarily not plugged with thrombi when the larger vessels are occluded, unless gangrene ensues.

Effects of Thrombosis.—The results of thrombosis vary widely with the situation and the extent of the thrombus, with the rapidity with which it is formed, and with the condition of the collateral vessels. Aside from the general symptoms, which depend mainly on the nature of the thrombus (*i.e.*, whether it is septic or aseptic) and on the possibility of embolism, evidences of thrombosis are referable chiefly to the obstruction of the blood-stream. A small thrombus in an unimportant vessel, and even an extensive thrombus in an important vessel, if the occlusion has occurred slowly enough to give the collateral vessels an opportunity to dilate, may give no clinical manifestations. Such, however, is not the case in the latter when a thrombus is quickly formed; when the collateral vessels are incapable of dilatation because of disease, pressure, cardiac weakness, and the like; or when the vessel is a terminal artery, *i.e.*, an artery having no collateral anastomoses, except capillary, with adjacent arteries—as, *e.g.*, those of the brain, spleen, and kidney. Under these circumstances serious changes in the part supplied or drained by the vessel follow. Such changes are due to anæmia or to damming back of the blood, according to whether the vessel involved supplies or drains the affected part. In order to avoid repetition, we shall refer the reader to the sections on Embolism and Contusions of Arteries for the symptoms and treatment of arterial obstruction, and to the section on Phlebitis for the symptoms and treatment of venous obstruction. Thrombotic gangrene has been discussed in an earlier volume. (Volume II.) Cardiac and capillary thromboses we shall pass over; the former belonging to the physician, the latter to the article on Gangrene and allied conditions.

Under wounds of veins we shall give a brief summary of the effects of ligation

* Arch. gén. de méd., July, 1889.

of the larger veins and the frequency with which ill results follow. For the differential diagnosis between thrombosis and embolism the reader is referred to the section on Embolism. (Page 189.) Post-operative thrombosis is discussed under Pulmonary Embolism. (Page 190.)

III. EMBOLISM.

Definition.—Embolism is the sudden blocking of a blood-vessel by a foreign body which has been brought by the blood-stream from some more or less distant part. The foreign body is called an embolus.

Nature of Emboli.—Emboli are usually detached portions of thrombi, but they may be vegetations from the valves of the heart, detached atheromatous plates, fat globules, air bubbles, portions of tumors, cells from some of the normal structures of the body, masses of bacteria, or parasites, such as the scolices of the echinococcus and the filaria sanguinis hominis. Various forms of dust, when inhaled, may be transported by the blood-stream to distant parts. Workers in wool, jute, and mother-of-pearl may breathe in particles of these substances, which finally lodge in the medulla of bones and cause sudden painful swellings at or near the ends of the diaphysis. Particles of paraffin which has been injected for cosmetic purposes may float off into the blood-stream as emboli, as may also particles of insoluble preparations of mercury which have been injected subcutaneously for therapeutic purposes.

Source of Emboli.—Emboli may arise in any portion of the vascular apparatus. Those arising in the heart from thrombi or diseased valves are the most important and the most frequent, from the internist's standpoint, while thrombosed veins furnish the most fruitful source of emboli from the surgeon's standpoint. Air embolism and fat embolism will be considered separately. Transportation of tumor cells by the blood-stream, or metastasis, is discussed in the article on "Tumors," and a full description of metastatic abscesses will be found in that on "Infections Complicating Surgical Diseases"—both of which articles are in Vol. I. Mention has been made above of the fact that inhaled particles may find their way into the circulation and constitute emboli. In a similar way substances introduced into the gastro-intestinal canal may be taken up by the blood-stream and deposited in the tissues. The pigmentation of the skin in argyria is an example of such deposition.

In certain bone diseases—*e.g.*, osteoporosis and osteomalacia—lime salts are transported by the blood-stream to other tissues, notably the mucous membranes of the lungs, stomach, and kidneys.

Emboli arising from thrombi vary in size from minute particles to masses several inches long. In shape they may be spherical, conical, cylindrical, or irregular. Sometimes a thrombus is transported bodily as an embolus. In the case of a bland thrombus that portion which projects from a branch into a larger vessel is the part most apt to become detached. Muscular contractions, blows, tight bandaging, and bending of a thrombosed vessel, as at the groin, may

force a portion of the clot into the general blood-current. The pumping action of respiration may assist in the detachment of venous thrombi close to the heart, but it probably has little effect on normally adherent thrombi in the extremities. The various forms of softening which thrombi may undergo render them, of course, very liable to dissemination by the blood-stream, particularly when the softening extends to that portion of the thrombus which is exposed to the blood-current. In the case of septic thrombi such dissemination results in pyæmia.

Seat of Impaction.—All particles floating in the blood-stream, when they are of larger calibre than the capillaries, become impacted in some portion of the vascular apparatus. The site of deposit depends on the region in which the embolus originates. Those arising in the area drained by the portal vein lodge in the liver; those arising in the general venous circulation pass through the right heart and lodge in the lungs; and those which come from the left heart or ascending portion of the aorta may lodge in any portion of the body. There are certain exceptions to these rules. The pulmonary capillaries are sufficiently large to permit the passage of minute emboli—*e.g.*, small tumor cells, air, and fat; hence such particles brought by the veins may be washed through the lungs into the left heart to be distributed by the arteries. Without passing through the capillaries of the lungs, however, it is possible for an embolus originating in a vein to find its way into the arterial circulation through a patent foramen ovale. This crossed or paradoxical embolism, as it is called, has, according to Welch, been observed in twenty-eight cases. Much more difficult to explain and of rarer occurrence is retrograde embolism, *i.e.*, the transportation of particles in a direction opposite to that of the blood-current—as, *e.g.*, from the left auricle into the pulmonary veins, or from the veins of the leg into those of the kidney. This does not apply, of course, to those cases in which the current in a vein is reversed owing to obstruction to its normal flow. Retrograde embolism from the left auricle into the pulmonary veins may be due to a temporary reversal of the blood-current during straining and coughing, particularly in the presence of mitral regurgitation, but it is difficult to understand how such reversal could extend to the peripheral veins. Ribbert believes that, with a feeble venous current, emboli may be pushed slowly backward by pulse waves in the veins.

The vessel chosen by an embolus and the distance it travels in such vessel are matters which are influenced by several factors. Emboli lodge more frequently in the right lung than in the left, because the right pulmonary artery is the larger. The lower lobes are more often affected than the upper for a similar reason, the lower branch of each pulmonary artery being the larger. Emboli originating in the left heart are more often swept along with the main current in the aorta than into the vessels of the head and neck; but, when they enter the latter, the left carotid is usually selected, since it springs directly from the apex of the aortic arch and, owing to its direction, is more parallel with the line of the blood-current. As the right common iliac artery presents a slightly greater angle with the aorta than the left, emboli are a trifle more prone to enter the latter.

The order of frequency in which embolic manifestations are found in the different arteries is, according to Welch, as follows:—Pulmonary, renal, splenic, cerebral, iliac and those of the lower extremities, axillary and those of the upper extremities, cœliac axis with its gastric and hepatic branches, central artery of the retina, superior mesenteric, inferior mesenteric, abdominal aorta, and coronary of the heart. As Welch observes, this list, like similar ones, does not give the frequency with which the various arteries receive emboli, as it is based on embolic manifestations only. He believes that the arteries of the lower extremity are more often recipients of emboli than the splenic or the renal: small plugs in the former leave no evidence of their existence, in the latter they always do. If one considers septic emboli only, the hepatic artery would come nearer the head of the list and the cerebral much lower.

The exact site, in the course of a vessel, at which an embolus lodges depends principally upon the size of the embolus and the force of the blood-stream. The smaller the mass and the swifter the current, the further the embolus will be carried. In addition to these considerations impaction is most likely to occur where the lumen of the vessel is suddenly diminished—*e.g.*, at the point where a large branch is given off or where bifurcation takes place. In the latter situation an embolus which projects into both branches is called a riding or straddling embolus.

Results of Embolism.—Under this heading we shall first consider the fate of the embolus itself, and the changes it may induce at the seat of impaction, aside from those resulting from obstruction to the blood-stream. An embolus, after lodging in an artery, induces a secondary thrombosis, which completes the closure of the vessel, if such has not already taken place at the time of impaction. The mass may then be regarded as a thrombus, for the subsequent changes are identical with those described under thrombosis. During the process of organization, when the thrombus is being absorbed and its place taken by granulation tissue, non-absorbable foreign bodies, if minute, may be enveloped by the leucocytes and subsequently transported to the liver, spleen, or bone marrow. Non-absorbable substances too large for such treatment are surrounded by granulation tissue, which subsequently becomes fibrous and so encapsulates the foreign bodies. When living tumor cells are transported as an embolus they may continue to proliferate and so give rise to metastatic growths. Animal parasites may perish and be absorbed or encapsulated: if they survive they develop in the vessel or, after having penetrated the vessel walls, in the surrounding tissues. In the horse, aneurysms are not infrequently produced in the anterior mesenteric arteries by the Strongylus armatus. Emboli charged with bacteria may undergo the septic liquefactive changes already mentioned under Thrombosis and allow further dissemination of the infection. Under favorable conditions the transported bacteria resume their activity and produce changes identical with those at the original point of infection. In this way are caused many of the metastatic abscesses in pyæmia. Bacteria, of course, may enter the circulation and be distributed to various parts of the body without the aid of blood-clot or other accompanying cellular material. On the other hand, all emboli con-

taining bacteria are not infective in their behavior, as has been abundantly proved by bacteriological examination of supposedly bland emboli. Inflammation, abscess formation, and gangrene are the most important changes caused by infective emboli. Embolic aneurysms were supposed by Ponfick to be due to wounding of the vessel wall by the impact, particularly, of a calcareous embolus. It is now thought that such aneurysms are caused by a softening of the vessel wall, as the result of the activity of bacteria derived from the embolus. (See Aneurysm, page 263.)

The changes in the parts supplied by an embolized artery are those resulting from the acute anæmia. Such changes vary with the part affected and with the condition of the collateral circulation. An embolus lodging in the pulmonary or the middle cerebral, or in a coronary artery of the heart, may cause the sudden death of the individual; in the central artery of the retina, blindness; in the principal artery of a limb, gangrene; and in the superior mesenteric artery, hemorrhagic infarction and sloughing of the intestine. In parenchymatous organs the anæmic area undergoes coagulation necrosis. The more highly specialized the cells in the part involved, the more quickly and certainly is acute anæmia followed by death of these cells. The ganglion cells of the central nervous system are said to be incapable of resuscitation after being deprived of blood for as short a time as half an hour. According to Litten, temporary ligation of the renal artery for from one to two hours causes an inevitable necrosis of many of the epithelial cells. In contradistinction to the susceptibility of parenchymatous cells to acute anæmia stand the cells of those tissues whose function is simply to support or to protect. The surgeon is familiar with the viability of skin and bone, both of which may be completely detached from their vascular connections and yet survive after being transplanted to another region.

Serious changes do not follow the impaction of an aseptic embolus in a small artery in a region supplied by large and numerous anastomosing vessels—*e.g.*, in bones, skin, and voluntary muscles. In organs supplied by terminal arteries, local death is inevitable. Although the intestinal arteries are not terminal, their occlusion by embolism is regularly followed by gangrene of that portion of the bowel which is supplied by the affected vessel. "Immediately after closure of the main trunk of the superior mesenteric artery of a dog, the intestine is thrown into violent tonic contractions and remains in an anæmic contracted condition for two or three hours; after which the spasm relaxes and the bloodless condition at once gives place to venous hyperæmia and hemorrhagic infarction, which appear in the third to the sixth hour after the occlusion of the artery. (Mall and Welch.) This intestinal contraction, which under these circumstances is equivalent to arterial spasm, is probably one, although not the sole reason why, in spite of free anastomoses, occlusion of the arteries supplying the intestine is followed by necrosis and hemorrhage. That the explanation is not to be found simply in the great length of intestine supplied by a single artery, is evident from the fact that, if the extra-intestinal arteries supplying a loop more than 5 cm. in length be suddenly closed, the loop becomes hemorrhagic and necrotic. (Mall and Welch, Bier.) That the conditions are essentially identical in man is

proven by the experience of surgeons, who have repeatedly observed the same results after separation of the mesentery close to the intestine over about the same length. The blood can enter at each end of the short-loop arteries, whose branches anastomose freely within the walls of the loop with those of the closed artery, there being a particularly rich arterial plexus in the submucous coat. (Heller.) But these anastomoses are insufficient to preserve the part; although, with reference to the extent of territory to be supplied, they are large in comparison with some of the trivial anastomoses which in external parts can respond effectively to the call for a collateral circulation to far larger areas." (Welch.) It is probable that similar spasmodic contractions occur in other muscular structures when deprived of blood, and that these contractions markedly interfere with, or—as in the intestine—wholly prevent, the entrance of blood into the affected area for hours after the impaction of an embolus.

The condition of the collateral vessels has a large influence upon the results of occlusion of an artery, particularly in the extremities. If the vessels are narrow and inelastic as the result of atheroma, they are incapable of meeting the demand which is suddenly made upon them to carry more blood, and the part falls into gangrene. The same result follows if these vessels have been destroyed by an injury or pressed upon by extravasated blood, exudate, cicatricial tissue, tumors, deformities, and like conditions. If, on the other hand, the collateral vessels are normal, or, better, if they are abnormally dilated as the result of lesions *e.g.*, aneurysm, tumors, etc., which interfere with the passage of blood through the main vessel, the sudden demand for more blood is promptly met and the affected part sufficiently nourished to maintain its vitality. Even with abundant collateral vessels, however, it is necessary that the blood be propelled with sufficient force to supply the undernourished tissues; otherwise, death of the part ensues. Hence the greater danger of serious consequences of embolism in old age, during convalescence from an infectious disease, during the progress of an exhausting malady, in chronic cardiac and pulmonary affections, and in parts whose circulation is already sluggish as the result of conditions like varicose veins and aneurysm. In a word, the factors which influence the results in embolized areas are the character of the cells in the affected part, the number, size, and elasticity of the collateral vessels, spasmodic muscular contractions in the region deprived of blood, and the force of the circulation.

In the absence of an efficient collateral circulation the part beyond dies. Such death is called gangrene in the extremities and on the surface of the body, and may be either dry or moist, according to the quantity of fluid in the tissues at the time of death. The shape of the gangrenous area rarely corresponds to that of the affected portion of the arterial tree, owing to the fact that at least a portion of this tree is irrigated by adjacent vessels. In the viscera the necrotic area is called an infarct, and is wedge-shaped or conical, with the base toward the periphery of the organ. Gangrene terminates in death of the individual, or in separation of the dead part from the living by ulceration, the line between the living and the dead tissues being called the line of demarcation. An infarct may remain bloodless (white or anæmic infarct) or it may become infiltrated with

blood (red or hemorrhagic infarct) which comes from adjacent capillaries and passes through the altered vessel-walls of the part. Anæmic infarcts are most common in the spleen, heart, kidneys, and retina; hemorrhagic infarcts in the lungs and intestine. In either case coagulation necrosis occurs, *i.e.*, the intercellular lymph and the cellular protoplasm undergo coagulative changes. The area of necrosis is soon surrounded by a zone of inflammatory tissue, which generates granulation tissue. This granulation tissue gradually replaces the infarct, which undergoes absorption, the area finally being occupied by scar tissue, which may be pigmented in a hemorrhagic infarct, or calcified, especially in the lungs. Infarcts in the brain frequently form cysts. If the embolus is septic the infarct undergoes moist septic gangrene or forms an abscess (metastatic abscess). The same result may follow when an aseptic infarct is subsequently infected.

Symptoms.—We intend here to give merely the symptoms referable to the occlusion of arteries, and not those which depend upon the presence of bacteria, parasites, or living tumor cells. The latter are dealt with in other portions of the work. It need hardly be said that, in many parts of the body, small bland emboli give no symptoms. The lodging of an embolus is generally thought to be attended by sudden severe pain at the point of impaction. In none of the cases of occlusion of the arteries of the extremities which we have observed has there been marked pain at the seat of obstruction; rather has it been referred to the area from which the blood has been excluded, hence due to the acute anæmia. Perhaps, if the initial pain in an embolism of the visceral arteries could be definitely localized, such would be found to correspond with the infarcted area rather than with the seat of embolism. Whether or not the impaction itself causes pain, the ischæmic area, if supplied with sensory nerves, subsequently becomes the seat of severe pain. In viscera without sensory nerves the pain is due to involvement of the serous coat. In mesenteric embolism the pain is probably due at first to the violent tetanic contractions of the intestine to which attention was called above, and later to the peritonitis which follows gangrene of the bowel. In a case of embolism of the abdominal aorta under our care the initial pain was so severe and so situated that the condition was at first thought to be hepatic colic.

Pallor is a symptom which can be observed in superficial tissues only. If the collateral circulation fail, it is succeeded by the discoloration of gangrene.

Pulsation fails in the vessel and its branches beyond the embolus, and is, at least theoretically, of greater amplitude than normal above the obliterated point. Absence of pulsation is a valuable sign, not only in obstruction of superficial vessels, but also in obliteration of any vessel which has superficial branches—as, *e.g.*, the aorta, the subclavian, and the iliac. Direct palpation of the hardened vessel is possible only when it lies near the surface. Increase in the size and number of the collateral vessels can be detected after a time when such are superficial. A rise in the general blood-pressure always accompanies the sudden occlusion of a large artery. This rise of pressure is greatest at the time of occlusion and gradually diminishes with the establishment of a collateral circula-

tion. When the abdominal aorta is suddenly obstructed, the rise in blood-pressure is very marked and may be manifested by cyanosis, epistaxis, hæmatemesis, blood in the stools, etc., and by signs of acute dilatation of the heart and œdema of the lungs.

The temperature of the ischæmic area, when situated in the extremities, falls below the normal, and, if gangrene follows, it falls to that of the surrounding atmosphere. In the same situation, even in the presence of pain, sensation becomes obtunded, the degree depending upon the intensity of the anæmia. In the event of gangrene complete anæsthesia ensues, although, just as happens after amputation, sensation may still be referred to the affected part.

Paresis and later paralysis occur in voluntary muscles whose blood-supply is cut off. Thus, in the limbs, movement is impossible. After embolism of the superior mesenteric artery there are, at first, a violent contraction of the bowel and, later, paralysis with distention, fecal vomiting, and constipation. Hence the diagnosis of intestinal obstruction in many of these cases. After embolism of the abdominal aorta the bowel and bladder may both be paralyzed. We should not fail to mention, however, that embolism of either the abdominal aorta or the superior mesenteric artery may be followed by bloody diarrhœa. Besides blood in the stools and hæmatemesis, hemorrhage, as a manifestation of embolism, may show itself externally as hæmoptysis in pulmonary infarction and as hæmaturia in renal infarction.

The remaining symptoms of embolism are referable to the impairment of special functions, and hence vary widely with the part involved. We shall, on a later page, consider pulmonary embolism following operations. In the section on Contusion of Arteries we shall briefly review the effects of occlusion of the carotid artery, but, for the details of cerebral, as well as spinal, cardiac, hepatic, splenic, and kidney infarction, we shall refer the reader to works on internal medicine. Embolism and thrombosis of the mesenteric vessels are discussed in that part of the work which is devoted to abdominal surgery. Embolism of the retinal vessels, with its sudden blindness and characteristic ophthalmoscopic picture, can be properly dealt with only by the ophthalmologist. The effects of obliteration of the arteries of the extremities we have given in some detail under Contusion of Arteries. Of interest in connection with the subject of embolism is the frequency of serious results following the ligation of large arteries, a résumé of which will be found in the section on Wounds of Arteries and in Vol. IV.

Differential Diagnosis between Embolism and Thrombosis.—The most important points to be considered in differentiating thrombotic from embolic occlusion of an artery are the rapidity of onset, the duration of the symptoms, the condition of the collateral vessels, and the finding of a lesion which might induce thrombosis or be the source of embolism. Sudden and extensive manifestations of acute anæmia in the territory irrigated by an artery point to embolism; the gradual onset of such symptoms, particularly if limited in extent, suggests thrombosis. It should be recalled, however, that an embolus which does not at first completely block an artery, may simulate a thrombus, and that in a rapidly forming thrombus the symptoms may appear with the characteristic

abruptness of embolism. If the symptoms quickly improve, the condition is more likely embolism, because the collateral vessels at the onset of embolism are of normal size and may by prompt dilatation meet the demand made upon them for more blood. When, however, an artery is gradually occluded, the collateral vessels progressively dilate, so that by the time the stream of blood is completely interrupted they are no longer capable of supplying the immediate and extensive dilatation which is further required for nourishing the affected part; hence the symptoms are permanent or disappear only slowly. If, therefore, the collateral vessels are found enormously enlarged when the symptoms first appear, one might properly conclude that the condition is one of thrombosis.

The finding of the lesion responsible for the thrombus or embolus is sometimes difficult, sometimes impossible. The sources of emboli have been enumerated above; the lesions producing thrombosis will be found under Thrombosis. Embolism is so much more frequent than thrombosis in the arteries, that, in the absence of a definite cause for thrombosis, the diagnosis of embolism is generally made, even though the source of the embolus cannot be ascertained.

Treatment.—The prophylactic treatment of embolism is given below in the section on Pulmonary Embolism after operation and in the section on Phlebitis. The measures to be taken in order to prevent gangrene in embolism of the arteries of the extremities are identical with those given on a later page in describing the treatment of arterial thrombosis following injury. In the same section is mentioned the possibility of removing an embolus in an accessible region. Embolism of the mesenteric arteries is treated by laparotomy and removal of the gangrenous bowel, if such be possible. At least two successful operations for this condition have been reported. (Brunner, in *Deutsche Zeitschrift f. Chir.*, Bd. LXXXIX, No. 6.) The treatment of other forms of visceral infarction falls within the province of the physician, if we exclude the incision of secondary abscesses and the removal of organs whose main artery of supply is completely plugged—as, *e.g.*, the spleen and the kidney.

Different Forms of Embolism.

Pulmonary Embolism.—Pulmonary emboli originate in the right heart or in any portion of the general venous circulation. The materials of which such emboli may be composed have been mentioned on a previous page. At present we have in mind only detached portions of bland venous thrombi, particularly those occurring after operations and injuries. Septic pulmonary infarction belongs to the article on "Infections which sometimes Occur in Various Surgical Diseases and Conditions." (Vol. I.)

The injuries which are particularly liable to be complicated by embolism are those which are accompanied by excessive hemorrhage and those which, like fractures, are associated with a hæmatoma or an extensive extravasation of blood, thus combining pressure with the diffusion of fibrin ferment. Embolism is favored after labor by the increased coagulability of the blood at this time, by the trauma of childbirth, by the wide veins of the uterus, and by the contractions

of this organ. As a matter of course, any injury or disease in which phlebitis appears may be complicated by embolism. (See Phlebitis.) Varicose veins always present the possibility of thrombosis and subsequent embolism. For the blood disorders, acute infective diseases, cachectic states, and other conditions in which thrombosis and consequently embolism may occur, we shall refer the reader to the section on Thrombosis.

The operations which are most frequently followed by thrombosis and embolism are those involving venous plexuses—*e.g.*, varicocele of the spermatic cord or broad ligament, and varix of the lower extremity: those performed on anæmic patients—especially hysterectomy for bleeding fibroids; and those which, like abdominal section, necessitate a prolonged recumbent posture. According to various statistics thrombosis of the lower extremity occurs in from 1 to 4.64 per cent of all abdominal operations, and of these about 30 per cent follow hysterectomy for fibroma, 15 per cent oöphorectomy, 10 per cent appendicitis, and 5 per cent operations on the kidneys. If we view the question from another standpoint, we find, among 727 operations for fibroids of the uterus, over $2\frac{1}{2}$ per cent followed by phlebitis (Schenck), and, of 3,334 appendicectomies, almost 0.9 per cent followed by phlebitis. (Haward.) In Cordier's 232 cases of post-operative thrombosis 6 had lung complications and 3 others died suddenly. In 1,140 laparotomies analyzed by Albanus 23, or a little more than 2 per cent, showed signs of pulmonary embolism, and of these 10 died. Baldy had 13 sudden deaths in 366 cases after operations for fibroids of the uterus. Haward found 7 cases of pulmonary embolism in 3,334 operations for appendicitis. The danger of injecting coagulating fluids into venous tumors, of introducing paraffin for cosmetic purposes, and of the hypodermic use of mercury in syphilis should be recalled in this place. Some of the cases of post-operative thrombosis are undoubtedly due to infective phlebitis, but that all thromboses after operation are due to bacteria, as some surgeons suggest, is manifestly riding fashion too hard. Of the 232 cases of post-operative thromboses of the lower limb collected by Cordier, 166 were clean cases, and in 56 no mention of sepsis or asepsis was made. We believe that most of the thromboses following aseptic operations are due to non-bacterial changes in the blood and to slowing of the blood-current.

All operations and injuries in which veins are severed are necessarily followed by thrombosis, for such is nature's method for controlling hemorrhage. This "thrombosis insensibilis," as Witzel calls it, extends to the next branch above or to the place where the blood flows with its normal force. Here the blood-stream continually abrades the end of the thrombus until it is organized, the little particles which are washed from the thrombus passing into the general circulation and causing no trouble. This normal or physiological embolism, which belongs to the healing of all wounded blood-vessels, Witzel calls "embolia insensibilis." If conditions favorable for the production of thrombosis exist (for which see Thrombosis), the clot extends, successively involving larger veins (progressive thrombosis), until it makes its presence known by symptoms. As these are identical with those of thrombo-phlebitis, we shall defer their enumera-

tion until we take up this subject. A thrombus which, in its extension, exceeds normal limits, but which gives no clinical signs of its existence, is called a latent thrombus. Such thrombi have been responsible for most of the cases of pulmonary embolism occurring in our own practice. We offer two reasons for this:—First, without clinical manifestations of thrombosis, no precautions are taken against embolism; secondly, a latent thrombus which is just extending into a large vein, without as yet completely occluding it, is more readily washed away than an extensive adherent clot which blocks the same vein and its branches and produces symptoms. In one case, after an operation for non-suppurative appendicitis, we had symptoms of pulmonary embolism at the end of the first week and the appearance of phlebitis of the left lower extremity at the end of the second week. We have already mentioned the preference thrombosis exhibits for the veins of the lower extremity and have given the reasons advanced for this preference. Cordier found that, in 232 cases of post-operative thrombosis, the left leg was involved in 213, the right in 11, and both in 8 cases. When the thrombosis is the result of a direct extension of a perivascular septic process the veins involved are, of course, those in the immediate vicinity of the wound.

Symptoms.—From the standpoint of symptomatology emboli lodging in the lungs may be divided into three classes, according to their size. We speak of the effects of embolism *per se*, and not of the septic processes which follow infective emboli.

1. Minute emboli cause no symptoms; indeed, as we have already indicated, "embolia insensibilis" may be regarded as a normal process after wounds of vessels.

2. Emboli large enough to block a medium-sized branch of the pulmonary artery may be followed by trifling or serious symptoms, according to the condition of the pulmonary circulation. If the force of the blood-stream is vigorous and the lungs normal, infarction does not occur, owing to the number and large size of the capillaries through which the area supplied by the blocked vessel is promptly nourished. If, however, the lungs are already diseased or the pulmonary circulation sluggish, hemorrhagic infarction may occur. This appears suddenly and often at a later period than the large emboli to be mentioned below. It presents the same symptoms and signs as pleuropneumonia. Bloody expectoration as a symptom of hemorrhagic infarction of the lung may be absent and necrosis of the infarct does not necessarily follow. It is not improbable that many of the pulmonary symptoms appearing as a pleurisy or mild pneumonia, most often within a few days or a week after operation, are in reality due to embolism.

3. A large embolus occluding the pulmonary artery generally causes instantaneous death. The same result may follow the plugging of one of its main branches, or the patient suddenly complains of severe pain about the heart and dyspnœa and dies within a few minutes. If the vessel is not completely blocked life may be prolonged for hours and occasionally for days. Indeed, in a few instances recovery has followed the appearance of even the most alarming symptoms. In these cases, in addition to the precordial distress and dyspnœa, the

respirations are rapid, the face cyanotic, the eyes protruding, the pupils dilated, the cervical veins swollen, and the pulse quick, weak, and perhaps irregular. The patient is restless, covered with cold sweat, and scents death. In other cases there is delirium or coma, and sometimes convulsions occur. In the early stages physical examination of the chest may reveal nothing abnormal; later, signs of œdema of the lungs appear. If we exclude operations involving the major veins, emboli of sufficient size to block the large pulmonary vessels rarely occur before the second or third week and seldom after the sixth week. The accident not infrequently follows some movement or pressure on the thrombosed vein, most often sitting up in bed, which necessitates acute flexion of the groin.

Treatment.—Although so little can be done after an embolus has been thrown into the circulation, much may be accomplished in preventing this accident. All those measures which are taken before operation to improve the general condition of the patient act in a prophylactic manner toward thrombosis and embolism. Particularly important is attention to the heart and lungs, if they are functionally impaired. During operation asepsis, careful hæmostasis, avoidance of bruising the tissues, particularly veins, by tearing or by the vigorous use of retractors, protection of the patient from cold, covering exposed viscera with hot compresses—all these are measures of importance against thromboembolism. Bandages applied too tightly should be avoided. After operation, shock should be combated and the normal functions resumed as quickly as possible; *i.e.*, the secretions should be attended to, the bowels moved daily, the regular diet reached at an early period, and the patient allowed out of bed as soon as possible. When the patient must remain in bed for a long time centripetal massage may be given and movements of the arms and legs encouraged. Witzel has the window open and orders the patient to take breathing exercises; if deep breathing cannot be practised because of pain, he advises small doses of morphine. Cardiac stimulants should be given if the circulation is sluggish.

In order to prevent thrombosis Lennander suggests raising the foot of the bed after abdominal operations, to favor the return flow of blood, particularly in the presence of cardiac asthenia or varices. In cases in which conditions are favorable for a progressive thrombosis, some of the substances likely to diminish the coagulability of the blood, which we have mentioned under Thrombosis, may be administered. Special mention should be made of citric acid, which Wright and Knapp* found, in 36-grain doses three times daily, to have a marked influence in lessening the clotting power of the blood during typhoid fever. They suggest also decalcifying milk by adding to each pint from twenty to forty grains of citrate of soda. Before progressive thrombosis makes itself known by local signs there may be a step-like increase in the pulse rate, with normal temperature (Mahler's symptom). This sign would be of great importance for an early diagnosis were it not that the pulse is influenced by so many other conditions and that the sign is by no means always present. After thrombosis has declared itself the part should be kept absolutely quiet, the patient being warned against any sudden movement. Tight bandaging, inunctions, and massage should be

* Trans. of Royal Med. and Surg. Soc., vol. lxxxvi., 1903.

avoided. Even palpation of the gentlest sort is attended with danger. (See treatment of Phlebitis.) Cardiac stimulants should be administered if the circulation is poor, in order to maintain an active flow of blood through the lungs and to encourage "embolia insensibilis." Sitting up and walking are not absolutely safe until the end of six weeks from the beginning of the process.

The treatment of embolic pneumonia differs in no way from that of ordinary pneumonia. In blocking of the pulmonary artery or one of its large branches, if the patient survive long enough, cardiac stimulants, oxygen, and perhaps bleeding may be employed.

Trendelenburg * suggests the removal of thrombi from the pulmonary artery, if the patient lives long enough for such procedure, by introducing a syringe into the pulmonary artery through an incision in the conus arteriosus, after thoracotomy. He tried this operation on an old woman, but was unable to draw the heart forward because of pericardial adhesions. At the autopsy the embolus, which was 10 cm. long and almost as thick as a finger, was found in the left pleural cavity, whether as the result of the "heart-pump," or not, could not be ascertained. Trendelenburg † later gives the following as a more simple and certain procedure: "A tongue-shaped flap, 8 to 10 cm. long, is made under the left clavicle, with the base at the left margin of the sternum. The upper edge corresponds with the under edge of the first rib, the lower with the upper border of the third rib. A portion of the second rib, extending outward from the sternum a distance of from 6 to 7 cm., is resected. If this does not give enough room, the third rib is included. Through the open pleural cavity the pericardium is incised at the level of the third rib, care being taken to avoid the phrenic nerve. The incision is extended above until the whole upper half of the pericardium is opened. The edges of the pericardium are then drawn toward the external wound with forceps, while an olive-tipped, curved sound is passed sidewise alongside of the pulmonary artery and, with a screwing motion, is pushed through the sinus pericardii transversus behind the pulmonary artery and aorta until its head reaches the sternum. The pulmonary artery is compressed against the sound with a finger, after the anterior wall of the artery is freed from the visceral layer of the pericardium and from fat. The artery is then incised and the embolus withdrawn with polypus forceps, which may, if necessary, be passed into the branches of the artery to a depth of from 6 to 8 cm. The wound is clamped with bent forceps in such a way that the edges of the arterial wound project a few millimetres beyond the forceps. The compression on the artery is now removed, the wound in the vessel is sutured, and the clamp is removed." In animals the artery was compressed for from one to two minutes without seriously interfering with the movement of the heart. Sievers ‡ removed two emboli—one 21 cm. long and 10 to 12 mm. in diameter, and the second 15 cm. long and 7 to 9 mm. in diameter—from the pulmonary arteries of a woman, twenty minutes after the onset of the symptoms. He

* Centralblatt f. Chir., 1907, No. 44, p. 1302.
† Centralblatt f. Chir., 1908, No. 4, p. 92.
‡ Deutsche Zeitschrift f. Chir., May, 1908.

used the last method described by Trendelenburg. The operation was terminated without difficulty and the patient lived fifteen hours.

Air Embolism.—As we have never had the misfortune to meet with this surgical catastrophe we shall base the following paragraphs largely upon a recent study of this subject by Delore and Duteil.*

Historical Sketch.—Since the middle of the seventeenth century various experimenters have caused death in animals by the introduction of air into the veins. Beauchêne, in 1818, was the first to publish a case in the human being, the accident occurring during the removal of a large tumor in which the external jugular vein was accidentally opened. In 1707 Méry reported a case of death from air embolism, but the observation is generally discredited. In 1839 Amussat was able to collect thirty-two cases, and in 1864 Green gathered sixty-seven cases. After the introduction of general anæsthesia the accident became very much less frequent, owing to the abolition of the struggles and crying of the patient, which could but tend to facilitate the entrance of air into an open vein. The tying of veins before they are cut or before their immediate seizure with hæmostatic forceps after they are cut, also has rendered air embolism exceedingly rare. Indeed, at the present time the accident is a surgical curiosity and some have doubted even its existence. It is quite probable that a number of the deaths from so-called air embolism were due to shock, the anæsthetic, or clot embolism. Welch calls attention to the importance of a bacteriological examination in cases in which gas is found in the circulatory apparatus at autopsy, as such gas may be generated after death by the bacillus aërogenes capsulatus or other gas-producing organism. In 1889 Hare introduced large quantities of air into the veins of animals without fatal consequences—quantities which were larger than could possbily enter during a modern surgical operation. It seems to have been proved that more depends upon the rapidity with which the air enters than upon its quantity.

Etiology.—Air may pass into the veins during the administration of an intra-uterine douche after labor, during intravenous infusion, and especially during operations at the base of the neck when the veins are gaping either from pathological change, anatomical disposition, or the result of the traction force of aspiration. Cases are cited which have followed cut-throat and venesection. The amount of air which might be introduced into a vein by the ordinary hypodermic syringe would probably be insufficient to cause serious trouble. The symptoms occurring in caisson disease are attributed by some to the formation of nitrogen bubbles in the blood. Janeway believes that the cerebral phenomena which sometimes follow irrigation of the pleural cavity in empyema may be due to air embolism. Lewin and Goldschmidt have demonstrated the possibility of air embolism after the injection of air into the bladder. The "dangerous zone" is the base of the neck and the apex of the axilla, as here the suction power of the thorax during inspiration is more marked than anywhere else in the body. Furthermore, the veins of the neck are more or less fixed by the fasciæ which they traverse and they remain gaping when severed.

*Rev. de chir., 1905, p. 229.

This arrangement is evidently intended to resist atmospheric pressure during diastole of the right auricle and expansion of the thorax. In about half the cases the internal jugular is the vein affected. Next in order of frequency come the external jugular and then the axillary or one of its branches. Cases of death following the entrance of air into the dural sinuses, facial, median, and internal saphenous veins also have been reported, as well as several apparently certain cases following labor. Delore * reports a case which occurred during a hysterectomy. Low † had a sudden death from air embolism during the puncture of a liver abscess, the cannula having been introduced into a large vein. In the dog Fischer found that in a large wound of the internal jugular at the base of the neck the entrance of air is constant, and almost constant in a similar wound of the axillary. Wounds of the external jugular and femoral were not, however, followed by such accident. Wounds of the external iliac and even of the inferior vena cava, according to Delore and Duteil, are not followed by the aspiration of air, even when the wound is made to gape by means of a cannula. On placing a cannula in a vein, after bleeding the animal, they observed the entrance of small doses of air, causing cyanosis, agitation, and an augmentation of the venous pressure, which forced the blood out through the cannula, thus arresting the aspiration. When the animal became calm the same phenomena were again observed. They were never able to obtain death in this fashion. When, however, a large quantity of air (40 to 60 c.c.), was introduced by means of a syringe, death followed in from one to two minutes. They conclude that the anæmia consecutive to hemorrhage favors the introduction of air into the veins, but only in doses insufficient to cause death. The rigidity of the walls of a vein as the result of phlebitis, or as the result of adhesion to tumors or perivenous inflammatory masses, also favors the inspiration of air. The veins may be made to gape also by the surgeon—as, for instance, by traction on tumors, extension of the head, and abduction of the arm in axillary dissections. Finally, in anæmia, in which the mass of blood is diminished while the capacity of the vessels remains the same, the entrance of air is greatly facilitated. It is not so much hemorrhage during operation which creates this danger as it is repeated hemorrhages previous to operation. In the former case the passage of blood from the vessel prevents the entrance of air.

Pathology.—The cause of death has been explained in several ways. Morgagni, and subsequently others, believed that bubbles of air are carried to the brain as emboli and that interference with the functions of the cerebrum is the primary cause of death. In support of this theory attention is called to the fact that in many cases the heart continues to beat for a certain length of time after the cessation of respiration and the production of unconsciousness. Nysten, Nicaise, and others have demonstrated, however, that the pulmonary capillaries offer an almost insuperable obstacle to the passage of air to the arteries, and they find in overdistention of the right auricle sufficient reason for death. Against this theory is lodged the fact that it would require a forced injection of air to raise the intra-auricular pressure to such a degree as to prevent contraction of

* Rev. de chir., Oct., 1903. † Arch. de méd. navale, 1907, No. 6.

the auricle. Under other circumstances the air has never a pressure superior to that of the venous tension. Moreover, the clinical fact remains that the heart continues to beat after other vital functions have been abolished. D'Etiolles thought that the air which is driven into the pulmonary capillaries ruptures them, thus producing an emphysema which compresses the neighboring capillaries and arrests the pulmonary circulation. Couty, however, was unable, in twenty-eight autopsies, to demonstrate emphysema in a single instance. Boerhaave, in particular, advanced the theory that the presence of air prevents the movements of the blood, because the bubbles do not permit the liquid particles to communicate, and hence prevent the transmission of the impulse given by the heart and the great arteries. Passet and Hauer found abundant explanation for death in air embolism of the pulmonary arteries, claiming that the frothy mixture cannot be driven through the pulmonary capillaries. Experimentally, the great difficulty of forcing frothy fluid through a capillary tube is easily demonstrated, but several experimenters have proved that air injected into an artery may appear in the veins and *vice versa*. Couty's explanation is as follows: —The air passes into the right auricle and ventricle, which it distends. The force of the contractions remains the same, but the resistance augments with the surface of the distended walls; hence the auriculo-ventricular contractions become incomplete, particularly in the auricle, and the cardiac orifices dilate. The air is pumped into the lungs and backward into the veins, insufficient blood reaches the brain, and fatal syncope ensues. Recently (1903), François-Franck, as the result of experimentation, came to the following conclusions:—A large quantity of air introduced into the veins accumulates first in the auricle, then in the ventricle, both of which it distends. The air is then mixed with the blood and passes into the pulmonary artery and back into the veins. The reflux of frothy blood into the veins results from the contractions of the ventricle as well as from those of the auricle, since the tricuspid orifice is dilated. The froth passes backward along the veins to the nervous centres, bubbles being found in the finest of the capillaries. At the same time the spumous blood passes into the coronary veins and through the pulmonary circulation to the left heart and the arteries. Death, however, is not due to mechanical obstruction to respiration. Through the arteries the froth is projected to the nervous centres, the veins of which are already filled with the same material, and an acute anæmia follows. The myocardium perishes as the result of air embolism of the coronary vessels.

The Symptoms.—The first sign to attract attention is a whistling, hissing, sucking, or gurgling sound, which may be accompanied by the appearance of bubbles in the wound. Such sounds, however, are not uncommon during operations on the axilla, the base of the neck, and the abdomen, or in fact in any region in which a tense layer of tissue is divided, thus allowing air to pass beneath it. In these cases, however, there are no symptoms. At the base of the neck hissing may be due also to accidental wounding of the pleura. Before the days of anæsthesia, immediately after the suction sound the patient would give a cry of agony, see death approaching, and be seized in the throes of a convulsion

or rapidly fall into syncope, with pale and livid face, dilated pupils, eyes turned upward, and often foam covering the lips. Now the picture is less dramatic. The respirations become rapid and noisy, the pulse quick and weak, and a gurgling sound is occasionally heard over the heart, which continues to beat for some time after the arrest of the respiration and pulse. Epileptiform convulsions sometimes occur, and death follows in a few minutes or perhaps not for several hours. Occasionally death takes place suddenly and quietly without even the initial bruit. Again, cases have been reported in which death has not occurred for several days. Poncet, in 1904, reported a case at the Lyons Medical Society in which, during the opening of a deep abscess of the neck, air entered the veins. The patient died fifteen days later with bizarre circulatory and respiratory symptoms. At the autopsy bubbles of air were found in the heart and large veins. The accident is not always fatal, however, and, according to Fischer, the patient in about half of these cases recovers. A few who have escaped the immediate dangers have perished at a later period from pneumonia.

The Treatment.—Certain precautions should habitually be taken when one operates in the dangerous zone. The wound should always be large enough to permit careful dissection, and the patient should be fully anæsthetized, so that there shall be no struggling. Instead of cutting and tying, one should tie and cut; in other words, whenever possible, the vessels should be isolated by blunt dissection and secured by a ligature before being severed. Bleeding vessels should be caught at once with hæmostatic forceps. The structures should not be torn apart, as the veins are thin-walled and easily injured. The fact should also be recalled that traction empties a vein, so that it may be quite unrecognizable and thus be severed for an adhesion or a band of fascia. In doubtful cases the band should be treated as a blood-vessel. All cervical veins, except the finest, should be permanently secured by a ligature, and forcipressure should not be depended upon, as such is unreliable, owing to the increased intravenous pressure in this region when the patient vomits, cries, or strains during the recovery from anæsthesia. Murphy places a gauze tampon beneath the sternal attachment of the sternomastoid muscle, in order to render the veins prominent and prevent the danger of negative pressure. Theoretically, at least, goitre operations under local anæsthesia predispose to air embolism. A hissing sound always demands immediate pressure with the finger or a sponge and careful investigation to determine its cause.

In the actual presence of air embolism the finger or a sponge should be immediately pressed over the opening in the vein, in order to prevent the entrance of more air. The vein may then be caught with hæmostatic forceps and ligated at a later period. It has been suggested that the wound be filled with salt solution so that air may be excluded, but this, of course, would not check continued bleeding from the peripheral segment of the vein. As soon as the opening has been secured, artificial respiration should be instituted, if needed, and stimulants administered hypodermatically. The proposal to keep the wound closed while inspiration is made, and to allow it to gape during expiration, is, of course, impracticable. On theoretical grounds it has been advised to raise the

patient to a sitting posture, in order to allow the air, which is lighter than the blood, to escape from the wound in the vein. This also is a procedure which would be more harmful than useful, as it would contribute to the anæmia of the nervous centres, hasten the respirations, and thus encourage the entrance of more air. Whether the patient should be bled or not, is a question on which surgeons differ; if such is desirable to relieve the embarrassed right heart, one of the veins at the bend of the elbow should be selected. Several authors have suggested the removal of the air which has gained entrance to the circulatory apparatus. Magendie introduced a tube into the injured vein and performed aspiration. Bégouin injected into the veins of animals a quantity of air which, as he had experimentally determined in other animals, would cause death. He then plunged the needle of an aspirator into the right ventricle and was able to save the life of the animal and demonstrate the escape of air by allowing it to pass through a layer of liquid. Delore and Duteil suggest that the needle be introduced into the auricle, since it suffers most from the distention in consequence of its thin walls. For this purpose the needle should be introduced in the third left interspace, about 1.5 cm. from the border of the sternum, in order to avoid injuring the internal mammary artery; and, as soon as the thoracic wall has been passed, the needle is pushed on obliquely toward the middle line. Although the edge of the lung may be punctured, the wound is so small that no ill consequences need be feared. The right auricle has been punctured in several instances, with success, for acute pulmonary œdema (Westbrook, Lévy, Dana) and once for air embolism; and, in the case reported by Delore and Duteil, large quantities of air mixed with blood were removed with a Potain aspirator, but the heart ceased to beat soon afterward.

Fat Embolism.—Historical Sketch.—Although obstruction of the vessels of the lungs and other organs by fat was spoken of by Magendie as early as 1827, and although Mueller, in 1860, reported a case of nephritic amblyopia in which the choroid vessels were filled with oil globules, the first case of veritable fat embolism was not reported until 1862, when Zenker found the pulmonary vessels loaded with fat, in a man who died after multiple fractures associated with rupture of the liver and stomach. In the same year Wagner published two cases which occurred during pyæmia and which led him to believe that fat embolism and pyæmia were intimately associated; but in 1865, as the result of a study of forty-eight cases collected from the literature, and of the experiments of von Bergmann (1863), he became convinced that the association was only accidental. It remained, however, for Busch, in 1870, to give the first accurate description of fat embolism, based largely on animal experiments carried out under the direction of von Recklinghausen. In 1895 Groubé * stated that there could be found in the literature the reports of 211 cases. Carrington states that 276 cases have been reported up to 1908 (Thesis for prize offered by Chair of Surgery at Jefferson Medical College, 1908), in only 40 of which the diagnosis was confirmed by careful autopsy by a competent pathologist.

Etiology.—Fat is a normal constituent of the blood in the proportion of

*Rev. de chir., July, 1895.

from one to three parts to the thousand. It is physiologically increased in amount during digestion, in obesity and pregnancy, and in the nursling, and is found in pathological quantities in many diseases, among which are gout, arteriosclerosis, diabetes mellitus, menstrual suppression, many acute fevers, chronic alcoholism, chronic nephritis, splenitis, tuberculosis, poisoning by phosphorus, potassium chlorate, and carbon monoxide, and in certain diseases of the heart, liver, and pancreas.* Lipæmia, occurring in the conditions mentioned above, does not cause sufficiently extensive fat embolism to induce symptoms, although at autopsy, particularly in cases of diabetes and atheroma, capillaries have been observed filled with oil globules.

It is probable that all extensive injuries involving fatty tissues are accompanied by an increased amount of fat in the blood, but such is rarely of sufficient quantity to cause trouble. Fat embolism, recognizable as such clinically, is most frequently seen after fractures and inflammation of long bones, owing to the disturbance of the medulla, but it may occur likewise after injuries or inflammation of any tissue containing fat. Of 177 cases of fat embolism cited by Scriba, 51.5 per cent were caused by fractures of bones, 14 per cent by acute and chronic inflammatory lesions of bones, 11 per cent by suppuration of the soft parts, 7 per cent by injuries of the soft parts, 7 per cent by degenerations of the osseous medulla, and 2 per cent by lesions of the fatty tissue within the abdomen. Of the 276 cases collected by Carrington, 60.8 per cent were caused by fractures. Amputations, resections, bloodless orthopedic manipulations (*e.g.*, breaking joint adhesions), and operations which, like excision of the breast, involve masses of fatty tissue, are among the surgical procedures which have been followed by fat embolism. It is said to occur also after child-birth, owing to injury to the pelvic fat. Old thrombi which have undergone fatty degeneration may be the origin of emboli containing large quantities of fat. The condition is rare in infants and in old age, most cases occurring between the twentieth and fiftieth years, and is three times more frequent in men than in women, owing to the greater exposure of the former to injuries.

Pathology.—After injuries fat passes into the blood-stream either directly through wounds in the veins or indirectly through the lymphatics. In either case the process is aided by the pressure of extravasated blood or inflammatory infiltration. Certain authors doubt the possibility of embolism caused by fat which has reached the blood through the lymphatics, regarding the lymph nodes as effective barriers against such accident. The occasional occurrence of fat embolism, however, at a time when the wounds in the veins are sealed with clot, seems to favor the view that sufficient fat can enter the circulation through the lymphatics to cause embolism. Perhaps the oil globules, when excessively numerous, reunite after passing through the lymph nodes and thus give rise to vascular plugging. At any rate, fat once in the blood-stream passes through the right heart and lodges in the lungs, here giving rise to symptoms much like those of other emboli. The occurrence of septic processes in fat embolism is purely accidental and depends upon the presence of micro-organisms,

*"Clinical Hæmatology," by J. C. Da Costa, Jr.

as the fat itself is not irritating. Owing to the non-adhesive character of oil globules and the large size of the pulmonary capillaries, fat is readily forced through the lungs to the left heart, whence it is distributed to all parts of the body, being taken up by the tissues, oxidized in the blood, or passed out of the body in the excretions, especially the urine. When death follows, it is caused by pulmonary œdema, cerebral embolism, or plugging of the coronary arteries.

The Symptoms.—As already indicated, fat embolism may be latent. As is the case with air, it is probable that a large quantity of fat must be introduced into the circulation in a short time in order to produce serious symptoms. Unlike clot embolism, which is usually postponed a week or longer after an operation or an injury, fat embolism commonly occurs within from thirty-six to seventy-two hours. Occasionally, however, the accident does not supervene for many days. The symptoms resemble in many respects those produced by other forms of emboli. When a large quantity of fat is suddenly washed into the pulmonary vessels, rapid death may follow, with symptoms similar to those of clot embolism. If the quantity is smaller, there are severe pain, dyspnœa, hurried, shallow respirations, cyanosis, and sometimes hæmoptysis. At the onset the body-temperature is apt to be subnormal, but later it ascends. The physical signs are at first indefinite; there may be a normal percussion note, restriction of the respiratory excursions, and coarse râles; if the patient survives, the later signs are those of consolidation. If the oil globules are forced through the pulmonary capillaries, there may be fat in the urine or total suppression of urine, and symptoms of embolism of the brain (convulsions, paralysis, coma, etc.). As might be expected, less severe symptoms are caused when the quantity of fat is still smaller, and in most of these cases fat embolism is never considered by the attending physician. If, in the presence of pulmonary symptoms after operation or injury, fat can be demonstrated in the urine, one should think of fat embolism, although it is probable that careful examination will reveal at least a slight lipuria after all operations and injuries in which many fat cells are ruptured. Lipuria may, of course, be encountered also in any of the conditions mentioned above in which excessive lipæmia is found. Scriba was able to demonstrate the presence of fat in the urine of all his cases of fracture. He found, however, that in fat embolism the lipuria was intermittent. The fat could be found from the beginning of the second to the fourth day, for several days; from the beginning of the tenth to the fourteenth, for several days; and thereafter at intervals of from six to ten days, until the end of the third, fourth, or fifth week. Statistics on the mortality of fat embolism are useless, as many of the lighter cases cannot be recognized, and in even the fatal cases, unless a very careful autopsy is made, death is ascribed to some other cause. Perhaps further researches as to the quantity of fat in the urine in these cases may establish some relation between the lipuria and the prognosis. Certain it is that, in a case of lipæmia, a diminution or total cessation in the fat excreted by the kidneys would favor vascular plugging, unless the source from which the oil globules are derived had been exhausted. This thought immediately suggests an investigation of the blood itself for fat, which, so far as we know, has not been

done in cases of fat embolism. Carrington found fat 13 times in 19 examinations of the blood of 3 cases of fracture, without symptoms of embolism; in the same cases he found fat in the sputum in 6 of 16 examinations. Finally, in cases of fat embolism one may find changes in the eye grounds upon ophthalmoscopic examination.

Treatment.—In order to prevent fat embolism, injuries, operative or accidental, which render a patient liable to this catastrophe should be kept at rest. Tight bandages and massage are dangerous in such cases. In wounds in which large quantities of fat are crushed, all oil gobules should be removed by irrigation, and drainage should be instituted. The incision of inflammatory lesions and the removal of stitches in wounds in which there is much tension, are also prophylactic measures of importance. Riener,* who states that he saw ten cases of fat embolism after bloodless orthopedic operations, during the last year, now performs such operations after applying a constricting band to render the limb bloodless. Before removing the band at the completion of the operation, he inserts a cannula into the upper end of the saphenous vein and pushes it on into the femoral vein. The band is then removed and the first rush of blood washes through the cannula any fat which may have entered the vein. Although Riener states that he has seen considerable quantities of fat flow through the cannula, he will probably not have many imitators, as the precaution is too formidable for an accident which occurs so rarely.

The treatment of the condition itself, in acute cases, is external heat, cardiac stimulation, and artificial respiration. The wound should always be opened, irrigated, and drained, to prevent the fresh entrance of fat into the circulation. The later treatment is that of the complications, of which the most important are œdema or inflammation of the lungs, cerebral embolism, and partial or total suppression of urine.

IV. ARTERITIS.

Arteritis, or inflammation of an artery, may be acute or chronic. Anatomically, the process may be divided, with reference to the arterial tunics, into periarteritis, mesarteritis, and endarteritis; but, from a clinical standpoint, this classification is of little value, as all three coats are generally more or less involved at the same time. It is not our intention to enter into a discussion of the medical features of this affection, which are fully described in works on internal medicine, but merely to present the subject from a surgical standpoint.

Acute Arteritis.—Acute arteritis may be productive (plastic) or suppurative (necrotic).

Acute Productive, or Plastic, Arteritis.—Acute productive arteritis follows injury of an artery or the impaction of a bland embolus. This is the form of arteritis which seals vessels after ligation, torsion, and wounds. As we have already pointed out, the vasa vasorum dilate, exudation follows, the intimal cells proliferate, and the clot is displaced by embryonic cells which are finally con-

*Centralblatt f. Chir., 1907, No. 13, p. 1272.

verted into fibrous tissue, thus obliterating the vessel. Acute arteritis may occur likewise during the course of, or just subsequently to, certain infectious diseases—viz., influenza, pneumonia, rheumatism, diphtheria, puerperal fever, syphilis, septicæmia, and the acute exanthemata. The disease exhibits a predilection for the arteries of the limbs, especially the lower. It is probable that the inflammatory changes in the arteries are induced by toxins; indeed, Thérèse found that the same lesions were caused by injections of the toxins of the streptococcus as by the organisms themselves.

The Symptoms.—The symptoms of acute arteritis during or following infectious fevers are pain, tenderness, and occasionally redness and swelling along the course of an artery. If thrombosis occurs the vessel, when superficial, may be felt as a hard cord, the pulse below is greatly diminished or absent, and the part from which the blood is shut off becomes cold, pale, paretic, paræsthetic. In the absence of an efficient collateral circulation the gangrene which follows is of the dry variety, unless the vein is simultaneously involved or unless the necrotic parts become infected.

The Treatment.—The treatment, in the initial stage, is identical with that advised for arterial thrombosis. (See Contusions of Arteries.) If gangrene ensues, the part should be removed according to the rules laid down in the article dealing with gangrene (Vol. II.).

Acute Suppurative, or Necrotic, Arteritis.—Acute suppurative arteritis arises from septic processes in the environing tissues or from an infected embolus. An acute septic endarteritis, resembling malignant endocarditis, with which it is usually associated, has been described. In suppurative arteritis distinct abscesses may be seen in the walls of the vessels, which subsequently become necrotic and separate as sloughs. This occurrence is always preceded by the formation of a thrombus, which, particularly in the smaller vessels, may remain sufficiently firm to prevent bleeding. If, however, the septic process invades the clot and causes it to undergo liquefaction, hemorrhage follows. Secondary hemorrhage is almost entirely due to this cause. In order to emphasize this fact more strongly it has been suggested that secondary hemorrhage be called septic hemorrhage. Suppurative arteritis rarely occurs unless the walls of the vessel have been previously injured; in fact, large arteries may be dissected from the surrounding tissues for a considerable distance by pus, and yet remain intact. This remarkable immunity from inflammation exhibited by uninjured arteries in contact with septic foci, now known to be relative only, was at one time thought to be absolute; indeed, in 1842, Liston's report of the first case of ulceration of an artery in contact with a purulent area was denied admission to the Transactions of the London Medico-Chirurgical Society, on the ground of inaccuracy. According to Monod,* who, in 1882, collected eighty-eight cases, ulceration of arteries occurs most frequently in connection with tuberculous abscesses and suppurative lymphadenitis, the result of infectious diseases, particularly scarlatina. The internal carotid has been opened by a suppurative tonsillitis and as the result of caries of the petrous portion of the temporal bone;

* Bull. de la Soc. de Chir. de Paris, 1882, p. 666.

in the latter instance perforation regularly occurs in the knee of the artery, in the carotid canal. The common carotid, the external carotid, and the smaller arteries of the neck have been ulcerated by neighboring suppurating processes—the aorta in tuberculous spondylitis, the common, internal, and external iliacs in appendiceal abscess,* the femoral in bubo, the popliteal in tuberculosis of the knee, the arteries of the palm and hand in cellulitis, and the intercostals in empyema. In these cases drains, foreign bodies, sequestra, etc., are said to have had no influence in causing the hemorrhage. The perforative ulceration of an artery may further be exemplified by the hæmoptysis of pulmonary tuberculosis, the hæmatemesis of gastric ulcer, and the bloody stools of ulcerative lesions in the intestine. The violent hemorrhages occurring in certain cases of malignant disease are due, not to a suppurative arteritis, but to invasion of the walls of the artery by the tumor cells.

The Symptoms.—Suppurative arteritis is rarely suspected until a hemorrhage occurs. Occasionally this takes place in an abscess before it has been opened. In such cases, if the artery involved is a large one, the abscess suddenly increases in size and takes on the characteristics of an aneurysm. In other instances the vessel gives way when the pressure upon it is relieved by an external discharge of the pus. Finally, the bleeding may not occur for days or weeks after the opening of the abscess.

The Treatment.—The treatment consists of direct compression, for the immediate control of the bleeding, and exposure and ligation of the affected artery on each side of the perforation. The cavity should then be thoroughly disinfected and drained. Some surgeons advise, because of the fear of infection of the ligature and repetition of the bleeding, ligation in continuity. Owing to the uncertainty of ligation in continuity (see Ligation for Wounds of Arteries), we believe that it should be performed only under very exceptional circumstances.

Chronic Arteritis.—Chronic arteritis (arteriosclerosis, chronic endarteritis, atheroma) is a chronic, inflammatory, and degenerative process of the arterial walls, which may involve the capillaries as well as the arteries (*arteriocapillary fibrosis*), and invade even the veins (angiosclerosis).

The causes are old age, increased blood-pressure, the result of habitual overeating and excessive muscular efforts, and chronic intoxications, among which may be mentioned syphilis, gout, rheumatism, alcoholism, lead poisoning, nephritis, diabetes, and excessive indulgence in tobacco. Occasionally the condition is observed after one of the acute infectious diseases such as scarlatina, typhoid fever, and influenza, it having possibly begun in these cases as an acute infection.

Chronic arteritis may be circumscribed or diffuse. The circumscribed form is seen most often in the large vessels, particularly the aorta, in the form of more or less nodular whitish patches, sometimes as large as a small coin, which are due to a proliferation of the deeper layers of the intima. (Fig. 69.) These patches may become fibroid or calcified (atheromatous plate), or they may undergo fatty

* Lebon, Thèse de Paris, 1893–94.

degeneration, becoming yellowish in color and cheesy in consistency (atheromatous abscess). Such an abscess, on discharging, leaves a necrotic patch (atheromatous ulcer). The media is often invaded by the disease and the outer coat thickened. Diffuse arteriosclerosis more commonly attacks the small vessels. The entire arterial wall is thickened, and the internal coat undergoes fatty degeneration and may subsequently be calcified.

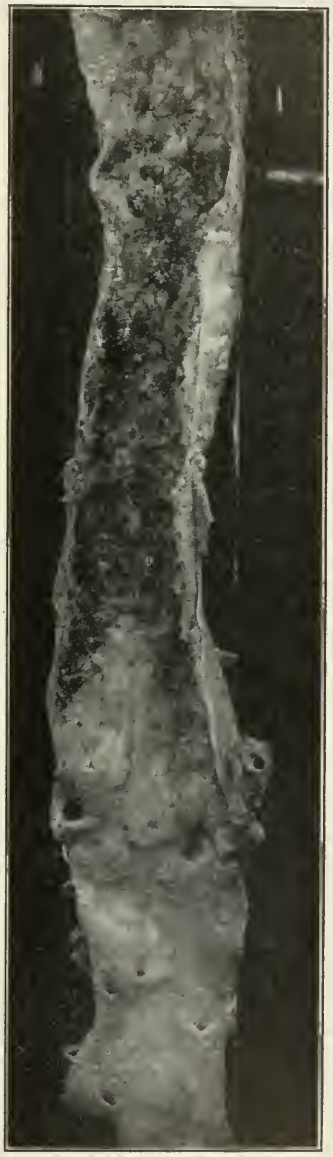

FIG. 69.—Photograph of an Aorta Affected with Chronic Arteritis. (Specimen from Pennsylvania Hospital Museum.)

Although arteriosclerosis is a condition which properly belongs to the physician, it possesses certain important surgical relations which require at least brief mention. The increased liability of diseased arteries to thrombosis following an injury (including the application of the Esmarch band), and the influence of narrowed arteries in causing bad results after ligation, after the impaction of an embolus, and in thrombosis, are pointed out further on, in the sections devoted to these subjects. The possibility of secondary aneurysm as the result of compression of a diseased artery we shall have occasion to mention on a later page. Here we may recall the increased danger of tight bandaging in individuals with hardened arteries, and may warn against the use of Bier's treatment, in such cases, without the most serious reflection on the possibilities of disastrous results. Surgeons should always bear in mind the possibility of arterial rupture when reducing an old dislocation or when forcibly straightening a contracted joint in an individual with atheroma. The possible effects of arteriosclerosis in inducing serious changes in the viscera, particularly the heart, lungs, and kidneys, demand a careful examination of these organs before any operative procedure. In the absence of demonstrable cardiac, pulmonary, and renal changes, those patients who are affected with chronic arteritis usually tolerate general anæsthesia and surgical operations remarkably well. Apoplexy, which is one of the dangers hovering over those with chronic arterial disease, very rarely occurs during the induction of anæsthesia or in the course of an operation, particularly if the patient is skilfully and fully anæsthetized. The struggling induced by forcing the anæsthetic or by operating during light anæsthesia must be regarded as highly dangerous. In circulatory troubles

pain is often more dangerous than anæsthesia. Although chloroform lowers the blood-pressure, its effects on the heart have generally led us to prefer ether for the anæsthetic. Siegel* believes that the young with arteriosclerosis do not tolerate general anæsthesia as well as the senile. Skin, bone, and fascial wounds heal promptly in individuals with arteriosclerosis, provided the disease is not far advanced. Amputation flaps may, of course, after removal of a leg for arteriosclerotic gangrene, slough if the section is not made high enough. Only imperative operations should be performed upon the lower extremities of those exhibiting the symptoms of marked narrowing of the arteries, since even trivial operations—*e.g.*, the excision of an ingrowing toe-nail—may furnish the starting point for gangrene. According to Siegel, intestinal wounds are unfavorably influenced by arteriosclerosis, particularly if the patients are emaciated. In such cases cutting through of the sutures, gangrene of the margins of the wound, and the formation of fistulæ are not uncommon. Although narrowed arteries, when severed, eject less blood than normal ones, the probability of cutting through of the ligatures applied during an operation is greater; hence primary hemorrhage is relatively slight and secondary hemorrhage relatively frequent.

Chronic arteritis tends to weaken the walls of the vessel or to narrow or obliterate its lumen. In many instances, however, the proliferation of the subendothelial layer is proportionate to the degenerative changes in the middle coat, and, although the elasticity of the vessel is impaired, the size of the lumen is not altered. When the vessel wall is weakened, dilatation and even rupture are likely to result.

That form of arteritis which is caused by syphilis bears the worst reputation in respect to the production of aneurysmal dilatation. Syphilitic arteritis may begin within a few months of the time of the chancre or not until after the lapse of many years. It may involve a whole system of vessels, a whole vessel, or a segment of a vessel, and is often bilateral. All the coats of the artery are involved, but the media suffers most, being infiltrated with numerous round cells, which infiltration results in its atrophy, degeneration, or fragmentation. If the infiltration is very abundant and the vessel walls are completely disorganized, rupture may occur, an accident which is most frequent in the basilar arteries of the brain (apoplexy). If only the musculo-elastic median coat yields, there is formed a cicatrix which may subsequently stretch and give rise to an aneurysm. The latter is most frequent in the major vessels.

Diminution in the lumen of arteries, as the result of sclerosis, is responsible for a host of nutritional disturbances. Those which particularly interest the surgeon are neuralgia, pancreatitis, bleeding from the alimentary canal, arteriosclerotic colic, intermittent claudication, and gangrene. The etiological influence of sclerosis of the neural vessels in neuralgia is recognized by most authors. As long ago as 1874 Leube called attention to the frequency of bleeding in intestinal catarrh in the aged. It is not improbable that chronic arteritis is responsible for this condition. Possibly, in some instances, gastric or intestinal bleeding

* Muench. med. Woch., 1906, p. 595.

after etherization is due to the same cause. It has been suggested that sclerosis of the arteries be included among the rare causes of gastric and intestinal ulceration. The relation of arteriosclerosis to hemorrhagic pancreatitis and chronic pancreatitis need only be mentioned. Arteriosclerotic colic is a term which has been applied to abdominal pain believed to be due to narrowing of the arteries of the affected part. This pain may simulate that of gastric ulcer, cholelithiasis, appendicitis, etc. The frequency of flatulency in the old suggests arteriosclerosis as a possible cause. Narrowed vessels may be competent, in times of repose, to supply adequate blood to a part, but be unable to dilate and meet the additional demands of that part when it is actively functionating. The result is a sudden and transient paralysis and anæsthesia when the brain is affected, an angina pectoris when the heart is involved, and arteriosclerotic colic when the abdominal vessels are chiefly concerned, or an intermittent claudication when the extremities are affected. The last is characterized by attacks of weakness and crampy pains in the muscles, particularly of the calf, and is to be regarded as a prodromal symptom of gangrene.

Arteriosclerotic gangrene is most frequent in the old (senile gangrene) as the result of senile atheroma, but may be found in the young (presenile gangrene) as the result of any of the other conditions mentioned in the etiology of chronic arteritis. Barrand* has collected 103 cases in which young adults were affected with gangrene following one of the infectious diseases. Seitz,† in 148 cadavers with arteriosclerosis, found 17 between the ages of 10 and 29 years. In most instances arteriosclerotic gangrene is precipitated by the formation of thrombi in the diseased vessels, being often aided by slow circulation the result of some cardiac trouble. von Winiwarter, Borchard, and others sharply differentiate the so-called presenile gangrene from senile gangrene, maintaining that the former is due, not to ordinary chronic arteritis, but to a special affection, obliterating endarteritis, in which the lumen of the vessel is completely closed by a proliferation of the intima. Manteufel, Weiss, and Bunge believe that the occluding mass found in the arteries owes its origin to the organization of thrombi which form on the roughened intima, and that, from an anatomical standpoint, presenile should not be separated from senile gangrene. Obliterating endarteritis is said to be caused by cold (Winiwarter), by some nerve affection (Fraenkel and Bevoeto), by syphilis (Haga), by alcoholism, or by the abuse of tobacco. It has been suggested that a relation exists between this affection and the gangrene occurring in Raynaud's desease and in ergot poisoning. Finally, there are cases in which the most careful investigation fails to reveal the cause of the arterial disease.

Treatment of Beginning Arteriosclerotic Gangrene by Arteriovenous Anastomosis.—The first successful arteriovenous anastomosis in the dog was performed by Glueck.‡ Unsuccessful experiments in this line were made, in 1902, by San Martin y Satrustegui, Bérard, and Carrel, and by Exner and Hoepfner, in 1903. In 1902 Carrel and Morel, and in 1905 and 1906 Carrel and

* Deutsch. Zeitschrift f. Chir., 1904, Bd. 74. † Allg. med. Zentralzeitung, 1897, No. 19.
‡ Watts, in Annals of Surgery, Sept., 1907.

Guthrie,* with improved technique, were able to unite arteries and veins with almost uniform success. "The threads and needles were the finest and strongest obtainable. The threads were sterilized in vaseline and applied when heavily coated with the same. The vessels were handled very gently and the endothelium was protected from drying by isotonic sodium-chloride solution or by sterilized vaseline. No dangerous metallic forceps were used. The greatest care was exercised to obtain accurate and smooth approximation of the endothelium of the vessels."

Lateral arteriovenous anastomosis for beginning gangrene of the lower extremity has been performed in two cases by San Martin y Satrustegui,† in one case by Jaboulay,‡ and in one case by Tuffier.§ End-to-end arteriovenous anastomosis of the femoral vessels for senile gangrene has been performed in two cases by Hubbard || and in one case by Lilienthal.¶ All these cases were unsuccessful so far as checking the gangrene was concerned. According to Carrel and Guthrie, after lateral arteriovenous anastomosis most of the red blood returns immediately toward the heart through the central end of the vein. The peripheral portion of the vein and its collaterals are distended and pulsate, but the valves are not forced and the red blood does not circulate through the veins. These authorities claim, however, that this may be accomplished by end-to-end arteriovenous anastomosis. As the result of experiments on the cadaver, Gallois and Pinatelle** found that colored fluid injected into the main vein of a limb returned immediately by the other veins and not by the arteries, and that, even after occlusion of the collateral veins by forceps, it was impossible to force the valves. We have never felt that arteriovenous anastomosis was justifiable for arteriosclerotic gangrene, since, even if the circulation could be reversed in normal vessels, which seems improbable from the experiments of Gallois and Pinatelle, such could not be expected when the arteries are obliterated as the result of thrombosis or of a proliferation of the intima.

V. INJURIES OF ARTERIES.

Injuries of arteries may be either simple contusions or wounds of various degrees of severity.

Contusions of Arteries.—Under this heading will be considered all injuries of arteries produced by blunt force and not immediately resulting in dissolution of the continuity of the external coat of the vessel.

Etiology.—The normal arteries, owing to their elasticity, are not often seriously affected by a contusion, unless it be of the severest grade. In atheromatous arteries, however, a slight contusion may be followed by thrombosis, rupture, aneurysm, the detachment of an atheromatous plate, or sloughing and hemorrhage. Turner (cited by Lejars, in *Rev. de Chir.*, 1898) tells of a man, aged

* Annals of Surgery, Feb., 1906.
† Semaine méd., 1902, p. 395.
‡ Semaine méd., 1902, p. 405.
§ Revue de chir., June, 1907, p. 1086.
|| Annals of Surgery, Oct., 1906, and Sept., 1907.
¶ Annals of Surgery, Jan., 1907.
** Revue de chir., 1903, p. 236.

thirty-five, who complained of pain at the elbow and swelling of the forearm after drawing his hand back to put it in his pocket. For several days the pulse could not be felt; it then reappeared, but subsequently disappeared after the same manœuvre. Several weeks later the man died. At the autopsy the brachial artery was found obliterated and its internal coat ruptured. Delbet* relates an analogous case of rupture of the inner coats of the brachial artery, in a patient who had been anæsthetized for resection of the jaw, and in whom the arm was simply separated from the trunk without violence. Denudation of arteries, even when extensive, does not cause macroscopic changes in the vessel walls or any interference with the blood-stream. D'Anna, as the result of his experiments, concluded that extensive separation of an artery from its sheath would interfere with the function of the vasa vasorum and that thrombosis or degeneration of the arterial walls and secondary hemorrhages would occur. In order doubly to disprove this assertion, Hoepfner resected the carotid artery in a dog, placed it in salt solution, then reimplanted it, without thrombosis or other ill effects following. Normal arteries may be compressed or retracted without fear of any permanent damage. The same is not true, however, of diseased arteries. Compression of normal arteries with the finger, tape, tourniquet, arterial clamps, etc., as has been abundantly demonstrated, may be continued for a considerable time without producing evil consequences. Bothézat † obtained remarkable results in experimental clamping of arteries. He clamped the femoral artery of dogs with hæmostatic forceps and removed them at the end of half an hour. The circulation immediately reëstablished itself and the crushed and thinned walls became slightly ballooned in the form of an aneurysm. This dilatation subsided after a time and the vessel seemed to recover itself completely, without obliteration of the calibre of the artery. Bothézat tells us that the femoral artery may be compressed in this manner for three hours without obliteration. It is needless to add that one would not expect such happy results in the human being. The occurrence of aneurysm after prolonged instrumental or digital pressure will be referred to in the discussion on aneurysm, while the dangers of the tourniquet and the Esmarch band will be spoken of in another section of the work. In this connection may be mentioned—although it is perhaps not exactly a contusion—the obliteration of an artery (*e.g.*, the subclavian artery) in juxtaposition to an exostosis or osseous abnormality—as, for example, a cervical rib. In these cases obliteration of the pulse is apt to occur at one of two periods—first, when the rib ossifies, and, secondly, in old age when the artery calcifies. In the latter instance obliteration is in all probability partly due to fracture of the internal coats of the artery. That the constant bending and unbending of an artery (*e.g.*, the popliteal) may cause sufficient injury to predispose to aneurysm is a well-established clinical fact. Contusions of large arteries by falls and blows are not common, as such are protected from bruising "(1) by their positions, which, generally, are deep and sheltered; (2) by their capacity to flatten readily, which results from the elasticity of their walls and the fluidity of their contents; (3) by the strength

* "Traité de chir." † Delbet et Le Dentu: "Traité de chir.," vol. iv.

of the arterial sheath and the looseness of the connective tissue which surrounds them, whereby considerable freedom of movement in lateral directions is allowed; and (4) by the prominence of contiguous muscles or other organs, which serves to receive or to deflect the vulnerating forces."* The order of the frequency with which individual vessels suffer from contusion is, according to Herzog,† who has collected 63 cases, as follows:—Brachial 18, popliteal 15, axillary 7, femoral 8, external iliac 4, common iliac 2, abdominal aorta 2, posterior tibial 2, subclavian 2, internal carotid 1, radial and ulnar 1. The form of injury is most frequently a violent blow, such as a kick of a horse, a runover accident, or compression between two cars. The accident is, therefore, almost exclusively confined to male adults, only three of the patients, in Herzog's collection, being women. In most instances the patients are above thirty; we have encountered in the literature only one case below twenty years. Of some importance, from a medico-legal standpoint, is the possibility of contusion of a large vessel by a fracture of an adjacent bone or by a dislocation of a neighboring joint. The following case, cited by Lejars, illustrates this point:—A man, aged fifty years, fell from a height of two stories and sustained a Colles' fracture. During his fall he tried to save himself by throwing his arm over a beam, but failed. The physician who was called applied a bandage as far as the middle of the forearm. Later, the entire forearm became gangrenous, and the patient was convinced that the practitioner had caused this gangrene by applying the bandage too tightly. Rosenberger, who amputated the arm, found a red band, due to the contusion, in the subcutaneous tissues at the bend of the elbow, the skin being normal. The radial and ulnar arteries were thrombosed as far as the brachial, and the internal tunic of each was ruptured, but not to a sufficient extent to cause it to curl up within the vessel. The external coats of the artery were uninjured. A somewhat similar case is reported by Moré. Of all injuries, those by gunshot wounds have the worst reputation in the production of contusion of arteries. This applies particularly to the ancient bullet of warfare and the modern leaden bullet of civil life. Several well-marked examples are given by Lidell in the second volume of the "International Encyclopedia of Surgery." "The large arteries of the extremities are, to a considerable extent, protected from gunshot perforation by the strength of the fibrous sheaths which invest them, by the toughness and extensibility of their own tunic, and by the readiness with which they can slip aside from the track of a gunshot missile, owing to the fact that they are elastic tubes, and that their contents are liquid." This is not true, however, of the modern, hard-jacketed, high-velocity, small-calibre bullet, which will sever an artery like a knife, unless the range be very great or the velocity diminished by ricochet or other means.

Amussat, Devergie, Simon, Kussmaul, Klotz, Mildner, and Faber have found that, in those who are hanged, the internal coats of the carotid are frequently ruptured.

Pathology.—The lesions found after the contusion of an artery vary with

* Lidell, in "International Encyclopedia of Surgery."

† Beitr. z. klin. Chir., Bd. 23, S. 643.

the amount of force exerted and the state of the walls of the artery. The more diseased the artery, the slighter the force necessary to produce a contusion.

Of the slightest grade, in which there is perhaps no change but a little ecchymosis of the vessel wall, we shall not speak further, as such causes neither immediate signs nor remote ill effects. The older surgeons explained some of the cases of obliteration of an artery after contusion, by rupture of the vasa vasorum and extravasation of blood between the vessel and its sheath in sufficient quantity to press upon and considerably narrow the lumen of the vessel. This was supposed to be followed by inflammatory swelling (traumatic arteritis) with consequent thrombosis and complete obliteration of the vessel. It is now known that in practically all instances the lesion is a rupture of the inner coats of the vessel and that such leads to thrombosis and complete plugging of the lumen; in other words, as in the application of a ligature, although the force acts from without inward, the lesions, owing to the friability of the internal coats, are produced from within outward.

The injury may expend itself on the internal coat alone, leaving the outer coats intact and practically normal. The lesion here observed is a cracking or fissuring of the intima, which may be complete or incomplete—*i.e.*, it may involve the entire circumference or only a part thereof. Complete circular division is best seen after the application of a ligature. In contusions by blunt violence the fissures are apt to be multiple and frequently involve only a portion of the circumference of the vessel. Experimentally Delorme found such wounds of the internal coat to be usually transverse, frequently corresponding to the horizontal interstices of the muscular and elastic fibres; they varied from three to ten in number and from 2 to 5 mm. in width. From a study of the specimens removed after death or amputation it appears that that portion of the internal coat which is first struck suffers most.

Wounding of the internal coat alone causes no extravasation of blood into the perivascular tissues, nor is there any danger of secondary hemorrhage. The sole result of clinical importance is thrombosis with its consequences. If the fissure is small and incomplete there may be a minute mural thrombus, which causes no interference with the blood-current, but simply protects the wound until healing is complete. Obliteration of the vessel by clot is apt to follow, however, if the rent in the internal coat is large, if the fissures are multiple and extensive, if the tunic is sufficiently detached to move back and forth in the blood-stream, if the detached tunic is infiltrated with lime salts, if tight compression is applied after the accident, or if the state of the heart or blood is such as to predispose to coagulation. The conditions just mentioned determine also the rapidity with which an occluding thrombus forms. It may ensue immediately after the injury or it may not develop for several hours or even days. Generally speaking, complete obliteration following a lesion of the internal coat alone is delayed, although in the femoral artery we have observed it to occur within a few minutes. As to the frequency with which partial obliteration occurs after injuries of this character one could not venture even a guess, as there are neither symptoms nor signs by which it may be recognized.

Yielding of the internal and middle coats is much more likely to be followed by immediate thrombosis, as when torn they curl up within the vessel in obedience to the elasticity of the middle coat. The lacerations are generally irregular, and may be transverse, oblique, longitudinal, or flap-shaped, the edges of the wound being fringed and torn. Not infrequently a portion of the circumference of the artery is respected, and occasionally the fracture of the internal coats extends in a more or less regular manner around the entire circumference of the vessel. The adventitia maintains the continuity of the vessel and prevents extravasation, although the blood may make its way for some distance between this coat and the media, sometimes for an inch or more. On visual examination the artery may appear normal, but is much more likely to be discolored or black, owing to the ecchymosis of the external coat. Pulsation is generally transmitted to the contused segment from the artery above, but on palpation this fact, together with the induration due to the thrombus, is readily determined. When the force has been very violent, or prolonged for some time, the artery may be flattened and empty, as if crushed in the jaws of powerful forceps. Cloquet describes a specimen of this sort (Figs. 70 and 71), the injury being associated with a fracture of the humerus. On each side of the narrowed portion, the vessel was distended for a short distance by coagulated blood. Ordinarily the clot, as in thrombosis from other causes, extends centralward in a conical form as far as the first collateral branch. Peripherally, the length of the thrombus varies. It may fill the main branch and invade the smaller arteries or it may terminate like the central portion near a large collateral. Upon its extent and upon the activity of the collateral circulation depends the integrity of the limb. If the injury is confined to the artery alone and the vessels are healthy and the collaterals abundant, no harm need follow; indeed, it

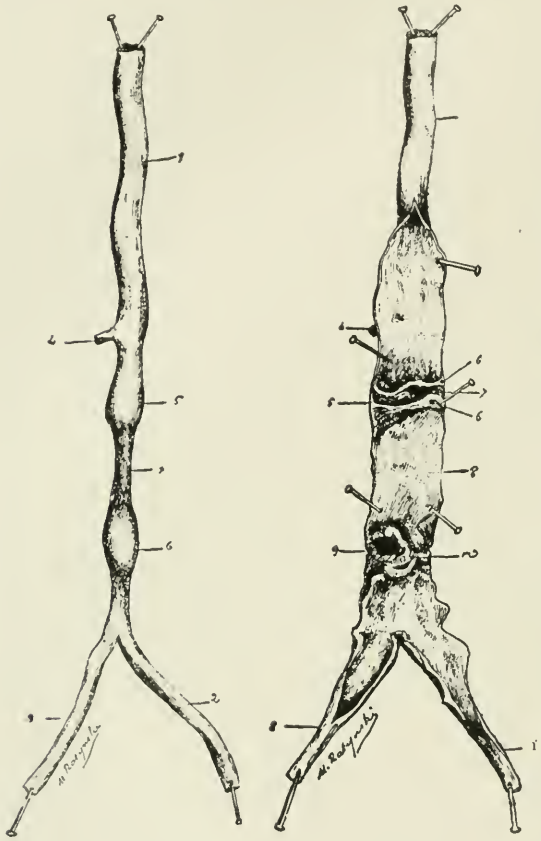

Fig. 70. Fig. 71.

Figs. 70 and 71.—Contusion of the Brachial Artery from Fracture of the Humerus. (From Cloquet, in *Revue de Chirurgie*, 1898, page 298.)

In Fig. 70, which gives a view of the artery as seen from the outside, note the distention of the vessel on each side of the contused area. In Fig. 71, which gives a view of the vessel after it has been laid open, the division of the inner coats at the distended spots is shown.

is highly probable that in most cases of this sort the diagnosis is never suspected. If the clot forms slowly, ample opportunity is afforded for the development of an adequate collateral circulation, which becomes progressively more efficient the more the lumen is closed; thus pulsation may never be absent from the peripheral vessels, even though the artery at the contused point becomes impervious. But if the vessels are narrowed by disease, or if the collaterals are involved in the injury or compressed by extravasated blood or a tight bandage, the collateral circulation will be insufficient and the thrombosis may extend to the finer vessels. If the venous circulation is not blocked, however, the artery beyond the occluded portion generally empties itself and will be found empty. In either event the limb falls into gangrene. Another possible factor in the production of gangrene—one which has been urged by several French writers—is the detachment of portions of the clot during the formation of the thrombus, the emboli plugging the smaller vessels and leading to circumscribed gangrene.

Symptoms.—The amount of shock present will depend principally upon the nature of the vulnerating force and the extent of the complicating lesions. There may or may not be an external wound in the skin. Of thirty-two cases in which this point is mentioned, the skin was intact in twenty-five (Herzog); but the perivascular tissues will generally be more or less contused and infiltrated with blood from rupture of the smaller vessels. In a few instances, however, the environing tissues, as well as the skin, present no gross changes. Hemorrhage from the contused artery itself does not occur primarily, and secondary hemorrhage, when it does occur, is practically always due to ulceration of the vessel the result of sepsis. In the presence of an open wound discoloration of the external tunic, with perhaps a hardening due to the thrombus, might be detected. The latter is occasionally felt also when the skin is unbroken.

Rupture of the inner coats of an artery is said to be accompanied by a sharp pain, but of this we cannot speak definitely, as, if such does occur, it must always be mixed with that of the traumatism. The only positive clinical signs of a subcutaneous contusion of an artery are those of obliteration of the vessel. This is always accompanied by pain in the limb below, as the result of the ischæmia. Pain may or may not be present at the point of thrombosis.

Cessation of pulsation in the vessels below the injured part occurs suddenly when the thrombus is rapidly formed or when a large portion of the clot becomes detached and forms an embolus which lodges in the vessel at a lower point. When obliteration is retarded the pulse gradually becomes more and more feeble and finally disappears, unless in the mean time the collateral circulation has become freely established. There are on record several instances in which the pulse was at first as strong and full as on the well side, but in which, after a number of hours, it could no longer be detected. In Bruemmer's case complete obliteration did not occur until the ninth day. Serious symptoms from late obliteration will, however, always be uncommon, owing to the opportunity afforded for the collateral vessels to dilate. Theoretically, the pulsation above the thrombosed area is more energetic than normal, but this sign is of no clinical value.

Loss of heat in the injured extremity is an expression of the absence of warm blood. It has been asserted that this fall in temperature is preceded by a brief elevation, but such is doubtful. The difference in the temperature in the two extremities is very marked and is easily appreciated by the hand, but may be accurately measured with the thermometer. In Bruemmer's case the difference in the temperature of the legs was almost ten degrees (centigrade).

Pallor results from the anæmia, but if there is much blood in the limb at the time the vessel is occluded, or if the venous circulation likewise is compromised, the limb becomes purple and mottled. The sluggishness or absence of circulation is easily demonstrated by pressing on the skin with the finger; in the former instance the color slowly creeps back into the white spot thus made, in the latter the blanched area remains.

Loss or diminution of tactile sensation may be quite evident, even while severe pain is experienced in the limb; and, indeed, pain may be referred to the limb even after gangrene is fully established, owing to the irritation of the nerves above. The area of cutaneous insensibility in the early stages is often irregular in outline and does not always correspond with that of the pallor and loss of heat. Thus, in Picou's case (contusion and thrombosis of the popliteal artery), sensation was abolished in the area supplied by the sciatic, but was preserved in the parts innervated by the internal saphenous nerve. The anæsthesia or paræsthesia may vary also somewhat from day to day.

Paresis or paralysis of the limb likewise follows, owing to the deprivation of blood.

The signs mentioned above, when marked and continued, are followed by gangrene, but, when present in a lesser degree, complete recovery is still possible. Such, however, is the exception, and the limb usually perishes for several reasons. Unlike simple ligation of an artery, after which gangrene is comparatively rare, in a contusion the accompanying vein also may be thrombosed. In the thirty-four cases collected by Lejars this occurred eight times. The collateral vessels too are apt to suffer from the trauma, or, if they escape direct injury, they may be compressed by the extravasated blood resulting from the associated laceration of the environing tissues. Even without a total rupture of the main vessel the hæmatoma may be of an enormous size if there be no external wound through which the blood may escape. Attention has already been drawn to the possibility of extension of the clot in the artery and to the possibility of the detachment of emboli, both of which occurrences add to the chances of death of the limb or at least a portion thereof.

The gangrene may be moist or dry. The former is more frequent, as the limb is generally œdematous and filled with fluid, owing, in many cases, to the interference with the venous return, as explained above. In the presence of a wound or abrasion the entrance of micro-organisms is facilitated, and, once lodged, infection here finds a most favorable site for development, owing to the depressed vitality of the tissues, so that in most instances a traumatic spreading gangrene will be inaugurated.

Dry gangrene occurs if the tissues are free from fluid and asepsis can be

maintained. If the circulation is gradually cut off by a slowly growing thrombus and if the satellite veins are patent, the conditions are most propitious for this form of local death. It is, therefore, late in appearance and runs a much more chronic course than the moist variety. Furthermore, it rarely extends beyond the ankle or the wrist, and is often irregular in its distribution. One toe or finger may shrivel up and become black, or all but one may be thus affected. Sometimes the process advances further in the skin than in the subjacent parts, or, on the other hand, the deeper structures at the upper limit of the gangrenous area may be covered by living skin. This bizarre arrangement is used as an argument for the production of the dry circumscribed forms of gangrene by emboli.

Finally, we must not fail to mention the influence of trophic disturbances resulting from the anæmia or concomitant contusion of the nerves.

The above symptoms are distinctly referable to the arteries of the limbs. The possible effects of contusion of the carotid are sufficiently demonstrated in Verneuil's case: a man, aged forty-six, was caught beneath an overturned wagon and sustained a contusion of the neck. Delirium and right hemiplegia followed, and he died on the fifth day in coma, with symptoms of cerebral compression. At the autopsy the right temporo-sphenoidal lobe was softened, and in the Sylvian artery a clot was found which extended down as far as the common carotid. The internal and middle coats of the internal carotid were ruptured. Thrombosis of the visceral arteries is dealt with in other parts of this work.

Diagnosis.—The signs of interruption of the blood-stream given above should always be sought when one has to deal with injuries like a fracture, a dislocation, or a severe contusion, particularly when caused by the kick of a horse or by a crushing accident. This is frequently neglected, and subsequent gangrene is likely to be ascribed to improper treatment, as in the case previously mentioned. The same advice applies with equal force to the examination of the condition of the nerves, with which, however, we are at present not concerned. It is possible that the pulse may be absent in a fracture or a dislocation, owing to pressure upon the artery in question, but such will be quickly determined after the reduction of the deformity. In the absence of conditions like those just mentioned, interference with the local circulation after an injury is due to a contusion or a wound of the artery. Depending upon the pulse alone, however, one might be misled by the normal variations which are sometimes encountered between the arterial pulsations of the two limbs or by such conditions as a unilateral cervical rib, a pre-existing tumor, aneurysm, etc. Signs of obliteration of the vessel, in the absence of a hæmatoma, particularly if associated with induration along the artery, clearly point to a contusion of the vessel. In the presence of a large hæmatoma the probability of a rupture of the artery must be taken into consideration. If the hæmatoma has an expansible pulsation and if a bruit can be heard on auscultation,—in other words, if a false aneurysm is formed,—the artery must necessarily be opened. These signs are by no means, however, always present when the artery is ruptured, and an equally large hæmatoma may be found after a simple contusion. In these cases an exact

diagnosis may be impossible, nor should it cause the surgeon any inquietude, as in each instance incision is indicated.

Prognosis.—In contusions of the arteries of the extremities the danger of death is mainly due to complicating injuries or to subsequent sepsis. External wounds are generally infected and add greatly to the danger. A moist, septic, rapidly advancing gangrene will, of course, render the outlook much more gloomy. In an uncomplicated contusion of one of the arteries of an extremity the danger to life is slight. Obliteration of the common or internal carotid, resulting, as it does, in anæmia of the brain, presents a much more grave prognosis. About one-half of those suffering from a recognizable contusion of a large artery die. Of the thirty-four cases collected by Lejars sixteen died.

Aside from the treatment, the prognosis concerning the life of the limb depends upon several conditions, but will always be, for the reasons already given, much worse than after simple ligation. If the vessels of the limb are narrowed and inelastic as the result of atheroma, the chances of the development of an efficient collateral circulation are slight; injury of the vein or of the collateral vessels likewise favors gangrene. Tissues whose vitality has been lowered by general debilitating diseases will, when their blood-supply is diminished, succumb more quickly than normal tissues. Of the 18 recoveries in Lejars' statistics only 4 escaped gangrene; of the 63 cases collected by Herzog 33 developed gangrene. It should be recalled that gangrene may not appear for a number of days after the shutting off of the circulation, and, on the other hand, that a limb with all the prodromes of gangrene may yet survive in its entirety or suffer only a limited loss of tissue. As already mentioned, a slowly forming thrombus with retarded obliteration of the artery may afford ample time for the development of an adequate collateral circulation.

Treatment.—The first indication will be to combat shock if such be present. Complications likewise will need attention, and they may be of such a nature as to preclude the possibility of diagnosticating or treating the contusion of the artery.

As soon as signs of arterial obstruction become evident, no matter what other measures are deemed advisable, the limb must be carefully disinfected, even though there are no external wounds. The nails should be clipped and cleansed and the part shaved. It should be thoroughly but gently scrubbed with soap and water, a piece of gauze being used instead of a brush, as the latter is too harsh. Next, the skin should be washed with warm bichloride-of-mercury solution and dried with sterile gauze. The limb may now be enveloped in dry sterile gauze, cotton, or wool, held in place by a lightly applied bandage, as compression of all sorts must be avoided. Slight elevation on two or three pillows should be secured, in order to drain the limb of venous blood without embarrassing the arterial circulation. In addition to these measures the part should be kept warm by hot-water bags laid alongside of, but not upon, the limb. In brief, the indications are to keep the part dry, warm, sterile, and slightly elevated. Gangrene may thus be prevented or, if it should occur, be forced to assume the dry and circumscribed form.

With the development of aseptic surgery and the progress which has been made in the suturing of arteries, more active procedures demand at least consideration. If the pulse alone has disappeared, if there are no signs of impending gangrene, and if no hæmatoma is present, the above treatment is all that is needed. A hæmatoma should always be opened, in order to lessen the compression which it exerts on the collateral vessels. If the hæmatoma is of large size, one can never be sure that the artery has not been opened. Hence, in these cases incision has a double rôle—to permit evacuation of the blood and to ascertain the condition of the artery. The clots adhere strongly to and infiltrate the environing tissues, but the tissues should not be scrubbed in order to remove the clots. All that is required is to relieve the tension, if the vessel itself has not been opened and if no other complications are present. If bleeding has completely ceased we believe it good practice to suture the wound without drainage, as the latter always predisposes to infection, particularly in bruised tissues.

On theoretical grounds ligation of the artery above the injured part has been suggested, in order to prevent the detachment of emboli. If the pulse has disappeared, indicating complete obliteration of the vessel, we can see no good reason for carrying out this procedure; if the pulse is still present, although of lessened force and volume, we believe the chances of embolism should be accepted rather than completely to suppress the circulation. Personally, we have given some thought to the possibility of restoring the circulation, after thrombosis or embolism, by opening the artery, removing the obstruction, and then suturing the wound in the vessel. This we have tried and we believed that we were the first to adopt this course. On looking over the literature, however, we find that we have been anticipated by both Ssabanajew and Lejars.

Ssabanajew's operation was performed in 1896.* His patient, suffering with polyarthritis rheumatica, was suddenly stricken with signs of gangrene of the leg depending upon obstruction of the femoral artery, which was believed to be due to an embolus. The femoral artery was exposed, but no occlusion was found in the expected situation. Owing to the desperate condition of the patient, further search was deemed inadvisable, and the vessel was closed with sutures and the limb amputated at a lower level. The patient died, nineteen days later, of endocarditis.

Lejars' patient was a man, aged 26 years, who was caught between two cars, sustaining a severe contusion of the left inguinal region.† Signs of thrombosis of the femoral artery were in evidence, and the foot became gangrenous. Six days after the accident the artery was exposed below Poupart's ligament, a soft black clot was removed, and the wound in the vessel was closed with sutures. The gangrene progressed, however, and one month later the leg was amputated below the knee.

Our first case was reported to the Phila. Acad. of Surgery, May, 1907. The patient was a man, aged 60 years, who had been squeezed between the tail-board of a wagon and a wall. Over the lower portion of the left abdomen and upper part of the corresponding thigh was a diffuse swelling due to extravasated blood. The

* Hoepfner, Archiv f. klin. Chir., Bd. 70, S. 417, 1903.

† Bull. et mém. de la soc. de chir. de Paris, 1902, p. 609.

skin was unbroken and there were no other injuries. Pulsation in the tibial vessels was as strong and full on the left as on the right side. About twelve hours after the injury, he complained of severe pain, first in the popliteal space, and later radiating down the leg to the foot and toes. The pulse disappeared from the tibial vessels and popliteal artery. The femoral could not be satisfactorily palpated because of the swelling mentioned above. The leg, as far as the knee, was pale and cold, and the toes and foot were shrivelled. Sensation was present but markedly reduced in the entire foot and leg. There was no power in the toes, and the ankle could be flexed only with difficulty. Movements of the knee were unimpaired. The thigh was warm and apparently in the same condition as on admission. Owing to the condition of the thigh, the very sudden onset of symptoms, and the seat of the initial pain, it was believed that a large clot embolus had been swept from the point of injury and lodged at the bifurcation of the popliteal. About twelve hours after the onset of pain and twenty-four hours after the injury the patient was anæsthetized with ether, and the popliteal artery opened by a small longitudinal incision. There was a slight flow of dark blood, but no clot could be found. A probe was gently passed up into the artery for about six inches and no obstruction was found nor flow of blood induced. The wound in the artery was closed with through-and-through silk sutures and the edges of the skin approximated. A longitudinal incision was next made over the femoral artery, from just above Poupart's ligament downward. The sartorius muscle had been ruptured and all the tissues were infiltrated with dark clots. The vein was uninjured. The artery was not discolored, but was hard to the touch from Poupart's ligament down to its bifurcation. Poupart's ligament was severed in order to permit an assistant to grasp the vessel above the thrombus, and the artery was opened by a longitudinal incision. After the clot, which was almost black in color and firmly adherent, had been removed, it was discovered that a calcified portion of the intima, like a valve, had been turned into the artery from the anterior wall, probably occluding it one-half. The posterior wall of the artery, although calcareous in places, was apparently uninjured. The detached atheromatous plate was removed, and the compression on the artery diminished for an instant, in order to wash out any remaining débris. The artery was then closed with through-and-through silk sutures. The circulation was immediately reëstablished, but after the lapse of a brief period pulsation below the injured point ceased. The arterial stitches were then removed and the lumen of the vessel was again found filled with clot. This was removed and the artery resutured. The same phenomena were repeated, and the hopelessness of securing a patent lumen by simple removal of the thrombus was realized. The injured portion of the artery was therefore excised by a diamond-shaped incision, with the idea of closing the wound transversely. This, however, was found to be impossible, and the artery was therefore completely severed and each end split on the posterior wall, the flaps thus formed being turned outward and the segments of the artery united by through-and-through silk sutures, which brought intima in contact with intima. Although the circulation was again reëstablished, pulsation in the artery below the site of anastomosis had, at the time when the skin wound was sutured, become very feeble, and no pulse could be felt in the tibial vessels. The gangrene, which was of the moist septic type, necessitated amputation through the upper thigh. The patient recovered from the amputation.

Our second case was one of embolism.* The patient was a man, aged 61 years, who was suddenly attacked with severe pain in the right foot, which rapidly extended to the lower third of the thigh and was accompanied by all the signs of obliteration of the femoral artery. The foot was shriveled, and the leg purplish as far as the upper third. Pulsation could not be felt in any of the vessels below the bifurcation of the femoral. Thirty-six hours after the onset of pain the common femoral artery was exposed by a longitudinal incision. It pulsated vigorously to within one inch of the bifurcation. From this point to the bifurcation it was hard, and below the bifurcation collapsed. The vessel was isolated, compressed, and opened by a longitudinal incision about one inch long. The thrombus was Y-shaped, corresponding to the bifurcation, the base of the Y being about one inch long and tapering at the tip. The limb corresponding to the superficial femoral was half an inch long and also tapering at the tip. The limb corresponding to the deep femoral was one inch long and likewise tapering. The color of the thrombus was dirty-white, with bright red spots and black blotches, except the terminal half-inch of the limb corresponding to the deep femoral, which was jet black. (Fig. 72.) The intima was smooth, although the vessel wall was decidedly thickened. On removal of the thrombus blood flowed freely from the peripheral part of the deep femoral, but not from the peripheral part of the superficial. The vessel was closed with a continuous through-and-through suture of silk, and over this was placed a second layer uniting the outer coats only. Pulsation immediately reappeared in the femoral below and in the popliteal, but not in the tibial vessels. The skin wound was closed without drainage. After operation pulsation, of about one-half the natural strength, continued in the popliteal for three days, then began to grow weaker, and finally disappeared on the eighth day. In the mean time a large vessel on either side of the patella (superior external articular, anastomotica magna) pulsated more vigorously as the pulsation in the popliteal became weaker. The pain in the leg continued, being particularly marked in the popliteal space. The line of demarcation which formed was an irregular oval, the inside reaching to the junction of the lower with the middle third of the leg, and the outside to the junction of the upper and middle thirds. In the deeper structures the gangrene ascended to a higher level. Forty-two days after the first operation the leg was amputated below the tubercle of the tibia, lateral flaps of equal length being employed. About fifteen ligatures were necessary, and the bone bled freely on section. The popliteal artery contained a small clot, and a probe passed up into the artery for several inches caused a slight flow of blood.

Fig. 72. — Thrombus Removed from Femoral Artery; actual size. (Dr. Stewart's case.)

Since the cases noted above were reported three others have been brought to light. Handley † attempted to wash an embolus from the left common iliac artery, twelve hours after its impaction, by passing a ureteral catheter through

* Trans. Phila. Acad. of Surgery, 1907.

† Brit. Med. Jour., Sept. 21st, 1907.

the profunda, femoral, and external iliac, and using salt solution. He succeeded in inducing a flow of blood through the catheter. Death occurred twenty-four hours later. Moynihan* removed an embolus from the popliteal artery, subsequently suturing the wound in the vessel. The patient lived four days. Doberauer† removed an embolus from the axillary artery fifty-two hours after its impaction. Thrombosis occurred as soon as the vessel was sutured, and an anastomosis was made between the artery and the vein, but whether it checked the gangrene or not, we are unable to state.

Perhaps the first thought which strikes one after reading the above cases is the inability, which was encountered in two instances, to locate definitely the obstruction by the mere symptoms. In our first case we feel sure that the mistake would not have occurred could we have palpated the femoral artery itself. It seems that the symptoms are not caused by the thrombus itself or even by the sudden impaction of an embolus, but are the result of the arterial obliteration—*i.e.*, of the acute anæmia. Thus, the pain, etc., are referred to the area from which the blood is shut off and not to the seat of obstruction.

It will be seen, however, that the operation of thrombectomy or embolectomy, if it may be so called, can be readily performed without danger of secondary hemorrhage. We believe it to be indicated, particularly when the intima is smooth, and that to be of value it must be performed as soon as possible after the arterial obstruction develops. Even though the vessel again becomes obstructed with clot, this may form slowly and give the collateral vessels a chance to dilate, thus saving at least a portion of the limb. The chief difficulty after arteriotomy for thrombosis is to prevent the re-formation of the thrombus, a difficulty which would not be encountered in dealing with an embolus soon after its lodgment. A thrombus intimately adheres to the internal tunic and can be completely removed only with some difficulty, thereby subjecting the delicate lining membrane of the artery to further injury. If the artery is simply opened, the clot removed, and the vessel sutured, the cause of the thrombosis—*i.e.*, the multiple cracks in the intima or the curling up of the internal coats—is not suppressed, and the thrombus will quickly re-form. There are several ways in which this may possibly be prevented. If the contusion is sufficiently limited, the injured portion of the artery may be resected, and the vessel anastomosed by Carrel's technique. The advantages of this method over Murphy's anastomosis by invagination are quite obvious, as the latter considerably diminishes the lumen of the vessel and does not permit of the removal of as much artery as the former. The technique of these operations is given on a later page. The extent of vessel which may be excised without exerting too much tension on the sutures will vary somewhat with the situation. Thus, in resections near joints, flexion may be utilized to diminish tension, while in other situations, particularly where the artery is bound to the surrounding parts by branches, it will be impossible to effect anastomosis after the removal of a large extent of the vessel. Severance of the collaterals for the purpose of facilitating anastomosis would of course be contra-indicated. Kuemmel was able to approxi-

* Brit. Med. Jour., Sept. 28th, 1907. † Prager med. Woch., 1907, No. 33.

mate the ends of a femoral artery after resecting 5 cm. during an operation for cancer of the inguinal region, and Ferguson after resecting one inch of the popliteal for a gunshot wound; in each instance the Murphy method was employed.

Another method of restoring the circulation after traumatic thrombosis, which at once suggests itself, is to substitute a segment of a vein for the injured portion of the artery, a procedure which has already been employed in the treatment of aneurysm, as we shall have occasion to note when we come to discuss the treatment of the latter condition. Whether or not the operation is feasible cannot be definitely stated at the present time. Experimentally, varying results have been obtained. Hoepfner performed the operation in animals ten times, a segment of a vein being transplanted to an artery. The vein at once became twice the size of the artery. The swirling of blood within it could be seen and, as in aneurysm, this led to thrombosis. Efforts were made to prevent the dilatation of the vein by doubling it, *i.e.*, by turning one end back like a cuff and also by suturing the surrounding tissues over it. The ultimate results were negative, as secondary hemorrhage occurred in one and thrombosis in all the others. Carrel and his associates have been more fortunate in the transplantation of vessels in animals. We shall have an opportunity to speak of this work more fully on a later page.

Whether or not the companion vein may advantageously be employed for this purpose should depend upon the artery involved. It would be a mistake to transplant a segment of the popliteal or the femoral vein to its accompanying artery, as, in case of failure, both the arterial and the venous circulation would be suppressed and the chances of gangrene would be very great. Probably the best vein to substitute would be the external jugular, although one of the brachial veins or even the opposite femoral vein might be employed. If the saphenous vein is sufficiently large it likewise might be transplanted. In the arm, where there are two venæ comites, one of these could be selected. In the neck the external jugular would serve, although interruption of the circulation in one of the internal jugular veins is not, as a rule, followed by serious consequences.

Anastomosis of the artery with the vein, either lateral or end-to-end, we believe to be useless, for the reasons already given when we discussed this operation for beginning gangrene. If gangrene follows, whether or not the above operations have been employed, the treatment of this condition will depend upon its nature and upon the condition of the patient. If it be of the dry variety and if the patient's condition causes no concern, the measures indicated above for maintaining sterility, excluding moisture, and preserving the life of parts of undecided vitality, should be continued until the extension of the process is known to be at an end, when amputation, with a view to preserving as much of the limb as possible, may be performed. By delay in these cases parts in which gangrene seemed at first inevitable will often be resuscitated, and ample opportunity will be given for the development of a collateral circulation, which will permit of conservative amputation. Early amputation is much

more likely to be followed by gangrene of the stump, unless it be performed at a high level.

Moist gangrene should be treated on the same general principles, but, if constitutional symptoms of sepsis appear, early amputation will be demanded: in the acute spreading variety immediate amputation well above the dead and dying tissue is imperative.

Wounds of Arteries.—Wounds of arteries are penetrating and non-penetrating. We shall dispose first of the latter.

Non-Penetrating Wounds of Arteries.—Non-penetrating wounds of arteries involve the outer or the outer and middle coats, but not the intima. Little is known of the behavior of such wounds, as they do not cause immediate hemorrhage nor do they interfere with the circulation. Michaux states that the wound in the outer tunic widens, but that a hernia of the internal coats does not occur. It is quite probable that a wound of the adventitia, in the absence of sepsis, heals without engendering any untoward sequelæ. If, however, septic microorganisms lodge in the wound, an ulcerative process may be inaugurated which will finally perforate the wall of the artery and result in secondary hemorrhage. Section of the internal and middle coats is a more serious accident, although this statement cannot be supported by accurate clinical facts.

Experimentally, an incised wound of the outer coats produces a cicatrix which is more solid and resistant than the artery itself. Most clinicians believe, however, that scar tissue here as elsewhere may gradually yield under constant pressure and give rise, after a longer or shorter interval, to an aneurysm. Thus is explained the arteriovenous aneurysm following phlebotomy, in which no signs of injury of the artery are in evidence. That hernia of the internal coat and rupture of the vessel may follow such accidents we believe quite possible, but here again we can give no authentic cases to fortify our opinion. When a secondary hemorrhage or an aneurysm follows a wound in the neighborhood of an artery one cannot be sure that all three coats were not wounded at the time of the accident and that the aperture was closed by a clot. Guthrie is said to have seen the carotid rupture eight days after a wound of the two outer coats.

Penetrating Wounds of Arteries.—Penetrating wounds of arteries may be punctured, incised, lacerated, and contused (ruptures, most gunshot wounds).

1. Punctured Wounds.—Punctured wounds, when produced by very fine instruments, such as intestinal needles, cause but little hemorrhage, which is easily and permanently controlled by pressure applied for a few minutes. Wounds of this nature have been repeatedly made in the suturing of arteries, the tapping of aneurysms, etc., and their innocuousness has been fully confirmed. Punctures of a larger size are either incised or lacerated wounds, according to the nature of the vulnerating instrument. Although there is almost always an external wound, such is not absolutely essential. Colles* reports a death from a punctured wound of the aorta due to a fish bone which had been swallowed the previous day. Nolan relates a somewhat similar case, the aorta being wounded by a sewing needle which had been swallowed by a lunatic. Rokitansky contributes

* "International Ency. of Surg.," vol. ii., p. 560.

a case in which the point of an inhaled dart pierced the innominate artery.* Punctures by osseous spicules from fractures are not frequent. Lidell cites a case in which the subclavian artery was punctured by a sharp fragment of the adjoining first rib, which had been fractured by a bullet. Occasionally an artery may be perforated by a sharp spicule projecting from a sequestrum. We have seen one case of this character in which the popliteal artery was wounded by a sequestrum from the lower end of the femur. Vascular perforations due to foreign bodies are more often secondary to ulcerations. Poulet † collected 33 cases of ulcerative perforation of large blood-vessels by foreign bodies which had emigrated from the œsophagus. In 17 the aorta was involved, in 4 the common carotid, in 2 the vena cava, in 1 the inferior thyroid, in 1 the right coronary vein, in 1 the vena azygos, in 1 the right subclavian artery, in 1 the œsophageal arteries, in 1 the pulmonary artery, and in 4 the arteries injured were unknown, owing to the absence of a post-mortem examination. When complicated by an external wound punctured wounds of arteries may be inflicted by any form of narrow object—as, *e.g.*, scissors, trocar, needle, knife, dagger, sword, bayonet, tenaculum, stone, splinter, etc. Small shot likewise may produce a minute opening in an artery.

The finest punctures may be followed by no hemorrhage. Theoretically, the tissues of the artery are separated without being wounded, and when the instrument is withdrawn they resume their normal place. This explanation is, of course, not absolutely correct, as there is some microscopic destruction of the tissues, but the elasticity of the arterial wall serves to close the wound immediately. A punctured wound produced by an instrument as large as an intestinal needle causes slight hemorrhage, which ceases after compression for a minute or two, or spontaneously after a slightly longer interval. Punctured wounds of larger size generally continue to bleed, but occasionally the hemorrhage ceases spontaneously. J. L. Petit, over one hundred and fifty years ago, set forth the mechanism of hæmostasis in these cases, and his explanation must still be regarded as sound. Owing to the small size of the wound and frequently to the compression of the environing tissues, a clot can form which seals the artery. The clot is shaped like a tack or the glass stopper of a bottle. The body of the tack fills the wound but does not extend into or interfere with the blood current. The head of the tack, or the flange of the stopper, is broad and contracts very firm adhesions with the exterior of the artery and the neighboring tissues. If the puncture is oblique, so that the wound in the external tunic does not exactly overlie that of the internal tunic, and particularly if its direction is with instead of against the blood-stream, coagulation is greatly facilitated. In some of these cases the arterial tunics may be slightly separated by infiltrated blood. This plug of coagulum is but a provisional hæmostatic agent. It may be dislodged at a later period, giving rise to recurrent or secondary hemorrhage. Definitive hæmostasis is due to the cicatricial tissue which displaces the clot, the latter being gradually absorbed. The cicatrix thus formed yields, in not a few cases, after weeks or months and gives rise to an aneurysm.

* Agnew's "System of Surgery." † "Traité des corps étrangers en chirurgie."

2. Incised Wounds.—Incised wounds of arteries are of frequent occurrence. They may be caused in many different ways, but are most frequently the result of knife wounds, inflicted accidentally or by design. Numerous incised wounds involving the vessels are produced by glass, notably in the upper extremity. Sharp spicules of bone resulting from fractures or necrosis likewise may make a clean cut in an artery. In modern wars injuries by cutting instruments are uncommon, but frequently the wound caused by the present-day army bullet is of an incised nature. Wounds in this class, owing to the smoothness of the section, present few points for the beginning of coagulation and no obstacles to retard the flow of blood; hence the bleeding is more profuse than in wounds of other varieties, and spontaneous hæmostasis is much less frequent. At the same time, owing to the absence of contusion and to the limited destruction of tissue, such wounds heal with great rapidity if their edges are approximated.

Incised wounds cause complete section or incomplete section of a vessel according to whether the circumference is wholly or partly divided.

In the case of a complete division, when involving a large superficial artery (*e.g.*, the femoral or the carotid) and communicating freely with the exterior, a fatal result generally follows in a few minutes, unless immediate aid is at hand. If, however, the vessel be of a smaller size and be deeply situated, particularly if the wound through the superficial structures be narrow and oblique, spontaneous cessation of hemorrhage may follow.

Spontaneous arrest of hemorrhage is described under two headings—the provisional or temporary, and the definitive or permanent.

Provisional Spontaneous Hæmostasis.—Provisional spontaneous hæmostasis depends upon the closure of the orifices of the severed artery with clot, the formation of which, among other factors to be mentioned later, is facilitated by the lessened force of the heart's action as a result of anæmia of the cerebral centres and by the progressive increase in the coagulability of the blood consequent upon the hemorrhage. Owing to the inherent elasticity of an artery its ends retract within its sheath immediately after the section. At the same time the circular muscular and elastic fibres contract and diminish the calibre of the vessel as far as the first collateral branch. The inner surface of the sheath, which lies exposed between the ends of the severed vessel and over which the escaping blood must flow, is composed of fibrous tissue rather than of endothelial cells, and hence lacks the smoothness of the intima and presents numerous minute eminences which favor clotting. The same is true of the environing tissues into which the blood infiltrates. The clot thus begun increases in size with the diminution of the blood-pressure until finally it completely fills the sheath and covers the ends of the vessel. This external coagulum becomes sufficiently firm to resist the blood-pressure, and gradually, by successive deposits of fresh clot, penetrates the lumen of both ends of the vessel, thus forming the internal coagulum. The latter is conical in form, with its base at the wound, and extends, in the proximal segment, as far as the first collateral branch, thus varying in length. In the distal segment

the internal coagulum is always smaller. Bleeding checked in this manner may recur as the result of increased blood-pressure, movements of the patient, or softening of the clot from infection, or the hæmostasis may be permanent.

Definitive or Permanent Spontaneous Hæmostasis.—Definitive or permanent spontaneous hæmostasis consists in the displacement of the clot by fibrous tissue, and is practically identical with the process of repair elsewhere. The clot becomes firmly adherent in the region of the wound, but may be easily separated from the intima at other points. The vasa vasorum in the walls of the artery dilate, and leucocytes immigrate into and gradually devour the clot, which is thus removed. At the same time the intima becomes covered with granulations which increase in number and finally replace the clot. This granulation tissue is vascularized by new vessels springing from the vasa vasorum, and is in time transformed into firm cicatricial tissue, which contracts and renders the end of the vessel more or less pointed. The changes are said to be less marked in the distal end of the severed artery, probably owing to the smaller clot present and the diminished blood supply; at all events, secondary hemorrhage is more frequent in this situation.

Incomplete section of an artery, or a lateral incised wound, may be longitudinal, transverse, or oblique. Longitudinal wounds of small size have the same features and behave in the same manner as punctures. When more extensive they gape, particularly in the middle, but to a much less degree than transverse or oblique wounds. The first accurate study of spontaneous healing of wounds of this character was made by N. Schultz,* who produced longitudinal incisions, 1 to 4 mm. long, in the large arteries of dogs, and then sutured the wound in the skin and muscle or only in the sheath. In most instances healing quickly occurred. The wound was at first plugged with a clot, convex outside and convex inside, which partly closed the lumen of the vessel and extended some distance centrally and peripherally. It was found that during the first five days the clot shrank, and that it was finally absorbed from within, so that there remained only a slight outward bowing of the lumen, formed by granulation tissue. On the inner side of this sac were found thick endothelial cells, and later the granulation tissue gradually became transformed into fibrous tissue. Wounds of from 1 to 1.5 mm. long were closed by fibrous tissue in eight days, and larger ones (2 or 3 mm. long) in from fourteen to twenty days. In preparations from fifty to one hundred and fifty-five days old it was difficult to find the wounded place. Under favorable circumstances small longitudinal wounds of large arteries may heal spontaneously, but there is always danger of subsequent aneurysmal dilatation.

Small transverse wounds become rounded, owing to the longitudinal elasticity of the artery, and may be regarded as punctures. Larger transverse wounds become oval or oblong and appear as if button-holed, so that permanent spontaneous hæmostasis occurs much less frequently than in complete sections. If the section involves more than half the circumference of the vessel natural arrest of bleeding is very rare indeed unless the ends of the vessel are joined by the

* Deutsche Zeitschr. f. Chir., Bd. ix., 1878.

smallest shred of tissue, when bleeding may cease in the manner already indicated for complete transverse wounds.

Oblique wounds require no special description. They approach in behavior the transverse or the longitudinal wounds, according to the degree of obliquity, and, generally speaking, are less dangerous than the former and more dangerous than the latter.

3. Lacerated and Contused Wounds.—Lacerated wounds of arteries are those whose edges are more or less irregular and frayed; practically, there is almost always some amount of contusion present. These wounds are caused by tearing or crushing, or by some other form of blunt violence. A spontaneous rupture of an artery also causes a lacerated wound. Like punctured and incised wounds, lacerations of arteries may or may not be accompanied by an external wound. Some authors class the latter as ruptures, which they describe under a separate heading, together with partial ruptures—*i.e.*, ruptures of the internal or internal and middle coats. We believe that complete ruptures, which, from a clinical standpoint, are always lacerations, should be studied under this heading, while partial ruptures, or contusions as we prefer to call them, demand a separate consideration.

(*a*) Lacerated wounds caused by tearing are best seen in those cases in which a limb is avulsed from the body by machinery. Tearing is partly responsible also for the vascular injuries sustained in some crushing accidents, in injuries by explosives, and in ruptures due to dislocations or attempts to reduce dislocations. When a limb has been torn from the body, the hemorrhage is often slight, and frequently the main artery of the limb can be seen hanging from the wound, throbbing with each pulsation of the heart, but without permitting the escape of blood. In such cases the artery is drawn upon until it snaps in two. The inner coats yield first and contract and curl up within the vessel, while the adventitia hangs over the end like a veil, sometimes in a twisted form. Bleeding, however, is occasionally excessive, and death may occur in a few moments from this cause. Injuries of this character produced by explosives seem to have a greater tendency to bleed than those caused by machinery.

(*b*) Gunshot wounds of arteries caused by the leaden bullet are almost invariably lacerations, although when produced at close range (*i.e.*, when the bullet is moving at a very high velocity) the wounds approach in appearance those caused by sharp instruments. In one gunshot wound of the brachial artery which we examined very carefully and in which a portion of the wall had been carried away, the wound was as smooth as if made with a sharp knife. The modern bullet, as we have already noted, may cause a wound with clean-cut borders, one which has, aside from some slight contusion, all the characteristics of an incised wound. Either form of wound may cause a complete or an incomplete division of the vessel. Perforation—*i.e.*, a wound passing through the artery but leaving a portion of the wall on each side intact—can occur only in the largest arteries (*e.g.*, aorta, carotid, innominate, subclavian, iliacs, and femoral).

The leaden bullet is that with which the civil surgeon has to deal, and in

civil life gunshot wounds of the arteries are not of frequent occurrence. Attention has already been drawn to some of the reasons for this fact. (See Contusions of Arteries.) In order to open an artery it is generally necessary for the leaden bullet to strike the artery directly while it is moving at a great velocity; otherwise a contusion rather than a wound results. Thus, if the bullet has already traversed bone, or if the velocity has been lessened by other means, the artery, even if in the track of the bullet, will probably escape laceration. In the War of the Rebellion primary lesions of the blood-vessels were reported in only 485 instances, and primary hemorrhage in only 110 out of the total of 245,790 gunshot injuries. This does not include arterial lesions in association with other grave injuries, nor the cases in which the victim died on the battle-field. Lidell estimates that more than fifty per cent of the latter died from hemorrhage.

Complete lacerations by the leaden bullet behave much like those due to other causes and, owing to the contraction and retraction of the vessel, hemorrhage may cease before a fatal amount of blood is lost, but the injuries are not so favorably disposed for spontaneous hæmostasis as those caused by avulsion. Moreover, the wounds are often infected, and, unless the vessel is permanently secured by a ligature, secondary bleeding is very prone to occur.

Incomplete lacerations are more frequent and more dangerous than complete lacerations, as the wound gapes widely and the vessel cannot retract within its sheath; nor is curling up of the internal coats likely to occur. If the wound freely communicates with the exterior or with one of the large cavities of the body, death soon occurs, unless artificial means are adopted to control the bleeding. If the wound in the soft parts is deep and narrow the bleeding may temporarily cease, as the ragged walls of such a wound offer numerous obstacles to the flow of blood and encourage clotting. A similar result may be obtained when the wound in the vessel is plugged by the bullet, by particles of clothing, by a fragment of bone, or by a bit of lacerated tissue. In some of these instances an internal clot may be formed and the bleeding be checked permanently, but such is of rare occurrence, and recurrent hemorrhage follows from dislodgment of the clot or other material which is restraining the bleeding, or, at a later period, secondary hemorrhage occurs from septic softening of the clot or sloughing of the devitalized arterial walls. If the wound has been closed by packing, suturing, bandaging, muscular contraction, or the sliding of one plane of tissue upon another, external bleeding may not be noted, although the vessel continues to leak, thus forming a diffuse traumatic aneurysm. A similar result follows when the clot which is occluding the wound in the artery gives way after the external wound is healed.

As the result of experimental studies on the cadaver, in which the arteries are empty and of diminished elasticity, thus favoring wounds, it was thought that the modern army bullet would invariably sever an artery if it were in the line of fire and that primary hemorrhage would occur much more often than with the old bullet. In recent wars, however, primary hemorrhage does not seem to have been very frequent; indeed, reports generally state it to be rare or extremely rare. Of fourteen hundred wounded in the Santiago campaign not one died of

external bleeding. The vessels are, of course, less likely to be injured by a small-calibre bullet than by one of large calibre. Most observers agree that a vessel cannot escape injury by being pushed aside. Owing to the sterility of the wound inflicted by the modern bullet and to improved wound treatment, infection and secondary hemorrhage are seldom seen. For the same reasons aneurysm will be more frequently encountered.

"Experiments on the cadaver afford very uncertain evidences as to the probable amount of hemorrhage to be expected from wounds with the small-calibre rifle. Nevertheless, experience thus far obtained from recorded cases in living subjects tends to show that the old saying, 'gunshot wounds do not bleed,' has been but little affected by the recent changes in weapons. In past wars an average of about one per cent of those wounded in battle have come under treatment with serious injury to blood-vessels; but, considering the smaller calibre and the fewer complications from lodgment and deformity with the new bullet, in future this percentage should be reduced. Partial division of vessels, however, where hemorrhage is most free, appears to be no less frequent with the new bullets than with the old. Primary hemorrhage in gunshot wounds usually presents one of two extremes: It is either very serious and, if not arrested, promptly fatal; or it is slight and easily controlled by compress and bandage; or it is practically absent. Slow, continuous hemorrhage rarely occurs except from certain wounds in the abdomen, liver, and lungs, where the conditions for its spontaneous arrest are unfavorable. When a vessel of large size is opened, fatal hemorrhage usually follows before any surgical aid is available; while smaller ones usually close spontaneously from contraction and coagulation, which light compression favors. All wounds bleed more or less for a time; but primary hemorrhage of a grave character will, no doubt, continue to be rare among those who come under treatment on the battle-field. 'Hemorrhage as met with in military practice will ordinarily be secondary, occasionally intermediary, almost never primary.'" (Conner.)

In wounds from artillery missiles and in lacerations by fragments of bone, blood-vessels of large size may be torn and lie for some time in a state of local shock, without immediate bleeding; but delayed hemorrhage in such cases is very frequent. Among 1,105 of the Japanese wounded, Haga found 12 cases of troublesome hemorrhage, all of which resulted from artillery missiles, and in all the hemorrhage was more or less delayed. Hemorrhage may be temporarily arrested by a fragment of bone or a piece of bullet lodging in the wound in the wall of a blood-vessel, and then it is likely to break out when the foreign body is displaced during transportation of the wounded or when it is removed by the surgeon. In some rare instances the coats of a blood-vessel have been contused by a passing missile, so as to result in necrosis and subsequent hemorrhage or in aneurysm. "Secondary hemorrhage in gunshot, as in other injuries, results from suppuration, which will rarely appear before the wounded are in the hospital. One great advantage from the introduction of the new bullet is that wounds made by it are less liable to infection and suppuration, with all the

consequences which follow such a grave complication, including secondary hemorrhage." (Forwood.)

Michaux * gives the following résumé of the effects of the new projectile in producing arterial wounds:—"(1) Lateral or incomplete wounds are clean-cut or very slightly lacerated, and vary in diameter from one-sixth to two-thirds of the calibre of the projectile. All the tunics are sectioned at the same level and there is no trace of curling up of these coats within the vessel. (2) Perforations can exist only in the largest arteries. The orifice is generally double, except in cases in which the projectile or particles of clothing which have been carried into the wound lodge against the posterior wall and act as a temporary obturator. Both openings are almost always clean-cut, gaping, and rounded, and are in diameter the size of the projectile. The three tunics are cut neatly without infolding of the media and intima. (3) Complete divisions are most often seen in the smaller arteries or in those of medium calibre. As Chauverl indicates, the section is very frequently of an incised nature on one side and lacerated on the other. Incurling of the internal tunics is never observed, but these membranes present transverse lacerations such as are found in contusions. When the vessel which has been carried away by the projectile has been solidly fixed at some distance from the point of injury, the wound is identical with that occurring in avulsion accidents. In ricochet shots the bullet may be deformed, and always moves with a much diminished velocity; hence the wounds are much like those caused by the leaden bullet, even to the liability to infection." (See also the article on "Gunshot Wounds" in Vol. II.)

(*c*) Crushing injuries, such as are frequently seen after run-over and machinery accidents, generally produce contused and lacerated wounds of arteries. The inner coats are curled up within the vessel while the external coat is drawn out. Hence grave primary hemorrhage is rare, but reactionary bleeding the rule, unless the ends of the vessel are permanently secured. The mechanism is much like that of ligation, the inner coats yielding before the outer. Occasionally the section is clean, the coats are severed at the same level, and the wound resembles one produced by a sharp instrument.

(*d*) Lacerations of vessels by fractures and dislocations are much more uncommon than one would imagine from the intimate relations of the vessels and bones in many parts of the body. Mention has already been made, in the preceding pages, of other forms of vascular injury produced by fractures. Lacerations of vessels caused by the same force (*e.g.*, bullets, etc.) that produces the fracture are, of course, of frequent occurrence, and this fact need not be further emphasized.

Lacerations caused by the fracture itself are more often complete than incomplete. Gurlt collected 25 cases of arterial injury in fractures, 5 of which died; of the remaining cases amputation was necessary in 10. Although we have had the unusual opportunity of observing a large number of fractures, we have never seen a laceration of a large artery due to the fragments themselves.

Turner † has recorded a case in which death followed rupture of the intercostal

* Duplay and Réclus, tome ii. † "International Encyclopedia of Surgery."

artery the result of fracture of the eighth rib. Several cases of laceration of the iliac vessels the result of fracture of the pelvis have been reported. Fractures of the clavicle are more likely to injure the vein than the artery, as the former is protected in part of its course by the scalenus anticus. Taylor* has collected five cases of wounds of the subclavian artery the result of fracture of the clavicle. Four arose in connection with fractures produced by direct violence and one from a fracture produced by indirect violence. Taylor reports also one case in which the innominate artery was supposed to have been injured. Gallois and Piollet † collected eleven cases of simple fracture of the clavicle complicated by lacerations of the large blood-vessels. The subclavian vein was involved six times, the subclavian artery three times, and the internal jugular vein twice. Death followed in eight instances. Skey and Laurent both cite cases in which the brachial artery was lacerated by a sharp fragment of a broken humerus. Several instances of laceration of the femoral artery due to the fracture of the femur may be found in the literature. The lower the fracture the greater the liability to injury of the vessels. Packard mentions eleven cases and Nepveu cites more than fifty cases of injury to the various vessels in fractures of the bones of the leg. Von Bergmann ‡ has recently reported two cases of fracture of the tibia with rupture of the popliteal vessels. Brunn § cites a number of cases of injuries to vessels as the result of epiphyseal separation, particularly of the lower end of the femur. The dislocations in which injury to the vessels is most likely to occur are those of the shoulder and those of the knee. In the former most of the vascular lacerations have been caused, not by the dislocation itself, but by attempts to reduce the dislocation. Hamilton gives the histories of eighteen cases of dislocation of the shoulder in which, during attempts at reduction, the axillary artery was ruptured, two in which the artery and vein were ruptured, and two in which the vein alone was ruptured. Guérin is said to have torn the arm from the body in an attempt to reduce a dislocation of three months' standing in a woman aged sixty-three. Hessmann ‖ has recently reported a case in which the axillary ruptured in a shoulder dislocation. The accident is most likely to occur in cases in which the arteries are diseased, and consequently gangrene is very apt to follow. Von Bergmann reports five dislocations of the knee with rupture of the popliteal vessels, in all of which amputation was demanded. One should recall the possibility of tearing the main vessels when forcibly breaking up adhesions for ankylosis, particularly in the shoulder and knee. According to Quincke arteries may be ruptured by a severe concussion of the whole body, such, for instance, as is caused by a fall from a height.

Wounds of the aorta are, as a rule, rapidly fatal, and hence seldom come under surgical treatment. "During the Civil War no wound in the aortic arch or in any part of the thoracic aorta lived long enough to receive hospital treatment." (Lidell.) This is not always the case, however, as the histories of many cases show. Lidell cites a case in which the abdominal aorta was injured by a

* Annals of Surgery, vol. xxxviii., p. 649.
† Revue de chir., July and August, 1901.
‡ Centralblatt f. Chir., 1905, p. 147.
§ Beitraege zur klin. Chir., Bd. lii., p. 594.
‖ Centralblatt f. Chir., 1906, p. 152

conoidal ball, the patient surviving forty days. From the same authority we quote the following:—"Guattini records the case of a man who survived an incised wound of the arch of the aorta eight years. Pelletan relates the case of a man who lived two months after a puncture of the aorta, near its origin, by a foil. Heil details a case in which the patient lived twelve months after receiving a stab in the ascending aorta. Green publishes an account of an autopsy held on a man stabbed, a month previously, in the aorta near its origin, with a narrow blade. In the *Journal de Médecine* is a similar history of a man who lived six days. Lerouge inserted in Saviard's 'Observations Chirurgicales,' which he edited, an account of a similar case, the patient surviving eleven days. Legouest quotes a unique instance of recovery from punctured wound of the aorta, the cicatrix having been verified a year subsequently, at the autopsy, after the occurrence of death from pneumonia. Demme saw a young Austrian perish from secondary hemorrhage four weeks after the reception of a gunshot injury of the descending part of the thoracic aorta. Cases of rupture of the aorta from external violence have been recorded by Morgagni, Laurencin, and St. Leger, and a specimen of this lesion is preserved in the museum of St. Bartholomew's Hospital. There is also a preparation, by Professor Theile, in the Museum of Pathological Anatomy at Berne, showing a laceration of the arch of the aorta, which was not fatal until several months after the accident." (Lidell.) Bretano * reports a perforating gunshot wound of the aorta by a 7-mm. bullet. Laparotomy showed a small retroperitoneal hæmatoma, which was not disturbed. The patient died at the end of seventy days from secondary hemorrhage from the liver. The autopsy showed that the aortic wound had been closed. Its presence had not been suspected at the time of the operation. The cases cited above show that wounds of the aorta are not without the sphere of the surgeon, and that their repair by artificial means is a possibility. Doubtless surgeons in the near future will have the courage to attack wounds of this character and attempt their closure. Indeed, this has already been done for a wound accidentally made during the removal of a retroperitoneal sarcoma, an opening 1 cm. in length being closed with silk sutures. The patient died several hours later, but the sutures had held and no leakage had occurred.† Traumatic ruptures of the thoracic aorta have recently been studied by Revenstorf ‡ who reports six cases. As the result of experiments on animals he concludes that the aortic wound is really due to bursting. The sternum is forced back against the vertebral column, and it so compresses the aorta that it bursts at a higher point. In other cases the heart is forced to the left and the lung upward, so that the compression is made on the left bronchus. In these cases the vessel yields, not so much from the rise in blood-pressure as from a tearing of the aorta. Morgagni saw a case in which the descending aorta had been ruptured by a blow on the back.

Instances of rupture of most of the abdominal vessels in contusions of the abdomen have been reported. Legouest observed a laceration of the aorta

* Centralblatt f. Chir., 1906; Beilage, p. 39.

† De Page, in Revue de chir., Nov., 1906, p. 619.

‡ Mittheilungen aus den Grenzgebieten der Medicin u. Chirurgie, Bd. xiv., p. 4.

above the promontory of the sacrum resulting from the kick of a horse. Several cases of rupture of the innominate and of the subclavian, which lived for days after the accident, are to be found in the literature.

Subcutaneous rupture of the axillary artery is fatal in more than two-thirds of the cases, according to Lidell. He mentions one case, reported by Pelletan, in which the artery gave way, in consequence of overstretching, from hanging by the hands, to relieve rheumatism. Lidell mentions also a rupture of the femoral artery caused by a violent muscular effort, a rupture of the external circumflex from a blow against the corner of a table, and a rupture of the anterior tibial from the blow of a spade, without any corresponding breach of the integuments.

Symptoms.—The symptoms of arterial wounds are general and local.

The general symptoms are those of acute anæmia. The skin and mucous membranes become progressively paler from the loss of blood. The expression is at first one of fright and apprehension, and toward the end there is a vacant stare. The skin is cooler than normal and generally, but not always, clammy from perspiration. The temperature, as a rule, sinks lower and lower until death occurs; occasionally, however, it remains at or near normal, particularly when the bodily heat has been maintained by external warmth. The pulse is small, dicrotic, and rapid, and its tension falls until it finally becomes imperceptible. We have seen one case, however, in which death occurred from hemorrhage about twelve hours after a rupture of the liver, but in which the pulse, although weak and exceedingly compressible, never exceeded one hundred. The respirations increase in frequency and become sighing or gasping in character. The patient complains of lack of air and begs in a feeble voice that the window be opened. (Air hunger.) Owing to anæmia of the brain there are roaring or humming sounds in the ears, a mist or darkness before the eyes, sometimes with strange colored spots or flashes of light, general disturbance of sensation, attacks of fainting, vertigo, and occasionally convulsions. The mind is at first clear and the patient is anxious and restless, and, perhaps more often than in any other condition, he realizes the extreme gravity of the situation and the danger of impending death. At a later period the mental faculties are benumbed and confused and coma finally supervenes. Owing to the loss of fluid from the vessels, thirst is often a prominent and harassing symptom. The eyes are glassy and the pupils dilated and tardily responsive to light. The hæmoglobin is said to be greatly diminished in amount. We have had the blood examined in only one case of grave internal hemorrhage, and in this instance the hæmoglobin was above the normal. The truth is, that the loss of hæmoglobin does not make itself apparent in the ordinary blood examinations for at least several hours after such loss; hence is not to be relied upon for diagnostic purposes in suspected acute internal bleeding. The above symptoms vary in intensity with the amount of blood lost and the rapidity with which such loss takes place. When the bleeding is so sudden and violent as to be mortal in a few minutes, the face suddenly becomes livid, or deathly pale, with a greenish or bluish tinge; the lips are dark in color and the pupils

widely dilated; the breathing is suddenly hurried, then long and gasping; the limbs toss to and fro, and death occurs with a convulsion or with general twitching of the muscles.

When the bleeding is more gradual,—*i.e.*, extending over a number of days,—the patient is slowly exhausted. Syncope attends the slightest exertion, and not infrequently nausea or vomiting accompanies recovery from the fainting attacks. The face grows thin and pale, and œdema of the extremities appears. The pulse is soft, rapid, jerking, the arterial tube being too large for the small amount of blood which it contains. Anæmic murmurs are detected over the heart.

Loss of half the blood contained in the circulatory apparatus is said to be almost invariably fatal. The amount of blood, however, which is necessary to flow from the vessels in order to produce death varies greatly with the individual and the duration of the bleeding. A sudden loss is not so well tolerated as a gradual leakage, and very young or very old individuals, as well as those whose general condition is depressed from disease, succumb more quickly than young healthy adults. Women are said to bear the loss of blood better than men.

After the bleeding has been controlled the blood pressure gradually rises, owing to the contraction of the blood-vessels and the passage into the circulation of a large quantity of lymph. The lymph carries with it hordes of leucocytes, and hence leucocytosis persisting for several days is commonly observed after the loss of a large quantity of blood. A rise of temperature, sometimes continuing for many days, is also of common occurrence, and is, we believe, much more frequent and of higher range in those cases in which considerable blood is allowed to remain in the tissues to be absorbed. The temperature in these cases is often irregular and may be interpreted as indicative of sepsis.

We have twice observed, after serious intra-abdominal hemorrhage, the appearance of blood in the urine, although the genito-urinary apparatus was in no way concerned with the condition causing the bleeding.

The local symptoms of arterial wounds may be studied, from a clinical standpoint, according to whether the blood escapes externally or is retained in the tissues or one of the cavities of the body—in other words, according to whether the hemorrhage is external or internal.

Arterial wounds communicating with the exterior by a large wound offer the best example for the classical description of arterial hemorrhage. The blood is bright red or scarlet in color, and is thrown from the vessel in jets synchronous with the systole of the heart. The stream does not intermit, however, between the jets, but simply remits—*i.e.*, the volume of the stream is greater and the blood is thrown with more force at each ventricular contraction. In bleeding from the largest arteries a distinct hissing sound is usually heard. The bleeding is not confined to the proximal orifice of the vessel alone, but the blood from the distal orifice is apt to be darker in color and to flow in a more even stream. In many parts of the body, notably in the regions of the palmar or plantar arches and in the neck, the distal segment of the artery may bleed with almost as

much vigor as the proximal, the blood issuing in jets in the same manner. The volume and force of the jet vary with the size of the vessel injured, and become less marked with the continuance of the bleeding. Owing to the disposition of the soft parts about the vessel or to the depth of the latter, the pulsatile character of the bleeding is frequently lost. Pressure on the artery between the wound and the heart arrests the bleeding, unless the peripheral segment of the vessel is liberally supplied with collaterals. Pressure on the artery distal to the wound increases the bleeding if the wound is incomplete, but has no influence upon the hemorrhage if the artery is completely divided. The pulse below the wound is absent if the section is complete, and diminished if it is incomplete. Pallor, loss of heat, and diminished sensation are occasionally observed in the limb beyond the wound, but gangrene seldom occurs when the blood has a free exit through the skin. The conditions under which primary or immediate hemorrhage does not occur have been mentioned above (crushing, tearing, etc.). In most cases of wounds of large arteries, excluding those produced on the operating table, the primary hemorrhage has ceased spontaneously or has been stayed by dressings or a tourniquet before the patient is seen by the surgeon. Unless definite means are taken to secure the wounded vessel the increased blood-pressure coincident with reaction from shock may be sufficient to drive the obturating clot from the vessel and cause a reactionary or recurrent hemorrhage. Such hemorrhage may be caused also by movements or efforts on the part of the patient, by exploration of the wound, by the removal of foreign bodies which temporarily plug the opening in the vessel, etc. Intermediary hemorrhage may be caused likewise by the slipping off, untying, breaking, or cutting through of a ligature.

Secondary hemorrhage occurs after reaction has been fully established and is almost invariably due to sepsis; indeed, Delbet suggests that it be called septic hemorrhage; but occasionally, in the largest blood-vessels, it is caused by the cutting through of a ligature or some similar accident. Secondary hemorrhage is called *d'emblée* (Legouest) when there has been no primary hemorrhage, and consecutive when there has been a primary hemorrhage. The peripheral orifice of the vessel has the worst reputation in respect to secondary bleeding, as it is here that the clot forms more slowly and is less dense. Of 3,245 hemorrhages occurring in the Civil War, 3,135 were secondary, and more than three-quarters were noted as occurring in the extremities. Secondary hemorrhage may occur at any period, but is most frequent during the second and third weeks, and especially about the end of the second week. After the third week secondary bleeding is uncommon, but has been observed even during the second and third months. If the vessel has not been secured at the time of accident, secondary bleeding may be due to a septic softening of the internal clot. In other instances it is due to the sloughing of a portion of the arterial wall, which has been badly contused, to the fact that a ligature, a spicule of bone, or a foreign body, ulcerates into the artery, and occasionally to the extension of an ulcerative process from the surrounding tissues. Since the advent of antisepsis secondary hemorrhages have become rare, and such lengthy

discussions of this subject as are found in the older works on surgery are no longer needed. While reactionary has the same general features as primary hemorrhage, secondary hemorrhage frequently manifests itself in a somewhat different manner. Thus, it is generally accompanied by septicæmia or pyæmia, and is much more prone to attack those suffering from diabetes, scrofula, nephritis, alcoholism, or some affection of the liver, largely because individuals with these maladies are predisposed to infection. The bleeding, as a rule, is not at once fatal, but, owing to the small opening which at first exists in the artery, it ceases spontaneously, the opening becoming occluded with clot as a result of the diminished blood pressure. These first bleedings may be slight in amount, but are of ominous import, and have been aptly termed signal or alarm hemorrhages. The hemorrhages may be repeated at intervals of hours or days until the patient is exhausted, or there may be a sudden and violent hemorrhage which causes death in a few minutes.

When the external wound in the soft parts is small and is occluded by clot or other means the local symptoms are identical with those of subcutaneous wounds of arteries.

Subcutaneous wounds of arteries—or ruptures, as many authors prefer to call them—present, in addition to the constitutional signs of anæmia when the loss of blood is large, special symptoms depending upon the location of the wounded artery and the tissues or cavity into which the blood escapes.

Unless the blood escapes through an external wound or into one of the large cavities of the body a hæmatoma which communicates with the lumen of the artery develops. This hæmatoma, according to different authors, is designated by the following different names: diffuse traumatic aneurysm, false aneurysm, aneurysm by extravasation, diffuse primitive aneurysm, diffuse primitive aneurysmal hæmatoma, primitive traumatic aneurysm, and diffuse aneurysmal hæmotoma. Michaux, who is responsible for the term diffuse aneurysmal hæmatoma, suggests that it be called "primitive" when following a wound of an artery and "consecutive" when following the rupture of a true aneurysm. It is formed suddenly, and increases in size with a rapidity proportionate to the size of the wound in the artery and the laxity of the surrounding tissues. Thus, in the axilla or thigh it may reach an enormous size, while in the palm of the hand or at the bend of the elbow, where the fascia is very dense and resisting, it is generally of small size. The constitutional symptoms of hemorrhage are apt to be marked in the former instance and absent in the latter. Owing to the sudden stretching of the tissues by the extravasated blood severe pain is generally experienced. The blood which has left the artery is transformed into soft clot, which is constantly augmented by the leaking vessel. This fact explains the clinical phenomena which a false aneurysm presents, and which are somewhat different from those of a true aneurysm. The swelling, owing to its tension, is generally firm, particularly at its borders. True fluctuation is seldom obtainable unless the injured vessel be small or obstructed. The skin, aside from being stretched, is at first unaffected, but, in the course of a few hours or days, depending upon the depth of the injured vessel, it becomes discolored with infiltrated

blood. The tumor cannot be reduced by pressure: in other words, the soft clots or semifluid blood cannot be forced to re-enter the circulation. Pulsation is practically always present, but is apt to be less marked than in true aneurysm. Even when the artery is plugged the tumor may exhibit an impulse transmitted from the underlying vessel. Thrill and bruit are often absent, and when present are, like pulsation, much more feeble than in true aneurysm. These signs depend upon the size of the orifice in the vessel. If it be large they will be correspondingly intensified, and if it be small, oblique, or filled with clot, they will be feeble or absent. The limits of the swelling are not clearly defined as in a true aneurysm, but gradually merge into the surrounding tissue. The cavity is irregular, owing to the varying resistance which the tissues present to the pressure of the extravasated blood. Even when the wound is incomplete the pulse beyond is often obliterated, because of the pressure of the effused blood; hence numbness, coldness, pallor, and partial paralysis are frequently observed in the limb below, and these conditions, if relief is not obtained, terminate in gangrene. In a few cases in which the opening in the vessel is small the wound may cicatrize and the clot be absorbed or organized. In other instances the opening persists, and, the resistance of the tissues proving greater than the blood pressure, an aneurysmal sac is formed. If the tissues yield to the pressure the sac ruptures, and death is inevitable unless immediate aid be at hand. The same result follows suppuration or sloughing of the tissues which restrain the extravasated blood. In general, it may be said that the tendency of the swelling in subcutaneous wounds of the major arteries is toward a constant increase in size, very rapid at first and later more gradual. Not infrequently the growth of the tumor is intermittent, owing to the transitory plugging of the orifices in the vessel with clot.

Of the special symptoms which follow bleeding into the cranium, thorax, abdomen, and other cavities or hollow viscera it is not our intention to speak, as such are given in detail on the pages devoted to the various organs thus affected. We must not fail to mention, however, the dyspnœa and dysphagia which may follow hæmatoma of the neck, as well as the serious cerebral changes which may follow injury or obliteration of the common or internal carotid artery.

Diagnosis.—The diagnosis of wounds of arteries presents no difficulties when the vessel is superficial and the blood escapes externally, the signs mentioned above then being quite clear. The blood is never dark in color like that coming from a vein, unless the patient is cyanosed, but even then it escapes in jets and is diminished or entirely checked by proximal pressure on the artery and augmented by distal pressure. The opposite, except in varicose veins in which the circulation is reversed, is true of venous hemorrhage. In wounds of the largest veins the blood may escape as a column of liquid, but rarely in spurts (see Wounds of Veins), although in certain situations (*e.g.*, at the base of the neck) it may be irregular, owing to the effects of respiration, straining, muscular efforts. As already mentioned, proximal pressure may fail to check arterial hemorrhage, notably in the smaller arteries of the extremities. When the wound in the soft parts is deep or irregular, or when the blood pressure is

markedly lowered from the loss of blood, the flow may be continuous instead of remittent. Absence of the pulse below and the signs of deficient irrigation of the extremity—viz., pallor, loss of sensation, heat, and motion—are not so often demonstrable as in subcutaneous wounds of arteries. In the presence of serious bleeding, however, one does not stop to note carefully these signs, but proceeds at once to suppress the loss of blood.

In the presence of a large subcutaneous collection of blood it is not always possible to determine whether or not an important artery has been injured. Pulsation, thrill, and bruit may be absent in a false aneurysm, and, owing to compression of a large neighboring artery, present in a purely venous hæmatoma. In cases in which, as the result of dislodgment of a clot or the yielding of the vessel-wall, the hæmatoma forms rather slowly some time after the injury, the swelling may be taken for an abscess, as the pain is often severe, and fever may be present from the absorption of fibrin ferment. This statement is particularly applicable to the arterial hæmatomata which form beneath dense fascia, notably at the elbow and in the palm of the hand. Apart from the pain, however, the local signs of inflammation are wanting. Michaux * reports a case in which, owing to the presence of sharp pain and of swelling in the right iliac region, associated with vomiting, a diagnosis of appendicitis was entertained. Operation revealed a large hæmatoma of the right rectus muscle due to spontaneous rupture of the epigastric artery. We saw one case in which, because of pain and hardening of the thigh, a rupture of the femoral artery was mistaken for cramps by the attending physician and vigorous massage was instituted.

The diagnosis of injury to an important vessel, although desirable, is not essential when a large, tense hæmatoma forms, as the treatment in either case is the same. For the discussion of the symptoms of cerebral compression, the signs of hæmothorax, the evidences of intraperitoneal hemorrhage, and the diagnostic value of hæmatemesis, hæmaturia, melæna, etc., as the result of vascular injuries, the reader is referred to the articles dealing with these parts.

Treatment of Arterial Wounds.—The treatment of all varieties of wounds of arteries consists in the immediate control of hemorrhage and the adoption of measures to combat the constitutional effects of the loss of blood. Let us first dispose of the latter.

The Constitutional Treatment of Hemorrhage.—The constitutional treatment of hemorrhage should, whenever possible, be inaugurated while the operation for the control of the hemorrhage is in progress. Stimulants and measures for raising the blood-pressure must be postponed until this time, because of the danger of increasing the bleeding. Efforts should be made to supply fluid for the heart and arteries to work upon, to economize the blood which remains in the body, to stimulate the heart and vital nervous centres, and to supply external heat. The first indication is best met by intravenous infusion of salt solution (see article on "Minor Surgery"), which should be sterile, filtered, and several degrees warmer than the normal temperature of the body. Delbet † has shown experimentally that the blood-pressure can in this way be raised

* Revue de chir., Sept., 1906. † Soc. de biol., June 6th, 1906.

about 1 cm. a minute. One may introduce the solution of adrenalin chloride, in the strength of from 1 in 50,000 to 1 in 100,000 of salt solution. Other stimulants also may be injected with the salt solution. Intravenous infusion likewise raises the bodily heat; indeed, not infrequently there is a chill followed by high temperature. The procedure is direct and immediate in its action and is therefore to be preferred to the subcutaneous injection of salt solution (hypodermoclysis), which is slower and more apt to be followed by infection or sloughing, particularly when a large quantity of solution is introduced in one place. The injection of salt solution into the rectum (enteroclysis, proctoclysis) is chiefly indicated at a later period, to compensate for the fluid lost by sweating and through the kidneys. In the recent past direct transfusion of blood, which at one time enjoyed some degree of popularity, was regarded as dangerous and no more efficacious than the infusion of salt solution. In 1906, however, Crile * conducted a series of experiments on animals from which he draws the following conclusions:—"Arteries and veins of varying sizes may be anastomosed by Carrel's method so as to be impervious to blood and free from clotting; the transference of blood from one animal to another is most definitely accomplished by anastomosing the proximal end of the vein of the donee; convenience need be the only consideration in the selection of the vessels to be anastomosed; the blood of one animal may be rapidly transfused to another; the blood of one dog is isotonic with that of another dog; if a dog be bled to the last drop of blood that will flow, and then an equal amount of blood be transferred from another, the transfused blood suffers no impairment by the blood or tissue of its new host, and, in turn, it causes no impairment, no hæmolysins are produced; and, finally, the transfused blood becomes a perfect substitute for the lost blood, and the factor of hemorrhage may be eliminated."

Direct transfusion was performed on six occasions, in two of which the operation was performed upon the same individual. "The donors in each instance regained the blood lost in from five to seven days. They were kept from their work only on the day of transfusion. All showed the usual temporary effect of the bleeding; no agglutinins, no hæmolysins.

"The donee showed neither nephritis nor hæmoglobinuria, no laking of blood, and no evidence that the new blood had in any way unfavorably affected the newly transfused blood. In other words, the conclusions reached in the laboratory were wholly realized in the clinic.

"The occurrence of spontaneous cessation of hemorrhage in two of the cases, each of which was pathologic, suggests strongly this method of treatment for cholæmic, hæmophilic, and other forms of pathologic hemorrhage.

"Since the healthy blood of one individual is apparently physiologically interchangeable with that of another, if the blood lost from one is replaced with an equal quantity from another, the factor of hemorrhage may, by direct transfusion, be eliminated.

"The transformation in these cases has been unequalled in my surgical experience, except in the relief from asphyxia by intubation."

* Jour. Amer. Med. Assoc., Nov. 3d, 1906.

Crile has since performed the operation many times—an experience which serves to fortify his original conclusions. The technique of direct transfusion is given in the article on "Minor Surgery" in Vol. IV.

To economize the blood which remains in the body (autotransfusion) the foot of the bed should be raised, in order to permit the blood to flow to the vital centres. With a like end in view bandages may be applied to the extremities. Crile uses the same principle by the application of a rubber suit which is blown up with a bicycle pump. (See article on "Shock" in Vol. I.)

Stimulation by the hypodermatic injection of such drugs as ether, brandy, strychnine, digitalin, atropine, and camphorated oil, by inhalations of ammonia, alcohol, or oxygen, by rectal injections of hot coffee, whiskey, etc., is to be used as indicated, but never before the bleeding has been controlled. If the respirations fail despite stimulation, artificial respiration must be employed. External heat is secured by the application of carefully protected warm-water bags.

Control of Hemorrhage.—The immediate control of hemorrhage is accomplished, in the presence of an open wound, by direct digital pressure on the artery in the wound, and then, in the extremities, by the application of a tourniquet above the wound. In a subcutaneous rupture digital pressure is made upon the artery above the point of rupture, until the tourniquet can be adjusted. Nothing further should be done until the patient has reacted from shock, when the parts may be carefully disinfected and the vessels exposed and dealt with directly for the purpose of securing permanent hæmostasis. In regions such as the neck, where elastic constriction is impracticable, digital compression must be maintained until the wound has been sufficiently enlarged to secure the vessel by other means. A bleeding artery within the cranium, spine, chest, or abdomen requires, of course, an operation for opening these cavities before the hemorrhage can be controlled. There are no contra-indications for operation to control dangerous hemorrhage, not even the most profound shock, unless the bleeding can be temporarily stayed until reaction is obtained.

The means for controlling bleeding permanently are many, but those employed by the surgeon are very few. They may be grouped under the following headings:—(1) cold; (2) heat; (3) elevation; (4) styptics; (5) compression; (6) acupressure; (7) forcipressure; (8) torsion; (9) ligation; and (10) suture of the vessel.

(1) Cold.—Cold has been deliberately used as a hæmostatic agent since the time of Celsus. "Baron Larrey states that, after the battle of Eylau, the mercury standing at about zero (Fahr.), ligatures were applied to the large blood-vessels only, in the operations generally, and that there was no trouble from hemorrhage, although the wounded, after having been cared for, were carried to a distance." (Lidell.) Cool air, as is well known, is a remarkably efficient hæmostatic for the smaller vessels. Part of the efficacy of Le Conte's method for controlling hemorrhage in wounds of the lung, by inserting a drainage tube in the pleural cavity, depends upon this factor. Cold in the form of ice, cold water, or evaporating lotions, will hasten the arrest of hemorrhage from small vessels, but should not be used in open wounds, because of the danger of

sepsis. The ice bag is frequently employed in internal hemorrhages not suitable for operation.

(2) Heat.—Heat, in the form of hot water (120° to 150° F.), is sometimes employed as a hæmostatic; it, like cold, acts by stimulating the contraction of the muscular fibres of the blood-vessels. Warm water relaxes these fibres and encourages bleeding. Cauterization with the actual cautery has been used from the earliest times for arresting hemorrhage. It chars the tissues, thus forming a plug which closes the mouths of the vessels. It should very rarely be employed, as the devitalized tissues must of necessity separate by sloughing, a process which interferes with the healing of the wound and may give rise to secondary hemorrhage when the slough separates. If used at all the cautery should be at a dull red heat; when bright red it severs the vessels like a knife and does not stop bleeding. The actual cautery is capable of stopping hemorrhage from arteries of medium size, but should never be used on large arteries. Electrohæmostasis is the term applied to a procedure in which the tissues to be divided during an operation are crushed with forceps and baked by means of an electric current. A special apparatus is essential for the application of this method, which not only possesses no advantages over the ligature, but is more apt to be followed by secondary hemorrhage; it has been employed by but few surgeons. The same may be said of the use of steam (atmokausis, zestokausis).

(3) Elevation.—Elevation alone is often sufficient to stop hemorrhage from the larger veins; it is peculiarly useful in bleeding from the extremities, especially the lower. It is often employed as an adjunct to other forms of hæmostasis, and also as a means for lessening bleeding during operations, particularly in regions where the tourniquet is inapplicable or in which, because of special conditions (*e.g.*, atheroma, etc.), it is inadvisable.

(4) Stypties.—Stypties are seldom employed by the surgeon, as most of them act, not by contracting the orifices of the vessels, but by producing a tough coagulum of blood which often interferes with healing. Among the stypties which have been employed may be mentioned the following: antipyrin, Monsel's solution (cotton containing Monsel's salt is called styptic cotton), alcohol, turpentine, tannic or gallic acid, silver nitrate, alum, sodium chloride, vinegar, chloride of zinc, tincture of matico, adrenalin chloride, and gelatin. Adrenalin chloride, which acts by contracting the vessels, is the most powerful styptic and the one most frequently employed, particularly in bleeding from mucous membranes. It may be applied on a swab or as a spray, in the strength of 1 in 10,000 to 1 in 1,000, or as a powder in the dose of from 5 to 10 grains of the suprarenal extract. At least one case of poisoning has been reported from its use locally. Gelatin, 5 to 10 per cent in normal salt solution (Carnot's solution), has been used with success as a local hæmostatic. It should be recalled that it is an excellent culture medium and that death from tetanus has followed its use. Among the drugs which are supposed to increase the coagulability of the blood or contract vessels and thus do some good when given internally, are: turpentine, oil of erigeron, opium, dilute sulphuric acid, acetate

of lead, ergot, hamamelis, gelatin, and chloride of calcium. Chloride of calcium (10 grains, t. i. d.) is largely employed to increase the coagulability of the blood in cases of chronic jaundice previous to operation.

The above measures are not to be employed for bleeding from one of the major arteries and are simply mentioned for the sake of completeness. In the presence of a wound of a large artery one of the following plans should be adopted:—

(5) Compression.—Compression of some form is of course the ultimate principle of all forms of hæmostatic agents. Compression may be (*a*) direct or (*b*) indirect or mediate—*i.e.*, upon the ends of the divided vessel in the wound, or upon the vessel at some distance from the wound.

(*a*) Direct compression may be effected by the fingers or by tampons, compresses, or pads.

Direct digital compression is sufficient to control the most violent hemorrhage from any part of the vascular apparatus, and is to be employed until more permanent hæmostasis can be secured.

Firm gauze packing will stop any venous and many forms of arterial hemorrhage, and may be used, even when a large artery is wounded, to control the bleeding until a more secure method can be applied. In the latter instance the packing must be very firm and be held in place by a tight bandage. Graduated compresses, consisting of layers of gauze gradually increasing in size, from below upward, so as to resemble an inverted pyramid or cone, were at one time recommended for the control of arterial hemorrhage in regions in which dissection sufficient to expose the bleeding ends of the artery (*e.g.*, the palmar arches) might mutilate important structures. Unless the pressure is made directly on the bleeding points the blood may widely diffuse itself in the tissues of the limb. In a somewhat similar way the internal mammary artery has been compressed against the inner surface of a rib, by pushing a gauze bag between the ribs and then filling the bag with gauze, so that, when it is pulled upon, pressure will be made from within outward. These methods are, however, uncertain when a large vessel has been injured, and should be used, if at all, only as temporary measures.

The pressure exerted on a bleeding point by the apposition of the edges of a wound with sutures or sterile adhesive strips is frequently sufficient to control bleeding, especially when such pressure is reinforced by a firm bandage. Thus, in the scalp, ligatures are frequently omitted, because of the difficulty with which they are applied in this region, and sutures are relied upon to check the bleeding. Again, in parenchymatous organs, such as the liver, kidney, etc., sutures are often employed for restraining bleeding. Bleeding from bone is sometimes controlled by filling the openings with antiseptic wax, catgut, filaments of gauze, or fragments of the bone itself. A large osseous canal may be plugged with a sterilized stick. In the rectum pressure may be made by inserting and inflating a colpeurynter; in a perineal wound following cystostomy, by inserting and stuffing a shirted cannula (*cannule à chemise*). In bleeding from a tooth-socket the cavity may be tightly packed with gauze infiltrated

with an astringent, and firm pressure made by binding the jaws tightly shut with a bandage. In the urethra pressure may be made by inserting a large sound, or, in the deep urethra, by making pressure against the perineum.

(*b*) Indirect pressure is used chiefly for the temporary control of bleeding until more permanent measures can be applied, or to prevent hemorrhage during operation. In the limbs it is best effected by means of a tourniquet applied above the wound. In hospital work practically the only tourniquet used is the Esmarch band; but, in an emergency outside of a hospital, such articles as a belt, suspenders, handkerchief, etc., may be tied about the limb, and tightened by means of a stick pushed beneath the band and twisted. A tourniquet is most effective when placed above the elbow or knee, as below these points the vessels are protected by bones and cannot be readily compressed. The disadvantages of the tourniquet are injury to the nerves, causing pain, anæsthesia, or paralysis; injury to the soft tissues, particularly rupture of the muscles if movements of the limb are made while the band is in place; in atheroma, partial rupture of or detachment of a calcareous plate from the walls of the artery; consecutive hemorrhage after the band has been removed, owing to the paretic condition of the blood-vessels; too great a rise in blood-pressure if the limb is elevated before the band is put in place; and, owing to the blanching of the tissues, difficulty in distinguishing between the arteries, veins, and nerves. It must also be remembered that a tourniquet which has been left in place for several hours may be productive of gangrene. In arterial surgery the vessel may be compressed by a clamp, tape, or the fingers of an assistant. In operations on the head Crile temporarily closes one or both carotids by the application of a specially devised clamp to the exposed vessel. Forced flexion is carried out by placing a pad in the popliteal space, groin, or fold of the elbow, and securing the limb in strong flexion by means of a bandage. Forced flexion is exceedingly painful and is employed only as a temporary hæmostatic in the absence of better methods.

Indirect digital compression lacks most of the dangers of the tourniquet, but requires a strong skilled hand, and even then may not be long maintained, except by relays of assistants. The common carotid, the vertebral, and the inferior thyroid arteries may be compressed against the transverse process of the sixth cervical vertebra at the anterior border of the sternomastoid muscle; the facial, against the inferior maxilla at the anterior border of the masseter; the labial and the coronary, by grasping the lip at the angle of the mouth between the thumb and index fingers; the occipital, against the underlying bone about midway between the mastoid process and the external occipital protuberance; the subclavian, against the first rib by the thumb or by the padded handle of a door key, pushed downward, backward, and inward, just behind the clavicle and outside the sternomastoid muscle; the axillary, against the head of the humerus at the inner edge of the coracobrachialis, with the arm raised to a right angle; the brachial, against the humerus at the inner edge of the biceps; the radial and the ulnar, at the wrist, the former just outside the flexor carpi radialis, and the latter just outside the flexor carpi ulnaris; the abdominal aorta, if

the patient is not too corpulent, against the spine at a level with and just to the left of the umbilicus; the external iliac, against the brim of the pelvis above the middle of Poupart's ligament; the common femoral, by pressure upward and backward immediately below Poupart's ligament, midway between the symphysis pubis and the anterior superior spine of the ilium; the popliteal, against the femur, a little to the inner side of the middle of the popliteal space; the anterior tibial, midway between the malleoli; and the posterior tibial, half an inch behind the tip of the internal malleolus. When secondary hemorrhage is feared the point for compression may be marked with ink or iodine and a tourniquet applied but not tightened; if bleeding occurs, the caretaker may screw it down on the point at once and thus control the bleeding until the surgeon arrives. An Esmarch band, however, is much better than other tourniquets for this purpose, as it may be applied without considering the location of the main artery.

(6) Acupressure was introduced by Sir James Y. Simpson, in 1859, but has long since been abandoned and is now of historical interest only. It was employed in three different ways: (*a*) A long needle was passed into the tissues, securing the vessel as the stem of a flower is fastened to the lapel of a coat; (*b*) the needle was inserted through the tissues on one side of the vessel, twisted through 180 degrees, and reinserted into the tissues; or (*c*) the needle was passed under the vessel, which was then occluded by wire or silk passed over its ends in a figure-of-8 fashion. In this paragraph may be mentioned also, as a matter of curiosity, arterioversion, which was advocated by Weber in 1875. By a special instrument the ends of divided arteries were turned back, as one would roll up his sleeves, and there fixed by a little pin.

(7) Forcipressure, or the crushing of the end of a vessel with strong hæmostatic forceps, has been employed in some form or other since the days of Desault. In 1865, according to Petit, Koeberle modified the forceps of Charrière by adding a catch. The forceps were still further modified, in 1868, by Péan, with the idea of using them exclusively in operations. The term forcipressure was proposed by Verneuil. Forcipressure is frequently employed for very small vessels. Thus, during an operation many of the little bleeding points which have been caught with hæmostatic forceps, give no trouble after the forceps have been removed at the completion of the operation. In certain cases in which the proper application of a ligature is very difficult and the vessel is of large size, the forceps may be left in place for from twenty-four to forty-eight hours, being, of course, covered with sterile dressings. Forcipressure is useful also before one ties a thick pedicle, as it attenuates the tissues and renders bleeding from shrinkage of the pedicle much less likely to occur. Very powerful forceps (vasotribe, or angeiotribe) have been constructed with this end in view, and indeed a few surgeons do not even ligate after the use of such instruments. Forceps thus left in a wound frequently cause pain, interfere with dressing, prevent closure of the wound, and are capable, in the cranium and abdomen, of causing extensive damage if pressed upon too forcibly by the dressings or during a change in the position of the patient. Perhaps forceps have been used more frequently for controlling hemorrhage after vaginal hyster-

ectomy than in any other operation. Forcipressure, like ligation, crushes the artery and causes the inner coats to contract and retract within the vessel. Bothézat,* as the result of experimental researches, concludes that the forceps should remain on the vessel for from sixteen to forty-eight hours. The former time suffices for an artery the size of the radial and the latter for a vessel the calibre of the femoral. The forceps must be immobilized in the dressing. Delbet explains the occurrence of secondary hemorrhage forty-eight or more hours after vaginal hysterectomy by the fact that the arteries are caught through a layer of tissue of considerable thickness. Forcipressure should be employed for large vessels, only when ligation or suture is not applicable.

(8) Torsion.—"Twisting the cut ends of arteries was distinctly recognized by Galen as an important means for restraining the flow of blood therefrom. Aëtius, Paulus Ægineta, and Rhazes also recognized torsion as a hæmostatic measure of importance. Subsequently it became obsolete. In 1829 Amussat revived its use by proving from experiments on animals that it was a safe and efficient means of staunching hemorrhage from many wounded arteries. Soon afterward Thierry followed to the same effect. Velpeau, however, first employed torsion on the human subject. In the same year Liber, Fricke, Dieffenbach, and others made numerous trials thereof in Germany, seemingly with entire success. The French surgeons, Louis and Delpech, met with several failures. The subject was deemed of such importance by the Institute of France as to require a thorough examination, and, accordingly, it was referred to Baron Dupuytren. His report was unfavorable to the method, except in its application to small arteries. Then torsion went out of use again, to be revived once more, however, by the late Professor Syme."† Torsion may be applied in two ways: free torsion and limited torsion. Free torsion (Thierry) is simply the twisting of a vessel several times after the application of hæmostatic forceps. Tillaux, however, advised rotating the forceps until the end of the vessel was twisted off. Limited torsion (Amussat) consists in drawing the artery from its sheath with one pair of forceps and grasping it close to the tissues with a second pair, the vessel then being twisted with the first forceps until the end of the artery is detached. Torsion ruptures the inner and middle coats, which contract and invert, and twists the outer coat. Torsion is no easier or quicker to perform than ligation and is less safe than ligation. Since absorbable ligatures can be made absolutely sterile, the old objections which were lodged against the ligature, and which were based upon its non-absorbability and the sequelæ of infection, are no longer to be considered. It is true that even the femoral and brachial arteries have been repeatedly and satisfactorily occluded by torsion, but it is true also that secondary hemorrhage is not infrequent after this method for controlling bleeding. We would limit its use to arteries too small to be dignified by a ligature and to certain plastic operations in which the presence of knotted ligatures is undesirable.

(9) Ligation is the most satisfactory method for the control of hemorrhage from any vessel large enough to be seen with the naked eye. In certain situa-

* Thèse de Montpellier, Nov. 4th, 1893. † "International Ency. of Surg.," vol. ii.

tions, however, the surgeon may attempt, not only to control the bleeding, but also to conserve the lumen of the artery by suturing the vessel.

The ligature, as a means for controlling hemorrhage, dates back to the remotest antiquity, nor do we know by whom it was first employed. Celsus, in the first century, was apparently acquainted with its merits, as were also Galen in the second century, Aëtius in the fifth, and Paulus Ægineta in the seventh. Rhazes, in the tenth century, advised the application of a double ligature and cutting the vessel between. Avicenna in the eleventh, Albucasis in the twelfth, Averrhoës in the thirteenth century, were all familiar with this method for occluding blood-vessels and it was recommended at different periods by Guy of Chauliac, Brunus, Theodoricus, Rolandus, and Lanfranc.* From this it may be seen that the real inventor of the ligature as a hæmostatic agent was not Ambroise Paré, to whom, however, the credit of introducing it as a means of controlling bleeding in amputations is probably due. In 1564 Paré published his work and insisted that the cautery should make way for the ligature. Cauterization, nevertheless, continued in favor, probably because the principles of ligation were not understood, and also because of the prevalence of sepsis. Thus, the ligature was accused of producing tetanus, convulsions, etc., and it was not until the beginning of the nineteenth century, after the studies of Travers, Abernethy, Lawrence, Cooper, Béclard, and Breschet, and particularly those of Jones, that the ligature gained much headway against cauterization and torsion. Surgeons were afraid to tie the ligature tight enough to rupture the inner coats of the artery, and accused the ligature material of causing untoward conditions which, as we now know, were due to micro-organisms introduced with the ligature. The ends of the ligature were left long and allowed to protrude from the wound, so that they could be removed when they had "rotted loose from the blood-vessel." In 1814, Physick, of Philadelphia, suggested the use of absorbable animal ligatures made of chamois leather, the strands of leather being rolled on a slab to make them round and hard.† Later, Hartshorn used strips of parchment, and Eve the tendons of the deer. These suggestions, however, seem to have been ignored or forgotten until Lister published his method of preparing catgut with chromic and carbolic acids. The ends of the ligature could then be cut off short and the ligature would disappear after it had served its purpose. Since that time catgut has gradually forced its way to the front as a ligature material. As prepared at the present time it is absolutely sterile and can be made to resist absorption for as long a period as is desirable. The sole practical disadvantage of catgut is that it is not so readily tied as silk. The rule, in ligating vessels, is to make a reef, or square, knot and never a granny knot or a surgeon's knot. This is readily done with silk, the first knot of which remains tight until the second is made. If a single turn is made with catgut it is apt to loosen during the tying of the second knot. If a surgeon's knot is made the constriction cannot be made so tight as with a single knot. The swelling of the catgut after it is placed in the tissues is, theo-

* "International Ency. of Surg.," vol. iii., p. 530.

† Cooper's "Surgical Dictionary," vol. ii., p. 130.

retically, sometimes an advantage and sometimes a disadvantage. Catgut should always be tied in three knots and the ends cut at least one-eighth of an inch long. The ligature should be tied by placing the ends of the thumbs or index finger upon the knot and separating these by using the first joint of the thumb or the second joint of the finger as a fulcrum. Some surgeons use catgut for all arteries, regulating its size according to the calibre of the vessel to be ligated; but most surgeons prefer to tie very large arteries or thick pedicles with silk.

A ligature may be applied to the bleeding end of a vessel (immediate ligation) or the vessel may be tied in its continuity some distance from the wound (ligation in continuity). Ligation of the bleeding end of an artery is conducted by seizing the end of the vessel, without any of the surrounding tissues, with hæmostatic forceps, drawing it a little way from its sheath, when such exists, and tying the ligature about the vessel, beyond the forceps, in a reef knot. There are some exceptions to this rule. With small vessels a little of the surrounding tissue is usually included in the grasp of the forceps, which should be removed as the first knot is tightened; otherwise, the ligature may slip off when the forceps is removed. Again, with badly diseased vessels it may be prudent, in order to prevent cutting through of the ligature, to include within the ligature a small portion of the surrounding tissues, care being always taken, however, to avoid the accompanying nerve. This operation was called mediate ligation. The second knot should be tied firmly, but should not be jerked, as such a manœuvre may break the ligature. With the smaller arteries the ligature may be tied with sufficient firmness to rupture the inner coats. With very large arteries this may result in cutting through of the ligature or dilatation and rupture of the vessel immediately proximal to the ligature. When one is dealing with these vessels the walls should be approximated only, the stay knot being employed. Chromicized catgut should be used for all but the largest vessels, for which floss silk is the best material, since it is less likely than other forms of silk to cut its way into the artery. A suture ligature is one passed through the tissues surrounding an artery by means of a needle. It is used in dense tissues from which the vessel cannot be drawn; in necrotic tissues or in atheroma, because of the fear that the ligature will cut through; in tissues such as the dura, mesentery, and omentum; and in any region to insure against the slipping of the ligature. Both ends of an artery should be ligated, as a free collateral circulation may make the lower end as dangerous as the upper. If the wound is a lateral one, a ligature should be placed on each side of it and the vessel completely severed, in order to allow it to retract. An artery capable of producing vigorous bleeding must be ligated in the wound, even though an operation is necessary for such procedure. Ligation in continuity for hemorrhage should be performed only under very exceptional circumstances, as it is often ineffectual owing to a free collateral circulation. Thus we lost a patient from recurring hemorrhage following ligation of the carotid for uncontrollable hemorrhage from the cheek. Again, the bleeding vessel may be a large vein, or an artery not derived from the vessel ligated. Possibly in cases in which the tissues are rotten from infection, or in which packing fails to control permanently a bleeding artery the ex-

posure of which would necessitate the destruction of important structures, ligation in continuity may be indicated. In the former instance recurring of bleeding would call for amputation.

A lateral ligature is one applied to the side of a wounded vessel after the edges of the wound have been drawn together with hæmostatic forceps. It is a method which is frequently used for occluding lateral wounds of veins, but practically never for arteries, as the ligature is very apt to be dislodged by the high blood-pressure in the artery and its peristaltic action, and also because it is more difficult to apply owing to the thick walls of the artery. We mention it in this connection because Bérard,* in removing a tumor of the mesentery in a woman aged sixty, tore a hole in the aorta and claims to have been successful in controlling bleeding by the application of a lateral ligature; the patient recovered.

The effects of a ligature, when it is tied as firmly as it should be, are rupture of the inner and middle coats, which curl up and retract, and the formation of a small thrombus, which is finally replaced by fibrous tissue, which thus obliterates the vessel. Catgut is absorbed and silk, in the absence of infection, becomes encysted. The rupture is transverse and generally linear, the inner coats lying in plaits turned toward the lumen of the vessel. A clot forms on each side of the ligature, although Baumgarten declares that this is not essential, and—with perfect asepsis—may be absent. The proximal clot is generally a little longer and thicker than that in the peripheral segment of the artery. It is conical in shape and generally adherent at its extremity, near the first collateral branch, and occasionally it penetrates, but rarely obliterates, the first collateral.

Surgeons have from time to time rebelled against the practice of tying a ligature tight enough to rupture the inner coats, believing that in certain instances, particularly in the presence of atheroma and when dealing with very large arteries, such as the subclavian and iliac, there is danger that the ligature will cut through or that dilatation and rupture of the artery will take place immediately proximal to the point of ligation. Saviard, in 1702, suggested, in order to prevent this accident, that the ligatures be broad, and that a piece of cloth or a segment of a rubber catheter be interposed between the ligature and the vessel. Jameson, of Baltimore, in the early part of the nineteenth century was a warm advocate of the plan of obliterating vessels without rupturing the inner coats, and for this purpose he used buckskin ligatures. In recent years Ballance and Edmunds have been the chief advocates of this method, advising the application of a stay-knot when dealing with large arteries. Two ligatures are passed around the artery side by side and each half is knotted; the two ends on each side are then used as a single thread and the knot is completed. Other surgeons have recommended that two ligatures be passed about the vessel with a slight interval between, and that the central ligature be tied so as to narrow the vessel considerably without obliterating it, thus acting as a buffer against the blood-current. There can be no doubt, theoretically, that one can tie a blood-vessel in such a manner as to obliterate it without injuring the inner

* Revue de chir., 1906.

coats, but that it would be very difficult to do this in actual practice is scarcely to be questioned. Bothezat has investigated this subject from an experimental standpoint and he finds that the minimum force which can be employed for arresting the blood-current always determines some contusion of the middle coat and laceration of the internal coat. When the tunics are left intact the process of obliteration requires a longer time and is less energetic.

Ligation of a large artery is followed by a rise in the general blood-pressure which decreases as the collateral circulation is established. When a large artery is tied the parts which it supplies become paler and colder until the collateral circulation is re-established; no change is noticed if the arterial wound has been complete.

The results of ligation of large arteries have been vastly improved since the advent of asepsis, and secondary hemorrhage is no longer as menacing as formerly. With hemorrhage conquered there yet remain the evils which may follow the cutting off of the blood-supply to the parts supplied by the vessel. The following statistics are taken from Hoepfner:—According to Schmidt (old statistics) ligation of the femoral artery gave gangrene in the proportion of 57.1 per cent, while Raabe gave, for ligation following injuries of the femoral artery in civil life, 19 per cent resulting in gangrene, and for such in war 21 per cent. Ligation of both femoral artery and vein, according to Ziegler's statistics of 60 cases, showed 48.3 per cent in which the limb became gangrenous. Steiner found that 55 per cent of the cases were followed by gangrene, after ligature of the femoral artery and vein, while the earlier statistics of von Bergmann gave 60 per cent. Janssen's statistics showed that 54.5 per cent of the cases in which the popliteal artery was injured terminated in gangrene, while simultaneous injury to the artery and the vein always gave gangrene. His statistics also showed that simultaneous injury to the anterior and posterior tibial arteries is equally as bad. Brilliant are the results in the upper extremity as compared with those in the lower. Of 90 cases of ligature of the subclavian, according to von Bergmann, only 2 were followed by gangrene (2.3 per cent); indeed, simultaneous ligation of the subclavian artery and vein may give no bad results except œdema. Ligation of the axillary gave gangrene in 6.6 per cent, and of the brachial in 18.75 per cent. In the case of the vessels mentioned above the integrity of the limb is at stake, whereas in the case of the carotid it is the integrity of the brain and the existence of the individual that are at stake. The prognosis is especially bad if the vessels are atheromatous, because the collateral vessel cannot dilate. Voluminous are the figures on this subject. Pilz (1880) in 914 cases found a mortality of 39.8 per cent; Le Fort, in 435 cases, 43 per cent; Zimmermann 31 per cent; and Vetere 37 per cent. Brain symptoms were apparent in 32 per cent, of which 56 per cent died (Pilz); but when the stream was slowly cut off the mortality was only 26 per cent. Of 789 ligations of the common carotid in Wyeth's table 41 per cent died. Of 47 cases treated by moderate surgical principles but one perished. (Reyher and Weljaminaw.) Cerebral involvement occurred in 20 per cent (Warren), in 26 per cent (Zimmermann), and in 25 per cent (Riese). Statistics referable to the results of ligation

of other arteries will be found in Vol. IV. The figures given above show clearly that ligation of a large artery should be avoided if there is any possible way to control bleeding and yet permit the blood to course through the artery undisturbed. For this purpose suture of arteries has recently sprung into prominence.

(10) Suture of arteries must always be considered when dealing with a wounded artery whose occlusion by ligation might result in gangrene or other serious trouble in the parts which it supplies—such arteries, for example, as the common carotid, axillary, brachial, external iliac, femoral, popliteal, aorta, and other large abdominal vessels.

As early as 1731 Petit showed that partial wounds of arteries could heal spontaneously with preservation of the lumen of the vessel. As the result of similar observations Lembert,* in 1762, suggested that it might be possible, in favorable cases, to pass a needle through the lips of an arterial wound and close the wound by winding a ligature beneath the needle. He made some experiments on the horse, but cites only one case in which the method was employed in man; he also mentions the fact that Hallowell, in 1759, closed, after this fashion, a wound in the brachial artery following venesection. The needle came away on the fourteenth day and healing was complete in forty-two days. The pulse on the affected side was present, but was weaker than that on the sound side. In 1773 Asman made some experiments on the femoral artery of the dog, using Lembert's technique. In two instances the operation was successful in controlling bleeding, but at a later period the vessel was found obliterated by scar tissue.

For one hundred and ten years surgeons relied with implicit confidence upon the work of Asman, and arterial suture was neglected, although Bell (1804), Jones (1805), Langenbeck (1825), Balling (1837), Porta (1851), and Emmert (1880) demonstrated that wounded arteries might heal spontaneously without obliteration of the lumen, and Fischer (1867) reported 72 healed wounds of the heart, in 12 of which were found foreign bodies. In the mean time, however, suture of veins received some attention and far outstripped its older brother. This subject, however, will be considered on a later page.

Glueck † seems to have been the first again to experiment with the closure of arterial wounds. He successfully used small ivory clamps which were to remain permanently; no thrombosis followed, but the method was not employed in man. In 1882 he closed a number of arterial wounds in dogs with sutures, but, despite great care, he was forced to ligate in order to control the bleeding from the needle holes. Notwithstanding his misfortune he still believed that the method would succeed with better technique and spoke of the possibility of curing by this means certain aneurysms of the aorta and other vessels.

In 1886 Postempski and in 1888 von Horrock experimented on animals and, although successful in controlling the bleeding, they were not successful in preventing thrombosis.

Jassinowsky,‡ in 1889, was the first to put arterial suture on a scientific

* "Medical Observations and Inquiries," London, 1762, vol. ii.

† Archiv f. kl. Chir., 1883, Bd. xxviii. ‡ Inaug. Dissert., Dorpat, 1889.

basis and to pave the way for its employment in man. He says that the question is intimately associated with the spontaneous healing of arterial wounds. The problem is to convert a large wound into a series of small ones.

Jassinowsky experimented on sheep and calves, because of the larger size of the arteries. He used fine silk, and asserts that after two months he could find no trace of the suturing material. Large catgut was found to be unsuitable because of its size, and small catgut was absorbed too quickly. He sutured the two outer coats only, inserting the needle 0.5 mm. from the edge of the wound and making the sutures 1 mm. apart. The sutures were tied in a double reef knot, care being taken not to pull them too tightly. He believed that there was less bleeding from the stitch holes when the intima was not penetrated. He found that the bleeding from the stitch holes was controlled by pressure kept up for about one minute in large thick-walled arteries, and for from two to three minutes in small ones. If the sutures were passed through all the coats compression was needed for five minutes or longer. With exact suturing of thick walls the compression was needed for only thirty seconds. He removed the lower clamp first and took off the upper one slowly. The sheath of the vessel was next sutured, then the muscle and fascia, and finally the skin, no drainage being employed. In 26 experiments he had no secondary hemorrhage and no aneurysms. He was unable to suture more than half the circumference of an artery, because of the strong retraction of the lips of the wound, and he stated that gunshot wounds and lacerations were not suitable for suturing, because the edges of the wound must be smooth.

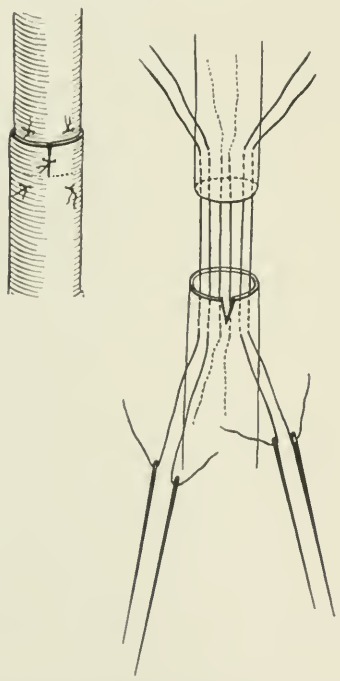

Fig. 73.—Murphy's Invagination Method of Suturing Arteries. The figure to the left shows the suturing completed. (From the New York *Med. Record.*)

After Jassinowsky a number of experiments were made by other authorities, especially by the Italians Ceccrelli (1890), Burci (1890), Lampiasi (1891), Moscatelli (1891), and Tansini (1890), some advocating and some condemning suture as the result of their experience.

In 1892, one-hundred and thirty-three years after Hallowell's case, Durante reported two successful arteriorrhaphies in man and Rosa one.

In 1894 Abbe made the first experiments with circular suture of arteries (end-to-end anastomosis), tying the ends of the vessel over an hour-glass-shaped tube of thin glass.*

In 1896 Brian and Jaboulay anastomosed vessels in animals, using U-shaped sutures which everted the edges of the wound and approximated intima to intima. The method was unsuccessful in dogs because of thrombosis, but it was

*New York Med. Jour., Jan., 1894.

successful on the carotid of a donkey. The credit for this method was claimed by Solomoni in 1900.

In 1897 Nitze used an ivory apparatus which he placed over one end of the vessel, which was then turned back like a cuff, and the other end of the vessel was drawn over it, so that intima lay in contact with intima. After suturing, the apparatus was removed.

In 1897 Dr. John B. Murphy * was the first successfully to perform circular arteriorrhaphy in man; he reported one case and made experiments on animals. Of twelve animal experiments two only were successful. Two or three double-headed sutures are inserted into the proximal segment of the artery, including the two outer coats only. These are then re-inserted at regular intervals, one-third to one-half of an inch above the end of the distal portion, from within outward. The threads are tied, thus invaginating the artery. (Fig. 73.) In order to facilitate invagination a small incision, from one-third to one-quarter of an inch in length, is made, parallel to the long axis of the vessel. Interrupted sutures are then inserted, binding the intussuscipiens to the surface of the intussusceptum, the sutures in the latter including the adventitia only. Murphy concludes that his procedure is applicable to large-sized vessels only. The method gives a double thickness of the artery at the wounded part, but narrows the lumen and presents a ring of rough tissue inside to aid thrombosis. It requires also that there be enough artery to invaginate. According to Murphy, loss of more than three-quarters of an inch of the vessel precludes invagination, except where the limb can be flexed.

In 1898 Glueck performed circular suture after excising a segment of the artery, which was temporarily threaded on one of the ends of the vessel and later brought down over the line of the suture and stitched in place. Instead of a ferrule of artery a segment of vein might be employed for the same purpose.

In 1899 Doerflex experimentally sutured arteries, using silk and penetrating all the coats of the vessel.† He performed invagination in four animals by the Murphy method, three of the operations being followed by thrombosis and one by death from hemorrhage. Doerflex thought that the dangers which were lodged against the through-and-through suture,—viz., a foreign substance in the lumen of the artery, endarteritis, and bleeding from the stitch holes,—were so slight as to be negligible. He collected 43 experiments in which the intima was included in the suture, with thrombosis in 5. He made 12 experiments himself with the through-and-through suture. After from five to eight weeks the suture could not be seen and nothing was found but a slight thickening of the artery with a slight prominence of the intima.

Payr, in 1900,‡ described a method of arterial anastomosis closely resembling that of Nitze, mentioned above, except that he used a magnesium apparatus which was ultimately absorbed. He brought intima in contact with intima and obtained good results. A thin magnesium cylinder, with a groove on the outer surface, was put over the proximal end of the artery, which was then

* New York Med. Rec., Jan. 16th, 1897.

† Beitraege zur klin. Chir., 1899.

‡ Archiv f. klin. Chir., Bd. lxii., p. 67.

turned back over the cylinder as a cuff, so that the intima faced outward, the cuff being fastened in place by a piece of silk tied around the cylinder at the site of the groove. The distal end of the artery was then drawn over the cylinder and likewise fastened by a silk thread tied around the cylinder in the groove proximal to the first ligature, so that the intima lay in contact with intima.

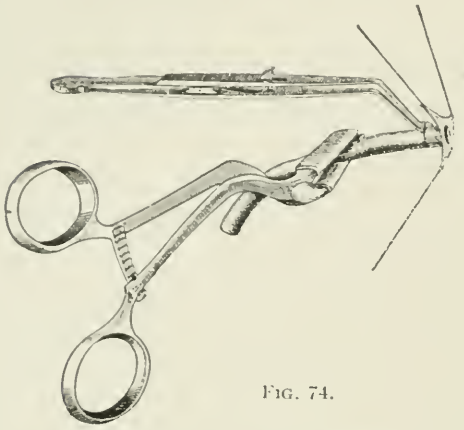

FIG. 74.

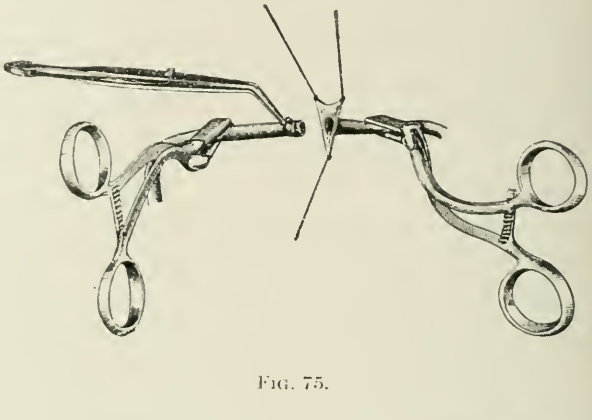

FIG. 75.

FIGS. 74 and 75.—Diagrams Showing Use of Payr's Magnesium Cylinder in Arterial Anastomosis. (From *Archiv für klinische Chirurgie.*)

FIG. 74.—The end of the proximal arterial segment has been drawn through the cylinder and is about to be reflected over the cylinder as a cuff.

FIG. 75.—The proximal end of the artery has been drawn through the cylinder, turned back over it, and secured with a ligature. The distal segment is dilated and ready to be slipped over the cylinder.

(Figs. 74, 75, and 76.)* In 1903 Hoepfner performed six circular arteriorrhaphies on animals by the Payr technique, with success in four instances, and with thrombosis in two. After six months only small particles of the metal could be found. Gas cysts formed in the two cases of thrombosis and secondary hemorrhage occurred in one case on the fifth day. The method of Payr is difficult to carry out and cannot be applied to vessels less than 3 mm. in diameter. Gas cysts are never found unless thrombosis occurs.

FIG. 76.—Payr's Arterial Anastomosis Completed. (*Archiv f. klin. Chir.*)

In Payr's second method † male and female aluminum cylinders were used, the male having four pegs and the female four holes. (Fig. 77.) The end of the artery was drawn through the male cylinder and caught on the pegs, so that the intima was turned outward. The peripheral end was treated in the same way and the cylinders were then joined. (Figs. 78, 79, 80.)

In 1902 Carrel ‡ described a method for suturing blood-vessels which seems to be the best yet proposed. It may be used for small vessels, makes an air-tight joint, does not diminish the calibre of the vessel, and can be employed in all cases in which suture is desirable. Extremely fine, straight, round, sharp-pointed needles are used. In end-to-end anastomosis three guide sutures are applied at points equally distant around the circumference of the vessel. Trac-

* Archiv f. klin. Chir., Bd. lxx., p. 434.

† Archiv f. klin. Chir., 1900, 1.

‡ Lyon méd., 1902, p. 859.

tion on each of these transforms the circumference into a triangle whose sides may be elongated as much as the elasticity of the coats permits. Each side of the triangle, after being made taut by an assistant drawing on two of the guide sutures, is sewed with a continuous stitch, the insertions of the needle being very close. Although it was originally advised that the intima be avoided, it is now known that such is undesirable. The steps of end-to-end anastomosis are as follows:—(1) Provisional hæmostasis with rubber-coated forceps applied from 1 to 2 cm. from the ends of the vessel. These are used by an assistant to bring the segments together. (2) Preparation of the ends of the vessel by cutting them square across. If the external tunic slides or rolls over the lumen a portion of it should be resected. (3) Passage of the three guide sutures as described

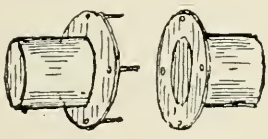

Fig. 77.

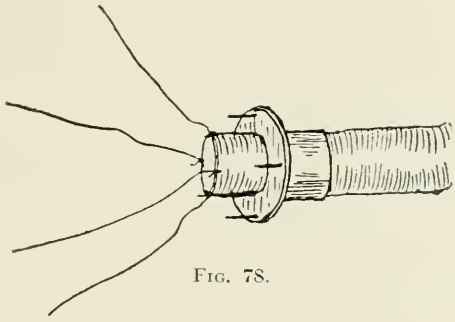

Fig. 78.

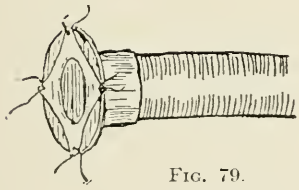

Fig. 79.

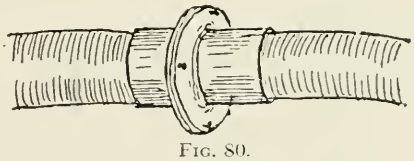

Fig. 80.

Figs. 77–80.—Diagrams Illustrating Payr's Second Method of Securing Arterial Anastomosis, viz., by means of Aluminum Cylinders. (*Archiv f. klin. Chirurgie.*)

Fig. 77.—The Two Halves of the Cylinder.

Fig. 78.—The End of the Artery is Shown to have been Drawn through the Cylinder.

Fig. 79.—The Arterial Wall is Caught on the Pegs so that the Intima is Turned Out.

Fig. 80.—Shows the Cylinders Joined.

above. Each suture is tied. (4) Transformation of the section to a triangle by drawing on the guide sutures (Fig. 81), thus dilating the vessel and facilitating suturing. Suturing of each side of the triangle with a continuous suture. (Fig. 82.) Termino-lateral anastomosis is performed in the same way. The opening in the large vessel should be slightly larger than the end of the smaller vessel.

In 1903 Amberg performed anastomosis by splitting the ends of arteries longitudinally for a distance of 3 or 4 mm., and turning the flaps thus formed outward, so as to bring intima in contact with intima.

Brewer * suggests closing wounds of large arteries with sterile adhesive plaster. The artery is first cleansed with ether. "A small strip of the plaster is next passed beneath the vessel, and the two corners are held by two small artery clamps in the hands of an assistant. The strip is then put gently on the

* Annals of Surgery, Dec., 1904.

stretch and the lower extremity of the strip held by the clamps is placed firmly in contact with the vessel, while the upper extremity of the plaster is slowly drawn upward. This causes the vessel to rotate with the plaster until the horizontal edge of the lower extremity of the plaster is on a level with the vessel and firmly adherent to it. The two clamps are then passed over the vessel and

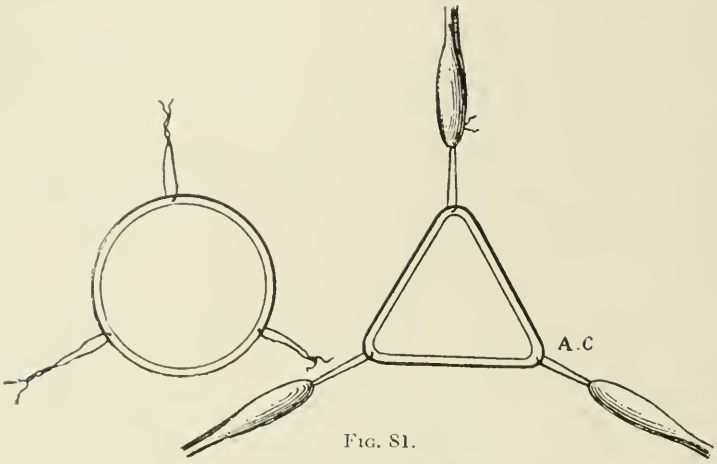

FIG. 81.

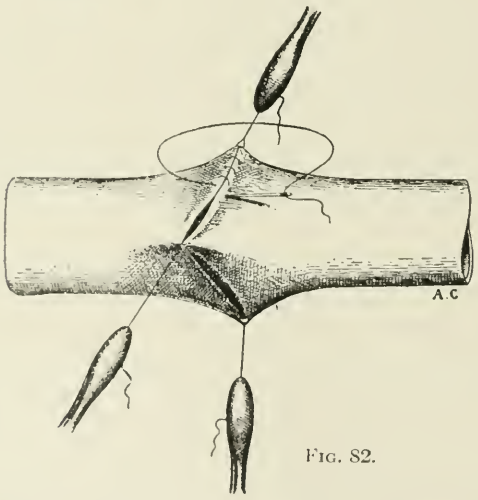

FIG. 82.

FIGS. 81 and 82.—Diagrams Showing Carrel's Method of Arterial Anastomosis. (From the *Lyon Médical*, 1902.)

FIG. 81, *a*, shows the three guide sutures passed at points equidistant around the circumference of the artery; Fig. 81, *b*, shows the circular end of the artery converted into a triangle by traction on the guide sutures.

FIG. 82.—In this Figure the Ends of the Artery are Approximated and Each Side of the Triangle is Sutured with a Continuous Suture.

the plaster is kept on the stretch while the operator, with his thumb and forefinger, gently rotates the vessel backward, and at the same time compresses the enveloping plaster until it adheres snugly. The redundant plaster is then removed and the vessel allowed to fall back to its normal position in the wound." (Brewer.)

This method has been successfully used in dogs but not in the human being.

It leaves a foreign substance which predisposes to infection, and it not infrequently, as shown by Brewer, causes thrombosis from too much pressure.

Dorrance * describes a method of arteriorrhaphy which he has successfully used in the horse and the dog, and which has the following advantages:—The suture does not protrude into the lumen of the artery, the interior of the artery is left smooth, and the liability to secondary hemorrhage is lessened by the double line of sutures. After clamps have been applied above and below the wound, the suture is passed through the two outer coats of the artery above the wound and tied. The needle then traverses all the coats of the artery on each

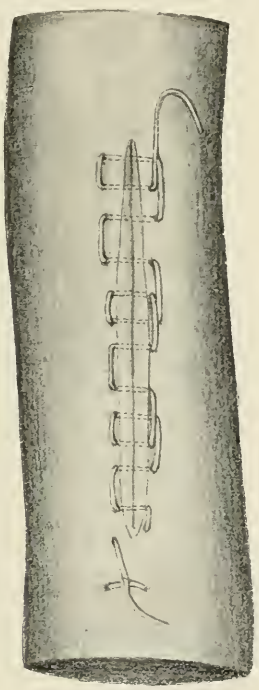

Fig. 83.

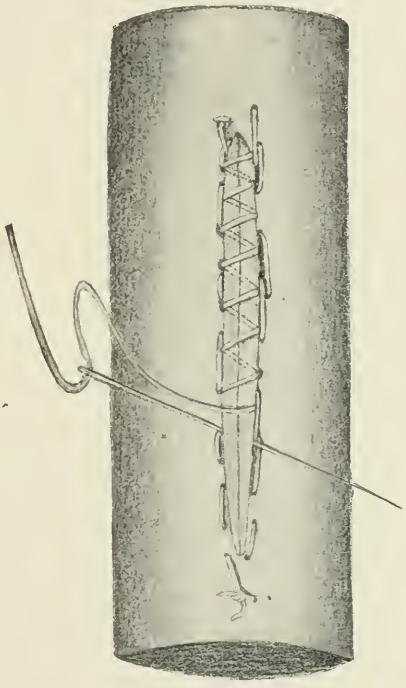

Fig. 84.

Figs. 83 and 84.—Dorrance's Methods of Suturing Arteries. (*Annals of Surgery*, Sept., 1906.)
Fig. 83.—Suture Inserted and Pulled Tight in Lower Half.
Fig. 84.—Mattress Suture Pulled Tight and Half Hitch Made; Whip Stitch partially Inserted but not Pulled Tight.

side of the wound, in the form of a continuous mattress suture, with the dropping back one-half of a suture length every third suture so that the edges of the artery are everted. The suture is secured at the lower end of the cut with a half-hitch, and brought back to the starting point as a continuous whip-stitch over the edges of the artery, outside of the mattress suture. (Figs. 83, 84.) This method, which appears to be identical with that described by Clermont in 1901 for the circular suture of veins, can be applied only to very large arteries and may then prove very useful.

De Gaetano,† in his work on animals, placed a glass cylinder in the artery to facilitate circular suturing, removing the apparatus before he tied the sutures.

* Annals of Surgery, Sept., 1906. † Centralblatt f. Chir., 1906, p. 72.

Microscopic examination of the cicatrices after arteriorrhaphy shows that the intima is regenerated and that the outer two coats are replaced by fibrous tissue. Burci, however, claims that complete regeneration of the three coats occurs. Jacobsthal found elastic elements in the scars, but no muscle fibres.

We have collected 53 cases of lateral and 10 cases of circular arteriorrhaphy for accidental wounds. These figures do not include cases in which arteries have been sutured for arterial and arteriovenous aneurysm, for the removal of emboli or thrombi, for the treatment of arteriosclerotic gangrene, or for the performance of direct transfusion, which cases may be found under their respective headings.

The cases of suture of lateral wounds belonged to the following surgeons: 1759, Hallowell; 1892, Durante (2 cases), Rosa; 1894, Heidenhain; 1895, Zoege-Manteuffel, Israel; 1896, Orlow, Battistini; 1897, Ziegler; 1898, Camaggio, Lindner, Ricard, Garre (2 cases), Nové, Josserand; 1899, Harte; 1900, Glueck, Seggel, Heinlein (2 cases), Koerte; 1901, Richard, Veau, Rotter, Pringle, Halstead; 1902, Artiz de la Torre, De Page, Matas; 1904, Brewer (2 cases), Wiart, Glauner, Bergmann (2 cases), Torrance, Plucker; 1905, Stewart, Martin, Jacobsthal, De Gaetano; 1906, Dana, Eichel, De Page, Ziembicki (3 cases); 1907, Poenaru-Caplescu; 1908, Stewart, Sherman. An analysis of these cases shows the following:—*Artery injured:*—Common carotid, 5; internal carotid, 2; axillary, 12; brachial, 8; radial, 2; abdominal aorta, 1; common iliac, 1; external iliac, 4; femoral, 12; popliteal, 6.—*Cause of injury.*—Venesection, 1; breast amputation, 6; removal of tumors elsewhere, 10; stab wound, 18; appendicitis operation, 1; operation for thrombosis of the internal jugular, 1; secondary hemorrhage following crush, 1; opening fistula of groin, 1; gunshot wound, 1; hernia operation, 4; reduction of dislocation of shoulder, 2; resection of knee, 2.

The size of the wound varied, in the different cases, from a mere puncture to an opening 20 mm. in length. Catgut was used in only ten instances, linen thread in one, celluloid thread in one, and silk in the remainder. In 20 cases the sutures pierced the two outer coats only, and in 19 the sutures were through-and-through; in the rest of the cases the depth of the suture is not stated. In 41 cases the pulse below the sutured point was present after operation and persisted; in 4 cases, although present at the completion of the operation, the pulse disappeared after an interval of some weeks or months, indicating a slowly forming thrombus. In 4 cases absence of thrombosis was determined at autopsy. In 2 cases the sutures tore out during the operation and it became necessary to tie the artery (the femoral and the iliac). Secondary hemorrhage occurred in 2 cases; in one, a wound of the axillary reopened on the twenty-first day, necessitating ligation of the vessel; in the other, involving likewise the axillary, death occurred on the twelfth day from hemorrhage; in both of these cases the wounds were infected. In a number of other instances secondary hemorrhage failed to appear despite the presence of infection. Gangrene is mentioned in only 2 cases (femoral, popliteal), although the companion vein was injured in several instances. In no case is aneurysm noted as a sequel.

The cases of circular arteriorrhaphy were reported by the following

surgeons: 1897, Murphy, Djemil Pacha (2 cases); 1899, Kuemmel, Krause; 1902, Fergusson; 1904, Delanglade; 1905, Stewart; 1906, Stewart, Brougham. Of these 10 cases the axillary artery was involved in 3, the brachial in 2, the radial and ulnar (same patient) in 1, the femoral in 3, and the popliteal in 1. In 3 the wound was caused by a bullet, in 1 by a piece of steel, in 1 by a stab wound, and in 5 the vessel was accidentally opened during a surgical operation. The largest amount of vessel resected was a portion 2 inches in length (femoral). In 7 cases the vessel was united with silk; in 3 the suture material was not mentioned. The Murphy method was employed in 8 cases and simple approximation in 2. In 5 cases the peripheral pulse could be felt at the close of the operation, and in 5 it was absent immediately after the operation. Infection occurred in at least 3 cases and gangrene in 2 (femoral, popliteal). In no case was secondary hemorrhage or aneurysm reported.

Finally, we may mention: Torrance's case * in which, following a compound fracture of the ankle, the anterior tibial artery was invaginated into the internal saphenous vein, the vessels later sloughing; and Golden's case † in which the posterior circumflex was drawn into the brachial artery through a slit in the side of the latter after the circulation through the brachial had been destroyed by an injury. In this case death followed in a few days from sepsis.

Our own ideas as to the technique of arteriorrhaphy are as follows:—Asepsis should be absolute, since slight infection, even though too mild to cause suppuration, may induce thrombosis. The vessel should be handled as gently as possible, and not more of the sheath should be stripped from it than is absolutely necessary. Provisional hæmostasis should be secured by an assistant who gently compresses the artery between the fingers at a convenient distance on each side of the wound in the vessel. Rubber-coated clamps of various sorts are unnecessary and more likely to produce lesions of the intima (and hence thrombosis) than the fingers. The edges of the wound should be smooth. If there is any fraying or laceration such should be removed with a sharp knife rather than with scissors, in order to avoid contusion. The needles should be as fine as are obtainable and should not have cutting edges. The silk likewise must be of the finest and may be sterilized, as suggested by Carrel, by boiling in vaseline. The silk is put into the vaseline dry, so that, when the proper degree of heat is reached, the entire strand becomes impregnated with fat. Carrel applies sterile vaseline also to the edges of the wound in the vessel to prevent drying. Salt solution may be used for the same purpose. In lateral wounds a guide suture, to be held by an assistant, may be placed at either end of the wound, in order to facilitate suturing. The continuous suture is more rapidly applied than the interrupted and there is less tendency to leakage between the points of insertion. The suture should penetrate all the coats of the artery instead of the outer and middle coats only, since the former is easier to apply and much more sure to hold. The points of insertion should be about 1 mm. apart and the suture so inserted as slightly to evert the edges of the wound and insure accurate contact of intima with intima. The less tension on the suture line the greater the chance of success. The distal

* Charlotte Med. Jour., June, 1907. † West Va. Med. Jour., April, 1907.

compression should first be removed, then the proximal very gradually, while pressure is applied to the suture line until the needle punctures cease to bleed. Next, the sheath should be sewed, then the fascia, and finally the skin. If the wound involves more than one-third or at most one-half of the circumference of the vessel most authors advise that the section be completed and an end-to-end anastomosis performed. This is best effected by the Carrel method, a brief description of which has been given above.

Unfortunately, in the very cases in which arteriorrhaphy for wounds is most strongly indicated,—*i.e.*, in those individuals with chronic arteritis, in whom the danger of gangrene after ligation is much increased,—the sutures are apt to tear out during the operation or thrombosis is likely to occur subsequently. Even in these cases, however, we believe that arteriorrhaphy should be tried, since, when one considers the probability of section of the vessel by a ligature, the dangers of sutures are at least no greater than those of ligation, and in the event of thrombosis the patient is no worse off than after the application of a ligature. Indeed, if the thrombus forms slowly, the collateral vessels may sufficiently dilate to prevent the occurrence of gangrene in the affected part.

Experimentally, the perfection of the technique of arteriorrhaphy has led to some interesting results. Arteries and veins have been transplanted successfully and even organs have functionated, at least for a few days, after being transplanted from one animal to another. (Carrel and Guthrie and others.) Hoepfner amputated and then replanted a leg in three dogs. In one animal the circulation remained intact four days. Vessel transplantation has been tried twice in man. Delbet,* after excising an aneurysm of the femoral artery, attempted to graft between the ends of the vessel a segment of a femoral artery from an amputated limb. The sutures tore out repeatedly, owing to the presence of atheroma, and he was forced to ligate.

Goyanes † extirpated a popliteal aneurysm and successfully transplanted a segment of the popliteal vein into the breach, using Carrel's technique. As to organ transplantation, Jaboulay ‡ reports two cases of chronic nephritis in which he transplanted a pig's kidney in one and a goat's kidney in the other to the bend of the elbow, anastomosing the renal artery with the brachial, and the renal vein with the median cephalic. Thrombosis occurred in both cases.

VI. ANEURYSMS.

Arterial Varix.—An arterial varix corresponds to a varicose vein; the artery is dilated, elongated, thickened, and tortuous. It is a condition which sometimes affects the large vessels in old age. Closely related to arterial varix is the compensatory dilatation of small and medium-sized vessels after occlusion of a large artery. The arteries supplying a region which is the seat of a cirsoid aneurysm are generally varicose, but the conditions are not to be confused.

* Revue de chir., June, 1907, p. 1086.

† Siglo medico, Sept. 8th, 1906; Jour. Amer. Med. Assoc., Oct. 6th, 1906, p. 1121.

‡ Semaine méd., Oct. 3d, 1906.

Cirsoid Aneurysm.—Cirsoid aneurysm was first described by John Bell, under the heading of aneurysm by anastomosis. Other terms used by various authors are: plexiform angioma, racemose aneurysm, racemose arterial angioma. The condition is an elongation and dilatation of the arterioles and larger branches of one or more arteries, which arteries are generally themselves widened and tortuous, either because the disease extends to them or because of the increased amount of blood which they are called upon to supply to the affected region. Not only is the arterial side of the terminal circulatory apparatus involved, but the capillaries also are greatly distended, forming large channels of communication with the veins, which likewise are dilated, thickened, and often pulsating. For such cases the term phlebarterectasia has been suggested.

Etiology.—The cause of cirsoid aneurysm is obscure. Most cases develop from simple congenital hæmangiomata. The reason for this transformation in many cases is stated to be injury, sometimes slight and repeated, such as that produced by a comb when the condition is on the scalp, sometimes a single trauma, as, *e.g.*, a dog bite.* Pregnancy, puberty, menstrual suppression, alcoholism, etc., have been cited as playing a part in the transformation of hæmangioma into cirsoid aneurysm, but are probably merely coincidental. Cases which develop later in life generally arise between the fifteenth and thirtieth years, occasionally from a preexisting angioma, but more often subsequently to some form of trauma, probably as the result of disturbance of the vasomotor nerves.

Pathology.—The growth is found most frequently on the scalp (Fig. 85), then on the face or neck. The site of predilection in the extremities is the hand (Fig. 86). The walls of the dilated and tortuous arteries, like those of varicose veins, are in places greatly thickened as the result of chronic arteritis and in others extremely thin, often forming pouch-like dilatations, which occasionally rupture. The venous walls are generally hypertrophied or fibrous. Both arteries and veins are greatly elongated and communicate directly with each other by enormously enlarged capillaries. The arteries supplying the affected region are dilated, elongated, and tortuous, sometimes for a great distance. The walls are at first thickened and hypertrophied, but later the middle coat may undergo fatty degeneration and the walls become stretched and thinned. The efferent veins undergo changes similar to those occurring in the arteries, but not to so great an extent. The deformed vessels are surrounded by new connective tissue, and hence cannot be straightened, even after removal from the body, unless the adhesions are separated. The skin, nerves, and muscles may be atrophied from pressure, and the bone, particularly the cranium, may, as in aneurysm, be eroded and even perforated. In Clemot's case, after perforation of the bone, an intracranial hemorrhage was induced by ulceration of one of the arteries.

The Symptoms.—The tumor exhibits a marked tendency to increase in size, sometimes gradually and sometimes, as at puberty or during pregnancy, rather rapidly. Yet it may remain stationary for long periods at a time. Recession

* Rotgans, in Hildebrand's Jahresber., 1897, p. 346.

and even spontaneous cure are said to be possible, although extremely rare eventualities. When the tumor is fully developed a tortuous, coiled, worm-like mass of pulsating vessels can be readily seen and felt. This mass is irregular, bosselated, and without well-defined limits. The overlying skin is apt to be thin and adherent in places, and not infrequently cyanotic or pinkish in color. The tumor is soft and elastic, and pulsates synchronously with the heart. Each pulsation is accompanied by a thrill, analogous to that of an arteriovenous

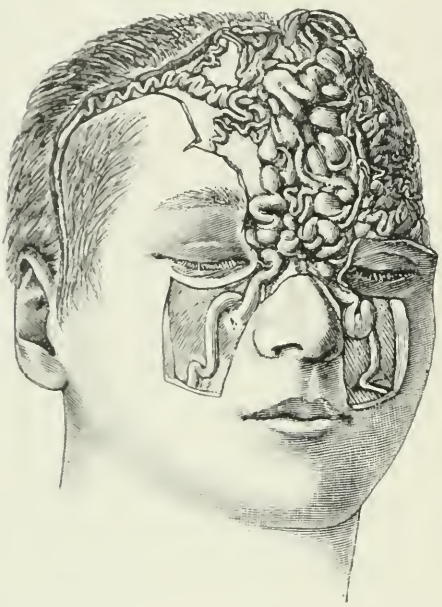

Fig. 85.

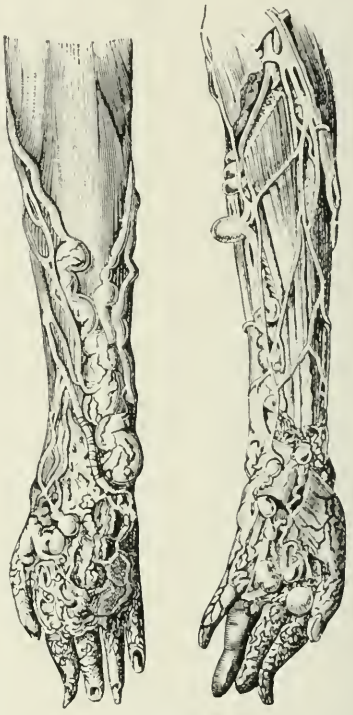

Fig. 86.

Figs. 85 and 86.—Cirsoid Aneurysms. (Tillmanns.)
Fig. 85. Cirsoid Aneurysm of the Head.
Fig. 86.—Cirsoid Aneurysm of the Hand and Forearm.

aneurysm, and by a bruit, which may be intermittent, or continuous with augmentation at each pulsation, and which may be heard some distance from the growth, particularly along the afferent arteries. Pressure on the principal artery of supply reduces the size of the mass and the force of the pulsation, thrill, and bruit, while pressure on the efferent veins acts in a reverse manner. Only in the extremities can the pulsation, thrill, and bruit be made to disappear entirely by proximal compression. In cirsoid aneurysm of the head the patient may be kept awake by the pulsation and bruit, and occasionally he suffers from pain and giddiness. When one of the extremities is involved the usefulness of the part may be impaired or destroyed, sometimes owing to involvement of the muscles and nerves. In either region the atrophied, adherent skin may ulcerate and give rise to alarming hemorrhages or serious infection. The possibility of changes in the soft parts and bones has been mentioned

above. In large growths the temperature of the affected part is elevated, but rarely more than one degree.

The Treatment.—The best treatment for cirsoid aneurysm is extirpation, each vessel leading to the growth being divided between ligatures. Except in the case of the smallest growths this is always a formidable undertaking, owing to the great quantity of blood which is unavoidably lost and the large amount of time required for ligating all the vessels. For these reasons the operation may be done in several stages, only a portion of the circumference of the mass being traversed at one time. Unfortunately, in many instances the disease is so widespread that excision is out of the question, and other methods must be considered. Ligation of the afferent artery has, as a rule, only a transient effect and is often dangerous. Of 73 cases in which the common carotid artery was tied for cirsoid aneurysm, death occurred in 21, and of those which recovered about one-half were cured. Of 9 cases in which both common carotids were tied at intervals 2 died, 1 was cured, and 2 improved.* Of 13 ligations for cirsoid aneurysm of the hand, only 2, according to Polaillon,† were benefited. In the extremities gangrene is a possible result of ligation. Cauterization is dangerous, owing to the fact that violent hemorrhage may accompany the separation of the sloughs. Compression of the tumor, or of the arteries which feed it, is only palliative. The injection of coagulating fluids, such as Monsel's solution, carbolic acid, boiling water, alcohol, etc., has been successful in several cases, but is not recommended because of the danger of embolism. Electrolysis is probably less dangerous. Payr ‡ suggests the pushing of little arrows of magnesium in all directions into vascular tumors through a small incision. The absorption of the metal induces coagulation with consequent destruction of the blood-channels. The *x*-rays also have been used in the treatment of these vascular growths. Finally, in the extremities, amputation may be required when repeated hemorrhages occur or, since free incisions cannot be made, when the part becomes infected.

Aneurysm.—An aneurysm is a hollow tumor containing blood and communicating with the lumen of an artery. Cirsoid aneurysm and arteriovenous aneurysm are frequently considered under this heading. The former has just been described, the latter will be discussed at the end of this section.

Aneurysms were recognized even in the earliest times. Rufus of Ephesus and Galen were familiar with the traumatic variety, but Antyllus seems to have been the first to describe the spontaneous form.

A true aneurysm is one whose walls are composed of one or more of the arterial coats; a false aneurysm, one whose walls are formed of condensed perivascular tissues.

According to their form aneurysms are divided into the fusiform or tubular, the saccular, and the dissecting.

A fusiform or tubular aneurysm (Fig. 87, *a* and *b*) is a dilatation and length-

* Wyeth: "International Encyclopedia," vol. ii.

† Bull. de la soc. de chir., 1884, p. 348

‡ Deutsche Zeitschrift f. Chir., Bd. lxiii., 1901, p. 503.

ening of a section of an artery, generally in the cranium, the thorax, or the abdomen. It is spontaneous in origin,—*i.e.*, the result of increased blood-pressure acting upon a diseased artery,—and is always a true aneurysm. Some of the mildest forms are called aneurysmal dilatations. Pressure upon surrounding organs is frequently responsible for the fatal result. Layers of fibrin are rarely deposited upon the walls, but rupture is unusual. When the wall does give way death follows or a false saccular aneurysm results.

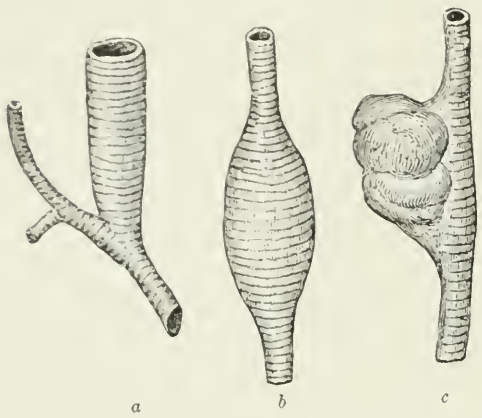

FIG. 87.—Different Forms of Aneurysm. *a*, Cylindrical aneurysm; *b*, fusiform aneurysm; *c*, sacculated aneurysm.

A saccular aneurysm (Fig. 87, *c*) may spring from a fusiform aneurysm or from the side of an undilated artery. It consists of a sac which communicates with the lumen of the artery by an opening in the side of the vessel; the entire circumference of the vessel is not involved. Many true and all false and traumatic aneurysms are of this variety. A saccular aneurysm is said to be circumscribed when the sac wall is distinct and complete, and diffuse when the sac has ruptured and the blood has extravasated into the surrounding tissues.

A dissecting aneurysm is found most frequently in the thoracic aorta. About eighty cases exist in the literature.* The blood finds its way into the arterial wall through an atheromatous ulcer and dissects the outer half from the inner half of the middle coat. A sort of sac is formed, which remains as such, or the blood may make its way back into the artery through another atheromatous ulcer. If a weakened spot in the outer tunic is found, extravasation into the perivascular tissues occurs. Letulle † reports a case in which a dissecting aneurysm extended the whole length of the aorta. During life practically all the blood passed through the aneurysm, which was as large as a thumb in calibre.

ETIOLOGY.—According to their mode of formation aneurysms are said to be traumatic or spontaneous.

A traumatic aneurysm is always saccular. Although many authors restrict the term traumatic strictly to false aneurysms the result of injury, we prefer, since trauma may cause a true aneurysm, to recognize both the true and the false varieties.

A true traumatic aneurysm occurs after contusions or partial ruptures of an artery—usually of the inner and middle coats. Wounds of the adventitia and media may result in a hernia of the intima, which, if it withstands the blood-pressure, forms an aneurysm (hernial aneurysm). Wounds of vessels which

* Coleman, in Dublin Jour. Med. Sciences, Aug., 1898.

† Société méd. des hôpitaux de Paris, Dec. 29th, 1905; Lancet, Feb. 3d, 1906.

have healed also may give rise to aneurysm, as the result of stretching of the scar tissue.

A false traumatic aneurysm follows those wounds of arteries (stab, incised, lacerated, gunshot) in which a hæmatoma is formed that communicates with the arterial lumen. The sac wall is formed by the condensed perivascular tissues and not by the coats of the artery.

Spontaneous or idiopathic aneurysms include, according to the usual classification, all which are not traumatic in origin.

Congenital aneurysm has been observed in various arteries and is often multiple. According to Eppinger * the elastic elements of the vessel have disappeared and the sac consists only of the intima and adventitia.

An acquired spontaneous aneurysm depends upon a weakening of the coats of the artery, particularly the middle, as the result of inflammation or degeneration. Acute suppurative arteritis may, as we have already noted, result in perforation of an artery into an abscess cavity, giving rise to a false aneurysm. If only a portion of the arterial wall is thus destroyed the remaining coats may be stretched to form an aneurysm (aneurysm by erosion).

Embolic aneurysms, according to Ponfick, are caused by direct injury to the vessel wall by sharp calcareous emboli. According to later observers these aneurysms are the result of infective softening of the vessel wall. Eppinger showed that the intima and a part or the whole of the media are destroyed by bacteria when one of these aneurysms forms, and hence he suggested the term mycotico-embolic as a proper designation for them. The aneurysm corresponds to the situation of the embolus and not to the segment of the vessel immediately proximal to it, as was at one time supposed, the belief being that the sudden blocking of the blood-stream caused this portion of the artery to dilate. In the horse aneurysms of the anterior mesenteric artery are not infrequently caused by the Strongylus armatus.

By far the largest number of spontaneous aneurysms are the result of chronic arteritis. The early stage of chronic inflammation of an artery, before compensatory thickening of the intima occurs, is the most favorable one for the production of an aneurysm. We have already mentioned the causes of chronic arteritis and called attention to the frequency with which the form that is caused by syphilis is followed by aneurysm, owing to the atrophy, degeneration, or fragmentation of the tunica media.

Although many individuals suffer from chronic arteritis, very few develop aneurysms; hence other conditions must in many instances be invoked as contributing factors—such, for example, as age, sex, occupation, etc.

Age.—Aneurysm is most frequent between the thirtieth and fiftieth years, during which time arteriosclerosis frequently begins, although the bodily condition is still sufficiently vigorous to lead to overexertion. Of 501 cases collected by Crisp 1 occurred in the first decade, 5 in the second, 71 in the third, 198 in the fourth, 125 in the fifth, 65 in the sixth, 25 in the seventh, 8 in the eighth, 2 in the ninth, and 1 in the tenth.

* Archiv f. klin. Chir., Bd. xxxv., 1887, Suppl.

Sex.—Aneurysm is about seven times more frequent in men than in women, probably owing to the greater frequency of injuries and violent exercise in the former.

Race.—Aneurysm is said to be more frequent in England than in the United States, France, or Germany, because, it is suggested, of the greater amount of alcohol consumed in that country. Aneurysm is rare in Italy and China, and, according to Weber, is unknown among the Hindoos. Rodman states that aneurysm is three times more frequent in the colored than in the white race.

Occupation.—Laborious occupations of all sorts predispose to aneurysm. According to Lawson, in 1866, the deaths from aortic aneurysm in the English army were eleven times more frequent than among the civil population. The pressure exerted by weapons, tight belts, and poorly fitting clothing is given as the cause of the greater frequency of aneurysm in the army than in the navy.

Trauma.—Not infrequently the patient gives a history of some form of trauma, slight or severe, and presents evidences of chronic arteritis. In these cases it is difficult or impossible to determine whether the trauma or the arterial disease has been the principal factor in the arterial dilatation. Certain forms of trauma of a chronic nature, such as that produced by an exostosis, may be followed by aneurysm. In these cases there is neither ulceration of the vessel nor rupture, but, as the result of pressure, a disturbance of the nutrition of the vessel, which causes chronic inflammation and subsequently degeneration of the middle coat of the artery.

Pathology.—In 551 cases of aneurysm Crisp found the thoracic aorta affected in 175, the abdominal aorta and its branches in 59 (making 41.7 per cent for the aorta), the popliteal in 137 (24.9 per cent), the femoral in 66 (11.9 per cent), the subclavian in 23 (4.1 per cent), the innominate in 20 (3.6 per cent), the vertebral in 7 (1.8 per cent), the axillary in 18 (3.2 per cent), the external iliac in 9 (1.9 per cent), the pulmonary, posterior tibial, common iliac, and gluteal each in 2 (0.3 per cent), the temporal, ophthalmic, subscapular, and brachial, each 1 (0.1 per cent). If one includes also minute aneurysms the arteries of the brain and the lung would head the list.

Number.—Aneurysms are generally single, but occasionally they are multiple and sometimes symmetrical. Manec has counted thirty in one case and Pelletier sixty-three in another.

Volume.—The size of aneurysms varies greatly. They may reach the dimensions of a large orange or even a child's head. The largest varieties are always of the false variety, even though originally made up of the coats of the artery. When the sac of a true aneurysm gives way to form a false aneurysm, the latter is sometimes called a consecutive false aneurysm.

Form.—An aneurysm may be smooth and symmetrical, particularly in the early stages, if it be of the true variety, but more often the sac yields more in some places than in others, thus giving it a bosselated appearance. Its shape is modified also by the character of the surrounding tissues, since it grows most rapidly in the lines of least resistance. Not infrequently it is grooved by neighboring nerve trunks. Owing to the direction of the blood-stream, that portion

of the sac which is distal to the mouth of the aneurysm is generally larger than the proximal portion, which is somewhat protected from the force of the arterial current. Although an aneurysm may be connected with the artery by a short, wide pedicle, which has been called the collar, more often it is sessile. Occasionally it seems to envelop the vessel like a saddle.

The Sac Wall.—In general the sac wall is thickest at its point of origin from the artery, and thinnest at its equator in the fusiform aneurysm, or just below this point in the saccular variety. As the result of inflammation, however, any portion of the wall may be markedly thickened, and as the result of a secondary diverticulum any portion may be greatly thinned. In the areas most dilated no trace of the middle coat can be found microscopically, while near the orifice of the aneurysm remnants of this structure may be demonstrated. The normal endothelium disappears in places and the internal tunic is represented by flat cells separated by fibrillar connective tissue, which may undergo fatty or calcareous degeneration. The external tunic is thickened and resembles in structure the internal tunic. In a false aneurysm the sac wall is formed of dense connective tissue lined by flattened cells which resemble the altered intima of a true aneurysm.

FIG. 88.—Aneurysm of Thoracic Aorta.
The patient, a man, aged 34, complained of dysphagia, dyspnœa, and pain in the region of the heart. There was a pulsating tumor to the left of the sternum, on a level with the third rib. Marked erosion of the vertebræ found at autopsy. (Pennsylvania Hospital case.)

The Mouth of the Sac.—The orifice of a recent saccular aneurysm is generally small and somewhat irregular. It may, however, have a punched-out appearance with sharp edges, and is occasionally fimbriated. With the growth of the aneurysm the mouth becomes oval, its long axis corresponding to that of the artery. Sometimes the mouth elongates to such an extent that the aneurysm resembles the fusiform variety.

Contents.—In the early stages, while the sac is small, the contents consist of fluid blood only. Later, when the sac increases in size, particularly in the sacculated variety in which the mouth is small or so situated as not to receive

the full force of the circulation, layers of fibrin are deposited upon the walls, the outer and older layers being dry, firm, and yellowish-white in color, the inner and younger soft, friable, and red. (Fig. 89.) In some cases the concentric disposition of the layers of clot is disturbed by sudden augmentations in the size of the aneurysm, so that fissures exist in the outer layers in which red clot is deposited. Nature rarely makes an effort to organize this clot, neither living cells nor vessels being present; the tendency is rather toward degeneration.

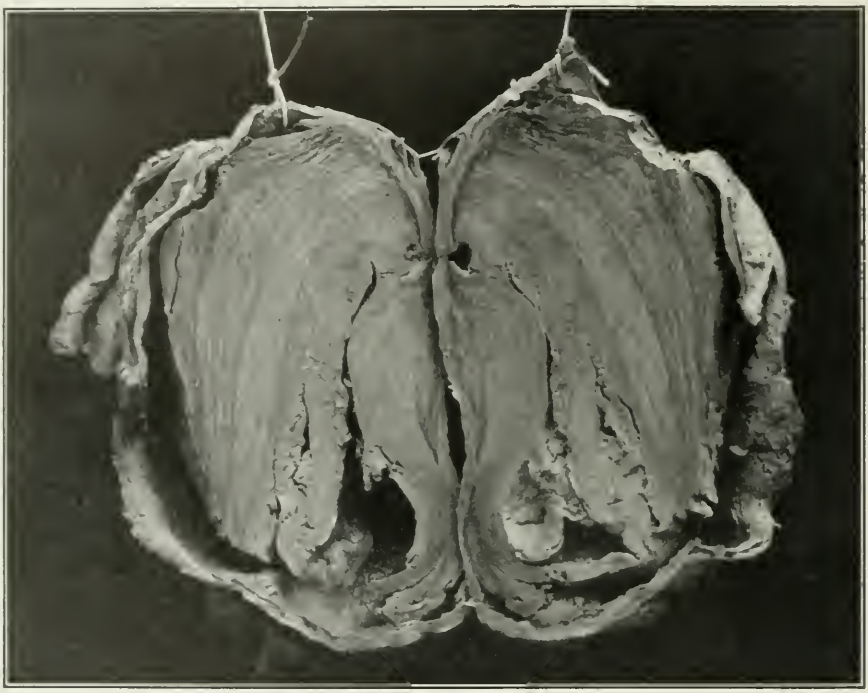

Fig. 89.—Thoracic Aneurysm, Showing Laminated Clot. (Pennsylvania Hospital case.)

Thus, in the outermost layers, granular and fatty changes are found, and often irregular cavities filled with atheromatous material.

Changes in the Environing Tissues.—The artery from which a true aneurysm springs is generally dilated, indurated, and flexuous—in other words, the seat of chronic arteritis. In certain cases, however, careful examination fails to reveal any pathological alterations in the artery above and below the aneurysm.

The collateral arteries are dilated in proportion to the obstruction offered to the blood-current in the main vessel. The satellite veins are compressed and sometimes thrombosed.

The neighboring nerves may be included in the sac wall and are frequently altered by chronic inflammation, giving rise to various motor, sensory, and trophic symptoms.

The bones in contact with the aneurysm are eroded as the result of a rarefying ostitis and may be perforated—*e.g.*, the sternum by an aortic aneurysm—or break spontaneously.

The joints likewise may be eroded, the ligaments ruptured, and spontaneous dislocation occur, or the aneurysm may rupture into a joint cavity.

The muscles are pushed aside, atrophied, and degenerated.

The surrounding connective tissue becomes condensed and indurated as the result of chronic inflammation, causing the aneurysm to adhere strongly to the neighboring tissues. Occasionally the inflammation becomes acute and eventuates in suppuration.

Evolution of an Aneurysm.—When, as the result of atrophy, fragmentation, degeneration, or rupture of the museulo-elastic middle coat of an artery, the walls of the vessel yield at a certain point, an aneurysm is inaugurated, saccular if the lesion be lateral, fusiform if the entire circumference is involved. As, at each pulse-wave, the blood is hurled against this weakened spot, there is soon formed a diverticulum, which, owing to its loss of elasticity, cannot completely empty itself of the blood from one pulse wave before another is forced into it. Thus there is a constant tendency to overdistention and dilatation of the sac and to stagnation of the blood within it, with the formation of eddies. The latter, combined with the alterations in the wall of the sac, leads to a deposit of clot over the lining membrane of the aneurysm. In this way successive layers of clot are deposited, the first layers adhering more intimately to the wall, and with the lapse of time becoming dry from the contraction of fibrin, and yellowish from the destruction of the blood pigment. Collateral vessels rising from the aneurysm may remain permeable, but frequently they are sealed with the clot. In the saccular variety the sac has at first the diameter of the mouth (crateriform aneurysm). Left to itself an aneurysm undergoes spontaneous cure, or results in death as the result of rupture of the sac, pressure upon important structures, cerebral embolism, or sepsis from suppuration of the sac or gangrene of the parts supplied by the affected artery.

A spontaneous cure is extremely rare. It may be due to gradual filling of the sac with layers of fibrin; to coagulation of blood within the sac the result of lodgment of an embolus above or below the mouth, this embolus being perhaps derived from the aneurysm; to the inflammation of the sac; or to rupture and subsequent cicatrization. An aneurysm cured by nature shrinks somewhat and becomes solid and may in time be represented by a mass of fibrous tissue. Preservation of the lumen of the artery, which is possible in the spontaneous cure of a saccular aneurysm, is rare.

Persistence of the aneurysm without increase in size, sometimes for years, also is rare. Broca * cites but five or six examples. More frequent are the cases in which, although the aneurysm steadily increases in size, the deposition of clot, at least for a time, maintains the cavity at the same size.

Normally an aneurysm increases in size until the wall gives way at its most thinned point. This results in a secondary or consecutive false aneurysm if the environing tissues limit the effusion, or in death from hemorrhage if the blood is unrestrained. The walls of all aneurysms of great size are composed of condensed perivascular tissues, with traces of the vessel-coats near the orifice of the aneu-

* "Des anévrysmes et de leur traitement," Paris, 1856.

rysm. The transition of a true into a consecutive false aneurysm may be slow and insensible, inflamed and thickened connective tissue being gradually substituted as the gap resulting from the parting of the arterial tunics becomes larger, or it may occur suddenly with a marked increase in the size of the tumor. Ordinarily, however, by rupture of an aneurysm one means a sudden break in its walls, through which the blood escapes into the subcutaneous tissues, into a normal cavity or hollow organ, into a neighboring vein (spontaneous arteriovenous aneurysm), or externally through the skin. The rupture may follow a trauma, an inflammatory ulceration, suppuration, or gangrene of the sac or its environs. Inflammation of the sac is of very frequent occurrence. The mildest form, adhesive or plastic in nature, tends to induce coagulation within the sac and to thicken its walls. The severer form may eventuate in suppuration and lead to rupture of the sac. When the infection is violent or the resisting

Fig. 90.—Popliteal Aneurysm. (Pennsylvania Hospital case.)

powers of the tissues are much depressed gangrene of the sac occasionally occurs. The severer forms of inflammation are always infectious in origin, the microorganisms generally reaching the affected part by way of the blood-stream.

Symptoms.—The symptoms of an aneurysm may be arranged in two groups: (1) those peculiar to the aneurysm itself; and (2) those due to pressure.

(1) The intrinsic symptoms generally develop insidiously. Even in the false traumatic aneurysm the characteristic features may be obscured for some time by the coagulation of the blood which is first thrown out. The tumor corresponds with the line of an artery and, if of the true variety, is at first small, smooth, well-defined, hemispherical or ovoid in outline, and movable perpendicularly to, but not in the axis of, the artery. (Fig. 90.) At a later period, as pointed out above, the sac becomes bosselated and fixed to the surrounding tissues with adhesions. In the beginning, when the contents are of a fluid nature and the walls thin, the swelling may fluctuate and be reducible by

pressure, while in an ancient aneurysm, whose walls are thickened by inflammation and whose contents consist largely of coagulated blood, these signs are wanting. In the absence of adhesions and inflammation the skin is normal in color and movable over the swelling.

The pulsation of an aneurysm is synchronous with the cardiac systole and expansible in character,—*i.e.*, the swelling increases in size in all directions, so that the palpating fingers are not only lifted but also separated. The number and amplitude of these pulsations may be measured more accurately with the sphygmograph. In aneurysms close to the heart the tracing may show three expansions, corresponding to those of the aortic pulse waves. (Fig. 91.) In the extremities the pulsation is ordinarily single, but may be double. The more clot within the sac and the thicker its walls, the less distinct is the pulsation. In old aneurysms pulsation is frequently more marked at certain points than at others, owing to the irregularity in the thickness of the walls.

The bruit heard on auscultation is usually loud, blowing, and harsh. It

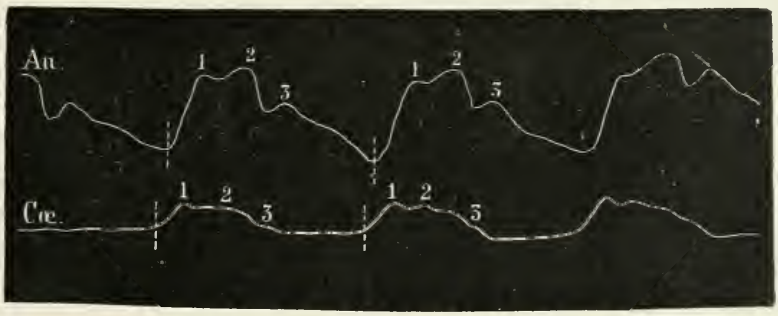

Fig. 91.—Sphygmographic Tracing of an Aneurysm. (Duplay et Reclus.) *An*, Curve obtained from aneurysm; *Cæ*, curve of normal heart.

coincides with the distention of the aneurysm, is shorter than the silence which follows it, and is more distinct when the mouth of the sac is small. It is caused by the swirling of the blood in the aneurysm, and not by the vibrations of the margins of the mouth, as was at one time supposed. Occasionally, in aneurysm near the heart, a second bruit, softer and more feeble than the first, is heard. According to François-Franck, this second bruit may result from a reinforcement of the pressure in the aneurysm coinciding with the second expansion, from the return of the blood into the artery, from aortic regurgitation, or from the displacement of air in the lung consequent upon the sudden relief of pressure during the systole of the aneurysm. An aneurysmal bruit is best heard where the sac is thinnest, and is sometimes transmitted along the parent artery.

A thrill corresponding with the bruit may occasionally be detected with the hand, but is never so pronounced as in an arteriovenous aneurysm.

Compression of the artery above the aneurysm causes the tumor to become smaller and softer and the pulsations to cease or be notably diminished. Compression of the artery below the aneurysm causes it to become larger and harder and the pulsation to become more prominent.

The pulse below the aneurysm is diminished in volume and retarded in time. Diminution in the volume of the pulse may be due to narrowing of the artery from any cause, and is therefore of less value than retardation, which may be regarded as pathognomonic. The greater the size of the cavity of the aneurysm, the greater the distensibility of its walls, and the larger the mouth, the more pronounced will be the retardation of the pulse. When the retardation is marked it may be readily appreciated by palpation of the corresponding arterial segments on each side of the body. Slight variations may be graphically shown by simultaneous pulse tracings. (Fig. 92.)

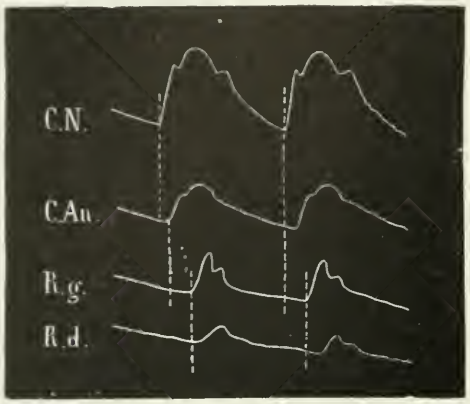

Fig. 92.—Sphygmographic Tracing of Artery on Distal Side of an Aneurysm Compared with the Tracing of the Normal Artery of the Opposite Side and Showing Retardation of the Pulse Wave. (Duplay et Reclus.) *C.N.*, Curve obtained from normal artery of opposite side; *C.An.*, curve obtained from artery on distal side of aneurysm; *R.g.*, curve of left radial artery; *R.d.*, curve of right radial artery.

(2) The pressure symptoms are similar to those of other tumors. Pressure on the artery causes a diminution in the size of the pulse distal to the aneurysm, and consequently, in some cases, a compensatory enlargement of adjacent arteries. If the aneurysm is sufficiently large to block, not only the main trunk but also the collateral vessels, gangrene occurs. Pressure on the veins causes œdema and compensatory dilatation of the superficial veins. Pressure on the nerves causes pain and perhaps motor, sensory, and trophic disturbances. Muscles are pushed aside, stretched, and atrophied, and bones eroded, causing severe, constant, boring pains and occasionally spontaneous fracture. Ligaments may be softened and cartilage absorbed, thus causing spontaneous dislocation. Other symptoms of compression vary with the structure involved. Thus, pressure on the trachea causes dyspnœa, on the œsophagus dysphagia, on the recurrent laryngeal nerve change in the voice and brassy cough, and perhaps decided obstruction at the rima from paralysis or spasm, on the sympathetic nerve dilatation and later contraction of the pupil, on the thoracic duct inanition, on the phrenic nerve hiccough, etc.

In the rare cases in which a spontaneous cure occurs the swelling becomes harder and shrinks, the pulsations gradually cease, the bruit disappears, and in time the aneurysm is represented by a mass of fibrous tissue. Pressure symptoms may persist and even be accentuated in such cases.

Rupture into the subcutaneous tissues is announced by severe pain, sudden increase in the size of the swelling, indistinctness of its outline, diminution or even disappearance of pulsation and bruit owing to the coagulation of the blood, and cessation of the pulse below the swelling. The general symptoms are those of acute anæmia and shock, and may be severe enough to induce death. The pressure of the extravasated blood may cut off the entire circulation of the

limb and cause it to become gangrenous, or it may result in inflammation and sloughing of the skin with consequent death from hemorrhage. When rupture occurs externally through the skin or internally into a large cavity death may be immediate or it may be deferred for a number of days. In the former event the rent is sufficiently large to permit a rapidly fatal hemorrhage; in the latter, the blood leaks from a small opening, which may be temporarily plugged by a clot, but sooner or later this is displaced or perforated and the bleeding recurs. Gairdner reports two cases in which rupture through the skin was followed by spontaneous cure. (Michaux.) When an aneurysm ruptures internally into one of the cavities or hollow organs there are sudden pain, symptoms of acute anæmia, and death. If rupture into the œsophagus or trachea occurs blood will pour from the mouth. Special symptoms occur in certain regions, *e.g.*, within the cranium, spinal cord, pericardium, pleura, etc.

Inflammation shows itself by redness of the overlying skin, œdema, pain, and increase in the local temperature. The outlines of the tumor become less distinct, and suppuration may occur in the surrounding tissues, in the sac wall, or within the aneurysmal cavity. Ulceration of the sac wall and skin is followed by the discharge of pus mixed with clot and finally fluid blood. If the inflammation is intense gangrene of the sac and overlying skin may occur. The general symptoms are those of sepsis, varying with the degree and character of the inflammation.

Gangrene of the parts beyond the aneurysm may follow subcutaneous rupture of the sac, owing to the compression of the extravasated blood upon the artery and its branches; to the impaction of an embolus derived from the aneurysm; or to violent inflammation, resulting in thrombosis of the parent artery. The symptoms of these affections have already been given.

Diagnosis.—The diagnosis of aneurysm is sometimes difficult or even impossible, as pulsation and bruit may be absent owing to the deposition of fibrin; and, besides, other tumors may exhibit these signs. A cyst, new-growth, or chronic abscess lying upon an artery may be elevated with each pulsation of the vessel, but the pulsation is not expansile, and it disappears if the tumor is separated from the vessel by the fingers or by changing the position of the patient. Pressure upon the artery above or below the tumor does not have the same effect as in aneurysm, and after removing the proximal compression the first pulsation is of full strength, while in aneurysm several pulsations may be necessary to refill the sac and reëstablish the original force of impact. A murmur the result of narrowing of an artery by the pressure of a tumor ceases when the latter is lifted away from the vessel. The pulse below the swelling may be diminished by any lesion which compresses the artery, but is delayed only by an aneurysm. This delay may be accentuated by compressing the artery above the swelling. On removing the compression the pulse is felt at once below the tumor if it is not an aneurysm, whereas if it be an aneurysm the distal pulse may not be appreciable for a period of time equivalent to one, two, or more pulse-beats. In cysts and abscesses the exploratory needle will reveal the contents of the swelling. Pulsating malignant tumors and nævi may not lie in the line of an artery or

influence the pulse below; pressure on the artery proximal to the growth may cause a diminution in size of the tumor but not so marked as in aneurysm. The shape of the growth may be irregular, the outline less distinct, and the consistency more variable; a bruit may be present, but is generally much less marked than that of an aneurysm. Aneurysmal pain has been mistaken for rheumatism, neuralgia, lumbago, and like affections. In certain cases, particularly where the lesion is located in the thorax or the abdomen, the *x*-ray has proved of service in diagnosticating aneurysms. Pulsation which cannot be felt may sometimes be seen with the fluoroscope.

Treatment.—The treatment of aneurysm may be medical or surgical.

Medical Treatment.—Medical treatment aims to diminish the blood-pressure and increase the coagulability of the blood; it may be used in certain cases to assist surgical treatment or in cases in which surgical treatment is not applicable.

The method of Valsalva was described in 1751 by his friend Albertini. The patient was put in bed for forty days, subjected to repeated bleedings and purgations, and given a diet just sufficient to prevent death from starvation. Although Broca stated that he had read of thirty cases of inoperable aneurysm which had been cured by this method, it fell into disuse for obvious reasons.

Tufnell's treatment, which is founded on the method of Valsalva, was really originated by Bellingham, in 1852, and later modified by Tufnell. The method consists in absolute rest in bed for two or three months, in order to lessen the frequency and force of the heart beats, and in limiting the patient to a small quantity of fluid and food, to increase the coagulability of the blood. Tufnell's dietary is as follows:—"For breakfast, 2 ounces of white bread and butter, with 2 ounces of cocoa or milk. For dinner, 3 ounces of broiled or boiled meat, with 3 ounces of potatoes or bread, and 4 ounces of water or light claret. For supper, 2 ounces of bread and butter, and 2 ounces of milk or tea, making in the aggregate 10 ounces of solids and 8 ounces of fluid food in the 24 hours, and no more." Thirst, if tormenting, may be relieved "by holding a pebble in the mouth to favor the secretion of saliva, or by sucking from time to time a small portion of ice."

Among the drugs recommended for aneurysm potassium iodide heads the list, even in non-syphilitic cases. According to Balfour this drug lowers the cardiac and vascular tension, thus permitting the sac to contract and its walls to thicken. Opium and the bromides are used to control pain, and laxatives to prevent the straining incident to constipation and to increase the density of the blood. Aconite or veratrum viride, to quiet the circulation, is strongly recommended by some physicians.

Among the internal remedies which have been given to increase the coagulability of the blood, but which are of very doubtful value, are iron, acetate of lead, gallic acid, tannic acid, calcium chloride, and gelatin. Since Wright's publication * in 1893, calcium chloride, in doses of from 10 to 30 grains, has been employed by many surgeons to increase the coagulability of the blood, particularly before operations on those suffering with chronic jaundice. A few

* British Med. Jour., 1893, vol. xi., p. 223.

cases of aortic aneurysm have been reported in which improvement has followed the administration of this drug.

In 1896 Dastres and Floresco showed that gelatin, when introduced into the blood, increases the coagulability. In the following year Lancereaux and Paulesco * suggested the subcutaneous use of this agent for the treatment of aneurysm. About 200 c.c. of a one or two per cent solution of gelatin in normal salt solution are injected beneath the skin of the thigh every ten days or two weeks, until from ten to thirty injections have been given. Sailer † gives the following directions for preparing the gelatin: "Add 5 gm. of sodium chloride and 100 gm. of gelatin to one litre of distilled water. Bring the mixture to a temperature of 80° C., while stirring until the gelatin is dissolved; then cool to 40° C., add the white of one egg, stir for several minutes, and boil the fluid. Next filter through paper, place the solution in test tubes holding 10 c.c., plug each tube with cotton, and sterilize in a sterilizer for fifteen minutes on three successive days. When a tube is to be used it is put in hot water until the gelatin liquefies, when it is drawn into a sterile syringe." The good results reported by Lancereaux have not been obtained in this country. Moreover, the danger of infection, particularly with tetanus bacilli, is so great as to contra-indicate its employment, unless one can be sure of the sterility of the solution. According to Dieulafoy twenty-three deaths from tetanus have followed the subcutaneous injection of gelatin for aneurysm. As gelatin may be given by mouth without destroying its coagulative influence, this method should be chosen if the drug is given at all. Gelatin is irritating to the kidneys; hence it should not be administered in the presence of renal disease.

Surgical Treatment.—The surgical treatment of aneurysm consists of (1) compression of the artery or the aneurysm; (2) the temporary or permanent introduction of foreign bodies into the sac; and (3) operative treatment.

(1) Compression of the sac.—Compression of the sac itself was first suggested by Heister in 1744. Pads and bandages were so arranged as to empty the sac and keep it empty. Owing to the dangers of rupture or suppuration of the sac, and of gangrene of the limb, the method has been abandoned.

Forced flexion of a limb was recognized, at an early period in the history of surgery, as a method for suppressing its circulation, but it was not until 1857 that the method was employed for the treatment of aneurysm. In this year Maunoir and Hart each reported a popliteal aneurysm cured by this procedure. Not only is the circulation in the limb arrested, but direct compression is made upon the sac. Aneurysms at the bend of the elbow and in the popliteal space are the only ones in which this method is efficacious. Forced flexion of the thigh in inguinal aneurysms has not been successful. Delbet ‡ states that forced flexion is successful in 35.55 per cent of the cases. He says further that the method is applicable only under certain conditions. The patient should be young, should not be subject to rheumatism or gout, and the articulation should be normal.

* Bull. de l'Académie de Médecine, 1897, vol. xxxvii., and 1898, vol. xl.

† Therapeutic Gaz., Aug., 1901.

‡ "Traité de chir.," par Le Dentu and Delbet, t. iv.

The aneurysm should be small and non-inflamed, with walls not too thin, and it should be situated a little below the joint. According to Delbet's statistics, forced flexion is followed by rupture of the sac eight times more frequently than after indirect compression. The average duration of the treatment in successful cases is fourteen days. The method is extremely painful and is not infrequently followed by permanent flexion of the limb. It is probable that very few modern surgeons have employed the method.

Massage of the sac for the purpose of dislodging a portion of the clot, with the hope that it might occlude the artery or the orifice of the aneurysm, was first practised by Sir Wm. Ferguson on two cases of subclavian aneurysm, one of which was followed by temporary confusion and giddiness, and the second by hemiplegia, owing to cerebral embolism. The method has deservedly fallen into complete desuetude.

Reid's method of rapid cure by compression aims to hold the blood in the sac until it coagulates. It was first used in 1875, for the treatment of popliteal aneurysm. The patient is anæsthetized and an Esmarch band is applied from the extremity to the root of the limb, being firmly applied to all parts except the aneurysm, which is permitted to retain a quantity of blood. A tourniquet which shuts off the circulation is then applied above the Esmarch band, which may or may not be removed. The tourniquet remains in place for an hour and a half, after which it is gradually loosened, to prevent the washing away of clot. Gersung suggested that the treatment be continued for half an hour, then supplemented by indirect digital compression, then repeated. Delbet gives the proportion of cures as 48.2 per cent and calls attention to the fact that indirect digital compression for a number of hours, by which the method should be followed, is perhaps the more important factor in the cure. Since Reid's method causes gangrene of the limb twice as often as indirect compression, it should never be employed.

Indirect compression,—that is, compression of the artery between the aneurysm and the heart,—although earlier applied in connection with direct compression, was first used alone for the treatment of aneurysm by Desault toward the end of the eighteenth century, and was an outcome of the work of Hunter, who showed that proximal ligation was able to check the circulation in the aneurysmal sac. The early attempts at cure by this method were generally unsuccessful, owing to the crude manner in which it was employed, and it was not until about 1825 that, chiefly through the labors of the Irish surgeons, the method obtained a strong foothold in surgery. In the early cases various forms of ingenious tourniquets and compressors were used to obliterate the artery; hence, ulceration and sloughing of the skin. Digital compression, although requiring relays of assistants, is more certain and precise and less likely to be followed by damage to the skin or the vessel. In either method the skin should be protected by a piece of chamois, the point of pressure should be shifted, and, if possible, pressure should not be made upon the main vein or upon a nerve. Although some authorities believe that the compression should be only partial,—*i.e.*, just sufficient to allow a small stream of blood to enter the sac, in order to

form a so-called active or laminated clot,—most surgeons agree with Le Fort that complete or total compression of the vessel should be employed. The compression may be continuous or intermittent. If continuous, the pressure is maintained without interruption until, by absence of pulsation and hardening of the aneurysm, coagulation is known to have occurred. If this does not take place within thirty-six hours the method should be abandoned, since the chances of cure are then very slight, while the probability of harm is increased by further continuation of the pressure. Continuous compression is agonizing to the patient and requires the use of narcotics. Perhaps less efficacious but certainly more humane is the intermittent method, in which the pressure is maintained for a number of hours each day, the patient being allowed to sleep at night. By combining the statistics of Barwell and Delbet, which comprise 255 cases, it appears that indirect compression is successful in about 50 per cent. Inflammation and suppuration of the sac are possible but rare accidents. Gangrene of the limb occurs in 6 per cent of the cases of popliteal aneurysm. (Delbet.) Berger and Annandale each report a case in which a second aneurysm formed at the compressed point. (Bouglé.) In a certain proportion of the so-called cures recurrence undoubtedly takes place at a later period. The most important contra-indications to indirect compression are advanced atheromatous changes in the feeding artery and inflammation of the sac.

Instrumental or digital compression may be applied to the artery also at a point distal to the aneurysm, as an aid to proximal pressure or in cases, such as aneurysm of the root of the carotid, in which proximal pressure cannot be applied.

Although the treatment of aneurysm by indirect pressure has many successes to its credit, and is attended by little risk, it is tedious, often painful to the patient, and is almost wholly displaced by operative methods.

(2) The Introduction of Foreign Bodies into the Sac.—Acupuncture, or the introduction of fine needles in such a way that they will cross one another and whip the fibrin from the blood, was employed by Home in 1796; the needles were withdrawn after several days. Macewen's method (1876) consists in the introduction of a long needle, with which the interior of the sac is scratched, with the hope of thus infiltrating the walls with leucocytes and so causing them to thicken. Several hours are consumed in going over the interior of the sac and only enough irritation is produced to set up a reparative exudation. Macewen cured in this way an aneurysm of the femoral artery and one of the subclavian. Moore's method (1864) consists in the introduction of a number of yards of coiled steel wire through a cannula; the wire assumes a spiral shape in the sac and is allowed to remain permanently. Silk, horse-hair, catgut, and other substances have been used in a similar way. Of fourteen aneurysms of the aorta treated by the Moore method, three resulted in cure, but one of these died later from rupture of the aorta; in nine cases in which an autopsy was made the effect of the wire in whipping fibrin from the blood was clearly demonstrated.

Electrolysis was introduced by Phillips, in 1829, but is often spoken of as the method of Ciniselli, who, in 1856, perfected the procedure. A platinum

needle is attached to the positive pole and a steel needle to the negative pole, each needle being insulated by vulcanite at the spot where it comes in contact with the tissues. The needles are plunged into the sac and the points slightly separated. A constant current of from 5 to 6 milliampères is passed through the sac for from half an hour to two hours. According to Ciniselli * the cases which give the best results are those in which the aneurysm is entirely endothoracic, sacculated, of small or moderate size and free from vessels arising out of the sac, and in which there are no valvular lesions. Of 32 cases fulfilling these conditions, all were benefited and a few apparently cured. Of 114 cases collected by Petit, 68 were improved.† The possible dangers of the method are bleeding from the punctures, suppuration, inflammation, and embolism.

The Moore-Corradi method consists in the introduction of wire, as first

FIG. 93.—Aneurysm of the Innominate, quickly fatal after Wiring and Electrolysis. (Pennsylvania Hospital case.)

suggested by Moore, and the passing of a galvanic current through it, this combination having first been employed by Corradi. The following technique is that of D. D. Stewart.‡ Hollow gold needles, with a calibre slightly larger than the wire to be employed and insulated with porcelain, are employed. Hunner uses a cannula insulated with French lacquer; the wire may be of gold, silver, or platinum, preferably the first-named, drawn to a 28 or 39 gauge and tightly wound on a spool so as to coil after entering the sac of the aneurysm. Iron wire is undesirable, as the electrical current decomposes the iron into a chloride and oxide, which may be washed from the sac and cause trouble. Steel wire is too stiff and may injure the sac. The amount of wire to be used should be estimated by the size of the sac. For a sac 3 inches in diameter a length of from 3 to 5 feet is enough; for a sac of 4 or 5 inches, a length of from 8 to 10 feet

* Gazette des hôpitaux, 1868 and 1880. † Allbutt's "System of Medicine," vol. vi.

‡ Annals of Surgery, 1902, vol. xxxv., p. 311.

may be employed. If too much wire is introduced, subsequent contraction of the aneurysm is prevented. With aseptic precautions the needle is plunged through the thinnest portion of the sac, and the spurting of blood is controlled with the thumb until the wire is pushed into the needle. This must be done carefully, the attempt never being made to introduce too much at one push, as in that event the wire kinks. If such an accident does occur another needle

FIG. 94.—Aneurysm of the Innominate after Wiring and Electrolysis; specimen removed from the patient shown in Fig. 93. (Pennsylvania Hospital case.)

may be introduced at another point. Perhaps, as Stewart suggests, it would be better regularly to introduce two needles, so as better to distribute the wire. The wires from the various needles are all joined to the positive pole. If the negative pole is connected with the needle the clot is always soft and friable. Bubbles of hydrogen tend to accumulate about the negative needles and assist in softening the clot. The negative pole should be attached to a large, flat

piece of clay, which after being moistened is placed upon the back or abdomen. The current is started from zero and gradually increased to 60 or 80 milliampères in the course of about ten minutes. The current is maintained at this point for from forty-five minutes to an hour and a half, when it is gradually decreased to zero. The needle is then withdrawn and the wire cut off close to the skin, beneath which it is buried. Blood continues to leak during the passage of the wire, but, as soon as a few milliampères of the current have passed, bleeding ceases and does not recur. The needle puncture is sealed with collodion. Hunner has collected 23 cases of aneurysm of the aorta which were treated by the Moore-Corradi method. In 9, or 39 per cent, the symptoms were ameliorated and life prolonged. Four cases (3 thoracic and 1 abdominal) were cured. Rosenstirn's patient is well, after the lapse of eleven years; one of Stewart's cases showed at autopsy, three years later, a consolidated aneurysm; Kerr's case was lost sight of at the end of ten months; and Noble's patient died, at the end of eight months, of another disease. Death was probably hastened in the remaining ten cases. In several cases the wire entered the aorta, and in one case, an abdominal aneurysm, the wire reached the aortic valves of the heart. In wiring an aneurysm of the abdominal aorta the sac should, of course, first be exposed by laparotomy. In a case of aneurysm of the arch of the aorta, in which we assisted Goepp with wiring, there was a transient paralysis of the arm from embolism; the patient was markedly improved, however, and was still living after nine years. In another case (Figs. 93 and 94), a rapidly growing aneurysm of the innominate artery, the patient died a few days after operation from pressure on the trachea. The method is by far the best for the treatment of sacculated aneurysms of the aorta, particularly in the thoracic cavity. It is, of course, not indicated in a fusiform aneurysm.

The injection of coagulating fluids originated with Monteggia. Monsel's solution, solutions of acetate of lead, tannin, and various other substances, have been employed. The danger of embolism can be avoided only when the artery can be compressed on each side of the sac during the injection—that is, in those cases which are best treated by operative measures, since even in these cases the coagulating fluid is apt to cause inflammation, suppuration, or gangrene of the sac.

(3) Operative Treatment.—Operative treatment embraces ligation, incision, endoaneurysmorrhaphy, extirpation, vessel-grafting or anastomosis, and amputation.

(*A*) Ligation may be performed in one of five ways: Anel's, Hunter's, Pesquin's, Brasdor's, and Wardrop's methods.

(*a*) Anel's method (Fig. 95, *a*), which dates back to 1770, consists in ligating the artery immediately above the sac.

(*b*) Hunter's operation (Fig. 95, *b*), first performed in 1785, is ligation above the sac but some distance away from it—*e.g.*, in a popliteal aneurysm, in Hunter's canal, in order to secure a more healthy segment of vessel. Scarpa advised ligation at a still higher point—*e.g.*, in a popliteal aneurysm, in Scarpa's triangle. Later, it was claimed that a further advantage of high ligation was the existence

of anastomotic branches between the ligature and the sac, which allowed a small stream of blood to course through the aneurysm and thus favored the formation of a laminated clot. Although in some instances the Anel method must be chosen,—*e.g.*, in aneurysms of the root of the carotid, subclavian, and iliacs,—whenever a choice is possible most surgeons select the method of Hunter when treating an aneurysm by proximal ligation. Our own views coincide with those of Broca, Delbet, Weber, and Koehler, who favor ligation close to the sac. If the vessel immediately proximal to the aneurysm is overlaid by the sac or is so deeply situated as to render its exposure a formidable operation, then, of course, ligation at a higher point is preferable. The objection that the nearer one approaches a spontaneous aneurysm the greater the degenerative changes in the vessel is not a strong one, since frequently the vessel is more diseased at the point at which the high ligature would be applied than close to

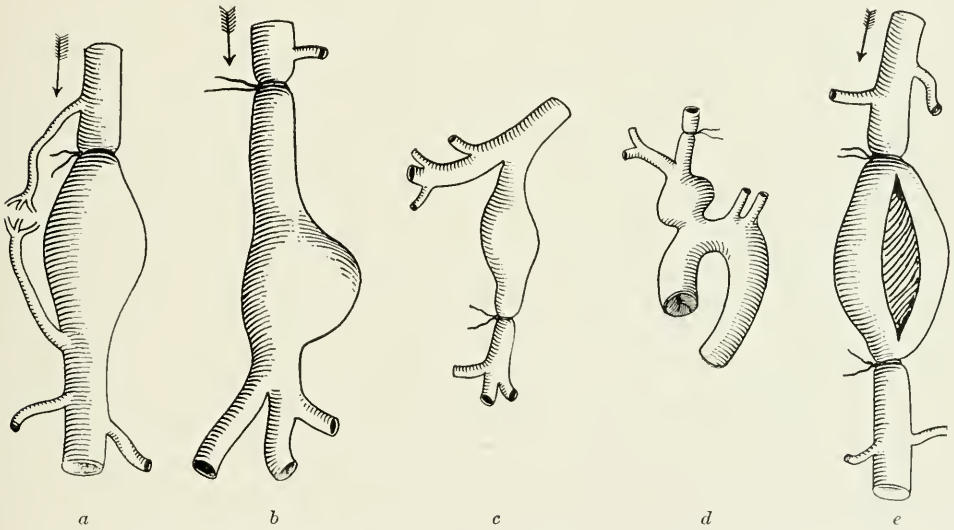

FIG. 95.—Special Ligations for Aneurysms. *a*, Anel's operation; b, Hunter's operation; *c*, Brasdor's operation; *d*, Wardrop's operation; *e*, Antyllus' operation.

the aneurysm. The presence of collateral vessels between the ligature and the sac is, we believe, a disadvantage, owing to the danger of re-establishment of the aneurysm if such vessels are large and numerous. As with digital compression, so with ligation; complete suppression of the circulation through the sac offers the best chance of obliterating the aneurysm. In any event, consolidation of the aneurysm is practically always accompanied by obliteration of the parent artery, the obliteration reaching to the first collateral below and as far as the ligature above. Hence the number of collateral vessels suppressed is greater the higher the ligature is applied, and consequently the danger of gangrene of the limb is correspondingly increased.

Proximal ligation by the Hunter method has long been a favorite operation, particularly in slow-growing, moderate-sized, non-inflamed aneurysms. It is contra-indicated in the presence of serious disease of the heart or a coexisting

internal aneurysm, which would be unfavorably influenced by the sudden rise in blood-pressure that follows ligation of a large artery; in cases in which compression of the feeding artery does not materially diminish the pulsation of the aneurysm; in widespread arterial disease; in threatened gangrene; and in the presence of extensive erosion of bone. As a rule, return of pulsation in the sac is observed after a day or two, owing to the development of a collateral circulation, but in favorable cases this subsides and finally disappears, the tumor becoming smaller and harder. Pulsation beginning a number of days after operation is generally permanent and will require some additional operation to deal with the aneurysm. The mortality of proximal ligation, between 1886 and 1895, according to Delbet, was 8.33 per cent, having been more than twice this much in pre-antiseptic days. During the same period the percentage of gangrene was 8.25 per cent. These figures include only those cases in which the gangrene resulted in amputation or death, and not those in which there was only a small superficial slough. Delbet holds that a certain proportion of the cases of gangrene are due, not to the sudden interruption of the blood-current by the ligature, but to emboli which are washed from the sac with the development of a collateral circulation. In five per cent of the cases the aneurysm either persists or recurs. Delbet was able to find six cases in which a second aneurysm developed at the point of ligation. Secondary hemorrhage and inflammation, suppuration, gangrene, and rupture of the sac are among the rarer complications of ligation. In some instances the pressure symptoms persist after consolidation of the aneurysm, and indeed, in those cases in which the nerves are enveloped by the sac, the sensory and motor phenomena, owing to contraction of the sac, may be aggravated.

(*c*) Double ligation, *i.e.*, the application of a ligature above and below the aneurysm, was employed for the first time, in 1812, by Pesquin. The operation is very rarely indicated. In those cases for which it is fitted—*e.g.*, aneurysm of the radial and ulnar arteries, in which the circulation is not stopped by proximal ligation,—extirpation is the better procedure.

(*d*) Brasdor's operation (Fig. 95, *c*), which consists in ligation of the artery immediately below the sac, was first performed about the middle of the eighteenth century. It is indicated, if at all, only when proximal ligation cannot be performed. In 11 cases of aneurysm of the root of the carotid in which this operation was performed 5 died, and 3 were said to have been cured.

(*e*) Wardrop's operation (Fig. 95, *d*), which was published in 1828, consists in the ligation of one of the branches of the artery distal to the sac—*e.g.*, ligation of the subclavian, in aneurysm of the innominate. The operation is rarely if ever performed at the present day.

(*B*) Incision of the sac after the artery has been tied immediately above and below, was first performed, in the third century after Christ, by Antyllus.

Antyllus' Operation.—In this method (Fig. 95, *e*) the sac is cleared of coagula, then packed, and allowed to heal by granulation. The method of Antyllus, until recently, was the best operation for those aneurysms of the limbs in which extirpation was injudicious, owing to widespread and dense

adhesions between the sac and the surrounding parts. In suppuration of the sac incision, after double ligation, is still the operation of choice. The principal danger is secondary hemorrhage. Convalescence is, of course, prolonged and infection is the rule.

(*C*) Endoaneurysmorrhaphy, or the Matas operation, is a derivative of the Antyllian operation. It was first performed by Matas in 1888. The procedure is applicable to all aneurysms in which the circulation through the sac can be provisionally controlled. The principle of the operation rests upon the fact that the aneurysmal sac, which is lined by more or less modified intima, when not disturbed from its vascular connections, is capable of exhibiting reparative reaction similar to that possessed by like structures elsewhere.* The circulation is arrested by means of a tourniquet or, when this is impracticable, by exposure and compression of the main artery on each side of the aneurysm. The sac is then exposed by a free incision parallel with its long axis. It is important that the attachments of the sac to the surrounding tissues remain undisturbed. The sac is then opened in the axis of the artery from one extremity to the other and cleared of its contents, the interior of the sac being gently but thoroughly scrubbed with gauze in order to remove adherent laminated blood clots. According to the type of sac present one may then proceed to perform an obliterative, restorative, or reconstructive operation.

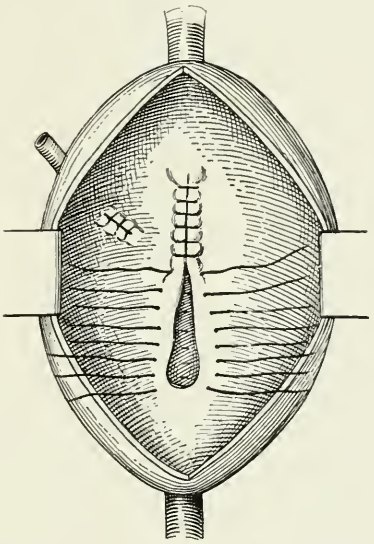

Fig. 96.—Shows the Orifices of the Aneurysmal Sac in Process of Obliteration by Suture. The first plane of sutures may be made with fine silk, but chromicized catgut is to be preferred. The sutures are reapplied very much like Lembert's sutures in intestinal work; the first plane of sutures should be sufficient to secure complete hæmostasis. The orifice of the collateral vessel on the left upper side of the sac is shown closed by three continuous sutures. (Matas, in the *Annals of Surgery*.)

Obliterative endoaneurysmorrhaphy aims to obliterate the aneurysm and also the artery from which it springs. It is indicated, according to Matas,† in "all aneurysms in which the sac is of a fusiform type, in which there are two or more orifices of supply, and in which the parent artery is entirely lost at the seat of the aneurysm by blending with the aneurysmal sac throughout its circumference." The edges of the sac are retracted and all visible orifices opening into the sac are closed with sutures of silk or, better, chromicized catgut, No. 2 or No. 3, curved needles and either a continuous or an interrupted suture being employed. The sutures should be about an eighth of an inch apart and a firm grip of the tissues should be secured, the needle penetrating at least one-quarter of an inch beyond the margin of the orifice, then dipping into the floor of the artery, and finally catching the opposite margin. (Fig. 96.) The

* Matas, in Annals of Surgery, 1903, vol. xxxvii., p. 161.

† Jour. of the Amer. Med. Association. Sept. 29th, 1906.

constrictor is then removed and the interior of the sac inspected for bleeding points, which, if found, should be closed by suture. The sac is next obliterated by approximating its walls as shown in Figs. 97 and 98. At the site of the tumor there will be a depression, varying in depth according to the original size of the aneurysm. No raw surfaces are left in view and drainage is not needed. After the dressings have been applied, the limb is wrapped in cotton and bandaged to a splint.

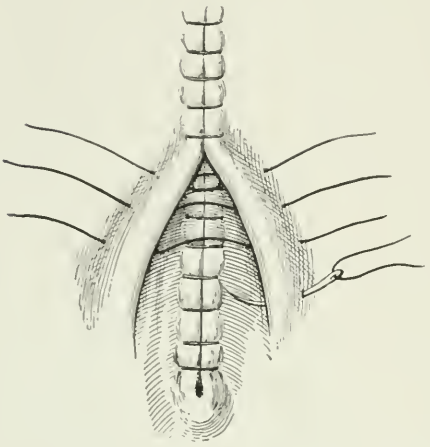

Fig. 97.—This Figure Shows a Second Row of Sutures—a Technical Detail of the Operation which is advantageous, but not necessary in every case. The first row of sutures has been completed and the arterial orifices have been obliterated. As the walls of the sac are usually relaxed, it is easy to insert a second series of sutures which add security to the first row, and, in addition, reduce the size of the cavity, which is to be obliterated by inversion of the skin and surplus sac walls at a later stage in the operation. This second row of sutures is applied as in the first series, by either the continuous or the interrupted method, with a curved needle and No. 1, 2, or 3 chromicized catgut. Large areas of the surface of the sac are thus brought in apposition, and the best opportunity is given for adhesion by plastic or exudative endo-arteritis. If the floor of the sac is rigid or too adherent to the underlying parts, this second row may be omitted, and the operation advanced to the last step—*i.e.*, the obliteration of the sac after suture of the orifices. (Matas, in the *Annals of Surgery*.)

Restorative endoaneurysmorrhaphy is applicable "to aneurysms of the sacciform type in which the parent trunk retains its continuity and normal outline, and the aneurysm is a sac simply grafted on the vessel. By making a free incision in the sac and washing out the clot one may expose, on the inside of the aneurysm, the opening leading to the artery, and may easily close it by a continued suture which penetrates through all the coats of the sac at the margin of the orifice of communication. (Fig. 101.) By this procedure the blood-supply of the sac is permanently arrested, the lumen of the parent artery remains patulous, and the arterial stream supplying the limb, or dependent territory, is immediately restored through its normal channel. The sac is then obliterated by bringing its endothelial surfaces together with buried sutures, and the surface wound is closed in the usual manner." (Fig. 102.)

Reconstructive aneurysmorrhaphy is applicable only "to fusiform aneurysms in which the coats of the sac are firm, elastic, and resistant, and the two openings leading to the main artery lie on the same level, in close proximity, and are situated at the bottom of a superficial or readily accessible sac." In this operation the continuity of the parent artery may be restored by making a new channel out of the sac walls, by suturing two folds of the sac over a rubber catheter in a manner similar to the construction of the canal in the Witzel gastrostomy. "As shown in Fig. 103, a soft-rubber catheter or tube, corresponding in diameter to the size of the parent artery, is laid on the floor of the sac and is inserted as a guide in the two orifices of communication. Two lateral folds of the sac are now raised from the floor on each side of the catheter by means of two sets of sutures, introduced on the Lembert plan. These ridges or

folds should be raised high enough on each side of the guide to cover it completely in the middle line. A row of sutures should now be placed in a series from one of the main orifices to the other, the catheter being left in situ until all are placed. The sutures are all tied except those in the centre of the line of union, and these are not tied until the guide has been removed." The sac is then obliterated in the manner already described.

Matas says: "That the fear that atheroma and degenerative changes will interfere with the healing and repair of the arterial tunics has been greatly exaggerated is shown by the abundant experience of the aseptic period in the ligature of sclerotic arteries in continuity, in the absence of secondary hemorrhage, in the amputated stumps of the aged, diabetic, and other arterially diseased subjects (Heidenhain, Webber, Barwell, and others), and is still demonstrated more fully by the observations and statistics of the partisans of the radical operation by extirpation (Delbet, Kubler, Ransohoff, Annandale, and others), who have reported numerous successful results in spontaneous as well as in traumatic aneurysms.

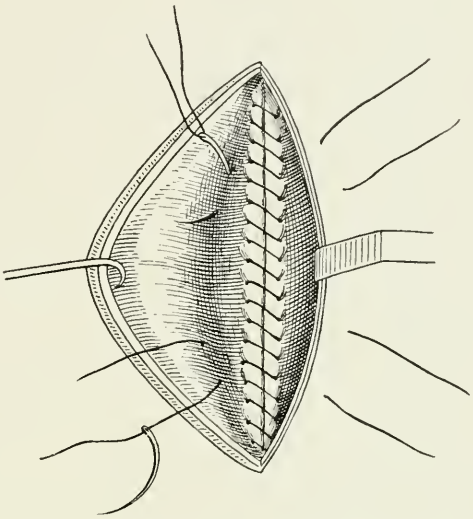

Fig. 98.—This Figure Shows the Details of the Method of Obliteration After the Floor of the Sac has been Raised by the Second Row of Sutures. Two deep supporting and obliterating sutures of chromicized catgut are inserted through the floor of the sac on each side. The number of these sutures will vary according to the size and length of the sac that is being treated. In the smaller aneurysms, one of the deep sutures on each side will suffice; in others, two or more on each side may be required to keep the surfaces in close contact. After the sutures are passed through the floor of the sac, the free ends of the threads are carried through the entire thickness of the flap by transfixion. The picture shows the mode of placing these sutures on the left side preparatory to transfixion of the flap. The two sutures on the right side have been carried through a flap and are in position. (Matas, in the *Annals of Surgery*.)

"The fallacies and dangers of the old operation of Antyllus lie (*a*) in the fact that the preliminary ligation of the main artery above and below the sac will not always control the bleeding from the collaterals, which often open into the aneurysm or into the main trunk between the orifices in the sac and at the seat of ligature. This compels a more or less extensive dissection of the sac out of its bed as one of the necessary features of the procedure, in order to secure all the collateral vessels that empty into the sac, unless the uncertain process of plugging the opening and packing the sac itself is resorted to. If the sac is dissected, as is usually done to secure the collaterals, the difficulties of the operation are increased, and the vitality of the limb is endangered by interfering with the collateral circulation, which, in many types of aneurysm, is most freely developed in the neighborhood of the sac.

"Another serious objection to the old Antyllian operation, as usually performed, is that the sac is allowed to remain as an open cavity in the bottom of

the wound, where it is packed or drained, and allowed to heal by granulation. This invites infection, suppuration, and its attendant dangers of secondary hemorrhage, all of which is obviated by the author's method of endoaneurysmorrhaphy, which does not disturb the sac from its vascular connection, and favors its prompt obliteration.

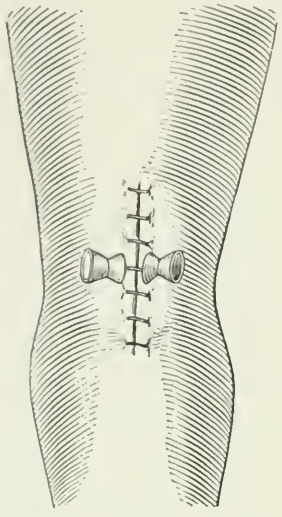

Fig. 99.—The Drawing Shows the Operation Completed. In this figure only two supporting sutures are shown on each side. The skin and sac walls form two lateral flaps on each side of the incision, and readily fall to the bottom of the sac, thus lining and obliterating the entire cavity. A series of interrupted, absorbable sutures are now placed in such a manner as to bring the edges of the skin in contact, several of these sutures including the floor of the sac in their bight (as shown in cross-section in Fig. 100), and thus closing the space entirely in the middle line. The two lateral supporting sutures are tied firmly over small pads or rolls of sterile gauze, thus bringing all the interior surfaces of the sac in apposition. (Matas, in the *Annals of Surgery.*)

"The uncertainties and dangers of extirpation of the sac are even more apparent than those of the Antyllus operation, because, in addition to the greater technical difficulties of extirpation, there is much greater risk of injury to the accompanying satellite veins and nerves which blend most intimately with the sac, and often compel the operator to limit his intervention to a partial extirpation, leaving behind a considerable portion of the sac wall in order to avoid injury to important adherent structures. The greatest objection to extirpation, however, lies in the decided interfering with collateral circulation in the immediate vicinity of the aneurysm, which entails a considerable risk of mortification in the distal parts. All these dangers are reduced to a safe minimum, and are largely eliminated by simply obliterating the sac instead of extirpating it."

That the Matas obliterative operation is superior to all other forms of treatment in cases in which it is applicable seems, at least in this country, to be generally admitted. Of 27 cases in which this operation has been performed there were 4 deaths, at periods varying from 2 weeks to 59 days after the operation, 2 from uræmia, 1 from sepsis, and 1 following ligation for an aneurysm which developed at a point above the site of operation. In one case there was a slight secondary hemorrhage, and in one gangrene, which necessitated amputation. There were no relapses. The only possible disadvantage, as compared with extirpation, of which we can think, is that, in cases in which the nerves are encompassed by inflammatory tissue or incorporated in the sac wall, the motor, sensory, or trophic symptoms may not be relieved. There is doubt, however, in the minds of many surgeons, as to the advisability of the restorative and reconstructive operations. Aside from secondary hemorrhage, which in the absence of sepsis need not be feared, there are two reasons for this doubt, viz., thrombosis may take place at the seat of operation and the aneurysm may recur. Occlusion of the newly made vessel by thrombosis has probably followed in most of the cases. In a case of popliteal aneurysm in which we performed the reconstructive operation, the pulse in the leg, which had previously

been absent, reappeared after the operation and persisted. Although the first pulsations in the tibial vessels were due, in all probability, to blood flowing through the repaired artery, it is likely that this vessel soon became occluded, and that the pulse persisted because of the development of a collateral circulation, aided by the removal of the pressure which the aneurysm exerted upon some of the collateral vessels. With, however, the application of the principles of modern vessel-suture (*i.e.*, fine needles, fine threads, close sutures, and the minimum of trauma), thrombotic occlusion should occur less frequently. If it does occur it may do so slowly enough to allow an efficient collateral circulation to form, and, if it occurs immediately, the same result would be obtained as in an obliterative endoaneurysmorrhaphy. Recurrence of the aneurysm is the strongest objection to these conservative operations, as it has occurred twice in seventeen cases (both times in the so-called reconstructive operations). These figures do not include arteriorrhaphy for recent aneurysms following wounds of healthy arteries, in which there is no question as to the best treatment. We group the restorative and reconstructive operations together, as there is no essential difference between them, except the size of the opening and consequently the number of sutures applied. As Binnie has pointed out, the aneurysm which Matas calls fusiform is in reality a sacculated aneurysm whose mouth has extended for some distance along one side of the artery. In a true fusiform aneurysm the reconstructive operation would not be applicable. In the seventeen cases mentioned above there were no deaths, no secondary hemorrhages, and no cases of gangrene. No doubt, with improved technique and larger statistics recurrence will be less frequent. A recurrence, of course, leaves the patient no worse than he was before, and the condition may be dealt with by any of the methods applicable to a primary aneurysm. As gangrene is inevitable in a certain proportion of all operations interrupting the circulation in the main artery of a limb, we believe that, despite the possibility of recurrence, the more conservative operations should be encouraged.

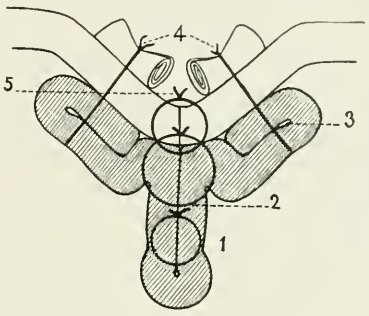

FIG. 100.—Sectional Diagram Showing Method of Obliterating the Aneurysmal Sac in the Fusiform Type of Aneurysm with Two Openings. The diagram shows the first row of sutures (1) which obliterate the orifice of the artery at the bottom of the sac. The second row of the sutures is shown higher up (2) and also the effect of the row in reducing the capacity of the sac. The obliteration of the remaining part of the cavity by the folding in or inversion of the sac walls, with the attached, overlying skin, is shown in 3. The function of the deep sutures (4) tied over gauze pads, and of the more superficial skin sutures (5) in obtaining firm contact of the apposed surfaces, is also shown. This drawing is purely schematic; it gives an exaggerated idea of the size of the sac walls, and is chiefly intended to give an idea of the position of the sutures and other parts. (Matas, in the *Annals of Surgery*.)

(*D*) Extirpation as a treatment for aneurysm was first performed by Philagrius, but is often called the method of Purmann, who reintroduced the operation in 1699. Before the era of antisepsis extirpation was so frequently followed by septic complications that it was seldom employed. At the present time many surgeons consider it the operation of choice, chiefly as the result of the writings

of Delbet. Delbet studies the operation from the standpoint of the mortality, the chances of gangrene, and the quality of the cure. In 1888 he found the mortality of ligation 18.94 per cent and of extirpation 11.32 per cent. The influence of antisepsis necessitated a change in these figures. In 109 cases of ligation collected between 1886 and 1895 the mortality was 8.33 per cent, while in 86 cases of extirpation there was not a single death. Antisepsis seems to have had much less influence on the incidence of gangrene. In 1888 the proportion of cases of gangrene after ligature was 7.58 per cent, and in 1895 it was 8.25 per cent. In 1888 extirpation gave 2.94 per cent of gangrene, and in 1895, 2.77 per cent. Extirpation not only obviates the danger of gangrene from embolism, which may occur after ligation, but also removes the compression from the collateral vessels and does not put out of commission as large a segment of vessel as ligation does. As to the quality of the cure after extirpation, the patient who escapes death and gangrene is definitely and radically cured, while after ligation there is not only the danger of recurrence, but the symptoms of pressure on the nerves may persist if already present, or, if not already present, they may be precipitated by the contraction of the sac. In his original statistics Delbet gives 12 cases of ligation in which the paralytic or trophic symptoms persisted, and in 2 of these cases they were so grave as to require amputation of the limb. In his later statistics he found, in 13 axillary aneurysms treated by ligation, 2 in which the arm remained powerless; and in 48 popliteal aneurysms treated in the same fashion there were 3 in which there were impotence and pain, the latter symptom being so severe in one case as to necessitate extirpation of the sac. After extirpation, nervous troubles never begin, and those which are present ordinarily disappear.

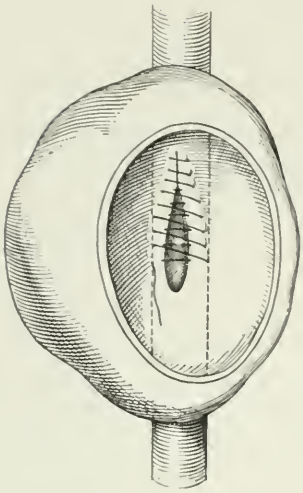

Fig. 101.—Restorative Endoaneurysmorrhaphy. The dotted lines indicate the position of the main artery in relation to the sac and to the orifice of communication. The object of the operation in this case is to close the orifice of communication without obliterating the main artery. The closure of the orifice with a continued suture is shown in the figure. (Matas, in the *Annals of Surgery.*)

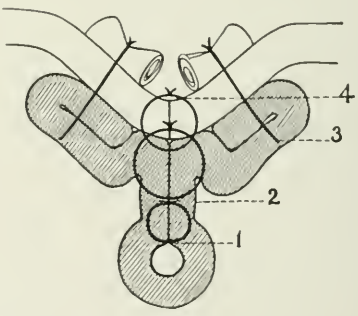

Fig. 102.—Restorative Endoaneurysmorrhaphy. 1. First line of sutures which close the orifice of communication and restore the lumen of the parent vessel; 2, second row of protecting sutures which also reduce the size of the sac; 3, supporting through-and-through sutures, which bring the roof and the floor of the aneurysm in contact; 4, sutures which hold the skin flap and sac in contact with the bottom of the cavity. (Matas, in the *Annals of Surgery.*)

It has been suggested that, before extirpation, the artery above the sac be compressed for a short period on several different days, in order to favor the development of a collateral circulation. If this course is adopted the pressure should be made as close to the sac as possible. In addition to the danger

of injury to a diseased artery, intermittent compression predisposes also to embolic gangrene; hence many surgeons ignore this suggestion. The operation is undertaken after the limb has been exsanguinated by elevation and the blood supply controlled by a broad elastic tourniquet applied at the root of the limb. In order that the satellite veins, which are often adherent to the sac, may be recognized before they are injured, Koehler suggests that a tourniquet be placed below the aneurysm, so that a certain amount of blood will remain in the limb. If the veins cannot be recognized during the operation, this lower band may be removed, when they will become distended with blood. After the sac has been isolated, great care being taken to preserve the collateral vessels and the nerves and to tie the vessels which empty into the sac, the artery should be doubly ligated above and below the sac and close to it, and the aneurysm removed. In 39 cases of extirpation Kubler * reports 9 cases of injury to the femoral vein. Such an accident should be treated by lateral suture or by anastomosis of the vessel. In some cases the operation may be facilitated by incising the aneurysm and introducing a finger into it, to act as a guide while the dissection is made close to its outer surface. After all bleeding has been controlled the wound should be closed without drainage. There are cases in which, owing to the size, situation, number, and character of the adhesions, extirpation is so formidable that some other method of treatment, either the operation of Antyllus or that of Matas, should be performed.

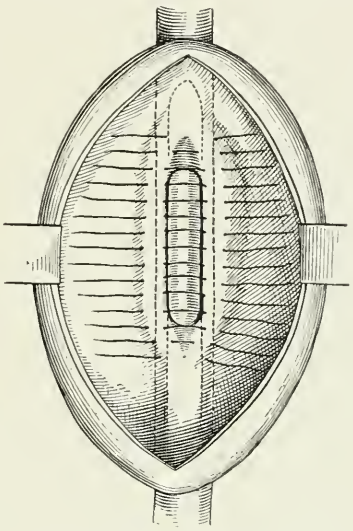

Fig. 103.—Reconstructive Aneurysmorrhaphy. The principle of this operation is precisely like that adopted in a Witzel gastrostomy. The figure shows the soft-rubber catheter lying on the floor of the sac and inserted in the two orifices of communication. The sutures are placed while the catheter is in position acting as a guide. (Matas, in the *Annals of Surgery*.)

(*E*) Theoretically, the ideal treatment of aneurysm would be end-to-end anastomosis of the two parts of the vessel after extirpation of the sac. The obstacles to be overcome in such an operation, notably in a spontaneous aneurysm, are obvious. In a small traumatic aneurysm, however, such a procedure may be feasible and advisable. Whether or not vessel transplantation will find a firm place in the treatment of aneurysm can be decided only by future experience. Lexer † extirpated an axillary aneurysm and, not being able to unite the opposite ends of the vessel, he transplanted 8 cm. of the internal saphenous vein into the arterial defect. The patient died five days later of collapse. The vein had united and was not thrombosed, but in the central arterial stump was a small mural thrombus at a point where a clamp had been placed during the operation. Goyanes,‡ in a popliteal aneurysm, severed the popliteal artery and

* Beitraege zur klin. Chir., 1892, p. 159.

† Centralblatt f. Chir., No. 31, Beilage, p. 12.

‡ Siglo medico, Sept. 8th, 1906.

vein above and below the sac, and then united the central stump of the artery with the peripheral stump of the vein above the aneurysm, and the central stump of the vein with the distal stump of the artery below the aneurysm, using Carrel's technique. The vein transmitted arterial blood and the patient recovered. Delbet,* after excising an aneurysm of the femoral artery, attempted to graft between the ends of the vessel a segment of a femoral artery from an amputated limb. The sutures tore out repeatedly, owing to the presence of atheroma, and he was forced to ligate.

(*F*) Amputation of the limb was at one time considered among the methods for the treatment of uncomplicated aneurysm. At the present day its chief indications are gangrene, marked erosion or dissolution of a joint, certain cases of rupture, suppuration, and secondary hemorrhage, and a rapidly growing aneurysm which has resisted all other means of treatment. Amputation has been performed in subclavian aneurysm to lessen the quantity of blood flowing through the sac.

Arteriovenous Aneurysm.—Arteriovenous aneurysm is an abnormal communication between an artery and a vein, allowing the blood to flow from the former into the latter.

According to Scarpa, anteriovenous aneurysm was first observed by Sennert. It appears, however, that Sennert, as well as others, although doubtless enjoying the opportunity to see this affection, believed such to be simple arterial aneurysm. To William Hunter † is due the honor, not only of discovering arteriovenous aneurysm, but also of detailing its symptoms with such accuracy that, even at the present day, little can be added to his description.

Etiology.—The formation of a communication between an artery and a vein may occur spontaneously or be the result of trauma. According to Delbet scarcely six per cent of the cases arise spontaneously. The aorta and vena cava are the vessels most often involved in spontaneous arteriovenous aneurysm, although the condition has been encountered affecting the iliac, femoral, popliteal, and posterior tibial vessels, the carotid artery and jugular vein, and, in Rizzoli's case, the occipital artery and transverse sinus, a defect of from 7 to 10 mm. in diameter existing in the skull. Spontaneous arteriovenous aneurysm is practically always the result of a preëxisting arterial aneurysm which becomes adherent to the vein and finally breaks into it. In Boling's case, in which no aneurysmal sac existed, the cause is given as an exostosis of the tibia. Bramann ‡ says that Rizzoli's case was one of cirsoid aneurysm which perforated the cranium, and that the congenital cases which have been reported are not arteriovenous aneurysms but cirsoid aneurysms. Guimaraês' case followed an abscess at the elbow.

Traumatic arteriovenous aneurysm may follow contusions, but they are generally the result of wounds. In Bramann's collection of 159 arteriovenous aneurysms there are 5 which followed a contusion, all, with a single exception,

* Revue de chir., June, 1907, p. 1080.

† "Medical Observations and Inquiries," 1761, p. 34.

‡ Archiv f. klin. chir., vol. xxxiii., 1886.

involving the vessels of the head and originating in a cirsoid aneurysm, which, by pressure on the adjacent vein, leads to atrophy of its wall and finally to a communication between the vessels. In Magnus' case, following a blow on the right eye, an arteriovenous aneurysm of the retina developed.

In Bramann's statistics there were 108 cases in which the disease followed punctured or incised wounds, and 29 in which it followed gunshot wounds. Of the former, 56 were due to venesection—3 in the temporal region, and 53 at the elbow. Of the 251 cases collected by Delbet, 3 involved the foot, 9 the leg (usually the posterior tibial vessels), 22 the popliteal vessels, 34 the superficial femoral, 26 the common femoral, 3 the external iliac, 2 the common iliac, 96 the bend of the elbow (usually between the basilic vein and the brachial artery as the result of venesection), 13 the upper brachial or axillary vessels, 1 the sciatic vessels, 6 the subclavian, 1 the ascending cervical, 19 the common carotid and jugular, 2 the internal carotid, 3 the external carotid, and 11 the temporal.

At the present time venesection as a cause of arteriovenous aneurysm would be rarely encountered, as the operation is seldom performed. Owing to the fact that the modern military bullet generally produces a narrow sterile wound which quickly heals, gunshot wounds of modern wars are comparatively often followed by arteriovenous aneurysm. Saigo * alone observed in Osaka 36 cases of aneurysm due to gunshot wounds during the war between Russia and Japan, 21 of which were arterial and 15 arteriovenous.

It is not our intention to enter into a discussion of pulsating exophthalmos, which although most often due to an abnormal communication between the internal carotid and the cavernous sinus, is generally described in works on ophthalmology. De Schweinitz and Holloway † have collected 313 cases of this affection and they give important references to the literature.

Pathology.—There are two forms of arteriovenous aneurysm, distinguished according to the presence or absence of a sac.

In the form without a sac the vessels are glued together in the region of the opening of communication and there exists a simple arteriovenous fistula, to which the name of aneurysmal varix is given, the term varix indicating that the vein is dilated. Aneurysmal varix in a pure form is rare. It is necessary that the artery and the vein suffer a lateral wound where they are in close contact, as by a bullet or other vulnerating body passing between the vessels. The extravasation which follows remains limited, since the blood from the artery finds it easier to pass into the vein than into the surrounding tissues. After a time the blood-clot is absorbed and the artery and vein, at the point where they communicate, are found firmly attached to each other by fibrous tissue.

When a sac exists in connection with an arteriovenous aneurysm the condition is called varicose aneurysm. Generally, the sac lies between the artery and the vein, the walls at first consisting of coagulated blood and later of fibrous tissue. This form Delbet calls *anévrysme variqueux enkysté intermédiaire.* If

* Deutsche Zeitschrift f. Chir., Bd. lxxxv., p. 577.

† Trans. of the Coll. of Phys., vol. xxix.

the vein has been perforated there may be a sac on the venous wall opposite the orifice of communication, or if the artery has been perforated a sac may be found at a similar point on the artery. In the former event, which is the more common, the arteriovenous aneurysm is called encysted venous, and, in the latter, encysted arterial. Very rarely there are two sacs—one intermediary and the other on the vein, as in Broca's case. An encysted arterial arteriovenous aneurysm with an intermediary sac has never been observed. In Ebenau's case, in which both femoral vessels had been perforated, there was a sac on the artery and one on the vein opposite the fistula, each about the size of a cherry. Park has described a case in which, after venesection, the brachial artery communicated with the brachial and median basilic veins. The brachial vein had been perforated and lay between the artery and the median basilic vein, upon which a sac had developed. In Larrey's case, which involved the popliteal vessels, and in Terrier's, which developed on the scalp, the peripheral end of the vein was obliterated, while its central end, as well as both segments of the artery, opened into the same cavity. Cadge reported a case in which the posterior tibial artery communicated with its vein, after these had been sectioned in an amputation of the leg. Finally, it is possible, after a complete section of both vessels, for each of the four ends to open separately into the same cavity. Generally, however, after both vessels have been severed the vein is compressed and its ends are sealed by the extravasated blood, and it is only when its orifices are held open by branches or by adhesion to the surrounding tissues that such a condition could obtain.

The sac of a varicose aneurysm is at first usually a cavity which has been made in the clot of the extravasated blood. Later, the clot is displaced by fibrous tissue and the cavity is lined by endothelium which spreads from the tunica interna of the vessels. Occasionally, however, the sac is formed by dilatation of an arterial or a venous cicatrix.

Unlike arterial aneurysms the sac rarely contains firm clots, owing doubtless to the activity of the circulation. Hence the sac of a varicose aneurysm rarely attains a large size and never heals spontaneously. As Delbet points out, the deposition of clot augments or obliterates an aneurysmal sac. By diminishing the capacity of the sac the clot raises the blood-pressure in its interior, and, if the resistance of the walls is not equal to the increase in pressure, the aneurysm enlarges. On the contrary, if the resistance of the walls is sufficiently great, the sac may be filled with clot and recovery follow.

The artery above the point at which it opens into the vein becomes dilated and often elongated and tortuous. The reason for these changes is said to be the diminished pressure within the artery, as the result of the loss of blood into the vein, whereby the walls of the artery atrophy and subsequently dilate. A better explanation, it seems to us, is that in consequence of the leak a much larger quantity of blood passes through the artery, which consequently must dilate to meet the demands made upon it.

Below the site of the arteriovenous fistula the walls of the artery are generally thinner and the lumen is diminished, by reason of the lessened amount of

blood which is pumped into the peripheral segment of the artery. Occasionally the peripheral segment of the artery is dilated and tortuous, a condition seen most often on the scalp and hence to be ascribed, according to Bramann, to a complicating cirsoid aneurysm. The vein into which the arterial blood is propelled dilates, its muscular coat undergoes hypertrophy, and it becomes elongated and tortuous. The degree and extent of this "arterialization" of the vein and its tributaries vary according to the size of the vessels involved, the size of the orifice of communication, and the duration of the abnormality. The facility with which the blood passes from one vessel into the other also influences the changes which the vein undergoes. Thus, in aneurysmal varix the vein suffers greater alteration than in varicose aneurysm, since in the latter the force of the arterial stream is diminished by reason of the sac through which it must pass. The character of the surrounding tissues likewise influences the degree of venous dilatation. In a case reported by Burckhardt the temporal vessels were involved in the parotid gland, but the dilatation occurred only above the gland. The time when the dilatation is first observed varies very widely, depending largely on the factors mentioned above. In the case reported by Kieser a varix the size of a cherry was noticed a few hours after the injury, while in others it has not been detected for months or years. In a case reported by Monmeret the varicosity did not make its appearance until twenty years after the injury. The size of the sac depends upon the size of the opening and, except in the infrequent cases of spontaneous arteriovenous aneurysm, is rarely larger than a hen's egg, although in Tillaux's case the tumor was as large as a child's head. The vein enlarges first, toward the periphery, as far as the first valves, which finally yield as the result of the pressure or become incompetent because of the dilatation, when the same process is repeated in the lower segment, until finally the whole vein with many of its tributaries is involved. The vein central to the orifice of communication likewise dilates and undergoes hypertrophy. Occasionally the peripheral venous segment is filled with clot, either as the result of the injury or as the result of deposition of fibrin upon the valvular lacerations following the forcing of these structures. Rarely, the central segment is thrombosed, either as the result of the injury or perhaps as the result of compression applied for therapeutic purposes.

The blood passes continuously from the artery into the vein, and does not, as Breschet thought, enter the vein with each cardiac systole and flow back into the artery between the pulsations.

Bramann, in a case of axillary arteriovenous aneurysm, found by means of a manometer that the pressure in the central end of the vein was from 56 to 64 mm. and, in the peripheral end, from 87 to 90 mm., while the normal pressure in the brachial vein was 9 mm.

The pathological changes in the tissues of the affected region consequent upon the circulatory disturbances will be described under Symptoms.

Symptoms.—In the beginning the copious bleeding which follows an arteriovenous wound, either ceases spontaneously or is controlled by pressure or other means. The diagnosis of simultaneous injury of the artery and the vein cannot

be made from the character of the bleeding. In the absence of an external wound the extravasation is likely to be less extensive than from a simple arterial wound, because the arterial blood finds its way into the vein.

The first and at the same time the most constant and most certain sign of an arteriovenous aneurysm is a characteristic bruit, which is sometimes heard immediately after the injury and sometimes not for days, months, or even years, according to whether the opening remains patent or is for a time closed by clot or by feeble scar tissue which later yields. The bruit has been likened to the buzzing of a bee, the humming of a top, the purring of a kitten, and the sound made by a bluebottle fly confined in a thin paper bag. William Hunter compared the sound to "what is produced in the mouth by continuing the sound of the letter R in a whisper." It is continuous, with a distinct reinforcement at each cardiac systole, and does not, as was thought by Nélaton and others, consist of an even continuous murmur and a separate intermittent murmur.

Corresponding to the bruit and likewise continuous, with a systolic reinforcement, is a characteristic thrill. Both thrill and bruit are most marked over the orifice of communication, upon the size of which depends the intensity of these signs. Furthermore, with the development of the varix, they are propagated along the dilated veins, sometimes for a considerable distance, but further peripherally than centrally. Franz,* however, found in his experimental work that the murmur was always, and the thrill generally, more marked in the central venous segment. One may, according to Bramann, hear the bruit along the entire vein and even along its branches in certain arteriovenous aneurysms of the brachial vessels, while in cases in which the femoral vessels are involved the bruit is seldom heard above Poupart's ligament or below the knee. In a few instances the bruit may be perceptible some distance from the patient, even as far as two feet (Brenner), and not infrequently, particularly in arteriovenous aneurysms of the head and neck, the continuous purring is heard by the patient, sometimes interfering with sleep and proving a most harassing and distressing symptom.

Of the several theories which have been advanced to explain the origin of the bruit the one generally accepted at the present time is that, as the result of its sudden propulsion into the vein, which is larger in calibre than the artery and in which the pressure is much lower, the blood is thrown into a series of violent eddies. The thrill depends upon the transmission of the vibrations of this whirling stream to the walls of the vein.

As the result of experiments on dogs, Franz found that the thrill and bruit rested upon the freedom with which the arterial blood flowed into the central venous segment, and that the peripheral segment of the vein had nothing to do with the origin of these phenomena, for, after ligation of the peripheral segment, these signs continued, and after ligation of the central segment they became intermittent. He found, further, that during forced expiration the murmur was intensified, as the result of the increase in the intravenous blood-

* Deutsche Zeitschrift f. Chir., Bd. lxxv., p. 572.

pressure. In several cases of varicose aneurysm of the neck the swelling was observed to diminish materially during deep inspiration. According to Nélaton elevation of the affected limb causes the bruit to become intermittent. Franz found this to be true in the peripheral venous segment but not in the proximal.

Not less characteristic than the bruit and murmur, although somewhat less frequent, is venous pulsation, synchronous with the arterial pulse, which is easy to detect in the superficial veins but often difficult or impossible to demonstrate in the deeper veins. As pulsation appears the veins dilate and become varicose. Both pulsation and dilatation are most marked at the level of the arteriovenous fistula, and involve both the proximal and the distal portions of the vein, but particularly the latter. In some cases the superficial veins, although markedly dilated, fail to show pulsation. Proximal compression of the artery, with very few exceptions, causes disappearance of the thrill, murmur, and pulsation. The same is true of compression of the sac between the artery and the vein, and of closure of the opening in the artery by pressure on the vein, which manipulations in many cases increase the strength of the pulse in the peripheral portion of the artery.

Sphygmographic tracings showed, in Franz's experiments, an anacrotic curve over the peripheral venous segment and over the sac. According to Marey, anacrotism in the vein is due to the longer time which the pulse wave requires to distend the vein fully, and to the fact that this distention lasts longer, owing to the lack of elasticity in the vein. Tracings made from the central venous segment and from the peripheral portion of the artery both show an almost straight line, there being only a few small elevations.

Owing to the lessened pressure in the arterioles and the increased pressure on the venous side of the circulatory apparatus of the affected region, the blood circulates with greater difficulty through the capillaries, and the part becomes œdematous and dark-red or bluish in color, particularly in the lower extremity. These congestive phenomena are, of course, increased when the part is dependent and lessened when elevated. In arteriovenous aneurysm of the carotid and jugular, giddiness, headache, attacks of syncope, and other cerebral symptoms may occur, particularly when the patient lies down. In Stimson's case there were blindness and choked disc.

As a result of the slow circulation in the part beyond the arteriovenous aneurysm and of the large amount of blood thrown into the dilated veins under the skin, the local temperature is generally lowered, sometimes, as in Bardeleben's case, as much as eight degress. In the neighborhood of the communication, however, the temperature is often greater than that of the healthy side. Elevation, massage, and active motions, by lessening the passive congestion, increase the temperature of the part. As the result of the loss of heat the patient often complains of coldness in the affected region, which is more sensitive to changes in the temperature of the atmosphere. Weakness, numbness, formication, and like sensations are occasionally present, and the muscles atrophy because of disuse. Eczema and ulceration are not infrequent, particularly in the lower extremity. Paralysis and anæsthesia are to be attributed to simultaneous

injury of the nerve trunks, which is most frequent in arteriovenous aneurysm of the axilla, owing to the close proximity of the vessels and the nerves in this region. In Franz's case, that of a twelve-year-old boy with an arteriovenous aneurysm of the femoral vessels, the affected limb was 3 cm. ($1\frac{1}{5}$ in.) longer than its fellow, indicating an increased blood-supply to the epiphyses; Cordonnier reports a similar case; in Brindejonc's case the leg was shorter and thinner than the sound leg.

Diagnosis.—The diagnosis is seldom difficult, except in those cases in which the vessels lie far below the surface. If one can demonstrate the characteristic thrill and bruit, even in the absence of venous pulsation, the diagnosis may be made with certainty.

The murmur of a simple arterial aneurysm is always intermittent and is generally confined to the aneurysmal sac. Transmission of the murmur along the vessels for a short distance is possible, but never in a central direction. A vascular murmur transmitted toward the heart is, however, occasionally heard over the veins, particularly of the neck, as the result of pressure or of impoverished blood, and such murmur is continuous and may vary in intensity, but the variations are irregular and not rhythmic, and the reinforcements correspond, not with the cardiac systole, but with the diastole, or with inspiration. In cirsoid aneurysm the artery and its branches are varicose and pulsation is everywhere the same in character. The murmur is softer and shows no systolic reinforcement. The thrill is weak or absent. Proximal compression of the main feeding artery has little influence on the pulsation, thrill, and bruit, which in arteriovenous aneurysm cease, not only after such compression, but also, in certain cases, after pressure directly on the orifice of communication. Cirsoid aneurysm is most frequent on the scalp and hand, where arteriovenous aneurysm seldom occurs.

Although the differential diagnosis between the two forms of arteriovenous aneurysm is often impossible until the affected vessels are laid bare by incision, in typical cases there are certain distinctive features. Thus, for example, the saccular dilatation opposite the orifice of communication in aneurysmal varix is circumscribed, oval, soft, and fluctuating, often movable and fully reducible, while the sac in varicose aneurysm is harder, immobile, more irregular, and not completely reducible.

Prognosis.—The prognosis of arteriovenous aneurysm depends upon its form and situation.

Aneurysmal varix rarely in itself threatens life, and may exist for years in a stationary condition, but the disturbances consequent upon the circulatory changes are as great as in varicose aneurysm. In a few cases, however, the vein becomes so greatly distended as to rupture.

Varicose aneurysm likewise may exist for many years without progression, but is apt sooner or later to increase in size, often suddenly, until rupture takes place, when the dangers are the same as those of a purely arterial aneurysm under the same conditions.

The phenomena resulting from congestion are generally most marked in the

lower extremity and least pronounced in the head and upper extremities. Interference with function occurs in both arm and leg, but seems more pronounced in the former, probably owing to the finer manipulations which this part of the body is called upon to perform. Elephantiasis, obstinate ulceration, and varices which threaten to rupture are most frequently seen in the leg. Arteriovenous aneurysm of the carotid and jugular may so disturb the circulation in the brain as to interfere with hearing or sight, or even cause death. In Joret's case there were strabismus and intellectual weakness, and later right-sided hemiplegia and epileptiform convulsions. The patient died at the end of two years and the autopsy showed several areas of softening in the brain on the affected side.

Treatment.—Hunter advised expectant treatment, recommending that the limb be used as little as possible. This advice is still sound in those cases of aneurysmal varix which remain stationary, do not interfere with function, cause little inconvenience, and are so situated as to make operation difficult and dangerous. Varicose aneurysm always demands active treatment.

Almost all the methods of treatment which have been used in the treatment of arterial aneurysm have been applied likewise to arteriovenous aneurysm, but with different results. The injection of coagulating fluids and galvano-puncture must be mentioned to be condemned. Of four cases in which the former was used there were two successes, and two followed by gangrene which necessitated amputation. Of 8 cases in which galvano-puncture was employed, 4 were successful, 2 showed no improvement, 1 resulted in suppuration of the sac, and 1 died.

Compression by the method of Reid and by forced flexion have been uniformly unsuccessful. Indirect compression is said to have been successful in two instances only, although it has probably been employed in most of the cases which have later been subjected to other forms of treatment.

Direct compression has been successful in a few instances of recent arteriovenous aneurysm at the bend of the elbow, and in two cases in which the femoral vessels were involved. The dangers are suppuration of the sac, increase in size or rupture of the aneurysm, and gangrene of the extremity. In Simon's case of arteriovenous aneurysm of the aorta and common iliac vein compression caused gangrene of the bowel and a fatal peritonitis. Guattani attempted by direct compression of the sac to transform a varicose aneurysm into an aneurysmal varix. Vanzetti recommended indirect compression of the artery above the sac and direct compression of the dilated vein at the level of the arteriovenous opening. His idea was to obliterate the opening between the artery and the vein and to transform the arteriovenous into a simple arterial aneurysm, which then would be more susceptible to successful treatment by further compression. Although the plan of converting an arteriovenous into the more serious arterial aneurysm cannot be regarded as judicious, direct compression of the vessels at the affected point, with indirect proximal compression of the artery, is without doubt the most efficacious form of compression in arteriovenous aneurysm, especially in recent cases, and in such cases may be tried, particularly if there are strong contra-indications to operation. Delbet gives the proportion of

recoveries after compression as thirty-two per cent, and concludes that the best of these methods is so little efficacious that it should not be employed unless one can do no better.

Proximal ligation of the artery, by the method of Anel and Hunter, would, at the present day, be indicated only when direct operative intervention could not be carried out, since, according to Delbet, it fails twice as often (45.45 per cent) as it succeeds (22.5 per cent), determines gangrene in almost as many cases (20.45 per cent) as it cures, and is followed by secondary hemorrhage in 11.37 per cent of the cases. Dupuytren suggested proximal ligation of the artery and ligation of the vein above and below the arteriovenous aneurysm, an operation which, it seems, has never been performed. Stromeyer advised ligation of both ends of the vein alone—a manifestly incomplete procedure.

Ligation of the artery above and below the aneurysm gives much better results than proximal ligation alone, particularly in recent cases of aneurysmal varix, but is very uncertain when a sac exists, or when collateral vessels are present between the ligatures.

Quadruple ligation—*i.e.*, ligation of both artery and vein above and below the aneurysm—is the best of the ligation methods, but, owing to the possibility of recurrence from the presence of collateral vessels, would, without incision of the sac or extirpation of the vessels between the ligatures, be indicated only under exceptional circumstances—*e.g.*, in cases in which the latter operations would prove very difficult and the condition of the patient was not such as to withstand a prolonged operation. As far as gangrene is concerned, quadruple ligation, incision, and extirpation stand on an equal footing. Of fifty-three cases in which these operations were performed, gangrene followed in 5.66 per cent.

Incision of the sac, with tamponage, after quadruple ligation, possesses the same disadvantages as the operation of Antyllus for arterial aneurysms.

Extirpation precludes the possibility of recurrence, but in certain cases, owing to the situation of the arteriovenous aneurysm or to the dense adhesions which bind it to the environing tissues, it is a formidable operation. Of thirty-two cases of extirpation thirty-one were successful. The method is certainly to be chosen when destruction of the vessels would cause little probability of gangrene or serious disturbances in the parts beyond—*e.g.*, in vessels of the second class. The chances of gangrene are of course increased if the arteries are atheromatous, and an examination for this condition should always be made before one proceeds with the operation.

Angeiorrhaphy, with preservation of the lumen of each vessel, is the ideal operation, since if successful the circulation remains uninterrupted and gangrene is prevented. It should therefore be attempted in all cases in which the major vessels are involved. Unfortunately, vascular suture is not always possible; at least in several cases the surgeon (J. C. Stewart, and also Cranwell *) began his operation with this procedure in view and, owing to unforeseen difficulties, was forced to ligate.

* Rev. de chir., Dec., 1906.

In 1901 Lissjanski,* in an arteriovenous aneurysm of the femoral vessels, resected the artery between ligatures and closed the opening in the vein with sutures. Matas † and Zoce Manteuffel have done similar operations. Perugniez,‡ in 1900, and Garré,§ in 1906, resected the vein and applied a lateral suture to the artery. All of these operations were successful.

Murphy,|| in 1906, was the first to preserve the continuity of both vessels. In an arteriovenous aneurysm of the femoral vessels, eighteen days after a gunshot wound, he applied a lateral suture to the vein and, after resecting the artery, joined the segments by end-to-end anastomosis. In 1898 Marchand operated successfully on an arteriovenous aneurysm of the brachial vessels by separating the artery from the vein and closing the openings with lateral sutures. Koerte,¶ in 1904, dealt with a recent arteriovenous aneurysm of the popliteal vessels in a similar manner and likewise successfully. Cranwell,** in 1906, left a small portion of the sac on each vessel, thus permitting him to close the openings by applying a lateral ligature. Lexer,†† in a popliteal arteriovenous aneurysm, resected 4 cm. of the artery and vein and united the ends of the vessels by the Payr method. The operation was successful.

Bicknam ‡‡ suggests that the principles of Matas' endoaneurysmorrhaphy might be applied in the treatment of arteriovenous aneurysms. In a varicose aneurysm he would incise the sac, close the openings in the artery and vein with chromicized catgut sutures, and obliterate the sac by suturing the roof to the floor. In an aneurysmal varix he suggests that the vein might be incised, the arteriovenous fistula sutured from within the vein, and the incision in the vein then closed.

The varices which accompany an arteriovenous aneurysm generally shrink considerably after the abnormal opening between the artery and the vein has been suppressed, and rarely would it be indicated to remove these dilated veins at the time of the operation for the arteriovenous aneurysm. This may be effected at a later period if the varices persist and give rise to trouble.

Amputation of an extremity for arteriovenous aneurysm would be indicated only when this affection results in gangrene or in repeated hemorrhage the result of sepsis—in other words to save life when less drastic measures are inapplicable or injudicious.

VII. PHLEBITIS.

Phlebitis, or inflammation of a vein, was first recognized by John Hunter, who demonstrated the fact that many of the ill results following phlebotomy were due to this affection. The condition may be acute or chronic.

Acute Phlebitis.—Etiology.—All wounds of veins are necessarily followed

* Wratsch, No. 10, 1901.
‡ Rev. de chir., Nov., 1906, p. 622.
|| Med. Record, Jan. 16th, 1907.
** Rev. de chir., Dec., 1906.
‡‡ Annals of Surg., May, 1904.
† Jour. Amer. Med. Assoc., Nos. 2–5, 1902.
§ Deutsche Zeitschrift f. Chir., May, 1906.
¶ Centralblatt f. Chir., 1904, p. 466.
†† Centralblatt f. Chir., 1907, No. 31, Beilage, p. 12.

by phlebitis; aseptic phlebitis being nature's method of permanently closing such wounds. Contusions of veins which injure the intima likewise are followed by inflammation. The best example of aseptic phlebitis following upon a rupture of the intima is that which seals the vessels after the application of a ligature. When the venous walls are already altered,—as, for example, in varix,—the slightest injury is often sufficient to start an inflammatory process. Prolonged pressure by tumors, etc., induces nutritive changes in the venous walls which are followed by phlebitis and obliteration. The presence of a primary thrombus or of an embolus induces inflammatory changes in the walls which embrace it. We have already mentioned, in the section on Thrombosis, the rarity of primary thrombi, and, in order to avoid repetition, we shall refer the reader to that part of the article for the various acute infectious diseases and cachectic states which may be complicated by thrombophlebitis, and for the results of bacteriological examination in such cases. Thrombosis following aseptic abdominal operations has already been discussed by us in the section on Pulmonary Embolism. In some of the instances mentioned above, notably in the normal healing of veins after sterile wounds, the process is undoubtedly aseptic, but the vast majority of cases showing outward evidences of phlebitis are due to infection of the venous walls with pyogenic bacteria. (See section on Thrombosis.) That septic inflammatory conditions about veins may spread by contiguity to the vessel walls and induce phlebitis is a common clinical observation. Bacteria may be transported to the vessel walls likewise by the vasa vasorum or the lymphatics, or they may enter directly from the blood-stream. In the last instance, as we have already pointed out, the veins on the left side of the body, particularly at the root of the limbs, are those most often affected.

Pathology.—The sharply localized, aseptic inflammation which seals wounds in veins is identical with the same process after arterial injuries, which we have described on an earlier page. This process of repair some authors refuse to call inflammation, although the phenomena are the same and the difference exists only in the intensity of the changes. In that form of inflammation of a vein which is recognized clinically as phlebitis the phenomena of inflammation are much the same as in other tissues. Here, however, the important changes, from a practical standpoint, are those in the intima, as it is only when this membrane is involved that thrombosis follows. As a matter of fact, the intima in acute phlebitis is always involved and generally primarily, even when the infection spreads from without inward. This is because of its delicate nature, being the first to yield in contusions; its resemblance to serous membranes, which possess a tendency to exudative inflammations; its situation, being exposed to the various bacteria and toxins which may circulate in the blood; and because the vasa vasorum terminate immediately beneath it. The process is, therefore, generally the direct result of changes in the endothelium consequent upon external injury or upon the action of toxins circulating in the blood-stream. In the former the intima is ruptured, in the latter its cells are degenerated; in either, the affected cells swell and project into the lumen of the vessel. At the same time the vasa vasorum in the outer coats dilate, and exudation follows, the walls therefore

appearing hyperæmic and thickened. Owing to the roughening of the intima and the production of large quantities of fibrin ferment, there is quickly formed a mural thrombus, which usually increases in size until the vessel is completely occluded. The manner in which a thrombus is formed, the changes it may undergo, and other facts relating to this subject, will be found in the section relating to Thrombosis. We wish here to call attention only to the changes in the venous walls. The material exuded into the vessel wall coagulates and is subject to the same fate as inflammation lymph elsewhere—viz., absorption by the lymphatics, organization by fibroblasts, or liquefaction by bacteria, *i.e.*, suppuration.

In the slightest form all the inflammatory tissue may ultimately be removed. When the process is more intense the muscular tissue disappears and the three tunics become markedly sclerotic. The most remarkable phenomenon in these cases is, according to Marie,* the vascularization of the vessel-wall during the progress of organization of the thrombus. The dilated vasa vasorum develop ramifications which finally traverse the intima and the thrombus. At a later period, when the sclerosed tissue contracts, a certain number of these vessels are obliterated; many, however, persist, and in some instances undergo further dilatation and form a cavernous plexus which compensates, to a certain degree, for the obliteration of the principal trunk. Here we may emphasize the fact that the presence of pyogenic organisms does not necessarily imply the presence of pus. Indeed, in most instances, owing to the slight virulence or small number of invading organisms, to the bacteriolytic power of the leucocytes and tissue cells, or to other causes, the inflammatory tissue undergoes resolution or organization and the thrombus is absorbed or converted into fibrous tissue (exudative phlebitis). When opposite conditions obtain, the thrombus in whole or in part is liquefied as the result of bacterial activity (suppurative phlebitis).

In suppurative phlebitis, which is much less frequent than the exudative variety and generally the result of a direct extension of the inflammation from the perivenous structures, the walls are crowded with leucocytes, which in places may form small abscesses. In some cases the tissues of the vein are destroyed by ulceration, thus allowing the suppurating thrombus to empty itself into the neighboring tissues. Hemorrhage is consequently a possibility, unless those portions of the clot which are in contact with the blood stream remain firm. Embolism may occur in either form of phlebitis. The large, suddenly fatal emboli are usually the result of exudative phlebitis, while suppurative phlebitis more often liberates small emboli which give rise to secondary abscesses.

Symptoms.—The symptoms of phlebitis are local and general.

The local symptoms are those of inflammation and those due to occlusion of the vein by thrombosis. The general symptoms depend upon toxæmia. The intensity of the symptoms varies very greatly with the extent and nature of the phlebitis and the resisting powers of the individual. The symptoms, both local and general, may be absent. Latent phlebitis is common in the pelvic veins, and may occur also in other parts of the body during the course of exhausting diseases, particularly tuberculosis and carcinoma. This form of

* Cornil et Ranvier: "Manuel d'histologie pathologique," t. iii., 1907.

phlebitis, which gives no external signs of its existence, is particularly dangerous because no precautions are taken to prevent the dislodgment of the thrombus. We have already cited a case in which, following operation, signs of phlebitis did not appear until after the occurrence of embolism. Similar cases have been reported by Schwartz, Pinard, Quénu, and Vaquez; the last designating these cases "*phlébite latente à début embolique*." In other instances the embolism is large enough to cause speedy death and prevent the *début* of the phlebitis. The severest forms of phlebitis are those which are due to septic wounds and badly drained, suppurating foci—*e.g.*, middle-ear disease and puerperal infection. Between these extremes are found all grades. In some cases the local symptoms are marked and the general symptoms trivial. This statement applies to many of the cases of femoral phlebitis following aseptic abdominal operations. In other cases the general symptoms predominate and the local signs are insignificant. Thus, thrombosis of the lateral sinus has been diagnosticated typhoid fever, pneumonia, etc. Only a small segment of the vein may be involved in the inflammatory process, as is frequently seen in varicose veins of the leg; or most of the veins, from the toes to the vena cava, may be implicated, as not infrequently happens in phlegmasia alba dolens. Ordinarily, phlebitis creeps from its point of origin along the affected vein. When a venous radicle is first involved progression occurs in the direction of the blood-stream, but, when a vein is attacked some distance from its point of origin, the inflammation may spread in both directions until the entire vein is affected. The vessels which communicate with the affected vein likewise are frequently invaded by the inflammatory process. Occasionally, however, cases are encountered in which segments of a vein are skipped by the disease. We recently observed a case of this sort in an old lady with a marked rheumatic predisposition. The process began in a small varicose vein over the lower part of the tibia, in which region there had been a small abrasion. The lesion at first resembled erysipelas, but soon subsided, leaving a thrombosed vein. In the same way successive patches, two or three inches in length and separated by irregular intervals of from three to five inches, appeared along the course of the internal saphenous vein and some of its branches. Finally, one of these sections in the thigh suppurated, necessitating an incision into the vein. Schwarz * describes two cases of what he calls phlebitis migrans, in which segments of the veins of both arms were attacked during the last stages of pulmonary tuberculosis. In these cases no micro-organisms were recovered and thrombosis did not follow, sections demonstrating that the process was confined to the two outer coats. He could find only two other cases in the literature, both of which gave a syphilitic history. Gouty phlebitis, according to Paget, often exhibits this jumping tendency. "It affects the superficial rather than the deep veins, and often occurs in patches, affecting (for example) on one day a short piece of a saphenous vein, and on the next day another piece of the same, or a corresponding piece of the opposite vein or of a femoral vein. It shows herein an evident disposition toward being metastatic and symmetrical." †

* Virchow's Archiv, 1905, Bd. clxxxii., p. 178.

† "Clinical Lectures and Essays," by Sir James Paget, 1875, p. 293.

Successive involvement of veins in various parts of the body points to some general cause, and is observed most frequently—aside from its occurrence in gout and rheumatism—in chlorosis, and in cachectic states depending upon conditions like cancer and tuberculosis. In Huel's case of chlorotic thrombosis the veins in various parts of the body were involved in quick succession until only the jugular and the right subclavian remained free. (Welch.) Cases of this sort, which Erlenmeyer terms *springende Thrombose*, are peculiarly liable to recurrent attacks.

The local symptoms in detail are as follows:—Pain is often the first symptom to attract the patient's attention. It varies greatly in intensity, according to the nature and seat of the phlebitis and the temperament of the patient. In the lower extremity, the part most frequently attacked, the pain, although often more or less generalized, is most pronounced in the groin, on the inner side of the thigh, in the popliteal space, and in the calf of the leg—in other words, along the course of the femoral and saphenous veins. The pain is usually constant, but may be neuralgic in type, radiating along the branches of the anterior crural and sciatic nerves, and sometimes along the lumbar nerves, in which case there may be, but rarely, vesical or rectal tenesmus. No doubt, in some cases there is an actual neuritis, caused by the irritation of the œdematous fluid (Klippel), or, more likely, by direct extension of the inflammation from the venous radicles in the nerve trunks. (Quénu.) The pain generally appears first in the groin, but occasionally toward the other extremity of the femoral or saphenous vein. Even when the pain is slight or absent, tenderness may be elicited by pressure over the affected vein. It is hardly necessary to add that such pressure should be of the most gentle kind and should always be made with the idea possibly of embolism in mind. In phlebitis of the iliac vessels pain and tenderness may simulate intraperitoneal affections. We have on several occasions, in the course of typhoid fever, seen the onset of an iliac phlebitis very closely mimic perforation of the bowel. Acute phlebitis of the large intra-abdominal veins (*e.g.*, the mesenteric) usually gives rise to agonizing pain which is generally interpreted as being due to some other cause.

Redness may possibly be seen in the most superficial veins, but, when present, it is usually due to inflammation about the vessel.

The local temperature is elevated in the presence of a periphlebitis, but in other cases no change may be appreciable; in the later stages it is said to be often lower.

When the vein is superficial it may stand out as a visible mound, owing to the presence of thrombosis, and be felt as a hard cord, unless the thrombus is soft in consistency. In many instances the vein cannot be palpated owing to the perivascular œdema.

Œdema quickly follows the pain; it is due to inflammation of the perivenous tissues or to obstruction of the venous circulation, one or both. Inflammatory œdema is most marked about the inflamed vein; œdema due to venous obstruction is greatest at the peripheral end of the involved vein. Thus, in phlegmasia alba dolens the swelling usually begins in the foot, owing to the venous obstruc-

tion, but may be noticed first at the root of the limb as the result of the inflammation. The amount and character of the œdema consequent upon venous obstruction is influenced by many conditions, and is not always in proportion to the size and importance of the vein involved. Obliteration of the inferior vena cava may be followed by extensive œdema of the lower half of the body, by swelling of one leg only, or by no œdema in either leg. Some of the visceral veins (*e.g.*, the renal and mesenteric), when suddenly occluded, cause serious disturbances in the parts which they drain, but may be gradually closed by a slowly forming thrombus without evil consequences following. In the other instances, particularly in the extremities, the suddenness of occlusion is of less importance than its extent; ligation of even the largest vein may cause little or no œdema. The same applies to a limited thrombosis. But when the clot extends along the entire vein and into its branches the collateral circulation is seriously embarrassed and passive venous congestion follows. Increased pressure in the vein stretches its walls, the cells of which suffer from inanition as the result of the more venous character of the blood. This leads to a transudation of the serum, which is greater in amount when the composition of the blood is altered by conditions like anæmia, cachexia, and infective diseases. If such serum is not absorbed by the lymphatics œdema follows. That something more is needed for the production of œdema than the mere quantity of fluid leaking from the blood-vessels is proved by the rapidity with which saline fluid injected beneath the skin is absorbed. The lympathic vessels themselves, which are closely related to the veins, may be inflamed or pressed upon by inflammatory exudate. It is not at all unusual, in phlegmasia, to find the inguinal lymph nodes enlarged and tender. The activity of absorption depends also on the composition of the fluid. "The larger the amount of proteid material the more difficult the absorption; watery solutions of crystalloids are absorbed with a rapidity proportionate to their dilution."* Thus, the exuded fluid of inflammation, owing to the greater amount of proteid which it contains and its higher specific gravity, is absorbed much more slowly than the fluid escaping as the result of mere venous congestion. The œdema is soft and pits deeply on pressure when due to venous obstruction only; it is firmer when caused by inflammation; and it is almost solid when due to obstruction of the lymphatics alone. The character of the œdema, therefore, varies according to which of these factors predominates. The color of the skin also varies, being white in lymphatic œdema, more or less cyanotic in pure venous obstruction, and of a rose tint when the perivascular tissues are inflamed. Occasionally, in phlebitis of the lower limb, the œdema is soft and white in the foot and more elastic and of a redder hue at the root of the limb. Some authors lay great stress upon the influence of the nervous system in the production of œdema. After ligation of the vena cava Ranvier found that, if the sciatic nerve in one limb is divided, œdema occurs in that limb only. Lazarus-Barlow † states that during passive congestion the tissues are deprived of nutriment and the waste products are not removed. This starvation of the tissues leads to arterial congestion and

* Haward, in Lancet, March 10th, 1906. † "Manual of Pathology," 1904.

outpouring of lymph, which, when in excess of that which can be absorbed, leads to œdema. The fluid which leaves the blood-vessels may accumulate, not only in the interstices of the tissues, but also in the cavities of the body—as, for example, ascites from obstruction to the portal vein, and effusion into the knee-joint in phlegmasia alba dolens. In some situations, notably in the intestine, the spleen, and the brain, and in other viscera, sudden occlusion of the veins is followed by hemorrhages, but, in peripheral venous thrombosis, although the escape of a few red cells is not uncommon, actual extravasation of blood is extremely rare.

When a vein is occluded its work must, of course, be carried on by its neighbors, which dilate to carry the additional volume of blood. Such enlarged collaterals, when superficial, constitute an important sign of obstruction to the deeper veins. In the lower extremity they are usually most marked below the knee and in the popliteal space, but it is in thrombosis of the inferior vena cava that the anastomotic circulation is most strikingly developed, the veins emanating from the saphenous opening and coursing up over the abdominal wall sometimes being as large as a finger.

The remaining symptoms of venous occlusion are referable mainly to disturbances of special functions and vary with the region involved. Thrombophlebitis of the lateral sinus may, by pressure in the jugular foramen, cause paralysis of the pneumogastric, glossopharyngeal, and spinal accessory nerves. Epistaxis may be caused by thrombosis of the superior longitudinal sinus. Exophthalmos and œdema of the orbit, and pressure on the branches of the fifth and sixth cranial nerves, may be caused by thrombosis of the cavernous sinus. In addition to œdema and cyanosis of the upper half of the body, and dilatation of the veins over the thorax and abdomen, thrombosis of the superior vena cava may cause epistaxis, headache, vertigo, tinnitus aurium, epiphora, and exophthalmos. Thrombosis of the portal vein may cause hæmatemesis, enterorrhagia, enlargement of the spleen, ascites, progressive marasmus, and sometimes hemorrhagic infarction of the intestine. Thrombosis of the splenic vein may be followed by hemorrhagic infarction and necrosis, or, owing to a vigorous collateral circulation, the spleen may be simply enlarged from passive congestion. Thrombosis of the renal veins may cause hemorrhagic infarction, hæmaturia, and albuminuria, but in many instances the collateral circulation is established and no symptoms are observed during life. Thrombosis of the mesenteric veins gives symptoms identical with those of occlusion of the mesenteric arteries—*i.e.*, sudden intense pain, constipation or bloody diarrhœa, vomiting, which may be fecal or bloody, subnormal temperature, rapid pulse, meteorism, and rigidity of the abdominal muscles.

The viscera being left out of consideration it may be stated that gangrene from thrombosis alone is extremely rare; indeed, many authors believe that it does not occur in the extremities in uncomplicated thrombosis. Cases have been reported, however, in which no other cause than venous thrombosis could be found for the gangrene, and, with a thrombosis sufficiently extensive to involve all the veins of a limb, it is not very difficult to understand how such might occur.

We have mentioned above the possibility of neuritis accompanying phlebitis of the extremities, and this may account for certain symptoms arising during the course of the disease and for some of the sequelæ. There may be motor, sensory, and trophic disturbances. The impotence of the involved extremity is often out of all proportion to the amount of pain and swelling, and may persist after the acute symptoms have subsided. Atrophy of groups of muscles is occasionally seen, particularly in the phlebitic club-foot which assumes the form of equinus or equinovarus, with the toes flexed and rigid. In this deformity the posterior muscles of the leg are wasted and contracted. Verneuil * reported a case in which the deformity appeared three weeks after the beginning of a puerperal phlebitis. Muscular hypertrophy also is occasionally observed. Besides the neuralgic pains to which we have already called attention, sensory disturbances may manifest themselves in the form of anæsthesia or hyperæsthesia of varying degree and extent. Implication of the trophic nerves may be partly responsible for the œdema during the acute stage, and in certain cases it may be wholly responsible for the persisting œdema following phlebitis. Other sequelæ, in the causation of which the trophic nerves may be more or less concerned, are elephantiasis, ulcers, purpura, herpes, and other eruptions. Varicose veins may, of course, be directly traceable to the venous obstruction. Haward states that, after phlegmasia alba dolens, not only the cellular tissue may be increased in quantity, but the bones also may be enlarged from the development of the subperiosteal connective tissue.

In enumerating the foregoing symptoms we have had in mind that form of phlebitis in which the vessel is occluded by an organizing clot—*i.e.*, exudative phlebitis. To these symptoms must be added those of suppuration when the thrombus is liquefied by the action of pyogenic bacteria. In such cases—*i.e.*, in suppurative phlebitis—the external wound, when such exists, may give rise to a thin pus and be surrounded by a spreading cellulitis, or it may be dry and only slightly inflamed. In either event red lines of lymphangitis may be seen running to the nearest lymph nodes, which are swollen and tender or even suppurating. In these cases the thrombus is softened and is either washed away as emboli (pyæmia), or forms a localized abscess, which, after being opened, discharges a thick, creamy pus, or a mixture of pus and blood. If that portion of the thrombus which lies next to the circulating blood is not hard and firmly adherent, secondary hemorrhage may follow. In some instances a number of abscesses form along the course of the vein at varying intervals, the thrombus between remaining solid.

The general symptoms, when present, are those of septic intoxication, septicæmia, or pyæmia. Fever is generally in evidence when the surgeon's attention is called to the phlebitis and sometimes for several days before external manifestations of the disease are apparent. In the milder forms the rise of temperature is not over a degree or two, and falls in the course of a few hours or days to normal. Occasionally the fever is intermittent, the rises corresponding to the invasion of successive segments of the vein or additional veins. Suppura-

* Comptes rendus de l'Acad. des Sc , March 31st, 1890.

tive phlebitis is frequently inaugurated by a chill, the temperature rising to 103° or 104° F., or higher, and the fever persists, being less in the morning and greater in the evening. In many cases there are violent irregular rises and falls of the temperature, characterized by severe chills and drenching sweats. The pulse increases in frequency, sometimes proportionately to the fever, sometimes without fever. Mahler lays great stress on a step-like increase in the pulse-rate, without fever, in diagnosticating beginning phlebitis, particularly of the pelvic veins after labor or abdominal operations. "In a typical case the pulse ascends while the temperature remains absolutely normal. The ascension continues while the temperature moves in the old path. If œdema appears, if a thrombotic string is palpable, or if pulmonary symptoms supervene, the pulse-rate reaches its highest point, and among other things the temperature rises at the same time. But, although the temperature falls in the next few hours, the pulse remains high."* Although the Mahler phenomenon is not always present, an increase in the pulse-rate, for which no other cause can be found, should make one consider very seriously the possibility of a latent or beginning phlebitis.

Other symptoms commonly associated with fever and due to interference with the secretions,—*e.g.*, dry mouth, coated tongue, digestive disturbances, constipation, scanty urine, etc.,—are present according to the degree and duration of the pyrexia. Pulmonary symptoms arising in the course of a phlebitis, although possibly due to other causes, are most likely to result from embolism. (See the section on Pulmonary Embolism.) Hebetude, stupor, restlessness, delirium, and like nervous phenomena are encountered only in the severer forms of suppurative phlebitis, in which there may be also hæmatogenous jaundice, enlargement of the liver and spleen, petechiæ in the skin and mucous membranes, or eruptions simulating urticaria, measles, or scarlet fever, and finally, owing to the detachment of septic emboli, metastatic abscesses in the lungs, bones, brain, spleen, kidney, and other parts.

Diagnosis.—Phlebitis is readily recognized by the local signs when the inflamed vein is superficial. It is not likely to be mistaken for lymphangitis, in which the redness is much more marked and the cord-like induration less pronounced; but the frequent coexistence of the two affections should be borne in mind. When, however, the vein is deeply situated, the diagnosis may be difficult or impossible, particularly in the beginning. Possibly in some of these cases Mahler's symptom may be of value. In some instances it is only after the inflammation has extended to the surface along anastomosing vessels that the condition is recognized. In others the occurrence of embolic pulmonary phenomena first suggests the possibility of phlebitis. In certain veins—*e.g.*, inferior vena cava and portal vein—the development of a collateral circulation is the most important sign. After labor or operation, or during the progress of diseases which predispose to inflammation of the veins, pain and swelling of the leg, in the absence of other causes, must be interpreted as due to phlebitis. Sometimes the general symptoms, when associated with a local lesion from which a vein might be infected, direct attention to the affected vein. Thus, in the presence

* Mahler: "Arbeiten aus der Koeniglichen Frauenklinik in Dresden," 1905.

of the general symptoms of septicæmia, with a discharging ear, the most likely cause would be thrombosis of the lateral sinus. A carbuncle of the lip, with exophthalmos and other eye symptoms, would strongly suggest infective phlebitis of the cavernous sinus. Symptoms of peritonitis with bloody diarrhœa, in the absence of injury, should always make one think of thrombosis or embolism of the mesenteric vessels. Cyanosis of the upper half of the body is perhaps the most striking symptom of thrombosis of the superior vena cava.

Prognosis.—The prognosis of phlebitis varies with its nature and situation. Exudative phlebitis of the extremities, after a stationary period or a series of exacerbations characterized by recurrence of the pain, fever, and œdema, generally subsides in the course of a few weeks, leaving the vein or veins obliterated. Consequently, persistent œdema and heaviness of the limb or the development of varicose veins are not infrequent sequelæ; in fact, return to the normal, after an extensive phlebitis of the lower extremity, is the exception. The sensory, motor, and trophic disturbances, which are for the most part rare, but which may persist for months or years, have been sufficiently emphasized above. Aside from involvement of the visceral veins, in which cases death sometimes follows from simple blocking of the circulation, adhesive (exudative) phlebitis can cause death only by embolism. Some statistics relative to this accident will be found in the section on Pulmonary Embolism.

Suppurative phlebitis is a much more grave affair. The patient may die from septic intoxication before the local signs are well advanced, or he may succumb at a later period as the result of pyæmia. For further details and percentage rates of death the reader is referred to the articles in which infective phlebitis of special regions is treated.

Treatment.—The prophylactic treatment of phlebitis occurring after operation has been described in the section on Pulmonary Embolism. Here we may add that, owing to the infective nature of phlebitis, whatever measures are taken to prevent or subdue infection in the tissues, are to be regarded as acting in a prophylactic manner toward inflammatory venous processes. The proper treatment of otitis media and mastoiditis prevents lateral sinus thrombosis; and the same is true with regard to other infective lesions about the head and face in their relation to the other sinuses. We must mention particularly carbuncle of the lip, which even surgeons, owing to the disfigurement produced by free incision or excision, are prone to dally with until the inflammation extends along the facial vein to the orbit and thence to the cavernous sinus. The prompt draining of suppurating areas, the antiseptic treatment of wounds, particularly compound fractures, the promptness with which the surgeon attacks intra-abdominal infections, and the careful precautions taken by the modern obstetrician to prevent the entrance of micro-organisms into the genital tract during or after labor, have enormously reduced the frequency of phlebitis.

In exudative phlebitis of the extremities the first indication is to keep the limb absolutely quiet, in order to lessen the chances of embolism. Sudden movements, particularly those involving flexion of the joints, are dangerous.

In many instances of phlebitis of the lower limb embolism has followed sitting up in bed, which necessitates acute bending of the femoral vein at the groin. The limb should be placed upon a splint in full extension and slightly elevated, thus lessening the amount of blood pumped into the extremity and favoring drainage from it. The part may be covered with cotton wadding, in order to protect it from injury. Cataplasms of kaolin, lead water and laudanum, and extract of witch hazel, or ointments containing ichthyol, belladonna, or mercury, may be applied, and at a later period the skin over the affected vein may be painted with iodine. Inunctions, however, and massage are exceedingly perilous at this time, and local medicaments must be laid on, not rubbed in. Bandages should never be tight but only firm enough to maintain the dressings in place. The most dangerous time, that in which embolism is most likely to occur, is the period covered by the second, third, and fourth weeks, but sitting up and walking are not safe until after six weeks have elapsed from the beginning of the process or from the beginning of the last exacerbation. The administration of drugs to diminish the coagulability of the blood, which has been advised by certain physicians to prevent the extension of the clot, does not commend itself to our judgment, as we fear that such drugs, if possessed of anticoagulative properties, might possibly render the already existing clot less firm. In discussing thrombosis we have given a list of the various substances which may hasten or retard the clotting of blood. The secretions should, of course, receive attention, and any constitutional malady, such as gout or rheumatism, should be treated with appropriate remedies. Sedatives may be needed for pain, and occasionally cardiac stimulants when the circulation is weak. Witzel believes that the maintenance of the strength of the circulation is the most important measure in preventing extension of the thrombus. An active circulation not only encourages "embolia insensibilis" and causes the thrombus to remain short, but also lessens the danger of infarction of the lung if a medium-sized embolus is detached. When the patient begins to walk an elastic bandage or stocking should be worn, to prevent excessive œdema and to encourage the development of the deeper veins by keeping the superficial ones empty. Massage is not safe until two or three months have elapsed, when it becomes a measure of great value. The treatment of the sequelæ (ulcers, varix, etc.) is fully given in other portions of the work. About the only forms of non-suppurative phlebitis in which operation is indicated are inflamed external hemorrhoids and thrombosis of the mesenteric veins. The former require incision and evacuation, or excision; the latter demands exploratory laparotomy and, when possible, excision of gangrenous intestine. Brunner* states that, of thirty-two operations for mesenteric thrombosis, two were successful.

Suppurative phlebitis should, when possible, be treated by excision, a procedure which was first suggested by Klebs. In other cases the vein should be opened and disinfected, after a ligature has been placed about it between the area of inflammation and the heart, in order to prevent pyæmia. Thus, in infective thrombosis of the lateral sinus, the internal jugular vein should be tied

* Deutsche Zeitschrift f. Chir., lxxxix., No. 6.

and the sinus opened, evacuated, and packed with gauze. The same principle has been suggested in the treatment of suppurative phlebitis of the portal vein. Trendelenburg has recently urged ligation of the internal iliac veins in puerperal sepsis. In 43 fatal cases he found thrombosis of the uterine and ovarian veins in 21, while Grossman found the same condition in 27 of 51 autopsies.* The general treatment of suppurative phlebitis is that of septicæmia or pyæmia. (See Vol. I.)

Chronic phlebitis is a term sometimes applied to the terminal stages of a protracted acute exudative inflammation of a vein or to the results of this inflammation—*i.e.*, sclerosis and obliteration of the vessel. Chronic inflammation and thickening of the venous walls without thrombosis is seen as the result of prolonged overdistention—*e.g.*, in varices and other forms of obstruction. A chronic phleboselerosis, which, like arteriosclerosis, may be widespread, is said to be caused by conditions like syphilis, gout, alcoholism, and lead poisoning. In syphilis, particularly of parenchymatous organs, the walls of the veins may be infiltrated with miliary gummata.

Tuberculous phlebitis resembles ordinary phlebitis, but when a vein is in the midst of caseating tissue, especially in the lung, kidney, and lymph nodes, its walls may undergo caseous degeneration.†

VIII. VARICOSE VEINS.

Varix (varicose veins, phlebectasia) is an elongated, permanently dilated vein with thickened walls. Simple dilatation of a vein does not constitute varix; the walls must be thickened.

Varicose veins may be found in any portion of the body, even in bone (according to Cornil and Ranvier). The condition is most frequently seen in the internal and external saphenous veins of the leg, and it is with the affection in this situation that we shall deal at the present time; other manifestations of this abnormality, such as hemorrhoids, varicocele, varix of the broad ligament and of the œsophagus, etc., being discussed in other sections of the work.

Etiology.—*Age.*—Varices are extremely uncommon in infancy and, when observed at this period of life, are usually congenital. Cases of this sort have been reported by Petit, Voiturier, Fournol, and Bousquet. It is worthy of note that congenital varices are most frequent in the upper extremity and are generally unilateral, although Lessar and Koenig describe congenital varices of the leg, Velker of the facial, and Bird and Bennett of the jugular.‡ It is probable that, although first giving trouble in middle life, many varices really begin in youth, owing to what, for want of a better term, we may call the varicose predisposition. It is not unusual to see varicose veins of the leg, associated with varicocele and hemorrhoids, develop without any definite cause. Statistics show that the abnormality begins to attract attention between the twentieth and thirtieth

* Annals of Surgery, Feb., 1907, p. 204. † Cornil et Ranvier, 1907, tome iii.

‡ Bouglé: "Chir. des artères, veines, lymphatiques et nerfs," Paris, 1901.

years, becoming more frequent with increase in age. In an examination of 917 individuals Sistach found 1.4 per cent, between 20 and 30 years of age, suffering with varix; 4.6 per cent, between 30 and 40 years; and 6.6 per cent, above 40 years.* In dispensary practice about 1 per cent are under 20 years, 20 per cent between 20 and 30 years, 25 per cent between 30 and 40 years, and 54 per cent over 40 years.

Sex.—According to Briquet varices are three times more frequent in men than in women. Most authors, however, assert that women are more often affected, owing to the influence of pregnancy. In our own experience about 60 per cent are women.

Heredity and other Conditions.—The influence of heredity is admitted by most observers. We have in mind one family in which both parents have varix of the leg; two children have hemorrhoids, varicocele, and varix of the leg; three other children have varix of the leg. Verneuil and others believe that rheumatism is a factor in some cases. Of 118 patients with varix, Moreau found 55 exhibiting some manifestations of articular rheumatism and 24 with rheumatic parents. Neuritis and certain other nervous affections are said to favor, in some instances, varix, owing to paralysis of the vaso-constrictors. Finally, chronic phlebitis from any cause may be followed by dilatation and elongation of the affected vein.

Occupation.—Any occupation which necessitates prolonged standing predisposes to varices—*e.g.*, that of porter, laundress, cook, compositor, salesman, etc. Prolonged standing in one position is much more influential in producing varices than walking, as in the former the blood in the extremities not only has to travel vertically upward, but also is largely carried by the superficial veins, owing to the compression of the deep veins by the tonic contraction of the muscles necessary to maintain the upright posture. In walking, the muscular contractions are intermittent and assist rather than retard the venous circulation.

Obstruction to the Venous Flow.—In addition to prolonged standing, the venous circulation may be retarded by cardiac or pulmonary disease, by tumors, cicatrices and enlarged lymph nodes, by a pregnant or displaced uterus, by the use of abdominal belts, by the wearing of corsets, by the pressure of a truss for hernia, by garters, etc. In pregnancy varices generally appear toward the middle of term, but occasionally at the end of the first month, when pressure cannot be incriminated as a cause. Varices are said to be due to a reflex trophic disturbance.

Compensatory Dilatation.—When the deep veins are blocked from thrombophlebitis or other cause the superficial veins must dilate to carry the blood back to the heart, and in such instances they may become varicose in nature. An abnormal opening between an artery and vein, such as exists in aneurysmal varix, causes a dilatation and thickening of the veins. The veins are said to "arterialize."

The cause of varix is not always distinct and positive; rather is it, in many instances, of a complex nature. Undoubtedly hereditary or acquired (through

* Duplay et Reclus.

phlebitis) weakness of the walls of the veins is the prime factor in a certain number of cases, but in the majority the condition is inaugurated by mechanical causes which retard or obstruct the return flow of blood from the extremities. Hence the frequency of varix in the most badly drained portion of the body—the lower extremities. No matter what the initial cause of the retardation or obstruction may be, the small superficial branches into which the perforating veins of the leg empty bear the greatest strain, as it is here that the back pressure in the superficial veins meets the forward pressure induced by muscular contractions on the perforating veins. These perforating branches are most numerous in the middle and lower third of the leg, but as those in the middle of the leg are, unlike those in the lower third, surrounded by muscle, the small superficial veins in the middle third are, according to our observation, usually the first to dilate, the process then extending to the larger branches, both deep and superficial. Following the dictum of Verneuil, however, many writers state that the disease always begins in the deep veins and is then propagated along the perforating branches to the superficial veins.

Anatomists describe three forms of perforating or anastomosing veins in the lower extremity: those which have no valves and in which the blood may run in either direction; those in which the valves direct the blood toward the periphery: and those which direct the blood to the deep veins. According to Houze and Le Dentu * the blood in the foot normally flows from the deep to the superficial veins, while in the leg and thigh the current is in the opposite direction. From this fact certain authors conclude that, when the veins of the feet are first involved, the process has begun in the deep veins. However this may be, the dilatation once produced renders the valves incompetent, and the consequent high pressure in the vein, together with the stasis in the vasa vasorum, induces a chronic inflammation and thickening of the walls of the vessel. With incompetent valves the walls of the saphenous vein must support a column of blood reaching to the heart, the pressure of which column is augmented by every effort made by the patient. Thus, coughing, straining, etc., cause a sudden increase in the distention of the vein, and even the swing of the leg in walking acts like a centrifuge in driving the blood toward the periphery. Trendelenburg, to whom particularly is due the credit for pointing out the importance of valvular insufficiency, demonstrates this condition as follows:—The patient is placed in the recumbent posture and the limb elevated, in order to empty it of blood. The internal saphenous vein is then compressed in the upper part and the patient asked to stand. The vein remains empty and does not fill from below upward as it should do normally, but when the compression at its upper part is removed it promptly and completely distends from above downward; in other words, the circulation in it is reversed. If, while the patient is in the semi-reclining posture, the limb is elevated, the blood in the vein extends only as far as a level corresponding to that of the heart. Chevrier † states that, if the varices fill very slowly from below upward in the Trendelenburg test, the

* Terrier and Alglave, in Revue de chir., June, 1906.

† Archives générales de chir., Jan. 11th, 1908.

valves of the branches connecting the superficial with the deep communicating veins are normal; but that, if they fill rapidly, the same valves are incompetent. This he calls the ascending reflux in contradistinction to the descending reflux of Trendelenburg. Valvular inadequacy may be demonstrated likewise by percussing the vein at its upper part, when a wave can be felt at a lower level (Schwartz's sign). Delbet demonstrated the increase of pressure in a varicose internal saphenous vein by means of a cannula introduced into the central end of the vein and connected with a mercurial manometer. Instead of being negative the pressure was 16 mm. with the patient recumbent, and it rose as high as 26 mm. when he stood up and strained.

Pathology.—Varicose veins are not only dilated but also thickened and lengthened, and, owing to the elongation, they are tortuous, sometimes so much so that the vein is doubled upon itself in numerous places for a considerable distance. At the onset the dilatation is uniform, but later it becomes irregular, being in some parts fusiform or cylindrical and in others sacculated. This irregularity in distention is due to the irregularity in the thickness of the walls of the vessel. Thus the walls may be extremely thick in certain sections and so thin as to break in others. The morbid process extends likewise to the valves, which are deformed and incompetent. According to Cornil the thickening of the walls of the vein in the beginning is due to hypertrophy of the middle coat, as the result of an increase in the muscular fibres and the connective tissue. Later, the connective tissue predominates and the wall becomes sclerosed, sometimes yielding in places and becoming extremely thin. The vasa vasorum are greatly dilated and themselves become varicosed, frequently rupturing and causing minute ecchymoid spots beneath or in the skin. Occasionally calcareous deposits are found in the fibrous tissue of which the vessel-wall is finally almost entirely composed. In a word, the changes are those of chronic phlebitis, which may, however, become subacute or acute and, by extension to the intima, give rise to thrombosis with its consequences. We have already directed attention to the occurrence of phleboliths, which are the result of the deposition of lime salts in thrombi, and which are often found, sometimes free and sometimes adherent, in varicose veins.

The inflammation does not limit itself to the vessel but spreads to the surrounding connective tissue (periphlebitis), the embryonic cells finally being transformed into fibrous tissue. Hence the vein becomes fixed, not only to the surrounding tissues but also to itself at the flexures, so that even after removal it may be necessary to sever a number of fibrous bands in order to straighten the vessel.

The remaining tissues of the affected part likewise may suffer alterations of varying degree. The lymph vessels may be involved and further contribute to the œdema, which then becomes harder in character and pits less readily on pressure. The arteries may undergo changes similar to those of the veins and even become blocked with thrombi or infiltrated with lime salts. The nerves, according to Quénu, may be the seat of an interstitial inflammation, not only in the immediate neighborhood of ulcers, but also at a distance,—*e.g.*, in the

thigh, where the surrounding connective tissue is normal. The muscles may show evidences of interstitial inflammation or more often fatty degeneration. The bones in the vicinity of ulcers may become carious, but more commonly there is an osteoperiostitis with overproduction of bone. Occasionally the ossification spreads from the bone along the fibrous intermuscular septa and aponeuroses. The skin is dry, wrinkled, scaly, in places white, and in others markedly pigmented, or not infrequently smooth, erythematous, eczematous, or ulcerated. The corium presents all the signs of an irritative chronic inflammation; between the fibrous fasciculi are found embryonic cells and the elastic tissue is sometimes hypertrophied. The sebaceous and sweat glands and the hair follicles are usually atrophied. The papillæ are sclerosed and atrophied, rarely elongated and hypertrophied. The epidermis is usually thickened.

Symptoms.—Varices are generally insidious in their development, but their progress is influenced very largely by the care which is given them, by the general health of the patient, by the coexistence of cardiac or pulmonary disease, and by the lesion to which they owe their origin. In conditions like arteriovenous aneurysm and pregnancy, varices develop quickly and are likely to subside when the cause ceases to exist, although the veins, if distended for a long period, are weakened, and the condition is prone to recur in a more pronounced form with renewal of the cause. Thus, a varix which may have disappeared after the first confinement reappears in increased volume and persists after repeated pregnancies.

Although, as we have already mentioned, varices begin most frequently in the small superficial veins of the middle of the leg they may first be noticed in the minute veins of the foot, about the malleoli or the knee, or in the neighborhood of the great trochanter. The veins are bluish or rose-colored and arranged like "stars or comets," *i.e.*, several veins radiate from one spot, or one or more trail in a more or less straight direction beneath or in the skin. In some instances the large trunks of the leg or thigh are first involved. Verneuil maintained that varix invariably begins in the deep veins, usually the post-tibial and peroneal. However this may be, in a well-advanced case most of the veins, both superficial and deep, are more or less involved in the process. Yet there are certain cases in which the affection remains strictly confined to a group of veins. Limited varices of this character most frequently involve the branches of the internal saphenous in the lower third of the thigh and at the saphenous opening, points where, as Terrier and Alglave point out, the largest perforating branches are found. (Figs. 104 and 105.) Although both extremities are involved in about seventy per cent of the cases, even in these the left is the more affected. Involvement of the right leg alone occurs in about ten per cent and of the left alone in about twenty per cent of the cases. The reasons for the predisposition of the left over the right side are similar to those given for the prevalence of thrombosis on the left side.

When varix begins in the deep veins, the diagnosis can only be suspected until the superficial veins dilate. The patient complains of a sensation of heaviness and fulness in the region of the calf after prolonged walking or standing, at which

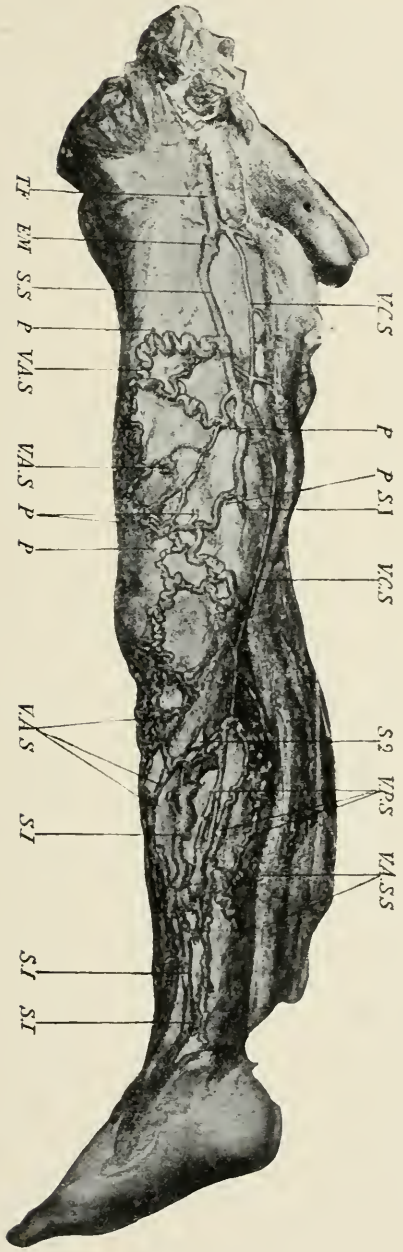

Fig. 104.

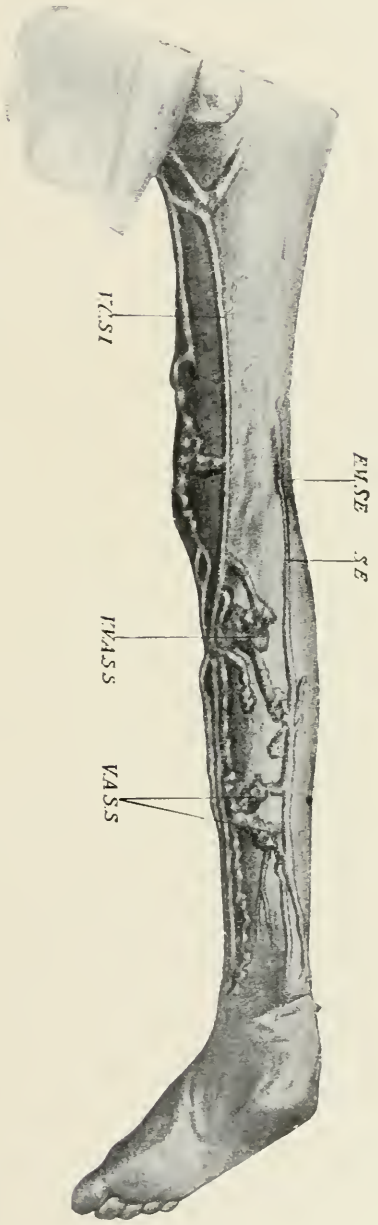

Fig. 105.

Figs. 104 and 105.—Dissection of a Case of Varix of the Lower Extremity. (Terrier et Alglave, *Revue de Chirurgie.*)

Fig. 104.—Inner Aspect of the limb. *T.F.*, Femoral vein; *E.M.*, ampullar dilatation of the saphenous at its junction with the femoral; *S.S.*, superior segment of the internal saphenous which has been resected between the points S_1 and S_2; *V.A.S.*, varices permitting blood to flow from the varicose veins of the leg to the superior segment of the internal saphenous; *S.I.*, inferior segment; *V.C.S.*, newly formed collateral, *V.P.S.*, posterior varices of the internal saphenous; *V.A.S.S.*, anastomotic veins between the internal and external saphenous veins; *P.P.*, perforating veins.

Fig. 105.—Posterior View. *V.C.S.I.*, Newly formed collateral; *V.V.A.S.S.*, anastomotic branches uniting the two saphenous veins; *S.E.*, external saphenous, *E.M S.E.*, upper end of external saphenous.

time there may be slight œdema about the ankle or over the lower end of the tibia, and a slight fulness of the calf appreciable on palpation. Sometimes there are cramps in the calf muscles or a tingling, prickling, or itching sensation in the skin, and occasionally pain in the sole of the foot; these symptoms disappear after lying down or elevating the leg. Pigmentary discoloration of the skin, minute furuncles, eczema, and other skin diseases, and marked increase in the secretion of sweat are other signs which are mentioned as occurring in deep varicosities. (Verneuil.*)

Deep varices occasionally reveal themselves during violent contraction of the calf muscles by rupture ("*coup de fouet*"), the symptoms of which we shall give farther on.

Varices of the minute veins of the skin present the appearance noted above. The changes in the subcutaneous veins—dilatation (cylindrical, fusiform, sacculated), elongation, tortuosity, alteration of the walls—can be both seen and felt in the later stages. The veins may appear bluish through the skin or the color may be obscured by a blackish or brownish discoloration of the skin. After the veins have been emptied they may still be felt as thickened bands beneath the skin. In the region of saccular dilatations, which are soft, fluctuating, and reducible, the vein wall and the skin may be extremely thin. The increase in the venous pressure caused by coughing, straining, and like efforts is best seen in such sacculations. The signs of incompetence of the valves we have already mentioned. The entire limb is enlarged, heavy, and often painful, particularly after prolonged standing.

In certain cases there is intense neuralgic pain along the sciatic or other nerves, due perhaps to a neuritis, or—as suggested by Quénu—to a varicose condition of the intraneural veins. Alterations in the nerves may be responsible also for the trophic disturbances which are sometimes observed, viz., thickening, striation, and incurvation of the nails, local sweating, lowered temperature (the affected limb sometimes being a degree or more below its fellow), muscular degeneration, and probably many of the skin diseases. Richet states that sensation to touch is diminished while that of pain is increased.

Complications.—Rupture may involve either the deep or the superficial veins. Rupture of the former generally occurs during violent contraction of the calf muscles. There is a sudden severe pain like the sting of a whip, "*coup de fouet*," which is followed by swelling and tenderness of the leg and difficulty in walking. After several days the blood makes its way to the surface and appears as an ecchymosis, particularly on the posterior surface of the leg. This accident was once thought to be due, not to the rupture of a deep varicose vein but to rupture of the plantaris. Rupture of a deep vein in other portions of the lower extremity likewise causes pain, swelling, and late ecchymosis. Occasionally there is formed a large hæmatoma, which may undergo absorption, inspissation and calcification, result in a cyst, or become infected and suppurate. A superficial varix may burst at a point where, owing to a saccular dilatation, the skin and vein wall are extremely thin. This accident may follow coughing,

* Quoted by Quénu, Duplay et Reclus, tome ii.

straining, or similar effort which suddenly raises the intravenous pressure; it may be caused by an injury; or it may occur spontaneously. The vein may be opened likewise by a wound or by ulceration. The hemorrhage is much more copious than after a wound of a normal vein, owing to the insufficiency of the valves and the gaping of the vein as the result of the thickening of its walls. Furthermore, when the valves are incompetent the bleeding is more profuse from the central end of the vein. When a large vein is opened the blood spurts from the wound, sometimes, according to Bouglé, with systolic reinforcements, and this accident may, if proper treatment is not promptly applied, be followed by death.

Thrombo-phlebitis is more apt to occur in varicose veins, owing to the stasis and the alteration in the walls of the vessels. This form of inflammation may be caused by an injury or may complicate one of the infectious or cachexic diseases already noted under Thrombosis, but is most frequently due to the entrance of micro-organisms through a scratch, a patch of eczema, an ulcer, or like lesion. In former years puerperal infection was a prolific cause. We do not, however, wish to convey the impression that all cases are due to infection; undoubtedly in some instances the process is sterile in nature. The usual symptoms of thrombo-phlebitis are in evidence, the extent and nature of the process varying with its cause. In the most frequent form a segment of the internal saphenous or a packet of varicose veins is involved, and the trouble generally remains localized, although extension upward along the superficial veins—or, much more frequently, when a convenient anastomosing branch is present, extension to the deep veins—may occur. In the last instance there is deep pain, sometimes crampy in character, with tenderness and swelling of the muscles, and œdema below the affected part. This group of symptoms is usually observed in the calf of the leg and often renders walking difficult or impossible. Embolism is less common than in thrombosis of non-varicosed veins, since in many instances the blood-current in the former is reversed and flows toward the periphery.

The phlebitis is usually of the exudative variety and ends in organization of the thrombus and obliteration of the vein. A localized varix may thus be cured, and, in an extensive varix, a properly situated thrombus may have the same effects as the Trendelenburg operation.

Suppurative phlebitis gives the symptoms which we have enumerated under this heading, the most dangerous feature being the possibility of pyæmia, although, for the reason mentioned above, the process is more apt to remain localized than in non-varicosed veins. When the inflammation is accentuated about the vein, lymphangitis is a frequent and serious complication, the simultaneous obstruction of the blood and lymphatic vessels markedly augmenting the swelling.

Ulceration is the most frequent complication of varix. The ulcer or ulcers are almost invariably situated on the inner surface of the middle or more frequently the lower third of the leg. Ulceration may follow the rupture of an ampullar dilatation of a vein or the bursting of a perivenous abscess, or it may

begin in a scratch, abrasion, or spot of eczema. In other instances the ulcer apparently begins spontaneously as a minute dot of necrosis, probably the result of capillary stasis and thrombosis, owing to the fact that the venous blood-pressure equalizes that in the arteries. The ulcer once inaugurated gradually increases in size, frequently involving a third, sometimes a half, and occasionally the whole of the circumference of the leg. This tendency to ulceration is due to malnutrition of the tissues of the leg as the result of poor circulation. Not only is there a tendency to stasis in the veins, but there may be in addition arterial disease and not infrequently an associated cardiac lesion. Neuritis also, when it exists, must be considered as a factor in the production and propagation of the ulceration. Alcoholism, syphilis, Bright's disease—in a word, any condition which lowers the resistance of the tissues—may be present in those with varicose veins and lend assistance to the progress of ulceration. For a description of the appearances of varicose ulcers the reader is referred to the article on "Ulceration" in Vol. II. The appearance of the ulcer itself, however, is not always typical, particularly in syphilities; it is here hybrid in nature and from inspection alone may be difficult to diagnosticate. To add to the difficulty the larger veins may not be markedly dilated; indeed, ulcers are more frequent in those with involvement of the smaller superficial veins. The ulcer is not always single but may have one or more smaller neighbors and sometimes whitish or pigmented areas near it, representing ancient healed areas of ulceration.

Eczema and like skin lesions are more frequently found in the neighborhood of ulcers than elsewhere, as is also a diminution in the sensibility of the skin. The ulcer itself, however, is not infrequently hyperæsthetic and the seat of severe pain. Enormous hypertrophy of the extremity with thick corrugated skin, the so-called pseudo-elephantiasis, is most often seen in those with large ulcers. A varicose ulcer is of course a possible starting-point for infectious complications like erysipelas, lymphangitis, and phlebitis, and may cause thickening of the underlying bone or even caries.

Club-foot due to the muscular changes consequent on inflammation or neuritis is a possible but rare complication. The usual deformity is equinovarus with flexion of the toes, much like the club-foot of phlebitis.

Prognosis.—Varicose veins of the extremities tend to progress and, with the few exceptions noted above, never disappear without treatment. Death can follow only from complications, which have been sufficiently emphasized above.

Diagnosis.—Superficial varices are easily recognized. At the saphenous opening, however, the affection may be mistaken for a femoral hernia, as both are reducible and both have an impulse on coughing. A hernia is reduced with a gurgle, which is unlike the thrill sometimes felt in reducing a saphenous varix; this thrill resembles the sensation imparted to the hand when fluid is expressed from a bulb syringe. A varix reappears from below upward, even when the finger blocks the femoral canal; furthermore, there are probably varices in the neighborhood. Symptoms similar to those caused by deep varices may be due to many causes—popliteal growths, lithæmia, sciatica, etc. A most careful

examination, both general and local, is therefore required in such cases. Perhaps the most important sign in deep varices is marked amelioration or disappearance of the symptoms when the patient lies down.

Treatment.—The treatment may be non-operative or operative.

Non-operative Treatment.—Non-operative treatment consists in removal of the cause if possible, gentle massage, the application of an elastic stocking or bandage, attention to the general health, including any complicating cardiac affection, and the relief of constipation. Any form of dress which unduly compresses the abdomen (such as a tight belt or corset) or the limb (such as a circular garter) should be discarded. Prolonged standing is to be avoided, although a moderate amount of walking is to be encouraged. While sitting the patient should, whenever possible, elevate the feet at least as high as a level corresponding to that of the heart. In the absence of eczema and phlebitis centripetal massage is a measure of some value, but should never be harsh because of the danger of irritating the skin. A localized varix without symptoms requires no elastic compression, but is better left to itself. When, however, there are evidences of extensive involvement of the veins compression of some form should be applied. Stockings made of a mixture of rubber and silk, having the toes and heel exposed and reaching to the knee, are the best for most patients. When it is necessary to include the thigh the stockings are difficult to maintain in place without a band about the waist. Flannel bandages and those made of elastic webbing (*e.g.*, the Randolph bandage) are cheaper and cleaner, being washable, but they require a little more trouble to adjust, and hence are often neglected by patients provided with them. The compression should be removed on retiring, when the limbs may be rubbed with alcohol, and replaced after the morning bath, at which time the limb is dusted with some bland powder like stearate of zinc.

If superficial varices depend upon obstruction or obliteration of the deep veins elastic compression may augment rather than diminish the circulatory troubles. In grave cardiac lesions the increase in blood-pressure consequent upon elastic compression may seriously interfere with cardiac action. In such cases the patient should be put to bed for a time and then very moderate compression made, in order, in the first instance, to encourage the establishment of a deep collateral circulation, and, in the next place, to accustom the heart gradually to the changes in the blood-pressure.

Operative Treatment.—Operative treatment has been practised in many different ways. Herapath (1843) incised the saphenous opening, and the fibrous ring in the popliteal space through which the external saphenous passes, believing that varix was the result of strangulation at these points. Other ancient methods, according to Bouglé, were simple transverse section of the vein (Brodie, Velpeau), subcutaneous section (Brodie, Guérin), ligature in mass of the vein and overlying skin (Chaumatte, 1627), ligature of the vein, the ligature being tied over a pad or a pin on the skin (Travers, 1822), subcutaneous ligation (Gagnebé, 1830), cauterization (Celsus, Paré, and others), galvano-puncture (Clavel, 1837), the seton (Velpeau, 1835), acupressure (Franc, 1835), serres-fines

(Vidal de Cassis), and denudation of the vein so that it might become gangrenous (Rigaud, 1875). The intravenous injection of substances like Monsel's solution, tannic acid, etc., was in favor, particularly in France, from 1853 until recently, despite the dangers of extension of the inflammation and embolism, and even at the present time it still has some advocates. Tavel* suggests that, if thrombosis does not follow the Trendelenburg operation, a syringe be put in the vein, some of the blood drawn out, and from one to three Pravaz syringefuls of carbolic-acid solution (5 per cent) injected. Perivenous injections of alcohol, ergotin, etc., were used by Broca and others, to induce indirectly an adhesive phlebitis. The only operations which are worthy of consideration at the present day are ligation, section between ligatures, and resection (partial or total) through an open incision.

Ligation, Section between Ligatures, and Partial Resection.—Ligation through an open incision was practised by Paré (1561), Dionis (1714), Home (1797), and others. Caius Marius had his varices resected by a surgeon whose name history fails to transmit to us. Extirpation of painful, inflamed, or giant varicosities was performed likewise by Celsus, Galen, Petit, and others. Owing to the frequency of phlebitis and purulent infection, however, these methods were avoided by conservative surgeons until the advent of antisepsis. Others sought to minimize the danger by the methods mentioned above. From 1875 onward ligation or partial resection was practised with increasing frequency at various situations, but particularly just above or just below the knee. It was not, however, until 1890 that Trendelenburg set forth the importance of valvular incompetence and recommended section of the internal saphenous between two ligatures at the junction of the middle and inferior thirds of the thigh, in order to break the long column of blood which the veins of the leg were forced to support. In 1895 Trendelenburg modified his original technique by ligating and severing the vein in three places, viz., at the middle of the thigh and above and below the internal condyle. Other operators have further modified the operation in various ways, generally by adding to or subtracting from the number of ligatures and by resecting varying lengths of the vein. Schede, Moreschi, and others encircle the leg with an incision, usually at the junction of the upper and middle thirds, sever all visible veins between ligatures, and suture the skin. Friedel† makes a spiral incision, beginning just below the knee, which encircles the leg five times and ends on the dorsum of the foot; all visible veins are tied and the wound is left open, to drain away lymph, particularly when there is a tendency to swelling or elephantiasis. Schwartz's method,‡ which is employed by many surgeons, and a description of which will serve to indicate the usual technique of these operations, is as follows:—After the customary antiseptic precautions have been taken, a tube is applied circularly about the root of the thigh. If one intends to remove large varicose packets, necessitating a long and painful dissection, a general anæsthetic should be employed; if the operation

* Korrespondenzblatt f. Schweizer Aerzte, 1904, No. 19.

† Langenbeck's Archiv, Bd. lxxxvi., Heft 1.

‡ "Traité de chirurgie" de Le Dentu et Delbet, t. iv.

consists merely of the application of multiple ligatures, a solution of cocaine, one per cent, is used. If there are simply masses of varicose veins in the leg or on the inner side of the knee, without dilatation of the saphenous vein in the thigh, these are extirpated widely, catgut ligatures being employed above and below and all collateral branches receiving ligatures. If, with the varicose tumors, the internal saphenous vein in the thigh is dilated, the tumors are removed and in addition the internal saphenous is ligated at several points; the latter alone is done in varix without large or painful varicose tumors. Four ligatures are generally used, sometimes five—three in the thigh and one or two in the leg. The vein is uncovered for a distance of four or five centimetres and carefully isolated; the collaterals are ligated; the saphenous itself is tied with catgut at each end of the incision, and the intervening portion is removed; and, finally, the skin is sutured with silkworm gut without drainage. Phelps ties the vein in thirty or forty places.

Total Resection of the Internal Saphenous.—Total resection of the internal saphenous was probably first practised by Ricard in 1903, although extensive resections were done by many surgeons before this time. Terrier and Alglave,* who have recently insisted that, in suitable cases, as much as possible of the internal and external saphenous veins (one or both) should be resected, describe their technique as follows: For resection of the internal saphenous an incision is made from the saphenous opening to the posterior border of the internal condyle of the femur, and, after the vein in this situation is resected and the wound sutured, the incision is continued to the anterior border of the internal malleolus. When there is an ulcer the incision is arrested immediately above it. The internal saphenous is ligated at the saphenous opening at the beginning of the operation, thus preventing the possibility of embolism from any lower segment of the vessel which might harbor a thrombus. The branches of the vein are ligated and severed as far as possible from the main trunk, and search is made, for a distance of several centimetres internal to the principal trunk, for a second vein which sometimes exists, and which it is necessary to remove if found. As the vein is drawn from the wound from above downward the perforating branches are torn or severed and require ligatures. These are of considerable size in the lower third of the thigh, where they communicate with the femoral vein. In the leg the lips of the wound are separated from the underlying parts for a distance of 4 or 5 centimetres, in order to expose the numerous varicose branches. These branches are often difficult to separate from the skin, owing to the firm adhesions resulting from chronic inflammation. There are cases in which this difficulty is so great that it is better to resect a fusiform strip, including the skin and the veins, and extending the whole length of the leg. After the collaterals have been ligated as far as possible from the main trunk, the varicose mass is separated from the aponeurosis from above downward, the perforating branches being ligatured as they are encountered, until the lower end of the incision is reached, where the vein is cut between ligatures. The wounds are closed with silkworm gut. For the external saphenous

* Revue de chirurgie, June, 1906.

an incision is made from a little below the middle of the popliteal space to a point a little above the external malleolus, toward the posterior portion of which it is directed. When an ulcer exists in the upper part of the leg the incision ends just above the ulcer and recommences just below it. In some of these cases, instead of the lower incision, the circular incision of Moreschi is made between the ulcer and the malleoli. Our own practice is to make a succession of small incisions along the course of the saphenous and to enucleate the vein beneath the skin lying between the cuts. Mayo, Narath, and Babcock employ special instruments—which, as we believe, are unnecessary—to assist in this subcutaneous enucleation.

The indications for operation are: circumscribed varicose tumors which are giving trouble; thin-walled diverticula which threaten to burst; ulcers or eczematous areas which refuse to heal; great pain, phlebitis, or thrombosis; the existence of portions of the varix over the crest of the tibia, where, as the result of injury, they may rupture or become inflamed; and the presence of a superficial reflux as shown by the Trendelenburg test. Without regard to the general condition of the patient operation is contra-indicated when a superficial varix is compensatory to thrombosis of the deep veins, since this would lead to permanent œdema. Cases in which elastic compression fails to ameliorate the symptoms (excepting irritation of the skin) are not suitable for operation.

The type of operation to be employed varies with the type of disease present. In a circumscribed varicose tumor excision should be practised, and in such cases the results are excellent. When the disease is more extensive we still believe excision to be the best treatment, the amount of vein tissue to be removed depending upon the extent of the disease. Thus, it may be necessary to remove only the affected portion of the saphenous in the leg, or it may be necessary to extirpate the entire internal saphenous from the groin to the ankle. In the worst cases both internal and external saphenous veins may be completely extirpated. These operations are the most radical and the most likely to be followed by permanent relief. Statistics are not sufficiently voluminous to warrant us in speaking definitely of the number of recurrences that may be expected after total extirpation, but that such will be very small, and that the operation will again become necessary only after a long period, there can be little doubt. The garter operation of Schede or Moreschi has undoubtedly assisted in the healing of varicose leg ulcers, but after a longer or shorter interval the ends of the severed veins are reunited by newly formed vessels. Trendelenburg's operation is indicated only when the circulation in the saphenous vein is reversed. In other cases it is harmful. It should be emphasized that valvular insufficiency may be present, as shown by impulse on coughing and by the transmission of fluctuation over a long segment of the vein, without reversal of the circulation, the manner of demonstrating which has already been described by us. Ledderhose says that normally the valves are not competent and only partly support the blood-column, but that they prevent reflux into the side branches, as they are generally found just distal to the mouths of large collaterals.*

* Centralblatt f. Chirurgie, 1906, p. 1903.

In cases in which it is indicated the Trendelenburg operation causes immediate disappearance or marked diminution in the symptoms in about eighty per cent of the cases, the proportion gradually diminishing with the lapse of years, owing to reëstablishment of the circulation through the saphenous vein. Of the recent statistics published on this subject those of Goerlich may be cited as showing the average results.* In only 27.54 per cent were there no objective symptoms. In all others there were either subjective symptoms or reëstablishment of the circulation. Speaking in round numbers the circulation was reëstablished by varices in the scar in 34 per cent, by dilated collaterals in 30 per cent, and by regeneration of the saphenous itself in 2 per cent. In spite of these bad objective results, over one-third of the patients were much improved, and only about 16 per cent showed no improvement. The good results were most numerous in cases observed within the two years immediately following the operation, and fairly infrequent between the third and twelfth years after operation (6 out of 53 operations). Viannay,† in a critical study of the Trendelenburg operation, speaks of the reported cases of reëstablishment of the venous circulation after ligation or limited resection of the internal saphenous, and states that the internal saphenous vein is normally double in 6.5 per cent of the cases, and that there is a large collateral canal in almost half of the cases. This auxiliary vein varies from 16 to 37 cm. in length and generally arises from the internal saphenous in the upper third of the leg, rejoining the same vein in the thigh at a height varying with the subjects. This canal is generally more superficial and more anterior than the principal trunk, and not infrequently it curves forward to embrace the internal condyle of the femur. Viannay concludes that the only point at which ligation can with certainty suppress the circulation through the internal saphenous vein is in Scarpa's triangle. The only exception to this rule is the existence of a double saphenous. In this region both trunks generally run close together and will be discovered by a surgeon who keeps this possibility in mind.

Delbet has recently suggested transplanting the internal saphenous into the femoral below a normally functioning valve of the latter, for the treatment of cases in which the valve at the mouth of the saphenous is incompetent.

Treatment of Complications.—Rupture of a superficial varix is treated by immediate pressure over the bleeding point and elevation. If a large vein has been opened it should be ligated. Rupture of a deep varix, in the muscles of the calf, for instance (*coup de fouet*), is treated by elevation of the leg, the application of an evaporating lotion, and moderate compression with a bandage. Phlebitis, when of the suppurative variety, should be treated by resection of the inflamed vein, in order to prevent embolism. The operation should be preceded by ligation of the internal saphenous near the saphenous opening. Exudative phlebitis or non-suppurative thrombosis has been treated in a similar manner by a number of surgeons. As embolism is rare in these cases we have always adopted the conservative plan, believing the thrombosis to be no more dangerous than excision of the inflamed veins, which is followed by embolism in

* Beitraege z. klin. Chir., Bd. lxxiv., p. 278. † Revue de chirurgie, Jan., 1895.

probably one or two per cent of the cases. The treatment of ulceration is given in Volume II., and that of club-foot in Volume IV.

IX. INJURIES OF VEINS.

Injuries of veins may be simple contusions or actual solutions of continuity (lacerated, punctured, or incised wounds).

Contusion of Veins.—By contusion we mean an injury produced by blunt force which does not sever the outer coat.

Etiology.—Normal veins are rarely seriously damaged by contusion unless it be of a violent degree. Diseased veins, such for instance as are found in varix, are more easily affected, and only a slight contusion may be sufficient to cause thrombo-phlebitis. Extensive denudation of veins, such as is often practised in modern surgical operations, is rarely followed by evil consequences, although in pre-antiseptic times phlebitis, thrombosis, sloughing of the vein, and secondary hemorrhage were not infrequently observed as the result of infection. Contusion of veins by violent and prolonged retraction of the edges of a wound is thought by some to be responsible for the phlebitis which is occasionally seen after aseptic operations. Verneuil * emphasizes the fact that thrombosis and phlebitis of the femoral vein may occur as a sequel of prolonged compression at the root of the thigh in the treatment of aneurysm. Crushes, fractures, gunshot wounds, and like injuries are those most apt to be associated with contusions of the large veins. We should note, however, that the modern military bullet, unless the range be very great or the velocity diminished, will sever rather than contuse the blood-vessel which it strikes. In those who are hanged, both the arteries and the veins may suffer contusion.

Pathology.—The mildest form of contusion causes a little ecchymosis of the wall of the vessel or perhaps a minute hæmatoma, but this, in the absence of infection, produces no untoward effects. In the severer forms the intima is ruptured and thrombosis follows. Although the endovein is the most delicate part of the vessel and generally the first to yield to a contusion, this predisposition is not as marked as in the arteries. The same may be said of the middle coat. The explanation offered for this is that the middle coat of the veins contains less muscle and more connective tissue than that of the arteries, and merges with the internal coat, being less sharply differentiated from it than in the arteries. The extent of the thrombosis depends, not only upon the violence of the injury, but also upon the previous condition of the walls of the vein, the presence or absence of infection, the rapidity of the venous circulation, and the composition of the blood. With a minute crack in the intima only a small mural thrombus may form, or, if the conditions are favorable to thrombosis, the vessel may be obliterated by clot. (See section on Thrombosis.)

As we have, because of its greater importance, dealt more fully with the pathology of contusions of arteries, many features of which are similar to those

* "Mémoires de chir.," t. ii., p. 15.

of the veins, we shall refer the reader to the former for additional facts concerning the effects of blunt violence on blood-vessels.

Symptoms.—Aside from shock and complicating lesions, a contusion of a vein resulting in thrombosis causes symptoms referable to the venous obstruction, which symptoms we have already noted in the section on thrombosis and phlebitis. Gangrene of the wall of the vein, which is seen most often after gunshot wounds, may cause secondary hemorrhage when the slough separates, but only in the presence of infection, which liquefies the thrombus. In the absence of infection the devitalized venous wall separates slowly and only after the vessel has been obliterated by an organizing clot.

Treatment.—The treatment of obliteration of a vein the result of contusion is that of phlebitis.

Lacerated and Incised Wounds of Veins.—Wounds of veins of this nature are divided into two classes, according to whether they penetrate the vein or not.

Non-penetrating Wounds.—Non-penetrating wounds involving the outer coat or the outer and middle coats of a vein are rarely seen by the surgeon, and probably heal without causing any serious alteration in the vessel. In the presence of sepsis, however, ulceration and secondary hemorrhage are possibilities. Voudey reports a case of incomplete wound of the internal jugular in which the internal tunic was forced outward in the form of a hernia.

Penetrating Wounds.—Penetrating wounds of veins may be punctured, incised, or lacerated (ruptures and most gunshot wounds).

Punctured wounds may be produced in the same way as similar wounds of arteries, which subject has already been considered in detail. A vein is sometimes deliberately punctured in order to withdraw blood or inject medicaments. In the finest punctures the hemorrhage is slight and soon ceases spontaneously. Larger punctures are either incised or lacerated wounds. The mechanism of hæmostasis after a puncture of a vein is similar to that already described for punctured wounds of arteries.

Incised wounds likewise are produced by injuries similar to those causing incised wounds of arteries. The wound may be longitudinal, oblique, or transverse, and the last may be complete or incomplete. The effect of the direction and extent of these wounds has been sufficiently emphasized in the section on Injuries of Arteries. Spontaneous hæmostasis is effected in much the same way as after arterial wounds. The process takes place more quickly, however, after venous wounds, owing to the lower blood-pressure, the presence of valves, and the composition of venous blood, all of which favor thrombosis. After complete section retraction of the ends of the vessel is due to its elasticity; contraction of the open mouths is due largely to the elastic tissue in the vein, muscle fibres being much less abundant than in the arteries. The effects of contraction of the surrounding muscular tissue is more marked, however, owing to the fact that the venous walls are thinner and less resistant. Curling up of the inner coats is less marked than in the arteries. Contrary to that which obtains in a severed artery, the clot in the peripheral venous segment is habitually longer and more important than that in the central segment; indeed, in the

latter a clot is sometimes absent. The central end of a severed vein promptly ceases to bleed when the valves above are competent, unless a large collateral joins this segment below the lowest valve. When the valves are incompetent, as in varix, or absent, as in the jugular, hemorrhage from the central end may be as great or greater than that from the peripheral end. Persistence of hemorrhage is favored by alterations in the venous wall such as are found in varix, in which the veins remain gaping because of their rigidity, and in which contraction and retraction are sometimes impossible. Hæmostasis is hindered also by normal adherence of the wall of the vein to surrounding resistant tissues, such as occurs in bones, at the base of the neck, and in the cranial sinuses. Any condition which raises the venous blood-pressure delays hæmostasis—*e.g.*, compression between the wound and the heart, cardiac disease, and interference with respiration. Movements of course tend to dislodge the clot, and infection may cause its softening. Permanent hæmostasis is the result of displacement of the clot by fibrous tissue (p. 225). In lateral incised wounds, which heal with preservation of the lumen of the vein, the cicatrix is finally lined by a layer of endothelium.

Lacerated wounds are caused by tearing and crushing accidents, by gunshot wounds, particularly those due to the leaden bullet, and by ruptures of veins. Lacerated wounds of a vein caused by tearing are frequent in the course of surgical operations, especially those in which tumors are removed by enucleation or by blunt dissection. Tearing enters into the production of lacerations following injuries by crushing, explosives, and the reduction of dislocations. When a vein is torn asunder the two inner coats yield at the same level and retract only slightly, the outer coat, according to Nicaise, projecting two or three millimetres beyond the inner coats. There is not the same tendency toward curling up of the inner coats as occurs in the arteries, although hæmostasis is more prompt, for the reasons already given. The general facts relating to lacerations of vessels due to crushes, gunshot wounds, and fractures and dislocations have been given in the section on Wounds of Arteries. Ruptures of veins occur in every severe contusion of the soft parts, giving rise to an ecchymosis or a hæmatoma. Rupture of the minute veins of the face and neck may be caused by violent compression of the thorax and abdomen (traumatic asphyxia). Rupture of the inferior vena cava, renal vein, portal vein, and other abdominal veins has followed severe contusions. Spontaneous rupture without traumatism is possible only in diseased veins, *e.g.*, varicose veins in various parts of the body.

Symptoms.—The symptoms of venous wounds are general and local.

The general symptoms, when a large amount of blood has been lost, are those of acute anæmia. (See p. 232.)

The local symptoms vary according to whether the wound in the vein communicates with the exterior or is subcutaneous.

Venous wounds communicating freely with the exterior are characterized by a flow of dark blood, which, when issuing from the larger veins, may take place in the form of a jet. This jet is always less pronounced than the spurt

from a wounded artery of corresponding size, unless the intravenous blood-pressure is markedly augmented as the result of obstruction to the venous circulation. Although the flow is generally continuous and unremitting, under certain circumstances—*e.g.*, as the result of deep expiration, straining efforts, or muscular contractions—it is augmented at intervals, but this augmentation does not, as in arterial bleeding, correspond with the systole of the heart. Rarely, the blood may be red and escape in jets synchronous with cardiac systole. Change in color is observed in certain intense fevers in which the circulation is so active that the blood does not remain in the capillaries long enough to be transformed, in marked dilatation of the capillaries the result of nervous influences, and toward the end of a severe hemorrhage, owing to the more free access afforded to the blood by the empty veins below the wound. (Duplay.) A pulsating jet may be caused by an underlying artery, or by an abnormal communication between an artery and a vein. With the exceptions noted above (*i.e.*, incompetent or absent valves and the opening of a large collateral into the vein between the wound and the lowest valve) the central end of the vein soon ceases to bleed. Bleeding from the peripheral end likewise soon ceases if the vein is a small one, but when the vein is large and even when it is small if the wound remains gaping because of alterations in the vessel-walls or of anatomical disposition, the hemorrhage continues unless means are taken to check it. Proximal pressure on the vein in a lateral wound increases the bleeding; distal pressure staunches it. In varix, however, in which the blood flows peripherally instead of centrally, the reverse is true. Moderate circular constriction of a limb above a wounded vein increases the bleeding even if the vein is completely severed; tight constriction always checks it, at least after the peripheral venous segment and its tributaries have emptied themselves.

The size of the escaping stream of blood varies according to the size of the vessel, the character (incised, lacerated, etc.) and direction (longitudinal, transverse, etc.) of the wound, the disposition of the soft parts about the wound, the proximity to the heart, and the presence and competency of the valves. Wounds of the main veins at the base of the neck and roots of the limbs, and of the large thoracic and abdominal veins, may cause rapid death.

When the wound in the soft parts is minute or occluded by clot or by other means, the local symptoms are those of a subcutaneous wound of a vein.

Subcutaneous wounds of veins the result of stab wounds, gunshot wounds, accidental injury with a tenotome, the reduction of a fracture or dislocation, the rupture of a deep varix, etc., cause bleeding into the tissues or into one of the cavities of the body. When the blood escapes into the tissues (interstitial hemorrhage), it either infiltrates more or less uniformly the surrounding parts and ultimately reaches the skin, where it appears as an ecchymosis, or it forms a hæmatoma. In either event there are pain and swelling, and the compression exerted by the extravasated blood may induce special symptoms according to its situation—*e.g.*, obliteration of the artery and gangrene, in the extremities; cerebral disturbances, in the cranium; dyspnœa and dysphagia, in the neck; etc. The amount of blood extravasated varies with the size of the vessel in-

jured and the construction of the part. In lax tissues like the scrotum and eyelids it is generally extensive; in dense tissues like the scalp it is usually slight. It is apt to be excessive in those who are delicate, in females, and in persons affected with hæmophilia or some allied condition, and less marked in the robust. The blood in an ecchymosis is ultimately disintegrated and absorbed. A hæmatoma is surrounded by a deposit of fibrin so that the edges feel hard and the centre soft; it may be absorbed, converted into a fibroid mass, undergo inspissation and calcification, or result in a cyst, or it may become infected and suppurate. A hæmatoma overlying an artery may pulsate, but the pulsations are never expansile in character.

Venous hemorrhage (internal hemorrhage) into one of the large cavities of the body (*e.g.*, pleural or peritoneal) is much more serious than an interstitial hemorrhage, as here even a comparatively small vein may continue to leak for hours or even days. The signs are those of effusion into the affected cavity, and the general symptoms are those of acute anæmia. If the hemorrhage is not sufficiently great to cause death the blood may remain fluid for days. Ultimately it is absorbed, infected, or converted into adhesions.

Complications.—The complications of venous wounds are simultaneous injury of the accompanying artery, air embolism (p. 195), clot embolism (p. 183), phlebitis (p. 297), and recurrent and secondary hemorrhage. The features of the last have been sufficiently emphasized in the section on Injuries of Arteries. It is unnecessary to detail the various lesions of nerves, muscles, bones, and viscera which may complicate wounds of the various veins.

Diagnosis.—The diagnosis of venous hemorrhage from arterial hemorrhage has been given in the section on Arterial Wounds.

Treatment.—The treatment of wounds of veins is to control the hemorrhage and combat, when necessary, the constitutional effects of the loss of blood. The means for dealing with the latter have been given in the section devoted to Arterial Wounds.

Wounds of smaller veins which are exposed to the air generally cease to bleed spontaneously. When such wounds continue to bleed it is usually the result of disease of the vessel-walls, alterations in the constitution of the blood, or augmentation of the blood-pressure. The last is often seen in the course of surgical operations as the result of partial asphyxia, troublesome venous hemorrhage ceasing after the jaw has been pulled forward and the patient allowed to breathe freely. It is hardly necessary to point out the importance of removing constrictions above a part from which venous bleeding is taking place—as, for example, a circular garter in a bleeding varicose ulcer. In certain forms of bleeding cold, heat, stypties, and elevation, as pointed out under Arterial Hemorrhage, may be employed. It is our intention here to speak only of wounds of the larger veins, for which the surgeon has at his command (1) compression, (2) forcipressure, (3) torsion, (4) ligation, and (5) suture of the vessel.

(1) *Compression.*—Direct digital compression should be employed in wounds of the largest veins for the immediate control of the hemorrhage, the pressure being maintained until some means of permanent hæmostasis can be devised.

Firm gauze packing, or tamponnement, is capable of checking any venous hemorrhage. It is a method which, although easily and quickly applied, necessitates an open wound, thus favoring infection and lengthening convalescence. Moreover, it increases the amount of cicatricial tissue, thus causing, in many instances, adhesions between important structures. It should, therefore, with important exceptions, be used only as a temporary measure, the individual vessels being secured with hæmostatic forceps as the packing is gradually removed. When, in a large freely bleeding cavity, the time and additional loss of blood necessary for securing a large number of small vessels seem to be more weighty objections than the disadvantages just mentioned, gauze packing may be considered the best means for controlling hemorrhage. In wounds of the cerebral sinuses gauze packing is regularly employed by most surgeons in preference to other means of hæmostasis, owing to its efficiency and the ease with which it may be applied. Here and elsewhere, when used for wounds of major veins, the tampon should remain in place at least a week, and then be removed slowly and carefully, after having been saturated with salt solution or diluted hydrogen dioxide, fresh gauze being in readiness to pack into the wound in case the bleeding recurs. Other methods of direct pressure have been described in the section on Arterial Wounds. In the same place are mentioned the various forms of indirect pressure for controlling hemorrhage, with their disadvantages. The effects of proximal and distal pressure on venous bleeding have been pointed out above. In this place we need only repeat that, in the presence of a freely bleeding wound, one does not stop to diagnosticate with precision the source of hemorrhage but controls it at once by direct pressure, which is maintained—whether the bleeding comes from an artery or from a vein, or from both—until more permanent methods of hæmostasis can be applied.

(2) *Forcipressure and* (3) *Torsion.*—The indications for forcipressure and torsion, in complete sections of veins, are identical with those which apply in case of arteries. Small lateral wounds are sometimes closed with forceps (lateral forcipressure) which are allowed to remain in place twenty-four hours, the idea being to secure hæmostasis without interrupting the blood-current. We believe the method to be indicated only when, in a small wound of an important vein, a lateral ligature or, better, a suture cannot be applied.

(4) *Ligation.*—Ligation is the usual and most certain method for controlling hemorrhage from veins. The remarks on the material to be employed and on the technique of ligation made in the section on ligation of arteries, applies with equal force to ligation of veins. Owing to the freedom of collateral circulation, ligation in continuity for venous hemorrhage should not be employed. The vein must be occluded at the bleeding point. The vein may be totally occluded by a circumferential ligature, or, in suitable cases, the wound in the vein may be occluded by a lateral ligature, without interrupting the blood-current.

Total or circumferential ligature of the main venous channels was regarded, before the antiseptic era, as a formidable operation, owing to the frequency of phlebitis, secondary hemorrhage, and gangrene. In 1826 Gensoul suggested that, when necessary to tie the femoral vein, the femoral artery be ligated at the

same time, in order to equalize the pressure between the arteries and veins of the lower extremity and thus prevent gangrene. Langenbeck thought that this operation was not only less likely to be followed by gangrene, but was also much more certain to control the bleeding. These ideas were accepted, particularly by German surgeons, who went so far as to ligate even the carotid artery in wounds of the jugular vein. As early as 1852, however, Cruveilhier * protested against this practice, stating that there did not exist a single positive case of gangrene following venous obliteration. In 35 cases of ligature of the femoral vein Niebergall † found 1 case of gangrene; in 24 cases of simultaneous ligation of the artery and vein he found 14 cases of gangrene. Franz ‡ found 2 cases of gangrene in 54 cases of ligation of the femoral vein. In 40 cases collected by Rageryoma gangrene did not occur in a single instance. (Hoepfner.) At the present time it may be confidently asserted that, with normal vessels and in the absence of infection, ligation of the main veins of the limbs is a benign operation which is not followed by gangrene. In all cases, however, of ligation of the axillary, femoral, and external iliac veins which we have had a chance to observe, there has been transient or permanent œdema. Ligation of the internal jugular generally causes a little œdema about the jaws and neck and occasionally transient headache. Dangel § reports a case in which, during the removal of carcinomatous lymph nodes, both internal jugulars were ligated. For only ten minutes were there cyanosis and quickening of the pulse; in this case, however, the collaterals had been dilated, owing to the pressure of the growth on the jugular. Depage || has ligated with success both internal jugulars, allowing a month between the operations. Morestin,¶ in a similar operation, saw immediately after the second ligation marked cyanosis, which was followed by death in a few minutes. Ligation of the jugular near the base of the skull, which suppresses the collateral circulation through the neck, and simultaneous ligation of both jugulars must be regarded as a serious operation capable of causing cerebral œdema and death. Simultaneous ligation of the internal jugular, the subclavian, and the innominate veins has been done four times without ill effects.**

The inferior vena cava was first ligated by Bottini. Other cases have been reported by Zoege-Manteufel, Heresco, Albarran, Goldmann †† Houze,‡‡ Hartmann, §§ Draudt,|||| and Delaunay.¶¶ Seven of these cases, in all of which the vein was accidentally wounded during an operation, recovered. In the successful cases there is more or less œdema of the legs and dilated veins appear on

* Schwartz, in "Traité de chir." par Le Dentu et Delbet, tome iv.
† Deutsche Zeitschr. f. Chir., Bd. xxxvii., p. 268.
‡ Deutsche militärärztl. Zeitschr., 1903, No. 9.
§ Beitraege z. klin. Chir., Bd. xlvi., p. 495.
|| Rev. de chir., Nov., 1906, p. 618. ¶ Same Ref., p. 617.
** Goldmann, in Lancet, London, Jan. 13th, 1906.
†† Lancet, Jan. 13th, 1906.
‡‡ Archiv. prov. de chir., 1905, No. 9.
§§ Bull. et mém. de la soc. de chir. de Paris, t. xxx., p. 57.
|||| Deutsche Zeitschr. f. Chir., Bd. lxxxiii., p. 109.
¶¶ Rev. de chir., Nov., 1906, p. 625.

the abdomen. The operation is indicated only when the ligature can be applied below the origin of the renal veins, although Tuffier believes that ligation above this point would not necessarily cause trouble; at all events, he has often experimentally tied the renal vein without finding changes in the corresponding kidney. Meyer * has in dogs severed the vena cava above the renal veins and implanted the distal end into the portal vein. Neither sugar nor albumin appeared in the urine. The suggestion may prove of value in the treatment of wounds of the vena cava in this situation.

Ligation of the normal portal vein is followed by gangrene of the liver and death. When, however, the vein has been gradually narrowed, as by a tumor, so that a collateral circulation may be established, ligation can be performed with safety. This statement is fortified by the case of Brewer,† and by that of Gies.‡ Ziani § suggests lateral anastomosis between the inferior vena cava and the superior mesenteric vein when it is necessary to tie the portal vein or the vena cava above the origin of the renals.

Ligation of the superior or inferior mesenteric vein causes hemorrhagic infarction and gangrene of the intestine. In 1897, however, Mayo Robson tied the superior mesenteric vein near its origin for an accidental wound. The patient recovered without exhibiting any untoward effects.

Although only the peripheral segment of a divided vein be found bleeding, both ends, at least of large veins, should be ligated, thus preventing the entrance of air during the operation and of fat or micro-organisms after the operation.

Effects of Ligation.—According to Nicaise ligation of a vein does not cause rupture of any of the coats. Ollier, however, affirms that the middle coat is ruptured by the ligature. We believe that it would be rather difficult safely to ligate a vein without injuring the intima and at least contusing the media. The vein is compressed into an infinite number of folds. A thrombus forms in the peripheral segment and extends as far as the first collateral branch, being finally replaced by fibrous tissue in the manner already described. The clot in the proximal segment is much shorter, and indeed may be absent. As in the arteries, it is possible to secure obliteration of the vein by adhesive phlebitis without thrombosis. Again, as the result of infection there may be induced a progressive thrombo-phlebitis which blocks most or all of the veins of a limb. This was the cause of many of the poor results obtained in former days.

Lateral ligature is applicable to small lateral wounds of veins. The method was first used by Travers in 1816; the ligature was applied to the femoral, the ligature slipped, the patient died. The edges of the wound are gathered in the bite of a pair of hæmostatic forceps and the ligature is placed beneath, thus closing the wound without interrupting the blood-current. Fine silk is the best material to use for this purpose, as it secures a firmer hold on the vessel walls than catgut. In most instances of lateral wounds of veins in which it is desirable to preserve the circulation through the vein, suture of the wound is much safer than lateral ligature.

* Centralblatt f. Chir., 1908, No. 8.
† Annals of Surgery, April, 1908.
‡ Jour. Amer. Med. Assoc., vol. l., No. 25.
§ Centralblatt f. Chir., 1908, p. 973.

(5) *Suturing of Veins.*—Suturing of veins was first attempted, in 1833, by Gensoul on the jugular of the horse, but the result was a thrombo-phlebitis because of suppuration. (Jassinowsky.) For some time after this, experimenters confined their studies to lateral ligation and the closure of small wounds of vessels with different forms of pressure apparatus, wooden pincers, serres fines, hæmostats, etc. Ollier, in 1857, and Nicaise, in 1872, again took up the subject of suturing veins in animals. Czerny, in 1881, was the first to practise suturing of veins in man. He sutured an ulceration in the jugular, but secondary hemorrhage followed two days later and he was forced to tie the vein, the patient subsequently dying of pyæmia. The following year, 1882, Schede, in removing carcinomatous inguinal lymph nodes, wounded the femoral vein, which wound he sutured with fine catgut. The wound healed without thrombosis. In 1888 Von Horroch showed experimentally that end-to-end anastomosis of veins could be performed without producing an obliterating thrombosis. (Jassinowsky.) Taddei, in 1901, found that the lumen of the vein could be diminished one-half by suturing without causing thrombosis. (Jacobsthal.) In 1888 Schede reported the first case of suturing the vena cava, the vessel having been injured during a nephrectomy. The patient died eighteen days later from another cause, but the wound was found healed, with no thrombosis. In the same report,* he collects thirty instances of suturing of the larger veins. Since this time the procedure has passed into current surgical practice and suturing of veins smaller than the innominate and vena cava is no longer reported by surgeons; it is therefore impossible to estimate the number of cases in which this operation has been done. Even in the presence of infection the operation seems to be as successful as ligation in permanently checking hemorrhage. Bad results have been reported in only a few instances—those of Czerny, Krause, Korte, and Segel. The innominate vein has been sutured twice, once by Marin and once by Ricard. The portal vein has been sutured by Schultz and by Depage,† the latter being an end-to-end anastomosis performed during a resection of the head of the pancreas. The vena cava has been sutured by Schede, Manteufel, Garre, Keen, Pousson,‡ Depage, Temoin, Perugniez, Ullmann, and Barnsby,§ eight of the patients recovering.

Microscopic examination of the preparations after suturing of a vein gives somewhat different results according to different investigators. Bureis claims that the vein may be completely regenerated. Jassinowsky found regeneration of the media but not of the elastic elements. Jacobsthal could find no muscular fibres in the scar.

End-to-end anastomosis of the divided femoral and axillary veins has been performed in man by Krause, Kuemmel, Payr, Doyen, Goyanes,|| and others. As mentioned above, Depage united the ends of the portal vein by suture.

The technique of suturing a vein is identical with that of suturing an artery. Catgut, however, is probably more often used for the suture material, and, in the

* Archiv f. klin. Chir., Bd. xliii., Hft. 3 and 4.
† Revue de chir., Nov., 1906, p. 618.
‡ Bull. de la soc. de chir., June 20th, 1903.
§ Rev. de chir., Nov., 1906.
|| Revista de med. y cir. pract. de Madrid, 1907, p. 979.

case of the largest veins, slight eversion of the edges of the wound, so as to bring intima in contact with intima, is perhaps desirable.

We believe that all wounds of major veins should, whenever possible, be closed by suturing rather than by the application of a ligature. When the other vessels are intact and healthy, ligation of the axillary, femoral, jugular, innominate, and vena cava (below the origin of the renal vessels) very rarely causes trouble other than œdema; but even this may and should be avoided by suturing. When a number of collateral vessels have been injured, when the arteries are narrowed by disease, when the circulation is impaired as the result of cardiac or pulmonary disorders, when the resistance of the tissues is greatly lessened as the result of diabetes, nephritis, or other debilitating maladies, the chances of gangrene or other serious disturbance after ligation of a main venous stem are greatly increased. Hence, in the presence of these conditions, suturing is more strongly indicated. In wounds of the superior mesenteric, portal, and vena cava above the origin of the renals, and in wounds of both internal jugulars, suturing instead of ligaturing is imperative to save life.

SURGICAL DISEASES AND WOUNDS OF THE STOMACH AND ŒSOPHAGUS.

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I. SURGERY OF THE STOMACH.

Introductory Remarks.—Surgery of the stomach must have for its object the restoration of this organ, as nearly as possible, to its normal anatomical condition. This is true without regard, in any individual case, to the pathological condition present which the surgical procedure is expected to relieve. These pathological conditions depend: first, upon injuries; second, upon the presence of pathological growths; and, third, upon the presence of some condition which interferes with some one of the various functions of this organ. The conditions that most often call for surgical treatment are those which are dependent, either primarily or secondarily, upon gastric ulcer.

In our efforts to correct any one of these lesions by means of surgical interference we should bear in mind the fact that at best our results must fall somewhat short of producing perfectly normal conditions. It is important to look upon the stomach as a machine which is normally arranged in the manner most favorable for the performance of its physiological functions, and that any change in the arrangement of this machine must necessarily result in a mechanism less competent than the original. In order to make this fact more apparent, we have introduced here a diagram (Fig. 106) which may be considered as representing this machine correctly in its normal condition. The left portion of the stomach serves the purpose of storing the food and mixing it with the gastric juice, thus preparing it for the right portion (about one-third of the organ) which serves as a grinding machine for the food after it has been mixed in the storage end of the stomach. This portion of the stomach is by far the most active, its contractions being powerful, and consequently it is the portion of the organ which is most frequently exposed to injury from within. It is separated from a second mixing apparatus, which is found in the duodenum, by the pylorus. The duodenum is embryologically a portion of the stomach, being formed by the foregut in the development of the fœtus. The mixing process at this point combines the food which has been prepared in the pyloric antrum of the stomach, with the bile and pancreatic fluid which enter the duodenum through the common duct.

It is important to consider all of these points simultaneously, because an anatomical defect in any one of these portions of the digestive tract will directly affect all of the other portions, and it is equally plain that any surgical inter-

ference which will change the relative functions of these parts, must result in physiological functions that are below the normal. To illustrate:—Pylorectomy primarily removes a portion of the grinding apparatus, and, secondarily, it eliminates from the act of digestion the mechanism for mixing the food, the bile, and the pancreatic juice in the duodenum,—*i.e.*, the mechanism which is specially provided for this purpose. Moreover, the new mechanism which will be supplied by the operation to take the place of the portion removed, must necessarily be quite defective; and this condition will in turn interfere, to some extent at least, with the normal storage of food in the cardiac portion of the stomach, although this has been questioned seriously by Cannon whose experiments upon

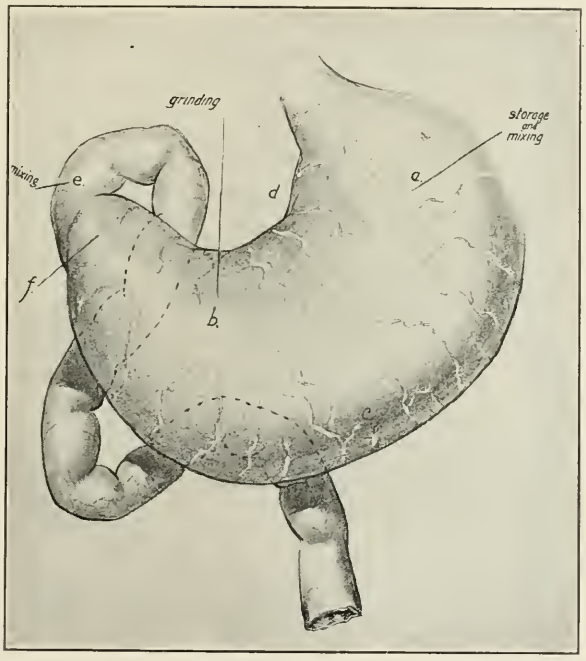

Fig. 106.—Diagrammatic Representation of the Stomach as a Machine Intended to Effect the Digestion of Food. Words indicating the physiological and mechanical functions of the different parts of the organ have been introduced at the appropriate places in the diagram. *a*, Dome of the stomach or cardiac end; *b*, pyloric end; *c*, greater curvature; *d*, lesser curvature; *f*, pyloric sphincter; *e*, duodenum.

animals seem to show that a gastro-enterostomy has little effect on gastric drainage. If these facts are borne in mind one will not undertake surgical procedures upon this organ so long as there is any likelihood of relieving by non-surgical treatment the pathological condition which is present.

If any given pathological condition can be relieved by internal treatment or by the use of hygienic and dietetic measures, then it is to be hoped that the mechanism will also be restored to the normal, as regards both its physiological and its anatomical properties. It is true that the causes which have once brought about the pathological conditions from which the patient seeks relief, may again bring about the same results,—in other words, that he will suffer from a recurrence.

This fact has been used as an argument in favor of surgical interference in many of these cases; the belief being held that, inasmuch as the surgical operation produces new conditions, the likelihood of a recurrence would thus be done away with. Clinical experience has shown, however, that these patients are compelled, after they have recovered from the effects of the operation, to observe certain dietetic and hygienic precautions; and it is therefore reasonable to suppose that, in many of these cases in which the troublesome symptoms recur, the patient would remain permanently cured, without surgical interference, if he were to observe, after the original successful course of treatment, these same dietetic and hygienic precautions. In brief, if patients who have recovered from ulcer of the stomach as a result of hygienic and dietetic treatment, were constantly careful in their diet for years, there would be but very little stomach surgery. Whatever may be said, then, concerning the surgical treatment of the various pathological conditions which will be discussed in this chapter, must be construed to apply, in the individual patients, to conditions which obviously can be relieved only by surgical interference. This includes such conditions as acute perforation of the stomach due to ulcer or gunshot or other wounds, complete obstruction of the pylorus or the œsophagus, and incipient carcinoma of the stomach. Aside from the cases which belong in the classes which have just been enumerated, the remarks in question apply only to those in which non-surgical relief has failed or in which the conditions preclude the possibility of a cure by non-surgical treatment. Under non-surgical treatment we would class especially dietetic and hygienic measures.

Interference with Gastric Drainage.—No other condition is so commonly the cause of gastric disease sufficiently serious to require surgical treatment, as is an interference with the normal drainage of the stomach. This may be congenital in its origin, as in the case of a congenital stricture of the pylorus, or it may be due to the presence of a pyloric ulcer or to the contraction following the healing of such an ulcer. Whatever the cause of the obstruction, the effects, if the obstacle persists, are of such a nature as ultimately to require for their relief a surgical operation. Should an operation, however, not be performed, the patient's distress will continue in proportion to the degree of the obstruction; or, if the obstruction is of a decided character, he will suffer from malnutrition in a degree proportionate to the seriousness of such obstruction.

Clinically, these patients either recover under dietetic and hygienic treatment, or the stomach undergoes anatomical changes such as are illustrated diagrammatically in the accompanying figure (Fig. 107). In the mean time the case pursues the following typical course:—In non-congenital cases the obstruction at the pylorus is accompanied, in its early stages, by a considerable degree of pain, which is usually located between the ensiform appendix of the sternum and the umbilicus. The patient feels uncomfortable after eating, and the distress is more marked after the ingestion of certain foods. He soon learns to classify various articles of food according to the amount of discomfort which they produce. Acids and raw fruits usually cause the greatest amount of distress. During this part of the course of the disease, the distress is usually greater if a

large amount of food is taken than if the patient eats but a small amount. Gastric lavage will show the presence of a great amount of mucus which is secreted for the purpose of protecting the painful point. At this time the stomach is not enlarged, and there is frequently a compensating hypertrophy of the muscular wall of the organ to overcome the obstruction at the pylorus. If the latter condition persists, however, hypertrophy will give place to dilatation. This will at first be slight in degree, as shown at 2 in Fig. 107. In the mean time the accumulation of mucus interferes with the gastric digestion. This it does by covering the surface of solid portions of food which have been placed in the stom-

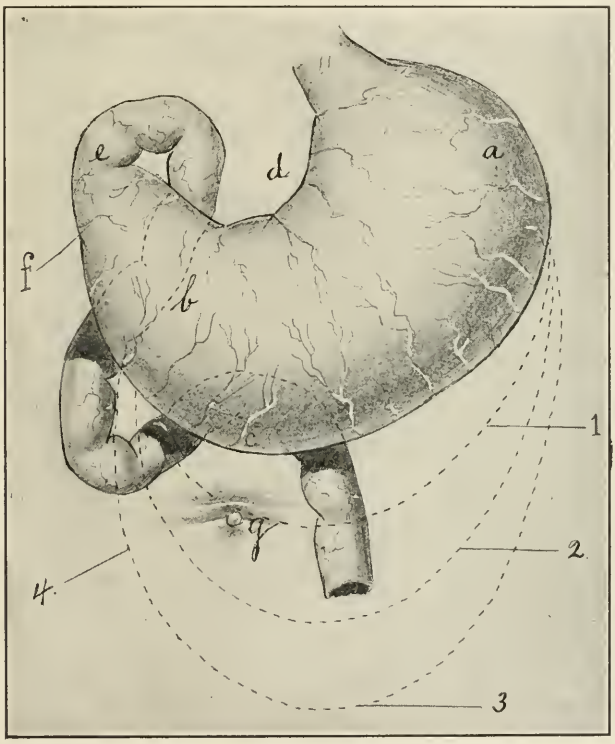

Fig. 107.—Diagram Showing, by Means of Dotted Lines (1, 2, 3), the Various Degrees of Deformity of the Stomach Due to Dilatation Resulting from Pyloric Obstruction. 4 indicates the height to which food has to be lifted (from the lowest point in the stomach cavity) before it can escape into the duodenum, *e*, through the pylorus, *f*; *a* represents the cardiac end; *b*, the pyloric end; *c*, the greater and *d* the lesser curvature.

ach. To compensate for this condition, there is a physiological increase in the secretion of hydrochloric acid, which in turn causes an increase in pain because of its irritating effect upon the pyloric ulcer. The difficulty of emptying the stomach contents into the duodenum will now be increased from one of two causes: either the ulcer becomes partly or completely healed, as a result of which change cicatricial contraction of the pylorus takes place and the degree of the obstruction is thereby increased; or the base of the ulcer and the tissue surrounding this lesion will undergo contraction, thus causing a mechanical increase in the obstruction. A third process, which has been frequently mentioned as an im-

portant cause, is the spasmodic contraction of the sphincter muscle of the pylorus, due to the presence of an ulcer within the grasp of this muscle. It is likely that this factor is more active in the early than in the later stages of pyloric obstruction.

In the mean time the dilatation of the stomach continues, as indicated at 3, in Fig. 107, and as a result the greater curvature extends a considerable distance below the umbilicus. This dilatation may be so great as to permit the greater curvature of the stomach to rest in the pelvis of the patient—a condition observed in one of the author's patients. This condition introduces another important disturbing factor in the mechanism of digestion. In the normal condition the food, in passing from the stomach into the duodenum, must be elevated only the distance from *c* to *f* (Fig. 107), while in the extremely dilated stomach it must be lifted the much greater distance from 3 to *f* (Fig. 107). It has been shown by Cannon and others that there is a shortening of the greater curvature of the normal stomach when food is forced through the pylorus into the duodenum and that in this way the pyloric end of the stomach takes the form of a funnel during this physiological act. Moreover, the course which the food has to pursue in passing from *c* to *f*, extends over a smooth, non-sacculated surface, while in its course from 3 to *f* there is likely to be formed at 4 a valve-like projection which will serve as a serious obstruction to the passage of food through the pylorus into the duodenum. At this stage in the course of the disease the stomach becomes incompetent to empty itself completely and there remains constantly in this lower pouch a certain amount of residual food. Here, as in every cavity in the human body, the retention of residual contents favors the development of micro-organisms, and in a short time a high degree of fermentation and decomposition will take place, and the patient will begin to absorb these products of decomposition instead of absorbing the products of normal digestion. It is at this stage that severe symptoms of malnutrition make their appearance. A careful use of gastric lavage, together with hygienic and dietetic treatment, will frequently prevent the progress of malnutrition by removing these decomposing substances and supplying food which can readily be absorbed. But it is not likely that, in any of these advanced cases, the mechanism can still be restored to approximately normal conditions without the aid of surgical interference. In cases, however, which have not progressed to this extreme degree, it is undoubtedly often possible to restore the anatomical conditions to an approximately normal state.

It is well to emphasize especially the importance of hygienic measures. One frequently encounters a case of almost hopeless stomach disease in a person of sedentary habits, overworked mentally, who goes out on the plains and returns, after a number of months, with the best stomach in town. So it is well to lay stress upon the importance, not only of dietetic and medicinal, but also of hygienic measures. It should also be stated that in this class of cases, which promise most from the careful and long-continued use of hygienic measures, surgical interference accomplishes the minimum amount of good. After a certain number of these cases of ulcer of the stomach have been carefully treated

in the manner indicated above, there will always be some—indeed, a considerable number—in which the stomach appears to be hopelessly ruined. This is frequently the experience of those who have ample opportunities to test thoroughly these non-surgical measures. At the end of the treatment the stomach is still, apparently, in the same pathological condition. Under these circumstances it may be assumed that the affection has reached a stage in which one of three things is possible: either an open ulcer exists, or the ulcer has already healed and its former site is occupied by a cicatricial obstruction, or this obstruction may be due to a more or less extensive induration at the base of the ulcer.

If the ulcer is still open, we have a number of very definite complications to fear besides the malnutrition, the discomfort, and the disability of the patient. We have first to consider the possibility of perforation of this ulcer and of the immediate death of the patient as a result of the perforation. We have also to consider the possibility of the patient's losing his life by the sudden loss of a large amount of blood or by a series of hemorrhages at shorter or longer intervals of time. Finally, the possibility that a carcinoma may develop at the seat of this ulcer must not be overlooked. That such an occurrence actually takes place in many cases of chronic ulcer of the stomach has been observed by many surgeons. It has been investigated with great care in a very large number of cases by Graham.

At this point it may be well to emphasize the fact that, in this condition as well as in all other intra-abdominal conditions,—such, for example, as pyosalpinx, appendicitis, extra-uterine pregnancy, gall-bladder disease, etc.,—the diagnosis has been perfected to a reasonable degree only as a result of the operation. When operations were begun for each and every one of these conditions, the views which we held were extremely vague. We have reached a reasonable degree of certainty in our diagnosis only by reason of the fact that, a probable diagnosis having been made in each one of a large number of instances, the correctness of this diagnosis was either proven or disproven by a surgical operation. It is therefore of great importance that both the surgeon and the internist should, in every instance in which the abdomen is opened for the relief of a condition of the stomach, be present at the operation, and should determine whether the ideas formed concerning the conditions to be found are correct or incorrect; because upon the ability to diagnose them correctly will depend our ability to treat these cases properly later on.

In a few instances practitioners of internal medicine, who almost always observe these patients before they apply to the surgeon for care, have attained great skill in diagnosis by following their cases into the operating-room and confirming or changing their original diagnoses in accordance with the pathological findings at the time of the operation. This plan should be adopted generally.

Gastric Ulcer and Its Sequelæ.—The diagnosis, in these cases of gastric ulcer, has usually been made and remade repeatedly before the patient comes to the surgeon for treatment. Indeed, if for any reason a patient affected with this disease should come to the surgeon in the first instance, it is likely that—except in a case of perforative ulcer or of malignant disease implanted upon the

ulcer—the patient will first have to be subjected to careful internal dietetic and hygienic treatment.

The first step in the diagnosis will be to determine whether the case is of an acute or of a chronic nature. It will therefore be more convenient to discuss the subject under the subheadings of Acute Ulcer of the Stomach and Chronic Ulcer of the Stomach.

Acute Ulcer of the Stomach.

In acute ulcer of the stomach there are usually two very definite symptoms. The first most constant symptom is pain, which is located, as a rule, about halfway between the ensiform appendix of the sternum and the umbilicus. This pain is at first intermittent and occurs only after some indiscretion in eating. During this stage pain can be elicited upon pressure, regardless of the fact whether the stomach be distended with food or not. In the second place there is usually some hemorrhage. This may be so slight that the blood can be detected only upon careful examination of the stools; then again, it may be so severe as to give the stools a characteristic black appearance; or, finally, it may be sufficiently severe to cause nausea and vomiting, in which case the blood will appear in the vomited matter. The amount of blood lost may be so considerable that the patient will show marked anæmia within a few days; but this symptom usually disappears in a short time if the hemorrhage subsides. Unless the loss of blood is very great these patients should not be subjected to operative treatment until they have thoroughly recovered from such loss. If absolutely no food is given by the mouth a patient suffering from acute gastric ulcer practically always recovers from the first attack. If, however, a small amount of nourishment or water is given before the patient has fully recovered, the distention of the stomach is likely to reopen the bleeding vessel, and the oftener this recurs the more anæmic the patient becomes. With increasing anæmia, the coagulability of the blood decreases, and this in itself increases the likelihood of subsequent hemorrhages.

Leube maintains that a single profuse hemorrhage, due to the presence of gastric ulcer, does not constitute an indication for operation. His enormous experience has proven to him that, with careful treatment, it is possible to cause a large proportion of these ulcers to heal permanently.

According to Dieulafoy, a hemorrhage not exceeding 200 c.c. of blood is not an amount sufficient to indicate positively the necessity of an operation; but he believes that, if one-half of a litre is lost, and especially if this hemorrhage is repeated once or twice, a surgical operation offers the only possible relief. Since the importance of keeping the stomach absolutely empty has become recognized, this statement can no longer be considered as correct. The occurrence, however, of so large a hemorrhage should always be considered a strong indication for operation, because it shows that one of the larger vessels has been eroded, and the larger the vessel the more easy will it be for the thrombus to become displaced.

Chronic Ulcer of the Stomach.

Clinical observation seems to show that only a small proportion of acute ulcers of the stomach progress, either continuously or by interruption, until they become chronic. The ulcer, after its first appearance, may go on causing symptoms until the condition may rightly be termed chronic. These symptoms may vary in severity during this period, or they may continue at the same degree of severity, or there may be a complete interruption of symptoms, so that both the patient himself and the physician may reasonably suppose that the ulcer is permanently healed. The recurrence may be brought about by some indiscretion in diet, by unfavorable hygienic conditions, or by overwork. A rather common exciting cause is indigestion from overwork, which causes a general neurotic state. The condition, called "nervous dyspepsia," is a common forerunner of a recurrence. It is often difficult to determine which is the cause and which the effect. The general nervous condition may disturb the digestion to so marked a degree that the irritation caused by undigested food may be sufficient to act as the exciting cause for the recurrence, especially as the malnutrition which accompanies this form of indigestion will in itself act as a cause for the recurrence. On the other hand, the irritation accompanying a recurrence in its early stages, before any very definite symptoms have appeared, may act as an important element in producing the nervous symptoms in these cases.

Very rarely the recurrence is due to a direct trauma from the ingestion of certain articles of food, such as hard crusts or fine particles of bone swallowed in eating game. This cause has been observed a sufficient number of times to be worthy of mention.

The chief symptoms of chronic ulcer of the stomach are: first, pain; second, obstruction to the passage of food; third, hemorrhage; and, fourth, malnutrition. The usual location of pain is at a point half-way between the ensiform appendix of the sternum and the umbilicus. This pain is increased upon pressure; it is usually increased upon taking certain articles of food. If the ulcer is located on the lesser curvature of the stomach, to the left of its centre, the pain is referred to a point a little below the centre of the sternum, and the pain at this point is felt if pressure is made upon the upper part of the abdomen.

If the ulcer is located at the pyloric end of the stomach, but does not extend beyond the pylorus, into the duodenum, the pain is usually increased after taking food. If there is an extension of the ulcer into the duodenum, the pain is most severe during the period of digestion. If the ulcer is located entirely on the duodenal side of the pylorus, or if it extends from the pyloric end of the stomach into the duodenum, the pain is usually more severe when the stomach is empty. In these cases pressure a little to the right of the median line, opposite to the umbilicus, elicits the greatest amount of pain.

During the late stages of chronic gastric ulcer there is referred pain in the back, which may extend up as high as the fourth dorsal vertebra. It is more commonly located to the left than to the right of the median line, but it may

appear on either side or in the middle. It can be distinguished from the referred pain due to the presence of gall stones, by the fact that the latter pain extends around to the right, at about the level of the tenth rib, while the referred pain from gastric ulcer does not take this course. It must be remembered, however, that the two conditions frequently occur in the same patient.

Dilatation.—Dilatation of the stomach is a late symptom of gastric ulcer. It is caused by the obstruction which the ulcer itself (plus its indurated base) offers in the pyloric channel or by the cicatricial contraction which results from the partial or complete healing of the ulcer.

Shaking the portion of the abdomen which is occupied by the stomach, from side to side, gives rise to a splashing sound in the presence of dilatation of the stomach. Percussion will further confirm this condition. In order to determine the actual degree of dilatation, it is best to introduce a stomach tube and to attach to the upper end of this a bulb holding a definite quantity of air. Then the stomach should be pumped full of air and its lower margin located by means of percussion. As soon as a slight amount of pain is elicited, or as soon as the patient complains of a feeling of fulness, no further air should be forced into the stomach. In case of an acute exacerbation of the symptoms in any given case, or if a hemorrhage has recently recurred, this method of diagnosis should not be employed, for fear of causing a perforation of the stomach. This accident has actually occurred several times since this method of examination was introduced.

Hyperacidity.—In chronic ulcer of the stomach, hyperacidity is almost always present. It has frequently been claimed that the presence or absence of free hydrochloric acid in the stomach and the presence of lactic acid can be used in making a differential diagnosis between chronic ulcer and carcinoma of the stomach. This method, however, is not to be trusted for making a differential diagnosis between the two diseases, and its employment is likely to cause serious mistakes. Extensive observations which have been made in a very large number of patients by a number of independent investigators seem to prove that free hydrochloric acid is absent from the stomach contents in a large proportion of normal stomachs in persons over sixty years of age. As carcinoma occurs more frequently in persons advanced in years it is plain that it would not be proper, in the examination of stomach contents, to place much reliance upon this element as a basis for the diagnosis of carcinoma.

Hemorrhage.—The copiousness of individual hemorrhages in chronic gastric ulcer may vary greatly. The amount of blood lost may be so small that it will require the most accurate chemical examination of the faeces to determine its presence. Then, again, the amount may be so large as to prove fatal. The bleeding may occur at very short intervals, so that the patient is subjected to an almost constant loss of small quantities of blood; or there may be considerable periods of time between recurrences. In some instances the hemorrhage occurs when the patient has an abundance of blood, and continues until he becomes anaemic; then the bleeding ceases, only to recur when a certain amount of plethora has been established. The blood may all pass into the intestine, and thus the occurrence of the hemorrhage is not discovered until the attention of

the patient is attracted by the discoloration of the fæces, showing the presence of partly digested blood. In other instances the patient may vomit the greater portion of the blood. The symptom of hemorrhage alone, unless it is severe, should not be considered an indication for operation except in cases in which the resulting anæmia is sufficient to determine the necessity for an operation. This may be the case in patients who have never had a severe hemorrhage, or in those in whom a persistent slight hemorrhage has resulted in the loss of more blood than could be reproduced by the body.

The Recognition of the Occurrence of Perforation.—The occurrence of perforation may take place in either of the conditions which have just been described—*i.e.*, in either the acute or the chronic form of gastric ulcer. A definite history of the existence of one or both of these conditions previous to the occurrence of a perforation is usually obtainable. The symptoms will correspond to the symptoms relied upon for the diagnosis of acute or chronic gastric ulcer. The patient suffers from a very acute attack, the exciting cause for which is usually some rather severe physical exertion. Occasionally the attack comes on after some indiscretion in eating. Very rarely does it occur without any apparent exciting cause. The patient suffers from extreme pain in the upper portion of the abdominal cavity, and he usually describes the pain as coming on with a feeling as though something had ruptured. The abdominal muscles immediately become tense and the patient is in a condition of severe shock. There may be vomiting of stomach contents or of blood, or there may be nausea, with unsuccessful attempts at vomiting. Physical examination elicits a tense condition of all the abdominal muscles, but especially of those in the upper half of the abdomen. There is severe pain upon pressure; and in most patients, but not in all, there is an absence of liver dulness. The condition of the pulse indicates the presence of shock. At first, there is no rise of temperature, but this comes on with the progress of peritoneal infection. If the condition is not relieved early, the late symptoms are those of peritonitis. The presence of liver dulness should never be taken as positive evidence of the absence of perforation of the stomach.

Operative Treatment of Perforated Gastric Ulcer.

Operation is always indicated in perforated gastric ulcer, provided the patient comes under treatment during the first twelve hours after the perforation has taken place.

Statistics show that the mortality of these cases does not exceed twenty-eight per cent, while that of cases coming under treatment more than twenty-four hours after perforation has occurred is three times as great. At this late stage the choice of operative treatment must depend upon the judgment of the surgeon. If the condition present indicates the probability of a closure of the perforation by a plug of omentum or by the presence of adhesions, it may be wise to sustain the patient with exclusive rectal feeding until a circumscribed abscess has formed as a result of the infection, which abscess may then be drained.

Technique in the Simpler Operations.—In cases which come under treatment

fairly early there are a few definite rules which should be followed:—First, there should be made a long median incision, extending from the ensiform appendix of the sternum to a point 5 cm. below the umbilicus. Then an immediate search should be made for the opening in the stomach, and, when found, it should be closed by means of a pad held in position while the stomach contents which have previously been forced out of the stomach are carefully sponged away. In searching for the perforation one should proceed systematically, in order to save time and to avoid inflicting a traumatism through manipulation of the parts. To insure the finding of the perforation, the stomach should be searched in the following order: first, the anterior wall; second, the lesser curvature; third, the greater curvature; fourth, the pylorus and duodenum; and, fifth, the cardiac end. Should no perforation be found after this search, the omentum and transverse colon should be elevated and the lower portion of the abdominal cavity carefully packed away with gauze tampons. Then an opening should be torn through the non-vascular portion about the middle of the mesocolon. If the perforation has taken place in the posterior surface of the stomach, some stomach contents will appear in this tear and should be carefully sponged away, and the perforation in the stomach should be treated in the manner which will be described in the treatment of perforations in other portions of the stomach. Usually a perforation of the posterior wall of the stomach is protected by adhesions, so that it is not often necessary to resort to the operation which has just been described.

In operating for perforations of other portions of the stomach, the surgeon grasps the perforation as soon as it is found, his object being to effect a temporary closure of the opening. A careful search should be made for every soiled surface, and this surface should be carefully sponged, so as to remove all of the stomach contents, while inflicting at the same time as little injury as possible to the peritoneal surface. Before proceeding with the operation, the surgeon should shut off the remaining portion of the peritoneal cavity by packing it with gauze pads. A stomach tube should then be introduced and gastric lavage should be carried out until the water returns clear. Care should be taken to siphon out all of the water so that the stomach may be manipulated, during the remainder of the operation, without danger of soiling the peritoneum by the further forcing out of any of the stomach contents.

The operation must accomplish three things: first, it must control the hemorrhage; second, it must effect a permanent closure of the opening; and third, it must produce a stomach free from any deformities which might later lead to obstruction. The hemorrhage has usually ceased by the time the operation is begun and it is consequently not necessary to pay any special attention to this condition. If the hemorrhage has not ceased, then it is well to place deep sutures of catgut through the wall of the stomach sufficiently far back from the edge of the ulcer to prevent cutting through when the sutures are tied. The tissues are usually very fragile and the sutures may easily cut through, unless they are tied gently. With care this complication can be avoided. The opening in the stomach may then be closed with a row of Connell sutures, covered by a second

row of Lembert sutures. It is usually best to place the row of sutures at right angles to the long axis of the stomach, to prevent such a narrowing of the lumen of this organ as might cause obstruction. It is best not to place the sutures too near the margin of the ulcer because of the danger of having them cut through if the patient should vomit. Instead of the Connell suture, one may employ, with equally satisfactory results, two rows of Lembert sutures. The first row should be placed quite deeply in order to secure a firm hold upon the walls of the stomach. The point of the needle should always engage in the submucous connective-tissue layer. If the approximation of the edges is satisfactory throughout, nothing further need be done; but, if it is not perfectly satisfactory, it is well to fasten a portion of the omentum over the line of suture by means of a few stitches. If there has been a large extravasation of stomach contents, a drain should be carried down through the upper angle of the wound to the line of suture, and a second drain should be inserted into the cul-de-sac of Douglas, through a second incision in the median line just above the pubis.

When the perforation is in the pyloric end of the stomach, the right kidney pouch may be infected. In this case it is well to insert a through drain through an opening in the abdominal wall just in front of the right kidney, care being taken not to injure the colon. When the perforation is located at the cardiac end of the stomach and there is an infection of the left kidney pouch, the same form of drainage should be placed in front of the left kidney. It matters little whether glass, rubber tube, or cigarette drainage be employed. The form of drainage preferred by the author consists of a split rubber tube, 2 cm. in diameter and containing a loose strand of gauze.

In case there has been only a slight amount of extravasation, a single drain introduced through the upper end of the abdominal wound and extending down to the suture line will suffice. Before the abdominal wound is closed, the surfaces of the exposed intestines, omentum, and stomach should again be carefully sponged, and, in order not to inflict a traumatism, these surfaces should be handled with the same degree of care that was recommended by us in our description of the first attempt to cleanse the soiled peritoneal surfaces.

If the perforation has taken place at a point near the pylorus, one may reasonably expect a certain amount of obstruction, and it may become necessary to perform a gastro-enterostomy for the relief of this obstruction. It is rarely either wise or necessary to perform gastro-enterostomy at the time of closing an acutely developed perforation of the stomach, because the additional time required is likely to be sufficient greatly to increase the gravity of the prognosis.

Gastro-enterostomy.—Gastro-enterostomy is performed, first, for the relief of obstruction of the pylorus; second, for the purpose of overcoming the irritation due to the passage of food over an ulcer in the pyloric end of the stomach; third, for the drainage of a severely distorted stomach; fourth, for the drainage of a stomach containing an inoperable carcinoma of the pylorus; and, fifth, for the purpose of establishing a communication between the remnant of the stomach and the intestine into which the greater or smaller portion of the pyloric end of the stomach has been inserted.

There are four distinct operations which should be considered, because each one of these methods is used with eminently satisfactory results by a number of the most experienced surgeons. They will be described in the order of their value.

The preliminary treatment, the incision, and the post-operative measures are the same in all of these operations. Consequently they will be described together, while each one of the operations will receive individual attention.

Preliminary Treatment.—In cases in which gastro-enterostomy is performed for the relief of an acute gastric hemorrhage, there can be no preliminary treatment, as the operation is an emergency operation and must be performed at once in order to prevent fatal hemorrhage. It has been stated before, however, that it is seldom necessary to perform this operation for acute gastric hemorrhage, because in most instances it is possible to carry the patient through this condition, to overcome the consequent anæmia, and thus to place the patient in a much safer condition for operation.

For several days before this operation it is advisable to give careful attention to the disinfection of the teeth and the cavity of the mouth. A mild antiseptic should be used as a mouth wash and gargle, and the teeth should be carefully cleaned several times during the day. The gastro-intestinal canal can be best disinfected by giving the patient only sterilized concentrated liquid nourishment, or by placing him on exclusive rectal feeding for from twenty-four to forty-eight hours, and by giving two ounces of castor oil in beer foam, at intervals of twenty-four hours, for two or three days. This will overcome the accumulation of gas in the intestines and will leave the gastro-intestinal canal fairly free from pathogenic micro-organisms.

If the operation is performed for the relief of pyloric obstruction, it is well to make use of gastric lavage two or three times a day for several preceding days. If the operation is for the relief of an obstruction due to carcinoma and associated with a tendency to hemorrhage, it is best to avoid this step. A number of antiseptics have been recommended. Of those which have been used by the author, oil of eucalyptus, given in doses of from five to twenty drops every three to six hours, has seemed to be the least objectionable. It is doubtful, however, whether any of these antiseptics are of any special value. Except in the presence of an open ulcer it is well to irrigate the stomach carefully and thoroughly with normal salt solution immediately before the patient is anæsthetized. In one instance, in the author's experience, the patient showed a marked degree of collapse after the introduction of the stomach tube, and an immediate operation demonstrated the existence of an acutely developed perforation. This would indicate the necessity of employing great care in selecting cases that are safe for the employment of gastric lavage.

In other cases the gastric lavage can be employed after the abdomen has been opened. If the stomach tube invented by Professor Kausch is employed, there is no danger of inspiration of stomach contents, provided the lavage is carried out while the patient is under the influence of an anæsthetic. If this stomach tube is not available, the foot of the table should be elevated, the

patient's head turned to one side, and only a small quantity of fluid should be introduced through the tube at a time. The end of the tube in the stomach can be guided by the hand introduced into the abdominal cavity through the incision, and thus the ulcer will escape the irritation which the tube is liable to cause by pushing against it. The stomach cavity will be perfectly emptied by the lavage.

Abdominal Incision.—It is well to make an ample incision, in order that the traumatism necessarily caused by the manipulations of the operation may be as slight as possible. The harm done the patient by a long incision is of no importance as compared with the harm done by drawing the intestines and stomach through a small opening. The shock following the operation is largely due to manipulation of the intestines and stomach, especially if there has been a considerable amount of tension upon the mesentery. With a large incision traumatism can be avoided to a great extent. The incision usually chosen extends, in the median line, from the ensiform appendix of the sternum to the umbilicus. If the gastric disease is complicated with duodenal ulcer, cholecystitis, or appendicitis, three conditions which are quite common, it is best to make the incision at a distance of from 2 to 4 cm. to the right of the median line and parallel with it, the right rectus abdominis muscle being split longitudinally. If this incision is chosen, care must be taken not to injure the deep epigastric vessels which lie between the posterior surface of this muscle and the transversalis fascia. The entire stomach should next be carefully inspected and palpated, and so also should the exposed portion of the duodenum, as well as the gall bladder and the ducts. The omentum, together with the transverse colon, is now drawn up into the wound, and the small intestines with the exception of the upper end of the jejunum are tamponed away with gauze pads. All of these steps are the same, no matter which method of gastro-enterostomy may be chosen.

During all of the subsequent manipulations it is important to keep the field of the operation carefully tamponed away from the surrounding structures, in order to prevent soiling. It is also important to leave all of the structures as much as possible within the peritoneal cavity, in order to prevent shock from exposure to the air.

The manipulation of the various intra-abdominal organs should be reduced to a minimum; every manipulation should accomplish a definite purpose. The success of the operation—no matter which method be chosen—depends very largely upon the observance of this precaution. Most of the complications—such, for example, as post-operative pneumonia, peritonitis, post-operative adhesions, and shock—are due to unnecessary manipulations during the operation or to the infection which has resulted from the trauma caused by these manipulations.

Gastro-Enterostomy by the Moynihan-Mayo Method.

The Moynihan-Mayo operation contains all of the elements which can be demanded from a satisfactory operation.

In the first place it is simple.

It can readily be performed by any surgeon who is competent to do abdominal surgery.

It does not expose the patient to a great amount of shock.

It places the opening at the lowest point of the stomach.

It provides an opening sufficiently large to guard against secondary obstruction due to contraction.

It establishes an immediate communication between the stomach and the jejunum.

It supplies a direct passage without angulation of the intestine.

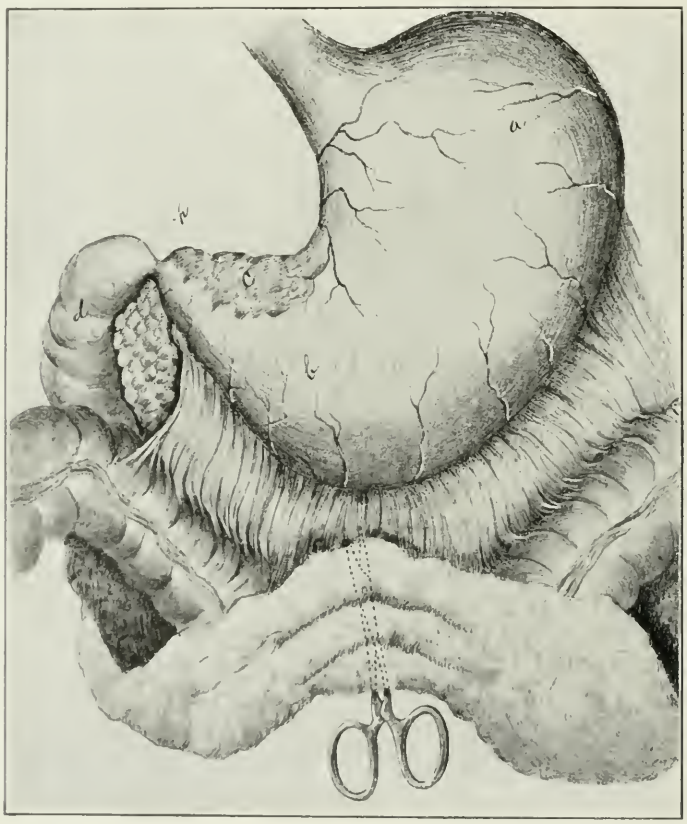

FIG. 108.—Diagram Showing the Application of Tenaculum Forceps to the Lowest Point in the Greater Curvature of the Stomach, as recommended by W. J. Mayo. The dotted line shows the forceps passing behind the omentum and transverse colon through the mesocolon to the lowest point in the stomach. *a*, Cardiac end of stomach; *b*, the pyloric end; *c*, area of disease; *p*, narrowed pylorus; *d*, duodenum.

It leaves no loop which later might cause strangulation of the small intestine passing through it.

It provides against soiling with intestinal or stomach contents during the operation.

It prevents the possibility of hemorrhage either during or after the operation.

In order to appreciate this method fully it is important to bear in mind the anatomical relations of the greater curvature of the stomach to the upper end

of the jejunum. Ordinarily the greater curvature of the stomach overlaps the jejunum throughout a distance of from 5 to 6 cm. The location of the jejunum corresponds very nearly to the lowest portion of the greater curvature of the stomach; it is of the greatest importance to place the opening in the stomach at the lowest point. Mayo has pointed out the fact that, by doing this, it is possible, in almost every case, to prevent regurgitant vomiting after gastro-enterostomy. That this occurrence, commonly called "vicious circle," can thus be

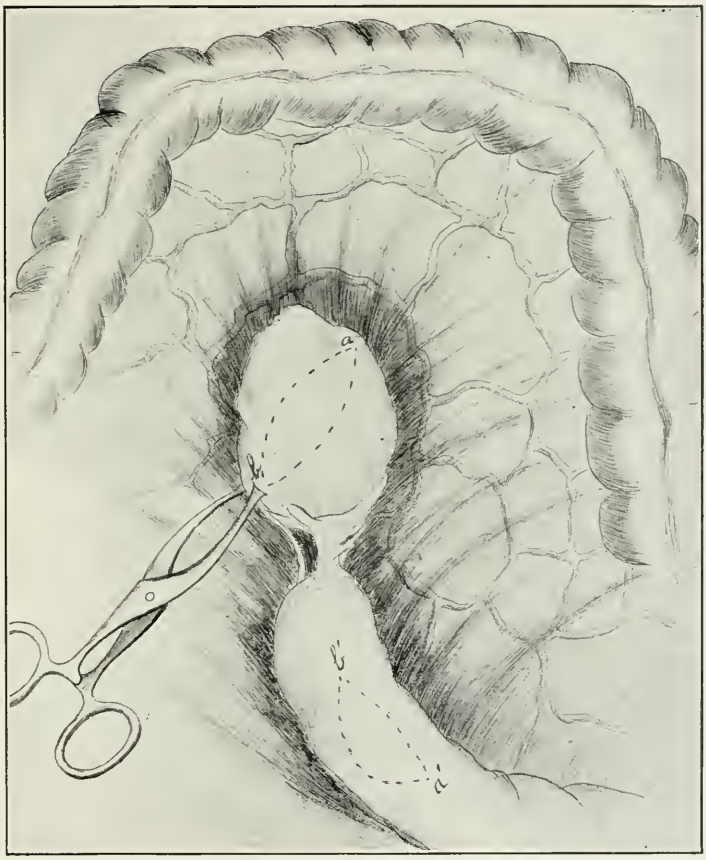

Fig. 109.—Diagram Showing that Portion of the Lowest Part of the Stomach which has been drawn through an Opening in the Transverse Mesocolon. The dotted lines, *a*, *b*, indicate the location and direction of the proposed opening in this part of the stomach, and the dotted lines, *a'*, *b'*, the proposed opening in the jejunum.

prevented, has also been proven in a large number of cases operated upon by the author.

According to Lewis, in about eighty per cent. of all cases the direction followed by the jejunum, after passing through the mesocolon, is from the upper right hand to the lower left. Consequently the opening on the posterior surface of the stomach should extend in this direction, as advised by Mayo and Munro.

Fig. 108 illustrates a plan which Mayo has devised for locating the point in the lower margin of the greater curvature of the stomach which corresponds accu-

rately to the point at which this margin crosses the duodenum. This point is located and permanently marked by passing a mouse-tooth tenaculum forceps through the mesocolon and fastening it to the desired point. The stomach is then drawn out through the abdominal incision, as shown in Fig. 109, and an opening is torn in the mesocolon at a non-vascular point opposite the crossing of the jejunum. (Fig. 109.) A second pair of delicate forceps is then applied upward and to the right of the point of application of the first forceps, at a distance of from 5 to 7 cm. according to the degree of gastric dilatation. This distance should be greater in cases in which the degree of dilatation of the stomach is marked, because, when the post-operative contraction occurs, the gastro-

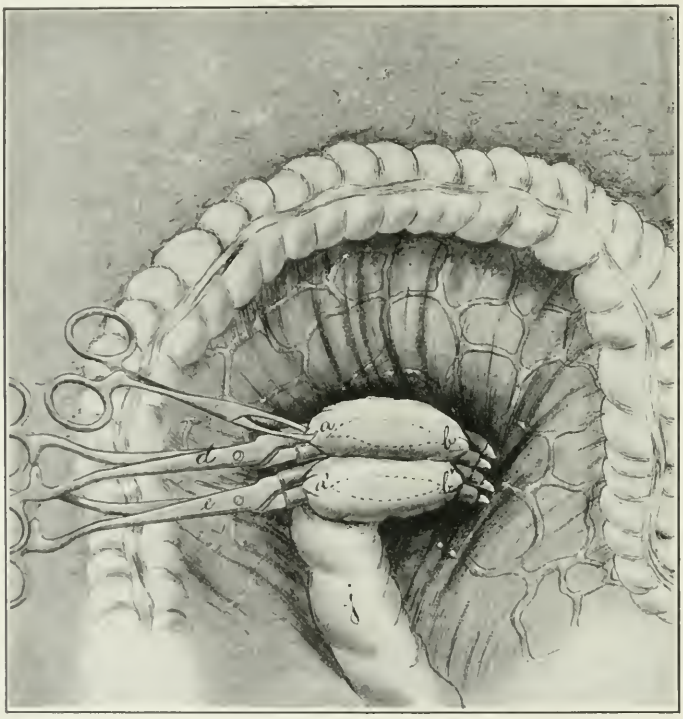

FIG. 110.—Diagram Showing Portions of Stomach and Jejunum held together in Position by Means of Clamps; clamp *d* being on the stomach and clamp *c* on the jejunum.

enterostomy opening will decrease to correspond with the degree of diminution in the size of the stomach. A pair of forceps is then applied to this portion of the stomach, as shown in Fig. 110, care being taken to secure a sufficient amount of projection of the stomach wall beyond the forceps to prevent tension during the act of suturing. It is well to protect the blades by drawing over each of them a piece of thin soft-rubber tubing, although this is not done by all surgeons. The jejunum is next grasped in the same manner, the portion chosen being a spot from 1 to 3 cm. from the point at which the intestine passes through the mesocolon, as shown in Fig. 109, *a'* to *b'*. The intestinal wall is grasped by the forceps in the same manner as is the stomach wall, and the two forceps are

placed side by side, as shown in Fig. 110. The steps indicated in Figs. 111, 112, 113, 114, 115, 116, and 117 are then carried out, with the result that the jejunum remains permanently attached to the stomach, as shown in Fig. 111. The tear in the meso-colon is next mended by suturing this border to the jejunum just

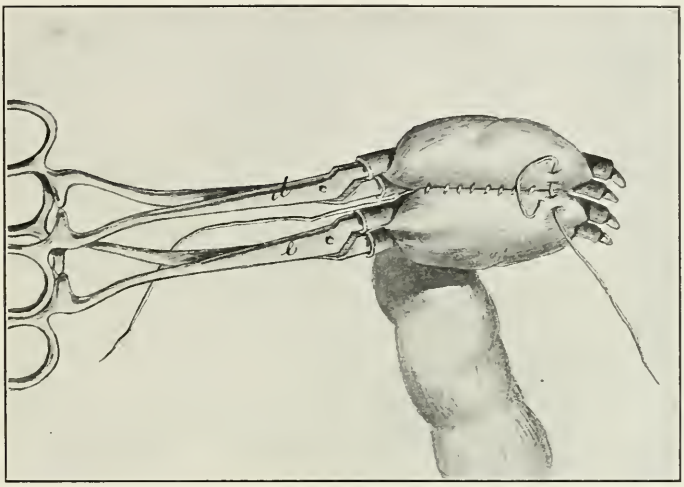

Fig. 111.—First Step in the Actual Uniting of the Stomach and Intestine. Clamp *d* is on the stomach and clamp *e* on the jejunum, and the posterior Lembert suture is in place.

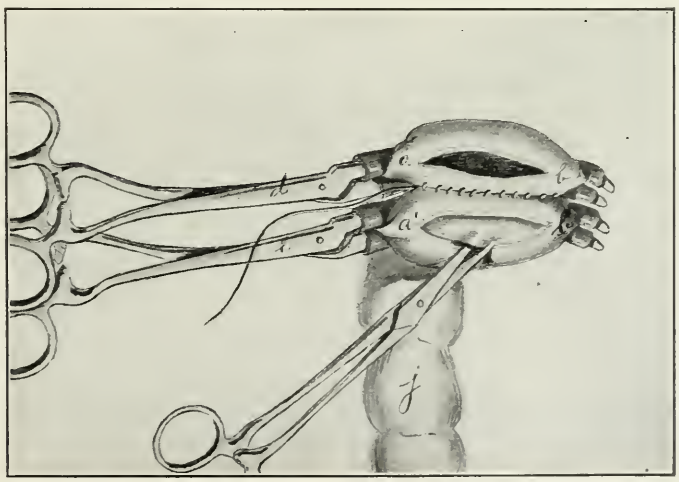

Fig. 112.—In this Diagram a further Step has been made in the Operation for Establishing Anastomosis between the Stomach and the Intestine. The opening in the former organ has been completed and that in the jejunum has been begun.

beyond the line of suturing, as shown in Fig. 118. The surface is then carefully sponged, and the abdominal wound closed.

It is important, especially in cases in which there is much fat in the mesocolon, to make the scar sufficiently large to prevent subsequent contraction and obstruction.

The steps of the operation, as shown in Figs. 111–117, are very simple. The first step consists in placing a continuous row of Lembert sutures, as shown in Fig. 111, the stomach and intestine being still intact. The next step consists in making in each of these two organs an opening a little shorter than the row of sutures that has just been applied. (Figs. 112 and 113.) The opening should be

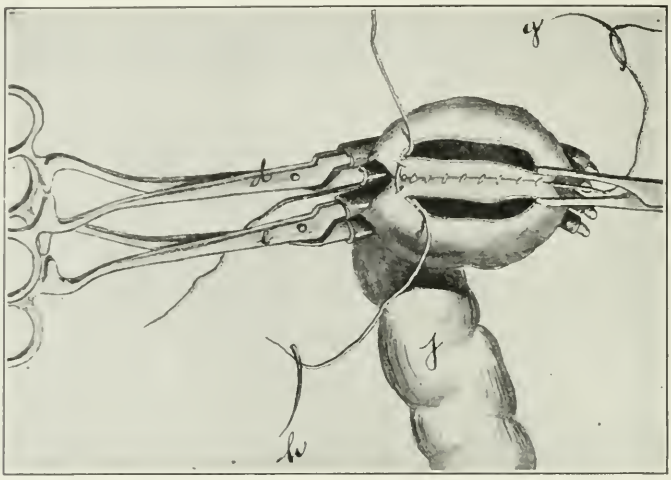

Fig. 113.—In this Diagram the Two Openings are Represented as having been completed; and the first suture, *b*, which passes through all the layers of the intestinal and stomach walls, is shown to be in place

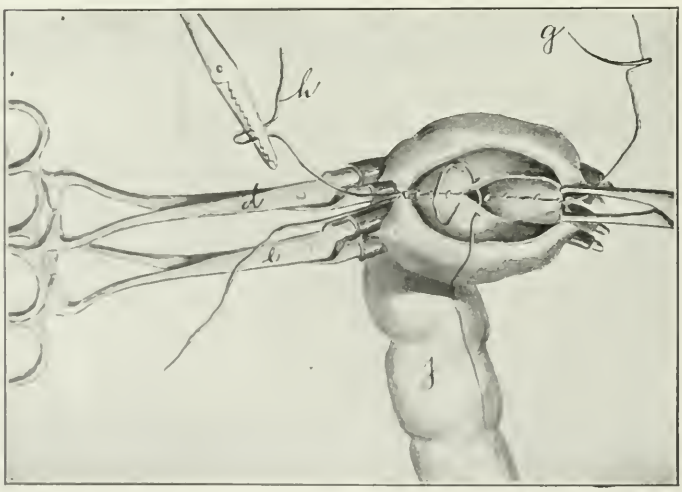

Fig. 114.—Diagram Showing the Relations of some of the Deeper Parts of the Anastomosis. (For details, consult the text.)

at least 5 cm. in length. Care must be taken not to permit any soiling from the stomach or intestinal contents which may be contained in the small portion which is held in the grasp of the forceps. This portion is carefully sponged, and then the edges of the stomach and the intestines are sutured by a continuous suture, preferably chromicized catgut, as shown in Fig. 113.

Fig. 114 shows in the foreground the superficial row of sutures which bring together all the layers of the stomach and the intestine and which pass through the entire thickness of the walls, while at a deeper level may be seen the row of Lembert sutures which were first applied. In Fig. 115 the sutures have been carried around in front so as to bring together the anterior edges of the anastomosis wound. In Fig. 116 this row of sutures has been completed, and the anterior Lembert suture is being applied, the clamps having been removed to facilitate this step. It is best to arrange the beginning and ending of these rows of sutures in such a way as to prevent the final tying of the sutures from coming exactly in the same place, because this might cause a slight defect—a defect, however, which can be easily corrected by placing one or two additional Lembert sutures at this point. It is still better to begin the Lembert suture to the right of the proposed gastro-enterostomy opening and the suture which grasps all the

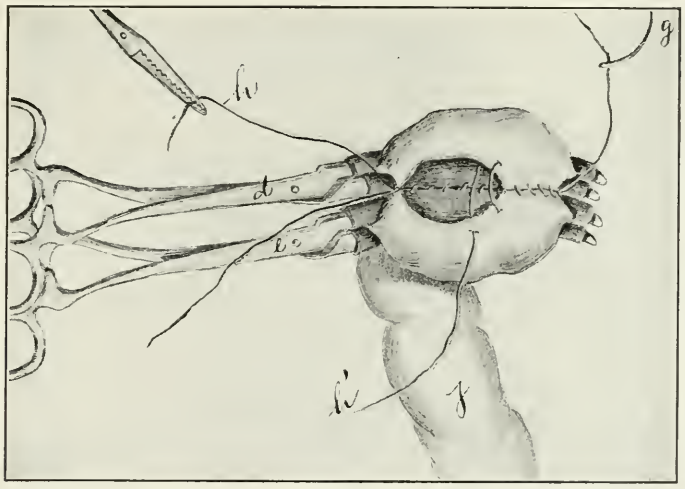

Fig. 115.—Diagram Showing a Still Later Stage of the Operation. Here both the posterior sutures are completed and the through suture is half completed anteriorly. (N.B. *b* and *b'* have been drawn, both here and in the other figures, so as to look like *h* and *h'*.)

layers to the left, by which arrangement the points of tying of these two sutures will be placed at the greatest possible distance apart.

It does not matter whether the deep sutures are applied, according to Moynihan's method, in the form of a glover's suture, with the stitches placed closely enough to each other to prevent hemorrhage, or whether Connell sutures are employed, as introduced by C. H. Mayo. The number of stitches necessary in this latter method is only one-half as great, and for this reason some surgeons may prefer this method. This suture will be described fully in connection with the Connell method of gastro-enterostomy (p. 365); it will therefore not be necessary to describe it at this point.

Fig. 119 shows the relative positions of the stomach, duodenum, jejunum, and transverse colon after the completion of the operation. It also shows the direction of the gastro-enterostomy opening and its location at the lowest point of the greater curvature of the stomach. Theoretically, this operation establishes the

best possible conditions; a large number of clinical results obtained by this method seem to indicate that it will ultimately be accepted as the ideal gastro-enterostomy.

Gastro-enterostomy by Means of the McGraw Elastic Ligature.

This method, which will be described in detail farther on, has been found most satisfactory in all cases in which there is not a complete obstruction of the pylorus. If there is a complete obstruction of the pylorus there can be no

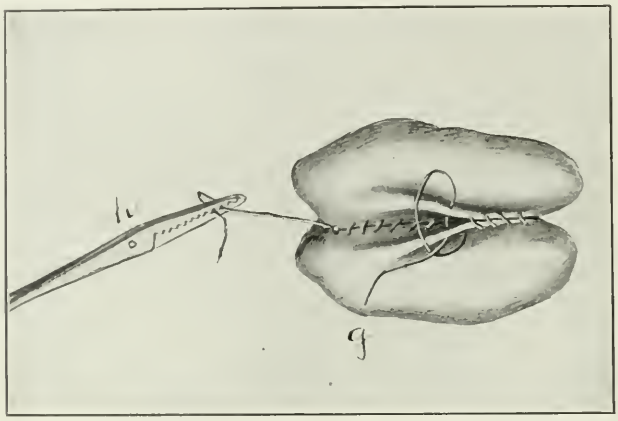

Fig. 116.—In this Diagram the Through Suture is Represented as Being Entirely Completed and the Anterior Lembert Suture as Half Completed. The clamps have been removed.

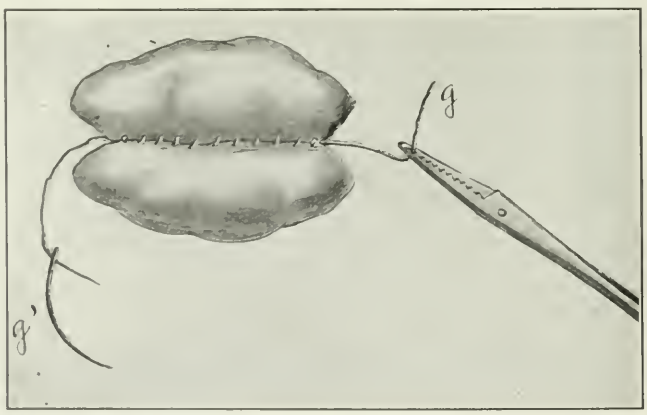

Fig. 117.—This Diagram Represents the Operation as Completed, Only the Anterior Lembert Suture Being Visible.

drainage into the intestinal canal from the stomach for at least one or two days. There may be an accumulation of fluid in the stomach which cannot pass into the intestines until the constricting rubber band has caused a sufficient amount of pressure necrosis to establish a communication. Ordinarily this accumulation of fluid is not a matter of importance because it can readily be evacuated by the use of gastric lavage. In patients who are greatly reduced in strength it is often

desirable to give some form of concentrated predigested food by way of the mouth, soon after the operation has been performed, and in these cases food cannot of course be safely given by way of the mouth, since it cannot pass from the stomach into the intestines if this method of operation is chosen. Moreover, it has been demonstrated clinically that the elastic ligature accomplishes its object much more slowly in patients who are greatly reduced in strength than it does in those who are vigorous. A certain amount of vital energy seems to be required if pressure necrosis is to take place. It has been found at autopsies,

FIG. 118.—In this Diagram is Shown the Manner in which the Jejunum, after Being Attached to the Stomach at the Spot where the Anastomosis is to be Established, is Itself Sutured to the Mesocolon in such a Manner as Completely to Close the Tear in that Structure.

in these greatly reduced cases, that, after the lapse of from three days to a week, the ligature had failed to cause the degree of pressure necrosis necessary for the completion of the gastro-enterostomy. Experiments, on the other hand, have shown that, in cases in which the tissues were more nearly normal, the ligature cuts its way entirely through in from two to five days. For this reason it is wise not to employ this method in patients who—by reason of the fact that they have experienced one or more severe hemorrhages, or because they are in a state of advanced cachexia due to the presence of carcinoma—are very greatly reduced in strength. In all other cases this method, if carefully applied, has given most satisfactory results. The author has employed it in more than two hundred cases and has obtained clinical results quite equal to those obtained with the method previously described. On the whole, however, he prefers the latter method, and he has employed it in a much larger number of cases.

The advantages of this operation are the following:—

It is exceedingly simple.

It necessitates but a slight amount of manipulation and therefore reduces traumatism to a minimum.

There is no soiling of the tissues with intestinal or gastric contents.

It prevents the possibility of a post-operative hemorrhage.

The opening can be made of any desired length.

The operation can be performed quickly.

It requires no special skill or ingenuity.

The patient shows very little, if any, shock after the operation.

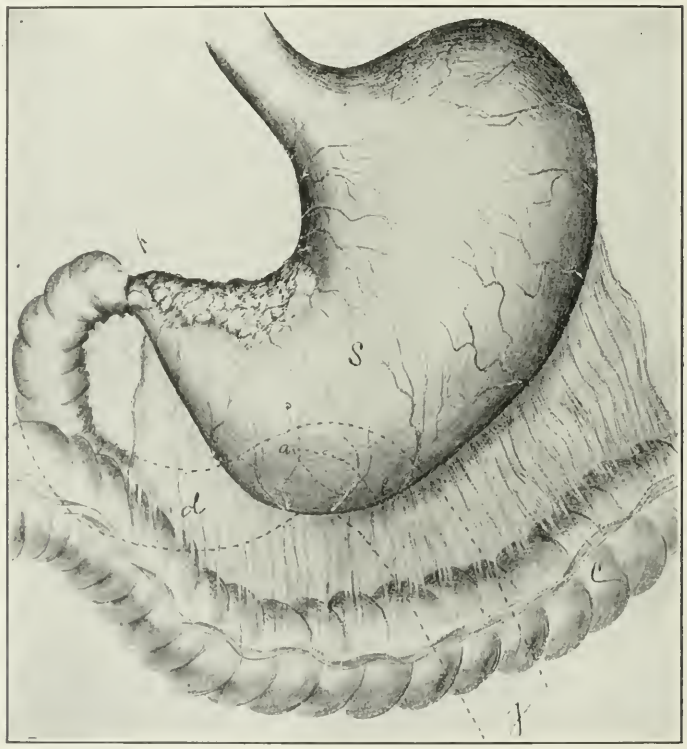

Fig. 119.—Diagram Showing the Relative Positions of the Stomach, Duodenum, Jejunum, and Transverse Colon after the Completion of Posterior Gastro-enterostomy. (The Moynihan-Mayo method.)

He is relatively free from pain, and can usually sit up in bed, with the aid of a head-rest, a few hours after the operation.

The method should not be employed in making a pyloroplasty.

It should not be used in making a cholecystenterostomy.

The edges of the gastric opening are perfectly smooth and the amount of cicatricial tissue resulting from the operation is very small.

The only objections to the operation are to be found in the facts that the rubber ligature employed sometimes becomes brittle with age and that there is not immediately produced a communication between the stomach and the intestine.

With increasing experience the surgeon takes less and less kindly to mechanical means in all forms of intestinal surgery, and for this reason, more than for any other, this method has failed to be accepted generally by surgeons. The author's experience with this method has proven it worthy of recognition, and he believes that it is excelled only by the method just described as the Moynihan-Mayo method.

Contrary to the author's experience, H. O. Walker reports excellent results in pyloroplasty performed by this method in a sufficiently large number of cases to merit recognition.

Technique of the Operation.—In this, as in the preceding operation, it is preferable to make a posterior gastro-enterostomy through a tear in the mesocolon, the beginning of the jejunum being united with the lowest portion of the greater curvature of the stomach. The preparatory steps are the same as in the

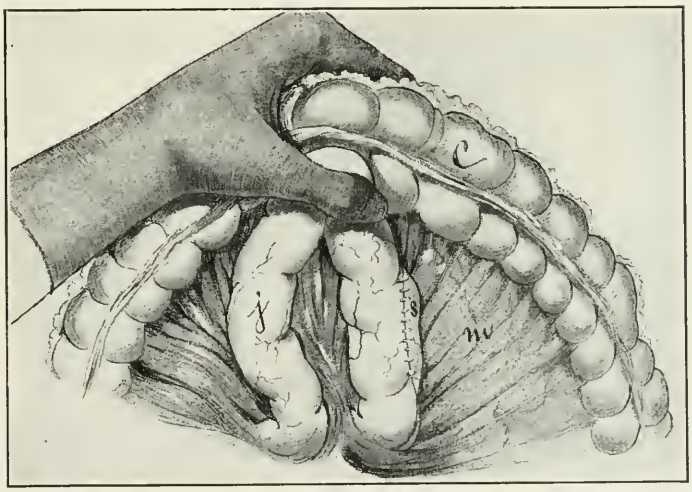

Fig. 120.—A Second Diagram Showing the Relative Positions of the Duodenum, Jejunum, and Transverse Colon, after the Completion of the Moynihan-Mayo Operation. The colon and small intestine have been lifted up in such a manner as to show the line of stitching on the posterior aspect of the bowel.

preceding operation. The transverse colon is drawn out of the abdominal incision and the beginning of the jejunum is located where it passes out from underneath the mesentery of the transverse colon. A hole is torn in the mesentery of the transverse colon, as shown in Fig. 109.

To make the various steps of this operation clear and concise the author has formulated a series of directions which, in order that the operation may be performed safely and that satisfactory results may be obtained, should be carefully heeded. These directions are as follows:—

1. A round rubber cord, 2 mm. in diameter, made of the best material, should be used.

2. A posterior row of Lembert sutures should be applied in the manner shown in Fig. 121.

3. A long straight needle, armed with the rubber ligature, is next passed

into the lumen of the intestine and out again at the desired distance (from 5 to 10 cm.) away from the point of introduction.

4. While an assistant holds the intestine the surgeon stretches the rubber in the needle, and when it is quite thin he draws it rapidly through the intestine.

5. The same step is repeated through the stomach, as shown in Fig. 122.

6. A strong silk ligature is placed across and underneath the rubber ligature, between the latter and the point where the stomach and the intestine come together, as shown in Fig. 123.

7. A single tie is made in the rubber ligature after the latter has been drawn very tightly.

8. The silk ligature is passed around the ends of the rubber ligature where they cross, and is tied securely three times, as shown in Fig. 124.

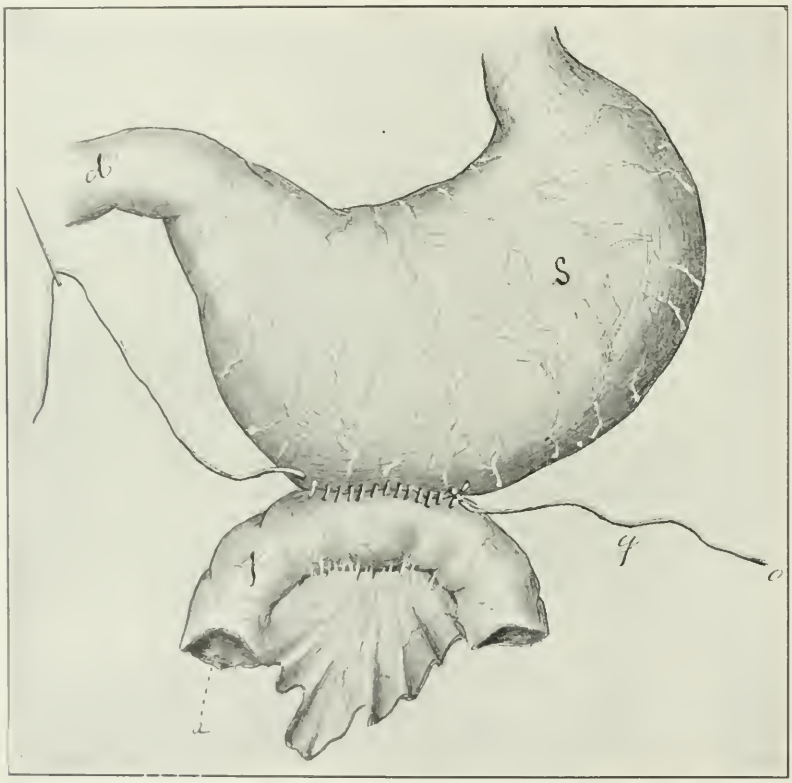

FIG. 121.—Diagram Illustrating the Operation of Gastro-enterostomy with McGraw Elastic Ligature. The posterior row of Lembert sutures (*g*) is in place. The lowest portion of the greater curvature of the stomach is chosen. In posterior gastro-enterostomy this must, of course, be drawn through the opening in the mesocolon. This is not shown in this and the succeeding diagrams.

9. The ends of the rubber ligature are released and cut off, the ligature itself being held by the silk ligature.

10. The Lembert suture is continued around the front until the point of its beginning is reached, at which point the two ends are tied, as shown in Fig. 125.

11. Care should be exercised to prevent tying the rubber ligature too far backward and thus getting behind the posterior row of Lembert sutures.

Gastro-enterostomy by the Method Advised by Roux.

In order to overcome the tendency to regurgitant vomiting, Roux has practised the following operation. The same preliminary steps that have been described on a preceding page are also required in this operation. The jejunum is located and a loop of this intestine is brought into the wound and held by means of a clamp the jaws of which are covered with rubber tubing to prevent injury by crushing, as shown in Fig. 126. A second clamp is then applied to the lowest point of the stomach, as shown in the Moynihan-Mayo method. (Fig. 110, at *a*.)

The length of the loop of the jejunum should be at least 20 cm. (from 20 to

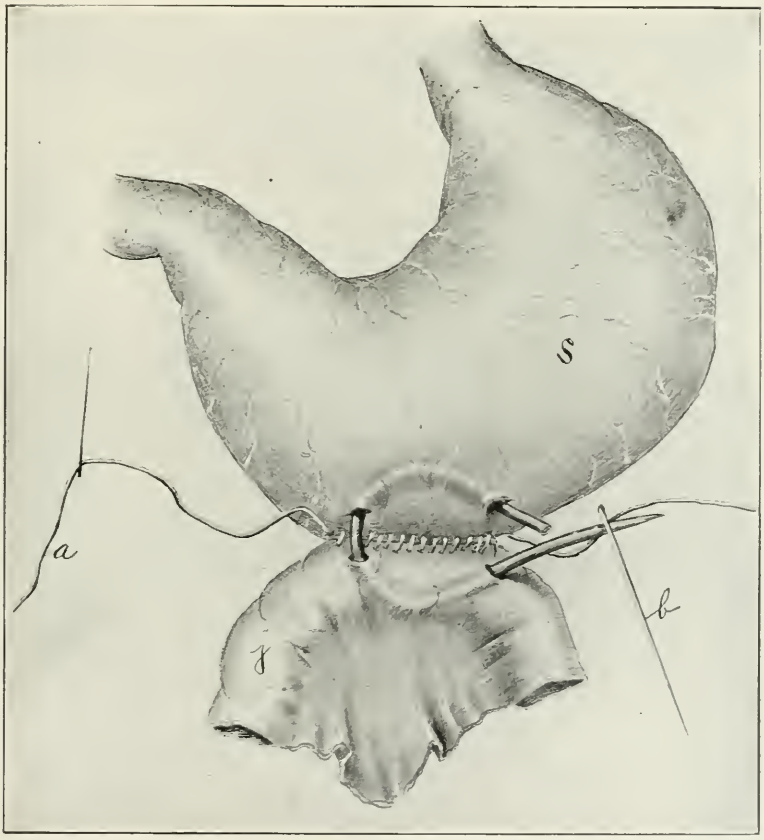

Fig. 122.—Diagram Showing the Second Stage of the Operation. (See Fig. 121.) The McGraw ligature, armed with the large needle *b*, is in place, and the posterior continuous Lembert suture (*a*) is shown.

to 30 cm.). The jejunum is then cut off at *a* (Fig. 126), and the extremity *b* is implanted into the other end of the jejunum, laterally, at *c*, while the end *d* is carried up to the lowest point of the stomach at the point *e* where it is implanted.

The clamp compressing the jejunum, and the clamp compressing the lower edge of the stomach, are not removed until the operation is completed. (Fig. 127.) In this manner all soiling may be prevented.

The anastomosis between the end *b* and the side *c* (Fig. 126) may be accomplished by the use of the Murphy button, as shown in Fig. 128, but it may also be accomplished by means of the Connell suture, or by means of a row of deep sutures and a superficial row of Lembert sutures. The same is true of the anastomosis between the end *d*, of the jejunum, and the opening *e* in the stomach. The diagram of the completed operation is shown in Fig. 127, the two branches of the jejunum forming the letter *y*. In this operation the suture method is replacing that by means of the button in the hands of most surgeons.

This operation can be performed as an anterior or as a posterior gastro-

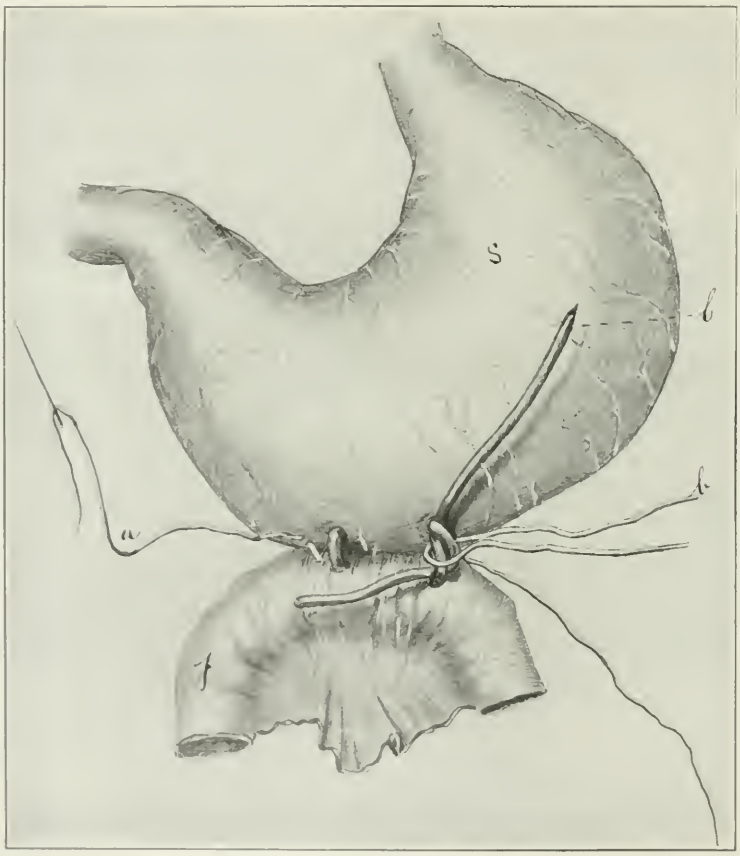

FIG. 123.—Diagram Showing the Third Stage of the Operation. A single tie has been made in the McGraw ligature (*l*) and the silk cord (*b*) is in place but still untied.

enterostomy. In case the anterior gastro-enterostomy is employed, the loop must be twice as long as when the posterior gastro-enterostomy is performed. There is of course a serious objection to this, in that it eliminates all that portion of the duodenum and the jejunum which lies between the point *a* and the point *b* (Fig. 126) from contact with food in the process of digestion.

The second objection is to be found in the fact that, if an anterior gastro-

enterostomy is made by this method, the branch of the duodenum, *a b* (Fig. 126), will be behind the omentum and colon, while the other portion, *a c*, will be in front of these structures—a condition which is likely to produce a considerable amount of tension. Moreover, unless the mesentery of the jejunum is unusually long, it is difficult to separate the parts *b* and *d* to so great a distance without causing tension upon the mesentery of this intestine.

Gastro-enterostomy with the Murphy Button.

There is no gastro-enterostomy operation more simple than that performed by means of the Murphy button. The following are its chief characteristics:—

It requires but a small amount of time.

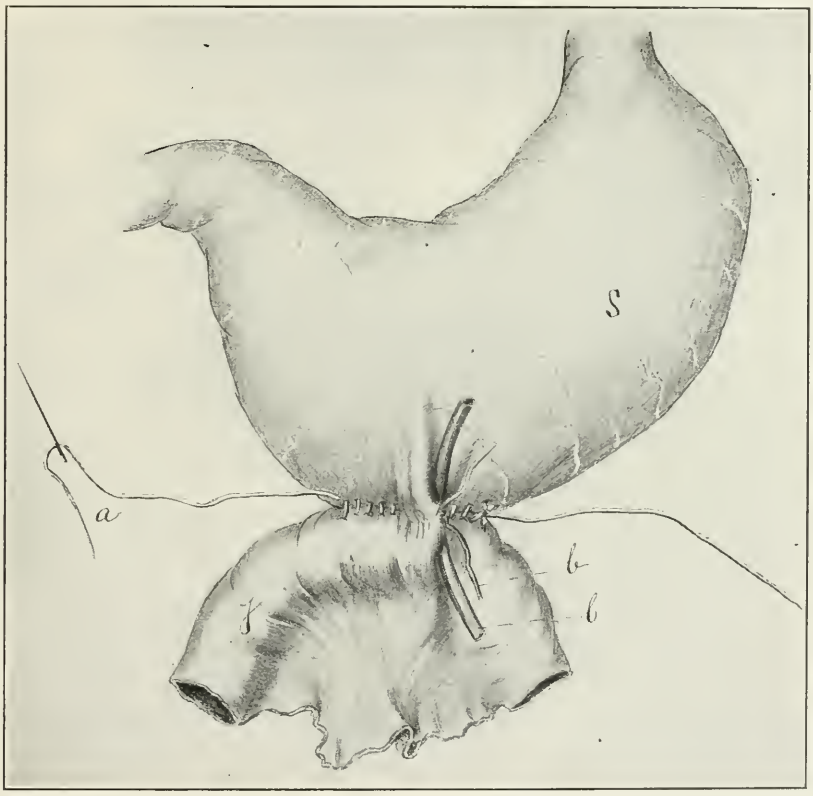

Fig. 124.—Diagram Showing the Fourth Stage of the Operation. The McGraw ligature (*l*) is tied very tightly and the silk cord (*b*) is drawn tightly around both ends, to prevent slipping. The long ends of the rubber ligature have not as yet been cut short.

The amount of manipulation is very slight.

The operation can easily be done by operators who have but a moderate amount of practical experience in intestinal surgery.

It leaves an anastomosis with the fewest possible adhesions.

It leaves the least amount of cicatricial tissue about the gastric opening.

It precludes the possibility of post-operative hemorrhage.

There are but two objections to the operation:—First, it is not possible to make an opening more than 4 cm. in length, even if the oblong button illustrated in Fig. 128, *b* is employed; and, in case there is a marked dilatation of the stomach at the time of the operation, the opening, by the time this organ has been reduced to the normal size, will be too small to drain the stomach properly. It has consequently been necessary, in a considerable number of these cases, to make a secondary operation for the purpose of enlarging this opening.

A second objection is to be found in the fact that the union between the intestine and the stomach does not become firm for some time after the operation has been performed, and in a number of these cases there has been a separation

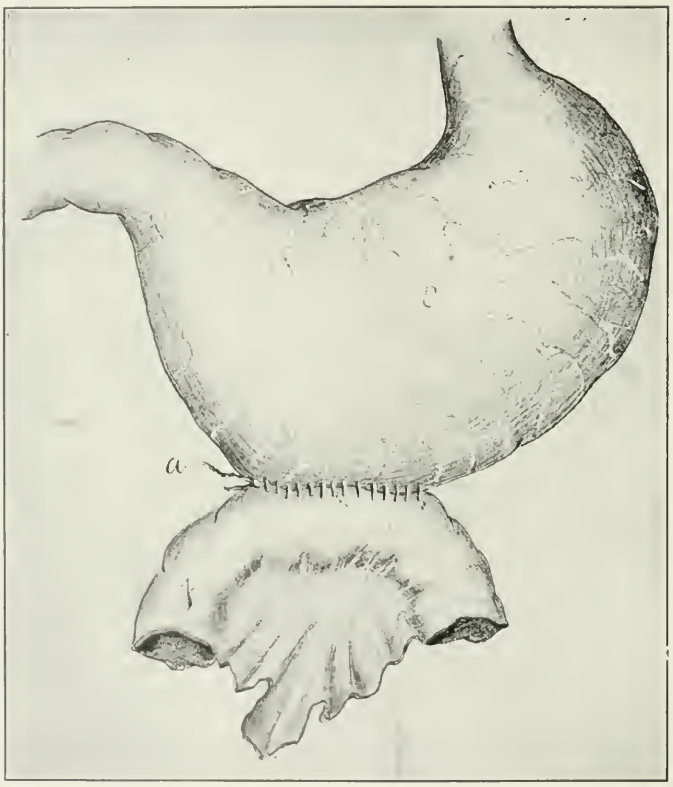

FIG. 125.—Diagram Showing the Completed Operation, with the Anterior Lembert Suture (*a*) Finished and the Ends Tied at the Beginning of the Suture.

of this union with leakage into the peritoneal cavity. In the author's experience this accident has occurred twice. Once it was due to a sudden paroxysm of vomiting which tore the intestine entirely loose from the stomach on the seventh day, after the patient had made a perfectly normal recovery. In the second patient there was a partial separation, with a consequent leakage. This case had progressed normally until the tenth day after the operation, when the patient made a quick motion which resulted in the separation of the intestine from the stomach, with partial leakage.

In order to prevent this accident, many surgeons re-enforce the anastomosis by the introduction of from two to four Lembert sutures. It is important to remember that a continuous suture should never be used in connection with the Murphy button, because it may prevent the latter from passing on through the intestine when union has taken place. This objection does not obtain with interrupted sutures.

This operation is indicated especially in cases of inoperable carcinoma of the pylorus with obstruction,—cases in which the patient is greatly reduced in

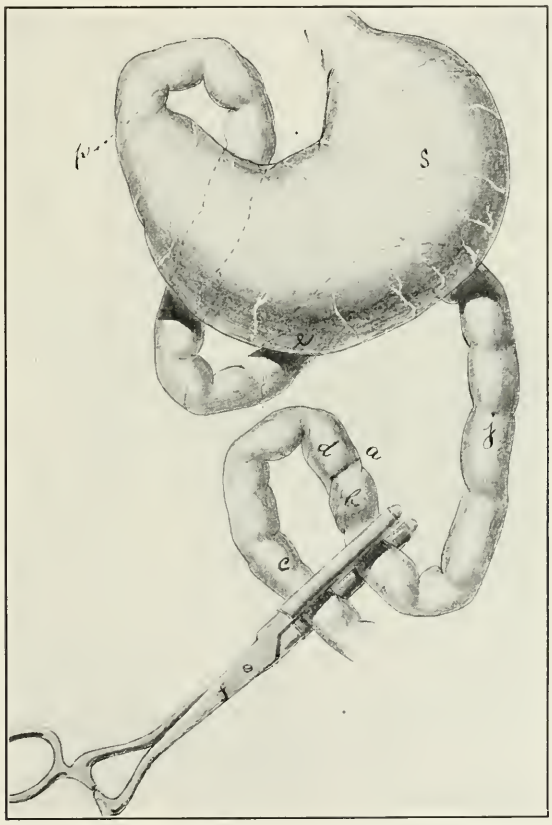

Fig. 126.—Diagram Showing Roux's Method of Gastro-enterostomy. *s*, Stomach; *p*, pylorus; *e*, point at lower part of stomach chosen for anastomosis; *j*, jejunum; *a*, point of section of jejunum; *d*, end to be attached to point *e* in greater curvature of stomach; *c*, point of anastomosis with *b* after the jejunum has been severed at *a*.

strength as a result of malnutrition. It is also indicated in cases in which the surgeon finds that the amount of time that would be required for making the suture anastomosis, would be a menace to the patient. In these cases it is well to make an anterior gastro-enterostomy, as shown in Fig. 129. In this operation the following points must be borne in mind:—

First, the opening in the stomach should be made at the very lowest point of this organ, as shown at *b*, Fig. 129. The presence of the large branches of the gastro-epiploic artery at this point frequently causes surgeons to place the

gastric opening on the anterior surface of the stomach, at the point *a*, Fig. 129. This blunder causes regurgitant vomiting in a large number of cases.

Second, the loop of the jejunum (*c*, Fig. 129) should be sufficiently long to pass around the transverse colon and the omentum without stretching, and without causing constriction. The distance between the point of anastomosis at *c* (Fig. 129) and the mesentery of the transverse colon should be about 40 cm. The circular suture is applied as shown at *b* (in same figure), care being taken to pass the needle quite through all the tissues, so that the vessels contained in the stomach wall shall be firmly grasped by this suture. After the suture has been

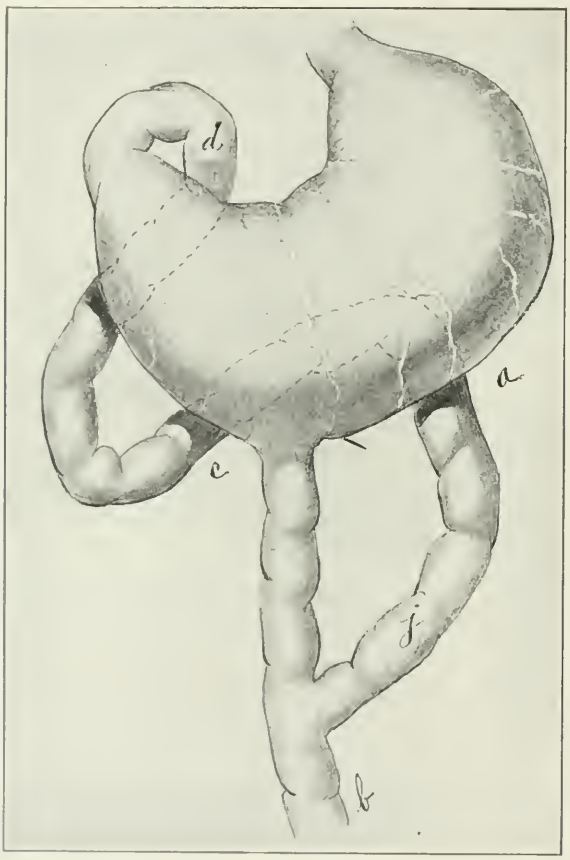

FIG. 127.—Diagram Showing the Roux Gastro-enterostomy Completed.

applied, the incision is made down to the mucous membrane, and a portion of this membrane is cut away, care being taken not to sever suture *b* while this is being done. The opening is made only just long enough to permit the introduction of the button without tearing the edges. In case the oblong button (Fig. 128, *b*) is used, this is inserted parallel to the gastro-epiploic vessels. The opening in this case need not be very long, because of the narrow shape of the instrument. Many surgeons who became accustomed to the use of this instrument before the introduction of a satisfactory suture method, still continue its use, but it is likely

that in the future this method will give way entirely to the suture method. Anterior gastro-enterostomy with the Murphy button will undoubtedly be limited in its application to cases of inoperable carcinoma of the stomach. For the relief of benign pyloric obstruction, the posterior method will, as it seems to us, be adopted almost universally.

Posterior Gastro-enterostomy.

In describing this operation I shall simply quote from my former work on the same subject. Lift up the large omentum; open the lesser peritoneal cavity through the non-vascular zone of the mesocolon, fix the mesocolon to the posterior wall of the stomach, about 8 cm. from the pylorus and close to the lower border, with four stitches, leaving room in the exposed gastric area for the insertion of the button. This converts a portion of the posterior wall of the

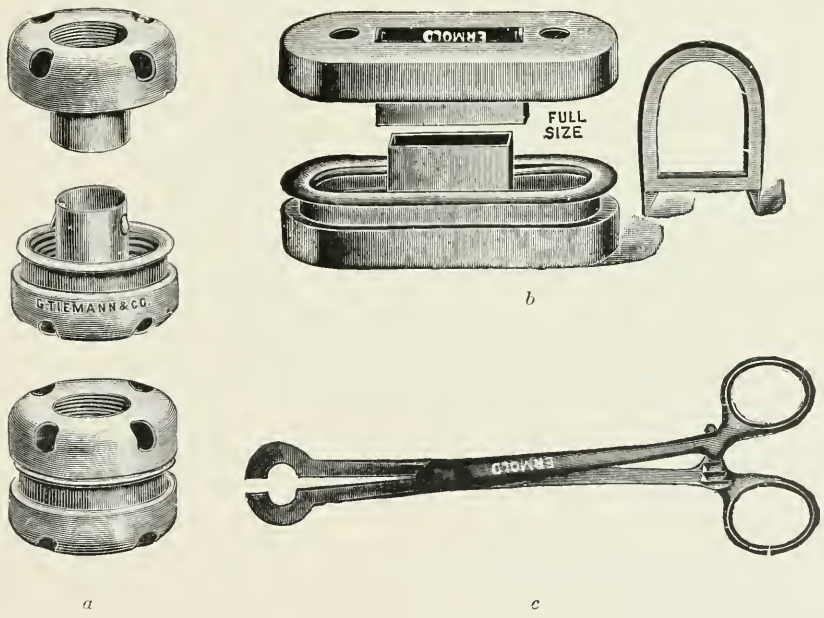

FIG. 128.—Round and Oblong Murphy Buttons, with Button Forceps. *a*, Round button; *b*, oblong button and key; *c*, button forceps.

stomach from a lesser to a greater peritoneal surface. It prevents the edges of the divided mesentery from forcing themselves between the edges of the stomach and duodenum, an occurrence which is responsible for many failures of union. The jejunum is then brought out, and two long floss needles, both held parallel to the branches of the gastro-epiploic artery and attached to opposite ends of one and the same linen thread, are inserted in the jejunal wall for a distance of 3 cm. The points of the needles face the operator and the needles lie parellel to each other and at a distance of from 5 to 10 cm. from the ligament of Treitz.

The intestinal wall is divided between the needles, which act as a splint. An opening, 2 cm. in length, affords sufficient room for the introduction of the button. Half of the button is inserted, the puckering string is tied, and the cylinder is grasped with the flat button-forceps (Fig. 128, *c*), which extends out to the operator's right. The opening of the cylinder during this time should be plugged with gauze. The jejunal fold is covered with a sponge, the under surface of the stomach is drawn forward, and the needles are inserted facing the operator. The stomach wall is divided for a distance of 2 cm., the thread drawn through, the button inserted, and the puckering string tied. The cylinder is

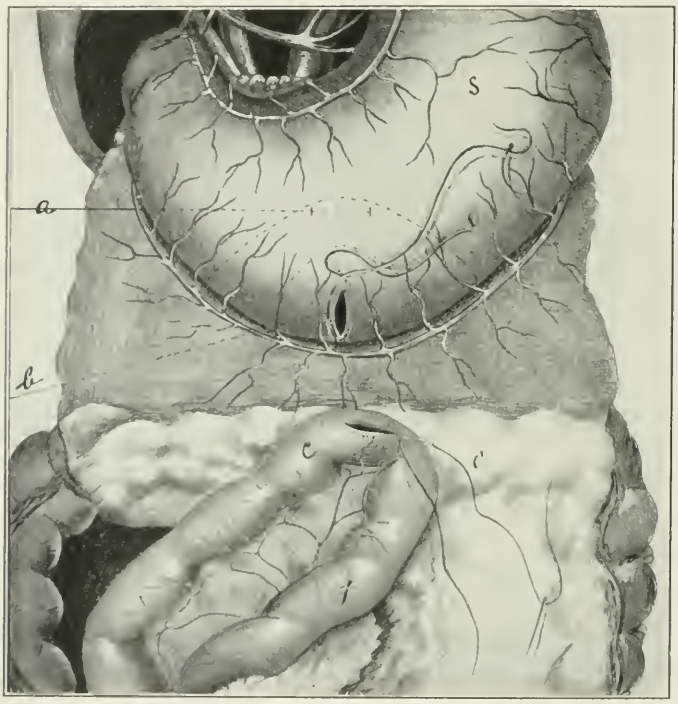

FIG. 129.—Diagram Representing Anterior Gastro-enterostomy with the Murphy Button. The dotted line at *a* indicates the position in which the gastro-enterostomy opening was formerly often placed by mistake—a blunder which caused regurgitant vomiting. *b* Shows the gastro-enterostomy opening in the proper position at the lowest point in the greater curvature of the stomach, the suture *c* being in place, *c* indicates the location of the incision in the jejunum. This incision is made longitudinally and the suture *c'* is in place.

grasped with the flat button-holding forceps, the latter being placed with the handles extending out to the operator's left. Both button-holders are now grasped and both cylinders are invaginated. The lower holder should be removed first and afterward the other, and the halves of the button should be pressed carefully together. Four additional interrupted Lembert sutures are placed at equal intervals around the button to give additional security. The oblong button (Fig. 128, *b*) acts as a splint during the repairing process, and it also prevents the kinking, which is one of the consequences of suture. The abdomen is then closed.

Gastro-enterostomy with the Connell Method of Suturing.

At this point it may be well to describe a method of suturing which is extremely simple and at the same time gives most excellent results, if carried out with due accuracy. The method has all the advantages of the Moynihan-Mayo method, together with that of greater simplicity.

Steps of the Operation.—The posterior wall of the stomach is exposed after the method described above. A fold of the stomach is caught in the bite of one of the side arms of a Roosevelt forceps. A fold of the jejunum is caught in the bite of the other side of this forceps. (Fig. 130.) An incision, from 5 to 7 cm. long, is then made in that portion of the stomach which projects above the forceps, and a similar incision is made in the projecting portion of the jejunum. In applying the Roosevelt forceps great care should be taken (as in the Moynihan-Mayo operation) to have the long axis of the opening in the stomach

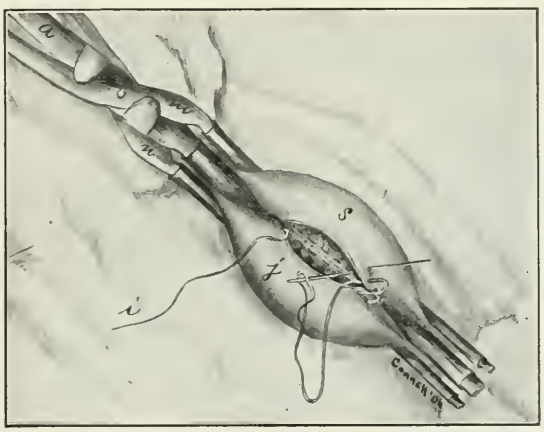

Fig. 130.—Diagram Showing a Fold of the Posterior Wall of the Stomach (*s*) and a Fold of the Wall of the Jejunum (*j*) Caught in the Jaws of the Roosevelt Forceps. The suture *i* has already been carried along the posterior border and is being started anteriorly. (From Connell.)

lie in the normal direction of the jejunum and to grasp the wall of the jejunum at a spot within 6 cm. of the point where it passes through the mesocolon, in order not to cause a kink in its lumen.

With a straight needle, threaded preferably with Pagenstecher's thread, the posterior row of sutures is first applied as shown in Fig. 130. Each stitch is applied squarely through all of the layers of the intestinal wall. The same suture is carried around in front, as shown in Fig. 131. The two lateral blades of the Roosevelt forceps are removed and the final end of the suture is tied to the beginning portion, as shown in Figs. 131 and 132.

The surface is next carefully sponged and inspected throughout; and if, at any point, there is found a slight defect, this can be remedied by the introduction of an additional suture.

The method has been found most satisfactory in careful hands. It is, of course, plain that every suture must be applied with great precision, but, with

reasonable attention, this can easily be done. The completed operation is shown in Fig. 132.

It is not necessary to use the Roosevelt forceps, which consists of three blades so arranged that the middle blade serves as a common blade for both

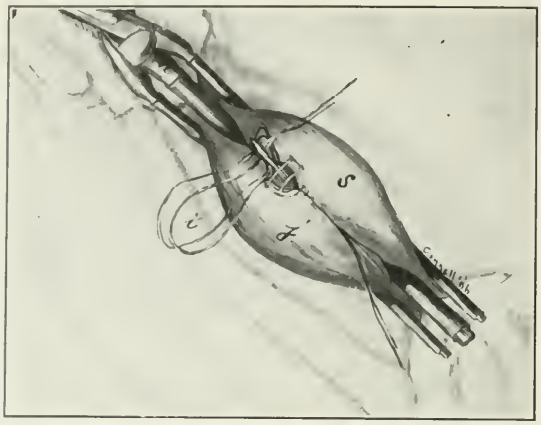

Fig. 131.—Diagram of a more Advanced Stage of the Work than that Shown in Fig. 130. The anterior portion of the Connell suture is almost completed, the entire Roosevelt forceps being still in place. (After Connell.)

forceps. The instrument has the advantage of holding the fold of the stomach and that of the intestine perfectly parallel. The ordinary stomach and intestinal clamps may be used quite as well.

The method secures a narrow line of union. It prevents hemorrhage from

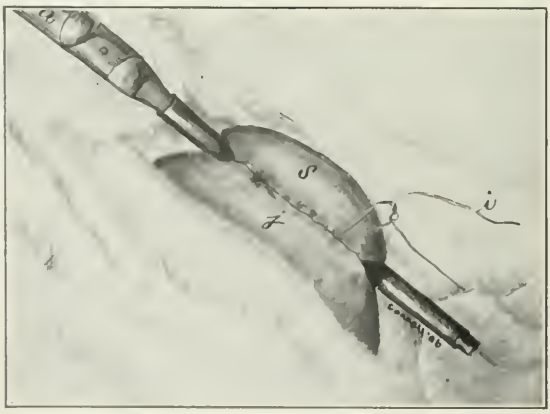

Fig. 132.—In the Stage of the Operation which is Represented in the Present Diagram the Lateral Blades of the Roosevelt Forceps have been Taken Away, the Middle Blade Being Still in Place and the Suture *i* Being Ready to Tie. (After Connell.)

the anastomosis opening and it has all the other advantages of any one of the other suture methods.

In applying the Connell suture it is important to grasp an equal portion of the tissue with each bite of the needle, in order to prevent puckering. Begin on the

mucous side of the intestine; pass the needle out through all of the layers, leaving a margin of one thirty-second of an inch in the bite at the peritoneal edge; next, cross over to the peritoneal surface of the stomach and pass the needle from the peritoneal surface through all the layers into the lumen of the stomach; then reverse the direction of the needle, passing it from the mucous to the peritoneal surface; next cross over to the serous surface of the intestine; and, finally, repeat this performance until the beginning point of the suture is reached.

Gastro-enterostomy with Excision of Pylorus for Indurated Ulcer. (Rodman's Method.)

Rodman has recommended excising the pyloric end of the stomach, in cases requiring gastro-enterostomy, because of the fact that this is the ulcer-bearing area in the stomach, and also, secondarily, because it is the area most commonly

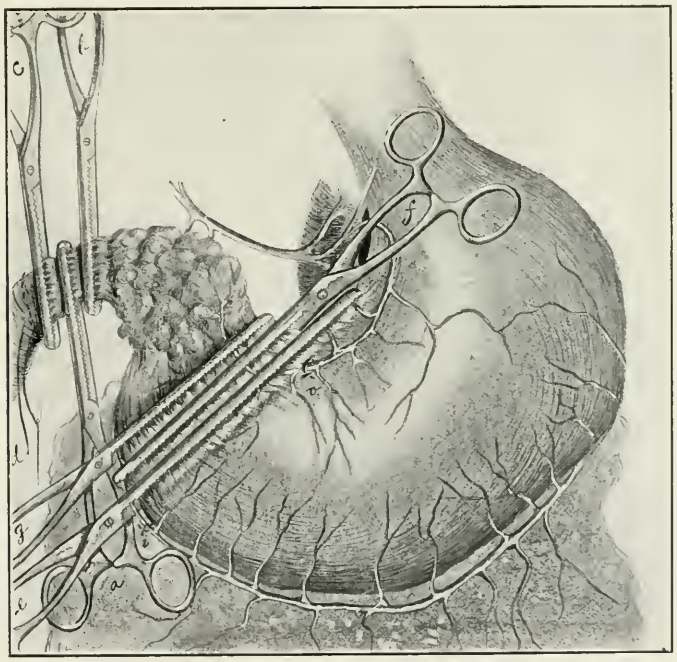

Fig. 133.—Diagram Showing the Mode of Applying Clamp Forceps to the Duodenum and Stomach in Rodman's Operation for Excision of the Pylorus. In excision for carcinoma, forceps *e*, *g*, and *f* are placed much farther to the right.

affected with carcinoma. At the present time this suggestion is usually adopted only in cases in which there is a bleeding ulcer or an indurated pylorus. In the latter case it is often almost impossible to determine, either before or during the operation, whether there is a secondary implantation of carcinoma or whether the lesion is simply an indurated ulcer. In case of doubt, it is always wise to remove the pylorus sufficiently far to insure the removal of all invaded tissue and at least 3 cm. beyond this.

This operation is the same, in every detail, as an operation for carcinoma of the pylorus, with the exception that, when a positive diagnosis of carcinoma

of the pylorus has been made, the mass of tissue removed extends farther to the left.

Technique of the Operation.—The peritoneum covering the upper end of the duodenum is torn at the point at which the forceps (*a*, Fig. 133) is applied. The intestine is then grasped in the bite of the forceps. A second pair of forceps (*b*) and a third pair (*c*) are then applied in an opposite direction, as close to forceps *a* as possible. In Fig. 133 these forceps are not placed as near each other as they should be. Forceps *a* is then removed, and the intestine is severed through the middle of the bite of the jaws of this instrument. This leaves a thin ribbon-like band of tissue projecting from both forceps *b* and forceps *c*.

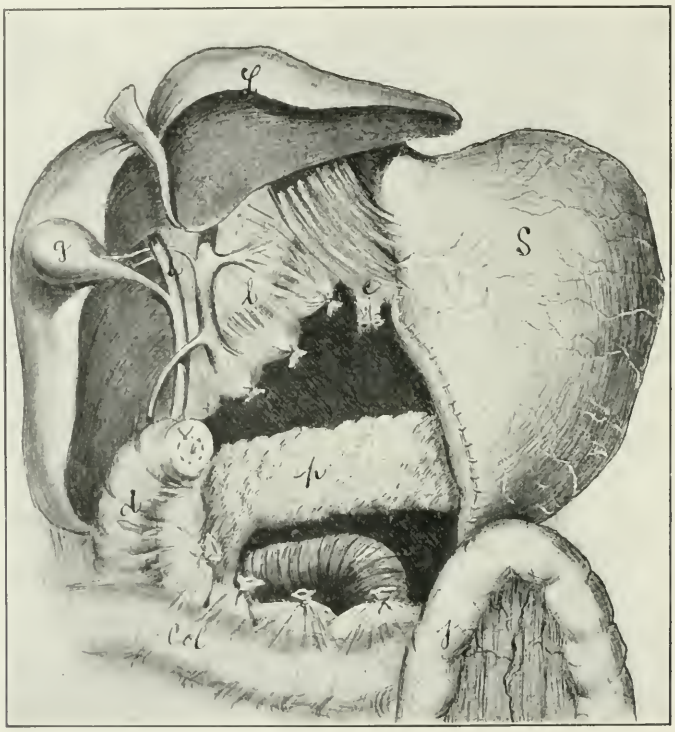

Fig. 134. Diagram Showing the Relations of the Parts after the Completion of the Rodman Operation. The anastomosis has been established between the pylorus and the jejunum. *S*, Stomach; *L*, liver; *g*, gall-bladder; *e*, *e*, remains of omentum; *d*, duodenum; *p*, pancreas; *j*, jejunum; *Col*, colon.

The portion projecting from forceps *b* is turned to the left and covered with a gauze pad. A purse-string suture, *d*, is then applied to the duodenum below forceps *c*, and the projecting ribbon from the bite of forceps *c* is grasped by three or more fine forceps (not shown in the diagram). Forceps *c* is removed and a catgut ligature is applied to the duodenum in the groove left after the removal of the instrument. The projecting ribbon-like tissue, together with the catgut ligature, is now inverted into the lumen of the duodenum, and the purse-string suture *d* is tied. A few interrupted Lembert sutures complete this portion of the operation. All the intervening vessels should be tied before they are severed

and great care should be taken not to injure the portion of the pancreas which lies just posterior to this field of operation. All of the vessels in the greater and lesser omenta of the line represented by the jaws of forceps *a* are now carefully caught with hæmostatic forceps and are then cut and ligated. It is well to begin at the right and proceed toward the left until a point is reached which is sufficiently distant from the ulcer to insure the removal of all of the diseased tissues together with an additional zone at least 3 cm. in breadth. Forceps *f* is next applied, and, directly to the right and to the left of it, forceps *e* and *g*

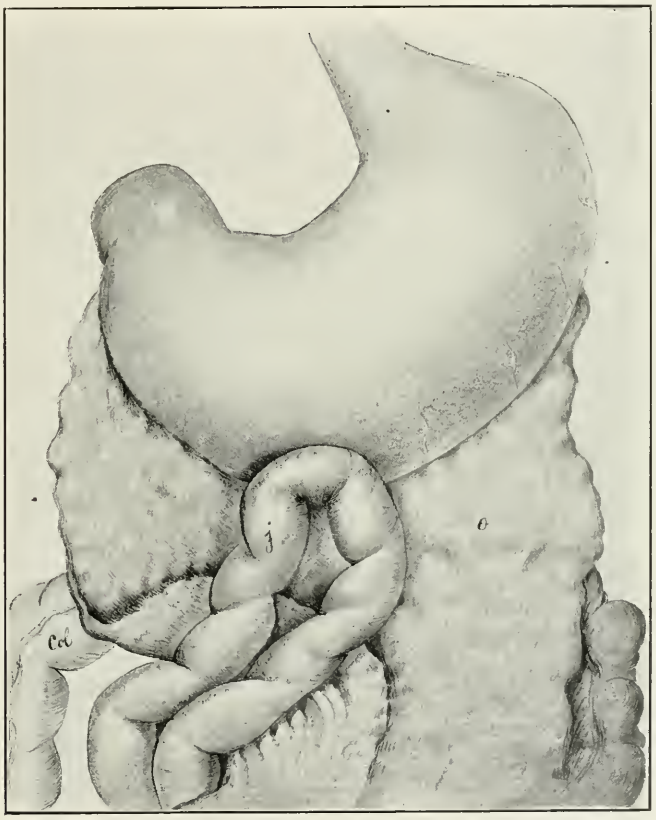

FIG. 135.—Diagram Showing the Relations of the Parts when the Anastomosis, after Excision of the Pylorus, is made between the Lower Part of the Stomach and the Jejunum.

are applied. A gauze pad is placed behind this end of the stomach and an incision is made through the groove left after the removal of forceps *f*. Forceps *e* will prevent soiling from the side of the stomach, and forceps *g* from the side of the pylorus. The projecting portion of tissue to the right of forceps *e* is now quickly sutured with a continuous catgut suture applied closely enough to prevent either leakage or hemorrhage. A ligature is placed around the gastro-epiploic vessels at *i* and another around the branch of the coronary artery at *o*. Then forceps *e* is removed and a row of continuous silk or linen Lembert sutures completes this portion of the operation. A gastro-enterostomy, establish-

ing a communication between the remaining portion of the stomach and the jejunum, completes the operation. This may be made anteriorly, as is done in the operation illustrated in Fig. 128, in which case the completed operation will result in the condition shown in Fig. 134. If the ulcer has been adherent to the pancreas, which occurs most commonly at the point *p* (Fig. 136), then drainage is always indicated. Otherwise, the omentum is carried up into the space left after the removal of the pylorus, and the abdominal wound is closed.

Pyloroplasty.

In cases of pyloric obstruction, due to cicatricial contraction following pyloric ulcer, the operation of pyloroplasty was introduced by Heinecke and Mikulicz twenty years ago. The operation consists in a longitudinal division of

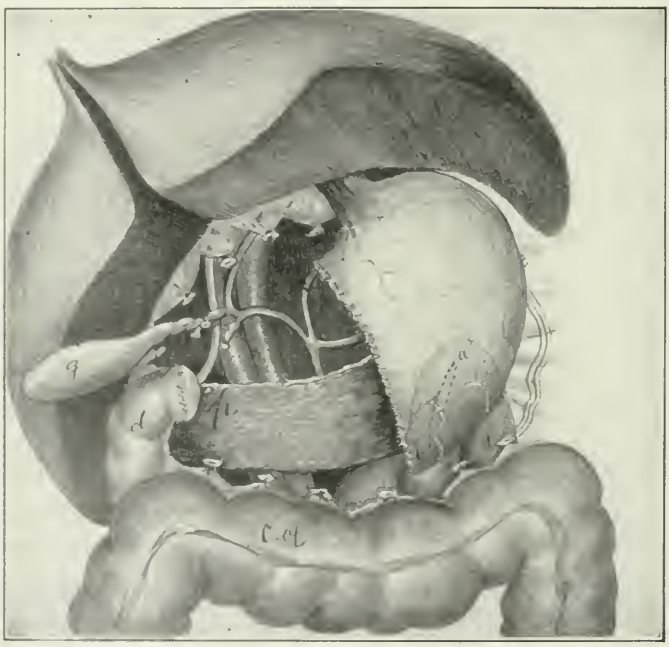

FIG. 136.—Diagram Showing the Relations of the Parts after Excision of the Pyloric End of the Stomach, with Posterior Gastro-enterostomy. *a b* Shows the location of the opening in the remaining part of the stomach; *Col*, the transverse colon; *p*, the pancreas; *d*, the duodenum; *g*, the gall-bladder.

the pylorus, the upper end of the duodenum, and the pyloric end of the stomach, as shown in Fig. 137. A suture is then applied at each of the points *a* and *b*. By making tension upon these sutures, the wound is opened transversely, in which position it is sutured either with the Connell suture or with one row of deep sutures including all of the layers, and a second row of superficial Lembert sutures. The condition which is left after these procedures have been carried out is shown diagrammatically in Fig. 138.

Theoretically, this operation should relieve pyloric obstruction; but the results which have thus far been obtained by most surgeons have been very

unsatisfactory. Out of a considerable number of cases which have been operated upon according to this method by the author, only a small proportion have been permanently relieved. Theoretically it seems as if, after this operation, the duodenum should maintain its relative position in the passage of food through the alimentary canal, whereas in gastro-enterostomy the duodenal portion of the small intestine simply serves as a duct for carrying the bile and pancreatic fluid into the jejunum. As a matter of fact, however, the second function—that of serving as a cavity in which the food and the pancreatic fluid become thoroughly mixed—is disturbed by the operation of pyloroplasty which destroys the pyloric sphincter. In the absence of the latter muscle the food in the duodenum cannot be definitely separated from the food in the stomach, for the purpose of thorough mixing.

This operation may be followed by the production of a considerable amount of connective tissue, both in the line of the suture and in the adhesions which

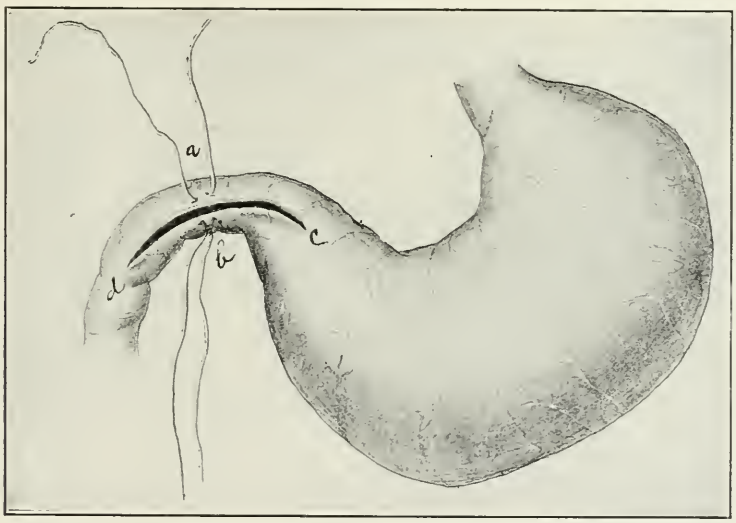

Fig. 137.—Diagram Showing the Heinecke-Mikulicz Method of Pyloroplasty, with a Longitudinal Incision (*cd*) through the constricted pylorus. The sutures *a* and *b* are in place.

have formed between the organ and the surrounding tissues at the seat of operation. The induration resulting from this condition may produce a secondary obstruction, and this, in all probability, accounts for the unsatisfactory results which have followed the operation. It seems that fairly good results occur only in cases in which the pyloric obstruction is due to a very narrow constriction without the presence of any great amount of connective tissue. In cases of this nature the best results are obtained by using the method of pyloroplasty introduced by Finney, a method which has now supplanted all other plastic operations upon the pylorus for the relief of constriction. In a few instances modifications have been suggested, but none of these seems to be of sufficient importance to merit a separate description.

Operation of Pyloroplasty Introduced by Finney.

The steps of this operation may be briefly described as follows:—Divide the adhesions binding the pylorus to the neighboring structures; also free, as thoroughly as possible, the pyloric end of the stomach and the first portion of the duodenum. Upon the thoroughness with which the pylorus, the lower end of the stomach, and the upper end of the duodenum are freed, depends, in a large measure, the success of the operation and the ease and rapidity with which it may be performed. This should be emphasized as one of the most important points in the operation. Frequently, at first sight, the pylorus seems hopelessly bound down; but, after a little patient toil and judicious use of the scalpel and blunt dissector, it is often found possible to free it with comparative ease. A suture, to be used as a retractor, is taken in the upper wall of the

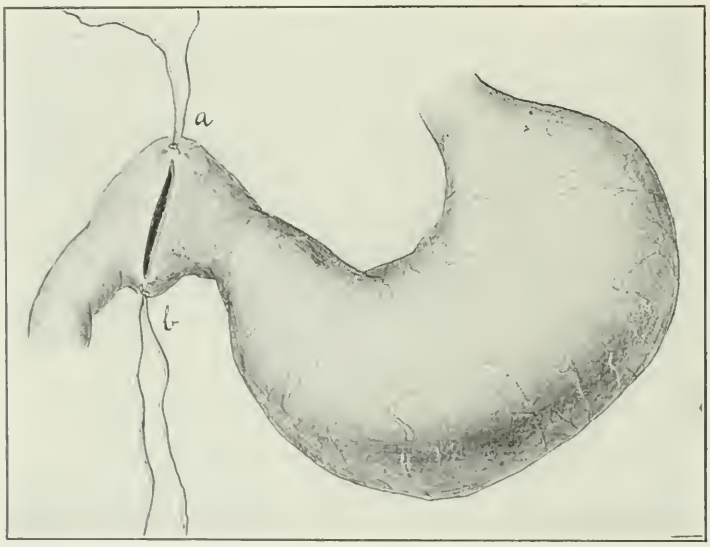

FIG. 138.—Diagram Showing the Sutures *a* and *b* in a Condition of Tension, as a result of which the wound is so placed that it may be sutured transversely to the long axis of the lumen of the pylorus, by which procedure some aid in overcoming the constriction of the channel may be secured.

pylorus, which is then retracted upward. Two other sutures are next inserted —one into the anterior wall of the stomach, and the other into the anterior wall of the duodenum, at equidistant points—say, 12 cm.—from the first suture in the pylorus. These two sutures mark the lower ends of the gastric and duodenal incisions, respectively. They should be placed as low as possible in order that the new pylorus may be amply large. Traction is then made upward on the pyloric suture, and downward (in the same plane) on the gastric and duodenal sutures. This keeps the stomach and duodenal walls taut, and allows the placing of the sutures with greater facility than if the walls remained lax. (Fig. 139.) The peritoneal surfaces of the duodenum and stomach, along its greater curvature, are then sutured together as far posteriorly as possible. (See Fig. 140.) In the case of this row the continuous suture is more easily and

quickly applied, and it can be re-enforced after the stomach and duodenum have been incised. After the posterior line of sutures has been placed, an anterior row of mattress sutures is introduced. These sutures are not tied but left long, in the manner indicated in Fig. 141. After they have been placed, they are retracted vertically in either direction from the middle of the portion included in the row of sutures. (Fig. 142.) After all the stitches have been placed and retracted, the incision is made in the shape of a horseshoe. The sutures should be placed far enough apart to give ample room for the incision. The gastric arm of the incision is made through the stomach wall just inside the lowest point of the line of sutures, and is carried up to and through the pylorus, around into the duodenum, and down to the corresponding point on the duodenal side. Hemorrhage is then stopped. It is well to excise as much as possible of the scar

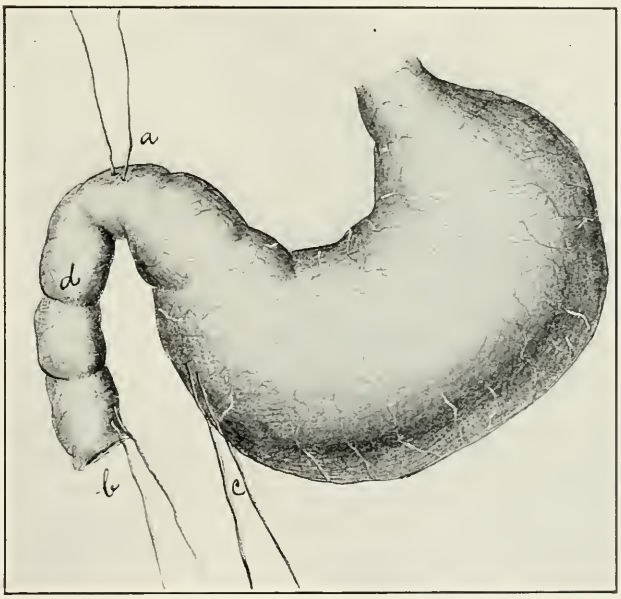

Fig. 139.—Finney's Pyloroplasty. The diagram shows the guide sutures at the pylorus (*a*), at a point lower down on the stomach (*c*), and on the duodenum (*b*); *d* represents the duodenum.

tissue upon either side of the incision in order to limit, as far as possible, the subsequent contraction of the cicatrix. A continuous catgut suture is next taken through all the coats of the intestine on the posterior side of the incision. (Fig. 142.) This re-enforces the posterior line of sutures, secures better approximation of the cut edges of the mucous membrane, and prevents the reunion of the divided intestinal walls. The anterior sutures are then straightened out and tied, and the operation is complete, unless one wishes to re-enforce the mattress sutures with a few Lembert sutures. (Fig. 144.) This procedure, as is readily seen, gives the minimum of exposure of infected surface. All the stitches are placed, and the posterior row tied, before the bowel is opened. The latter is allowed to remain open just long enough to control the hemorrhage. The size of the newly formed pyloric opening is limited, in this operation, only by the

mobility of the stomach and duodenum, and by the judgment of the operator. The length of the incision made is about 12 cm. Unless the stomach is very much dilated or has descended to an unusual extent, the lower limit of the new outlet is at or near the level of the most dependent portion of the organ.

The procedure described above was carried out with great satisfaction by the author in a number of cases, and he recommends it in all cases in which the walls of the pylorus are not much thickened and in which not much scar tissue is present. It is well to trim off, with scissors, redundant edges of mucous

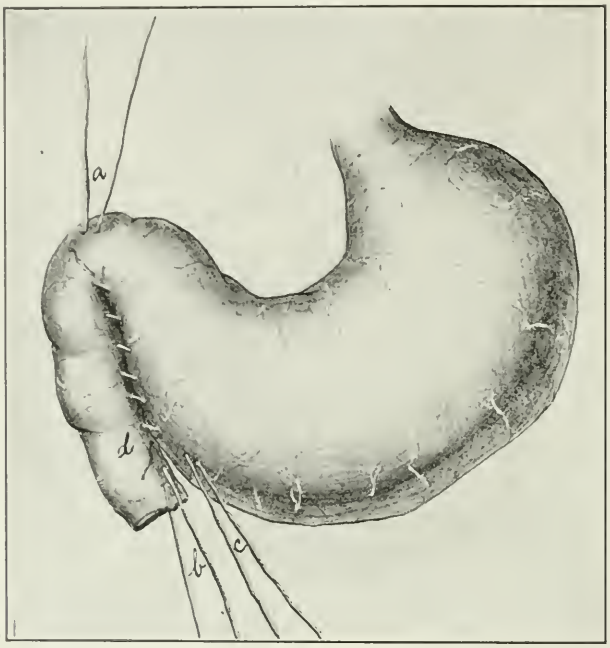

FIG. 140.—Finney's Pyloroplasty; Second Stage of the Operation. The diagram shows the posterior row of sutures in place; they constitute a continuous Lembert suture.

membrane, in order to prevent the formation of a valve-like fold of mucous membrane at the new pylorus.

When the stomach is much dilated, there is no contra-indication, in this operation, to the performance, at the same time, of gastropexy or gastroplication, if one considers either of these procedures indicated.

An Original but now Discarded Method of Pylorectomy.

At this point may be discussed an original method of pylorectomy, with attachment of the duodenum to the stomach. (Fig. 145.) The portion of the stomach included between the dotted vertical lines *a* and *b* represents the pylorus containing either an ulcer or a cicatricial constriction. The difference between the diameter of the lumen of the duodenal stump and that of the stomach, is represented by the difference in the length of the lines *a* and *b*. In order to reduce the size of the lumen at *b* to such a degree as to make it

approximately equal to the lumen of the duodenum at *a*, the end of the stomach is folded in, as indicated by the line *c*, or as indicated by the line *d;* or it may be folded in, both along the lesser and along the greater curvature, to half the amount indicated by *c* and *d*.

In addition to the difficulty just mentioned there are still other grave objections to this operation, and it has consequently been abandoned by nearly all surgeons of much experience. The operation of closing the end of the stomach and making a gastro-enterostomy at its lowest point has been generally adopted in its place. The chief objection to this operation comes from the fact that there is frequently a point of leakage at the spot where the two rows of sutures (*c* and

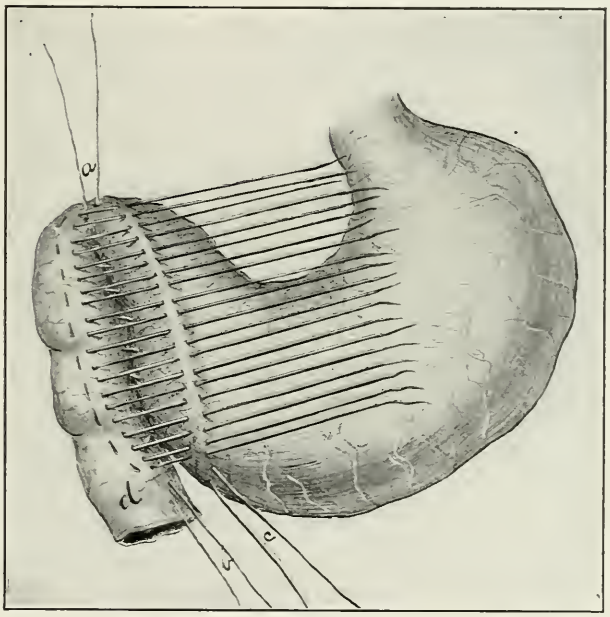

Fig. 141.—Finney's Pyloroplasty; Third Stage of the Operation. The diagram shows the interrupted mattress sutures in place, but not tied.

d, Fig. 145) meet. This is explained, first, by the frequent presence of tension, and, second, by the fact that, in the posterior suture line, the surfaces united are not covered throughout with peritoneum. The method is mentioned here simply because it was at one time a recognized procedure. It is now, however, almost completely discarded.

Gastro-duodenostomy.

Gastro-duodenostomy has a number of theoretical advantages which correspond to those mentioned in connection with pyloroplasty. Between the duodenum and the pyloric end of the stomach it is practicable to establish a communication sufficiently large to satisfy the wishes of the operator. A portion of the pyloric end of the stomach is grasped with clamps, and a corresponding portion as regards size is grasped, in a longitudinal direction, upon the anterior

surface of the duodenum. In each of these there is then made an opening (*a* and *b*, Fig. 146). The edges of the wounds thus made are then united in such a manner that a channel of communication is established between the two organs. This may be accomplished by means of the Connell suture or by a row of Lembert sutures re-enforced by a row of deep sutures, the deep sutures extending along the edge of the incision and grasping all of the layers. They are placed sufficiently close to each other to prevent hemorrhage. The Lembert sutures are placed around the outside of this row. In case the gastric ulcer is located on the anterior surface of the pyloric end of the stomach, this method

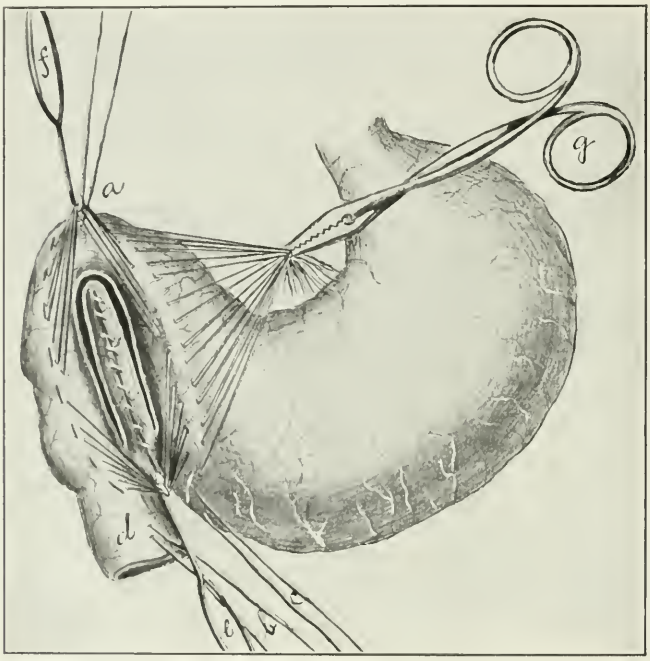

FIG. 142.—Finney's Pyloroplasty; Fourth Stage of the Operation. The diagram shows the interrupted mattress sutures held aside by means of tenacula *e* and *f*. It also shows a horseshoe-shaped incision through the pylorus. This incision lays open the lower end of the stomach and the upper end of the duodenum.

cannot be employed, for the friable condition of the tissues would probably result in leakage. The objections that were mentioned in connection with pyloroplasty and with Finney's operation, are also true concerning this operation.

Willard's Gastro-Duodenostomy.

This operation consists in establishing an anastomosis between the duodenum and the pyloric end of the greater curvature of the stomach, as shown in Fig. 147. Theoretically, the operation does not seem unreasonable, but it is open to serious objections. In this operation the portion of the duodenum involved is near the point of entrance of the common duct; observations upon the cadaver have shown that, in a considerable proportion of cases, the duct of Santorini and the duct of Wirsung enter the duodenum at a considerable distance from the entrance of

the common duct, and they are often so small that it is difficult to recognize them during this operation. Consequently they might easily be injured.

Kuemmel's Gastro-Duodenostomy.

This operation consists in severing the duodenum beyond the contraction, closing its proximal end, and implanting its distal end into the pyloric end of the greater curvature of the stomach, as shown diagrammatically in Fig. 148. The same objections which have been mentioned in connection with pyloroplasty, as well as with Willard's gastro-duodenostomy, would apply to this operation.

Before we leave the discussion of this form of treatment of pyloric obstruction,

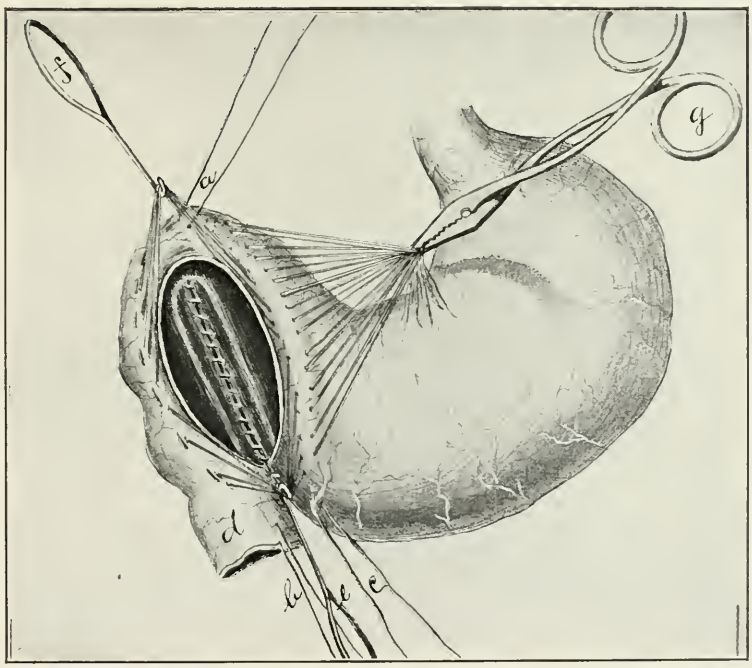

Fig. 143.—Finney's Pyloroplasty; Fifth Stage of the Operation. The diagram shows the posterior row of continuous through-and-through catgut sutures in place.

due directly or secondarily to the presence of gastric ulcer, it may be well to state that gastro-enterostomy in itself is usually sufficient to relieve chronic or recurrent ulcer of the pyloric end of the stomach; and, in case of bleeding ulcer of the stomach, this treatment in itself is usually sufficient to relieve the patient permanently, provided the gastro-enterostomy opening is made at the lowest point of the stomach and is sufficiently large.

The greatly reduced condition of patients suffering from this condition occasionally, though rarely, makes it seem proper to add to the gastro-enterostomy a gastrostomy, as illustrated in Fig. 149, so that it may be possible to introduce food into the intestines in these cases without the danger of irritating the ulcer. A method of introducing liquids into the duodenum through a cholecys-

tostomy opening by permitting the fluid to flow through a drainage tube sutured into the cholecystostomy opening by the drop method has been recommended and practised by Dr. L. L. McArthur. This will be much more simple than a gastrostomy, and, if aseptic liquid nourishment only is employed, the method seems to have great merit. It is important to arrange the apparatus in such a manner that the flow takes place very slowly.

The same result can be accomplished by passing a small, soft, pure rubber tube, not more than 1 cm. in diameter, through the nose into the stomach, and through the stomach into the jejunum, precisely in the same manner as illustrated in Fig. 149. Peptonized food can then be slowly injected through this tube, which will deliver it into the jejunum without touching the stomach.

Still another method may be followed. The tube may be passed through

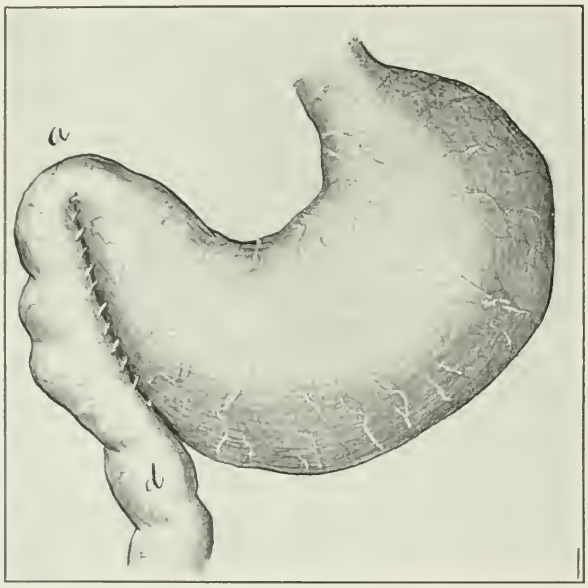

Fig. 144.—Finney's Pyloroplasty Completed. The diagram shows the continuous Lembert suture in front. This suture has been added for purposes of re-enforcement.

the œsophagus and through the stomach into the jejunum, the upper extremity of the tube reaching a point just behind the incisor teeth. A silkworm-gut suture is passed through the upper end of the tube out through the mouth and fastened to prevent the tube from being swallowed. Patients become accustomed very quickly to the thread projecting from the mouth and it does not annoy them. The food may be introduced into the upper end of this tube through a glass tube attached to the end of a funnel by means of a piece of rubber tubing. If the mode of feeding selected is that by means of the tube introduced as shown in Fig. 149, gastrostomy must be made in such a manner that the opening in the stomach will close spontaneously when the feeding tube is withdrawn.

A gastrostomy operation is made precisely as it would be without this additional provision. A fold of the anterior wall of the cardiac end of the

stomach is picked up and three successive purse-string sutures are placed as shown in Fig. 150. A small puncture is then made in the middle of these circles, and the rubber drainage tube is passed into the stomach through this opening. Then the three purse-string sutures are successively tied, causing an infolding of the stomach wall, which is then attached with a few fine silk sutures at the point at which the rubber tube passes through the abdominal wall. The lower end of the rubber drainage tube is carried through the gastro-enterostomy opening into the jejunum for a distance of 30 cm., in order to prevent its retraction into the stomach. (Fig. 149.) It is doubtful whether this operation is really of much value in practice, because one can usually support these patients, after the operation, by the use of rectal feeding and by normal salt transfusions, and on the second day concentrated predigested liquid food of a non-irritating quality

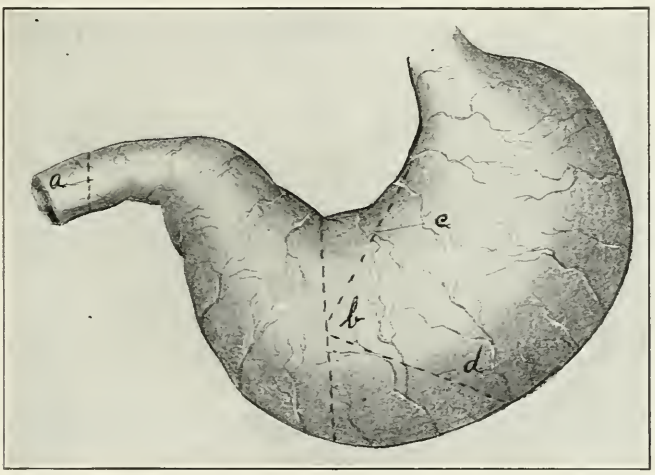

FIG. 145.—Diagram Illustrating an Original Method of Pylorectomy, with the Formation of a New Pyloric End of the Stomach by Reducing the Large Open End of the Stump by Means of a Plastic Operation. In the latter operation the narrowing is effected by removing, by means of incisions carried along the dotted lines which converge toward *b*, all that portion of the organ which (in the diagram) lies to the left of these lines.

may be given by way of the mouth. In case this gives rise to nausea gastric lavage may be employed. This should be done immediately if the patient suffers even to a slight extent from nausea or vomiting. It is a most useful and quite harmless procedure.

It has been the author's experience that in gastro-enterostomy, as performed by the Moynihan-Mayo method, nourishment may be given by way of the mouth, with safety and comfort to the patient, on the second or third day. With this operation, then, it would not be necessary to add gastrostomy.

Hour-Glass Stomach.—The hour-glass stomach is in rare cases a congenital deformity, but, in the vast majority of all cases in which it is found, there is a history of preceding gastric ulcer.

Moynihan* states that, in every one of his twenty-two cases of hour-glass

*Medico-Chirurgical Transactions, vol. 89.

stomach, there had been previous symptoms pointing to chronic gastric ulcer. In four cases the history strongly pointed to former subacute perforation. This observation, that the symptoms point to the presence of a chronic gastric ulcer, corresponds to the author's experience.

The diagnosis of hour-glass stomach is usually made at the time of operation, or during the progress of the examination of a case in which the diagnosis of gastric ulcer has been made. The following is a most striking symptom:—If the stomach is filled with water and washed thoroughly by means of siphon-refilling until the water which returns is perfectly clean, the stomach will still have a feeling of fulness, and in a few moments it will be found that a quantity of offensive fluid can again be siphoned out, although no further fluid has been introduced into the stomach. In some cases the passage of fluid from the cavity

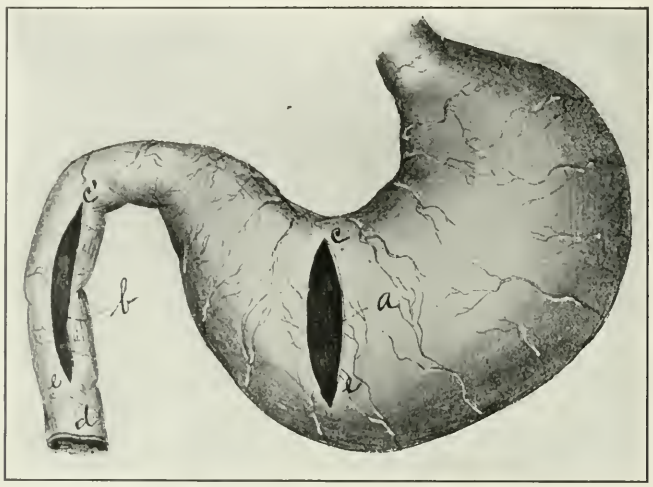

FIG. 146.—Gastro-duodenostomy. The diagram shows the incision in the stomach at *a* and that in the duodenum at *b*.

to the left into the cavity to the right can be heard plainly with the stethoscope. In other cases, after thoroughly emptying the stomach by means of gastric lavage, and while distending this cavity with gas, one can outline the hour-glass shape by percussion.

In advanced cases the patient has all the symptoms of gastric ulcer, that of emaciation being especially marked.

Operative Treatment.

The object of the operation is to establish as nearly as possible normal conditions of drainage for the stomach cavity. If the two portions of the hour-glass stomach are approximately equal in size, this can best be accomplished by uniting the two halves of the stomach after removing the intermediate narrow portion. If the latter contains enough tissue to warrant the surgeon in preserving a part of it, the operation is much more easily and satisfactorily performed, because it is then necessary to remove only a V-shaped portion, as indicated at *c* in Fig. 151.

After the abdomen has been opened, but before the excision is made, it is well to introduce a stomach tube into the cavity *a* (Fig. 151). The latter should be thoroughly irrigated, and then the end of the tube should be manipulated until it projects into cavity *b*. Then this cavity also should be thoroughly irrigated, care being taken to siphon out all of the fluid before the tube is withdrawn into cavity *a*. The communicating portion of the hour-glass is then compressed in order to prevent any further leakage into cavity *b*. Then cavity *a* is once more carefully irrigated, care being taken to siphon out all of the fluid before the stomach tube is withdrawn. The tissues of the stomach are then grasped in clamps along the line *i c i'*, the projecting portion is cut away, and the

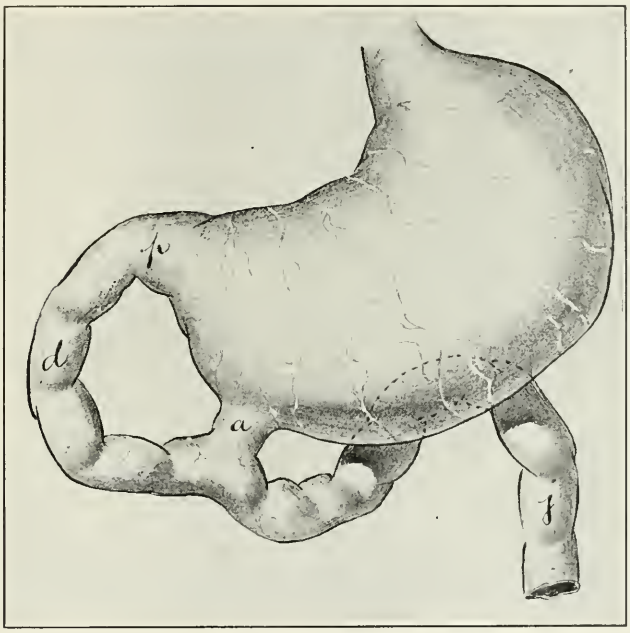

Fig. 147.—Willard's Gastro-duodenostomy.

cut edges of the stomach wall are united throughout by means of the continuous suture, preferably of chromicized catgut. As soon as the first row of sutures has been applied, the clamps are removed and this row of sutures is covered by the application of a row of Lembert sutures. If the communicating portion of the hour-glass is composed almost completely of connective tissue, it is better to apply the clamps along the lines *a* and *b* (Fig. 151), and then to complete the operation as before. The operation may also be performed by the use of the Connell suture, instead of the continuous suture.

If the greater portion of the stomach is represented by the cavity *a*, and but a very small remnant is represented by cavity *b*, then it is better to perform a posterior gastro-jejunostomy by one of the various methods which have already been described, because an excision of the constriction, in this case, will be likely to result in a pyloric obstruction, and consequently a gastro-enterostomy

will have to be performed, at some later date, for this condition, and the patient will gain nothing from the more serious operation upon the stomach.

An operation—known as gastro-gastrostomy—for the production of a communication between the two segments of an hour-glass stomach, has been recommended and practised in some cases. This operation consists in making an incision upon the anterior surface of both lobes of the hour-glass stomach (at *a* and *b*, in Fig. 152), and uniting these two openings, thus doubling up the stomach from side to side and securing between the two cavities a sufficiently free communication to permit proper drainage. The suturing may be done as in the operation just described, with or without the application of clamps to prevent leakage (Fig. 153.) The resulting conditions, after this operation, do not

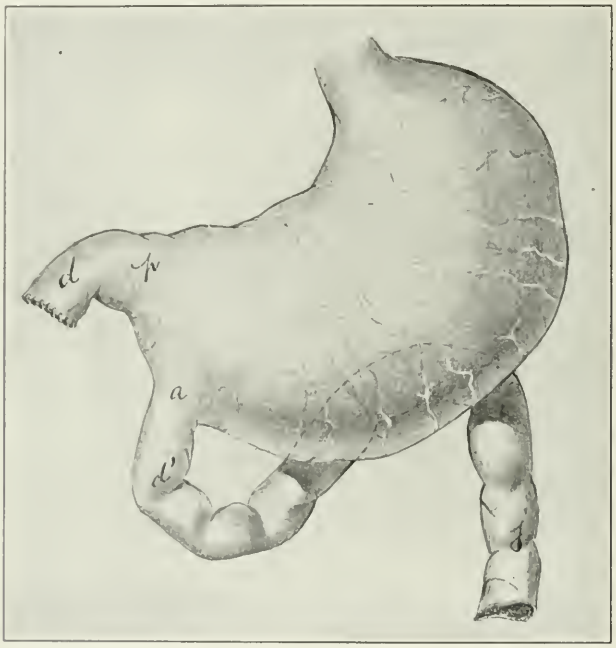

FIG. 148.—Kuemmel's Gastro-duodenostomy. In the diagram the duodenum is represented as having been severed and permanently closed by inversion and suturing together of the cut edges at *d*. The pylorus (*p*) is left undisturbed, because this usually contains much cicatricial tissue. The distal end of the severed duodenum (*d'*) is sutured into the stomach at *a* by means of Connell sutures, by Moynihan's clamp-and-suture method, or by Murphy's button.

compare favorably, from an anatomical standpoint, with those which remain after the operation illustrated in Fig. 151, but the operation in itself is much easier to perform, and the immediate danger from the operation is less. In either operation it is important not to injure the coronary artery, either by suturing or by applying clamps, because an injury to this vessel is likely to result in gangrene of that portion of the stomach which is supplied by this vessel. In case the constriction, in an hour-glass stomach, is near the pyloric end of the stomach and is complicated by an open ulcer, it is well to resort to a partial gastrectomy, removing the portion between the lines *a* and *b* (Fig. 145), then performing a gastro-jejunostomy, and making the anastomosis between the lowest

portion of the cavity *a* and the first portion of the jejunum. This will result in a condition corresponding exactly with the condition following a pylorectomy for the relief of any other pathological condition.

Obstruction of the Pylorus Due to Inflammatory Adhesions.—The conditions which have just been described are frequently associated with inflammatory adhesions. The longer the gastric ulcer exists and the nearer it approaches perforation, the more extensive will be the adhesions which are found at the time of the operation. The cause for adhesions in this vicinity, however, does not always come from the extension of an infection from the

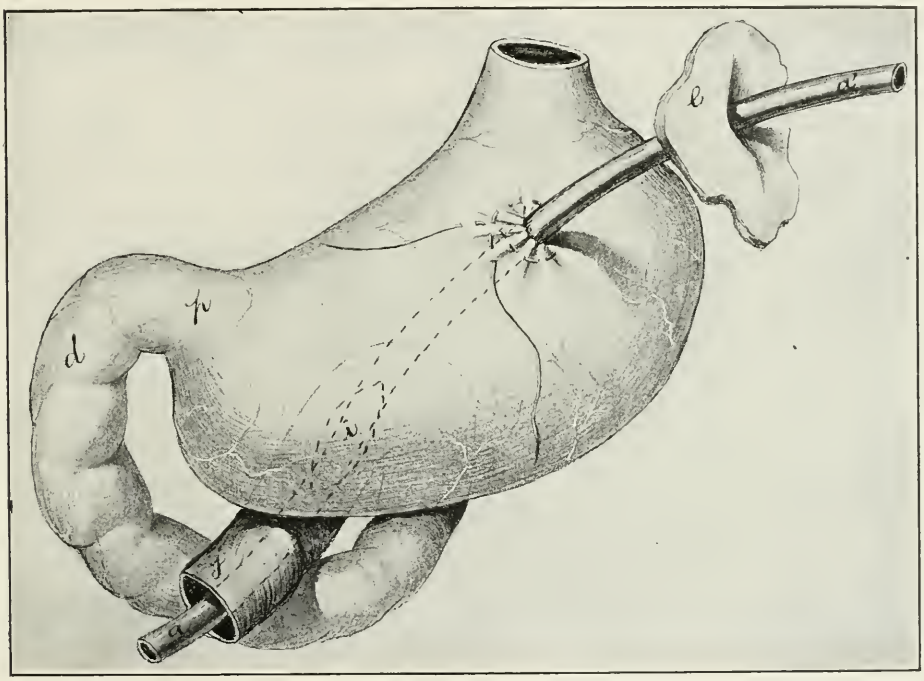

FIG. 149.—Diagram Showing Gastrostomy in Connection with Gastro-enterostomy. *p*, Pylorus; *d*, duodenum; *j*, jejunum; *a*, feeding tube; *e*, abdominal fistula. The circular suture which folds in the stomach wall around the feeding tube and thus prevents leakage, will, of course, be attached to the parietal peritoneum, the abdominal wall (*e*) being drawn here, in the diagram, at a distance to make it possible to show this suture.

cavity of the stomach, but quite as frequently from an infection in the gall-bladder and biliary ducts, or from an infection coming from a duodenal ulcer or from the pancreas, although the latter organ is more commonly affected secondarily from an ulcer of the stomach.

Aside from adhesions due to these sources of infection, one occasionally encounters adhesions which are quite as troublesome clinically. These adhesions are caused by a more or less extensive peritonitis due to an acute appendicitis or to an infection of the Fallopian tubes. The omentum, in these cases, becomes adherent to any of the organs with which it may come in contact, and when these adhesions become firm there is created a severe tension upon the upper attach-

ment of the greater omentum, a tension which interferes greatly with the mobility of the stomach, and which may in some cases cause a serious obstruction to the pylorus. This condition may result secondarily in an ulcer of the stomach with its immediate or late results, or it may remain stationary and interfere with the physiological functions of the stomach, thus giving rise to distress which will vary with the degree of the distortion caused by these adhesions.

Treatment.—The treatment consists in relieving this tension at every point and preventing its recurrence by covering the abraded peritoneal surfaces with portions of the surrounding loose peritoneum.

In most of these cases the condition as it existed before the patient was subjected to surgical treatment may still continue to exist after this treatment. Although the treatment just suggested will remove the cause of the trouble,

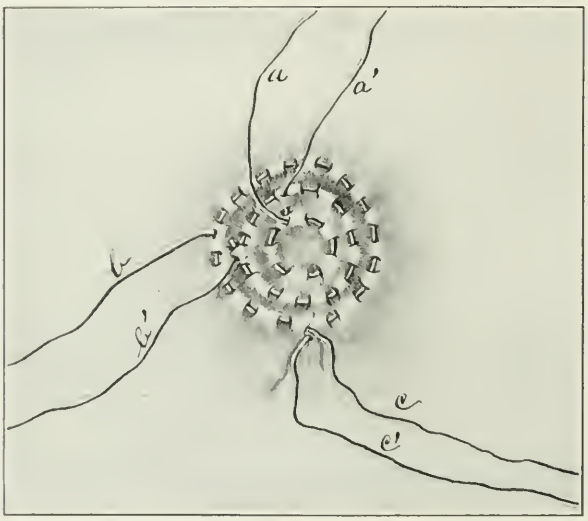

FIG. 150.—Diagram Illustrating the Use of Circular Purse-string Sutures at the Location of the Gastrostomy Opening in the Stomach.

there will still remain the secondary conditions which have resulted from the existence of these adhesions. Many of these conditions may be relieved at a later date by careful dietetic and hygienic measures. If, however, the adhesions are in the vicinity of the gall-bladder,—between the gall-bladder, the duodenum, the liver, the splenic flexure of the colon, and the pylorus,—then it is not possible to relieve the condition by the method described above, and it will be necessary to resort to gastro-enterostomy in order to obtain permanent relief from pyloric obstruction.

Gastrorrhaphy.

One of the sequelæ of pyloric obstruction is ulcer of the stomach accompanied with a deformity such as is indicated in Fig. 154. This condition may also be associated with gastroptosis. In these cases the greater curvature of the stomach is always much lower than normal, and in many instances the lesser

curvature is also far below its normal level. There is usually, at the right extremity of the greater curvature, a pouch-like deformity which interferes seriously with the passage of food from the stomach into the duodenum. In order to reduce the size of a stomach which has this form, the anterior stomach wall may be doubled upon itself along the broken line *c*, Fig. 154. A continuous suture is applied in such a manner as to unite the dotted lines *b* and *b'*, and it is made to include all the layers down to, but not through, the mucous membrane. The second row of sutures is applied in such a manner as to unite the lines *a* and *a'*, Fig. 154. This elevates the original greater curvature very nearly to the level of the lesser curvature, and a new greater curvature of the stomach is thus formed from the posterior wall of the stomach. The level of this new greater

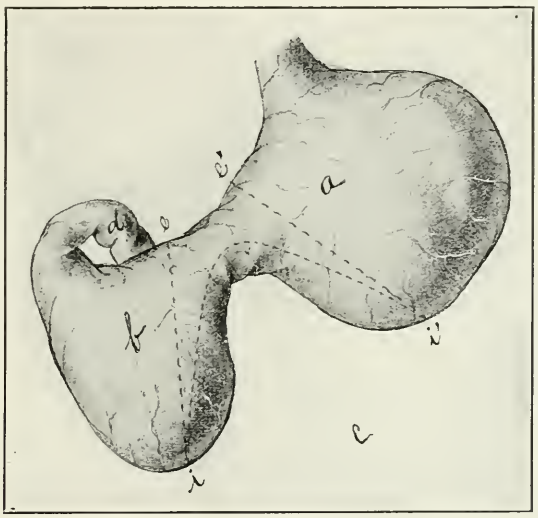

FIG. 151.—Diagrammatic Representation of an Hour-glass Stomach. *a*, Cardiac end; *b*, pyloric end; *c*, point of greatest narrowing; *i c i'*, line of excision of cicatricial contraction; *i e* and *i' e'*, lines for applying constriction forceps and also lines of incision in cases of resection of the stomach.

curvature will be situated about half-way between the levels of the original greater and lesser curvatures, approximately corresponding to the line *c*, Fig. 154. Theoretically, this operation seems to promise benefit to the patient. However, the results actually obtained have been disappointing and the same unfavorable results have followed the practice of other similar operations intended for the relief of this same condition.

After-treatment of Gastrorrhaphy and Gastro-enterostomy.

As the after-treatment is the same for both of these operations it seems proper to speak of it at this time.

The patient should be placed in a nearly upright sitting posture as soon as possible after he recovers from the anæsthetic, and until that time it is well to have the head of the bed elevated to the extent of about twelve inches. This position seems to favor the drainage, into the intestine, of any mucus which may accumulate in the stomach after the operation. It also favors the expulsion of

gas through the œsophagus. Occasionally the patient suffers from acute gastric dilatation after an operation upon the stomach, but more especially after the operation which has just been described. This condition is characterized by a feeling of fulness and is associated with a sudden dilatation of the abdomen, which is not easily recognized when the abdomen is covered by a dressing. The heart is displaced upward, the breathing becomes labored, the heart beats very rapidly, and the patient gives the impression of having become suddenly very ill. This condition may occur at any time, without any especial warning. In the author's experience several patients have died in this condition before it was discovered that an acute dilatation of the stomach is not a rare post-operative condition following stomach and gall-bladder operations. The condition can easily be relieved by passing a stomach tube. Great quantities of gas will escape, the pulse-beat and the breathing will become normal, and the patient's

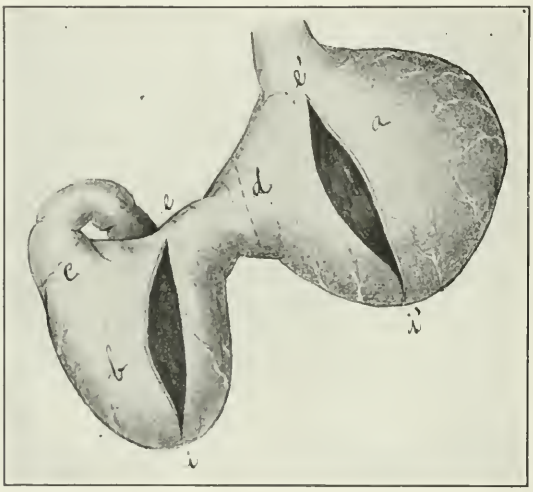

Fig. 152.—Diagram Showing Lines of Incision, *c i* and *c' i'*, into the Two Halves of an Hour-glass Stomach, when a Gastro-gastrostomy is Performed.

recovery will again proceed in a normal manner. It is well to instruct the resident physician and the surgical nurse under whose care these patients are placed, to introduce the stomach tube even on the slightest suspicion of an accumulation of gas in the stomach, because if the stomach has once been greatly distended it is not likely to be relieved so easily and in so permanent a manner as when the tube is introduced at the very beginning of the distention.

Feeding.—If the patient's condition is not too greatly reduced it will be best, for several days or until the patient becomes hungry, to restrict the feeding exclusively to nourishing enemata; and yet there are not a few surgeons who begin to give concentrated liquid nourishment on the second day after the operation, and with apparently satisfactory results. In the case of anæmic patients the author has given this form of nourishment by way of the mouth, and at the same time he has administered concentrated predigested food in normal salt

solution by way of the rectum, at intervals of three hours on the second day after the operation. If the patient is troubled with nausea or with pain, gastric lavage should at once be employed, but it is important to remember not to put more than half a pint of water in the stomach at one time, for fear of subjecting the sutures to too great tension. The fluid should be at a temperature of 105° Fahrenheit. This procedure may be repeated as often as the disturbance occurs. Milk is usually not borne nearly so well as broth, gruel, or buttermilk, or the various commercial concentrated liquid foods.

The after-treatment should be carefully continued for months after the patient leaves the hospital, in order that all of the mechanical and chemical

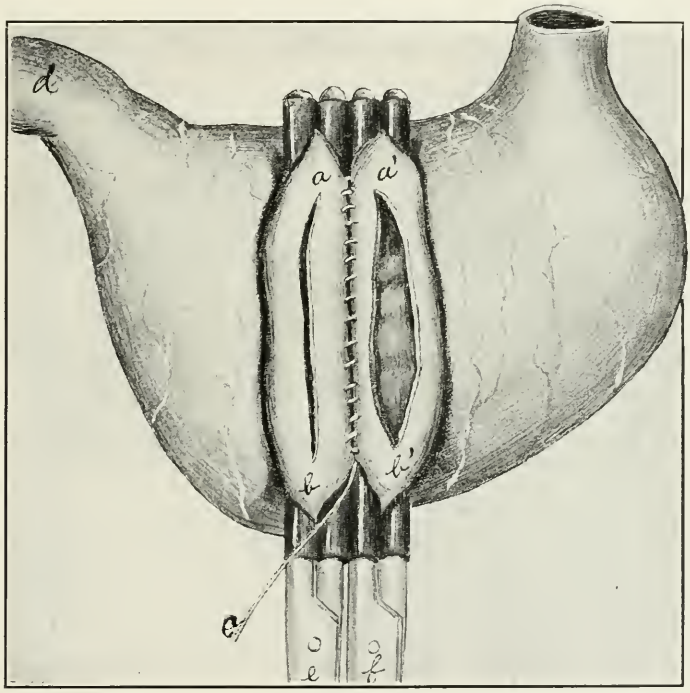

FIG. 153.—Hour-glass Stomach. The diagram shows how, in the operation of gastro-gastrostomy, the folds of the two halves of the stomach are held by clamps *e* and *f* while the openings *a b* and *a' b'* are being united. The posterior Lembert suture *c* has been completed.

functions of the stomach may return to as nearly a normal condition as is possible with the changed anatomical conditions due to the operation itself. The treatment, however, should be almost entirely dietetic and hygienic.

Patients whose condition necessitates an operation upon the stomach are usually not at all sensible as regards their diet—partly from the fact that the pathological condition present in the stomach has prevented them from eating with comfort the foods that are ordinarily wholesome and easily digested, and partly from the fact that they have never learned to eat properly. This latter fact has frequently much to do with bringing about their stomach disease.

The drainage, when unobstructed, prevents hyperacidity of the stomach—one of the chief difficulties existing before the operation, and one which interferes

greatly with the proper digestion of food. The food to be given to these patients during convalescence should consist of soft digestible meats like scraped raw meat that has been heated sufficiently to make it palatable, sterile boiled rice, tapioca, sago, and bread that has been carefully toasted and then soaked in milk or in cream which has been diluted with hot water. Later on, tender roast beef or broiled steak, broiled fish, and vegetable purées made of peas, beans, carrots, asparagus tips, and cauliflower may be given. Eggs, either soft-boiled or scrambled, or in the form of an omelet, are also permissible. It is important to prevent the use of foods which will cause a mechanical irritation—such, for example, as vegetables containing husks, berries with seeds or skins, etc. Very hot or very cold drinks should be avoided; so also should spices, pickles, alcoholic beverages, and coffee. Milk or cream diluted with hot water makes an ideal drink for these

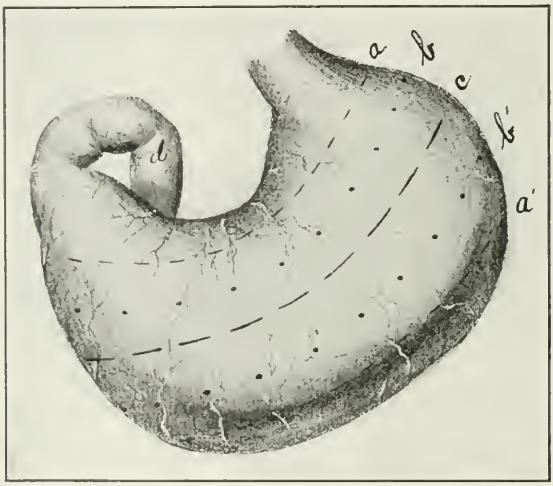

FIG. 154.—Diagram Illustrating the Manner of Performing a Gastrorrhaphy for the Cure of a Dilated Stomach Associated with Gastroptosis, but without Pyloric Obstruction. The lines *a* and *a'* and *b* and *b'* are to be united.

patients, and in time they come to prefer it to tea or coffee. Hot breads, pan cakes, and pies should be permanently prohibited.

In feeding these patients one should be very careful not to make the intervals between meals too short. Unless thoroughly predigested foods are given, the times when nourishment is administered should be at least three hours apart. Later on, when convalescence has been established, the periods should be extended to from four to six hours. If this precaution is not taken, the stomach—by reason of its inability to empty itself between meals—will be subjected to the same condition which existed when it contained residual substances,—a condition which, before the operation, was due to the existence of pyloric obstruction or to a pouching of the greater curvature of the stomach. Clinical experience has shown that, unless the importance of all of these precautions is thoroughly impressed upon the patient during the early part of his convalescence, he will surely commit errors in this direction which will produce unsatisfactory results

following the operation. This dietetic and hygienic treatment should be directed and controlled by the physician for a number of years after the operation.

In a few cases these patients suffer from constipation after the operation. This is most readily relieved by giving two teaspoonfuls of Carlsbad salts in a large glass of warm water half an hour before breakfast. Many of these patients thrive if they are given, each day, a single meal composed of from a pint to a quart of good milk or buttermilk. This will allow regular rest for the stomach and at the same time it will supply the patient with an abundance of food. Occasionally milk or buttermilk, if given pure, will not agree with the patient, while, if diluted with about ten per cent of lime water, it is borne very well.

Much discredit has fallen, especially upon the operations for gastrorrhaphy and gastro-enterostomy, because this precaution of continuing careful hygienic and dietetic treatment for a long period of time has been neglected; the patients upon whom one or other of these operations had been performed falling again into the hands of stomach specialists whom they had abandoned before the operation.

At this point it may be well to direct attention to the fact that no benefit can come from gastrorrhaphy in patients whose digestive disturbances are due to a general neurotic condition. Of late, many of these neurotic patients have had their attention directed to their gastric disturbances, and, as a result, their gastric disturbances have become more pronounced. It seems, therefore, as if, in many of these cases, the neurotic condition were secondary to the malnutrition resulting from gastric disturbance.

It is plain that a general neurotic condition would not preclude the co-existence of gastric ulcer, of pyloric obstruction, or of a dilated stomach, but the relieving of any one of these conditions would not cure the neurosis. It is consequently wise to refer these cases for treatment to the neurologist, who, while he may fail, with the measures at his command, to afford the desired relief, will at least not add a mechanical and anatomical blemish as serious as that of a gastro-enterostomy.

Gastroptosis.—There are few patients in whom gastroptósis exists in an uncomplicated form. Originally it is accompanied by a more or less general enteroptosis—a condition in which all of the intra-abdominal organs fail to retain their proper vertical positions. Thus, for example, when the patient is in a standing position, the edge of the liver is below the normal line; the kidneys, especially the right one, are lower than normal; the transverse colon, the cæcum, and the small intestines are all just above the brim of the pelvis; there is frequently at the same time a diastasis of the recti muscles of the abdomen. Several years ago many of these patients were subjected to gastro-enterostomy, in the hope that they might be relieved of their digestive disturbances by establishing gastric drainage; but the results were most unsatisfactory.

A number of operations have been devised for suspending the stomach at the proper level, but none of these methods, with the possible exception of the one devised by Beyea, has given satisfactory results. This method is described by the author as follows:—

Operation by Beyea.—"The patient, after being prepared for the operation of celiotomy and anæsthetized, is placed upon the operating table in a position opposite to that employed for operations through the lower portion of the abdomen. The object of this position is to permit the elevation of the chest and upper portion of the abdomen, to allow gravitation of the intestines and stomach out of the field of operation, and in order to gain every advantage of the Trendelenburg position. The skin of the abdomen is then scrubbed with ether, alcohol, and a mercuric chloride solution, and the field of operation is surrounded by sterilized towels. An incision is made through the linea alba, midway between the xiphoid cartilage and the umbilicus. The tissues are separated in the usual

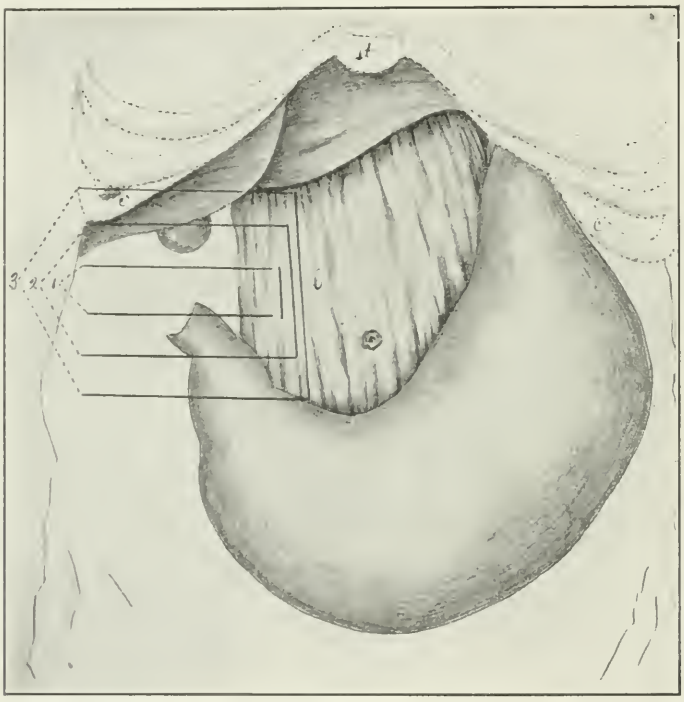

Fig. 155.—Diagram Illustrating Beyea's Operation for Relief of Gastroptosis. *l*, Gastrophrenic ligament. 1, 2, 3, sutures used for shortening this ligament and thus elevating the stomach.

manner and the peritoneal cavity is opened, exposing a small portion of the lesser curvature and the cardiac end of the stomach, the gastrohepatic ligament or omentum, the gastrophrenic ligament, and the lower portion of the left lobe of the liver. The table is then elevated to the inverted Trendelenburg position and the stomach is displaced still further downward and out of the wound by means of gauze sponges. This procedure causes the gastrohepatic and the gastrophrenic ligaments to become slightly stretched and separated from the underlying structures, which permits an accurate determination of the length of these ligaments and very greatly facilitates the operative manipulations. The gastrophrenic ligament is seen well developed, and evidently forms a strong support to the cardiac end of the stomach. The joining portion of the gastrohepatic ligament

is composed of thin, delicate peritoneum, increasing in thickness and strength toward the right or pyloric end of the stomach. Retractors are introduced and the liver is held aside by placing a gauze sponge beneath the retractor. Three rows of interrupted silk sutures are then introduced so as to plicate and thus shorten the gastrohepatic and gastrophrenic ligaments in the following manner. The first row, beginning in the gastrophrenic ligament and extending across the gastrohepatic ligament to a point almost opposite the pyloric orifice and hepatico-duodenal ligament, is introduced so as to form a plication of the centre of these ligaments, and includes, from above downward or vertically, about 4 cm. of tissue. (Row No. 1, Figs. 155 and 156.) They are practically mattress sutures, including sufficient of the delicate tissue (1 cm.) to insure against their tearing out. Five sutures, about one inch apart, are now introduced from right to left

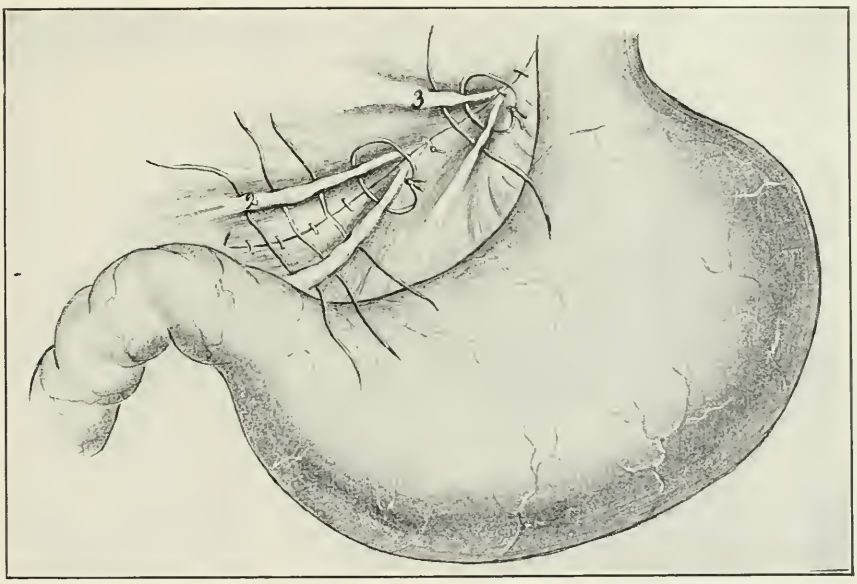

FIG. 156.—Diagram Illustrating a More Advanced Stage of Beyea's Operation for the Relief of Gastroptosis. The deepest row of sutures of the gastrophrenic ligament has been completed, as shown at 1. The second and third rows, 2 and 3, are partly completed.

and caught in the hæmostatic forceps. The next row of sutures (row No. 2), is introduced in the same manner, but it extends 2.5 cm. above and the same distance below the first row. Then a third row (row No. 3) is introduced just above the gastric vessels and a short distance below the diaphragm and liver. The suturing is strictly confined to the normal ligamentary supports, and the distance between the rows from left to right is increased with the length of the ligaments, being greater toward the right. The gauze sponges are now removed, and the first, the second, and finally the third row of sutures secured, the stomach, particularly the pyloric end, being elevated to a little above the normal position. The abdominal wound is closed by suturing the peritoneum with catgut, the fascia with catgut, and the skin with an intracutaneous silk suture; in addition, three re-enforcing silkworm-gut sutures are passed through the skin and fascia."

Beyea's operation has one distinct advantage over the others which have been described: it carries the lesser curvature of the stomach to a relatively high level as compared to the level of the pylorus. In gastroptosis there seems to be a sagging down of the portion of the stomach which lies between the pyloric attachment and the œsophageal attachment, both of which parts are relatively fixed. The resulting deformity in the stomach makes it very difficult for food to be expelled through the pylorus because of the distance to which it must be elevated. Moreover, this deformity increases very appreciably the storage end of the stomach and decreases the grinding end to a corresponding degree. Both of these conditions are of course unfavorable for the normal progress of digestion, and must in time result in producing an accumulation of residual contents in the dependent pouch formed by the greater curvature of the stomach. With the increase in this condition comes a condition of malnutrition, because the patient absorbs products of decomposition instead of products of normal digestion.

Careful and thoroughly applied gastric lavage is of great benefit to these patients, as it removes decomposing stomach contents and leaves the stomach in as favorable a condition as possible for digesting food next placed in its cavity.

In case operative treatment is determined upon, gastric lavage should be carefully employed for a number of days before the operation. It is best to perform the lavage about three hours after meals. Half an hour before meals give half a teaspoonful of Carlsbad salts in moderately hot water. This will dissolve the mucus and leave the stomach in a fairly good condition.

The operation just described for the relief of this condition carries the lesser curvature of the stomach to a point a little above the normal level, in order to make up for some slight sagging which is certain to occur as a result of the stretching of the cicatricial tissue caused by the suturing of the gastrophrenic ligament.

After-treatment.—Directly after the operation gastric lavage should be carried out at least twice a day during the time the patient is in the hospital. Nourishment should be given in the form of enemata until the patient shows marked symptoms of hunger, when concentrated foods in small quantities should be given by way of the mouth. If the stomach maintains its characteristic position, the conditions for normal digestion will of course be greatly improved, and within a few months the patient's nutrition will be markedly benefited. Among these patients there are many who suffer from a general neurotic condition, and, unless this be entirely due to malnutrition resulting from the gastroptosis, the neurotic condition will not be benefited.

Duodenal Sphincter.—In a considerable number of cases in which it seemed difficult to make a differential diagnosis between disease of the pylorus, disease of the duodenum, and disease of the gall-bladder and ducts, the author has found an anatomical condition which seems of sufficient importance to receive some especial attention. This condition consists in an increase in the circular muscle fibres at a point below the entrance of the common duct into the duodenum. These muscle fibres may be arranged in one or in two groups. They may be placed directly below the entrance of the common duct or they may

be located at any spot below this point in the wall of the duodenum, but usually they are located from 2 to 5 cm. below this point, as shown in Fig. 157.

The author has not as yet been able to determine the proportion of bodies in which the circular muscle fibres at this point in the duodenum are sufficiently numerous to produce a distinct sphincter—a sphincter, however, which is never so pronounced as the pyloric sphincter. Neither has he been able to determine whether the presence of this duodenal sphincter is due to hypertrophy of the muscular fibres natural to the part or whether it represents a congenital peculiarity.

In these cases there is usually a marked dilatation of the duodenum above this sphincter and frequently the pylorus is wide open. This condition may

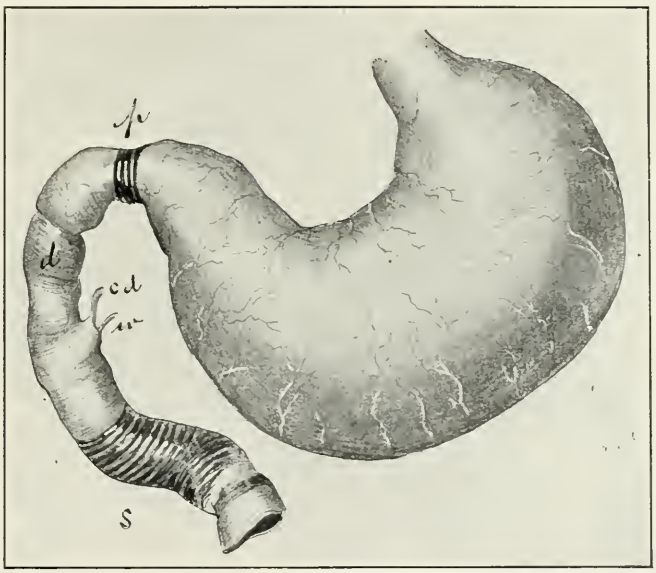

Fig. 157.—Diagram of the Stomach and Duodenum, Showing the Pylorus (*p*), the Common Duct (*c d*), the Duct of Wirsung (*w*), and also the location of the increase in circular muscle fibres at *s*. The latter, however, is exaggerated in the drawing, as it is never nearly so powerful a sphincter as the pylorus, but it is usually broader than the pylorus.

exist independently or it may exist as a complication of ulcer of the stomach, duodenal ulcer, or cholecystitis. It has never been observed in connection with a marked degree of gastric dilatation, probably because the obstruction due to the presence of this sphincter is not sufficient to cause a dilatation of the stomach.

It is well to bear this condition in mind in all cases, because it will serve to explain a number of cases in which the conditions found at the time of operation do not correspond with the diagnosis.

Carcinoma of the Stomach.—The surgical treatment of carcinoma of the stomach has received much attention during the last twenty-five years,—that is, since it was first introduced by Billroth. Woelfler, Mikulicz, Czerny, Kocher, Mayo-Robson, Moynihan, Hartmann, and many others abroad, and, in this country, Mayo, Monro, Murphy, and others have written extensively on this subject, and have developed a technique which is as far advanced as is the

technique connected with the surgical treatment of any other abdominal condition.

The important point in the surgical treatment of carcinoma of the stomach is to be able to make an early diagnosis. The success of the treatment depends quite as much upon this diagnosis as upon the operative technique after the diagnosis has been made. It is, however, but rarely that an early diagnosis is made in these cases, because, as a rule, they do not come into the hands of the surgeon until they are far advanced, except when they come with a mistaken diagnosis of ulcer of the stomach.

The medical practitioner should bear constantly in mind the importance of what has been stated above, in order that he may place any patient who may be suspected of having carcinoma of the stomach, under surgical treatment as early as possible.

Recently Elsberg has published a method which, when fully developed, promises to equal the tuberculin test in tuberculosis in the diagnosis of even the earliest beginning of carcinoma. It is likely that the method will undergo important changes in the near future, and therefore it will not be best to describe it in its present form.

The fact that gastric ulcer and carcinoma both occur most frequently in the pyloric end of the stomach, would indicate that the carcinoma may have developed upon the ulcer. This belief has been borne out by a study of the histories of many cases. Fuetterer has also shown experimentally that carcinoma—at least in some instances—develops from a gastric ulcer. These facts point toward the advisability of undertaking surgical treatment at an early stage of the disease in cases in which it is not possible, without an exploratory incision, to make a positive differential diagnosis between carcinoma of the stomach and gastric ulcer.

Diagnosis.—In the early stages of carcinoma of the stomach the symptoms are practically the same as those which have already been described as characterizing gastric ulcer. Later, when the carcinoma becomes ulcerated, there are distinct symptoms due to the absorption of septic material. The hemorrhage differs little from that observed in gastric ulcer. Still later in the course of the disease, there is an unmistakable cachexia, which is more or less marked according to the extent of the carcinoma in the stomach itself or of its metastases in other organs, or according to the degree to which it has invaded surrounding structures. That much of the cachexia is due to absorption, from the stomach and intestines, of products of decomposition, is proven by the fact that this condition is usually reduced, to a marked degree, whenever gastric lavage is employed regularly two or three hours after food has been taken. At a still later stage of the disease, a distinct tumor may be felt through the abdominal walls, this recognition being facilitated by the emaciation of the patient as well as by the growth of the tumor. Unfortunately, when the latter has reached such a size that it can be palpated through the abdominal walls, it is usually too late to obtain a permanent cure.

Often the presence of a tumor is simulated by the contraction of the rectus

abdominis muscle which takes place when palpation is made. This condition is especially marked in the presence of gastric ulcer in which there has been acute irritation.

Chemical Examination of the Stomach Contents.—In advanced carcinoma of the stomach the chemical examination of the stomach contents, obtained an hour after a test meal has been given, usually shows the absence of free hydrochloric acid and the presence of lactic acid. It is well to make this test; nevertheless, a negative result should always be ignored when a diagnosis of carcinoma has been made from a study of the history and the remaining symptoms. This test is not reliable during the early stages of the disease, when surgical treatment promises a fair chance for relief. It is consequently not advisable to allow the patient to advance to a hopeless condition in order to make a diagnosis by means of this test.

Microscopic Examination of the Stomach Contents.—In the early stages of carcinoma of the stomach the microscopic examination of the contents of this organ usually shows nothing but blood and other substances which are regularly found in the contents obtained from the normal stomach or from one in which only benign ulcers are present. In the more advanced cases of the disease the Boas-Opler bacillus is likely to be found, and it is often possible to siphon out, through a stomach tube, fragments of the tumor tissue together with the stomach contents; but here, again, the patient's condition has reached such a point that surgical treatment will be of no permanent benefit to him. If, then, cases of carcinoma of the stomach are to be benefited by surgical interference, it is necessary to operate during the early stages when the local disease is still quite circumscribed. In order to carry out this early treatment it may often be necessary to make an exploratory incision for the purpose of confirming or disproving the diagnosis. It is usually possible to make a positive diagnosis after the abdomen has been opened, and after one has been able to palpate the growth carefully; but even then it is sometimes impossible to make a differential diagnosis between an indurated ulcer and a carcinoma. Surgeons who have had much experience in operating for the relief of this condition, have occasionally, while laboring under the belief that they were removing a beginning carcinoma, removed in reality what proved afterward to be a non-malignant indurated ulcer of the pylorus; and *vice versa*. This error is of but slight importance, as the same treatment may be properly applied to both of these conditions; the only difference between the two being that a somewhat more extensive operation is indicated in the presence of an incipient carcinoma because of the likelihood of a recurrence if any of the surrounding lymph nodes are not removed.

Technique of the Operation for the Removal of a Carcinoma of the Stomach.—In determining how large a portion of the stomach should be excised, in a case of carcinoma of this organ, it is well to bear in mind the distribution of the lymph nodes as well as the distribution of the arteries. The removal of all the affected nodes is necessary if the patient is to be made reasonably safe against a recurrence. A knowledge of the distribution of the arteries is necessary in order that the surgeon may determine just how much of

the organ may be removed with relative safety as regards the immediate recovery. So far as the latter question is concerned, it matters little how large a portion of the pyloric end of the stomach is removed, provided one does not go beyond the point of entrance of the coronary artery; but, when a greater portion is removed, the mortality is immediately increased to a great degree. Fortunately, the removal of this limited portion of the stomach suffices in a vast majority of cases.

These points are illustrated beautifully by the anatomical studies of Hartmann and Cuneo, which show that the lymph nodes which are infected in case of carcinoma of the stomach do not usually extend beyond the point of entrance of the coronary artery.

Fig. 158 shows the area of the stomach which usually remains free from infection with carcinoma. The portion to the cardiac side of the area, which is included between the dotted lines, is known as the dome of the stomach. This portion usually remains free from carcinoma in all operable cases. The dotted lines represent the lines of choice through which different surgeons make their incisions in partial gastrectomy for carcinoma of the pylorus. The remaining portion of the organ with its lymph channels is likely to be involved, and so also are the lymph nodes along the greater and the lesser curvatures.

If we bear this distribution of the lymphatics in mind we shall be more likely to make a complete excision of all of the diseased tissues than would be possible if we were to proceed empirically altogether. There can be no doubt but that, in this as in every other region of the body, the success of an excision of carcinoma depends upon the extensive removal of surrounding tissues as well as upon the careful removal of the lymph nodes which are in a position in which they are likely to become invaded.

Whenever the tumor itself has invaded any of the immediately surrounding tissues its removal does not promise a sufficient likelihood of permanent cure to be worth while. In fact, if the obstruction is overcome by performing a gastroenterostomy, the tumor frequently ceases for a time to grow, its ulcerated surfaces heal, and the general condition of the patient improves to a marked degree. This can usually be improved by giving the patient one or two grains of methyl blue (pyoctanin) three or four times a day, and from five to ten drops of oil of eucalyptus an equal number of times. These remedies seem to exert a disinfecting effect upon the ulcerated surfaces. On the other hand, if an attempt is made to remove or partially remove these carcinomata, in cases in which the complete removal is impossible, one frequently observes a very rapid increase in the growth. The operation seems, in many of these cases, to stimulate the growth to a marked degree. For this reason it seems wise not to attempt the removal of a carcinoma of the stomach in any case in which it is plain that a complete removal is impossible.

Some years ago, there was laid down, by a number of surgeons, a rule according to which gastrectomy or partial gastrectomy was permitted only in cases in which there was no secondary involvement of lymph nodes, because it seemed certain that in all of these cases the disease must have advanced to a hopeless

degree at the time of the operation. Further experience has shown, however, that this was too broad a supposition. It has been found, for example, that in many cases the enlarged lymph nodes are inflammatory in character and do not contain secondary carcinoma. In any given case, then, in which it seems possible to remove the entire primary growth, it is best to undertake this even

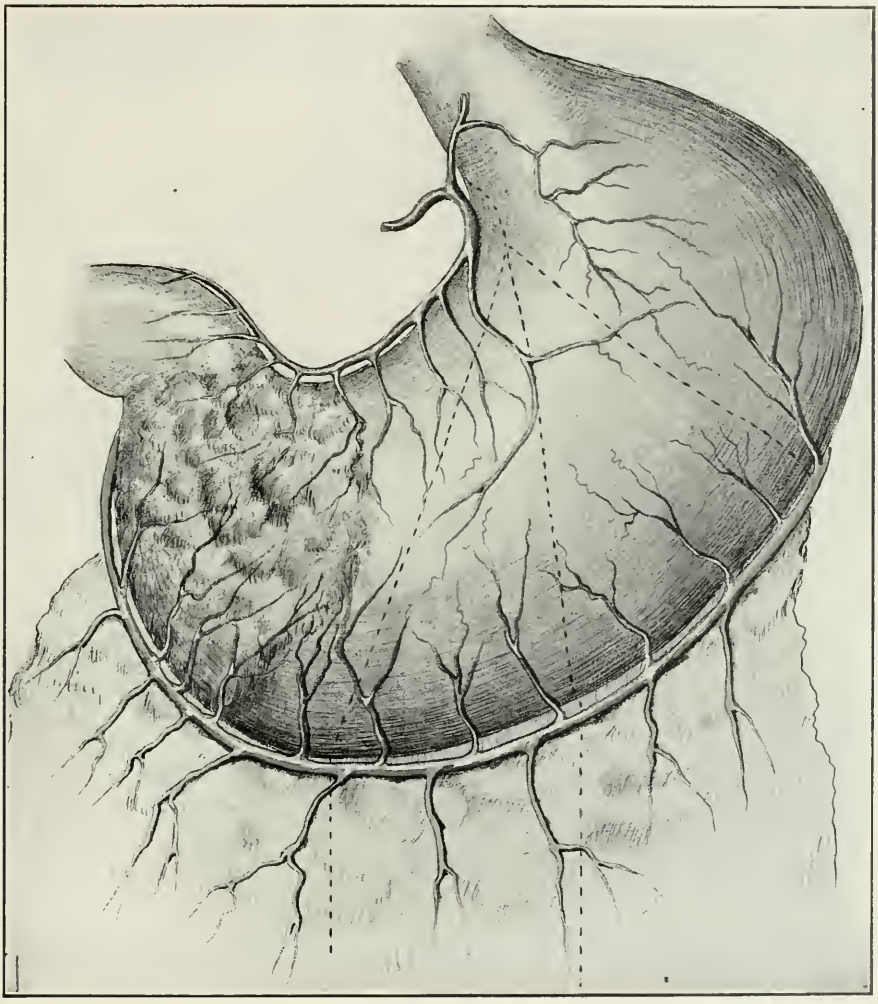

FIG. 158.—Stomach with Carcinoma of the Pylorus. The diagram shows the arrangement of the blood-vessels along the greater and lesser curvatures, and it also indicates, by means of dotted lines, where the different surgeons prefer to make their incisions in partial gastrectomy for the relief of carcinoma of the pylorus.

though there be an involvement of lymph nodes. Of course, the latter must be very carefully removed at the same time.

It may be well to enumerate the dangers which this thorough excision involves, so that they may be kept in mind during each step of the operation:—

(1) There is danger of necrosis of the remaining portion of the stomach if care is not taken to preserve a sufficient supply of blood from the lesser curvature

of the stomach. Ordinarily this danger can be avoided by not carrying the incision beyond a point a little to the right of the coronary artery, but, in case of an anomalous distribution, which is not altogether uncommon, care must be taken to preserve a suitable arterial branch.

(2) Injury to the pancreas is likely to be followed by fat necrosis and by suppuration. In case such an injury occurs, the surface should be carefully sutured and a gauze or cigarette drain should be introduced down to the point of injury and out of the upper angle of the abdominal wound.

(3) The loop of the duodenum lying behind the pyloric end of the stomach may be injured. This can be avoided easily by bearing in mind the location of this intestine.

(4) The median colic artery may be caught, and this may result in a gangrene of the transverse colon. This danger may be avoided by lifting up the pyloric end of the stomach and clamping and severing the greater omentum step by step.

(5) There is danger of infection. This danger must of course be avoided by carefully packing away the surrounding structures with gauze pads.

(6) There is danger from tension between the jejunum and the stump of the stomach. This danger can be avoided by selecting the proper portion of the jejunum to which the stomach is to be attached.

(7) There is danger from pneumonia following the operation. This danger is probably due in large measure to unnecessarily severe manipulations during the operation and to the position in which the patient is placed after the operation. As soon as possible after the operation the patient should be placed in a sitting or semi-sitting position, and, until this can be done, the head end of the bed should be elevated twelve inches. The patient can usually be placed in the semi-sitting position within six hours after the operation.

(8) Another post-operative danger, which may be mentioned here, consists of the acute dilatation of the remnant of the stomach—an occurrence which is accompanied with pain and dyspnœa and sometimes with nausea. This should be relieved by the introduction of a stomach tube and by the use of gastric lavage, care being taken not to introduce more than from 200 to 300 c.c. of fluid at a time through the tube, and to measure carefully the amount withdrawn as well as the amount introduced.

(9) Post-operative vomiting constitutes a real danger which should be relieved immediately by the use of gastric lavage, which may be repeated as often as may be found necessary for permanently stopping the nausea and vomiting.

Gastrostomy.

Whenever there is a complete closure of the œsophagus from any cause, or when there is so extensive a narrowing of this tube that not even liquids can be introduced into the stomach, it will become necessary to provide a means for the introduction of nourishment and fluids into the stomach in order to prevent starvation or death from thirst. For a time it is possible to overcome the

distress of these patients by the administration of nourishment and water *per rectum* or by the subcutaneous injection of normal salt solution; but this will not suffice for any considerable period of time. It is consequently far better to perform gastrostomy as soon as the patient fails to obtain an amount of liquid nourishment sufficient to maintain his weight and strength.

The operation is borne well if performed before the patient is exhausted by hunger and thirst, and, for a time, the benefit to the patient is so great that the operation is one of the most satisfactory procedures which the surgeon is called upon to perform for the relief of patients suffering from malignant disease. One condition, however, must be secured by the operation, because without it the patient usually is even more unhappy than he was before the operation. The gastrostomy opening must absolutely prevent any leakage of stomach contents. Any operation which does not insure this condition must be rejected as useless.

Technique of the Operation.—An incision about 5 cm. (1½ in. to 3 in.) long is made parallel with, and splitting the middle of, the left rectus abdominis muscle, half-way between the ensiform appendix of the sternum and the umbilicus. The precise length of the incision will depend upon the extent of the contraction of the stomach and the thickness of its wall. In the case of a contracted stomach with a thick wall it is necessary to make the incision longer than in the case of a large, thin-walled stomach, in order to secure a sufficient amount of space for performing the necessary manipulations without causing too much traumatism. The anterior wall of the stomach is then drawn out through this incision (Fig. 159), and at the most prominent point two separate silk or linen purse-string sutures are applied in concentric circles and left untied. The inner circle—*i.e.*, the circle described by the first suture—is about three-fourths of an inch in diameter. It is well to start at different points about the circle with each suture, in order to prevent confusion. These sutures pass through all the layers of the stomach wall down to, but not through, the mucous membrane, as shown in Fig. 160. A small puncture is then made in the centre of the inner circle, and through this is introduced a Jacobs retention catheter from ½ to 1 cm. in diameter. The pushing in of this catheter through the small opening causes the tissues of the stomach wall to become infolded, and this infolding is still further increased when the purse-string sutures are drawn tight. The circular purse-string sutures are next tied in succession, the one nearest the tube being tied first. In this manner more and more of the wall of the stomach is inverted, until a sufficient amount has been turned in to prevent permanently any leakage even if the tube is removed temporarily. This can be still further accomplished by placing a few Lembert sutures on each side of the tube, as shown in Fig. 160.

The enlargement at the end of the tube prevents its slipping out of the opening. The stomach is then sutured to the peritoneum and the transversalis fascia with catgut sutures; and it is further supported by a deep suture which, placed on either side of the tube, grasps in succession all of the layers of the abdominal wall and then all the layers of the stomach wall down to, but not

through the mucous membrane. These sutures may consist of silkworm-gut or of silk. (Fig. 161.)

If this method is carefully carried out, the opening may be maintained for an indefinite period of time without danger of leakage.

The projecting portion of the tube is fastened to an abdominal bandage and its end is closed with a cork. If the patient desires food, he attaches a funnel to the end of the tube and pours any kind of liquid nourishment into the stomach, being careful to do this slowly. A large glass syringe may be used in place of

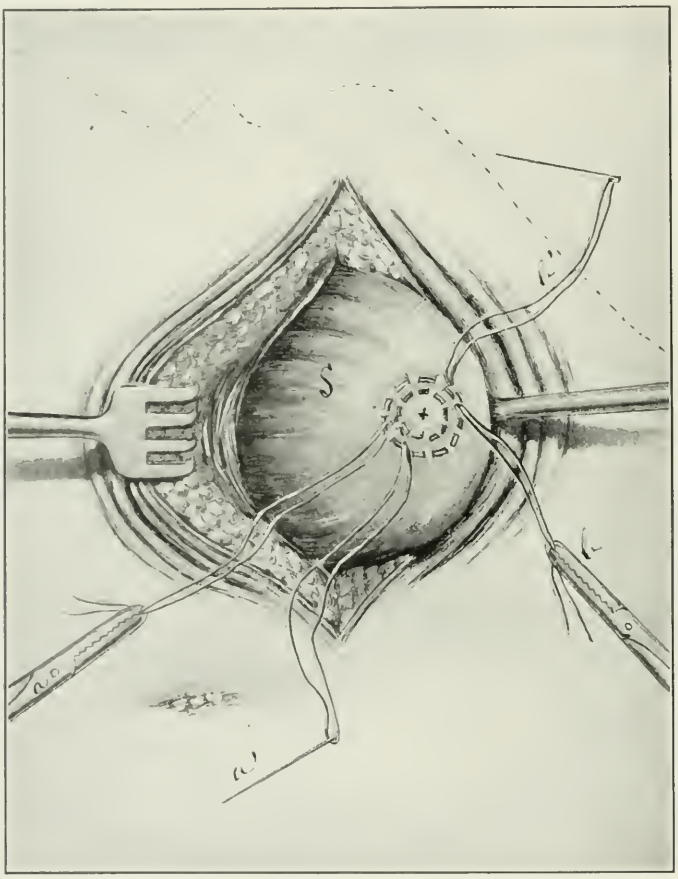

Fig. 159.—Gastrostomy. *S*, Stomach; *a a'* and *b b'*, circular silk sutures; *x*, point of puncture for introduction of tube.

the funnel if purées or any other semi-liquid substances which are too thick to run through a tube, are to be given.

If the patient wishes to enjoy the taste of food he may chew the food thoroughly and then place it in the syringe and force it through the tube into the stomach. In this plan there is the further advantage of having the food mixed with saliva during the act of mastication.

In some of these patients who have become much reduced in strength, the adhesions formed between the stomach and the abdominal wall are very frail

and require to be increased by means of some irritation. For this purpose the use of iodoform gauze has proven very satisfactory. It is applied in the following manner:—A piece of iodoform gauze is folded around the feeding tube, as shown in Fig. 162, and stitched to the stomach by a number of interrupted catgut sutures. All of the other steps of the operation are carried out as above, this simply being an additional safeguard. After about ten days the catgut sutures will be absorbed and the gauze may be withdrawn. It will usually be found that by this time the adhesions between the stomach and the abdominal wall have become quite firm.

Many of these patients gain considerably in weight after this operation has

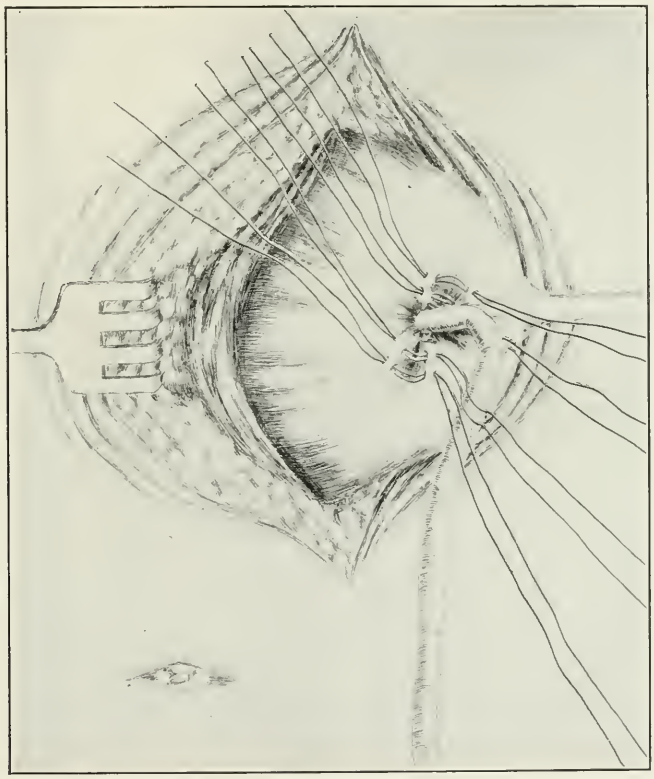

Fig. 160.—The Diagram Shows how Lembert Sutures have been Applied on Each Side of the Catheter in order to invert the wall of the stomach further and thus prevent leakage.

been performed, because the stomach and intestines are usually entirely free from disease. In many instances the freedom from irritation of the constricted portion of the œsophagus results in a subsidence of the obstruction, so that these patients frequently become able again to take liquids through the mouth.

If, owing to the marked character of the œsophageal obstruction, the patient has suffered severely from thirst before the operation, half a pint of warm normal salt solution should be poured into the stomach through the feeding tube at the close of the operation, and this procedure should be repeated every half-hour until the patient is satisfied. If he has still been able to swallow before the

operation, he may be allowed to drink water naturally after its completion, provided this causes no distress or annoyance. Otherwise, the water should be given entirely through the feeding tube. In the mean time the patient should be fed regularly every three hours with peptonized milk, raw egg, the juice extracted from roast beef or broiled steak, rich broths, soups, and mush. The food can be poured into the stomach through a funnel, or an ordinary glass syringe may be attached to the feeding tube and this will serve as a funnel.

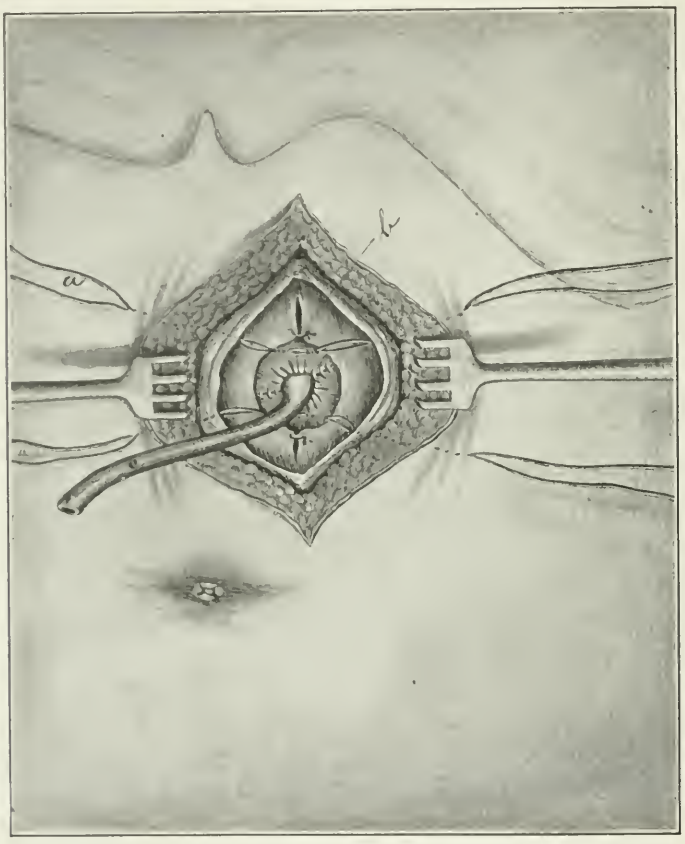

FIG. 161.—Gastrostomy. Diagram shows a Jacobs retention catheter (*c*) in place. *a*, Deep silkworm-gut sutures for closing wound in the abdominal wall; *b*, catgut suture uniting the peritoneum and the transversalis fascia with the stomach.

Later, the patient may chew thoroughly any kind of food and thus mix it with saliva. He can then inject this through the feeding tube into the stomach.

Witzel's Gastrostomy Operation.

Another method which has given excellent results is that introduced by Witzel. It has been satisfactorily employed in many cases. The principle involved is identical with that of the operation which has just been described.

Technique of the Operation.—The stomach is approached by an oblique incision made below the left costal arch and carried through the skin and fascia.

This incision passes through the anterior sheath of the rectus abdominis muscle; then through the muscle itself, causing a vertical separation of its fibres, next through the posterior sheath of this muscle; and, finally, through the peritoneum. A portion of the anterior wall of the stomach is now drawn through the wound. A velvet-eyed rubber tube is laid against the anterior wall of the stomach, generally in such a position as to correspond with the outer wound, with the blunt end of the tube toward the cardiac end of the stomach and the opposite end of the instrument directed toward the lesser curvature. A portion of the tube, about two or three inches in length, is now buried in the anterior stomach wall

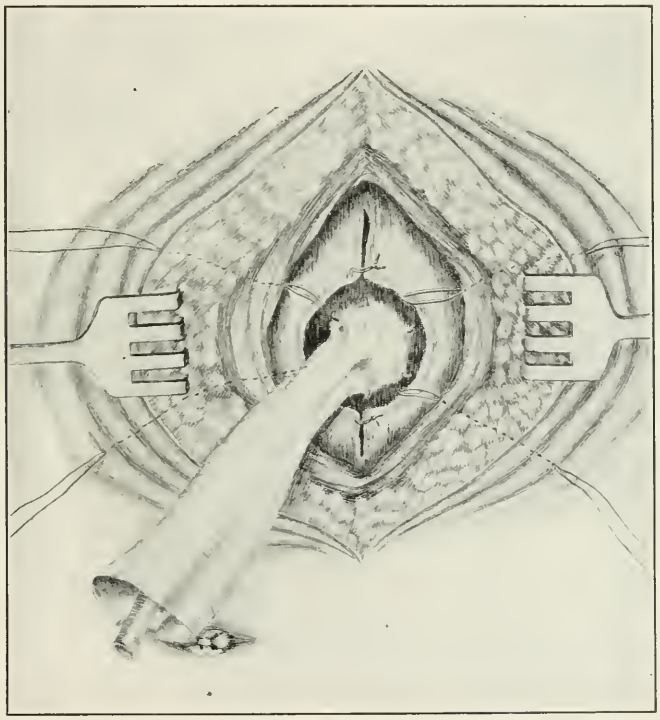

Fig. 162.—Diagram Showing the Manner of Introducing a Piece of Iodoform Gauze. The gauze is folded around the catheter and attached to the wall of the stomach by catgut sutures.

by means of Lembert catgut sutures placed from an eighth to a fourth of an inch apart and extending at least half an inch beyond the point at which the tube is to enter the stomach. This tube is so placed as to avoid the larger vessels. (Fig. 163.) All the sutures except the three or four at the lower end of the tube, are next tied, thus burying the instrument in the tissues. This part of the stomach wall is then held in such a way as to separate it from the posterior wall and to make the site of entrance of the tube into the stomach prominent. A quick stab wound is next made with a narrow sharp-pointed bistoury through all the layers of the stomach wall at the point of prominence. The end of the tube is then thrust through the opening into the cavity of the stomach, and the three or four sutures which were temporarily left untied at the lower end of the

tube, are at once tied, thereby preventing leakage from the stomach. (Fig. 164.) The stomach is now allowed to drop back into the abdominal cavity, but the portion of the stomach which contains the buried tube remains in contact with the edges of the wound. The serous and muscular layers of the stomach in the immediate neighborhood of the tube are next united by interrupted catgut sutures with the two edges of the parietal peritoneum. (Fig. 164.) The external abdominal wound is then closed in the usual manner, the rubber tube being allowed to project through it. (Fig. 165.) In order that it may be held in its proper place, a silk suture is passed through the outer part of its wall and is fastened to the skin. The tube is left in place for four or five days, and then a soft-rubber tube is inserted whenever it is necessary to feed the patient.

If at any time there should be a small amount of leakage, sufficient to irritate

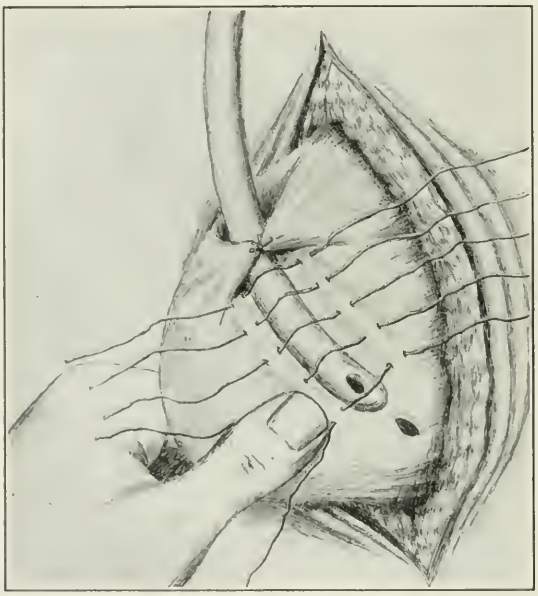

FIG. 163.—Witzel's method of Gastrostomy. The diagram shows the manner of burying the tube in the fold of the stomach wall by means of Lembert's sutures. (After Richardson.)

the skin, it is well to introduce a tube slightly larger and to confine the patient exclusively for several days to egg-albumen diet. The whites of two eggs may be given through the tube four times a day at intervals of four hours. This removes the irritating effect of the gastric juice, and after the second day the larger tube may be replaced by a smaller one, as quite a marked narrowing of the canal will have taken place in the mean time. The feeding in general must of course be carried on as described in connection with the last operation.

Marwedel's Method of Gastrostomy.

This operation resembles Witzel's in most of its essentials. In two respects, however, the procedure is different. The tube is buried between the mucous coat, on the one hand, and the serous and muscular coats on the other; and the

parietal peritoneum is sutured to the skin before the stomach wall is attached to the edges of the incision in the abdominal parietes.

Technique of the Operation.—As soon as the peritoneal cavity is opened the parietal peritoneum is brought out and sutured to the skin at the margin of the wound. The anterior wall of the stomach is brought up and sutured to the parietal peritoneum at the edges of the wound. An incision about two inches long is now made through the serous and muscular coats of the stomach. The serous and muscular coats are then dissected from the muscosa on both sides for a short distance. A rubber tube is next laid between the split coats of the stomach, which are then sutured over it with catgut. The sutures at the lower

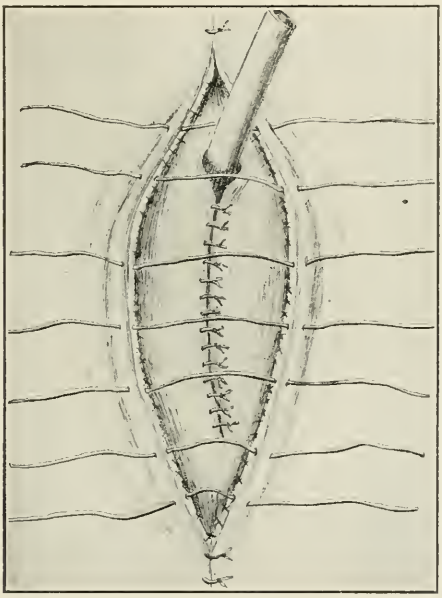

Fig. 164.

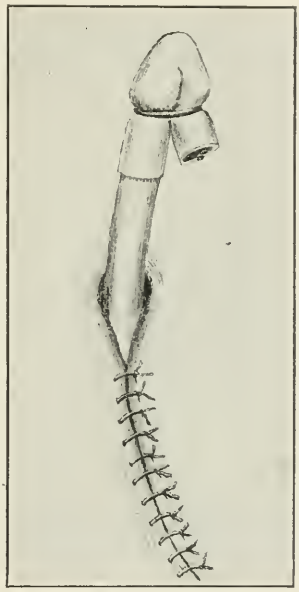

Fig. 165.

Fig. 164.—Diagram Showing a Later Stage of Witzel's Method of Gastrostomy. The stomach is sutured to the abdominal parietes, and the sutures for closing the outside abdominal wound are in place. (After Richardson.)

Fig. 165.—Diagram Showing Witzel's Method of Gastrostomy Completed. (After Richardson.)

end extend beyond the intended opening and are placed, but not tied. When all the rest are tied an opening is made through the mucous coat, the tube is thrust into the cavity of the stomach, and the lower stitches are at once tied. The margins of the abdominal wound are then sutured together with silkworm-gut.

The Ssabanajew-Frank Gastrostomy Operation.

This operation has also given excellent functional results, especially in cases in which there is a soft and pliable stomach wall, and more particularly in those in which the stomach is reasonably large. There are many cases, however, in which, nothwithstanding the fact that they require a gastrostomy, the operation cannot be satisfactorily employed. These are cases in which very little food

has been introduced into the stomach for a number of weeks or months, and in which therefore the organ will be much contracted. In the presence of such a contraction it is not practicable to perform the operation satisfactorily.

Technique of the Operation.—An incision, from 5 to 7 cm. long, is made parallel to and along the left edge of the costal arch, as indicated in Fig. 166. The rectus muscle is separated vertically by blunt dissection. A second incision 2 cm. long is now made parallel to, and 3 cm. above, the first incision. The skin between these two incisions is tunneled, and a cone-shaped portion of the

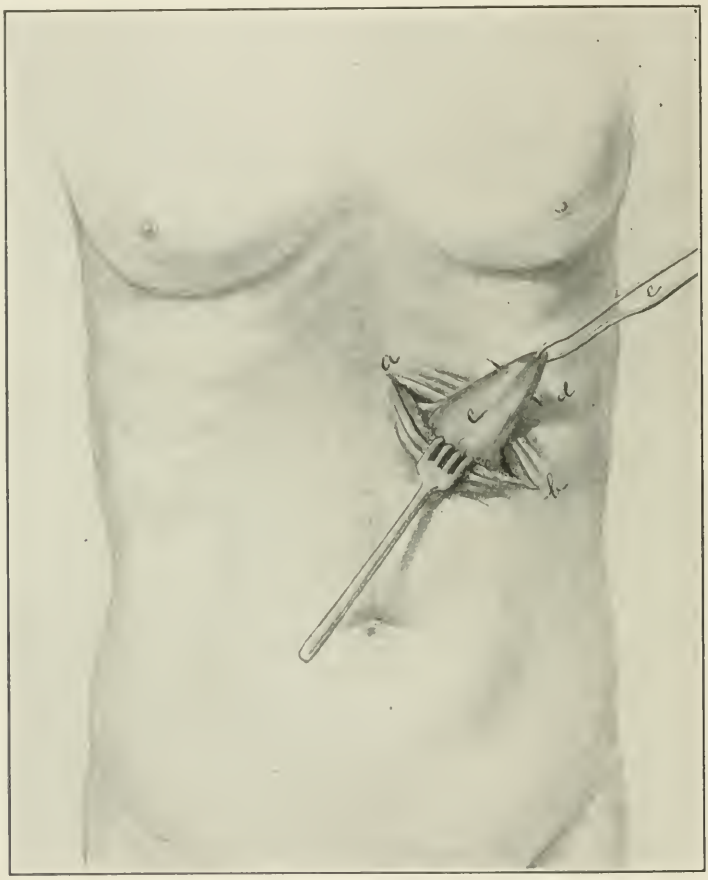

Fig. 166.—Gastrostomy; the Ssabanajew-Frank Operation. *a b*, Primary incision; *d*, secondary incision; *c*, fold of stomach drawn out by means of suture *e*.

anterior wall of the stomach is drawn out (by means of a silk traction ligature passed through the serous and muscular coats) through the opening made by the first incision and is then pulled through the tunnel, its free end projecting a distance of 2 cm. beyond the opening of the latter. (Fig. 167.) The apex of the cone is nearer the greater than the lesser curvature and nearer the cardiac than the pyloric end of the organ. Only so much of the stomach as may readily pass through the tunnel described above should be drawn out. The edges of the skin wound are carefully sutured to this projecting portion of the stomach

and the wall of the organ further down is sutured to the edge of the peritoneum and the transversalis fascia, in order to reduce the tension upon the skin. (Fig. 167.) The projecting portion of the stomach may now be opened, or, if the case is not very urgent, it is better to open the stomach several days later, in order that firm adhesions may take place in the mean time. The projecting portion of the stomach passing over the edge of the ribs forms an efficient valve to prevent leakage.

A modification of this operation which has been adopted by a number of

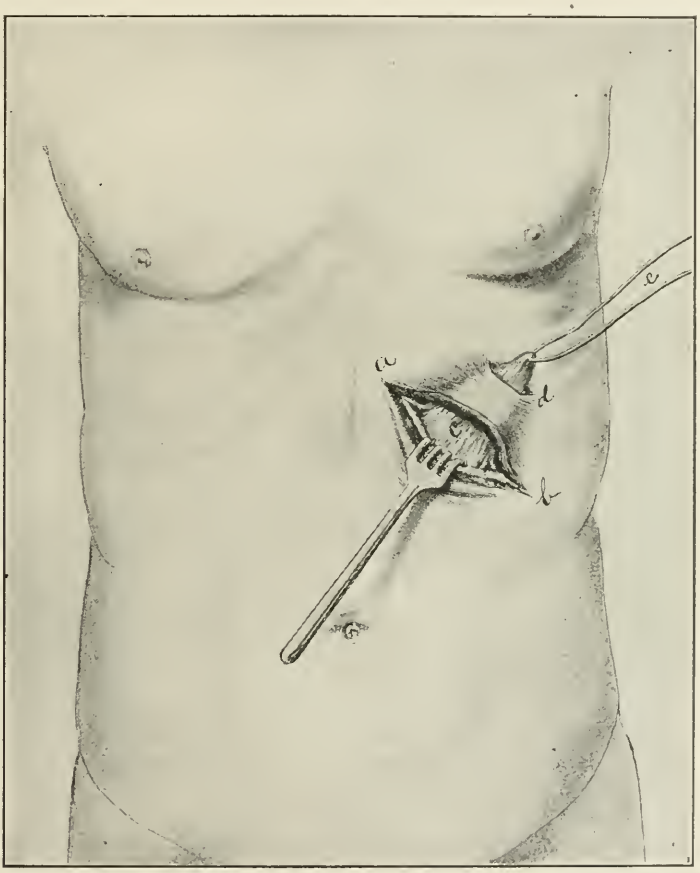

Fig. 167.—Gastrostomy. The diagram shows a later stage of the Ssabanajew-Frank operation. The portion of the stomach which was drawn through the opening made by the primary incision is here represented as being pulled through the canal made underneath the skin by the secondary incision.

surgeons, consists in making the same incision that has been described in the previous two operations and then proceeding with the operation according to the method that has just been described. This incision, as shown in Fig. 168, has the advantage of being a muscle-splitting operation, which leaves the abdominal wall somewhat stronger than does the incision employed in the Ssbanajew-Frank operation.

The remaining steps of the operation are the same as those just described.

II. SURGERY OF THE ŒSOPHAGUS.

Surgery of the œsophagus, in comparison with surgery of the rest of the gastro-intestinal tract, is limited, and probably will always remain so on account of the nature and position of the organ itself.

In many conditions the treatment is of a palliative nature. The distress from interference with the function of the œsophagus is so great that these palliative measures seem worth while.

Introductory Remarks with Regard to the Anatomy of the Œsophagus. —The œsophagus has three coats: an outer or muscular coat, which is composed

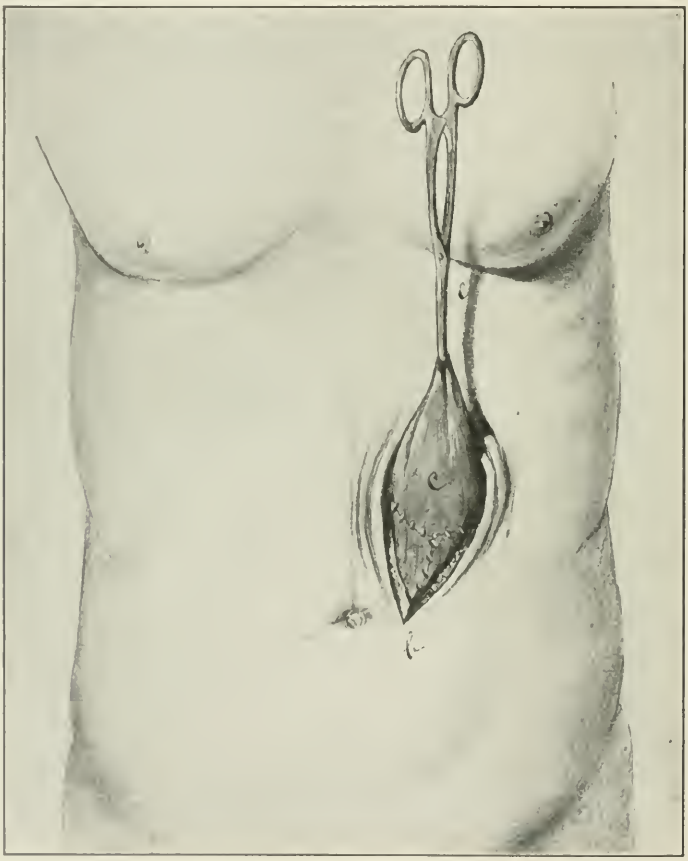

Fig. 168.—Gastrostomy by a Slightly Modified Method. In the diagram the incision in the abdominal wall is vertical instead of oblique.

of two layers; an inner mucous or glandular coat, which is covered with pavement epithelium; and a middle connective-tissue layer, which unites the two principal layers. The outer layer of the muscular coat is composed of longitudinal fibres, and the inner layer of circular fibres. The longitudinal fibres are attached anteriorly to the posterior surface of the cricoid cartilage; the circular ones are a continuation downward of the fibres of the inferior constrictor muscle.

The œsophagus is about ten inches in length and extends from the lower end of the pharynx to the stomach. Its position, in the greater portion of its course, is a little to the left of the middle line. At its commencement it is in the median line; then it inclines to the left until it reaches a point near the middle of its course, where it passes to the middle line back of the arch of the aorta and then deviates to the left again, goes forward through the diaphragm, and enters the stomach to the left and in front of the arch of the aorta, at the eleventh thoracic vertebra.

The œsophagus, at its beginning, is represented by a transverse slit, and as it descends it becomes more of a tube until, at the point where it passes through the diaphragm, a transverse section of it is nearly round. According to Mosher[1] * the œsophagus has four constrictions. The most important one is at the beginning of the tube, back of the cricoid cartilage. The next narrowing of importance is at the cardiac end, where the œsophagus passes through the diaphragm. The constriction back of the arch of the aorta and that behind the left main bronchus are of less importance.

Methods of Examination.—The most common method of examining the œsophagus is that by means of bougies. In exploring the tube it is important to remember that under normal conditions the œsophagus possesses the four constrictions mentioned above. It is also important to know the total length of the œsophagus and the distance of its most important portions from the front teeth. The œsophagus is ten inches (about 26 cm.) in length. It begins at a point six inches (15 cm.) distant from the incisor teeth and passes through the diaphragm sixteen inches (40 cm.) from the same teeth. It is crossed by the arch of the aorta at a point ten inches from the incisor teeth.

The examination with the bougie should be conducted very carefully and slowly, for in this way only is it possible to follow the course of the œsophagus without inflicting an injury, especially when it is in a diseased condition.

Two kinds of bougies may be used for sounding the œsophagus: the English bougies or the olive-tipped bougies. The former are constructed of a woven texture impregnated with a gummy material, and they can be softened or hardened by placing them in warm or cold water respectively. In this manner they can be bent into any desired shape. The olive-pointed bougies consist of a flexible, hard-rubber staff, on the point of which is placed an olive-shaped tip of hard rubber or ivory.

When a stricture is present, it is easier to determine its location by means of the olive-tipped bougie than by the English bougie. Before sounding an œsophagus, artificial teeth should be removed and the patient should be examined for aneurysm of the aorta. The passing of bougies, in cases of aortic aneurysm, has been known to cause death from hemorrhage.

Patients who are being examined for the first time are apt to gag, thus rendering the examination very unpleasant. This can be overcome, to a great degree, by first spraying the pharynx with a four-per-cent solution of cocaine, the patient being allowed to swallow a little of the same, and then waiting five

* These numbers refer to the Bibliography at the end of the article.

minutes before passing the sounds. The bougies are passed with the patient in the sitting posture. The patient sits with the head erect or bent a little forward, then the operator places the index finger of his left hand on the base of the tongue, pressing downward and forward, while with the right hand he passes the bougie along the posterior wall of the pharynx to the beginning of the œsophagus. The patient is now told to swallow and the bougie will pass on into the œsophagus.

A bougie half an inch in diameter should pass easily through every portion of the œsophagus. Its failure to pass is a sign of a stricture. A bougie three-fourths of an inch in diameter is as large as should ever be used in dilating a stricture.

If, in passing a bougie, one meets with an obstruction, it is sufficient, under normal conditions, to withdraw the instrument a short distance and then to advance it again, or the difficulty may be overcome by asking the patient to swallow or to bend the head a little forward. Examination of the œsophagus with bougies frequently takes the place of inspection and palpation.

Œsophagoscopy.—Œsophagoscopy cannot be considered an important aid in diagnosis. Little can be determined by this means that cannot be determined by the more simple methods of examination. The simplest and safest form of œsophagoscopy is that by means of a straight tube, the light being thrown into this either by a Leiter panelectroscope or by a Casper electroscope. Numerous devices for œsophagoscopy have been invented during the past few years, but not much evidence of value has accumulated from their use. Einhorn is one of the few authorities who place reliance upon this clinical method in diagnosis.

Radioscopy.—Radioscopy is frequently a valuable aid in the diagnosis of œsophageal lesions, especially in the location of foreign bodies. It may also be considered in connection with the diagnosis of strictures, dilatation, and diverticula.

A fairly well-defined outline of the œsophagus can be obtained by an *x*-ray photograph, provided a large quantity of bismuth, mixed with some starchy food, is administered just before the picture is taken.

Percussion.—Percussion is of minor importance in the diagnosis of lesions of the œsophagus. In the case of a diverticulum in the neck, if the sac is filled with gas, percussion will give a tympanitic note; if filled with food, it will give a dull note. Occasionally, in the presence of a tumor of the œsophagus, one is able to determine a dull area corresponding to the location of the growth.

Diseases and Injuries of the Œsophagus.

Malformation of the Œsophagus.—The congenital deformities of the œsophagus possess very little practical significance. In the majority of these cases the patients have other deformities at the same time, as a result of which they are either born dead or die a few days after birth. Such children have so little vitality that only in rare cases would they be able to stand the necessary surgical

measures. The most common deformity is division of the œsophagus into two portions, usually two blind pouches, which may or may not communicate with the trachea. The origin of this deformity is explained by the development of the œsophagus and the trachea. The trachea and lungs are developed from the ventral portion of the foregut. For some time there is a cleft between the trachea and œsophagus before separation becomes complete. Disturbances of development during this period may produce the various kinds of deformity. In such cases the children are unable to swallow at all, or else the food comes back through the nose. They can live only a short time (thirteen days being the longest period, according to von Hacker [2]). They die of inanition or from pneumonia caused by the entrance of food from the upper portion, or by the escape of mucus from the lower portion, into the lungs. Gastrostomy has been suggested for the relief of the condition.

Inflammatory Processes of the Œsophagus.—*Acute Catarrhal Inflammation.*—Acute catarrhal inflammation of the œsophagus may result from the irritation caused by foreign bodies, or from a mild scalding, or from swallowing some chemical agent of an irritating nature, but not strong enough to cauterize. The disorder is characterized by the secretion of mucoid material. (The more severe forms of inflammation are described farther on, under the head of Toxic Œsophagitis.)

Chronic Catarrhal Inflammation.—Chronic catarrhal inflammation of the œsophagus occurs in chronic alcoholics, and also in cases of stenosis of the œsophagus from various causes—as, for example, from the accumulation of food in the dilated portion above the stricture. It is characterized occasionally by hyperæmia, which in time leads to ectasis and a marked thickening of the epithelium. The œsophagoscope will show a cloudiness of the mucous membrane, which secretes a sticky mucoid substance. These cases usually recover without any complications when the cause of the inflammation is relieved.

Diphtheritic Inflammation.—Diphtheritic inflammation of the œsophagus is not of frequent occurrence. The diphtheritic membrane occasionally extends from the pharynx into the œsophagus, and in rare cases true diphtheritic ulcers have been observed. Recently von Eiselberg, Erlich, and von Hacker [2] have observed cicatricial formation following these diphtheritic ulcers.

Thrush.—Thrush involving the œsophagus should not be confused with diphtheria. It occurs most often in children, but is occasionally seen in adults who have become exhausted from disease. It usually extends from the mouth and forms a yellowish or grayish white deposit. The frequent application of a three-per-cent solution of borax will usually effect a cure in these cases.

Toxic Œsophagitis.—Toxic or corrosive œsophagitis occurs after the ingestion of some chemical caustic substance, or after the swallowing of a scalding fluid. From a surgical standpoint toxic œsophagitis is the most important inflammation of the œsophagus, because of the complications which are apt to follow, especially the formation of strictures. In cases where the injury is only superficial, the epithelial layer alone may be thrown off and no complications will follow. Where the erosion is deep enough, however, to cause a slough of the entire thickness of

the mucosa, with perhaps some of the muscular coat, the inflammation may extend beyond the œsophagus, giving rise to a peri-œsophageal abscess which extends into the mediastinum. The eroded area undergoes cicatrization after the slough is thrown off, and, as a result of the contraction of this scar tissue, a stricture is apt to result. Swallowing of a large amount of one of the concentrated alkalies or acids is apt to end fatally on account of the slough which it usually causes in the stomach.

The author recently had under his care the case of a woman who tried to commit suicide by swallowing one ounce of strong hydrochloric acid. She was remarkably free from œsophageal symptoms, but, nine days after the ingestion of the acid, she vomited a large roll of tissue, which proved to be a considerable portion of the mucous lining of the stomach. This tissue was in one piece, was somewhat gangrenous in appearance, and measured fifty square inches. The patient was kept on liquid food and she had no symptoms referable to the œsophagus, but she complained somewhat of a burning pain in the stomach. At the end of about four weeks she began to lose in weight rapidly, and every second or third day would vomit a large amount of dark fluid. I first saw her twelve weeks after the swallowing of the acid. At this time she complained of a large swelling in the abdomen, which conveyed to her the impression of being a large sack of water. She was greatly emaciated, and, on examination, there was found a softish mass which extended from the epigastrium to the symphysis pubis. A distinct splashing sound could be elicited, and there was observed a peristaltic wave which started in the left inguinal region and traveled upward to the region of the pylorus. A stomach tube was inserted without any difficulty, and a large quantity (about five quarts) of a dark-brownish fluid was withdrawn. The patient was placed on rectal feeding and gastric lavage was carried out three times daily for three days. Then a laparotomy was performed. The stomach was found to have contracted to the level of the umbilicus, and there was a cicatricial mass in the pyloric end of the organ which caused practically a complete obstruction of the pylorus. A gastro-enterostomy was performed. The patient did very well for nine days, when she died suddenly from pulmonary embolism. Examination of the œsophagus at the autopsy showed no evidence of injury from the swallowing of the acid.

Treatment.—The treatment of corrosive œsophagitis is principally symptomatic at first—viz., rectal feeding and the administration of ice and narcotics. Examination with bougies should not be undertaken as long as there is any evidence of recent ulceration. Such ulcerations usually persist for from two to four weeks according to the degree of the burn. After four weeks bougies may be passed as a prophylactic measure against the formation of a stricture.

Phlegmon of the Œsophagus.—Phlegmonous inflammation of the œsophagus is of rare occurrence. This purulent inflammation may occur after penetrating injuries and injuries caused by caustics, or through an extension from an abscess of the stomach, or, finally, through a rupture of the peri-œsophageal abscess. The inflammation may be circumscribed or it may be diffuse, extending over a large area. An abscess may form in such a manner as to produce a bulging of the mucous membrane of the œsophagus and thus cause an obstruction. Such abscesses usually rupture spontaneously into the œsophagus. The symptoms,

in these cases, vary. They consist of fever, chills, difficulty in swallowing, and pain along the course of the œsophagus, especially behind the sternum. There may be coughing and regurgitation of pus if an abscess has already formed. The treatment is ordinarily symptomatic, but some authors suggest œsophagoscopy and incision in case of abscess formation.

Ulcer of the Œsophagus.—Various forms of ulceration are met with in the œsophagus—the gangrenous ulcer from pressure, the syphilitic, the tuberculous, and the peptic or round ulcers. Gangrenous ulcers may be caused by pressure exerted either from within or from without. Goitre or some other tumor may make pressure upon the cricoid or one of the tracheal rings, and this pressure, being transferred to the œsophagus, may eventually cause a necrosis of one or both of the walls. Aneurysm of the aorta may act in the same manner; and so also may foreign bodies lodged within the œsophageal tube.

Syphilitic ulcers may occur in the œsophagus, but they are very rare. They usually are situated in the upper portion of this tube. The lesion is ordinarily a gumma, and it frequently results in scar formation causing constriction. In many cases the diagnosis is made by noticing the effect of antisyphilitic treatment.

The occurrence of a tuberculous ulcer has recently been positively determined, but such ulcers are very rare.

Peptic or round ulcers, analogous to those found in the stomach, occasionally are found in the œsophagus. They are frequently associated with ulcers of the stomach and are situated in the lower portion of the œsophagus. They may or may not cause symptoms, but when such symptoms are present they are those of gastric ulcer.

New-Growths of the Œsophagus.—*Carcinoma.*—Carcinoma is the most frequent of the new-growths of the œsophagus; in fact, it is the most common disease met with in the œsophagus. It may occur either as a primary or as a secondary growth. When secondary, it usually occurs by direct extension from some neighboring organ. It may also occur through inoculation from the secretion of a carcinomatous ulcer higher up in the gastro-intestinal tract.

Carcinoma of the œsophagus is most common in the male, and, as is true of other carcinomas, it is usually a disease of advanced life. The growth itself is usually situated at one of the normal constrictions of the œsophagus—as, for example, opposite the cricoid cartilage, at the bifurcation of the trachea, and at the hiatus of the œsophagus. This fact rather favors the view that there may be some connection between repeated irritations and the development of carcinoma, as these portions of the canal are more constantly subjected to irritation than is the rest of the œsophagus. Strictures also are most common at these points. So it is possible that carcinoma develops in a cicatrical stricture or in some other scar.

It is estimated that about fifty per cent of the cases of œsophageal carcinoma occur at the cardia or just above where the œsophagus passes through the diaphragm; about forty per cent are found near the bifurcation of the trachea; and less than ten per cent are located in the cervical portion of the œsophagus.

Symptoms.—The most important and usually the earliest symptom of carcinoma of the œsophagus is dysphagia. The manifestations are those of a slowly advancing stenosis. The patient, when he first consults a physician, usually gives a history of having been in good health until within a few months, at which time he began to have some difficulty in swallowing meat or other coarse food. This condition gradually becomes worse: the patient has difficulty in swallowing the soft foods, and finally he confines himself to liquid food. By the time the patient consults the surgeon, it will usually be found that he has been living on liquids for a considerable time on account of the difficulty of swallowing solids. Hand-in-hand with the difficulty of swallowing, there are usually a sense of weakness and a progressive loss of weight.

Considerable improvement may be noted upon the administration of non-irritating liquid foods. Thus, a gain of several pounds may follow the administration of an abundance of milk, cream, and raw eggs, but it lasts only for a short time. There is seldom any vomiting, but usually a regurgitation of food and large quantities of mucus. This regurgitation may take place very quietly and is entirely different from vomiting. In the later stages the accumulation of thick tenacious mucus above the stenosis may cause gagging and retching which are very annoying to the patient.

It is not uncommon for the patient to have, rather early in the disease, some degree of hoarseness, which gradually becomes more pronounced on account of the further involvement of the recurrent laryngeal nerve. Seeling[3] reports a case of carcinoma of the œsophagus in which the hoarseness was the earliest symptom, preceding the dysphagia by a few months. This hoarseness did not follow a cold or any disturbance of the respiratory tract.

As a rule, there is more or less pain associated with carcinoma of the œsophagus. The pain is described as a sense of burning or pressure in the throat or chest, especially during swallowing. Occasionally the pain precedes the dysphagia. It is frequently perceived in the back, radiating to the shoulders and the back of the neck. The loss of weight and strength in these cases is at first due to the dysphagia, and later it results also from the malignant pathological process. In advanced cases it is not uncommon to have a contracted pupil on one side. According to Hitzig this is found in about one-sixth of the cases. The left pupil is the one most frequently involved. This symptom is due to the pressure upon the sympathetic nerve.

While an involvement of the recurrent nerves may occasionally be found as an early symptom, it most often means that the disease has made considerable progress. The pressure may be due to the growth itself, but is probably most often due to an involvement of the lymph nodes. Besides hoarseness, this pressure may cause attacks of dyspnœa.

If the disease advances toward the spinal column, the patient may develop a paraplegia, either from compression or from destruction of the spinal cord. If this happens before the signs of obstruction of the œsophagus are marked, the case may simulate one of caries of the spine.

Diagnosis.—By taking a careful history of the case one can usually obtain

many important diagnostic points. In a patient with slowly progressing œsophageal stenosis, for the production of which no traumatic, specific, or other etiological factor can be found, it is proper to assume that the obstruction is more apt to be due to a new-growth than to a cicatricial lesion. And if, in addition, the patient be past forty years of age and of the male sex, and if, besides the above-mentioned symptoms, there be emaciation and cachexia, the diagnosis of carcinoma becomes fairly certain.

On palpation a tumor or induration is occasionally felt in the neck. This may be the primary growth, but most often it represents one or more lymph nodes which have become affected by metastasis. Examination with bougies may further aid in the diagnosis by determining the existence of an obstruction and the exact spot at which it is located. This examination may prove negative, even though a carcinoma be present. The growth may be so small that the bougie may glide past it without encountering a definite resistance. A negative examination may also be due to the fact that necrosis has taken place, or to the fact that the portion of the tumor which projects into the lumen of the œsophagus is growing only in the long axis of the tube, so that it causes no obstruction. After ulceration has taken place, additional information may often be obtained by passing a stomach tube or a hollow bougie; for particles of tissue are apt to be caught in the fenestra of the tube, and an examination of these particles may enable one to make a positive diagnosis.

It is often difficult to differentiate between carcinoma of the œsophagus and aneurysm of the aorta. Kucken[4] reports two cases of carcinoma of the œsophagus in which the diagnosis of aneurysm of the aorta was made and in which the correct diagnosis was not even suspected until it was revealed by autopsy. If one bears in mind the arrangement of the lymph nodes of the mediastinum, he will readily perceive how two conditions so diverse as an aneurysm of the aorta and carcinoma of the œsophagus may cause almost identical symptoms. The lymph nodes are in actual contact with the œsophagus, so that in many cases secondary involvement of these structures occurs very early, often in the beginning of a carcinoma of the œsophagus. This being the case, we have in the mediastinum a tumor which may cause the ordinary signs and symptoms that are produced by an aneurysm in the same location. The lymph nodes may enlarge so much more rapidly than the primary tumor, that there may be symptoms of intrathoracic pressure before there are any signs of obstruction of the œsophagus. In such a case as this, the symptoms would naturally be the same in both conditions, for these symptoms are due to pressure on the same structures.

Dyspnœa, which is a fairly constant sign in cases of aneurysm of the aorta, is at the same time almost as constant a sign in carcinoma of the œsophagus. In both the aneurysm and the mediastinal metastasis resulting from an œsophageal cancer, the dyspnœa is due to pressure on the bronchi or the trachea.

Involvement of the recurrent laryngeal nerve is usually considered to be a confirmatory sign of aortic aneurysm, but the facts will not warrant such a conclusion. For example, Scheeh[5] collected forty-two cases of paralysis of the

recurrent laryngeal nerve, and in this series he found five cases which were due to aneurysm of the aorta, four cases to carcinoma of the œsophagus, and three cases to mediastinal and pulmonary tumors. Thus we see how little aid the symptom of recurrent paralysis affords in differentiating between aneurysm of the aorta and carcinoma of the œsophagus.

Dysphagia very naturally causes one to think that he is dealing with a growth of the œsophagus. Lebert,[6] however, states that, in one-third of all cases of aneurysm of the aorta, the œsophagus is compressed sufficiently to cause dysphagia. Even though the aneurysm does not press directly on the œsophagus, it can cause dysphagia by pressure on the vagus or its œsophageal branches.

Even the presence of cachexia does not add very strong evidence in favor of carcinoma, for a large proportion of all patients suffering from aneurysm of the aorta show a well-pronounced secondary anæmia due to a complicating nephritis or endarteritis.

Thus we see that it is often difficult to differentiate between carcinoma of the œsophagus and aneurysm of the aorta, when the growth is situated in the thoracic portion of the œsophagus, especially if there is an early involvement of the mediastinal lymph nodes.

Prognosis.—The prognosis of carcinoma of the œsophagus is always unfavorable. So far as is known, no permanent cures have been obtained even after resection. The average duration of the disease is from six months to two years. As a rule, the majority of the cases succumb one year after the first manifestations of the disease.

Death usually takes place slowly from inanition and carcinomatous cachexia, or there may be the typical picture of pyæmia. Where the wall is perforated and a rupture takes place into one of the air passages, death occurs as a result of pneumonia or of gangrene of the lung. Occasionally these cases meet with a rapid or a sudden death from erosion and rupture into the large blood-vessels.

Treatment.—The treatment comprises the following non-operative procedures: dilatation with bougies and dilatation by permanent tubage. The operative methods are: resection of the œsophagus, œsophagostomy, and gastrostomy.

Dilatation with bougies is quite widely employed, especially by the general practitioners. This is usually successful for a time, as the soft carcinomatous tissue yields readily. This form of treatment is often unavoidable, as the patient will not consent to the employment of any operative procedure. It should be borne in mind that the bougies cause mechanical irritation and that the growth may be excited by their use. Great care should be exercised in the use of the bougies on account of the danger of perforating into a neighboring organ during the procedure. The conical-shaped English bougies are the best for this purpose, as they are soft and pliable. They are introduced as described in a preceding part of the article. Occasionally the carcinomatous stricture is so small that it will be impossible to pass the bougie through it. If such be the case, there should first be passed a filiform bougie to the end of which is attached

a conical steel spiral bougie such as is shown in Fig. 169. When this is withdrawn, a small-sized English bougie is employed, and then afterward bougies of a larger size are passed. Some temporary relief is afforded in this manner.

Permanent dilatation by introducing a hard-rubber tube into the stricture is seldom used. Unpleasant accidents may occur, such as breaking or swallowing

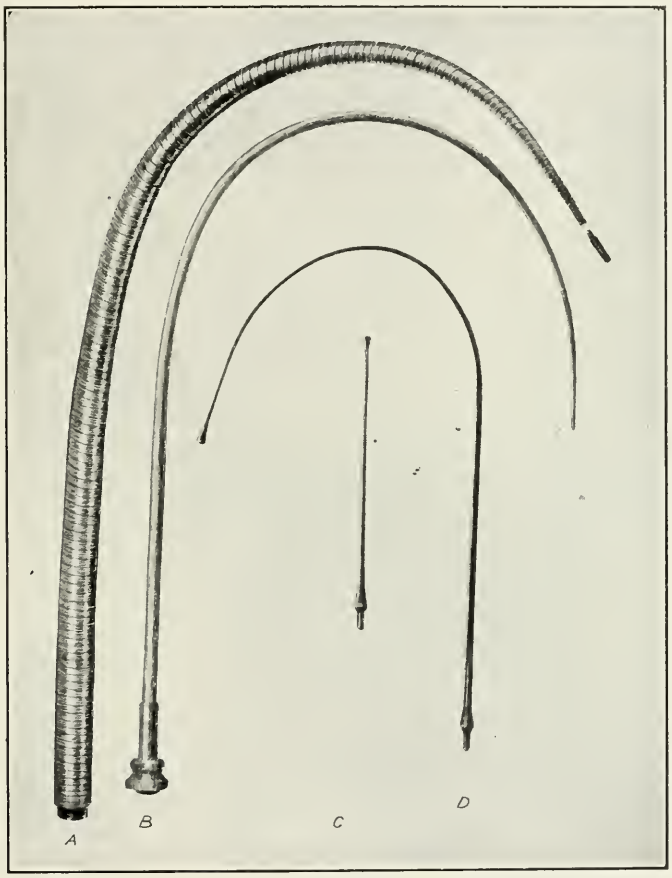

FIG. 169.—Œsophageal Bougies. *A*, Graduated flexible bougie, hollow and made of spiral steel; *B*, lead rod to be placed in lumen of *A*, enabling the operator to give the bougie definite curves; *C*, short, *D*, long filiform bougie to be screwed into the distal end of *A*.

the string; and, besides, the constant presence of the string in the mouth is very annoying to the patient.

Resection of the Œsophagus.

The majority of cases of carcinoma of the œsophagus are not accessible to radical treatment. The author has had no personal experience in resection of the œsophagus for carcinoma. In the few cases recorded in the literature on the subject, the immediate mortality is high and the relief in the other cases was only transitory.

It is quite probable that with the further development of Sauerbruch's

method of operating within a pneumatic cabinet, under negative pressure, a satisfactory operation for resection of the œsophagus in cases of carcinoma may be made possible. In 1903 Professor von Mikulicz appointed Sauerbruch to investigate the question as to how the occurrence of a pneumothorax in intrathoracic surgery might best be prevented, the main point to be considered being the finding of a practical method of carrying out transpleural resection of the œsophagus for carcinoma—a procedure which, up to the date named, had been followed by disastrous results in experiments both upon animals and upon the human subject.

Sauerbruch,[26] taking as a basis the known fact that the difference between

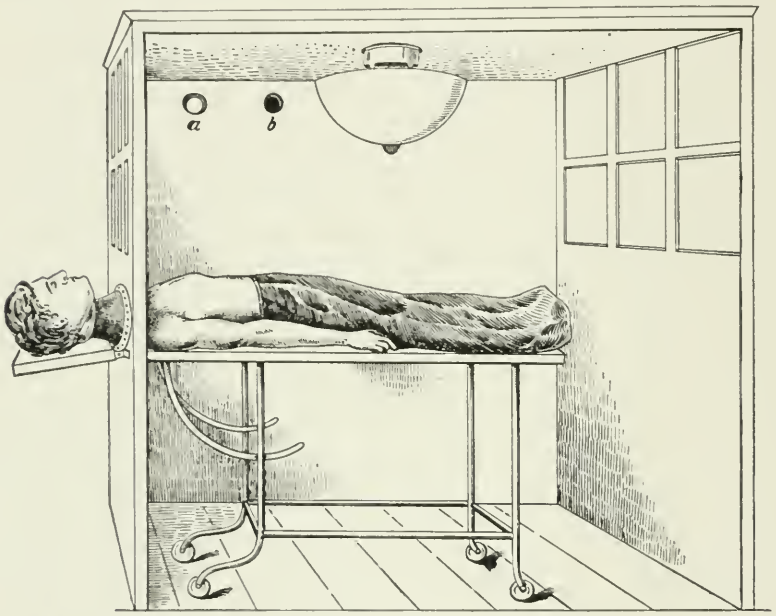

Fig. 170.—Sauerbruch's Pneumatic Cabinet. *a*, Opening of the pipe that connects with the suction pump; *b*, valve to let in air and regulate the negative air pressure.

the intrabronchial pressure and the pressure at the surface of the pleura is about 7 or 8 mm. Hg, conceived the idea that if this normal relationship of pressure could be maintained while the thorax was open, a pneumothorax would not occur. With the object of testing this belief he constructed his pneumatic cabinet. (Fig. 170.) This cabinet has the shape of a cube. It is large enough to accommodate the operator and two assistants, and it contains an operating table and two small hinged tables for instruments and dressings. The floor, the ceiling, and the four walls, up to a height of about one metre, consist of iron; the rest of the walls are constructed of strong glass. The whole cabinet is made absolutely air-tight, the door being held tightly closed by means of an iron bar which presses it against a thick rubber encasement. In the end opposite the door, on a level with the top of the operating table, there is a circular opening which is closed by a rubber septum. The rubber has a circular opening through which the head of the patient can be forced without difficulty, whereupon

the septum spontaneously closes around the neck like a cuff. On the other side of the chamber, near the top, is an opening with which is connected a suction pump. Next to this there is a valve which permits the renewal of air within and regulates the rarefaction of the air with respect to the air-pressure. This can be regulated from within the chamber. It has been proven that a negative pressure of 10 millimetres is sufficient to guarantee the expansion of the lung.

The preparation for an operation within the chamber is as follows:—All instruments and supplies are prepared and placed in the cabinet. The patient, partially anæsthetized, is brought into the chamber and placed upon the table; the head, forced through the rubber cuff, rests outside upon a small table beside which the anæsthetist has his seat. The operator and assistants take their places, the door of the cabinet is then closed, and the apparatus is set in motion. As soon as the manometer shows an air-pressure of minus 10 to 15 millimetres the operation begins. The operator does not experience any special difficulty in breathing. Sauerbruch calculated that in the cabinet, with a negative pressure of 10 millimetres of mercury, one lives under the same atmospheric pressure as on a mountain having a height of 300 metres (about one thousand feet).

Œsophagostomy.

Œsophagostomy is occasionally performed and the patient fed through the fistulous opening thus established. This operation is applicable only in cases of carcinoma situated high up in the cervical portion, at which point the opening can be made below the stricture. It is doubtful whether feeding through an œsophageal fistula is less annoying to the patient than through a gastrostomy opening. At all events, the latter procedure is much easier for the patient to carry out himself. As a rule, a gastrostomy is preferable to an œsophagostomy as a method of providing these patients with the means of obtaining nourishment.

The technique of the operation is described under the heading of Foreign Bodies in the Œsophagus. (Page 422 et seq.)

Gastrostomy.

Gastrostomy is indicated where the patient cannot take enough food by the mouth, as is shown by rapid emaciation. The earlier the operation is performed the more satisfactory will be the result. If a positive diagnosis of carcinoma is made, a gastrostomy should be performed even though the patient can still swallow liquids. The operation, of course, cannot stop the progress of the disease, but it may inhibit the ichorous decomposition which is caused by food remaining in the ulcerated area. As a result of the operation the carcinoma may grow less rapidly, because the continuous irritation from the passage of food has thereby been relieved. Oftentimes both physicians and surgeons decide upon an operation too late. This accounts for the fact that the mortality is rather high in this operation. If gastrostomy is performed at the proper time, the life of the patient may be prolonged for several months or even for a longer period than one year.

If the obstruction is complete the operation should be performed at once after an evacuation of the bowels has been secured by means of a large enema. On the other hand, if there is still a narrow channel through the obstruction, it is well to administer some saline mineral water every morning for several days, in order to secure a free evacuation of the bowels, because one frequently finds, in these cases, large accumulations in the colon, the result of prolonged constipation. The removal of these accumulations is very desirable, as the patient will bear the operation much better if there is no decomposing material in any part of the intestinal canal.

If the patient is very weak it is often possible to increase his strength considerably by giving him the various concentrated and predigested foods in considerable quantities at regular intervals of two or three hours for a few days. Ordinarily, however, these patients bear the operation well if it is performed rapidly and with a minimum amount of traumatism. It is therefore only necessary to give the above preparatory treatment to patients who have had little or no care previous to their admission to the hospital.

The field of operation is prepared as in every abdominal operation.

(For further details regarding the operation of gastrostomy the reader is referred to what has already been said upon this subject in the first part of this article. See page 398 et seq.)

Cysts, Papillomata, Myomata, and Sarcomata of the Œsophagus.—Many of the growths occurring in the œsophagus, such as warts, cysts, papillomata, fibromata, and lipomata, possess only a pathological interest, as they rarely cause disturbance.

Klebs has pointed out the analogy between diseases of the œsophagus and those of the skin. Thus, in the œsophagus are found warts which are usually small and which spread over different portions of the tube. It would seem probable that these warts might develop into carcinoma, as happens in the case of warts of the skin, but, up to the present time, such a transformation has never been demonstrated.

Retention cysts of the mucous glands have also been described. On account of their small size they usually do not cause any symptoms.

Fibromata and lipomata also occur, but they are very rare. They are usually autopsy findings, as they run their course without producing symptoms.

Sarcomata of the œsophagus are rather rare, and the symptoms and course of the disease are similar to those of carcinoma. A positive diagnosis can be made only by securing a portion of the tissue for microscopical examination. The treatment is the same as that described for carcinoma.

Polypi or pedunculated tumors of the œsophagus are rather rare. They are usually attached in the upper end of the œsophagus, in the region of the cricoid cartilage. If they are small, they cause no symptoms; the larger ones may cause difficulty in swallowing, and occasionally the distal end of the polypus is thrown upward into the throat causing choking and difficulty in breathing.

Cubbins [5] has reported a case of œsophageal polyp which was removed by operation. The patient was forty-five years of age and had previously been

healthy. During the administration of an anæsthetic for the reduction of a dislocated shoulder-joint, the patient vomited, and during this act a pedunculated tumor was extruded from the mouth. The tumor was grasped and measured and found to protrude four inches from the mouth. The patient's wife would not consent to the removal of the tumor; so it was returned into the mouth and the patient swallowed it. Later, he was anæsthetized again, and several attempts were made to remove the polyp by introducing forceps down through the œsophagus, but these efforts were unsuccessful. Shortly afterward, the patient began to develop symptoms of obstruction and at the end of three months the obstruction was so marked that he was unable to swallow anything but liquids. He was now prepared for an operation on the neck, and attempts were made to nauseate him, so that he would throw up the tumor. His stomach was filled with water and some apomorphine given, but no fluids would come up. He was then anæsthetized, but all attempts made to draw the tumor from the œsophagus failed. A lateral œsophagotomy was performed, and the tumor was found situated on the anterior portion of the œsophagus, with the pedicle a little to the left of the median line, just above the cricoid cartilage, and extending down the œsophagus a distance of about seven inches. It was ligated and removed and the wound closed with packing. The tumor measured 16 cm. in length and 5 cm. in diameter; its pedicle measured 1 cm. It weighed 210 grams.

Injuries of the Œsophagus.—*Trauma from an Internal Source.*—The injuries of the œsophagus which are produced by violence from within are: those resulting from swallowing the various corrosive drugs, those inflicted by foreign bodies that have been swallowed, and the injuries caused by passing bougies, coin-catchers, and other instruments. Injuries from the passing of instruments are particularly liable to occur in the presence of pathological changes such as carcinoma, ulcer, stricture, etc. Perforation of the œsophagus is a serious condition, as it may result in a fatal mediastinitis or pleuritis.

External Injuries of the Œsophagus.—The œsophagus, being so deeply situated, is very rarely injured by violence from without. Wounds of the cervical portion are the most common, and they usually occur as a result of attempted suicide. These wounds, as a rule, are situated high up on the neck in the region of the larynx or hyoid bone, and consequently the wound of the alimentary canal is either high up in the œsophagus or in the pharynx. In these cases the respiratory passages are practically always injured at the same time. The characteristic sign of injury of the œsophagus is the escape of food through the external wound, although this may be absent even in gunshot or stab wounds if the edges of the wound are in close apposition.

Injury of the œsophagus alone in the thoracic portion of its course is extremely rare. Such an injury may result from a dagger, a bayonet, or a bullet. Injuries of adjacent organs, such as the heart, the lungs, the large vessels, etc., which are usually fatal in themselves on account of their anatomical position, are apt to occur at the same time. The danger from injury to the œsophagus is in itself very serious, as food is likely to escape into the surrounding tissues and to cause an ichorous abscess, a mediastinitis, or a pleuritis.

Treatment.—When the injury is in the cervical portion, the first things to

be done are to control the hemorrhage and to prevent asphyxia. It is frequently necessary to perform a tracheotomy. If the condition is such as to warrant an operation an attempt should be made to suture the œsophagus, and also the trachea if that has been severed. The best method to adopt is that employed in suturing the intestines: the mucous membrane being sutured first and then the muscular coat over this.

In case the injury is in the thoracic portion, the treatment is practically hopeless. It is usually limited to feeding the patient *per rectum* or through a stomach tube, if this can be passed down beyond the injured portion. If the patient is in a condition to stand an operation, a gastrostomy will afford the best means of feeding him.

Foreign Bodies in the Œsophagus.—The lodging of foreign bodies in the œsophagus is not an uncommon occurrence and is classed as one of the emergencies in the practice of surgery; it frequently requires prompt action on the part of the surgeon. The accident is most often seen in the very young and the insane. The foreign bodies most often found are: coins, buttons, pins, keys, glass beads, bones, and various kinds of small toys. Foreign bodies such as fish bones, fruit stones, and pieces of glass and enamel, are frequently found in food. In adults the foreign body most frequently found in the œsophagus is a poorly fitted set of artificial teeth which have not been removed at night or which have been swallowed during an attack of syncope or convulsions.

Hugh M. Rigby [7] reports the case of a child who swallowed a toy bicycle which became lodged in the œsophagus at a point seven inches distant from the teeth.

From what has been said it will be seen how great is the variety of foreign bodies which may call for consideration. The situation at which a foreign body may become lodged depends considerably upon the nature and size of the object. In the case of small pointed bodies, which penetrate the mucous membrane easily, they may lodge at any point in the course of the œsophagus. Very large bodies cannot, as a rule, pass the isthmus and remain lodged in the pharynx. Small sharp-pointed bodies, like fish-bones and wooden splinters, which project from a morsel of food, are apt to be driven into the wall of the pharynx during the first act of swallowing. Large bodies which pass the isthmus are apt to become impacted at the upper border of the cricoid cartilage, or where the œsophagus is crossed by the left bronchus, or where the œsophagus passes through the diaphragm.

Symptoms.—The symptoms vary according to the situation of the foreign body and according to its size and shape and the amount of obstruction present; they also vary in accordance with the amount of pressure exerted upon other organs, such as the trachea or the larynx. Nausea, a sense of obstruction and pain on attempting to swallow, and occasionally a reflex cough are usually present. If the body is large and remains in the pharynx, it may press upon the opening in the larynx and cause choking, accompanied by cyanosis, etc.

If the obstruction is complete, all food will be regurgitated. When the

obstruction is high up in the œsophagus the regurgitation will take place immediately on attempting to swallow: if it is low down a little time may intervene before the food is regurgitated.

In cases in which the foreign body has sharp edges which cause injury, the patient complains of a stabbing pain at a definite point on attempting to swallow. This point, when the foreign body is situated high up, is likely to correspond to the location of the obstruction. When the impaction is lower down, the pain is usually referred to the region of the sternum, though the obstruction may be at a lower level.

Diagnosis.—Occasionally a positive diagnosis of an impacted foreign body can be made simply from the history of the case and the symptoms. On account of the serious complications which may arise from a foreign body remaining in the œsophagus a long time, an attempt should be made, even in doubtful cases, to determine the presence or absence of a foreign body.

The pharynx should be inspected by means of a mirror and palpation should be made with the finger. External palpation should also be made, as large bodies in the cervical portion of the œsophagus can often be felt, or there may be a point of tenderness corresponding to the location of the foreign body.

In most cases a foreign body can be detected by passing a bougie, and its precise situation may also be determined in this manner. The best bougie to employ for this purpose is a whalebone staff with a cylindrical tip of ivory or metal. When a foreign body is touched with such an instrument, a clicking or rubbing sound can be heard or at least felt.

Examination with the *x*-ray, either by means of the fluoroscope or by the aid of an *x*-ray photograph, is an important aid in diagnosis and has proved to be entirely practicable in many instances.

The œsophagoscope may be used in these cases both as a means of diagnosis and as an aid to treatment. Sippy[9] says: "that the chief value of the œsophagoscope is for removal of foreign bodies. Here it becomes indispensable." A foreign body firmly lodged in the œsophagus constitutes a serious condition: unless removed, it sooner or later causes the death of the patient.

The early use of the œsophagoscope for the removal of a foreign body must be strongly urged. During the first day or two after a foreign body is lodged, very little inflammation is present, but, after three or four days or a week, this inflammation becomes intense. An abscess may form: perforation of the wall of the œsophagus is apt to follow; and, above all, after the lapse of a short time, the inflammation surrounding the foreign body becomes so marked as to render its extraction a difficult matter. Whenever, therefore, a foreign body is lodged in the œsophagus in an inaccessible possition, from which it cannot be dislodged either upward or downward, the œsophagoscope should be used at once; and, with the aid of this instrument, it will be found that, in a great many cases, the foreign body can be extracted.

Treatment.—The treatment of foreign bodies lodged in the œsophagus should be instituted as soon as the diagnosis has been made. The various methods which dispense with a cutting operation should be tried first—namely, extraction

through the mouth; forcing the foreign body down into the stomach; extraction with the aid of the œsophagoscope.

Extraction through the mouth should be attempted in cases of foreign bodies which, by their character and situation, can be removed without undue force. The longer a foreign body has been embedded, the more cautious should one be

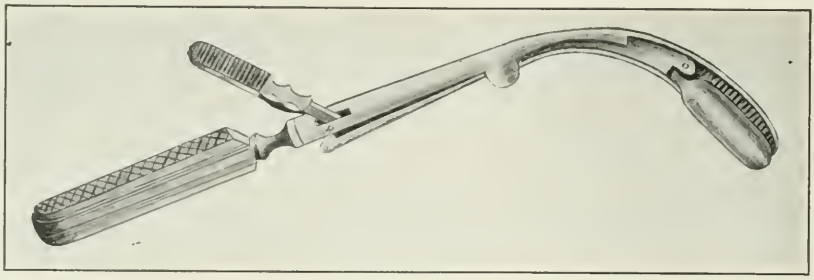

Fig. 171.—Lutter Forceps.

in one's efforts to remove it. The various forms of pharyngeal and œsophageal forceps are adapted principally to the removal of foreign bodies from the pharynx and upper œsophagus. (Figs. 171, 172, 173.) Fig. 174 represents an instrument —Graefe's coin-catcher—which, when it is passed beyond the foreign body and then withdrawn, is likely to catch the body and bring it out. This instrument is useful in cases in which the object is lodged in the lower portion of the œsophagus and does not completely obstruct the tube. The Weiss fishbone catcher, with ring, metal tip, and Sympson's hook contrivance, is represented in Fig. 175. It is passed beyond the object with the bristler folded and held in place by

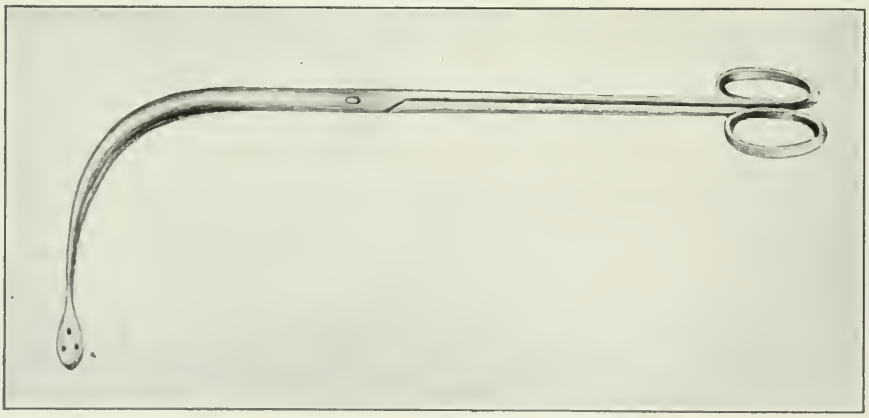

Fig. 172.—Pharyngeal Forceps.

Sympson's contrivance (*a*); it is then opened like an umbrella and the walls of the œsophagus are swept from below upward by withdrawing the instrument held open, as in *b*. This instrument is most useful in removing fishbones and other small objects. Graefe's coin catcher (Fig. 174) consists of a whalebone staff, one end of which carries a small sponge, the other end being provided either

with a shallow basket which turns on a hinge, or with a smooth double hook movable in both directions. The instrument is passed beyond the foreign body and then turned upon its axis before being withdrawn.

After the œsophagus has been examined with a bougie and the location of the foreign body has been determined, œsophagoscopy should be performed with the intention of extracting the foreign body through the mouth or of pushing it into the stomach. There are many cases in which a foreign body can be removed through the mouth by aid of the œsophagoscope, an œsophagotomy or possibly a gastrotomy being thus avoided. Œsophagoscopy should be attempted only by those who have had special training and have mastered the technique of the procedure.

A foreign body should not be pushed down into the stomach unless one is fairly certain that the procedure will not be a disadvantage to the patient. The

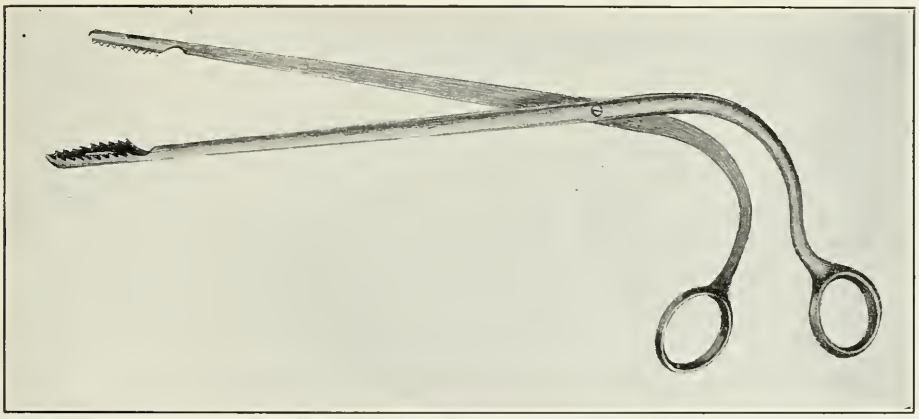

Fig. 173.—Œsophageal Forceps.

cases in which this method is justifiable are those in which the foreign body is smooth and is not too large to pass the pylorus, and which, besides, cannot be easily grasped with extraction forceps. The procedure is also permissible in cases in which the foreign body is of a soft nature, such as a piece of meat, a potato, etc. The best instrument for this purpose is the ordinary bougie with a cylindrical tip. In case a foreign body passes into the stomach, or is pushed down into the stomach, its passage will be facilitated by feeding the patient mashed potatoes for a few days.

Where the methods mentioned above are unsuccessful, or where they are contra-indicated, a surgical operation should be performed. Even though the foreign body be of such a nature that it will probably not pass the pylorus safely, it is justifiable to push it down into the stomach and perform a gastrotomy later, for the latter operation is much simpler and less dangerous where a foreign body is situated in the stomach than where it is impacted in the œsophagus.

There are two methods of approach: one by an external œsophagotomy, and the other by a gastrotomy. The selection of the method must depend upon the location of the impaction. As a rule, if the impacted body is located at the

cricoid cartilage or at any spot above the suprasternal notch, an œsophagotomy should be performed; if it is located below the sternal notch, a gastrotomy should be done.

Œsophagotomy.

The patient is anæsthetized and placed with the shoulders well raised and a sand bag under the neck, so as to throw the head somewhat backward. An incision is made on the left side of the neck, along a line corresponding with the anterior border of the sterno-mastoid muscle. It is carried directly down to the muscle. Blunt dissection is now used until the anterior belly of the omo-hyoid muscle is reached. This muscle and the sterno-thyroid and sterno-hyoid muscles are retracted inward. The lateral wall of the trachea can now be felt, and, when the wound is stretched open, the œsophagus should be seen immediately behind the trachea. Great assistance in locating this tube can be rendered by placing a bougie with a large bulb in the œsophagus and pressing the end toward the wound. The œsophagus is now separated from its connections, both anteriorly and posteriorly, by means of blunt dissection, so that it is possible to bring the œsophagus up near the edges of the skin wound. The remainder of

Fig. 174.—Graefe's Coin-catcher.

the wound is now packed off with small pads so as to prevent any discharge which might come from the œsophagus from infecting the wound. An incision is next made upon the bulb and the cut edges of the œsophagus are grasped by means of two mouse-toothed forceps. The œsophagus is then explored by means of the finger, and the foreign body is removed by the aid of a curved pair of œsophageal forceps. Great care should be taken to sponge away any mucus that escapes from the œsophagus. After the foreign body has been removed, the wound in the œsophagus should be closed with two layers of catgut sutures, the outer row consisting of Lembert stitches. A small drain is now carried down to the œsophagus, all of the deep structures are sutured in their normal position with catgut, and the margins of the skin are approximated with horsehair stitches. The patient should receive no food or liquids by way of the mouth for a week or ten days. In well-nourished patients the nourishment and fluids can be administered *per rectum*. In very weak individuals the nourishment can be given by passing a tube through the nose down into the stomach.

The prognosis, in cases of œsophagotomy, depends mainly upon the time at which the operation is performed. If it is performed within the first twenty-four to forty-eight hours, the prognosis is good; if it is performed after this time, and if ulceration or perforation has taken place, the prognosis is very grave.

Gastrotomy for the Removal of a Foreign Body in the Œsophagus.

The removal of a foreign body through the stomach is justifiable in all cases in which the body is situated too low in the thoracic portion of the œsophagus to be reached by œsophagotomy, and in which, at the same time, it cannot be removed by other means. It is indicated, therefore, in cases in which the foreign body is situated more than 26 cm. (10 inches) from the teeth, as well as in those in which the body is lodged in the cardiac end of the œsophagus; and it is especially indicated in cases in which the foreign body is large and angular or irregularly shaped.

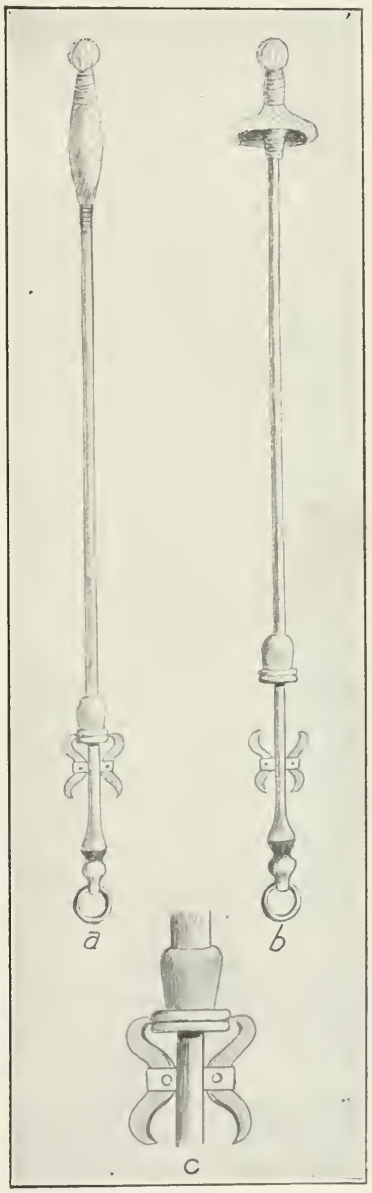

Fig. 175. Weiss Fishbone Catcher. *a*, Bristle folded and instrument ready to be introduced; *b*, bristle expanded and instrument ready to be withdrawn; *c*, Sympson's hook contrivance.

In performing gastrotomy for the removal of a foreign body in the œsophagus, the surgeon should make the incision through the edge of the left rectus abdominis muscle or obliquely along the costal margin. When the peritoneal cavity is opened the intestines should be packed away by means of sterile gauze pads, to guard against soiling the peritoneum by any leakage from the stomach. The dome of the stomach is now brought forward and out of the peritoneal cavity, if possible. The stomach wall is grasped with mouse-toothed stomach forceps and then incised. The contents of the organ should be removed by packing dry gauze pads in and out through the opening in the stomach wall. The lower end of the œsophagus is now explored by passing one finger through the opening in the stomach wall. The edges of the stomach wound should be held well beyond the edges of the abdominal wound, a pair of œsophageal forceps should be passed through this opening up into the œsophagus, and the foreign body should, if possible, be extracted. In the more difficult cases, in which various procedures are necessary in order to loosen and bring down the foreign body, it is most practicable to enlarge the incision and pass the whole hand into the stomach, as recommended by Richardson. If the foreign body cannot be reached with the finger and removed by the aid of forceps, the string method, as used by Bull and

Finney, should be tried. A small sound or bougie is passed either through the mouth or from below through the gastrotomy opening. A string, which has been armed with a small sponge or piece of gauze is attached to the end of the sound and pulled back through the œsophagus. An attempt is now made, by drawing this sponge through the œsophagus, either to bring the foreign body up and out through the mouth, or to pull it downward into the stomach. After the foreign body has been removed, the management of the opening in the stomach depends upon the amount of traumatism which has been inflicted upon the œsophagus. If the foreign body is removed early and with little injury to the œsophagus, the wound in the stomach should be completely closed by first applying a Connell suture to the two edges and then covering the area by means of a Lembert stitch. In case the foreign body has been present for a considerable length of time, thus favoring the belief that an ulcerated condition may exist, or if the œsophagus is injured considerably during the removal of the foreign body, then a temporary gastrostomy should be done for the purpose of administering food until the œsophagus shall have recovered from the injuries inflicted. The gastrostomy should be so planned that the opening in the stomach will close spontaneously in a short time. This can be accomplished by carefully folding the serous surface of the stomach inward around the feeding tube, thus making it impossible for any eversion of the mucous lining of the stomach to take place. If this is done in the manner described, the fistula in the stomach will close in a short time after the removal of the feeding tube.

Among the complications which may follow the swallowing of a foreign body the most important are hemorrhage and phlegmonous processes resulting from injury to the œsophagus. Ulceration, perforation, or gangrene of the œsophagus is apt to be followed by a phlegmonous process which may lead to suppuration in the pleura, in the mediastinum, or in the loose connective tissue between the vertebral column and the œsophagus, or it may result in pneumonia or in gangrene of the lungs.

In the presence of any of the above-named complications, the prognosis is usually unfavorable.

Stricture of the Œsophagus.—Of the organic strictures of the œsophagus, those which are caused by carcinoma are the most frequent; the next, in the order of frequency, being the cicatricial stenosis, the result of the healing of an ulceration. The latter is produced by some form of traumatism, such as the swallowing of a caustic alkali, an acid, or a hot fluid; and it may also be caused by a wound or by the prolonged lodgment of a foreign body. It is occasionally due to typhoid ulceration. Thompson [10] reports three cases which came under his observation and nine other cases which have been described in literature. The most common cause—and this is especially true in children—is the accidental swallowing of concentrated lye. In adults, carbolic acid, ammonia, etc., are frequently taken, but in only a small proportion of the cases does the patient live to develop a cicatrix; the immediate mortality is high. Occasionally the breaking down of a syphilitic gumma may leave an ulcer, and the healing of this lesion causes a stenosis. Tuberculous ulceration of the œsophagus

is very rare. The healing of an ulcer of the cardia which extends into the œsophagus may, in rare cases, result in a cicatricial stenosis of the œsophagus. Spasmodic stricture of the œsophagus is not a rare condition, and must always be kept in mind when one is considering the causes of obstruction of the œsophagus.

A pressure-stenosis of the œsophagus may result from extra-œsophageal conditions, such as tumors involving the thyroid body, enlarged tracheal and mediastinal lymph nodes, aneurysms, pericardial effusions, peri-œsophageal abscess, and spondylitis.

Although strictures may occur at any part of the œsophagus, they are most frequently found at the site of the three natural constrictions of the œsophagus—viz., at the entrance of the œsophagus, at the level of the bifurcation of the trachea, and in the region of the hiatus of the œsophagus.

Symptoms.—Difficulty in swallowing is present in all cases of stricture of the œsophagus. The degree of dysphagia depends upon the degree of stenosis. In cases of cicatricial stenosis the narrowing usually develops slowly, and the dysphagia comes on gradually. At first, the patient experiences difficulty in swallowing solid food, especially meat. Early in the disease there is usually a sense of pain or discomfort in the œsophagus at the point of the stricture, especially during the act of swallowing. Occasionally, the patients locate the stricture incorrectly, as the pain may be referred to the region of the sternum and cricoid cartilage when the obstruction is located in the lower portion of the œsophagus. As the stenosis increases, the difficulty in swallowing becomes more marked, and the patient soon develops a rather characteristic symptom—that, namely, of being careful to take only a small amount of food at a time, and then to swallow it slowly. He frequently gags, and then carries out certain motions with his head. There is often regurgitation of food. If the obstruction is high up in the œsophagus, this regurgitation takes place immediately; if it is lower down, a short time may intervene before the regurgitation takes place. Where the obstruction is very marked, mucus and swallowed saliva accumulate in the œsophagus and constitute a great annoyance to the patient by being frequently regurgitated into the mouth. As soon as the obstruction is pronounced, loss of weight takes place from lack of sufficient nourishment.

Diagnosis.—In mechanical stricture of the œsophagus there is present a group of symptoms which are self-evident; of these, the dysphagia and the regurgitation of food are the most prominent. When a patient complains of difficulty in swallowing or of vomiting at the time of eating, we should put him to the test and observe what happens during the ingestion of food and drinks. Even though the obstruction has existed for only a short time, we shall observe that the patient has learned to eat slowly, to take only small bites of food, and to masticate very carefully. If the stenosis is very marked, even liquids will be taken slowly, and it will be evident that the patient is making an effort to cause the food to go down. If he is urged to eat more rapidly, he will say that it is impossible. If eating is forced, there will be a regurgitation of food usually mixed with mucus. This takes place without any effort on the part of the patient and

is very different from the expulsive effort which usually accompanies vomiting. The patient can practically always distinguish the difference between the act of vomiting and the regurgitation of food. If the history of a patient indicates the presence of a stenosis, we can confirm the diagnosis by passing a stomach tube or bougie. Before such instruments are used, however, a careful examination of the patient should be made to determine if there is any contra-indication to the employment of this measure. The presence of an aneurysm, or of high-grade arteriosclerosis, or of pronounced heart incompetency renders the procedure unsafe. As a rule, it is best to pass a soft stomach tube first; but the exact location and degree of the obstruction can be more accurately determined by the employment of bougies with olive tips. The diagnosis and location of an œsophageal stenosis is usually easy, but to determine the exact nature of the obstruction is often a difficult matter. In adults carcinoma is by far the most common cause of stricture. It is characterized by the same symptoms as those described above. Its onset is usually gradual, although the inability to swallow solids may come on suddenly. The course of carcinoma is progressive, there is a gradual loss of weight, and later there is cachexia. Metastatic growths should always be looked for, although they are rarely of value in the early diagnosis. As there is a tendency toward early ulceration in carcinoma, the presence of blood in the stools is an important diagnostic sign. In carcinoma the passage of even a soft stomach tube usually causes bleeding on account of the presence of an ulcerating surface.

In cicatricial stenosis there will be a gradual and persistent obstruction, with the absence of the above-mentioned symptoms. There is usually a history of swallowing some caustic acid or alkali. This history, together with the presence of a firm obstruction as determined by the passing of a bougie, will usually suffice to make the diagnosis of cicatricial stenosis.

Treatment.—Much can be done to prevent the formation of troublesome strictures following traumatisms of the œsophagus by treating the condition before contraction takes place. After a patient has swallowed some caustic substance, Meyer suggests that systematic sounding should be instituted after the lapse of from two to four weeks. Foreign bodies should not be allowed to remain in the œsophagus until ulceration has taken place.

Measures to be Employed in Dilatable Strictures.—Gradual dilatation is the operation of choice in this class of cases. If the stricture is not too tight the woven flexible bougies are suitable for this purpose. The bougie is lubricated with vaseline, olive oil, or glycerin, and passed in the method described in the section relating to the examination of the œsophagus. (Page 416.) In the tighter strictures a bougie with a whalebone stem, to which may be attached ivory olive-shaped tips of different sizes, will be found most valuable. These tips should be made long and tapering, so that they may enter the stricture with greater ease than do the ordinary olive-shaped tips, and the size employed should gradually increase. There are many cases in which the woven flexible bougie or the olive-shaped tips cannot be passed, and the surgeon is then apt to pronounce the case one of impermeable stricture. However, in these cases one may,

with care and gentleness, easily pass a filiform bougie, even though several sittings are required. In such cases several small filiform bougies, on one end of which screw threads are cut so that it may be attached to a flexible dilator, as shown in Fig. 169, should be inserted (one after the other) into the œsophagus and gently pushed against the stricture in the same manner as filiforms are inserted into the urethra. By manipulating first one bougie and then another, one will usually succeed in causing one of them to slip through. The tapering flexible bougie is now attached to the filiform, which serves as a guide, and the bougie is then pushed on through the stricture. After the filiform has been passed a few times, the passage of the woven flexible bougie or one of the olive-shaped tips can probably be effected. These should be passed in increasing sizes at intervals of two or three times a week. After a few days, when the patient has become accustomed to this procedure, the largest flexible bougie passed should be left in place for a period of from five to fifteen minutes.

Many months are usually required for the thorough dilatation of one of these strictures, and, after the patient is apparently cured, sounds should be passed occasionally for several years.

Methods to be Employed in Non-Dilatable Strictures.—In strictures which are impermeable from above, or which cannot be successfully treated by dilatation through the mouth, the treatment depends upon the condition of the patient and upon the location of the stricture. If the patient is in an exhausted condition from prolonged starvation, a temporary gastrostomy should be performed and the patient nourished in this way until his general condition shall have improved. By this means, rest is given to the affected parts and then, later on, it may be possible to dilate the stricture from above; or, if it be not possible, some form of retrograde dilatation may be used.

The following is quoted from Mayo [11]: "For stricture in the vicinity of the cricoid cartilage external œsophagotomy, after Billroth, is the operation of choice. Like the perineal cut for stricture of the urethra, the funnel-shaped retraction of the cut portion is caused by adhesion to the external tissues divided and it lessens future contraction. This operation, first performed by Mitchell and later by Annandale, has stood the test and should not be long delayed.

"For dense stricture above the arch of the aorta and below the point which can be directly divided, Gussenbauer's combined œsophagotomy is the best operation; through an external incision in the neck a tenotome is introduced and passed downward to the stricture, which is then divided."

The most common, as well as the most serious, strictures are those at the lower end of the œsophagus. The best method of dealing with these is by some form of retrograde dilatation.

Œsophageal strictures which are impermeable from above, will almost invariably permit the passage of a bougie from below, because the pressure of the food in trying to pass down the œsophagus renders the canal basin-shaped, while on the distal side the œsophagus is funnel-shaped. Thus naturally a bougie will pass more readily upward through the stricture.

The Author's Method.—The same incision is made as that which is used in

ordinary gastrostomy. The stomach wall is brought out of the wound and a purse-string suture is applied in such a manner as to describe a circle one inch and a half in diameter. An incision is next made in the stomach wall large enough to admit one finger. A filiform bougie is now passed through the stricture, either from above or in a retrograde manner. A silk cord is attached to the end of the bougie and pulled up through the œsophagus and out through the mouth. A stronger silk cord is attached to this one and in turn is drawn through downward. This performance is repeated until a very powerful silk cord has been drawn through double and tied upon itself, as shown in Fig. 176. The

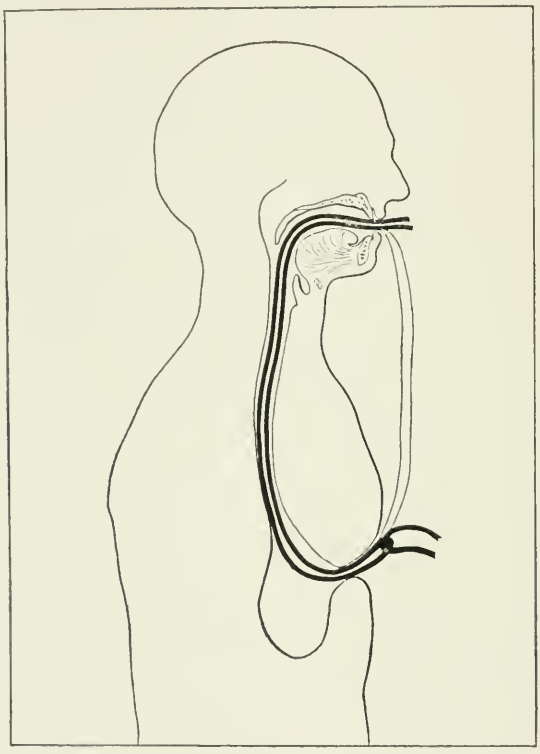

Fig. 176.—Dilatation of Stricture of the Œsophagus. The diagram shows a continuous double thread of heavy silk passed through the mouth, pharynx, œsophagus, stomach, and gastrotomy wound, and from this to the mouth a rubber drainage tube drawn through by the loop in the string, and a second drainage tube looped into the first, to be drawn back through the stricture.

feeding tube is fastened in the stomach by tying the purse string. The silk cord is left in place; it passes around through the œsophagus and stomach and out alongside the feeding tube, so that it cannot be dislodged by any accidental manipulation. The operation is then completed by suturing the stomach to the peritoneum and transversalis fascia.

The feeding tube is left in place for a few days while the stomach is becoming thoroughly attached to the abdominal wall, during which time the patient receives an abundance of nourishing food.

The dilatation is now begun in the following manner:—By means of the

continuous double cord another cord is carried through the stomach into the œsophagus and out through the mouth. This cord should again be double, so that a rubber drainage tube may be looped into it and drawn through the stricture, as shown in Fig. 176. In this diagram, however, the rubber tube is looped directly upon the original silk cord, which is not a safe practice, because, if the cord should break, it might be difficult to replace it, while there is no danger of its breaking in simply carrying through another cord. The rubber will stretch out into a thin body when drawn through a tight stricture, but when relaxed it will act as a powerful dilator. The size of the rubber tube may be increased, or any desired number of tubes may be drawn through the stricture

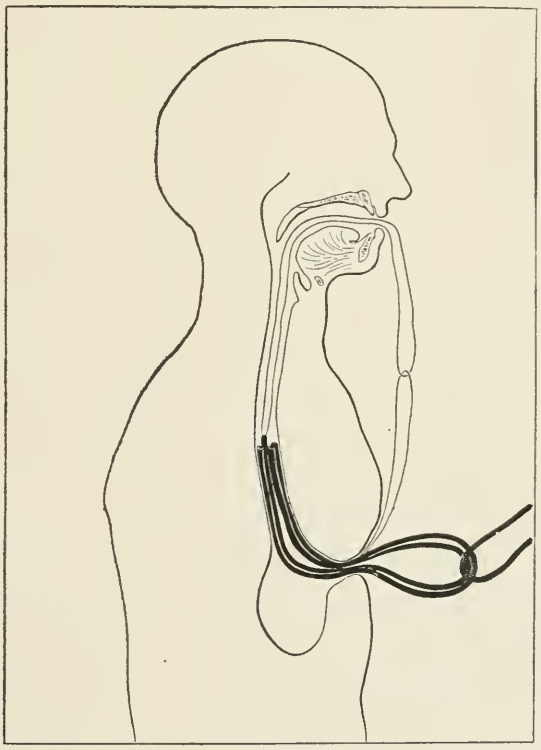

FIG. 177.—Dilatation of a Stricture of the Œsophagus. In this diagram a large double tube is represented as having been drawn into the stricture, in which position it is left for a time in order that it may exert a dilating influence.

at the same time, as the calibre of the latter increases. (See Fig. 177.) The rubber tubes may be drawn back and forth. The first one is drawn through the mouth and out of the opening in the stomach by means of the silk cord. The dilatation can now be carried on by looping a larger rubber tube through the loop of the other tube. By means of the latter, draw the larger tube up through and out of the mouth, and then repeat this until as large a tube as desired may be drawn through the stricture. This, however, requires a large opening in the stomach, which is not necessary if the tubes are simply looped into the silk cord; and by alternating the direction of the pull, the tube is first drawn out by its

free ends and then in by the silk loop. Later on, a Barnes dilator in a collapsed condition may be drawn into the stricture, as shown in Fig. 178. In this diagram the dilator is being drawn up from below, but it can be drawn down from above with no more difficulty. The fact that the dilator is engaged in the stricture may be recognized by the difficulty which one experiences in drawing it into the narrow opening. It should also be noted that the shoulders upon the bag have a tendency to keep it from slipping beyond the stricture.

When once in place the Barnes dilator is inflated with air by means of a rubber bulb. The patient's own sensations must serve as a guide to the degree of

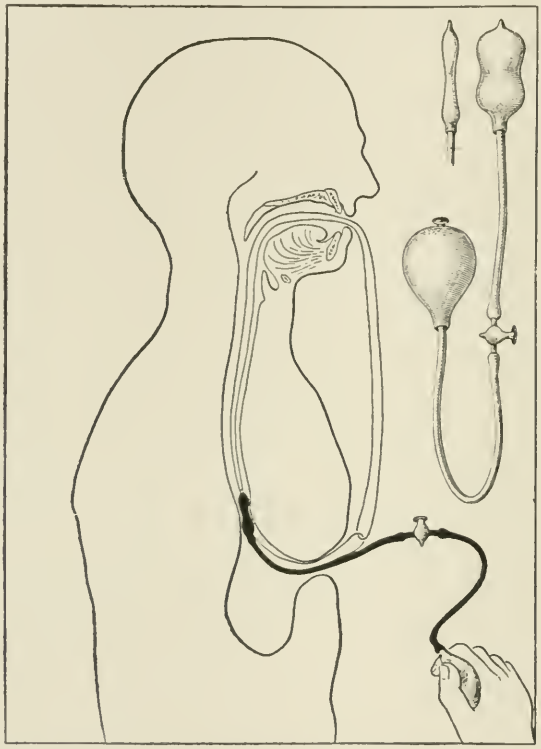

Fig. 178.—Dilatation of a Stricture of the Œsophagus. The diagram shows a Barnes dilator introduced after partial dilatation has been accomplished by the method illustrated in Figs. 176 and 177.

dilatation which it is safe to make use of at any given time, and to the length of time during which it is wise to leave the dilator in place.

Sippy has constructed a dilator which is superior to the Barnes dilator and which can be used in the same manner. The dilator consists of a rubber bag, about three and one-half inches long, encased in a silk bag, which limits accurately the distention which may be produced. When inflated with air the silk bag has a circumference of about 15 cm. The dilating force is accurately controlled by this bag, and the maximum pressure is exerted at the point desired. The silk bag is itself covered with a rubber bag, to prevent friction.

In case simple dilatation, either by the use of the rubber tubes or by means of the Barnes dilator, does not expand the stricture rapidly enough, the edges

of the stricture may be rendered tense either by drawing as many rubber tubes as one can into the stricture or by employing the inflated bag, as shown in Fig. 179, and then using the silk cord after the fashion of a chain saw (as is done in the method of Abbe) and thus cutting the edges of the stricture. After a considerable degree of dilatation has been accomplished, it is well to attempt the passage of œsophageal bougies from above. These should be passed every day at first, then once a week for several months, and finally once a month for many years. The patient can be taught to pass the bougies himself, and he should then report personally to the surgeon from time to time. This is

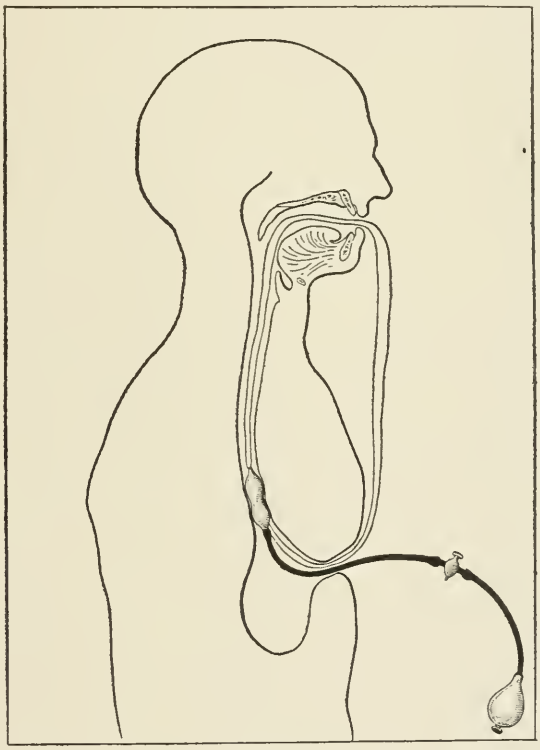

Fig. 179.—Dilatation of a Stricture of the Œsophagus. The diagram shows the Barnes dilator in position and distended.

desirable because the patient often imagines that he has succeeded in passing a bougie when he has passed it only down to the stricture.

After the feeding tube has been removed, in those cases in which an adequate passage through the œsophageal stricture has been established by dilatation, the opening in the stomach will usually close spontaneously.

Abbe's String-Cutting Method.—The abdomen is opened and the anterior wall of the dome of the stomach is brought up and sutured to the edges of the abdominal wall. An opening is made in the stomach and two fingers are inserted into its cavity and passed along its anterior wall for the purpose of locating the opening of the œsophagus. Abbe [12] calls attention to the fact that it is often difficult to locate the œsophageal opening. In connection with this statement

Abbe says:—"This has been interesting to me from a physiological point of view. We ordinarily think of the stomach as pictured in anatomy, showing a funnel-shaped expansion of the œsophagus where it joins the stomach wall. It has never been my experience to find this condition in the living stomach. As one's finger passes back and forth over its upper interior aspect, one feels an even surface more like the interior of any dome-shaped cavity. This surface is maintained by the circular sphincteric muscle layers, and it is not until a moment's pressure of the finger at the right place causes them to yield, that it slips upward into the œsophagus.

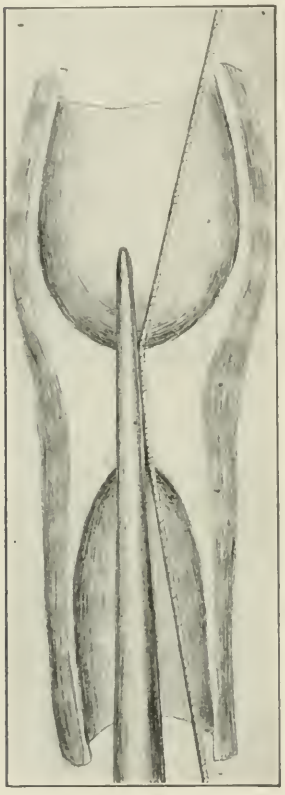

Fig. 180.—Abbe's String-cutting Method. The dilating bougie and string are in place

"I have never seen this point stated in any surgical work, and it has interested me as representing an always present physiological condition which prevents food regurgitation."

When the œsophageal opening has been located, a long filiform whalebone bougie, guided by the index finger, is passed up along the œsophagus from the stomach to the mouth. To the end of this a heavy silk string is tied and pulled up into and out of the mouth. A tapering bougie is now passed up along the string and through the stricture until it becomes wedged tight in the latter. (Fig. 180.) The string is now pulled back and forth like a saw, cutting the tight stricture band. (Fig. 181.) As the stricture gives way, the bougie is passed further up until it again becomes tight; the string-sawing is then repeated until a large bougie can be passed from the stomach to the mouth. Instead of passing the bougie up along the string, as described above, one may draw through the œsophagus a second string, to the lower end of which a Billroth dilating bougie is tied, and by means of this string the bougie is drawn upward until it becomes tightly engaged in the stricture; the sawing process may then be employed in the manner described above.

The fundamental principle of this operation is this: the dilator must be pressed tightly into the stricture in order that the string moving to and fro may eat its way through the stricture. No tissue will be affected by the string, except where it is on the stretch.

The gastrotomy opening may be closed immediately after the cutting process is completed, or it may be left open for a few days until it is demonstrated that a large-sized bougie may be readily passed from above. Bougies should be passed every other day at first, then weekly, then once a month for a year, and after that once each year.

In some cases it is possible to pass a small-sized bougie through the stricture from above, but these strictures are so dense that they will not yield to the

bougies. For such a case, Dr. Joseph D. Bryant devised a small bougie that carried a string around the advancing end down from above through the stricture for the purpose of cutting the latter by the string method without performing a gastrotomy. Abbe[12] modified this bougie in such a manner as to make its use more simple and practical. He devised a dilating metal guide which carries a string down to the face of the stricture and back again, so that, working entirely from the patient's mouth, he was able to wear a passage through the stricture on the same principle that applies in his original string-cutting operation. The patient's head is held back in a position which will render the œsophagus as straight as possible. The instrument is gently pushed

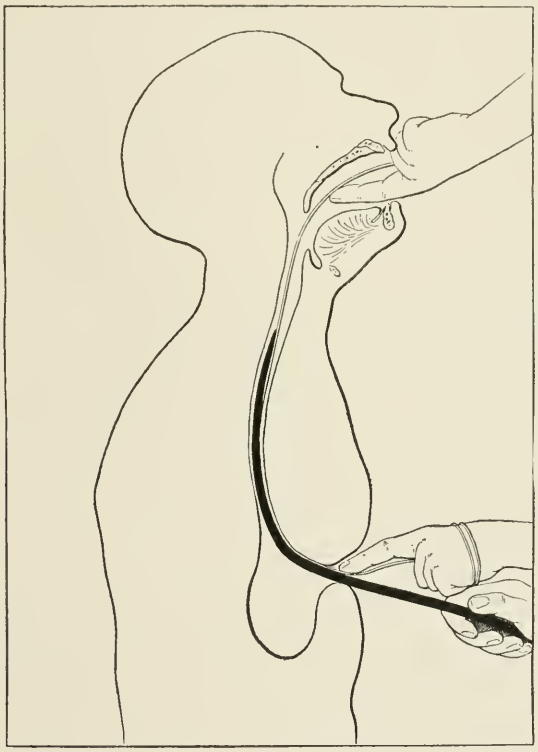

Fig. 181.—Diagram Illustrating Abbe's String-cutting Method for Œsophageal Stricture.

down the œsophagus until the probe-ending guide engages in the stricture and the metal shoulder bears hard upon it. While the operator forces the instrument onward, the assistant pulls the string back and forth in the tube and wears away the cicatrix where the string passes against it.

Billroth's Method.—A filiform bougie is passed into a gastrostomy opening and up through the stricture to the mouth or out through an external œsophagotomy opening, and a strong thread is drawn down through and out of the opening in the stomach. Then, to the lower end are fastened in succession conical bougies the tips of which are capped by a metal point into which the string is tied. From the smallest to the largest ones, these are thus safely

drawn up through the stricture, with no danger of perforating the wall of the œsophagus.

In performing any of the retrograde methods of dilatation one is apt to have difficulty in passing the first string through the stricture. It may not only be impossible to pass a bougie from above, but one may also experience great difficulty in finding the cardiac opening. In such cases a silk thread may be floated through from above, as advocated by Dunham. This is accomplished by having the patient swallow a silk thread down to the stricture. The patient is then given a swallow of water. As this trickles down through the stricture it may carry the thread through with it, and then the thread can be fished out through the gastric fistula.

Hagenbach reported a case in which he was unable to find the stricture from below after making a gastric fistula. He caused the patient to swallow a perforated shot to which a thread was attached. This passed through the stricture into the stomach and was hooked out of the fistula, and thus acted as a guide for the future dilatations.

Dr. Morris [13] reports a case of stricture of the œsophagus following the drinking of hydrochloric acid and describes a method of forming a gastric fistula.

"Charles M., seventy-one years of age, drank hydrochloric acid by accident. The œsophagus became nearly or completely occluded during the following three weeks. Rectal alimentation. Loss of weight, 30 pounds. Patient extremely feeble when I first saw him on November 25th, 1907. Operation at St. Mark's Hospital on the following day. Incision parallel with the left costal border, in the expectation of performing Witzel's operation. Stomach so much contracted that it was found impossible to perform this operation. A ribbon of skin about an inch wide was dissected away from either side of the original incision. Ribbons about four inches long remained attached at their cephalad ends. Free ends of ribbons drawn into an opening in the stomach near attachment of gastro-colic omentum and sutured to mucosa in such a way as to leave a round tube of skin. Margins of ribbons sutured in such a way as to complete this tube. Gastro-colic omentum easily wrapped about the tube and sutured to the abdominal wall to guard against leakage and to help furnish lymph circulation for the tube of skin. Rubber tube left within the skin tube with one end in the stomach and the other end free outside. Wound closed. Operation performed rapidly and it seemed to be very satisfactory from a mechanical point of view. Patient, too feeble to rally, died the following day.—When occasion presents itself for repeating the operation, I shall dissect up a strip of skin four or five inches long and two inches broad, for making the skin tube, instead of having it consist of two ribbons of skin. So far as I can judge, this skin tube can be carried to the stomach easily, no matter how much it may be contracted and retracted; and the operation appears to be more simple than the classical ones. The skin tube lies obliquely to the plane of the abdominal wall and would apparently remain closed against leakage of stomach contents, and at the same time would allow passage of the feeding tube."

Dr. Eugene Bircher [14] describes a plastic operation for the relief of stenosis of the œsophagus. He calls it "Œsophago-Jejuno-Gastrostomie." The operation was performed by Professor Roux and is described as follows:—

A piece of jejunum sufficiently long to reach from the stomach to the mouth was isolated and cut off. The lower end was implanted into the stomach and the upper end was carried through the abdominal wall. The skin from the sternum was undermined and, opposite the upper end of the sternum, an opening was made in the skin through which the end of the jejunum was drawn out. The edges of this wound were sutured to this free end of the jejunum. Care was taken in loosening the jejunum to secure for it a sufficient blood-supply. Food was introduced through the jejunum into the stomach, and this food could pass out into the intestines through the remaining portion of the jejunum which was attached to the stomach.

Kocher attempted to use this method, but failed, as the patient was advanced in years and the circulation was not sufficient to supply the portion of the jejunum which was to be transplanted. It was consequently necessary to make a jejunostomy.

Bircher has devised another operation in which he forms a subcutaneous œsophagus out of a portion of the skin of the chest which he attaches to the anterior gastrostomy opening. The operation was performed twice and promised well, but the patient died from intercurrent disease.

Diverticula of the Œsophagus.—Diverticula of the œsophagus are pouch-like sacculations of a portion of the circumference of the tube. The characteristic feature of a true diverticulum is to be found in the fact that it is a sharply defined, pouch-like protrusion of the œsophageal wall lined with mucous membrane.

According to their etiology three forms of œsophageal diverticula are recognized: pressure diverticula, traction diverticula, and traction-pressure diverticula. Traction diverticula seldom produce any symptoms by which they may be recognized during life, and they are only occasionally found at autopsy. Traction diverticula are generally the result of the traction caused by the shrinkage of some scar tissue attached to the wall of the œsophagus. This is most often the result of softening and suppuration of mediastinal and bronchial lymph nodes, especially in tuberculosis of the latter. These nodes are usually situated at a point near which the œsophagus crosses the left bronchus. They are commonly adherent to the œsophagus, and, as cicatrization takes place, the anterior wall of the œsophagus is drawn out, thus giving rise to small dilatations of the œsophagus, as first described by Rokitansky.[15] Traction diverticula may also result from the spreading of an inflammation from the pleura or pericardium to the œsophagus and its surrounding areolar tissue. They are generally small funnel-shaped recesses, and their walls may consist of all the tunics of the œsophagus or of the mucous membrane alone.

Zenker[16] speaks of the direction of the lumen of these pouches as being practically always oblique or horizontal, with the orifice directed downward. This direction of the lumen of the sac, which affords only a slight chance for the arrest and retention of food, probably explains why clinical symptoms are so rarely observed in pressure diverticula.

Although traction diverticula are generally looked upon as being of slight importance, they may result in perforation of the wall of the diverticulum and

thus become a serious menace to life. When perforation takes place it is either from some sharp foreign body becoming lodged within, or from ulceration caused by pressure of retained food. When death results from a traction diverticulum, it is generally due to the fact that a perforation causes an infection of the mediastinum or a gangrenous pneumonia. There are on record a few cases in which particles of food have become arrested in the sac and have caused a degree of distention which has eventually resulted in the formation of a pressure diverticulum. To this group of cases Olkonamides[17] has given the name "traction-pulsion diverticula." These cases are of clinical importance because they give rise to the same symptoms as do those which are primarily caused by pressure. Regurgitation, vomiting, dyspnœa, and pain from pressure when the diverticulum is filled with food are symptoms common to this group and to the pressure diverticula.

In the case of traction diverticula there is no satisfactory treatment, even though the diagnosis is made during life. The treatment is limited to prophylactic measures, such as avoiding rapid eating and drinking and limiting the patient to a liquid and soft diet. If the traction diverticulum becomes a traction-pressure diverticulum, death from inanition is the usual termination. Relief by means of surgical measures other than a gastrostomy is unattainable on account of the deep location of the sac.

Halsted,[18] for convenience of description and because of the difference in the clinical importance and mode of development and the variation in the symptoms produced, classified pressure diverticula as follows:—

(1) Those of the pharynx proper.

(2) Those at the pharyngo-œsophageal junction (the border-line cases or Rosenthal's "Grenz-diverticula").

(3) Diverticula having their origin in the middle third of the œsophagus, somewhere near the bifurcation of the trachea, mostly just above the left bronchus (the epibronchial group of Leutgert).

(4) The deep-seated diverticula—those in which the origin is below the level of the left bronchus, while the fundus is located a variable distance above, but usually near, the diaphragm. These have been termed "epiphrenal diverticula."

The diverticula of the first group are usually on the lateral aspect of the œsophagus and are not placed posteriorly as are those of the pharyngo-œsophageal type. Most of the lateral diverticula of the œsophagus are of congenital origin, probably originating from the remains of the third and fourth branchial clefts.

Trauma may be an important factor in the development of a diverticulum of the pharynx. Excessive pressure within the pharynx, from continued blowing on wind instruments or from shouting, may—if the pharyngeal wall has been weakened from previous disease—result in the formation of a diverticulum. The chief symptoms, in diverticulum of the pharynx, are cough and dyspnœa, both of which symptoms are due to the escape of the contents of the sac into the air passages and also in part to the pressure exerted upon the larynx or the

recurrent laryngeal nerve. As a rule, the œsophagus is not obstructed to any marked degree, and the patient does not suffer from inanition, as happens in cases of œsophageal diverticulum.

The pharyngo-œsophageal pressure diverticulum, which is also known as Zenker's diverticulum, is the most common and the most important from a clinical standpoint. Diverticula of this class develop exclusively in the median line posteriorly, at a natural defect in the posterior wall of the œsophagus, just below the pharyngo-œsophageal opening. The origin of these diverticula has not been definitely determined. It has been assumed that pressure from within, caused by regurgitation of food or by severe retching and vomiting, may result in a bulging of the œsophageal wall at this point. Cases have been reported in which the symptoms of a diverticulum developed soon after the arrest of a foreign body, such as a piece of bone, in this portion of the œsophagus. The accumulation of food at this point may result in a pouch-like dilatation, which at first develops posteriorly and later is dragged to one side, to the left, the fundus being in relation to the lateral wall of the œsophagus. As the diverticulum develops, it extends downward along the course of the œsophagus and displaces the latter so that the axis of the pharynx and the orifice of the diverticulum are in a line, thus making it easy for the food to enter the diverticulum. The capacity of the pouch varies from a few cubic centimetres to a half-litre or more. In the early stages the symptoms may be only slight, such as dryness and irritation about the throat. Later, the sensation of a foreign body may be present. As the sacculation becomes larger, the food accumulated in the sac crowds its wall against the œsophagus and obstructs the lumen of the latter.

When this stage is reached there will be difficult deglutition and regurgitation of food. According to Sippy [19] a tumor is discoverable in one-third of the cases. This may be situated posteriorly or to one side of the œsophagus, but rarely on both sides. The majority of the patients learn that, by holding the head in a certain position, they will be able to swallow, others learn to empty the sac by making pressure upon it with the hand. It frequently occurs that hours are consumed in taking a meal. In some cases a peculiar gurgling sound is heard during the act of swallowing. In most cases there is a constant retention of particles of food in the sac, and in consequence a fetor is produced which may become intolerable. It is often noticed that the patient can swallow better during the early part of the meal. As the sac fills, it crowds upon the œsophagus and obstructs its lumen.

The diagnosis can usually be made from the above symptoms. The history of the gradual development of these disturbances and the regurgitation of unaltered food should always arouse suspicion of a diverticulum. If a tumor develops in the neck during a meal and can be emptied by pressure, the probability that a diverticulum exists is greatly increased. If a bougie is passed, it is usually arrested at a point near the cricoid cartilage. If the bougie is slightly withdrawn and the direction of its point changed, it may pass on into the stomach. It frequently happens that a bougie may pass readily one day and not the next. Occasionally, when a bougie has passed into the diverticulum, a

second bougie may at the same time be passed on into the stomach. This would be impossible if there were only a stenosis. Bismuth suspended in oatmeal gruel may be administered and an *x*-ray picture taken. If the sacculation is sufficiently marked the picture will show the location and approximate size of the sac.

Diverticula which are situated at the level of the left bronchus are rare and are known as the epibronchial diverticula of Leutgert. This authority believes that the anatomical relations between the œsophagus and the left bronchus explain the origin of these diverticula at this point and also account for the frequency of the development of carcinoma of the œsophagus at the same point. On examining specimens of the œsophagus, after it had been removed with the lungs and bronchi intact, Leutgert found that there is a distinct bulging of the anterior wall of this tube at the point where it is crossed by the left bronchus. Above this point there is a more or less distinctly marked recess, varying in different specimens from a slight depression to a pocket deep enough to admit the tip of a finger. He believes that the obstruction caused by the left bronchus is sufficient temporarily to arrest the food, and that the presence of the latter, especially if it happens to form an abnormally large bolus, may deepen this epibronchial pocket and thus lead to the formation of a diverticulum.

Diverticula of the lower third of the œsophagus are mostly situated just above the diaphragm, and for this reason they have been named epiphrenal diverticula. The etiology of this group has never been definitely determined. The supposition is that some of these are traction-pulsion diverticula, although there are few lymph nodes in this part of the œsophagus. Some of these diverticula probably owe their origin to a constriction of the œsophagus at a point where it passes through the diaphragm. This constriction may be due to the contraction of a cicatrix or it may be dependent upon a congenitally narrow opening in the diaphragm.

The symptoms of the deep-seated diverticula are vomiting or regurgitation of food during or soon after the meal. After vomiting, the patients are again able to resume their eating. Occasionally it is found that, after eating a small quantity of food, there is a sense of weight or pressure in the region of the sternum. These disturbances slowly increase; larger quantities of food are vomited and less food enters the stomach, so that the patient gradually becomes emaciated.

The diagnosis is based upon the clinical history and upon the results obtained by an examination with bougies. For this purpose a bougie with a curved tip like that of a Mercier catheter is most convenient. With these bougies it is usually easy to pass by the diverticulum or, by turning the point, to enter the sacculation. It is also easy to determine whether the diverticulum is situated to the right or to the left. A bismuth mixture may be administered and an *x*-ray photograph taken for the purpose of determining the size and location of the diverticulum.

The treatment of œsophageal diverticula in the cervical region may be either non-operative or surgical. The non-operative plan of treatment consists in

the persistent use of sounds and stomach tubes. Permanent benefit to the patient can rarely be expected by this method of treatment. The surgical treatment consists of either a palliative or a radical operation. The palliative procedure consists in performing a gastrostomy to secure a means of administering food. When the patient is in a bad general condition, it may be advisable to perform a temporary gastrostomy in order to make it possible to improve the patient's general condition sufficiently to justify the performing of the radical operation. This also affords a method of administering food without feeding by the mouth until the wound in the œsophagus has healed. Extirpation of the sac, as first suggested by Kluge, is considered the best method for effecting a permanent cure of this condition. The chief danger from the operation seems to be from infection, which may occur from the contents of the sac during its removal or from leakage from the œsophageal wound after it has been sutured. The technique of the operation is as follows:—An incision is made along the anterior border of the sterno-cleido-mastoid muscle, from the level of the hyoid bone to the clavicle. The œsophagus is now reached by means of blunt dissection. No vessels of any importance are encountered except the superior thyroid and occasionally the inferior thyroid. Either one or both of these may be ligated. The thyroid gland can be drawn to one side and, if not enlarged, it will not be in the way. The sac, when located, should be carefully enucleated like that of a hernia. The most important step in the operation is the closing of the œsophagus after the removal of the diverticulum. Probably the best method is the one employed in suturing the edges of an intestinal wound. According to this method, the mucosa is first sutured, then the muscular coat, and finally the adventitia, catgut being used for the first two layers and silk for the last. Halsted, after considering all the various methods of suturing the opening in the œsophagus, expresses the belief that the most satisfactory result will be obtained if the following course is adopted:—First, pass a purse-string stitch around the neck of the sac; second, apply (distal to this) a temporary ligature to the neck of the sac; third, perform abscission of the sac beyond the temporary ligature; fourth, invaginate the end of the stump and tie the purse-string suture; fifth, introduce Lembert's sutures of catgut into the neck of the sac; and, sixth, close the defects in the muscular wall of the œsophagus by sutures.

It is advisable to drain the wound by carrying a piece of iodoform gauze or a cigarette drain from the œsophageal suture out through the skin incision.

Girard [20] devised an operation for the radical cure of those diverticula of the œsophagus which have small or medium-sized sacs. The operation consists in cutting down upon the œsophagus, enucleating the diverticulum, invaginating the sac into the œsophagus, and closing the defect in the muscular wall by suturing. He operated upon two patients by this method. In one case an ideal result was obtained; in the other, a fistula followed, but it healed in a short time.

Goldmann [21] describes an operation for the cure of diverticulum of the œsophagus which seems to merit especial attention. He introduces a probe into the diverticulum and makes an incision along the anterior portion of the sterno-

cleido-mastoid muscle. Then he elevates the exposed portion of the thyroid gland and removes it if it is enlarged. He next, with the aid of the guide in the diverticulum, dissects out the latter very carefully without disturbing its attachment to the œsophagus. Then he draws out the sac into the upper angle of the wound, and temporarily attaches its end to the skin with fine sutures, after it has been ligated with catgut ligatures at its entrance into the œsophagus. Finally, he tampons the wound in the immediate vicinity of the diverticulum and closes the remainder of the wound. A week later, the gauze tampon is removed and the diverticulum is cut off outside of the catgut ligature. The entire wound is by this time lined by protective granulations, so that even if there be a slight leakage, as in the case of the patient described, this will do no harm, because there can be no absorption and because drainage is then necessary. The drainage, however, may be removed as soon as it is certain that there will be no leakage.

The treatment of the epibronchial diverticula and the diverticula located just above the diaphragm is unsatisfactory. Irrigation with some mild antiseptic solution will prevent irritation and ulceration of the mucous membrane. These irrigations and the passage of bougies often afford considerable relief.

Idiopathic Dilatation of the Œsophagus.—By idiopathic dilatation of the œsophagus is meant a dilatation with no ascertainable organic cause. The œsophagus usually becomes dilated throughout a large portion of its extent; sometimes it is involved, practically throughout its entire length, in a spindle-shaped or cylindrical dilatation. Our lack of knowledge of the etiology of this condition is indicated by the variety of the names under which the cases have been reported—cardiospasm; idiopathic, fusiform, or diffuse dilatation; and dilatation without anatomical stenosis. Herrick,[22] in writing upon this subject, quotes Lassen as grouping the pathogenesis of the condition under the following five heads:—

(1) There may be primary spasm of the cardia, with secondary dilatation of the œsophagus above the spasm and hypertrophy of musculature—conditions very similar to those encountered in the stomach, where we have dilatation of that organ following obstruction of the pylorus.

(2) Primarily, we may have a predisposition to muscular weakness, a condition of atony allowing stagnation of food to occur; next, dilatation; and then, through irritation, spasm of the cardia. This view is held by Sorenheim.

(3) A third view is that advanced by Kraus. According to him, there has been found, in experiments on lower animals, that contraction of the cardia, with relaxation of the circular fibres of the œsophagus, may take place through defective vagus innervation. He believes that the same thing may occur in man.

(4) A fourth view is that of primary œsophagitis with secondary reflex spasm of the cardia and, later, dilatation.

(5) There is found, at times, as a congenital condition, a pouch just above the cardia. This pouch, which is spoken of sometimes as the *Vormagen*, or cardiac antrum, may, through an accumulation of food, or under the constant pressure of food, dilate; and this influence may serve as the basis for the dilatation.

Probably no one of the agencies referred to in these theories is entirely responsible for the condition. It is possible also that several of these factors might act in combination to produce this condition in a given case. Clinically, so far as we can judge from the history of these cases, a definite spasm of the cardia seems to be one of the earliest manifestations of dilatation of the œsophagus. Plummer,[23] from a study of the histories in a large number of cases, found that spasm was almost invariably present at the outset, and that this symptom was followed, at a later period, by the evidence of dilatation—that is, by retention of food in the œsophagus. He considers this the most convincing evidence that the spasm precedes the dilatation, and that primary atony is relatively a rare condition. The fact that, early in these cases, there is evidence of muscular hypertrophy in nearly all cases which have come to a post-mortem examination would speak against primary atony, and furnish further evidence in favor of primary spasm. There seems to be no reason why spasm should occur in primary atony unless we accept Kraus' theory of a simultaneous atony and spasm from degenerative changes in the vagus. His theory rests upon the finding of degenerated fibres in the vagus in one case in which an autopsy was made. His observations have not been confirmed.

The cause of the spasm is a matter of speculation. In the majority of the cases a definite etiological factor cannot be found. In a few of the cases reported there were gross lesions of the œsophagus, such as ulcers, fissures, and carcinoma of both the cardia and the stomach. Plummer has found three cases of carcinoma complicated by cardiospasm, and one case of hour-glass stomach due to syphilis with secondary cardiospasm. In his study of forty cases of cardiospasm, only three of the cases had neurasthenic symptoms; and evidence of the existence of œsophagitis previous to the onset of the cardiospasm could not be elicited from any of them.

Sippy states that "the spasm is on a nervous basis; hence the condition is likely to be found in nervous individuals." This symptom has developed after profound emotional disturbances, such as fright, grief, and worry. In one case reported, the difficulty in swallowing followed the suppression of menstruation; the patient feared that she was pregnant. A blow on the sternum was the exciting cause of the spasm in another case. The condition has developed during the course of an acute infectious disease—such, for example, as pneumonia and scarlet fever. A case of congenital origin has been reported. The symptoms of cardiospasm may be divided into three stages: first, cardiospasm with some difficulty in swallowing, but no regurgitation of food; second, cardiospasm with immediate regurgitation of food; third, cardiospasm with the dilated œsophagus, with retention of food in its dilated portion, and with regurgitation of this food at irregular intervals after taking.

In the majority of cases the first attack of spasms occurs suddenly while eating. A spasmodic choking sensation is experienced at some point along the course of the œsophagus, most often located in the region of the cardia. This sensation is rarely described as a pain and may be referred entirely to the epigastric region or to the upper portion of the œsophagus. Sometimes the spasm is

described as a delay in the passage of food, or it is said that the food sticks beneath the sternum. Soon it is noticed that the patient eats very slowly and finds it difficult to swallow. It may be necessary to wash the food down with water. The patient may go through certain movements of the body and arms, or take deep breaths, in order to force the food down.

In the second stage the regurgitation of food occurs immediately after swallowing. During the early portion of the progress of the affection the attacks occur periodically, but with varying degrees of intensity, and with remissions or intermissions covering days, weeks, months, or years. The affection pursues its slow and unmodified course. As the cardiospasm becomes more complete, the regurgitation of the food and the secretions of the œsophagus come on more frequently and more regularly.

In the third stage, after dilatation is established, the spasmodic choking sensation may be absent. The patient is able to take the first portion of his meal quite comfortably, but the food is retained in the dilated œsophagus instead of passing on into the stomach. After the sac is filled, further food is regurgitated or forces some of the preceding portion into the stomach. Of the contents of the œsophagus at the close of a meal, the more fluid portion may gradually slip through into the stomach. The solid food with mucus is usually regurgitated later at irregular intervals. Solid food like meats may remain in the œsophagus for several days. Plummer states that the sac never completely empties itself and that on many occasions he has withdrawn from two to sixteen ounces of food after the patient has fasted for from twenty-four to thirty-six hours. The regurgitation of food is often looked upon as vomiting both by the patient and by the physician. Some patients insist that the food enters the stomach but will not stay there, while others state that it lodges beneath the sternum. Practically all of them complain of a sense of weight and discomfort in the chest and they also declare that the regurgitated food is not sour.

The diagnosis of cardiospasm is apt to be difficult in the beginning, especially in patients who might be suspected, on account of their age, to be suffering from carcinoma of the cardia. But, in advanced cases, the diagnosis should not be difficult. Generally, the diagnosis can be premised from the history. According to this, the patient, without previous warning, experiences sudden difficulty in swallowing, or he unconsciously gets into the habit of nibbling his solid food and following each act of deglutition with a swallow of water. At first, liquids are often swallowed with greater difficulty than solids. After dilatation has taken place the obstruction is observed just as markedly when liquids as when solids are swallowed.

Holmes [24] states that "when dysphagia occurs with a liquid, especially with cold water, it is almost diagnostic of cardiospasm as opposed to stricture from any other cause."

Dysphagia is a most common symptom, but the difficulty in swallowing usually fluctuates more than it does when the stricture is due to organic disease. Normally, immediately after swallowing food or drink, the œsophagus will be found empty. When cardiospasm is present a considerable quantity of liquid

containing food particles and mucus may be withdrawn from the œsophagus even hours after food or drink is taken. In one of Sippy's cases 500 c.c. of water could be aspirated from the œsophagus several minutes after it had been swallowed. The stenosis was so impervious to liquids that one ounce of olive oil given at night was recovered from the œsophagus the next morning practically without the loss of a drop, and yet the lower end of the œsophagus presented no anatomical narrowing.

An important diagnostic feature is to be found in the fact that there may be little or no obstruction to the passage of a bougie, even in cases in which a large quantity of food is retained in the œsophagus. In the average case, when a sound is passed, it will be temporarily arrested at the cardia, and then, when slight pressure is made, it will pass on into the stomach. A large bougie will often pass as easily as a small one. This is not true in case of an organic stricture. For these cases Plummer has devised an olive-tipped bougie which may be passed on a silk thread as a guide. (Fig. 182). The patient slowly swallows six yards of silk thread. This passes down through a sufficient number of coils of intestine to prevent its withdrawal when it is pulled taut. Plummer has the patient swallow three yards in the afternoon and three yards on the following morning. In this manner the first portion forms a snarl in the œsophagus or stomach and then passes out, in this snarled state, into the intestines during the night; the remaining portion passes afterward without snarling. The olive-shaped tips for threading on this string are drilled from the tip to one side of the base. The olive-shaped tip, after being fastened on the end of a whalebone staff, is threaded upon the silk thread protruding from the mouth. The string is now pulled taut as the sound is passed on down the œsophagus. The silk thread, acting as a guide, directs the bougie straight into the orifice at the cardia, and thus the resistance which is encountered when the olive-shaped tip is made to slide along the flaring wall of the œsophagus, or when it has to straighten out some fold just as it is about to enter the cardia, is avoided. The character of the resistance met with at the cardia is of the utmost importance in the differential diagnosis of organic and spasmodic stricture of the cardia.

Fig. 182.—Whalebone Staff with Olive Drilled for Silk Thread.

Excitement, overwork, and worry are apt to increase the spasm. The patient frequently awakes at night and finds food upon the pillow or finds his mouth and posterior nares filled with contents of the œsophagus. In organic stricture the retention of food and mucus is slight in comparison with what it may be as the result of cardiospasm. *X*-ray pictures of the dilated œsophagus may be obtained by having the patient swallow bismuth subnitrate (suspended in oatmeal gruel) until the choking sensation occurs. Then the photograph should be taken.

It happens very rarely that a diverticulum is the cause of an obstruction at the cardia. There should therefore seldom be any difficulty in differentiating

the condition from cardiospasm. Rumpel's differential test consists of first introducing into the stomach a stomach tube with lateral perforations in its lower half; then another tube, without perforations, is passed into the diverticulum. Water is now introduced through the tube supposed to be in a diverticulum. The first fluid collects in the diverticulum and does not pass through the other tube into the stomach. When more fluid is introduced and the diverticulum is full and overflows, the fluid passes through the long tube into the stomach and can be recovered from that point. The contents of the diverticulum can be removed separately through the short tube. If one is dealing with uniform dilatation of the œsophagus, the fluid at once escapes from the short tube into the œsophagus and then through the long tube into the stomach and can be recovered from that point.

To complete the diagnosis of cardiospasm an œsophagoscopic examination should be made.

Forcible dilatation is the best method of treating cardiospasm. Until recently the treatment of cardiospasm has consisted of such ineffectual measures as the following: looking after the patient's general condition; placing the patient under the best hygienic conditions; restricting the diet to fluid non-irritating substances; prescribing effervescent drinks; administering sedatives; passing large bougies; and, as a last resort, performing a gastrostomy. The passing of bougies has been followed by good results in some cases, but, if there is much dilatation of the œsophagus, such results are only temporary. It is impossible actually to stretch the orifice by passing sounds, because one cannot pass a bougie large enough to produce actual stretching of the muscle fibres. Other means have been devised for stretching the cardia. Rosenheim and others have used rubber bags which were introduced as far as the seat of the stricture and then distended with fluid or air. When the bag was distended, expansion took place at the points of least resistance,—that is, downward into the stomach and upward into the dilated œsophagus,—and consequently very little stretching occurred at the desired point. This method, however, gave better results than did the passing of sounds. Mikulicz [25] reports that he has operated upon four cases, apparently with perfect success. He performed a gastrostomy and then passed an instrument resembling a uterine dilator through the stomach into the cardia. The instrument was gradually opened until the blades were separated to a distance of about 7 cm. (nearly 3 inches). Two of the cases were perfectly well at the end of eighteen months and two others at the end of rather more than nine months. Mikulicz's idea in employing such forcible dilatation of the cardia was to produce an effect similar to that produced in stretching any sphincter to a point productive of paralysis. This grave operation is justified only when the condition is serious and when equally good results cannot be obtained by simpler means. In the majority of cases forcible dilatation can be accomplished from above without the aid of a cutting operation.

Sippy has constructed a dilator consisting of a rubber bag which is about 10 cm. long and is encased in a silk bag that limits the distention produced. When

the bag is inflated the circumference measures about 15 cm. (6 inches). With this bag the maximum pressure is exerted at the desired point. The silk covering is encased in a rubber cover to prevent friction. A long non-elastic rubber tube is attached to the bag at one end and connected with an air pump at its other end. It is essential to measure the amount of pressure exerted within the bag during the dilatation, and this is accomplished by connecting a column of mercury with the tube that passes from the bag to the pump. The exact distance of the cardia from the incisor teeth is measured by a bougie. The bag, in a collapsed condition, is carried down into the cardia by means of a whalebone staff. The dilatation is now accomplished by distending the bag with air. The cardia will stand a pressure of 500 mm., but Sippy has found that a pressure of from 100 to 300 mm., exerted for a period of three minutes, suffices in most cases to accomplish the object desired. The number of dilatations requisite ranges from one to ten. This method of treatment is used without the aid of an anæsthetic.

The immediate results obtained from this method of treatment are most striking.

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SURGICAL DISEASES OF THE DIAPHRAGM, AND SUBPHRENIC ABSCESS.

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I. GROSS ANATOMY.

Surgical anatomy will first claim a few words. In forced expiration the right arch is on a level, in front, with the fourth costal cartilage; on the side, with the fifth, sixth, and seventh ribs; and behind, with the eighth. This is 2 cm. higher than the left arch. In a forced inspiration it descends for a distance of from 2½ to 5 cm. A small defect in the muscular tissue exists between the attachment to the xiphoid process and the neighboring cartilage. This area might be used as a place of drainage between the anterior mediastinum and the abdominal cavity.

The relations of the peritoneum to the diaphragm are of the utmost importance, as we shall see under Subphrenic Abscess, and we therefore think it advisable to give here Godlee's review of these relations. (*Brit. Med. Jour.*, 1900, II.) A considerable portion of the diaphragm is not covered by the peritoneum. On the right side it is completely in contact with other structures without the intervention of this membrane, except in front of the anterior layer of the right lateral ligament of the liver and for a small part of the right crus corresponding to the Spigelian lobe, which is covered by the posterior layer of the lesser omentum. The latter touches also a small portion of the left crus, reaching outward to the inner edge of the suprarenal capsule and upward as far as the commencement of the gastro-hepatic omentum. The remainder of the left side is covered by the peritoneum only above and in front of the gastro-splenic omentum and the flexure of the colon—in other words, in front of a line nearly corresponding to the outer border of the kidney. But from the parts usually described as covered by the peritoneum two narrow portions must be excluded: one that runs outward from the middle line and corresponds to the left lateral ligament of the liver (which ligament extends to the lower border of the left lobe near the back); and a second one which runs forward from the same point and corresponds to the upper attachment of the falciform ligament. The structures in actual contact with the under surface of the diaphragm are: near the middle line, behind, the right crus, the head of the pancreas; to the right of this, the vena cava and the right renal vein, separating the right crus from the second portion of the duodenum; and, to the left of it, the cardiac end of the stomach. Each suprarenal capsule touches the diaphragm above the internal arcuate ligament. The remainder of the right side of the

diaphragm is in contact with the liver, while the remainder of the left side of that structure touches part of the left lobe of the liver, a portion of the stomach, the convex posterior surface of the spleen, and the splenic flexure of the colon. Of the kidneys, the portion which is in contact with the diaphragm is the upper part of the posterior surface; of the stomach, it is a part of the left end—an area of peculiar shape.

II. HISTOLOGY.

Lymphatics.—The lymphatics of the diaphragm are of great importance, not so much because the organ is rich in these vessels as because they are the means by which infection is carried from the under to the upper surface, or *vice versa*. Each lateral half of the diaphragm has a distinct system of lymphatics, one of the peculiarities of which is that it possesses only a few vessels of intercommunication. (Küttner, German Cong. of Surg., 1903.) These vessels are in quite direct communication with various viscera above and below the organ, but in particular with the pleura above and with the parietal peritoneum and the liver, through the falciform ligament, below.

Muscatello, in 1895, showed that fluids and solids may pass through the endothelial layer of the peritoneum—fluids in many places, the solid particles only through the spaces of the central tendon of the diaphragm. Experimenting with carmine, etc., Clark (*Jour. Am. Med. Asso.*, Aug. 10th, 1901) found that his results were in entire accord with Muscatello's statements in regard to the rapidity of transportation of granules and the routes which they took. Shortly after the injection of the pigments the central tendon of the diaphragm, which normally has the appearance of ground glass, becomes intensely colored through the deposition of the granules in the diaphragmatic lymph spaces.

The important question as to the manner in which infection is taken up by the lymphatics and transferred from the abdominal cavity to the upper surface of the diaphragm has received a number of conflicting explanations, but has finally been most thoroughly worked out by McCallum (*Johns Hopkins Hospital Bulletin*, Vol. XIV., p. 146, May, 1903), and we shall here make free use of his experiments and delicate plates. As to the mechanism of the entrance of fluids into any of these (lymphatic) channels by direct filtration, under the laws of osmosis and mechanical pressure, it is easily understood. It is not, however, so easy to explain the method by which insoluble granules gain entrance. That they do so with great rapidity has been long known.

There have prevailed two ideas concerning the openings in the peritoneum. According to one view the so-called stomata are openings of considerable size, surrounded more or less regularly by a radial arrangement of cells; according to the other, the stigmata with which the name of Arnold has been frequently associated, are conceived of as much more minute openings, which may occur along the line of union of two adjacent epithelial cells or at the point of union of several. Although the diaphragmatic peritoneum is not the only part of the

peritoneum engaged in absorption, it is generally agreed that it is the most actively absorbing portion. In order to comprehend the mechanism of absorption it is necessary to study especially the minute anatomical relations of the lumina of the lymphatic channels on that side of the diaphragm which faces the so-called cavity of the peritoneum. It will readily be seen that the crucial point is the demonstration of the entrance of the granules into the lumina, for, once they are within the lymphatic channel, their transportation to the pleural side of the diaphragm is an easy matter to understand. Passing through the diaphragm are short lymphatic trunks which connect the network on the pleural surface with that on the peritoneal. On this surface muscle bundles run for the most part parallel with one another and also to some extent radially, being separated by connective tissue in which lie the lymphatic canals. These canals, which also run partly in parallel and to a less extent in radial directions, receive the communicating canals from the pleural surface. They are somewhat beaded or bulged along their course, but it has not yet been determined whether they are or are not provided with valves (as are those of the pleural side, viz., with long filmy valves). They project a little above the muscle into the overlying connective tissue on the peritoneal side. The bundles of this connective-tissue layer are in general parallel with one another, but diverge here and there to leave lozenge-shaped spaces which in man often measure from 2 to 3 mm. in length. The connective-tissue bundles, and therefore also these spaces, run in a direction transversely or obliquely across the radially arranged muscle fibres.

Now the parallel lymphatic canals are most abundantly connected by anastomosing channels which run obliquely or transversely across the intervening muscle bundles and lie generally nearer the peritoneum than the radial trunks themselves. In general, all of these anastomosing channels open into the radial trunks by exceedingly wide and numerous openings, so that there is the freest possible intercommunication. In their arching course they come to lie in the spaces between the connective-tissue fibres of the layer overlying the muscle, that is, in the lozenge-shaped spaces, and here they are separated from the peritoneal cavity by only an extraordinarily thin layer of tissue. (Fig. 183.) These anastomosing sac-like channels are easily seen with the naked eye. They appear as clear areas, generally a little sunken below the surrounding tissue, but when distended they are elevated above the surroundings and appear as tiny vesicles. When granular matter is injected into the peritoneal cavity it is found on examination, after a time, that these blind sacs—lacunæ, we will call them—are injected with this material and from them we can trace it into anastomosing trunks of the pleural network, into the efferent trunks, and then very readily into the mediastinal lymph nodes (and thence to the subclavian vein). Where actual entrance of the pigment into the lacunæ has not yet occurred, it is found deposited almost exclusively upon their roofs. It is also found that when the lacunæ lie between the connective-tissue bundles and are thus situated obliquely or transversely over the muscles, they are themselves traversed by finer fibrils which cross them obliquely and which consist no doubt merely of diverging superficial fibres of the main layer. When, therefore, the lacunæ

are examined in their distended condition one sees these fibrils cross its bulging surface like ropes across a full sail. Elastic fibres, too, often stretch across the roofs of the lacunæ. The endothelial lining of these ultimate lymphatics is shown to be an *exquisitely complete one;* over the whole surface of the distended lacunæ the endothelial cells are adjusted to one another with the utmost delicacy and accuracy, there being *no signs of a preformed opening.*

Thus is fashioned one part of the roof of a lacuna. Another important one is the layer of peritoneal epithelial cells which present the following characteristics:—The cell body is relatively small, contains the nucleus surrounded by granular protoplasm, is quite widely separated from the adjacent cells, and is connected with them only by protoplasmic processes or bridges. Over these gaps, however, the perfectly hyaline, thin, flat superficial layer of the cells extends like the widely projecting eaves of a house, to meet (or almost meet) a similar

Fig. 183.—Diaphragm of a Dog in which the Lymphatics have been Injected with Silver Nitrate. The lacunæ are intended to appear as arching anastomoses between the radial trunks which lie at a lower level and to communicate with them freely by wide openings. (W. G. MacCallum, in the *Johns Hopkins Hospital Bulletin*, May, 1903.)

projecting layer from the next cell. Both Kollossow and Muscatello find that the *lining is a perfect one.* The significance of the partial separation of the cells, which results from a contraction of their protoplasm, will be explained farther on.

What then is the nature of the tissue which lies between the peritoneal epithelium and the endothelium of the lymphatic? A homogeneous basement membrane lies directly beneath the epithelium. It is imperforate everywhere except in those areas in which it forms a part of the roof of the lymphatic, and there it is pierced with numerous fenestrations. There can be made out in the roofs of the lacunæ between the epithelium and the endothelium, a lattice work of fibres which has a general resemblance to a fenestrated membrane. Close examination shows, however, that it really consists of anastomosing bundles of fibrils which form more or less rounded meshes. (Fig. 184.) Fine elastic fibrils and

scattered connective-tissue cells make up the remainder of the tissue which separates the peritoneal epithelium from the lymphatic endothelium, a tissue which is thus seen to be far from compact and which on section shows abundant wide crevices and spaces, the significance of which will appear later. If we inject the lymphatics with a colored solution under pressure the fluid which comes through is colored too, but if we use a suspension such as carmine, the fluid which filters through is clear, the suspended particles being left behind. This experiment, therefore, shows the completeness of the membrane.

FIG. 184.—Endothelium of a Lymphatic Lacuna Showing the Process of Separation of Small Portions of the Cell Body from the Elongated Process. (W. G. MacCallum in the *Johns Hopkins Hospital Bulletin*, May, 1903.)

It appears, then, that the peritoneal cavity is lined by a complete layer of epithelial cells which lie on a basement membrane that is uniformly thin except where it overlies the lymphatic lacunæ, at which points it is represented by a lattice work of fibrils that separates the peritoneal epithelium from the surface of the lymphatic. Approaching the peritoneum at these points are the sacs or lacunæ which are the absorbing terminals of the diaphragmatic lymphatics, and which, while possessed of a complete lining of endothelium, are separated from the peritoneal cavity only by the loosely woven connective tissue and the peritoneal epithelium.

We have to deal, therefore, with at least three elements which can afford a certain obstruction to the progress of the material absorbed from the peritoneal cavity, viz., the epithelial layer, the basement membrane, and the endothelial layer. After the injection of a large quantity of India ink into the peritoneum the fluid in that cavity is soon found to be practically a thick suspension of amœboid leucocytes, a great many of which are found to be laden with pigment granules. The lacunæ in the diaphragm are found to contain a great quantity of pigment, a large part of which is contained in leucocytes. Leucocytes generally laden with pigment swarm about over the surface of the lacunæ, and leucocytes thus laden can actually be seen in large numbers *making their way with their load of pigment through the roofs of the lacunæ*. (Fig. 185.) Often one can see four or five going through different points in the roof of one lacuna. The epithelial cells, and especially those which lie over the lacunæ, are frequently phagocytic and become loaded with pigment. Similarly, the connective-tissue cells underlying them may often show a pigment content. Finally, the endothelial cells in the lymphatic become swollen and loaded with pigment. Hence, it may with reason be concluded that phagocytosis at least plays a very important part in the act of transportation.

Respiratory movement has been emphasized as an aid to absorption; the lymphatic channels being alternately distended and compressed, and an actual pumping action being carried on. In order to determine, by actual experimentation, whether or not this aid is necessary to absorption in the living dog,

an elimination of the respiratory movement was brought about. It was found, after each such experiment, that there was always a fairly abundant injection of the lacunæ. The vital activity of the cells (phagocytosis) is, therefore, capable of inducing by itself an injection of the lymphatics. That this is not the only factor, however, is shown by the presence of free pigment granules in the lacunæ; and, in order to determine how these granules effected an entrance into the lacunæ, it was decided to eliminate one by one the possible adjuvant factors. In the first place, the agency of the leucocytes was eliminated, while the respiratory movements were maintained. The elimination of the active phagocytosis of the epithelial and endothelial cells was effected by partially paralyzing the cells with chemicals. Despite this paralyzing effect the cells still retained

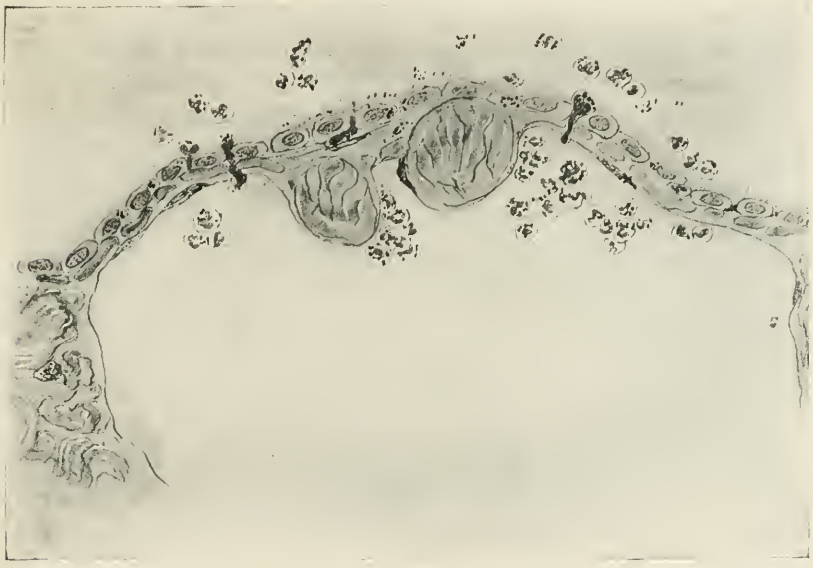

Fig. 185.—Roof of a Lacuna in Section, Showing the Entry of Pigment by the Aid of Phagocytic Leucocytes. Epithelial and endothelial cells are also phagocytic. (W. G. MacCallum, in the *Johns Hopkins Hospital Bulletin*, May, 1903.)

a certain amount of absorptive power, as evidenced by the fact that it was still found possible to obtain an injection of the lacunæ. Absorption, therefore, is not exclusively dependent on phagocytosis. The fields illustrating this show the following conditions: the epithelial cells are slightly contracted and rounded off, thus causing them to become separated a little from one another, and the pigment granules are arranged (see Fig. 186) along the margins of the cells and appear to be pressing through in every part of the intercellular space. Evidently these epithelial cells offer a very slight obstruction indeed to the entrance of pigment. Through the lattice work of fibres, between the epithelial and endothelial layers, the granules may be traced down to the endothelium (Fig. 187). Here they may run along the surface of the endothelium and cause it to bulge inward into the lymphatics; their final escape taking place through the inter-

cellular spaces. We are warranted in ascribing their progress through the three layers to the pumping action of the respiratory movements.

No support whatever, as it appears to us, can be found for the statement that there exists an open communication between the peritoneum and the lymphatics, nor is it permissible to uphold the idea that the peritoneal cavity forms a part of the lymphatic system. The mechanical aspiration of granules through the lax cell membrane by the respiratory movements is possible, but it plays a part distinctly secondary to phagocytosis as a means of absorption.

The diaphragm is something more than a mere organ of respiration: indeed, Forbes (*Amer. Jour. Med. Sc.*, July, 1880) goes so far as to consider it more as an appendage to the circulatory system. That portion of the diaphragm which is attached to the base of the pericardium is prevented from descending

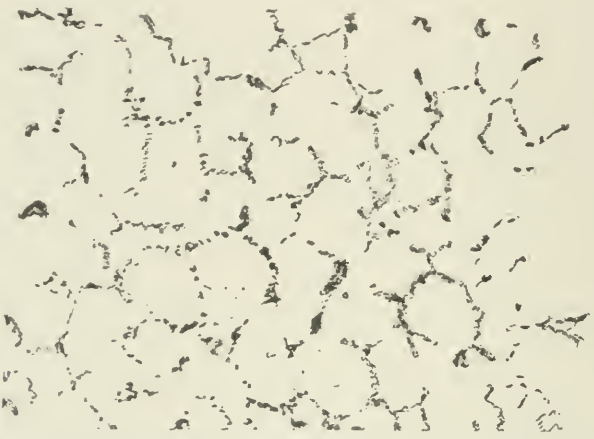

FIG. 186.—Surface of Peritoneal Epithelium, Showing Mode of Distribution of Pigment injected into the peritoneal cavity. (W. G. MacCallum, in the *Johns Hopkins Hospital Bulletin*, May, 1903.)

in inspirations by the *superior tendinous crura* of the diaphragm, which are formed by the lateral parts of the fibrous pericardium ascending on both sides to be attached to the apex of the bony thoracic cone, and through the deep cervical fascia to the processes of the cervical vertebræ and to each stylo-maxillary ligament. These superior crura of the diaphragm are connected by transverse and oblique fibrous bands, thus forming a fibrous scaffolding for the support and protection of the heart and its great vessels. This fibrous scaffolding is made tense and open for the lodgment and for the protection of the heart and the large cardiac vessels and for the promotion of the circulation of the blood through them by the contraction of the muscular diaphragm independently of the descent of the muscular wings. The opening for the vena cava, the highest point in the central tendon, has a fixed position. The edges of this opening being inextensible and continuous with the external coat of the vessel, the vein remains patulous throughout the respiratory act, and the blood is therefore sucked up through the cava into the thorax whenever the diaphragm contracts. It is the contraction of the diaphragm, and not its descent, that is necessary for effecting this result. Forbes further considers that it is by the traction of the

diaphragm through this fibrous structure that the closure of the ductus arteriosus of the newly born infant is effected.

This influence of the diaphragm upon the circulation is shown by the fact that the first effect of an injury inflicted upon this organ is experienced by the heart; and, in support of this, are adduced the cases of Deruginsky, Reeve, and others, to be presented farther on.

If one side of the diaphragm is lacerated or paralyzed, the heart is pushed

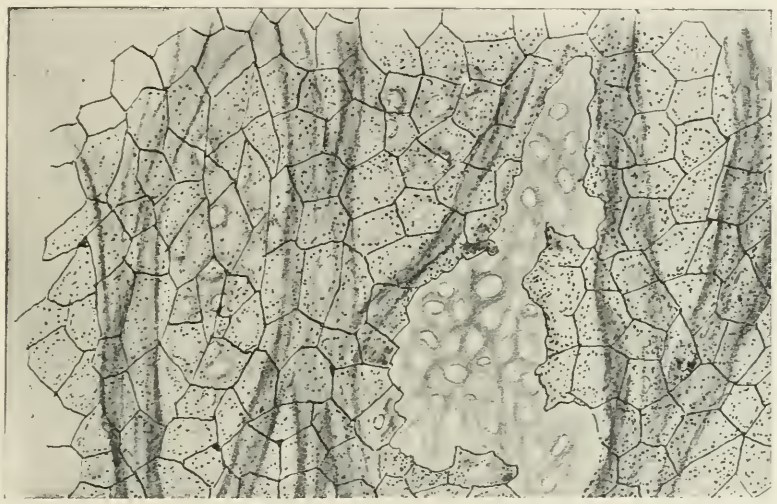

FIG. 187.—Superficial Layer of Diaphragm Stained with Silver Nitrate, etc., Showing the Lattice Work of Fibres Overlying the Lacunæ. (W. G. MacCallum, in the *Johns Hopkins Hospital Bulletin*, May, 1903.)

over to the opposite side by the atmospheric pressure, the lateral fibrous scaffolding being no longer supported on the affected side. In bilateral paralysis, the heart is pushed backward.

III. NEW-GROWTHS OF THE DIAPHRAGM.

Almost no mention of tumors of the diaphragm is made in literature. Two cases of secondary sarcoma of this organ will be mentioned below. It is not believed that sarcoma of the diaphragm is ever primary. Instances of lipoma of the organ are known, and this is not surprising since some fat naturally exists in the diaphragm. Enchondroma can easily encroach on it, as tumors of this nature are of frequent occurrence on the costal arch. Cysts have been discovered on the diaphragm and their rupture may cause perforation of this organ.

IV. FAULTS OF DEVELOPMENT.

The development of the diaphragm takes place centrifugally—that is, from the central leaflet (floor of the pericardium) outward. This explains why congenital defects, which are presumably from incomplete development, are so

much less frequent in the central portion, the writer having found but one case where an opening into the pericardium existed. The almost complete restriction of defects to the left side leads to the assumption that the left side develops later than the right; indeed, this deduction is the only explanation we have for this phenomenon and that of eventration.

The actual openings are more often in the muscular than in the tendinous portion; they are frequently found in the fleshy portion between the left and middle leaflets. They are circular in shape and, as regards their size, they may be so large that they occupy the greater part of the diaphragm. Owing to the fact that the two serous membranes (pleural and peritoneal) are continuous at the opening, the margin of the latter is everywhere smooth. It is stated that all congenital hernias are false, that is, they are not provided with a sac or a serous covering; this condition being due to the fact that the congenital opening is not covered with peritoneum, the latter membrane joining the pleural around the edge of the opening. An apparent exception is shown in Frey's case, shortly to follow. Subjects of these congenital hernias are otherwise well-formed babies, but they generally do not survive more than a few hours or days, although there are instances on record where they have reached adult age.

Frey gives, in the *Montreal Medical Journal*, August, 1895, a very thorough account and dissection of an adult case of congenital hernia, which shows other congenital changes in the diaphragm and a very movable kidney.

"Age 57. Family history negative. Was able to work all day long until a fortnight previous to his admission, when he first noticed swelling of feet and a paroxysmal shortness of breath. During the next week he continued his heavy work, as cook in a camp. By the end of this time, his dyspnœa prevented him from sleeping, nor could he lie down for more than a few minutes at a time. His appetite completely failed him. He then worked at odd jobs, never giving up until his admission to the hospital. For five days before, the orthopnœa had been constant. As a boy he was always healthy and strong; as a cook he was able to work hard. Since youth he had taken alcohol in great quantities, and the only time he had noticed dyspnœa on exertion, was five years ago. He was an extremely stout man of large frame and broad chest, and large flabby muscles. On admission, the general cyanosis was very marked, and, during the paroxysm of dyspnœa, the face and neck became of a deep purple hue, and the superficial veins engorged and prominent. The heart impulse could neither be seen nor palpated. The sounds were very faint, distant, and exceedingly irregular. The heart was beating 110 to the minute, but only 70 beats to the minute reached the radial artery, very irregular and compressible. On the left base of the chest behind, although dulness on percussion was more marked than on the right side, no adventitious sounds were heard. This condition was not accounted for during life. The liver dulness was masked by intestinal tympany. The patient died, very cyanotic, with the most extreme paroxysm of dypsnœa, death extending over several hours. On autopsy, a large mass of omental tissue, a portion of the stomach, and a part of the kidney were projected into the thoracic cavity. The diaphragm was removed in its entirety, with all the organs in connection with the hernia. Previous to its removal, the fact that the right kidney was so high, led

to an examination of the extent of motility of the organ, and it was found that the kidney could be easily moved as far upward as the fourth rib, while there was equally full movement downward. On spreading out the diaphragm it was found to be of relatively great size in circumference, and very muscular, save in the hinder portion of the left side. The left leaflet was not more than one-fourth the size of the middle tendinous portion. This made the muscle about the left border of the diaphragm appear unusually extensive. [Or does it not mean that the opening to be described intruded on the tendinous, rather than on the muscular portion?—J. C. R.] The right crus was readily made out and was stout and prominent, while the left was with difficulty isolated, and was comparatively small and thin. Almost immediately behind, and to the left of this tendinous portion, separated from the edge of the latter by a muscular band 5 mm. in width, and more prominent, thick, and bulky than the neighboring muscular tissue, lay the defective portion. This may be considered as being composed of two portions: viz., a full opening, or more truly openings, extending from the thoracic into the abdominal cavity, and a large area of thinning of the diaphragmatic tissue. This thinning was represented purely as a layer of fused serous coats of the two cavities, with no intervening muscle (or tissue). This thinned tissue formed independent coverings over the portion of the stomach protruding as a hernia, into the thoracic cavity, and over the left kidney, the protrusion not being through the free openings. The entire defective area measured 79 x 79 mm."

In another case (*Le Bulletin Médical*, Dec. 19th, 1904), that of an infant, which died on the second day, the convex surface of the liver showed a furrow produced by the cutting edge of the diaphragmatic opening. The heart was pushed back and to the right, the base being at the right nipple and the upper boundary at the right border of the sternum. The opening in the diaphragm was large and occupied the left half. The stomach was in a vertical position and occupied the left half of the thorax, and a part of the liver, the transverse colon, and the small intestine had also escaped from the abdomen.

In some of the cases reported the spleen and the greater part of the small intestine were found in the thoracic cavity.

An important, though rare, congenital defect, for it is considered to be congenital, is the *Eventration of the diaphragm.* (Sailer and Rhein, *Amer. Journal Medical Sc.*, 1905; N. S., CXXIX., 688, 705.) This expression signifies an abnormally high position of the diaphragm in the trunk, this position being due to the relaxation of the organ which results from a deficiency of muscular fibre. It has been called by some, although incorrectly, pseudohypertrophic lipomatosis of the muscle. The symptoms are usually slight or they are entirely lacking, and the condition does not interfere with the duration of life. All reported cases are pathologically much alike. The condition is always found on the left side, the diaphragm on this side reaching to the third rib; but the right half of the organ may also in these cases reach a somewhat higher level. Eventration of the diaphragm has very seldom been diagnosed; it is usually mistaken for hernia, and also sometimes for hypoplasia of the lung, for dextrocardia, for primary defects of the diaphragm, and for acquired lesions such as phrenic paralysis. In all cases there are: normal resonance on percussion in the upper

part of the left lung; tympany below a certain line, which varies from the fourth to the second rib; tympany posteriorly, usually from the angle of the scapula down; the ordinary signs of dextrocardia; the signs which appear to indicate the presence of viscera abnormally present in the lower part of the left thorax; sounds of gurgling and splashing, especially when liquids have been swallowed; an area of dulness in the lower part of the thorax after the patient has taken a considerable amount of food; and sometimes distinct hippocratic succussion sounds. Frequently there is, on the posterior aspect of the thorax, an area of dulness due to dislocation of the spleen. Litten's phenomenon is usually absent. As a puncture for diagnostic purposes and even an operation have been undertaken under these circumstances,—and, of course, with danger,—it is well to exclude all other causes of tympany in the lower part of the chest before one resorts to either of these measures.

A condition similar to that which has just been described, but acquired and not congenital, is Lahn's *degeneration of the diaphragm* (*Lancet*, Aug. 17th, 1878), in which the muscular tissue becomes thinner and paler than normal.

Phrenoptosis, which is an acquired condition, is the reverse of eventration. It is a downward displacement of the diaphragm. Glenard (*Revue des Maladies de la Nutrition*, 1905) considers it as merely an accessory episode of the general tendency to ptosis.

Other diseases of the diaphragm which may possibly assume some importance from a surgical viewpoint, are rheumatism, spasm (clonic and tonic), paralysis, and purulent diaphragmatic pleurisy. There are certain signs of the latter which are worth noting. Besides the local pain, the phrenic nerve becomes the seat of hyperæsthesia at its superficial expansion in the epigastrium, especially over a small area located a few inches below the xiphoid cartilage. At the same time an exaggerated sensibility is manifest in the course of the nerve in the neck. Another sign is depression of the last rib.

After empyema, and especially after Schede's and similar operations, the diaphragm, under the influence of abdominal pressure, encroaches more than it normally should upon the pleural space. Thus, the lower part of this space is obliterated to a much greater degree and earlier than the upper.

V. WOUNDS AND HERNIÆ OF THE DIAPHRAGM.

Wounds.—Wounds of the diaphragm are hardly possible, without an accompanying wound of the thoracic or abdominal cavities, and indeed the wounding of all three is usual. The wedge-shaped space between the diaphragm and the ribs is called the costo-diaphragmatic sinus, and to the very bottom of this the lungs do not reach. A penetrating wound in this region will divide the diaphragm and open both pleural and abdominal cavities, without wounding the lung. Such a case is found in the "Surgical History of the War of the Rebellion." In this case (that of Robert Stolpe) a musket ball entered the side of the chest and penetrated thence into the alimentary canal, from which

it was later passed. A mass of lung tissue, the size of a small orange, projected from the body, and could not be replaced. It sloughed off, and the surface of the wound became covered with epithelium. After this there was but slight evidence of (abdominal) hernia, the protruding mass of lung acting, no doubt, as a block to protrusion of any of the abdominal viscera. Many months later, the small remaining tumor suddenly increased in size, after a strain in lifting, the respiratory sounds in it became feeble, pressure on it produced gurgling and nausea, nausea manifested itself after eating, and there was local pain. A portion of the stomach had evidently escaped into the tumor, which varied in size and contained both lung and stomach. In a similar case, in which bile in addition escaped into the tumor, there was so little prostration that the subject was able, soon after he had been injured and without any protective dressings over the wound, to walk a mile and a half. He eventually recovered and voluntarily re-entered the campaign.

Wounding of the neighboring viscera is an almost invariable occurrence when the diaphragm suffers, and the liver, spleen, and lungs are frequently involved, especially the first two.

Rupture or tear of the diaphragm from a blow, a crush, or a strain is common. For the production of such a tear or rupture it is not necessary that the patient should strain very hard or that he should receive a severe blow; and consequently we are compelled to assume that in some of these cases there must have been a congenital weak spot. The blow need not be of such a character as to cause a penetration of the parietes or even of the skin, nor is it necessary that any of the other viscera should be wounded. These indirect tears are more common in middle-aged men, and there is on record a case in which the patient suffered two successive tears of the diaphragm with hernia. A crush may be so severe as to precipitate most of the abdominal viscera into the thorax; the result, of course, being the death of the patient.

Wounds of the diaphragm, in connection with the wounding of other organs, may be very severe, and still recovery may take place. Such a case, of an unusual character, suggestive as to treatment, and well worth recording, is narrated by Abbe in the Transactions of the New York Surgical Society, Dec. 14th, 1898.

A man, while riding a bicycle, impaled himself on the shaft of a wagon. The shaft first penetrated the right arm, separating the biceps and vessels from the humerus; thence it crushed into the chest, breaking the tenth rib at the mid-axillary line, and tore through the diaphragm and liver, detaching the latter somewhat from its posterior support. The shaft next swept in a backward direction, making a ragged, flat laceration through the liver, in which could be laid the flat of the hand, caught the kidney against the spine, and cut its upper third almost completely off. It was several hours before shock passed off, and then the urine was intensely bloody. The tenth rib was resected in order to give plenty of room in reaching the pleura, from which was sponged a quart of clotted blood, mixed with bile and urine. The lacerated wound in the diaphragm was now enlarged to admit the hand. As blood flowed freely from the liver, a temporary

packing was placed in the wound of this organ while an incision was made below the ribs to reach the kidney. This organ was palpated with both hands, one hand being introduced into each incision. The patient's condition did not permit of resection of the kidney. Extravasated blood was wiped from the peritoneal cavity, but no intestinal contents were found. Iodoform gauze was now introduced through the upper opening and firmly packed in the wound, beginning at the kidney and continuing up through the liver and between the liver and the chest wall. The gauze was then brought up through the diaphragm and the chest wall. A lighter tamponade was placed in the pleura below the retracted lung and the lower wound was partially sutured. The patient barely rallied and it was a month before he was out of danger; and during this time urine and much of the bile were discharged through the wound. High fever. The bile first ceased, but the urine continued to flow through the now narrow sinus for a period of two and a half months.

Wounds of the diaphragm may occur in operations undertaken for other purposes. Thus, for example, Deruginsky (*Annals of Surgery*, May, 1906) removed a portion of the diaphragm in the course of an operation for the eradication of a sarcoma of the chest wall. In a previous operation which he had performed for the same purpose, the incisions required did not involve the diaphragm, but they did penetrate the thorax. In spite of the resulting pneumothorax, the patient breathed quietly and her pulse was unaffected; and after the operation there was no dyspnœa. We mention this absence of embarrassment, as regards the respiration and pulse, because of its bearing on the hindrance which a pneumothorax is supposed to offer to operative procedures upon the diaphragm, a subject which will be dwelt upon later. A large gauze tampon was placed in the pleural cavity, and, when this tampon was removed on the fifth day, it was observed that no air entered. At the later operation (that for the removal of the sarcoma which had returned after the first operation) the chest wall, from the seventh to the twelfth rib, was removed, together with a portion of the diaphragm. On this occasion when the pleural cavity was opened, the lung immediately collapsed, and at the bottom of the cavity the heart could be seen undergoing rhythmical contractions. Again, the thoracic cavity was filled with a gauze tampon; and at this moment threatening heart failure developed, although the respiration continued to be regular. Saline infusion and other restorative measures were employed. Before resection of the diaphragm was undertaken, this structure was carefully dissected from the peritoneum; and while this was being done there occurred some retching, which caused the peritoneum to protrude into the pleural cavity like a bladder, while above it the heart could be seen suspended, temporarily deprived of its lower attachments. The projecting peritoneum was pushed back and held by the hand of an assistant. To the surface of the cut muscular tissue, from which the sarcomatous nodules had been removed, the cautery was now applied, and then the cut edge of the diaphragm was sutured to the seventh rib, whereby the thoracic cavity was separated from the abdominal. A tampon was introduced into the inferior angle of the wound, and the external wound was su-

tured. Marked shock followed, but the patient breathed freely and the respiration was of a quiet character. On the seventh day following the operation there was some dyspnœa, which was not relieved by removal of the tampon. An exploratory puncture made on the eleventh day revealed neither air nor fluid in the pleural cavity, but a stitch abscess was opened, and the opening of this abscess seemed to relieve the moderate fever and the dyspnœa which were present. The lung expanded. Eleven weeks later when the autopsy was made, it was ascertained that the diaphragmatic curtain had been entirely restored, the edge of the organ having become adherent to the lower border of the seventh rib along the line where the sutures had been applied. About two-thirds of the entire diaphragm (?) had been taken away. The lung was adherent to the parietal pleura, by sarcomatous rather than by inflammatory tissue.

In several respects, the author's case * is very similar to the one reported above, although the amount of diaphragm removed was not nearly so large. The enchondroma sarcomatosum (?) of the chest wall measured thirty-three inches in its circumference, necessitating the removal of a piece of the chest wall equal in area to two outspread hands. Fully a third of the growth was inside the chest and attached to the diaphragm. As a result of the operation the whole pleural cavity was exposed to view, including the pulsating pericardial sac and the completely retracted lung. No attempt was made to preserve the peritoneum. The remains of the diaphragm and some fascia were brought together to make a partition between the abdominal and thoracic cavities, the skin flaps previously made were sutured, and all spaces, including the pleural cavity, were drained by, but not packed with, gauze. There had been little disturbance of respiration during the operation, and the only reactions observed afterward were occasional attacks of dyspnœa with rapid pulse and, on the third day, a single rise of temperature (to 103° F.) that lasted for an hour. Some of these disturbances were caused, or accompanied by, moderate abdominal tympany. Recently, the writer, while removing a large kidney, was obliged to divide the two lower ribs, and he forewarned the anæsthetist carefully to watch the patient when the pleura was opened. Close observation, however, failed to discover any change in the respiration or the pulse, although slight symptoms of shock gradually came on, as in the three other cases.

Wounding of the diaphragm has, in the past, been considered very dangerous, because of the imagined interference with the bellows action of the thorax. This and a similar fear of pneumothorax are responsible for devices looking to the maintenance of respiration while the chest is open. One of these is the Fell-O'Dwyer method of artificial respiration, a procedure which dates back to an early period and which has not been as widely adopted as it deserves to be.† In this method, air under pressure is intermittently supplied by a bellows that is worked by the foot, and this air is conducted to the trachea (by way of the

* Annals of Surgery, May, 1903.

† Journal of the American Medical Association, June 9th, 1900; Buck's "Reference Handbook of the Medical Sciences."

larynx) by a tube like that used for intubation purposes. A similar process is that described by Brauer in the *Deutsche med. Wochenschrift,* Sept. 21st, 1905, and April 5th, 1906. Another plan is to employ the Sauerbruch pneumatic cabinet * which was devised in the Breslau Clinic under Mikulicz's direction. In this cabinet are confined the operator's and the patient's bodies; the latter's head projecting through an air-tight orifice and collar. A negative pressure of from 12 to 16 mm. of mercury is maintained within the chamber. In it Sauerbruch has performed extensive operations (involving both pleuræ) on the chests of dogs, with no ill results to lungs or respiration. He has devised an œsophagotomy of the lower end of the organ by means of a thoracotomy and division of the diaphragm. Of the two inventions, the cabinet is probably the more practical, but the Fell-O'Dwyer has the advantage of being more easily obtained and transported. (See also page 418 et seq. in the present volume.)

Green, in *Surgery, Gynæcology, and Obstetrics* (Chicago, May, 1906), has gone into these methods thoroughly, but his experiments and the gathered examples seem to him to argue quite as much against the use of positive pressure as they do in favor of its use. If this be true—and, in the light of the above operations and many similar ones which might be adduced, the truth seems to be established—we may conclude that these methods of respiration are unnecessary where but one pleura is opened, and that possibly a positive pressure is actually prejudicial. In those cases in which both pleuræ are opened the employment of such artificial aids is positively necessary. These remarks apply to adults. Children are much more disturbed by an open pleural cavity because the tissues of the mediastinum are less stable and make a poor barrier between the two sides.

The preceding statements seem, therefore, to dispose of one bugbear of the surgery of the chest—a bugbear that at one time appeared to be of a very serious character. As a matter of course, the careful surgeon will limit as much as possible the ingress and egress of air through the opening in the chest wall, and this can be quite effectually accomplished by the insertion of a firm gauze tampon in the orifice of the opening when the manipulations no longer require it to be kept open. The entire filling of the pleural cavity, as was done by Deruginsky, seems unnecessary, if not positively harmful; indeed, it appeared in that case to be the cause of the embarrassment of the heart. Seidel places, over penetrating wounds of the chest, an air-tight case provided with a window through which inspection may be made and which is constantly connected with a partial vacuum. The object of this contrivance is to facilitate drainage and expand the lung.

The surgeon will not hesitate to enlarge wounds of the diaphragm when hemorrhage, incarceration, or adhesion invites. For closing defects the only remedial measure for which we possess a precedent is that of drawing together whatever remnants of tissue can be made available; and experience justifies the statement that very uncertain substitutes seem to suffice as a partition

* Mittheilungen a. d. Grenzgebieten d. Med. u. Chir., 1904, xiii.; W. Meyer, in Annals of Surgery, May, 1905; Boston Med. and Surg. Jour., April 13th, 1905.

between the thoracic and the abdominal cavities. A stronger partition, if it could be obtained, would, of course, be better, especially on the left side, where there is not the firm support of the liver; but there seems to be little material from which to shift flaps. The only supply that seems to suggest itself is the inner surface of the abdominal parietes, and this would hardly be utilized, unless there were already an extensive opening. Deruginsky's practice of preserving the peritoneum seems to be neither advisable nor necessary, except when infection is present. To leave that membrane intact, in a case of malignant disease of the diaphragm, would, in these days of indifference to the open abdomen, be simply to invite a recurrence of the disease.

In such severe injuries as those which occurred in Abbe's case, there is, of course, little opportunity to do more than apply promptly and thoroughly a tamponade, while holding one's self ready to attack the complications as they successively arise.

In the case of nephrectomy mentioned above, in which the diaphragm was detached from the ribs, the writer re-attached it by wrapping it around the lower edge of the rib, thus reaching better tissue in which to place the sutures and making a cover for the exposed and roughened ends of the ribs.

The best route by which wounds of the diaphragm may be approached will be discussed under the heading of Treatment in the next section of this article.

Diaphragmatic Hernia.—Cases of congenital diaphragmatic hernia in the newborn have been discussed under defects of the diaphragm. Acquired hernia may take place through congenital openings or thinnings, through some of the natural openings such as the stretched aortic or œsophageal opening, or, finally, through tears; and when a trauma is the causative agent the hernia may be produced immediately or only at some later period. The large majority of the tears—over five-sixths of them—are on the left side. The reason given for this is that the mass of liver substance protects the diaphragm and to a certain extent unites it to the right side; but it is probable that the real reason for the difference is to be found in the fact, already stated above, that defects of development which cause a thinning of the diaphragm are found more commonly on the left side. The ruptures which take place in the muscular portion are only moderately in excess of those which occur in the tendinous portion. Congenital hernias number over a third of all diaphragmatic hernias, those from direct injury a third, and those from indirect injury a quarter.

Ninety per cent of acquired hernias are false, that is, devoid of sac, the serous coverings having been absent (at birth) or ruptured at the time of protrusion, thus leaving the escaped organs naked in the thoracic cavity. The order of frequency with which the several abdominal organs escape through the rupture may be stated as follows:—stomach, omentum, and colon. Besides these a large part of the small bowel, the spleen, the liver, the cæcum, and the kidney have been found.

With the increase of our knowledge of diaphragmatic hernia, it has been ascertained that this affection is not so rare as was once supposed. Of the cases collected before 1874, but two-tenths of one per cent had been diagnosed

before death. In the case of an open wound with protruding abdominal viscera, there seems to be no excuse for overlooking a diaphragmatic hernia. On the other hand, if only a bit of omentum has escaped into the pleural cavity, the only symptoms present may be those of indigestion, malaise, etc.—that is, the symptoms of an adhesion. Still more obscure are the symptoms in such a case as the following: A young man was taken with sudden pain in the umbilicus; the pain remained entirely abdominal and no rise of temperature nor other symptoms occurred for three days. Then the symptoms assumed such a grave character that surgical interference became necessary, and thus the existence of a diaphragmatic hernia was discovered. If the opening in the diaphragm is very large, so large that the abdominal viscera lie in both cavities and without constriction, there may be more or less pain, inability to lie on the side, and shortness of breath, but there may be little else in the way of symptoms. There is also likely to be some evidence of pneumothorax, and intestinal gurgling will be heard within the thoracic cavity.

If a portion of the intestinal tract is suddenly forced through a relatively small opening in the diaphragm, the symptoms will be those of obstruction; but if the volume of displaced organs is large, the embarrassment to respiration and circulation, due to the crowded condition of the thoracic cavity, will overshadow the symptoms of obstruction and may, indeed, be the cause of an early fatal ending. Such an ending has taken place as early as from the eleventh to the fifteenth hour after the accident. The writer has seen complete collapse occur some time after the performance of an abdominal section,—from which the patient subsequently recovered,—and yet, when the abdomen was re-opened, nothing could be found to explain the condition except a very moderate intestinal distention. If distention of abdominal viscera can cause such disturbance, when they are still within the abdomen, it is fair to assume that an encroachment of much smaller bulk in the thorax may suffice to cause dangerous symptoms.

Again, acute dilatation of the stomach, which occurs at times after the disturbance caused by some slight operation, may be assumed to crowd the thorax, even when only a part of the organ stands at a higher level than the diaphragm. If an early fatal issue does not occur in those cases in which a part of the abdominal viscera passes through the opening into the pleural cavity, then in the course of time the symptoms of incarceration, obstruction, or strangulation dominate the scene. These several conditions will be observed in the cases of hernia to be mentioned in detail farther on. Pain is usually present, though it may be absent. Distention of the abdomen is the rule. When, as a rare event, retraction does occur, it is due probably to constriction, located high up in the alimentary canal. This not only obviates much of an accumulation above the constricted point, but the vomiting which it induces keeps the canal emptied.

The *physical signs*, when a hollow viscus is the part incarcerated in the hernia, have a resemblance to those of pneumothorax in that they comprise a tympanitic note over the hernia, amphoric tinkling, and sometimes succussion sounds. Excessive thirst is the rule, and hiccough is fairly often present. Litten *

* Deutsche med. Wochenschrift, No. 5, 1895; also Vol. I., p. 529, of the present work.

describes a "diaphragmatic phenomenon" for this lesion as he does for subphrenic abscess and other thoracic disorders. It consists of a visible horizontal depression crossing the lower side of the chest and moving up and down with respiration—a sign which is of special value in unilateral conditions. In ruptures of the diaphragm with hernia this phenomenon can be seen below the tympanitic area and may be of importance when the tympany of the abdomen is slight.

When the Roentgen rays are used, the canal is rendered visible by the introduction of bismuth, mercury, or a stomach tube. If, by the aid of these, it is visible above the convex diaphragmatic line, its presence in this situation furnishes adequate proof of the existence of a diaphragmatic hernia. On the other hand, a negative finding would not exclude a hernial protrusion, for a constriction would be competent to prevent the passage of these objects along the canal.

In very obscure cases a manœuvre of Maragliano's* may be tried, but it must be resorted to early, before a weakening of the bowel wall would render bursting likely, and, of course, no force should be employed. The patient in Maragliano's case was suffering from influenza at the time, and the hernia developed suddenly during a fit of coughing. After ordinary measures of diagnosis had been considered, the intestines were inflated by a pump introduced *per rectum;* and it was found, after the inflation, that the abdomen was not increased perceptibly in girth nor the diaphragm displaced upward. It was discovered, however, that the thorax had increased one centimetre in girth. It was also noticed that, simultaneously with each insufflation, a sound was audible in the fifth interspace. The procedure, as described up to this point, and if carried out with care, is a commendable one; but as much cannot be said of what follows, and it is described only to be condemned. Maragliano introduced a hollow needle into the left thorax (and presumably into the intestinal canal there lodged) and injected a certain amount of liquid. Bubbling could be heard as the residual air in the pump entered the intestine. The intestine was distended with fluid when a dulness appeared in the thorax over an area where there had previously been resonance. The final step, which I have just described, might be permissible under some circumstances.

In a case in which there was much constriction at the borders of the opening, one would hardly be justified in excluding a protrusion of a hollow viscus into the pleural cavity if a negative result were obtained from the first stage of Maragliano's procedure, or from the later injection of fluid, or from an examination with the *x*-ray.

Other points connected with the diagnosis have already been discussed under Wounds of the Diaphragm.

Diaphragmatic hernia is occasionally discovered *post mortem* in patients who have died from other causes, and in whom there had been little reason to suspect such a condition during life. This corresponds with the frequent observation that a patient seemingly recovers from a traumatic hernia, or from

* Gaz. degli Osped. e delle Clin., Feb. 15th, 1897.

the accident which caused the latter, and yet at some later date experiences a dangerous attack. The following brief histories relate to cases of this nature:—

A fall of thirty feet fractured the femur and bruised the chest, but did not fracture any ribs. Collapse and vomiting. Some shifting dulness in the flanks. Patient made progress under medical treatment and in two months was discharged. Afterward he had attacks of pain in the epigastrium, increased by taking light food, but there was no vomiting. Two months later he was seized with severe pain and vomiting and died in two days. Stomach and colon had escaped through an opening in the diaphragm the size of the index finger. (*Brit. Med. Jour.*, Dec. 22d, 1900.)

A man was squeezed between cars; no ribs were broken; he recovered. Sixteen weeks later, he died with failing heart and dyspnœa. Autopsy: large and small intestine in the pleural cavity, adherent to each other and to the lungs. (*London Lancet*, June 30th, 1880.)

A stab wound in the seventh intercostal space. Patient well in two weeks. Two and a half years later, obstruction of the bowels; cœliotomy. Autopsy: part of the omentum and seven inches of the colon found in the left pleural cavity; weakening of old cicatrix in the diaphragm. (Trans. St. Louis Med. Soc., Jan. 31st, 1891.)

Sudden symptoms of internal strangulation of the bowels in a well man; in addition, dyspnœa and pain; no strain; death in twenty-four hours. Autopsy: Eighteen inches of small intestine in the pericardial sac; congenital opening in the diaphragm the size of a silver quarter of a dollar. (*Brit. Med. Jour.*, Jan. 7th, 1899.)

Dennis, in the *St. Paul Med. Jour.*, Oct., 1905, publishes a case which, because of its bearing on this point of latency, as well as on account of other features, is reported in some detail.—A young man received a severe blow on the left thorax from a buggy pole, and, while the wound was not of a penetrating nature, the injury kept him in bed three weeks, and it was three months before he felt entirely well. From the twelfth to the eighteenth month after the accident he suffered from indigestion and constipation, and, during the recent six weeks, he has lost fifteen pounds in weight, his appetite alternating between good and poor. Two weeks ago he was thrown over the head of a pony, with the result of a little lameness only. Next, he was seized with nausea and vomiting after doing some jumping and then immediately afterward swimming for half an hour. The vomiting continued on the second day; abdomen retracted and slightly tender in the epigastric region. Calomel followed by enemas on the third day gave one good movement; later, there was no result. On the fourth day, the pulse and temperature were normal, the tongue clean; patient able to walk; much retraction of the abdomen; no pain; respiration nearly normal; vomiting continued. Fifth day, operation. Incision in epigastrium. It was found that the omentum, the transverse colon, and the greater part of the stomach had escaped into the pleural cavity through a hernial opening in the left side of the diaphragm. It was difficult to draw these out, because the negative state of the pleural cavity caused the displaced organs to be *drawn back with each respiration*, even against strong pulling on them. An extensive adhesion of the omentum to the upper surface of the diaphragm added to the difficulties. Resection of a rib stopped the suction and made it possible to reduce the displaced organs. [Would not a simple incision

of sufficient size between two ribs have accomplished the same purpose?—J. C. R.] The opening in the diaphragm was found to consist of a split of the muscle fibres about three and a half inches long, the edges of which fell together when the hernia was replaced. In order to provide the edges of this opening with an adequate support, gauze was packed behind it, in the angle between the chest wall and the upper surface of the diaphragm, and the free end of the mass was brought out through the wound in the thorax. Dyspnœa, which made it impracticable to suture the diaphragm, was relieved for some days by the use of oxygen. On the fourth day an attempt was made to suture the diaphragm, but the plastic exudate, which by that time had formed, concealed the wound so effectually that it could not be found. Despite the facts that the wound had not been sutured and that an empyema subsequently developed, what appeared to be a complete and permanent cure followed—due probably to the formation of adhesions between the thoracic wall and the damaged diaphragm.

Do these latent cases, even when examined in the fuller official records, prove that the hernia has not existed from the first, and that the rent in the diaphragm has remained for long periods patent, though empty? We think not, although that such may be the case in some instances is possible. The fact of finding adhesions between the imprisoned viscera, and between them and the pleura, casts suspicion on the recent occurrence of their extrusion; and when it is remembered how innocuous great scrotal hernias may be notwithstanding the fact that their necks are small, and how long large foreign bodies may remain in vital regions unsuspected by anybody, it can easily be imagined that the abdominal organs have, in these cases, been in the thorax from the time of the original injury, and that, as may be observed in inguinal hernia, they have in many instances been gradually protruded. The sudden onset of symptoms of obstruction or strangulation proves nothing as to the recent protrusion of the viscera, for other internal hernias are known to remain latent for years before revealing themselves. Improbability pleads against the claim, founded on clinical cases similar to the preceding, that a tear of the diaphragm remains unhealed, for generally it is in the form of a separation of fibres and would be expected to fall together as naturally as the fibres in McBurney's incision for appendicectomy, and as we have seen them do in Dennis' case. As a compromise this explanation is offered:—At the time of injury a fold of peritoneum only may have been nipped by the rent and may have formed adhesions, or a viscus may have pushed a sac before it through the diaphragm and then have fallen back leaving the sac to adhere. There would then be a permanent weak spot or opening through which at any time viscera might be forced.

This latency of hernia will be seen in a number of the cases to which reference is about to be made for other reasons. Chandler's case, for example, furnishes an instance of the occurrence of a hernia through one of the natural openings of the diaphragm—an opening, it is true, which had been enlarged by trauma.

(Chandler's Case.) Ten years previously the man had fallen from a tree, injuring himself so severely that he was confined to his bed for six weeks. When

he started to work he complained of a sharp pain deep in the left hypochondriac region. The pain, of varying severity, had continued until the present attack, when it became suddenly quite severe and death ensued in twenty-four hours.

At the autopsy the liver was found dragged to the centre of the abdomen, its border being dark and congested; the spleen was congested and pressed upward and back; the œsophageal opening in the diaphragm was ruptured, admitting a ball one inch and a half in diameter, and through this opening the stomach, all the small intestines (to a point eight inches above the ileo-cæcal valve) and also that part of the large intestine which is included between the hepatic flexure and a point eight inches above the sigmoid flexure, had escaped into the thoracic cavity. The intestines were almost coal-black and distended.

VI. TREATMENT OF WOUNDS AND HERNIÆ OF THE DIAPHRAGM.

Even though patients survive the original accident, as we have seen that they do in many instances, there still remains the necessity for an early operation, because they are living under an impending calamity. (It is assumed, of course, that an acceptable diagnosis of hernia has been made.)

Lenormant, of the French Surgical Society, whose article * we freely use, asked the question, whether, in the presence of a wound of the diaphragm which had been satisfactorily diagnosticated, an immediate operation should be performed. The answer given was unanimously in the affirmative. Indubitable reasons were given by Font Réaulx. The wounds under consideration involve both the abdominal and the thoracic cavities, and it is now a well-established custom, if serious symptoms invite, to enter either of these cavities when wounded. In cases of this kind there are almost always accompanying lesions of the viscera of either cavity or of both, and these almost always require operation for their correction. As has been plainly shown, the existence of an opening between the two cavities already exposes the patient to great perils. Although cicatrization of a wounded diaphragm has been proved possible by Refetto's experiments on dogs, such cicatrization is known to be rare. The rarity of this event is due to the persistence of the primitive hernia.

The mortality of these wounds, if left to themselves, is very considerable. In 1893 Frey collected 33 cases in which no attempt at treatment had been made. Of this number 29 died. In 2 of the cases there was a hernia of the omentum, and in 29 there were herniæ of other viscera. Death by strangulation occurred in 21; it took place immediately in one-third of these, and at some later time in the remaining two-thirds. More recently, Font Réaulx has collected 21 cases which had been left untreated and in which 16 deaths occurred. In addition to the lamentable results previously cited, may be mentioned cases by von Bergmann, Spillman, and Severeanen (each one case) and by Schaetzler (two cases). On the other hand, cases in which operative interference has proved successful are now easy to find. Among the number may be mentioned that of a man whose chest had been wounded by the tusk of a wild boar. From the

* Revue de chirurgie, 1903, xxvii.

wound, which was located in the eighth interspace, a loop of intestine protruded. An operation performed immediately after the injury gave permanent relief.

Walker has reported the following case:*—

A young man was pinioned under a falling tree, but not crushed. Shock extreme; pulse rapid, thready, and intermittent; dyspnœa marked; respirations shallow, jerky, and rapid; pain agonizing in left breast, increased by coughing, etc. Among the other symptoms observed were: a short cough, with sputum streaked with blood; vomiting at first of simple food but later stercoraceous; abdomen distended; no result from enemata; diminished expansion of left chest; the base of it tympanitic, with amphoric breathing; a succussion sound heard on shaking the thorax; apex of heart displaced two inches to the right; seven or eight ribs fractured on the left side. The abdomen was opened in the epigastric region. A knuckle of bowel eight inches long and much congested was found firmly held in a rent in the diaphragm. It was reduced after considerable traction and with some difficulty. Air then rushed in and out through the opening, which was in the muscular part of the diaphragm and admitted three fingers. Lung and heart easily palpated; the former showed no rupture; there was no blood in the pleural cavity, but clotted blood (three ounces) was found in the abdomen. With difficulty, four interrupted sutures were placed in the diaphragm; the patient's condition prevented the introduction of any additional sutures. Pain and tympany continued for twelve hours, but these symptoms were relieved by free catharsis effected by the use of salines. Rapid recovery. Work as a carpenter resumed.

Altogether, three hundred cases of operation have been reported. Some of them, like those just reported, had uninterrupted recoveries; in others there were serious complications; but all ultimately recovered. To the latter class belongs Manana's case, in which the wound was in the seventh left interspace. The eighth and ninth ribs were resected, food was found in the pleural cavity, and the rent in the stomach was sewed up. Persistent pleurisy followed, but eventually healing took place.

Successful operative cases have been reported by Nimi, of Naples, Italy. In one of these, in which there had been a stab wound, resection of a portion of the eighth rib was found to be necessary. With the removal of this part of the rib it was discovered that there was a wound, 25 mm. long, in the diaphragm; and after this wound had been sufficiently enlarged it was seen that a wound, 2 cm. long, also existed in the stomach. The latter wound and also that in the diaphragm were sutured. No drainage. Outside walls sutured. In another of Nimi's cases two wounds were found in the liver and one in the kidney, both of them requiring to be sutured in order to check a considerable hemorrhage. In a third case the hemorrhage, which came from a vessel in the diaphragm and was considerable, was controlled by ligature.

The conclusion is therefore warranted that, whenever it is possible to affirm the existence of a wound of the diaphragm, with or without a wound of the viscera, the indication is urgent to interfere, in order to close the wound and thus to prevent all possibility of consecutive hernia.

* Trans. Amer. Surg. Association, 1900, p. 246.

In some cases a diagnosis can be made with certainty, as, for example, when a portion of the omentum or of some other abdominal viscus emerges through the wound. Instances of this manifestation, which is of rather frequent occurrence, have already been given. In such cases a diagnosis is evident and the course to pursue clear; but when there is no certain sign, when the seat and direction of a wound of the chest make it probable, however, that a lesion of the diaphragm exists, the surgeon ought, by direct exploration of the wound and by careful examination of the superior part of the abdomen, to assure himself of the state of the muscle and then to decide whether or not he should undertake to suture the tear in the organ.

When an operation is decided upon, the question arises, What is the best route to follow? Surgical opinion is divided. Some—as, for example, Refetto, Schoenwerth, Glantenay, and Auvray—have given the preference to a cœliotomy, while others advocate the route by way of the thorax. Borouck followed the abdominal route in a case in which transpleural interference was prevented by hemorrhage. This is the only case on record in which it was found necessary to abandon the route by way of the chest.

The Abdominal Route.—The results of these cases of cœliotomy (eight in all) are far from brilliant. Two were cured. Refetto, by the abdominal incision, could not reach the wound in the diaphragm and was then obliged to perform at the same time a thoracotomy. Death followed. Four succumbed to wounds of the stomach, the existence of which had not been perceived at the time of the operation. Of the two cœliotomies described in detail on a previous page, that performed by Dennis had to be supplemented by an opening in the chest to prevent suction (successful), and in Walker's case it was found necessary to exert upon the viscera a degree of traction that many surgeons would not like to make, especially if the operation was performed a considerable length of time after the wound had been inflicted. As special difficulties of the abdominal route may be mentioned the following:—It is not at all easy by this route to reach the wounded viscera, the wounds themselves being situated, as a rule, vis-à-vis to the opening in the diaphragm; prolonged and difficult manœuvres are required to bring the wounds into view; the sac itself, being located above the diaphragm, cannot be reached directly by this route, if it should be found necessary to enlarge the tear, the task will prove difficult of accomplishment by way of the abdominal opening; and, finally, it will be found exceedingly difficult by this route to apply sutures to the diaphragm, repeated trials being often required before success is attained. In Dennis' case, for example, the attempt had to be abandoned. The difficulty is due not alone to the dome shape of the region in which the suturing must be done, but also to the presence of the stomach and colon, organs which are difficult to keep out of the way of the needle, and which make suturing actually dangerous. The only period at which the adoption of the abdominal route is permissible is that immediately following the infliction of the wound, before adhesions and tight constrictions have had time to form. In the case of inguinal hernias an exactly analogous situation is encountered when the attempt is made to attack the hernia from the

peritoneal cavity. Two or three times, in the history of surgery, strong advocates have arisen for the plan of approaching these hernias from within, but they have always been met with deaf ears.

The Thoracic Route.—This route presents great advantages. It has one decided merit, viz., that the external wound itself serves as a guide. The chest is to be opened at the site of this wound, and the course of the wounding instrument is to be followed step by step. This course is not necessary when the diagnosis is made certain by the presence of a hernial protrusion at the mouth of the wound or by other unmistakable signs, but it is to be followed when probabilities are to be rendered certainties by exploration. Further, this is the most direct route; it affords space for reducing the hernia if one is found to exist, and for enlarging the diaphragmatic wound and treating the sac, and it also permits the use of pincettes in holding the edges of the wound together while suturing is being done. There are two objections to thoracotomy. The first is the danger of pneumothorax. Lenormant reports great diversity of opinion in regard to this, but, after the full discussion of the subject already given under Wounds of the Diaphragm, it will be necessary only to add that, in twenty-two of his cases, the difficulty was not mentioned once. The second objection is, that the route does not permit exploration of the peritoneum and its contents. This objection is valid in regard to those cases in which it is necessary to remove from the peritoneal cavity particles of food, blood, etc.; but, in the cases in which it is important to ascertain what viscera have been wounded, we have seen that the objection lies the other way, that such wounds have been more often overlooked in operations by way of the abdominal route than in those by way of the thorax. This is doubtless because the wounds in the viscera lie vis-à-vis to those in the diaphragm; and then, so far as treating these wounds is concerned, Nimi and others have shown us that the stomach, liver, and kidney can be successfully sutured from above. Of course, no hard or fast rules can be made for surgical procedures, and each case will be approached according to its individual features; but, from the observations given, the superiority of the transpleural route in the treatment of thoracico-abdominal wounds seems to be indisputably established. The experience gained from clinical observation is confirmed by that which is furnished by the statistics of these two operations; the mortality for cœliotomy being 62.5 per cent, while for thoracotomy it is only thirteen per cent.

Technique of the Operation.—A regular technique is difficult to establish, because of the great variations in the wound. A few of the different procedures will be mentioned here. Some operators use a large trap-door opening; Rydygier makes an incision in the fifth or sixth interspace, commencing at the costal cartilage. From the posterior end of this a vertical incision is made downward, covering several interspaces, and the triangular flap of skin, muscle, and bone is turned downward and inward. Slobet makes an elliptical cut that extends from the fourth rib obliquely downward to the eleventh rib and then upward to the fourth. After this flap has been reflected he divides the seventh, eighth, and ninth ribs in front and behind. Rochard suggests excision of the

ninth rib through an incision about fifteen centimetres in length; the operation to be proceeded with only after retraction of the lung has taken place. Resection of one rib is certainly often sufficient, and it is seldom that the incision need extend above the eighth rib in front, or the seventh behind. Sometimes there is already loss of rib tissue (in one case the fragment measured 24 cm. in length) and a trap door can then be lifted with little further division. Notwithstanding the statement that, in a mere separation of the fibres of the diaphragm, the edges of the wound would fall together without the aid of sutures, we must adopt the stern lesson of clinical experience and suture the wound in every case where the patient's condition permits it. This can be best done by holding each edge quiet by means of a pincette and then uniting the two, after accurate coaptation, by means of a continuous or glove stitch of chromicized catgut. Through an opening in the chest wall this is not a difficult procedure, because of the dome-like upward curving of the diaphragm. In each individual case the question whether drainage is to be used or not, will have to be decided upon its merits. Successful results have been obtained in some cases without drainage. There need be no hesitation about enlarging the wound in the diaphragm if, for the purpose of reducing a hernia or of repairing viscera, such a step seems desirable. In fact, it is preferable to make such an enlargement rather than to use any force in our attempts at reduction. If pneumothorax causes trouble after the operation a measure may be adopted which was used in the Civil War and long before, viz., the removal of the air from the chest by aspiration. Whatever air may remain behind is usually soon absorbed.

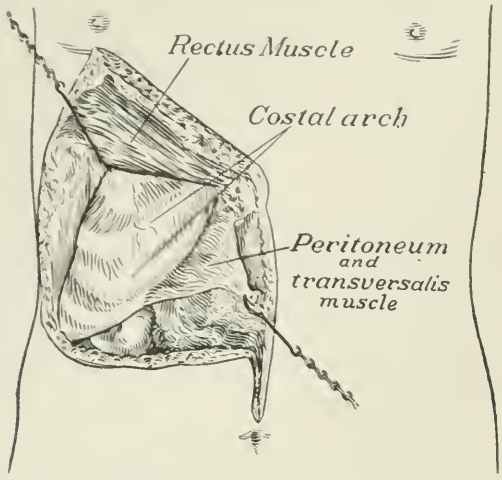

Fig. 188.—Incision. Flap turned back, exposing costal arch, to which the peritoneum and transversalis muscle remain attached. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

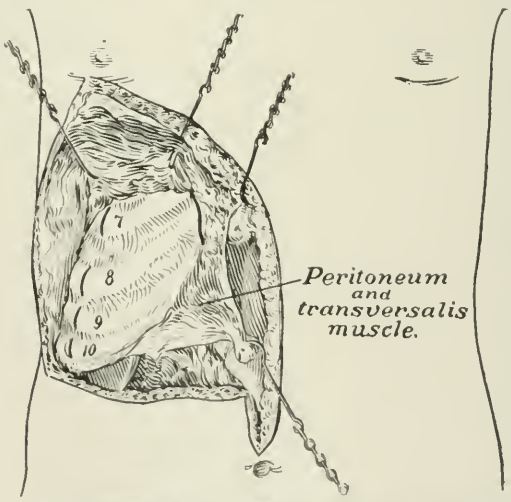

Fig. 189.—Incision. Flap turned back, showing the seventh, eighth, ninth, and tenth costal cartilages divided close to where they join the ribs, and also the seventh cartilage divided near the sternum. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

Another mode of traversing the chest, in order to reach the diaphragm, is that first used by Walther in 1892. According to this plan the same course is pursued as that which is adopted in all cases where intentionally we traverse the pleura to reach the liver, that is, by stitching the diaphragm to the parietes of the thorax, a method that will be further described under Subdiaphragmatic Abscess. The plan has been followed by von Frey, Amante, Henri Girard, Zeidler, and Grekow. Lenormant has had "no personal experience with the method, but, from my cases, the other plan has seemed so simple of execution, and has given such perfect results—to others as well as to myself—that I see no reason for abandoning the latter." Unless infection be present this course certainly seems unnecessary. As in the case of hernias in other parts of the body, protruded omentum had better be amputated, especially so if the mass is of considerable bulk.

Other points of technique will be found in the sections of this article which relate to the treatment of wounds and of subdiaphragmatic abscess.

The conclusions given above in regard to the policy of operating "remain true and reliable whether there are or are not accompanying wounds of viscera; upon the latter depends largely the gravity of the prognosis." On the other hand, if these conclusions prove true in chronic diaphragmatic hernia, in cases in which we have reason to suspect the existence of hernia, do they also hold true for the interval between an accident and the appearance of strangulation? Should an operation of election be undertaken for the radical cure of a diaphragmatic hernia? The only case of this kind which we are able to report is Llobet's,* in which by means of an extensive plastic operation on the side of the chest, an old hernia was cured. A man had received, twelve years before, a deep puncture in the eighth intercostal space on the right side. This injury was followed, in the course of forty-eight hours, by a small swelling which increased in size when the patient coughed. At the end of twelve months it had become as large as a hen's egg, and subsequently, although it did not enlarge, it caused increasing pain and discomfort, and much difficulty in breathing. Otherwise the patient was in fair health. The respiratory movements were less free than normal. A flap of chest wall was made in the manner described in detail in

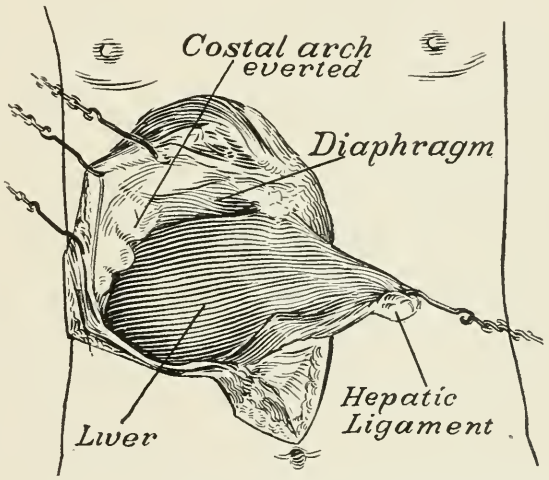

Fig. 190.—Incision. The skin-muscle flap having been returned to its place, it and the underlying costal arch were then raised and turned back against the wall of the chest, thus exposing the liver fully to view and showing the hepatic ligament being pulled toward the median line. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

* Revue de chirurgie, Mar., 1895.

Llobet's article. After it had been lifted up it was seen that the external tumor formed part of a large hernia, containing omentum and a portion of the transverse colon. The protruded omentum and the hernial sac were resected and the opening in the diaphragm was closed by two rows of sutures—one for the peritoneum alone and one for the muscle. The trap door was then replaced, the detached portion of the ninth rib being fixed in its place by wire suture, and the structures by two rows of sutures. The hernial orifice in the eighth interspace was closed by a suture. At the end of the third week, the patient was regarded as absolutely cured.

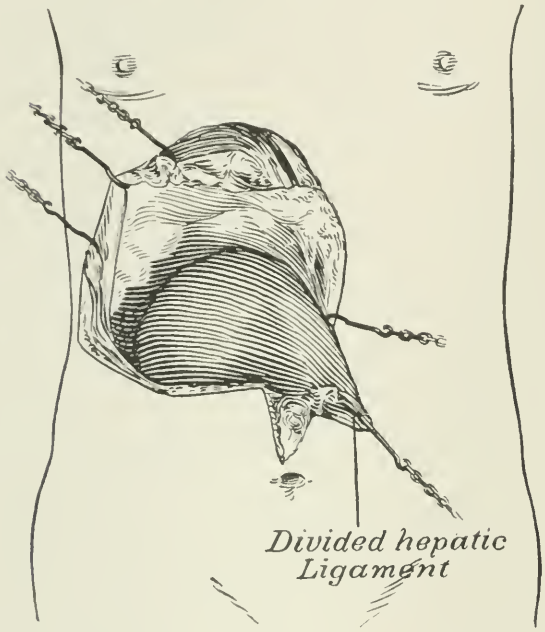

FIG. 191.—Incision. Hepatic ligament divided as high up as where it is attached to the diaphragm. Strong traction is being used upon the ligament in a direction partly downward and partly toward the median line for the purpose of bringing the liver more extensively into view. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

This case, when considered in connection with the general principles of diaphragmatic surgery now so well elucidated, will lead surgeons at the present time to treat an old phrenic hernia in precisely the same manner as they do any disability which imperils the patient's life—viz., by a systematic operation.

Dr. E. Wyllys Andrews, in *Surgery, Gynæcology, and Obstetrics*, Feb., 1907, makes the following suggestion with reference to suturing the diaphragm:—"The diaphragm (from the abdomen) was difficult of suture. The expedient was adopted of making a transpleural exclusion by one or two deep loop or mattress stitches. These extended through an intercostal space across the lower angle of the pleural cavity into the peritoneum, through the diaphragm, where the fingers inside received the needle. The latter was then pushed back on the other side of the cut and then through the skin. In this way the thin edge of the pleural cavity, as well as the wound in the diaphragm and the wound in the chest wall, were occluded, the lung having receded. The rushing of air at once ceased."

For syncope, especially that resulting from chloroform narcosis, it has been proposed to apply rhythmic massage to the heart by inserting the hand through an incision in the epigastrium and grasping the organ through the diaphragm without opening the latter. (Such an opening, however, has been made in a few cases.) In a majority of the twenty-five cases reported (*Revue de chirurgie*, Paris, 1906, XXVI., No 3) the cardiac contractions continued as long as the massage lasted.

To reach the dome of the diaphragm Willy Meyer (in the *Journal of the American Medical Association*, Oct. 6th, 1906) recommends the following plan of resecting the costal arch. He was driven, on the spur of the moment, to adopt this course in removing a large spleen, and he suggests that it may be followed to advantage in reaching the cardia in operating in case of shot wounds of the diaphragm, etc. To the median abdominal incision is to be added a transverse one, which should extend to the tip of the eleventh rib. The space between the posterior surface of the belly of the rectus and the mass of tissue composed of the peritoneum, the posterior sheath of the rectus, and the transversalis fascia, is then entered. From here, by means of blunt dissection, there is no difficulty in reaching the border of the costal cartilages (Fig. 188), for the simple reason that the rectus and the external oblique muscles have their origins farther up on the thorax and are attached to the latter, in the portion which is concerned in the present operation, by very loose connective tissue only. Then the seventh cartilage, which represents the union of three separate costal cartilages, was cautiously divided by the knife close to its sternal attachment, and the seventh, eighth, ninth, and tenth cartilages were likewise divided just in front of their union with the ribs (Fig. 189). After this has been accomplished the flap composed of skin and muscle is replaced in its normal position and two sharp retractors (or, better, the assistant's hands) are hooked into the peritoneum, and the costal arch is raised. Later, the osteoplastic flap is returned and pressed into position, the edges of the incision are sutured, and the abdomen is well strapped with zinc adhesive plaster and snugly bound by a binder.

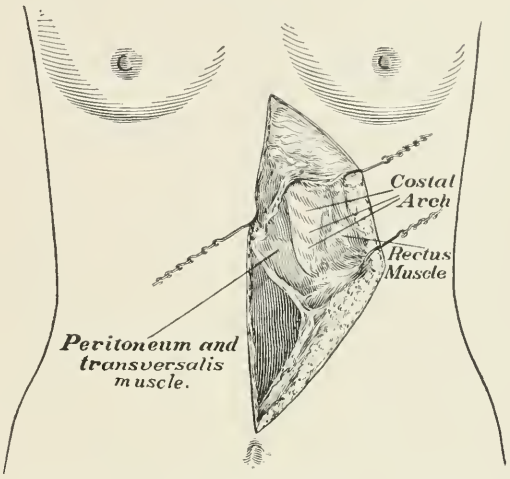

FIG. 192.—Straight Median Incision. Rectus muscle is pulled outward and upward, the peritoneum and transversalis muscle toward the median line. The costal arch is exposed. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

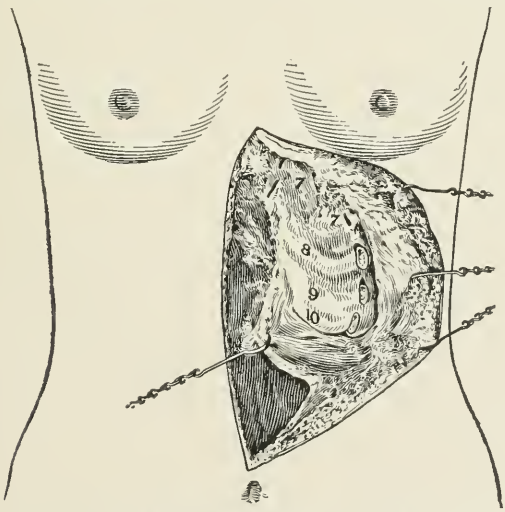

FIG. 193.—Straight Median Incision; cartilages of the eighth, ninth, and tenth ribs divided. In this specimen the cartilage of the eighth rib is not united with that of the seventh near the sternum. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

In case of need the ribs may be divided in place of their cartilages, the division being made at points located farther outward, and in addition the fifth and sixth ribs may also be divided. The convex surface of the liver can be better reached by pulling on the suspensory ligament (Fig. 190) or by dividing the latter and then using it for strong downward traction (Fig. 191).

From operations made upon the cadaver Meyer has learned that the usual median (or rectus) incision can well be combined with osteoplastic resection, without making at the same time the transverse incision mentioned above (Figs. 192, 193, and 194), but of course the amount of available space which will be secured in this manner will not be as great as that afforded by the T-shaped incision or by an oblique incision extending from the xiphoid cartilage to the tip of the tenth rib (Fig. 195). If the latter incision is primarily feasible it will afford excellent access, but in order to close it properly it will be found desirable to employ through-and-through sutures.

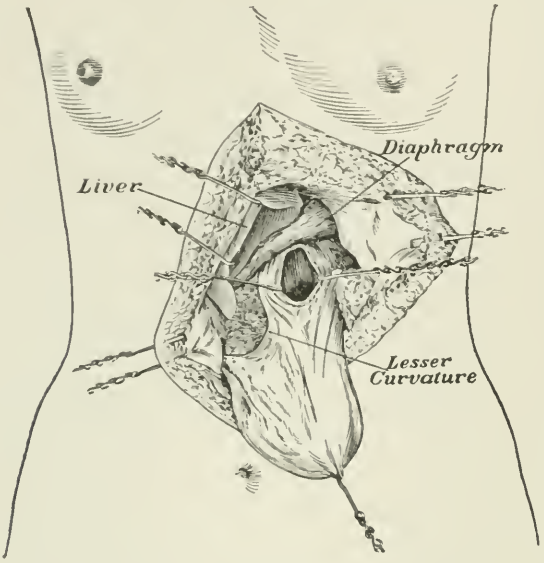

Fig. 194.—Straight Median Incision. Lumbar region of the cadaver raised; skin-muscle-bone flap pulled upward and outward, exposing a large area of the stomach; the cardia incised (the dark area in the centre of the picture), and the cut edges held apart by hooks. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

I cannot leave the subject without contrasting, by means of a quotation only twenty-five years old, the present state of the surgery of this region with that of 1881. "We are silent on the subject of treatment. We cannot hope to close the aperture [in the diaphragm] by any measures which science or mechanical surgery would justify; could we accurately detect the existence of a protrusion it were in vain to attempt its reduction with any benefit to the patient, or credit to ourselves." (Holmes' "Syst. of Surg.")

VII. SUBPHRENIC ABSCESS.

In preparing this section, the freest use has been made of M. Grüneisen's comprehensive article, "Ueber die subphrenischen Abscessen," *Archiv f. klinische Chirurgie*, 1903, No. 70.

Collections of pus under the diaphragm can come from different organs, and the course of the case is influenced a good deal by the location which the pus occupies—*i.e.*, whether it is within or without the peritoneal covering. Such collections are separated from the rest of the peritoneal cavity by the transverse

colon with its mesocolon and its attached omentum, these structures together crossing the cavity like a partition. A focus of inflammation or of suppuration located below the diaphragm may be barred from the remainder of the cavity by adhesions between the colon, omentum, and parietes. Out of 288 cases the cause is distributed among the various organs in the following proportions (percentages): Stomach, 32.2; appendix, 26; biliary passages, 8; thorax, 3.8; intestines, 3; perinephritic structures, 3; female genitals, 3; pancreas, 2; spleen, 2; duodenum, 1; ribs, 0.5; and the remainder, in unknown parts, 5. The distribution according to causes was: traumatic, 3.8 per cent; echinococcus, 2 per cent; metastatic, 2 per cent. An unusually important part in etiology is played by the appendix. Apparently far removed and without close anatomical relationship, this organ still supplies the cause in a large number of cases. A second much smaller group of primary causes is found in diseased ribs, pleura, and mediastinum, but, taken all together, these lead to very few cases of subphrenic abscess.

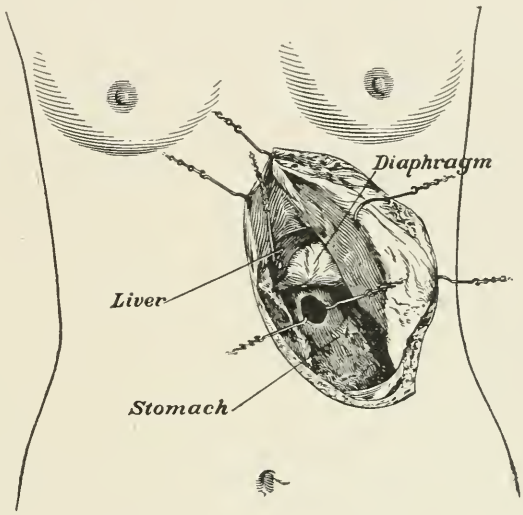

FIG. 195.—Oblique Incision. After division of the costal cartilages, as before (Fig. 193), an osteoplastic flap is raised, exposing the vault of the diaphragm, and an incision is made in the cardia. (Willy Meyer, in the *Journal of the American Medical Association*, October, 1906.)

The locations of the pus collections may be as various as the causes. With reference to this point, it will be found that two large groups may first be distinguished—the intraperitoneal and the extraperitoneal, *i.e.*, those whose walls are entirely made up of peritoneum, and the others which spread themselves between the tissues of the diaphragm and its peritoneal covering. Of these two classes of cases the intraperitoneal is decidedly the more common. The extraperitoneal collections cannot, of course, occupy the whole dome of the diaphragm, because the peritoneum is attached so firmly at places that it cannot be stripped off by the fluid. Hence, retroperitoneal subphrenic abscesses can be spoken of as such only in a restricted sense, rather as suppurations that reach up under the diaphragm. But these retroperitoneal phlegmons may enter the peritoneal cavity by breaking through the membrane, between the liver and the diaphragm. Abscesses of this nature and source are often connected with perityphlitic (appendiceal) abscesses. Maydl has observed that extraperitoneal abscesses perforate more freely into the chest cavity than do those of the intraperitoneal type, but, in the case of the latter, exudation into the pleura is more frequent.

Besides this division into intraperitoneal and extraperitoneal subphrenic

abscesses, the position as to right or left calls for consideration, for there is some variety of boundaries here, especially on the left side, where several different organs are to be found. On this side are to be described three regions of occupancy: 1, the "space" between the liver and the diaphragm; 2, "*loge perisplénique*," a region which is bounded on the inner side by the stomach and the pancreas, on the outer by the diaphragm and the ribs, and above by the diaphragm and the outer part of the left lobe of the liver; 3, the "*loge rétrostomachale*," the bursa omentalis or "lesser cavity." In general, to the first of these regions may be assigned abscesses resulting from perforation of the stomach; to the third, those from perforation of the stomach and from pancreatic suppuration; but all such designations of limits can be schematic only, as the variations and overextensions are so numerous. Only the intraperitoneal right-sided abscesses between the liver convexity and the diaphragm, and the left-sided ones containing gas are characteristic, and this to a limited extent. Usually we may assume that abscesses lie on the same side of the body as the organs from which they spring. Especially is this true of retroperitoneal abscesses. In the case of intraperitoneal abscesses, there are more exceptions, but even of these it is still generally true. Abscesses of appendiceal or gall-duct origin lie on the right side, those originating in a perforation of the stomach and in splenic disease lie on the left. In the case of an abscess originating in the stomach the location will probably be on the right side if the disease started from a carcinoma, because the pylorus is the part more frequently affected by cancer; but it will be located on the left side if the disease started from an ulcer of that organ. Occasionally these abscesses are a part, or more often a remnant, of a general peritonitis, in which, after absorption has taken place, or after operative drainage, some vestiges remain encapsuled behind the colon or under the diaphragm, and these at any time may assume an acute phlegmonous character.

Children are less disposed to this affliction than adults, the proportion given in the latest statistics being about eighteen per cent. In them the abscess is likely to develop suddenly and to run a quick course, and Maydl shows that the cause is very seldom to be found in the subdiaphragmatic region. Parietal (costal) caries is a more frequent factor than it is in adults, and so is tabes mesenterica. Disease of the appendix is now known to be a frequent cause of subphrenic abscess in children.

The *course* of abscesses of this region may be extremely slow, or indeed they may slumber for long periods. A man convalescing from typhoid developed on the left side an abscess which was approached through the pleura. The knife could find but one small spot in the stony wall of the abscess through which an opening could be made. The abscess was drained. Later, the calcareous walls were removed from the liver, stomach, spleen, omentum, and transverse colon. The presence of the bacillus of typhoid was demonstrated. From the character of its wall it was evident that the abscess must have existed for a long time, and that it must have become reinfected by typhoid bacilli. (*Erft. Med. Jour.*, Dec. 22d, 1909.)

The character of the abscess contents depends on the origin of the trouble.

It may be creamy pus from the kidney or rib; thin, dirty-looking, foul-smelling pus from the appendix; a thin, serous fluid when it represents a remnant from a general peritonitis; pus mixed with gas when it has originated from an appendicitis, or, as was observed in one case, a fluid of a golden green color; and a dirty-looking pus, with gas and particles of food and a distinctly sour smell, when it has originated from a perforated stomach. Sometimes, in an abscess which has originated from a perforated stomach or from a perforated duodenum, the cavity, although large, may contain almost no pus, but, instead, putrid gas —a circumstance which may lead to serious mistakes when aspiration is resorted to as a test. The frequency with which such collections contain gas has been much overestimated. Furthermore, the origin of the gas has received various explanations, some maintaining that it comes only from the perforation of a gas-holding viscus, while others claim that it is generated by gas-producing organisms. Both are correct. Perforation of gas-holding organs is known to occur as a frequent cause of such abscesses, and gas can certainly escape at the same time. Then, again, if a perforation occurs without escape of gas the extravasated matters contain organic material which is ready for putrefaction —*i.e.*, for the development of putrefactive bacteria. Or, without the presence of a perforation, organisms can readily pass through the inflamed bowel wall, as we know they do in strangulations. Finally, we have gas-producing inflammations in other parts of the body. Claimont and Rauzi (*Wiener klinische Wochensch.*, 1905, XVIII., No. 25) fully support Grüneisen in his contention that in abscesses such as are here under consideration, gas may and often does come from bacterial growth, while Leyden, on the other hand, maintains that it comes from a perforation only. The first proven case was Weber's, and the responsible parasite the Paracolibacillus aërogenes. As showing the difficulty of reaching a conclusion as to the source of the gas such a case as the following may be cited: —The patient, an adult, after suffering for four weeks from what was called a "peritonitis" (which might easily have been pleurisy), passed into a condition of collapse, with coughing, breathlessness, stitches in the left side, etc. A large abscess was found beneath the diaphragm. It contained putrid gas, but no stomach contents. Operation and the establishment of drainage failed to prevent a fatal issue. At the autopsy were found: a large empyema; two small perforations in the very thin diaphragm, both of them leading into the adherent lung; a large round ulcer in the stomach which was adherent to the liver.

Symptoms.—It is generally claimed to be impossible to give an harmonious clinical picture of this affection or to distinguish it clearly from other diseases, so many are the different aspects and changing conditions under which it is met. This is doubtless true, since subphrenic abscess is a malady which results from or accompanies other and often very various ailments—in short, is a symptom of some other trouble. While it may not always be practicable to ascertain the mode of origin of a subphrenic abscess, it is agreed that, only by the earliest possible recognition of the condition and a correct perception of the clinical picture, are we able to undertake the one practical measure for its relief, viz.,

the emptying of the abscess. On this account it will be desirable to present, from the confusing multitude of symptoms, only the relatively constant features.

The subphrenic abscess is a circumscribed peritonitis. We see the beginning of it under the features of an acute or gradually developing peritonitis. Often, after some insignificant complaint, which it was only possible afterward to refer to the original disease, the patient suffers sudden collapse, nausea, vomiting, and pain. In other cases, especially those in which the disease advances behind the peritoneum, the course is of a more insidious character, the picture less clear. The subjective symptoms are naturally and correspondingly various. Shooting pains between the shoulders and singultus, which are mentioned by many as characteristic symptoms, have not been observed by others. In most cases there is a distinct rise of temperature, and this is the only piece of evidence which reveals the existence of an infection. The absence of fever does not disprove the presence of an abscess.

Physical examination often shows characteristic signs. There may be, on the affected side of the lower part of the thorax, a rounding out which does not take part naturally in the breathing. The interspaces are obliterated, widened, or protruded, and are often painful under pressure. "Litten's diaphragm phenomenon," in which the position of the diaphragm on the thoracic wall is to be seen by inspection, is not noticed by many observers, but an inflammatory œdema of the loin or of the lower thorax may be discovered. This latter manifestation is more frequent in the case of a retroperitoneal than in that of an intraperitoneal abscess. Breathing sounds may be heard below the level of the dulness, and, if a deep inspiration be made, the line at which the breathing sounds and the vocal resonance are heard, and at which the fremitus is felt, will be distinctly lowered. Liver dulness may be distinguished from abscess by the fact that the former is distinctly lessened by the knee-elbow or prone position. If a very emaciated patient is examined in a good light, it will be noted, if the pleura be healthy, that the lower margin of the lung moves up and down with respiration, and further confirmation of this fact may be obtained by auscultation and percussion. Then, in addition, it can be determined, in the case of a subphrenic abscess, that the area of dulness is situated below this line. The dull area and the tympanitic area may extend as high as the second rib and as far down as the iliac fossa.

Whether the subphrenic abscess lies to the right or to the left, or in front or behind, are questions to which usually an answer can be given. An abscess on the right side may reach from the middle line behind to the ligamentum suspensorium of the liver, and will be limited in front either by adhesions between the parietes and the liver or by the transverse mesocolon. When, therefore, such an abscess is present, there will be found a much depressed liver border together with the area of liver dulness (=abscess dulness) much increased upward. In typical cases the upper line of this area of dulness is convex upward. Above this line will be found normal lung sounds, provided there be no intrapleural fluid. In some cases this line may be depressed by inspiration, but

necessarily only to a slight extent, since the diaphragm is weakened and lamed by the inflammatory process and its mobility interfered with in some measure by the mass of pus accumulated beneath it. Winiwarter considers that this upward extension of the area of dulness comes less from an elevation of the diaphragm by fluid than from an œdematous thickening of the same from inflammation. At any rate, the upper line of dulness is not as distinct as in pleuritic effusion.

If gas is mingled with the pus, its presence is to be recognized by its clear tympanitic note and bell-like sound, which changes its position with the change in position of the patient, but which persistently maintains its position at the top of the dull area. In the upright position there are to be found, from above downward, normal lung resonance, a sharply outlined tympanitic zone, and then the dulness—a characteristic and pathognomonic grouping of these three zones.

Very similar are the relations of those subphrenic gas abscesses which are located on the left side and which originate from a perforation of the stomach. The walls are formed above by the diaphragm, on the right by the falciform ligament, and below by the very much depressed left lobe of the liver in conjunction with the stomach and spleen. The epigastrium protrudes; the abdomen below the abscess is soft and compressible. The diaphragm occupies a high position. In the epigastrium is found tympanites. Here, then, we have again the same grouping of three zones.

Pressure symptoms, in the case of large abscesses, are generally less pronounced than they are in pleural exudates, and the degree of displacement caused is manifested particularly in the abdominal viscera because of their greater compressibility and mobility. Although the upper limit of the area of dulness may extend above the normal line of the diaphragm, the lung may still possess fair expansive power and may exhibit normal sounds. In left-sided abscesses the heart is pressed somewhat upward, not to the right; in right-sided abscesses it is pressed only a little to the left.

More obscure are the abscesses which originate in disease of the kidneys or the ribs. So far as their location is concerned these develop on the back wall of the thorax and they may escape detection for a long time before they take on rapid growth. In many cases they present only the signs of a small pleuritic effusion, and when they are accompanied, as they frequently are, by such an effusion, it is almost impossible to demonstrate their presence. In many of these cases the first thing that calls attention to the real seat of the trouble is the development of a secondary pleurisy.

The participation of the pleura is by far the most frequent and practically the most important complication of subphrenic abscess; important because it often changes or dominates the clinical picture and the physical signs, and again, because it often requires an additional surgical attack. This concomitant inflammation is rendered almost inevitable by the extensive contiguity of the two spaces. The disturbance may be confined to a simple fibrous exudate, which causes adhesion to take place between the leaves of the pleura, or gives

rise to a collection of fluid of varying dimensions and composition (from sterile serum to actual pus). The virulence of such an exudate, however, is generally much less than that of the original abscess, the peritoneum seeming to act as a filter. This infection of the pleura comes about in various ways, and is favored by the movement of the diaphragm, as explained in the earlier part of this article (page 454). It may take place in any of the following ways:—

By metastases, by way of the blood stream.

By means of germs carried through the lymphatics of the diaphragm.

By the direct growth of germs through the diaphragm.

By an advance of the inflammation by way of the retroperitoneal and retropleural tissues.

Because of the nearness of the two cavities, the first—that is, the indirect—course will be very seldom followed. If the abscess is retroperitoneal, the fourth course is the natural one; if it is intraperitoneal, either the second or the third course is the one likely to be followed. Burkhardt has carried out a series of experiments which show that the third course is possible, and the following report of an autopsy furnishes good corroborative evidence:—

Stomach adherent to the anterior abdominal wall, the attachment beginning in the middle line and reaching to the arch of the ribs. Within the area of the attachment is a perforation with sharp edges, the size of a five-cent nickel. A right pleural abscess. The subphrenic abscess extends over the whole top of the liver. Near the highest point of the abscess may be seen several crater-formed ulcers in the diaphragmatic peritoneum; they reach almost to the pleural surface but do not quite penetrate. On the corresponding pleural surface are deposits of pus which lead indirectly to the empyema.

The following case furnishes an illustration of the fourth course:—

The patient was taken suddenly ill (1891), and nine days later a retrocæcal phlegmon (probably of appendiceal origin) was opened by an incision over the crest of the ilium. After four days, the incision was enlarged diagonally upward because of extension of the phlegmon. There was found a large abscess which had surrounded the kidney and had loosened it from its fat capsule; the kidney itself was healthy. The abscess extended obliquely upward behind the peritoneum under the diaphragm to the spine. The suppuration advanced through the diaphragm to the retropleural tissues. Nine days later, resection of the eighth and ninth ribs was performed, and thus access was gained to a flat limited abscess near the spine. In the pleural cavity there was serous exudate which later became absorbed.

Such a perforation of the diaphragm is seen more frequently in cases of retroperitoneal abscess, while inflammation of the pleura (serous exudate) without perforation is more common in the intraperitoneal variety. This is because of the protection afforded by the serous covering, which shields the diaphragm from the harm that bacteria or their toxins may inflict. The moderate degree of intrathoracic inflammation which accompanies a subphrenic abscess is not to be determined by physical signs, but only through the opportunity of inspecting the parts which is afforded by an operation or by an autopsy. The

frequency of this complication is therefore not to be stated with any degree of certainty; it is estimated at sixty-six per cent.

If the suppurative perforation of the diaphragm occurs at a point where there is an old pleuritic adhesion, the abscess will empty itself directly into the lung and thus a spontaneous cure may be effected. Leyden held that this was, to a certain extent, a typical course: but, since the malady has become a surgical one, this outcome is seldom witnessed. Such an occurrence is manifested by a sudden and distressing cough, accompanied by the expectoration of great quantities of dirty pus. With the emptying of the abscess this purulent discharge at once ceases, but such a lung fistula has been known to persist for six months before healing finally occurred.

Analogous to the pleuritic is the pericardial complication, which occurs in rare cases. In most of these the purulent pericarditis coexists with empyema and there is no direct communication between the two cavities. In the following instance the question naturally suggests itself, Might not this condition, which was observed at the post-mortem examination, have resulted from the perforation of a subphrenic abscess through the diaphragm into the pericardium? The apex of the heart was found bound to the pericardium and to the diaphragm by a fibrous mass one inch square and nearly one inch thick. The death of this patient, who had occasionally suffered from slight difficulty in breathing, occurred suddenly. In another case the pericardium was found to be thickened over an area about one inch and a half in diameter and this thickened portion was mistaken for the diaphragm.

The degree to which the symptoms of a subphrenic abscess will be altered by an accompanying pleuritis will vary greatly according to the severity of the complicating disease. The more severe the thoracic complication the more apt is it to obliterate the manifestations of the primary trouble, and thus to obscure the diagnosis. Yet, as we have said, the secondary pleurisy may be the first thing to direct the surgeon's attention to that region of the body. If a simple subphrenic abscess without gas is complicated by a pleuritic effusion, then the area of dulness caused by the former passes directly into that which is dependent upon the presence of the latter. All previously mentioned differentiations between the two fall to the ground; the displacement downward of the liver, etc., can be equally well accounted for by the pleural exudate. With abscesses containing gas the conditions are different. In these cases there will be, between the first and second zones of the three described above—*i.e.*, between the lung resonance and the tympanites due to the gas—a fourth zone, viz., that corresponding to the dulness caused by the presence of the exudate. And here let me call attention to the importance of making an examination of this kind—provided no serious contra-indications exist—with the patient in both the sitting and the lying-down posture.

Another complication of subdiaphragmatic abscess is that in which the perforation takes place into the general peritoneal cavity. Attention has already been called to the fact that the subphrenic collection of pus may be an encysted part of the products of a previous peritonitis. It is possible, however,

that a general peritonitis may develop from that which occupies a limited area under the diaphragm—a catastrophe, fortunately, which is seldom reported. One such case occurred three years after the performance of a gastro-intestinal anastomosis, the abscess coming from a new perforation in the jejunum.

Perforation into other hollow organs is so rare as to be negligible. That such may be most serious in its consequence is shown, however, by a single case of perforation into the bowel. In this case the abscess cavity filled with gas; artificial drainage was established; but, in spite of this, the opening of communication did not close, and the suppuration continued its course to a fatal termination.

Other complications are those which commonly occur in all abscesses, and which are therefore of no particular significance here; I refer to metastases in kidneys, lungs, brain, etc. One case may be mentioned where a gall stone offered the point of least resistance to a pyæmic abscess. A fatal cholempyema followed.

Diagnosis.—In spite of the fact that a large number of these cases are not and cannot be certainly diagnosed, we are continually increasing our success in the treatment of these comparatively rare diseases because of increasing knowledge. It is therefore of special importance to obtain a full history of the case, for by its aid we may be able to learn that the primary disease was located in the abdomen, or at least that a primary origin within the chest is highly improbable. If there is a secondary rise of temperature in such a case, subphrenic abscess must be kept in mind as well as other complications. As an instance of such a secondary rise of temperature, and as an illustration of how little help, toward the establishment of a diagnosis, is often furnished by the existing signs and symptoms, the following case is given by Hartwell. (Trans. New York Surgical Society, March 8th, 1905.)

The patient, a woman of 48, had suffered for seven days from pain in the right hypochondriac and anterior lumbar regions. (Her previous history was not obtainable.) She was poorly nourished. Thoracic viscera were normal. There was considerable tenderness in the right lumbar region, and a tumor, which gave the impression of being a kidney, could be felt just above the iliac spine. There was also tenderness in the region of the right appendix. Temperature, 100° to 102.5° F.; pulse, 100 to 120; respiration, 24 to 28. Pain persisted with varying intensity. Because neither the condition of the kidney nor that of the appendix seemed to account for the symptoms a compromise incision was made. The tumor proved to be a kidney. There were many adhesions in the neighborhood of the gall bladder and the transverse fissure of the liver, and a lesser number around the appendix. There were no indications, however, of a cholecystitis nor of an abscess in this region. The adhesions were broken up and the structures around the subhepatic region were freed; the appendix was removed; and, by means of a posterior incision, the kidney was secured. The appendix showed a very mild grade of inflammation. For five days following the operation the symptoms were entirely relieved, and the temperature and pulse were normal. Then, for the following two weeks, a temperature of 100.5° F. was frequently reached. Both wounds healed. Ten days later, her temperature rose to 102° F. Her health and

strength gradually deteriorated, and râles developed over the right lower chest; a diagnosis of pulmonary tuberculosis was made. She returned to her home and remained there three weeks, during which time her irregular fever and pain persisted and the emaciation progressed. Six weeks from the date of the first operation the presence of fluid was demonstrated in the right chest, low down, and a puncture made through the ninth space, in the posterior axillary line, afforded escape to pus. An inch and a half of the ninth rib was resected just anterior to the angle of the scapula. The pleural cavity was closed by stitching the two layers together and by gauze packing. An incision made through the two pleural layers and the diaphragm exposed to view the posterior superior surface of the liver. The œdema and fibrous exudate indicated the proximity of pus. An incision was then made into the presenting surface of the liver and a blunt instrument was pushed onward until it afforded escape to some thin grayish pus. This opening was enlarged and almost a quart of the fluid was evacuated. The abscess seemed to be rather under (or behind?) the liver than in its substance; the puncture passed through the organ near its posterior surface. The kidney still remained fixed. The wound was packed and drained. A prompt and uninterrupted recovery followed. By the end of five weeks the cavity of the wound had become obliterated. The pleura did not become infected.

There are no certain physical signs by which in all cases collections of fluid above the diaphragm can be distinguished from those situated below this structure. In the case of large abscesses the following signs may be mentioned: a sharp horizontal or convex line limiting the area of dulness above; the sudden transition from dulness to vesicular breathing; and, in the case of gas-holding abscesses, Leyden's points which may be relied upon as classical. In cases of pyopneumothorax in the lower part of the chest, the following signs are of importance: full percussion note down to the edge of the ribs; then dulness in the lower rear regions where the fremitus and murmur fail; metallic tinkling and succussion sounds are distinct; at the same time signs are to be found which show that above this region the lungs are intact and expansible, and that they are carried down with deep inspiration. The dulness which indicates the presence of an exudation changes quickly and distinctly when the position of the body is changed, but this sign is much less pronounced in the case of a collection of fluid beneath the diaphragm.

It is not possible to make a differential diagnosis between a subphrenic abscess and an encapsulated basal empyema. Under these conditions all signs apply with equal value to collections under and to those over the diaphragm. In right pleural effusions it may be of some assistance to remember that the heart is displaced to the left and the liver downward, whereas in subphrenic abscess there is a distinct area of resonance between the dulness of the heart and the corresponding lateral boundary of the chest. The region over the dorsal vertebræ also gives a clear sound on percussion. (Trivius, *Medizinskoje Obozrenji*, Warsaw, Nov. 6th, 1894.) For further aid in establishing the diagnosis the history will have to be relied on. Equally impossible is it to determine positively the existence of a subphrenic abscess that contains no gas, when a large pleural exudate coexists. But when gas appears in the abscess, the diag-

nosis is made easier by the presence of a zone of tympanites between the two zones of dulness.

If, with the symptoms of pleural effusion, there is found a tympanitic area which changes its place with respiration, but which does not rise to the highest point under change of position, as it does in true pyopneumothorax, but on the contrary remains confined to a circumscribed spot within the area of dulness, then may one with some degree of certainty make the diagnosis of a subphrenic abscess. But, it must not be forgotten that a pyopneumothorax encapsuled within the thorax, at its lower part, shows the same features. Where an experienced man is led to the discovery of a subphrenic abscess through the presence of a pleural exudate it is generally in a case in which the abscess is small, is situated low down and behind, and is covered by the pleural exudate. These cases are rare, but the surgeon should suspect the existence of such an abscess when his operative interference (for the relief of the pleural exudate) is not followed by the relief which he has a right to expect, or when the badness of the patient's condition is out of all proportion to the extent of the pleural disease.

The next step in reaching a diagnosis is to make an *exploratory puncture*, a measure which can seldom be dispensed with. A hollow needle of sufficient length and strength, while attached to the exhaust of an aspirator, is slowly introduced and (still under exhaust) withdrawn. In this way very shallow abscesses, which might otherwise be overlooked, can be found. The puncture had better be made in the area of most intense dulness, and best if it can be made in the last interspace or beneath the costal arch. If possible, the puncture should be made at that point where it is intended later to incise. Thus, the possible establishment of a separate infected tract, which might lead to suppuration, may be avoided. Several, or even many punctures should be made before the search is abandoned; it being assumed that there was sufficient ground on which to make the first puncture. With the usual precautions, the procedure is harmless, unless perchance the bowel should be penetrated, which is scarcely a possible thing. Infection of the pleura is unlikely to occur, because the muscular planes of the diaphragm quickly close the opening. It is important that, while withdrawing the needle, it be kept attached to the flexible suction tube of the syringe, in order that no pus be spilled along the track.

If it be found necessary to penetrate quite deeply before reaching pus, a subphrenic abscess is more likely than a pleuritic exudation. The passage of the needle through the diaphragm can usually be discovered by the sense of touch, but Fürbringer's claim that this is further shown by the pendulum-like movement of the needle is probably unreliable, as is also Pfuhl's sign of the same—viz., a flow rhythmical with the respiration. Puncture may disclose two collections by withdrawing different material from different depths of the same puncture or from different punctures. Such a finding has occurred in one instance where several encapsulated collections lay in the pleura. As a rule, however, the finding of different kinds of fluid, when such a puncture is made, means that there are separate collections of fluid above and below the diaphragm. In view of the fact that suppuration may develop in the course of the puncture,

this little operation should never be undertaken except when the surgeon is ready to follow it immediately by incision.

Means of diagnosis are far from exhausted if the Roentgen rays have not been used. If the lung or pleura is not at the same time diseased observations made with the fluoroscope give particularly clear results. If gas is present with the pus the picture is very characteristic—a perfectly clear field lying above a dark shadow and bounded above by the line of the diaphragm with its usual contour. Upon shaking the patient, the motion of the fluid can plainly be seen. Monro reports a case in which these rays showed the position and outlines of the abscess clearly, after rib resection and several punctures had failed to reach it.

Liver abscess and subphrenic abscess have naturally been mistaken, one for the other.

Prognosis.—At this late day in the development of surgical knowledge and from what has already been said, it is scarcely necessary to state that a favorable result is to be obtained only from the establishment of thorough drainage at the earliest possible moment. It is therefore equally necessary to establish the diagnosis early, and this can almost always be done. The results of operation are difficult to give, since the vigor of the attack and the point of origin vary so greatly. As a rough estimate, it may be said that two-thirds of the cases, in the hands of competent surgeons, have recovered after operation, and one-third have died. This seemingly high mortality is easily accounted for when it is remembered that the collection drained—*i.e.*, the subphrenic abscess—is secondary,—a symptom only of some other primary trouble. A large part of this mortality, in the past, belongs to cases which originated in an appendicitis. With the greater knowledge which we now possess in regard to this trouble, we shall expect not only a greater proportion of lives saved, but also fewer cases which are permitted to advance so far. Most of the deaths occur soon after the operation—a fact which shows at how late a stage it was undertaken, and then, besides, after the subphrenic abscess has been emptied, there usually remains, for attack, the primary affection, not to mention later complications (like empyema) which must be operated upon.

The following brief history of a case (Vanlair, *Revue de Médecine*, No. 7, 1893) shows from what serious and complicated conditions a child of six may recover and also the undesirability of not operating more promptly:—

The patient, a child of 6, was suddenly seized with a chill, followed by fever, and there soon developed tympanites, diarrhœa, and pain in the epigastrium. The breathing became accelerated, but there was no cough nor any peritoneal effusion. On the tenth day there were found evidences of a beginning effusion at the base of the right lung and at the same time a painful tumor, which gave forth a dull sound on percussion, was observed in the epigastrium. Broncho-pneumonia developed at the base of the left lung. There were chills and irregular pyrexia, and there was an appreciable degree of emaciation. After several days percussion revealed the existence of tympanites over the centre of the tumor, with dulness and a sensation of resistance over the peripheral portions. In a

few more days pneumothorax appeared at the middle of the right side of the chest; it was not accompanied by cough. A thrombosis was discovered in the left femoral vein, and there was a hard painful tumor above Poupart's ligament. When an opening was made in the epigastrium, pus appeared, followed by fecal matter; then, with each inspiration, there was an escape of gas. The cavity communicated with the colon by a small opening and with the pleural cavity by a larger perforation through the diaphragm. The opening in the colon was sutured, the cavity was drained by a special opening, and the chest by an opening low down on the lateral wall. Later events were: a fecal fistula; fresh provision for drainage; a pleuro-pneumonic fistula; eclampsia; final cure.

Treatment.—There are two principal indications for treatment, viz., to empty the abscess completely and to provide for subsequent free drainage. It is not necessary to say that aspiration through a needle does not satisfy either of these indications. The fact that it has in a few instances succeeded does not alter the wisdom of the rule that this procedure should not be employed for therapeutic purposes; for where it has succeeded it is because the abscess was very small or the infection was of a mild grade. The dangers of aspiration are now too well known not to counteract these few favorable results.

Subphrenic abscess can be approached by two routes—that through the lower aperture of the thorax and that through its bony wall. The relative advantages of these have been discussed fully in the section relating to Diaphragmatic Hernia. The disadvantage of crossing the pleura is often nil, since adhesions are generally present. For retroperitoneal (perinephritic, etc.) abscesses the lumbar incision is naturally adopted; for those which owe their origin to a perforation of the stomach, the epigastric route, with or without a counter-opening through the loin or between the ribs, is preferable; for abscesses on the right side where the liver is much depressed, the incision along the costal arch will be found convenient; and for collections that do not reach beyond the confines of the chest, resection of a rib will be necessary. Against the last plan many surgeons have protested, some attempting in every case to attack the disease through the loin, pushing aside the pleura, and resecting or not the eleventh and twelfth ribs. On the other hand, accumulating experience has shown that opening the pleura is of little danger (see also under Wounds of the Diaphragm) and furnishes the freest drainage. If the leaves of the pleura are found not to be adherent to each other, the question arises, Should the pleural cavity still be opened? In reply I would say that it can safely be done by first removing from the pleural cavity any exudate that may be present, and then packing round about with gauze or drawing the diaphragm by guy-sutures against the parietes before incising this structure. Even when there are adhesions there is often also an exudate at the same time, and if this remains or becomes infected, the pleura can be drained by further resection, or both the pleural and the abscess cavities may be drained by a single opening. The exudate may also be withdrawn by an aspirator and the opening closed by suture; or, without opening the pleura, one may sew its costal layer to the diaphragm and then make an opening through both structures.

Subsequent absorption of the fluid has been observed to take place after the employment of both methods. When there are neither adhesions nor an exudate a similar course should be followed: the parietal pleura should be stitched by a continuous back stitch to the diaphragm, the line of suture should be protected by gauze, and then the abscess should be opened. To be sure, infection has in several instances followed this procedure, and in one of them a large collection of serum formed and was later absorbed, but it is still the best course to pursue. The solidity and impermeability of this line of union is shown by two cases; there was poured out a serous exudate which did not become infected. Operators who choose by preference the lower incision only, have been obliged, in some cases, to resort later to the resection of a rib.

A warning is here given against searching at once for the origin of the trouble. In addition to the usually unfavorable condition of the patient a contra-indication to such search exists in the danger of thereby destroying protecting adhesions, just as the search for a diseased appendix destroys, in some cases, the life-saving limiting adhesions which may have formed around it.

It is better to administer a general anæsthetic than to employ local anæsthesia, for it is necessary, in most cases, to make both a resection and a counter-opening. Local anæsthesia should be reserved for the weakest patients.

Mention of the method of Cantlie (*International Clinics*, Vol. LV.) in reaching deep hepatic and subphrenic abscesses, should not be omitted, as it is distinctly more than aspiration and is founded on much experience. After locating the collection by aspiration, Cantlie substitutes a wide trocar for the needle. Through the latter he passes a rubber tube, which is held in place while the trocar is withdrawn. The tube is then stitched in place and connected with siphon drainage.

The following case, which occurred in the practice of the writer, shows the importance of dependent drainage. Shortly after receiving a strain in lifting, a young man developed the symptoms of internal abscess, and in the course of sixteen days this was bulging prominently over the region of the gall-bladder, with dulness over that quadrant of the abdomen and the lower part of the right chest. The collection was easily opened, but a counter-opening in a dependent position was not sought because the surroundings (in the country) were not suitable for an extensive surgical procedure. Directions were left regarding posture to facilitate drainage, but these were not followed. At the end of three weeks the patient was found to be extremely ill and much emaciated from the sapræmia caused by the faulty drainage. There were still reasons for not searching for a place for counter-drainage; so the patient was placed on his face and instructions were given that he should maintain this position, only slight variations of attitude being permitted. In three days he was symptomatically well.

Subphrenic Abscesses of Appendicitic Origin.

Very mild grades of inflammation of the appendix, even the so-called latent appendicitis, may start the gravest secondary infections. Most of the latter are intraperitoneal, but the form of appendicitis which is most prone to cause them is the form in which the inflammation advances toward the retrocæcal tissues.

It has been found by experiment that, when coloring matter and pus are injected into the tissues surrounding the appendix, they follow a course first between the layers of its mesenteriolum, next along the tissues lying behind the cæcum and ascending colon, and then upward to the kidney or the liver. Perforation of the appendix is not necessary for such transference. There has been reported a case in which the inflamed but unruptured appendix was removed on the third day of the illness, and yet in the mesenteriolum of this appendix there were found several small abscesses. On the eleventh day appeared the first symptom (secondary rise of temperature) of subphrenic abscess, which was emptied by an incision thirteen days after the first operation. In another case the appendix was found lying in the tissues behind the cæcum, the peritoneal cavity showing neither adhesions nor abdominal fluid. The tip of the appendix showed a perforation that opened into a large retroperitoneal abscess which extended as high up as the top of the kidney, and finally communicated with an intraperitoneal abscess the size of a man's fist.

The different means by which infection reaches the hepatic region from the appendix have been estimated and observed by Monro, and presented by him in an article which was published in the *Annals of Surgery*, Nov., 1905. In addition to the ways mentioned—viz., by means of the lymphatics behind the peritoneum, with or without the formation of an abscess on the way, and with or without a pre-existing abscess of the appendix—it must be remembered that infection may be propagated by a pylephlebitis of the portal vein. It is in cases of this nature that hepatic abscesses, which are much more frequent in the right lobe than in the left, form an intermediate step between the original focus of infection and the subphrenic collection of pus, just as later we shall see the same thing taking place when the infection comes via the hepatic duct. Transference by the portal vein is naturally more rapid than by the lymphatics and usually gives a violent clinical course. Different observers hold different opinions as to the respective parts played by the lymphatics and the veins, or at least as to the route travelled when the infection appears in the liver. Retroperitoneal lymphangitis is often to be demonstrated after appendicitis, and yet in these same cases it is the portal system by way of which the metastasis takes place.

Diagnosis of portal pylephlebitis in the course of an appendicitis is now a possibility; such a diagnosis having been made by Monro two days after the patient entered the hospital and twelve days after she was taken ill. In this particular case there was nothing to call attention to the appendicitis except a distinctly local tenderness on deep pressure—a condition which had been previously overlooked. There was also slight jaundice. Several liver abscesses were immediately opened and also an appendiceal abscess. A slight jaundice which manifests itself between the primary and secondary fevers of the illness has been considered a sign of a thrombophlebitis, and it is believed by some that the latter may in some cases be only transient and that spontaneous recovery may follow. Chills are suggestive of a pylephlebitis. The following case illustrates these points and also shows the great length of time which may

elapse before the secondary abscess forms, or at least before it makes its appearance:—

A woman had an appendiceal abscess which was opened; the appendix, however, was not found. No improvement followed; instead, she had delirium and chills, and a month later a large mottled liver was explored with negative results. The jaundice then faded, but an abscess in the neck required opening. Three and a half months after the first operation, during a slow convalescence, a swelling appeared in the right lumbar region. This was opened between the ninth and tenth ribs and foul pus was evacuated. Recovery followed.

Indeed, the appearance of the secondary abscess may be delayed for so long a time that no traces remain of the original inflammation in the appendix, or, if any such be found, they will consist merely of a little thickening or of some adhesions—*i.e.*, of lesions which seem so much out of proportion to the grave secondary condition that many might hesitate to infer a connection between the two.

That a slight phlebitis may be mastered by the organism has received no proof in the dead-house, but the experiments of Lemaire support this view. They show that the liver offers, against the colon bacillus, protection to the general system up to a certain extent; purification of the infection (if it be not too violent) taking place in a few hours, and repeated purification occurring if the reinfection be not of too violent a character and if it do not take place too soon after the preceding infection. Other authorities state that they have found in the liver cicatrices of small healed abscesses, or abscesses that were encapsuled. Because of this ability of the liver to neutralize successive doses of toxic material, if not too large, and also because all portal infections are not the result of thrombi or of emboli in gross, it may be possible in a given case to improve the outlook for a favorable issue by lessening (at the first operative interference) the supply of noxious material. This may be accomplished by the complete removal of the inflamed appendix as a reservoir of toxic material, and also of its mesenteriolum, which, as we have seen, may contain foci of suppuration.

Subphrenic abscesses that originate in portal infection are much less circumscribed than those which have developed through direct extension or through lymphatic communication. Consequently they are much less amenable to drainage. Young adults, it is claimed, furnish most of the cases of portal infection following appendicitis; but, as the same age furnishes most of the cases of appendicitis, it is difficult to form a correct estimate in regard to this point.

The course of retroperitoneal abscesses is determined by the course of the lymphatics, never by gravity. We may, in some measure, be forewarned of their approach by the fact that, during an attack of appendicitis, the body temperature reaches an abnormal height. The temperature of an uncomplicated appendicitis is generally quite moderate, so that, when the fever attains an unusual height and is accompanied by chills, the inference is warranted that an invasion of the posterior lymphatics or tissues has probably taken place.

By the time this phlegmon has reached the subphrenic space, we should be ready to meet it there.

The second case mentioned in this section (p. 481) shows that a retroperitoneal abscess often becomes, in its final stage, an intraperitoneal one. This is explained (see under Anatomy of the Diaphragm) by the fact that the attachment of the diaphragm to its serous covering is relatively firm, and consequently, when a retroperitoneal abscess reaches the dome, it cannot enlarge much further without breaking through the diaphragm, or, more easily, through the peritoneum into the peritoneal cavity.

A purely intraperitoneal abscess may develop from an appendicitis in the following ways: the pus may be transferred bodily, as after a perforation has taken place; an abscess may develop in some pocket near the liver which the cleansing of the abdominal cavity failed to reach; or, finally, the subdiaphragmatic abscess may follow a general peritonitis (of appendicitic origin) where the peritoneal cavity and the iliac fossa have not been opened. Another and most unusual way is that in which the appendiceal abscess becomes encapsuled through adhesions and thus a channel is formed which reaches actually to the phrenic region. In such a case the channel may reveal itself to external touch as a resistant mass extending from the ilium to the liver. The course usually followed is through the fossa that lies outside the ascending colon and between that and the abdominal parietes; the position of the appendix appearing to determine this upward course of the pus outside the cæcum. An abnormally high cæcum naturally adds to the safety of this walling-off process, and in one such case the pus was actually directed to the left side of the diaphragm. Finally, as was shown in a case upon which the writer operated, it seems permissible to assume that the pus may, in individuals who have long and movable organs, be transferred intraperitoneally in still another manner. In the case referred to there was found, on the inner surface of the abdominal parietes, a little dextrad of the mammary line and nearer the ribs than the ilium, a small abscess, the walls of which were formed externally by the abdominal parietes, and on all other sides, by thick, gristly masses of omentum. In close proximity, but not (at the time of the operation) directly in contact with the abscess cavity (although at one time it doubtless did lie in contact with it), lay the tip of the appendix deeply buried in the same adhesions. At the point of its nearest approach were the evidences of previous perforation or gangrene, while the rest of the organ was normal. If this small direct appendiceal abscess had advanced but an inch and a half further, it would have touched the convex surface of the liver.

The fact that an appendix is dependent and that the pus escaping from it flows into the pelvis does not preclude the development (from this source) of a subphrenic abscess. In confirmation of this statement may be mentioned a recorded case in which the pelvic collection of pus penetrated to the root of the mesentery and, ascending along the spine, formed a right-sided subphrenic abscess. There were, in this case, many adhesions in the pelvis, in both pleuræ, and in several parts of the abdomen, and the mesenteric lymph nodes were enlarged and swollen.

When a left-sided subphrenic abscess comes from the appendix, it is, in all probability, an intraperitoneal one and usually represents something left over from a general peritonitis, as explained above. The retroperitoneal abscess of appendicitic origin must culminate on the right side. It will now be seen that it is no easy matter to determine the course which has been travelled by an abscess, whether intraperitoneal or extraperitoneal. Sometimes retroperitoneal phlegmons coexist with intraperitoneal abscesses. Which one of the two is to be considered the primary trouble will be decided by a careful weighing of the evidence. The following case will serve as an illustration of such a combination as that to which I have just referred:—

During the progress of an abdominal operation an intraperitoneal encapsulated appendiceal abscess was opened. By aspiration through the seventh right interspace a quantity (circa 300 c.c.) of cloudy fluid was removed. Then the tenth rib was resected and a liver abscess, composed of foul-smelling pus, was evacuated. It was found afterward that the area of dulness on the right side, extending up as high as the fourth rib, had not diminished perceptibly. Several punctures were made and the eighth rib was resected. In this way it was found possible to drain a large subphrenic abscess through an opening in the anterior axillary line. Recovery began; then followed a renewed rise of body temperature and increased discharge from the abscess. Resection of the ninth rib in the scapular line; pleura found to be non-adherent; transpleural opening of abscess in back of liver; drainage. Five abscesses developed in the thigh, and death occurred soon afterward. At the autopsy the following conditions were found:— Atelectasis of the right lung; between the rectum and the bladder there was an unopened abscess; a pus canal existed between the kidney, the liver, and the parietes, with a side channel that led between the right pleura and the spine. Although some of these collections of pus were intraperitoneal, most of them were certainly retroperitoneal.

The contents of these abscesses correspond to their origin; the pus is usually thin and dirty and always foul-smelling. Gas has been found very seldom and then in retroperitoneal collections, showing that it had originated from bacterial growth and had not escaped through an opening in the intestinal canal. Osmosis of gas through a membrane, however, should not be forgotten as a possible source of gas, or at least of odor, in an abscess lying in close propinquity to the bowel.

Thoracic complications are not rare in these cases, and, in a few instances, perforation into the lung has taken place. Dr. Rufus D. Hall, of Cincinnati, has reported such a case. Ten days after an appendiceal abscess had been opened the patient became very ill and remained so for two or three weeks, when an abscess opened into the lung and bronchi, a pint or more of pus being discharged in a few hours. The discharge lasted for several weeks, after which the patient recovered.

Pericarditis has been reported as a consequent complication.

The time which elapses between the appearance of the first symptoms indicating the development of the complication, and the rupture of the sub-

diaphragmatic abscess, may not be more than five days, but, if the period be estimated from the attack of appendicitis—the real beginning of the trouble,—it will be found to be much longer. In some cases it has appeared as late as six weeks after the appendicitis.

The prognosis, as a matter of course, varies greatly in the different cases. The course followed by the pus in its advance from the appendix to the neighborhood of the diaphragm would seem to have considerable influence upon the behavior of the secondary disease. It must also be remembered, as I have already stated, that infections which travel by way of the portal vein are specially virulent. It is also a fact, however, that the statistics furnished by different observers are quite contradictory. The abscesses that contain gas are particularly fatal. Grüneisen's wide experience in these cases supports the claim of many conservative surgeons that mere drainage of a simple appendiceal abscess is sufficient to effect a cure in almost all cases. He had no recurrences after simple incision and drainage of both collections of pus, although it is true that in one instance there was a fæcal fistula which would not close until a resection of the bowel had been made. It would seem as if the plan of treatment which has just been mentioned did not harmonize with the suggestion previously given, viz., that the entire organ and its peritoneal stalk be removed. The meaning that I intended to convey is this: where there are no contra-indications to the removal of the appendix, this structure should be removed thoroughly; but I hold that a well-circumscribed abscess, which can be reached without opening the general abdominal cavity, often constitutes a contra-indication to such removal.

It is not yet possible to give the proportion of subphrenic abscesses that follow an appendicitis, because the results from modern methods have not been tabulated. Weber, who operates early, reports but nine in three hundred and fifty cases. Naturally, the earlier the operation, the less often are such suppurative complications to be expected. An operation on the third day did not, it is true, prevent the formation of an abscess on the eighth; but the "third day" is an uncertain term, as we have pointed out, because no man knows which was the first day.

Subphrenic Abscesses of Gastric Origin.

In these cases there must be a perforation of the viscus, and such a perforation results either from an ulcer, simple or carcinomatous, or from a trauma. By far the larger number come from a simple ulcer, and those which come from a carcinomatous ulcer occur so late in the process that they can have no interest for the surgeon. If the ulcer perforates into the free peritoneal cavity a limitation of the inflammation is very unlikely, although this is helped by the prompt meteorism and by any gas which may collect above the stomach and thus push the latter down against the intestines. It is also helped by the fact that an ulcer is usually accompanied by perigastric adhesions before it perforates. When an ulcer thus perforates, it causes suppuration under the adhesions and

the pus may then slowly push its way to the diaphragm. The pushing of an aspirating-needle toward the diaphragm during the act of expiration may also be responsible for the advance of the pus in that direction.

A perforation located on the posterior wall of the stomach makes much stronger and thicker adhesions, which thus bind the organ tightly to the left lobe of the liver and to the pancreas. Perforations on the anterior wall and near the greater curvature are more likely to excite a general peritonitis; and yet there are on record some exceptional cases in which a circumscribed abscess formed as a result of a perforation in this part of the stomach wall. Perforations in the posterior wall and lesser curvature are likely to be followed by an infection of the lesser abdominal cavity. A rupture near the fundus is rare, but is much more apt than those located in other parts of the stomach to lead to a perforation through the diaphragm. An abscess which owes its origin to ulceration of the fundus of the stomach is generally on the left side. The course of these abscesses may be slow (subacute), as shown in the following case (*Erft. Med. Journal*, May 22d, 1897):—

A man who had suffered from dyspepsia, but who had never had hæmatemesis, was seized with severe epigastric pain and vomiting. Morphine relieved the pain and the vomiting ceased. It was afterward thought that at this time a small perforation must have occurred in the stomach or the duodenum. Ten days later, the patient had severe catching pain at the lower angle of the right scapula where coarse friction sounds were heard. Short cough but no expectoration. Temperature, 101° F.; pulse, 114. No signs of peritonitis. Two days later the entire border of the diaphragm was displaced upward. The area of liver dulness was replaced with tympanites, which extended as high up as the nipple. At the base of the chest on the right side there was marked dulness as high up as the angle of the scapula, and the breathing-sounds were entirely absent. Above the tympanitic area was a transverse band of dulness, two inches wide. Dyspnœa considerable. The tympanites of the stomach was easily differentiated. Two days later, an incision in the posterior axillary line, between the eighth and ninth ribs, afforded escape to a large amount of pus and gas. Serum was found in the pleura, and two weeks later this had changed to pus, which was aspirated.

On the other hand, the course may be extremely rapid, as is shown in the following case, which was reported by Meyer (*St. Petersburger medicinische Wochenschrift*, No. 40, 1892) as a case of phlegmonous gastritis:—

A man who had indulged in over-eating had, on the following day, a chill and some slight delirium, with vomiting of bile soon afterward. The vomiting continued and in a few days there were marked evidences of peritonitis, with slight jaundice and albuminuria. The area of hepatic dulness increased in extent, while posteriorly the pulmonary sounds became impaired. Pulmonary œdema, death. Autopsy: Pleural cavities contained a little turbid serum with coagula; in the pericardium there was an excess of clear serum. The diaphragm was elevated to such an extent that the heart lay in a horizontal position. The upper surface of the liver, and the ileum just above the valve, were covered with pus and fibrin. (In view of the fact that, at this date, examinations of the appendix were rare, is it not possible that fulminating inflammation of this organ was the prime cause

of these lesions?) The small peritoneal cavity contained a purulent and fibrinous fluid. Spleen enlarged. The portal vein contained a recent thrombus. The fundus of the stomach presented ecchymoses of the mucous membrane, and close to the cardia, on the posterior wall, were two small abscesses that lay between the mucosa and the muscularis and contained thickened pus. Some implication of the dura mater.

A subphrenic abscess of gastric origin is usually much expanded and occupies the entire left half of the diaphragmatic dome. The left lobe of the liver, the stomach, and the spleen are pushed down in such a manner as to leave space for a great cavity which is separated from the general peritoneal cavity by the transverse colon and meso-colon, the walls of which are attached to the parietes by adhesions. The front wall of the abscess cavity is formed by the omentum and abdominal parietes, and the right wall by the ligamentum suspensorium which has been pushed to the right. That particles of food are not often found in the abscess is due to the fact that the first perforation is usually minute in size, permitting the gas and thin fluid to pass, but not the thicker material. In most of these cases the pleura is later involved, but it is only very seldom that the inflammation culminates in an empyema. Perforation of the diaphragm occurs rather more frequently than in abscesses of appendicitic origin.

The general clinical picture is much more characteristic than is that of an abscess of appendicitic origin. The value of Leyden's signs of "subphrenic pyopneumothorax" is now established. The history seldom fails to point to long-standing stomach trouble. The attack is sudden and is characterized by collapse. The length of time between the occurrence of a perforation and the appearance of the abscess varies from four days to four weeks. Severe internal bleeding may dominate the picture.

The following case will show the complex character of these abscesses:—

A woman with stomach difficulties had a sudden attack of pain and hæmatemesis. Abdominal distention and tenderness; behind the uterus an elastic swelling. On the twelfth day incision was made in the posterior fornix; it gave exit to a light-brown, foul-smelling pus. Fourteenth day: elastic tympanitic resistance, of the size of an apple, in the epigastrium. Fifteenth day: gas and putrid pus (without food particles) were evacuated from this tumor (abscess) which was located between the diaphragm and the stomach. No perforation discovered. Convalescence set in. On the twenty-seventh day fever, pain in the left side, and a diminution of the discharge were noted. External wound closed. Thirty-second day: splenic dulness enlarged; tympany; friction sounds; diaphragm elevated 2 cm. Several punctures were made before pus was at last found. Then an incision was made parallel to the ribs, and it was found that the abscess cavity reached forward to the mammary line, upward to the sixth rib, and backward to the posterior axillary line. On the one hundred and twenty-sixth day, gastro-enterostomy was performed for the relief of the gastric ulcer.

In this case the pus took a course the reverse of that observed in a previous case, where it ascended behind the peritoneum from the region of the pelvis.

There is on record a case in which a subphrenic abscess of gastric origin healed without open drainage—a rare event. Presumably, in this case, encapsulation took place at the point where the gastric ulcer was preparing to perforate. Notwithstanding the fact that many punctures were made, no abscess was found, but a large collection of gas was drawn off. Even when the contents of an empyema were emptied by resection of a rib, no evidence of a subphrenic abscess was discovered. A later gastro-enterostomy proved that such an abscess had existed, as evidenced by the obliteration of the subphrenic space and by the presence of scars. The great accumulation of gas had prevented much extravasation of fluid.

Among the complications pyopneumothorax is extremely rare, and so is pericarditis. The mediastinum was implicated in a single case. The proportion of cases of ulcer which rupture directly through the diaphragm is variously stated.

Typical cases, with protrusion of the epigastrium, are best opened at that point, with a counter-opening at the side. If the abscess is located nearer the back, a resection alone will do.

The prognosis is not quite so good as when the abscess is of appendicitic origin. Cases even of pneumothorax, if subacute, are known to have healed where drainage alone was provided.

Subphrenic Abscesses of Duodenal Origin.

These abscesses are usually located on the right side, to the right of the falciform ligament. In the following unique case the pus pushed its way from the front of the duodenum, through adhesions, to the front edge of the liver and thence to its convexity:—

The first symptoms—stomach cramps—were observed by the patient early in January. During the following month they became more frequent and more severe, and at the same time it was noted that a tumor existed in the cæcal region and that it was increasing in size. An area of dulness was also noted in the right lower thorax. A puncture made in this region gave negative results. At the beginning of March it was found that the area of dulness extended as high up as the angle of the scapula. March 7th: high fever; protrusion, in part tympanitic, in the region of the liver. In the cæcal region there were felt two "strings" or bands which reached to the liver region. Slight icterus. March 12th: several punctures negative; pus reached in the ninth space behind; resection of rib; incision of the diaphragm. After several punctures of the liver, pus was found well to the front, in an illy defined cavity. Much bleeding from the opening that had been made with a blunt instrument; tamponade; improvement; tympany remained. March 22d: several punctures gave gas only, and it was inferred that the bowel had been entered. Soon afterward chills. March 28th, puncture gave escape to offensive gas. Incision at costal arch in mammary line opened a smooth-walled cavity between the liver and the diaphragm; it contained little pus but much gas. Death. Autopsy: Strong adhesions between the ascending colon and the liver, they enclosed a pus canal the size of the finger. This canal ex-

tended from the anterior superior spine of the ilium to the convexity of the liver, and also led under the omentum to the duodenum where there was a perforation and where stomach contents were found. The subphrenic region was found distended to the level of the second rib. One-half litre of pus was present in the right pleura. A perforation penetrated through the diaphragm and the pleura. In the substance of the diaphragm were several abscesses. In addition to the abscess in the liver which had been opened, there was another which appeared to have no connection with either the portal or the hepatic vein. The appendix was found lying in the midst of the adhesions, but it was intact.

Subphrenic Abscesses of Cholangitic and Echinococcic Origin.

There are two ways in which it is possible for the infection to spread from the gall-tract to the subphrenic space. It may, for example, pass through a perforation in the gall-bladder or gall-ducts and give rise to a pericystic abscess in or under the liver, and this in turn may, at some later date, involve the under surface of the diaphragm. Evidence of these different steps may often be seen in operations on the gall-tract. In the next place the gall-ducts may be greatly distended (*e.g.*, through the presence of obstructing gall-stones), and this condition of distention may extend back as far as the finer ramifications in the liver. Should these become infected, the inflammation may easily pass to the convex surface of the liver. The following condensed report of an autopsy furnishes the only example of this condition of which I have any knowledge:—

Extreme icterus; the upper surface of the left lobe of the liver covered with thick purulent lymph, beneath which may be seen multiple focal abscesses that extend down into the liver substance; old adhesions surrounding the hepatic ducts; common duct impermeable below, widely dilated, and containing disintegrating gall-stones; liver enlarged, hard, and deeply bile-stained.

The course last described is the same as that observed in cases in which the subphrenic abscess owes its origin to echinococcus disease. There is, however, one appreciable difference between the two: in cholangitis the abscesses are very small, while in the case of echinococcus disease large cysts break through. The course pursued in cholangitis is shown in the following brief account:—

The patient had had gall-stone colic for a year without icterus. At time of operation there was slight fever, and the abdomen was distended and tender, especially over the liver. No discoverable tumor. An incision over the gall-bladder released much sweet bile. Bladder itself quite small; no perforation found. Bile had passed between the adhesions as far as the convexity of the right lobe of the liver. Stone in cystic duct; otherwise the passages were free. Uneventful recovery.

Abscesses such as are now under consideration are generally right-sided and intraperitoneal; as a rule, they also contain bile and occasionally stones. On account of its instructive character I will give here a brief account of one of Maclaren's cases of subphrenic abscess of cholangitic origin.

The abscess, which reached from the liver to the umbilicus, was incised and a quart of bile-stained pus was evacuated. The gall-bladder filled with stones could be felt above. Drainage established. Improved health. Four and a half months later, a second operation showed a contracted, universally adherent gall-bladder containing stones and no bile. The liver was very firmly fixed, and, in separating adhesions between the liver and the diaphragm, the finger unexpectedly broke into a large abscess. Without withdrawing the finger, which was allowed to remain in the abscess cavity until the following manœuvre was completed, the operator resected two inches of the seventh rib in the anterior axillary line, opened the pleura, tamponed the opening all around until all inspiratory sounds had ceased, then opened the abscess through the diaphragm and let out eight ounces of thick, offensive pus. Counter-opening in the back. Seven days later, two stones were discharged. Slow recovery followed.

The history of the ailment and the general position of the region diseased will, in most cases, lead to the adoption of a correct diagnosis. The height of the upper limit of the liver will aid the surgeon in determining whether or not a perforation has taken place in the gall-bladder. As to the best method of operating, the decision should depend upon the object which the surgeon has in view. If he desires to attack the primary disease he should make his incision in the rectus abdominis muscle; but, if his chief object is to secure proper drainage, he should make his incision in the patient's back. When an abscess of the liver is present at the same time, it may be found best to press the organ firmly upward and then to reach the abscess from above by making an incision through the diaphragm.

In a fair share of the few cases of echinococcus which have been reported, a previous operation for removal of cysts has been responsible for contaminating the subphrenic space and thus establishing in this locality an additional centre for the growth of the parasite. As the echinococcus is often found in the liver, that organ is responsible for a large percentage of the cases of subphrenic echinococci, the cysts of which, being located either on or in that organ, often burst into the space under discussion. The following cases show that it is not always possible to make out clearly the true nature of the disorder:—

For five months the patient had suffered from typical gall-stone colic. When he came under observation he had fever and was intensely jaundiced. He also had catarrh of the bladder, for the relief of which an incision was made and drainage established. Three weeks later, thoracotomy; a large echinococcic sac was emptied and partly drained. For a short time bile appeared in the fluid that escaped from the wound in the sac. As the pleura had been sutured at the time of the resection, the pleural cavity remained uninfected.

In another case it was evident, from the fact that daughter cysts had occasionally passed by the bowel with accompanying colic and icterus, that there must have existed a communication between the cyst and the gall-passages. Notwithstanding the existence of a general peritonitis and of great prostration, Lobker's operation was performed. An incision made in the bulging epigastrium gave exit to large quantities of a cloudy serous fluid from the abdominal cavity. The cut edges of the peritoneum were sewed to the parietes, as was also the left lobe of the

liver. An opening was then made in the liver and two litres of pus, containing numerous vesicles and a large portion of the parent cyst in necrotic pieces, were evacuated. The cyst occupied the whole space between the liver and the diaphragm. After the effects of the shock had passed off, the patient made a rapid recovery.

The Australian surgeons have had much experience with echinococcus disease, and it may, therefore, be advantageous to mention their method of attacking a cyst of the upper surface of the liver. After resecting the eighth or ninth rib near the costal arch, they make one bold stroke of the knife through the diaphragm into the cyst. Then they insert one finger, pull out the cyst, and insert a drain, thus completing the operation in five or six minutes.

Subphrenic Abscesses of Splenic Origin.

These abscesses are generally caused by the lodgment of a septic embolus in the spleen. The various sources from which such an embolus may come are these: endocarditis, pyæmia, typhoid fever, rheumatism, etc. That the spleen has first broken down is shown by the necropsy, or by finding in the discharge pieces of spleen, of microscopic dimensions or of some size. Post-partum sepsis, as a matter of course, furnishes a plentiful number of cases. These abscesses always lie within the arched space formed by the bony thorax, to the left side and behind. They are neither to be clearly palpated, nor percussed. A diagnosis is seldom made. The first symptom is pain, due to splenitis, and it may manifest itself as early as eight weeks before the disease is recognized. Since the abscess in the spleen is secondary and the subphrenic abscess tertiary to some other trouble, the illness is commonly of a severe character, with high fever, symptoms of a general septic condition, and dulling of the sensorium. Generally, the presence of a pleural exudate is the only thing that is demonstrated by the examination. In most cases empyema develops as a complication. In some instances perforation of the diaphragm has occurred. The finding of bloody pus may be considered characteristic of a burst splenic abscess.

The prognosis in the present class of cases, as in the other classes, depends on the nature of the primary disturbance. If the abscess owes its origin to an ulcerative endocarditis the outlook is naturally hopeless. In all cases the course is long and the prognosis uncertain and at best unfavorable. Nevertheless, a cure has followed the establishment of drainage even when the conditions were severe. The spleen has been known to be extruded from the abdomen by an abscess in which it floated, this abscess bursting at the navel. Resection of a rib is indicated in all cases, especially as the thoracic viscera are so frequently implicated in this form of the disease. In one of the cases observed, a gas-containing abscess developed over the spleen eight days after an attack of typhoid fever. Puncture in the ninth interspace revealed the presence of pus. After an absence of one year the patient returned and a resection of the tenth rib was made. Pieces of spleen were discharged. Eleven weeks later he died of a violent pneumonia. At the autopsy strong adhesions were found between

the lung and the spleen, and abscesses containing air were found in the latter organ.

Subphrenic Abscesses of Rarer Origin.

Subphrenic abscesses of *pancreatic* origin are rare, because the usual primary cause, necrosis, is rare. Pancreatic calculi must not be forgotten as a possible cause. The collection of pus is confined to the bursa omentalis. It develops in an upward direction and toward the left, where it is easily attacked from the side. In one case, after resection of a rib, the diaphragm was incised, and a tough, fixed, rough membrane, which proved to be the inflamed peritoneum, protruded from the wound. It was not found necessary, as is usually the case, to incise the peripancreatic abscess from in front, and thus to open the peritoneal cavity. This may indeed be the better way of reaching pancreatic abscesses, if they show signs of developing toward the loin, for better drainage is thus secured and the general cavity of the peritoneum is protected.

Subphrenic abscesses of *perinephritic* origin are rare, notwithstanding the fact that suppuration of the kidney is relatively common. In the first place, only the upper pole of the kidney is in contact with the diaphragm. Consequently, when the pus of a renal abscess breaks its way through the capsule of the kidney it must first perforate or dissect up the peritoneum before it can form a distinct abscess beneath the diaphragm. Then, in the next place, perinephritic abscesses have a greater tendency to descend beneath the psoas fascia to the pelvis than to force their way upward. Finally, the setting up of a retropleural inflammation or an empyema, even after the perforation of the diaphragm has taken place, is a more frequent result of the bursting of a renal abscess than is the development of a subphrenic collection of pus. Doubtless, in a number of instances the existence of the renal abscess has been overlooked. Urine free from contamination does not necessarily exclude pyonephrosis. In one case of subphrenic abscess it was erroneously supposed, when it was incised, that it was of appendiceal origin, because the pus came from a cavity that extended along the psoas to the pelvis. As a matter of fact, the source of the trouble lay in a stone in the kidney, with kinking of the ureter. Tuberculosis is naturally a not infrequent cause and requires nephrectomy, partial or complete.

J. Wm. White points out that pains about the loin or the hip-joint are often symptoms of this abscess; and a still more valuable symptom is flexion of the thigh and the trunk, with pain when it is extended (tension of the psoas under the ligamentum arcuatum internum). When such symptoms are associated with some obscure disease of the lower part of the thorax the surgeon should not fail to examine the upper part of the abdominal cavity.

Costal disease can lead to subphrenic abscess only when the ribs affected are adjacent to the diaphragm, and then only when they are diseased on their inner surfaces. The necrosis has always been of a tuberculous nature, although trauma must be conceded as a possible cause. However, in those cases in which a trauma has been the direct exciting cause it has been found that tuberculous disease of the bone previously existed. In one instance the costal necrosis ap-

peared to be of a metastatic nature, following a furuncle. The subphrenic abscesses of costal origin are generally slow in forming, seven months having elapsed in one case between the first pain and the recognition of the trouble. There may be a collection of pus outside as well as inside the ribs. If the abscess heals after mere emptying, the presumption is that it was not caused by a necrosed rib, particularly not by a necrosis of tuberculous origin.

While *pleural inflammation* so often follows subdiaphragmatic disease, the reverse is rare. The disturbance may go so far as to produce fibrinous deposits, but we have no means at our command by which we can actually demonstrate this during life. Even where the lower abscess develops consecutively to a higher one, the causative connection can only be surmised.

Lymphadenitis and *suppuration of mesenteric lymph nodes* may be causes of a subphrenic abscess. The subsequent rupture of the latter or of the retroperitoneal abscess into the peritoneal cavity, occurring coincidently with the collapse or disappearance of the swelling due to the abscess, may easily be mistaken for the occurrence of a perforation caused by a typhoid intestinal ulcer. The violent infection which soon supervenes may be sufficient to distinguish it from the typhoid accident.—Since tabes mesenterica is known in the fœtus, such a catastrophe may occur very early in life. Nobel has reported a case of this nature in which the infant had suffered, since the time of its birth, from tabes. On the fifty-first day several ounces of creamy pus burst from the navel. Autopsy showed the subphrenic abscess intermediary between the caseated lymph nodes and the navel.—Pyosalpinx following labor is reported as the cause in some cases. As gonorrhœa is now considered the usual cause of this pelvic condition, it will be proper here to ascribe the cause to the coccus of Neisser. It is claimed that abscess of the liver is a necessary intermediate stage in such transference.

Among the other possible causes of a subphrenic abscess may be mentioned hæmatocele, bullet wounds, strains and contusions causing extravasations, typhoid furuncles, especially of the face, childbirth, and mediastinal abscess.

SURGICAL TREATMENT OF GENERAL SEPTIC PERITONITIS.

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Introductory Remarks.—Septic peritonitis is a surgical disease and its treatment should be exclusively surgical. Until the year 1880 the treatment of general peritonitis had been mainly medical. Toward the middle of the last century Alonzo Clark, of New York, introduced his well-known method, the most important feature of which was the giving of large doses of opium. For thirty years this continued to be the most popular and successful method and its almost universal employment certainly reduced the mortality of this grave disease. About the year 1880, the operative interference was first considered and laparotomy soon became the prominent method of treatment. It quickly displaced the older methods and was accepted as the most rational and successful plan of treatment. It cannot be said, however, that all surgeons are entirely in accord as to the propriety of operating in all cases of general septic peritonitis. The majority undoubtedly favor operative interference at all stages of the disease. Others favor operation in the primary stage only, and still a third party prefer treatment by rest and starvation, with postponement of the operation in the expectation that localization of the septic process will result. The details of the numerous operative methods have greatly varied. That the results which have followed these various plans of treatment do not seem, until within recent years, to have greatly differed, is a proof of the strong reparative power possessed by the human peritoneum, and of its ability to abort or localize septic processes. Recently there has been greater unanimity of opinion as regards the principles of treatment. There is still, however, considerable difference of opinion as to the operative details. Elaborate and painstaking methods are rapidly disappearing in favor of simpler measures. The result of this change from the thorough but more complicated methods of the past to the simpler ones of the present has been most encouraging. The mortality of the disease has been greatly reduced.

It must be distinctly understood that the same methods should not always be employed in the treatment of general septic peritonitis. Operation is generally, but not invariably, indicated. The removal of the infecting focus is indicated, and is of the greatest importance, but cannot always be safely accomplished. There are many exceptions to all such general rules. The adoption of any one method for all cases is a mistake. The principles of treatment are not always the same, and the details of practice should vary accordingly. While it is true that immediate operation is indicated in the majority of cases, yet it is

also true that in certain other cases it is contra-indicated. There is also, in certain cases, an elective time for operation. The cause of the peritonitis must, to a certain extent, influence the decision as to which of these courses it is best to adopt.

Causes of Septic Peritonitis.—The causes of peritonitis are varied and numerous. To call peritonitis *spontaneous* is simply to display our ignorance. It is questionable whether it is logical to attribute peritonitis to rheumatism or exposure to cold. Traumatism can be regarded as a direct cause of aseptic, and an indirect cause of septic, peritonitis. It is always possible for aseptic peritonitis to become septic, as it is not difficult, especially if the intestinal wall has been injured, for bacteria to migrate into the peritoneal cavity. Under certain conditions, even without visible lesion of the intestine, bacteria may pass through its wall. Septic peritonitis can, however, have but a single cause, viz., infection by pathogenic bacteria. The germs alone, without other irritating material, may enter the peritoneal cavity, or in addition there may be the contents of one of the hollow viscera, or other foreign material. Inasmuch as the etiology of the disease influences the treatment it will not be amiss to mention the usual causes of general septic peritonitis. These are mentioned below in the order of their approximate frequency. Appendicitis heads the list, and is responsible for nearly four-fifths of the cases.

(1) Appendicitis—any of the various types of inflammation.
(2) Perforative ulcers of the stomach and duodenum.
(3) Puerperal infection (extension from a puerperal uterus).
(4) Perforation of the Intestine due to
  (a) Typhoid ulcers.
  (b) Foreign bodies.
  (c) Tuberculosis.
  (d) Diverticula.
(5) Suppuration or gangrene of
  (a) Gall-bladder.
  (b) Liver.
  (c) Meckel's diverticulum.
  (d) Spleen.
  (e) Kidney.
  (f) Pancreas.
  (g) Lymph nodes.
  (h) Prostate.
(6) Traumatic rupture of
  (a) Stomach.
  (b) Intestine.
  (c) Gall-bladder.
  (d) Urinary bladder.
(7) A septic embolus from some distant focus, as a pneumonia or a meningitis.
(8) Pyelophlebitis.
(9) Suppuration or breaking-down of an intra-abdominal neoplasm.
(10) Post-operative.

Prophylactic Precautions.—Prevention, as a matter of course, should be the keynote in the treatment of all abdominal diseases which tend toward peritonitis. This article deals solely with septic peritonitis already established. The most important point in its treatment is the early recognition of its development. This is not always easy. While generally the onset is announced by frank and distinct changes in the symptoms of the causative disease, yet occasion-

ally the first symptoms noted are those of peritonitis, the causative disease not having been recognized. In other cases the grave symptoms of peritonitis develop so slowly and insidiously that the septic inflammation has already become more or less generalized before we are really aware of the development of this dangerous complication. This treacherous behavior of certain abdominal diseases—as, for example, appendicitis—is the strongest argument for early operation. Could such a rule be established, the number of cases of peritonitis would be greatly reduced. It is also true that where, for one reason or another, early operation has not been performed, peritonitis would be a much less frequent complication were proper precautions observed concerning food and medication. (See Ochsner's method, on page 522.) The physician and surgeon are often to blame for neglect of such precautions. Overfeeding and castor oil are responsible for many a case of peritonitis and for many a death.

Terminology.—There has been, and there still is, some confusion as to the proper adjectives to employ in describing the different forms of peritonitis. The terms "general" and "diffuse" are considered as synonymous. When employed, they mean that the septic inflammation has extended throughout the entire peritoneal cavity. It is useless as well as impossible to ascertain whether or not every square millimetre of surface is affected, but, for either one of these terms to be appropriately employed, there must be infection in all quarters of the cavity, extending up into each flank and down each loin into the bottom of the pelvis. The term "diffuse" is rather to be preferred. The term "universal" is also appropriate, though less popular. The term "spreading" is largely employed, but is somewhat indefinite, as it does not indicate the extent of the spread, which may be slight or extensive. In connection with this term, we must not forget that peritonitis is frequently a conservative process. It may be Nature's method of protecting herself from a local septic lesion. A peritonitis may spread in an attempt to surround this lesion by adherent structures, and we should be careful not to regard this beneficial measure as a spreading septic infection. We should therefore be careful, in certain cases, not to handicap Nature by a too hasty operation. This conservative and protective attempt, however, often fails, and there is need of most skilful and careful observation in order to decide whether or not it is to be successful.

(1) We will first consider those cases of peritonitis which have been caused by a frank and free perforation of one of the hollow viscera (stomach or intestine). Under these conditions a steady stream of septic as well as of chemically and mechanically irritating material continues to flow into the general cavity of the peritoneum. This structure, as a rule, is capable of absorbing a considerable amount of poison, but when this steady stream continues to issue forth through the perforation in the gastric or intestinal wall, its localization or absorption cannot be expected and the occurrence of such a fortunate outcome is so unusual that its possibility should be entirely ignored. Immediate operation is demanded. The general principles and details of the operation, to be later described, should be carried out; but, in addition, it is often necessary, and always wise, to remove by irrigation the foreign material which has escaped into the

abdominal cavity. At the same time the perforation or tear must be appropriately repaired.

(2) Appendicitis is by far the most frequent cause of general septic peritonitis. It is accountable for about eighty per cent of the cases. The peritonitis may result from direct extension of the septic inflammation caused by the diseased appendix, or it may be excited by infection from the poisonous material which issues from a perforation in its wall.

One occasionally encounters cases of peritonitis in which the cause cannot be ascertained prior to the operation. Generally, however, even in these obscure cases, there is some symptom or other which directs suspicion to a definite organ. If there be an absolute lack of such symptoms, both positive and negative, it is generally wise, especially if the patient be a male, to make a provisional diagnosis of appendicitis. According to the doctrine of probabilities this diagnosis will, in most cases, prove correct.

Every surgeon of large experience must encounter a certain number of moribund patients. As regards acuteness of judgment and surgical wisdom, some communities are better educated than others, yet in every locality there will always be found timid and unwise practitioners, men who will allow their patients to drift on and on toward a fatal general peritonitis. This negligence, however, is not the only reason why desperate cases will fall into the surgeon's hands, for it is not an unusual thing to see a fulminating peritonitis blaze up almost without warning,—a case that is hopeless from the first. In many of these semi-moribund cases it is a difficult task for the surgeon to decide whether or not operation be indicated or justified. In some of them it is certain that an operation should not even be considered, for it will be worse than useless and will only bring discredit on surgery.

It is needless to describe the appearance of a dying man. The young surgeon, however, who has not yet seen many patients in this state, should not be deceived by the mental alertness which they sometimes manifest. The pulse may be imperceptible at the wrist, the extremities cold and blue, and yet the patient may be bright and talkative up to the very moment of his death. The excessive anxiety of expression is, however, generally very noticeable. The difficulty of deciding is even greater when we encounter patients who, though desperately ill, are yet not in such a deplorable condition as to exclude all chances for recovery if they are subjected to a prompt and rapidly completed operation. There is the possibility always that the patient, especially if he be below middle age, may be rescued from the very jaws of death. He should not be deprived of this chance, faint as it is. It is not easy to describe in words the signs and appearances which make the case hopeless and contra-indicate operative interference. If the vomiting be excessive and profuse, the countenance dusky, the finger-nails blue, the pulse 150 and almost imperceptible, it is generally wiser to abstain from operation, especially if the patient has passed his thirty-fifth year. But if the patient be a child or a healthy young adult, there may be—even under such desperate circumstances—a possibility of recovery should an operation be performed. The contra-indications are even stronger if the

mind is confused and dull. This is apt to indicate profound septic or uræmic poisoning, and renders the prognosis hopeless.

The arriving at a decision is perhaps less difficult when the condition of the patient appears less desperate, when the pulse, though perhaps 130 to 140, is yet distinctly felt at the wrist, and when the sluggishness of the circulation is less marked. In all these cases it is understood, of course, that the other symptoms (vomiting, distention, etc.) are typical of a general peritonitis. The point of the greatest importance, in reaching a conclusion, is perhaps the age and natural constitutional resistance of the patient. While it is not true that nearly every youthful person will recover and nearly every old person die, if operated upon for peritonitis, irrespective of the type of operation performed, yet this strong statement contains a certain kernel of truth. The prognosis of elderly patients with these alarming symptoms is exceedingly bad, and is practically hopeless if they have led dissipated lives. The young and previously healthy patient, who has led a moral life, has always some chance for recovery. There is no other disease in which youth counts for so much in its influence upon a favorable prognosis. It is always well to be perfectly frank with the patient's friends, and to allow them to share in the responsibility of electing or rejecting operation. Some families prefer to take the chance of an operation, even if it is not better than one in one hundred, while others would, under the same circumstances, decline to take the risk. It is justifiable, even when we know that the risk is very great, to advise operation in a case in which the outlook is otherwise *absolutely* hopeless. When, through an intestinal perforation, septic material continues to pour, we must conclude that operation affords the only possible chance of recovery. It is easier under these circumstances, even in the most desperate cases, to recommend operative interference. Where, however, appendicitis is the cause, the sepsis factory may not be so active, and may at any time "close down"; in other words, the case cannot be judged as absolutely hopeless. Under such conditions, therefore, we are not always warranted in taking such very great risks. It is the surgeon's duty to advise operation if there be the slightest chance for recovery. He must not take his reputation into consideration, nor shrink from the possible criticism which may be directed against him for "cutting up" a dying man. His first duty is toward his patient; he must, however, protect himself by a frank statement, to the friends, of the extreme gravity of the operation. Fortunately, within the last few years, the medical profession have become more alert in their recognition of symptoms which are suspicious of peritonitis, and are more ready to call for the services of a surgeon. The public, at least, now recognize that appendicitis and kindred diseases demand the opinion of a surgeon. As a consequence, fewer moribund cases are thrown into our hands.

All cases of septic peritonitis are, however, very serious, and we must expect that many a desperately ill man will still demand our attention. When our opinion is sought for a patient who is in the primary stage of a general septic peritonitis (due to appendicitis), what plan of treatment shall we advise? Shall it be operation or the so-called Ochsner method? A categorical answer cannot

be given to this question. The great majority of surgeons, however, would recommend immediate operation in all such cases. There can be no question but that, for children or young adults, this should be an almost invariable rule. When, however, the patient is an elderly or broken-down individual, there is room for difference of opinion. The danger of an operation is very great. A considerable proportion of these patients can be safely carried along, by the adoption of the Ochsner method of treatment, until the process localizes itself, and then a less dangerous operation can be performed. Unfortunately, this happy result does not always follow, and when the peritonitis continues to advance, we may then regret that the non-operative plan was selected.

It is of the utmost importance that we should recognize that, in certain patients, at the very commencement of their peritonitis, their resistance may not be as great as it will be after the expiration of a few hours, the fighting qualities having been more or less overwhelmed by the sudden attack of the sepsis. The local conditions are unfavorable for an immediate operation. The intestines are markedly distended and paretic. The heart is much depressed by the suddenness of the blood infection. In a few hours both these conditions may have improved. The intestines will probably partially recover their tone, the leucocytes will increase rapidly in number, and the phagocytes will be better prepared to carry on the fight. A delay of a few hours is therefore sometimes of advantage. The surgeon must wait, however, knife in hand, ready to interfere at a moment's notice, should the patient fail to show signs of gain in his powers of resistance.

When a patient is brought to us in the more advanced stage of general peritonitis,—say, on the second or third day of the disease,—what plan of treatment shall we advise? The arriving at a decision is now more difficult. The chances of recovery under any plan of treatment are slight. Operation will, however, in the average case, probably give a slightly better chance for recovery than will the adoption of the Ochsner method. Much depends on the age and natural resistance of the patient. In reaching a decision all the personal and social features of the case should be taken into consideration. The weight of surgical opinion, however, rather favors operation. And yet, an intelligent minority of surgeons would doubtless prefer treatment by the Ochsner method.

(3) The type of peritonitis which owes its development to the other causes mentioned above is very similar to the two types already described. The indications for treatment are also similar, and the choice of method will somewhat depend on the quantity and quality of the septic material which is escaping into and infecting the peritoneal cavity.

Ante-Operative Preparation of the Patient.—The ante-operative preparation of the patient who is suffering from general septic peritonitis is not of so much importance as it is in laparotomies which are performed for the relief of other conditions. He should not be disturbed by elaborate preparations, either local or general. His entire vitality should be preserved in order that he may stand the shock of the operation, and that he may make a strong fight against the sepsis from which he already suffers. He must not be annoyed by measures

which will cause either physical or mental irritation. Such measures are sometimes enforced simply because it is the rule of the institution or of the surgeon.* These patients are in a desperately weak condition, and it is of especial importance that they be not disturbed by the fussing over trifles which, perhaps for a strong patient, may be quite harmless, though annoying, but which, for this class of patient, may be absolutely dangerous. It is difficult to enunciate definite rules for the preparation of these patients. Every operator is apt to have his own methods. The state of the gastro-intestinal tract and the force of the heart are the conditions which demand the most attention. As regards the stomach, it is of course important that it be as empty as possible. If, however, it appears to be comparatively quiet and not overfilled with fluid, it is better that it should not be disturbed. If, on the other hand, it is filled with fluid which is generally of a spinach-green or dark-brown color, or of the character of coffee grounds, it is generally wise to employ lavage, either before the anæsthestic is administered or before anæsthetization has been carried to the full surgical degree. In a case of peritonitis in which there is profuse vomiting, it is never wise to employ lavage when the patient is fully under the influence of the anæsthetic, as there is always danger that the substances vomited may enter the trachea and pass downward into the lungs. This is, indeed, one of the calamities which may happen during the operation itself, when the patient is pouring out large quantities of dark-colored fluid. If the reflexes be totally abolished, the danger of self-drowning is considerable. A great responsibility rests on the anæsthetist. Death on the table has occurred more than once from this cause. Lavage during the progress of the operation may be necessary because the constant flooding of the mouth and pharynx prevents the proper administration of the anæsthetic and imperils the life of the patient by the immediate risk of drowning and also by the later danger of inspiration pneumonia.

As regards the intestinal tract, it may be said that, if any doubt exists as to the generalization of the peritonitis, a cleansing enema should not be given, for its effect will be still further to spread the infection. On the other hand, it must be admitted that the effect of such a lavage will in some measure be beneficial in relieving the intestinal distention, but this advantage is more than offset by the greater danger of the extension of the peritonitis. Should the peritonitis be general, this danger need not be feared, and the administration of such an enema immediately prior to the operation is often of advantage. Possibly the fluid injected will not be expelled; but, even if such failure result, no harm will follow, for after a temporary discomfort the water quickly passes into the blood-vessels, which usually have been sadly depleted by the vomiting.

It is generally wise to omit skin preparation until the patient it at least partially anæsthetized. Some patients, however, will not be disturbed by shaving and the application of a green-soap poultice. If this can be accomplished it will be of advantage, for, after anæsthesia is complete, not an extra moment should be consumed with skin preparation.

*The enforcement of general rules for the preparation of patients, while perhaps necessary in large institutions, is often disastrous to the comfort of the patients.

The Administration of an Anæsthetic.—The anæsthetist is of more importance than the anæsthetic. Ether, if administered by an inexperienced man, is more dangerous than chloroform when given by an expert. The latter anæsthetic, however, should never be employed unless a skilled anæsthetist can be secured. Under ordinary circumstances ether is the safer reagent, and it should be administered by the so-called "open method." As a rule, the circulation is poor, and the preliminary use of nitrous oxide gas, unless it be administered conjointly with oxygen, is apt to increase its sluggishness. Sometimes the preliminary use of chloroform, until the reflexes are abolished, is of advantage. Whatever be the anæsthetic chosen, the duration of its administration should be as short, and the degree of anæsthesia as light, as possible. Spinal anæsthesia is but rarely indicated. Its depressing effect on the heart is greater than is that of a general anæsthetic skilfully administered. In the case of some patients, local anæsthesia may be advisable, but its disturbing mental effect and the depressing influences of most of the drugs used for this purpose, should not be forgotten.

Operative Technique.—Rapidity and gentleness are the two important qualities of the successful operator, but they are of even more essential importance when the laparotomy is performed for peritonitis. In operations of this character, the slow or rough operator cannot expect favorable results. His mortality will be much greater than is that of the surgeon who works rapidly and handles the intestinal coils with delicacy. Very few of these patients will successfully withstand an operative period of more than thirty minutes; indeed, any laparotomy for peritonitis should be completed well within this half-hour period. Too much attention cannot be given to these features of the operation. Many a surgeon wonders why his results are inferior to those of other operators. He does well to wonder, for the explanation may sometimes be his cumbersome and clumsy technique. An operation is often prolonged many minutes because of lack of complete preparation of all the necessary paraphernalia. Everything should be ready for immediate use. The failure to sterilize some instrument or to provide solutions at the proper temperature may mean a delay of several minutes. Such delay may turn the scale. The wrong suture material or the awkward needle may mean aggravation of the surgeon and perhaps less perfect technique. Improper temperature of the solutions may increase traumatism or induce shock. Poor assistance on the part of surgeons or nurse may cause unwarrantable delay. Because of the great importance of such complete preparation, the surgeon himself or an experienced assistant should critically examine the entire operative outfit before the patient is placed upon the operating table. For this purpose, two pairs of eyes are better than one. Surgeons are apt to have their own peculiarities as regards instruments, sutures, sponges, compresses, etc. Every operator will work better with his own assistants and with his own tools than with those of another. It is well, therefore, for the operator to be personally certain that instruments which are satisfactory to himself, are at hand and ready for immediate use. It may be thought that excessive importance is being given to these details, but they are really the most important part of the entire operative procedure. No other details will so influence results.

Operators who employ radically different methods will often obtain results that are almost equally favorable, but, on investigation of their technique, it will be generally found that these men, besides being gentle in their manipulations, complete the operation rapidly, mainly because of thorough preparation and well-trained assistants.

The Incision.—The incision should be of such length that the surgeon may quickly and properly remove the cause of the peritonitis. A length of from 7 to 12 cm. (3 to 5 inches) generally suffices for this purpose. If this length does not afford ample approach, the incision can easily be made longer in a few seconds. In operations for desperate conditions, the future strength of the abdominal wall is of comparatively minor importance, but the surgeon's endeavor should always be to avoid unnecessary damage to any part of man's anatomy. The possibility of future hernia should always be borne in mind, as some form of intermuscular incision will often prove as efficient as one which passes directly through the abdominal muscles. The McBurney gridiron incision will sometimes afford sufficient space for the necessary manipulations, especially if the operator be accustomed to work through a small incision. More frequently, however, a larger opening is needed, and this can easily be provided by extending the McBurney incision by means of a transverse (Lennander) or a vertical (Weir) cut through the anterior sheath of the rectus muscle, which is then retracted inward toward the median line. The Kammerer (or Battle) incision is most satisfactory, though perhaps it is not so well suited for the purpose of drainage. Probably, however, the incision which is best suited for the majority of operators is a vertical one directly over the right rectus, with vertical separation of its fibres. Another excellent incision which is much employed, is one along the outer border of the right rectus muscle. This has the advantage of giving abundance of room for any intra-abdominal work, but it is somewhat more likely to be followed by hernia. If the incision employed be the oblique one, directly through all the abdominal muscles, the chances for future hernia are great. The position of the incision should necessarily vary according to the location of the original lesion. An area should be selected which will give the readiest access to the lesion. Its adaptability for purposes of drainage should also be considered, but this feature is not of so much importance because a counter-opening can always be made for this purpose. The lesion is most frequently to be found in the right half of the abdominal cavity—as, for example, a perforated appendix or Meckel's diverticulum, a gastric, duodenal, or typhoid ulcer, a gangrenous gall-bladder, a pancreatitis, a right-sided pyosalpinx, etc. In all of these conditions a vertical incision through the right rectus muscle will afford easy access to the lesion. Indeed, in cases of doubt, but where the right side is suspected, this incision is probably the most satisfactory. It will not, of course, reach such lesions as a perforated diverticulum of the colon, an abscess of the spleen, or even, perhaps, a perforating ulcer of the cardiac end of the stomach, but all of these are unusual conditions which could not be reached by even a median incision. If, in a case in which the cause of the peritonitis is unknown, there be no signs pointing to a left-sided lesion, one of the incisions through the right rectus should gen-

erally be selected, as there are about ten chances to one that the lesion will be found to the right of the median line. Wherever the original incision be situated, a secondary opening may be found necessary, either for readier access to the lesion or for purposes of drainage. Uncertainty as to the nature and position of the original lesion is not at all uncommon. Under these circumstances, the original incision should be as short as possible, as it can afterward be lengthened upward or downward according to the situation of the lesion, and thus unnecessary cutting of the abdominal wall may be avoided.

The incision should be made quickly down to the peritoneum. This structure, however, should be divided most carefully, as there is always risk of injuring the distended intestines which are in close approximation or even slightly adherent to this structure. It is useless in these operations to protect the edges of the wound from skin contamination by means of layers of gauze. As soon as the peritoneum has been divided, fluid, which may be either turbid serum or pus, escapes. It merely flows out and does not issue in a spurt as it is apt to do when a localized abscess has been opened. The intestines, usually much congested and distended, are then apt to crowd themselves out of the wound. They must be gently restrained by gloved fingers, rubber protective, or moist pads of gauze. While they are thus protected and held aside, search is made for the cause of the peritonitis; and in this search both the sense of sight and that of touch are employed. Usually some definite organ is at least suspected, and should be at once sought out and examined. If the lesion involves the stomach or the intestine, the unhealthy portion should be brought out of the wound and rapidly repaired. If it be located in an organ which cannot be brought to the surface, it should be so isolated by gauze that the necessary manipulations can be safely made. While this is being accomplished, the intestines are generally troublesome, crowding themselves into the operative field and—if deep suturing is used—causing embarrassment to the operator. They should be carefully restrained and protected by moist gauze pads held in place, perhaps, by broad retractors. Sheets of rubber protective are even less injurious. It is of the greatest importance to avoid damage to the serous coat of the bowel. Removal of the endothelial cells opens up new avenues to infection. While these details are being accomplished, if it be the operator's desire to employ irrigation, the nozzle of the irrigating tube should be introduced as soon as the decision that irrigation is desirable has been reached. Many valuable minutes can thus be saved. During all this time it is of the greatest importance that the intestines be carefully protected from injury, as little exposed to the air as possible, and kept warm and moist. Mere contact of the intestinal wall with gauze, if dry, will produce a slight irritation, and for this reason the gauze pads should be as gently applied and as scantily employed as is possible. Patches or plaques of lymph (fibrin) are frequently seen scattered over and adherent to the intestinal coils. It is often a temptation to pick them off the wall of the bowel, but this should not be done, because the result would be a raw surface, and a new area exposed to infection.

The Type of Operation Employed.—The general type of operation, which in

this year of 1909 is generally adopted, is a gradual development from the various methods that have been practised in the past. It has been reached mainly through the principle of excluding those useless and burdensome details which experience has shown to be not only unnecessary but also dangerous. American surgeons deserve the main credit for the development of this modern operation. Our technique, however, is not definitely settled, and it must be distinctly understood that no one method is suitable for all cases. As to some of the minor details of the operation, there are still radical differences of opinion. In a general way, the steps of the operation are as follows:—The intestines must be handled with delicacy and kept warm and moist. Search for the lesion must be conducted cautiously but rapidly. When found, it must be suitably repaired or removed. If there be masses or quantities of foreign material, irrigation with hot salt solution should be employed for their removal. If the fluid be turbid serum or thin pus, irrigation had better not be employed; if it consist of thick and foul pus the advisability of irrigation must be decided by the operator's personal judgment. Each separate collection of pus should be opened and, if necessary, separately drained. Drainage, in the shape of a small tube or cigarette, is usually advisable; preference being given to the tube if the pus be foul and thick or if there be a sloughing area far from the abdominal wound. In the absence of these conditions the cigarette will usually suffice. It is often wise to make a counter-opening for drainage, either in the loin or (if the patient be a female) through Douglas' sac into the vagina, in order that pocketing of pus in these regions may be prevented. The wound should be partially closed by sutures, and retention sutures (left untied, but ready to be tied later) should be passed through the abdominal wall close to the point where drainage emerges. If the patient is in collapse on the table, a venous infusion of 1,000 c.c. of salt solution may be given. It would be simpler to commence proctoclysis on the table, but unfortunately it is apt to be rejected when the patient is under the influence of the anæsthetic. It should be at once begun, however, when the patient reaches the bed. Whiskey can be added to the solution. The patient should be immediately placed in Fowler's position. Unless the patient is in a condition of grave shock drugs should not be employed. It is much wiser to rely on hot salt solution injected into a vein under the skin, or *via* the rectum. It is especially unwise to whip up a tired heart by injections of strychnine. The winning post is still far off, and reserve strength is needed for the ensuing fight. Much harm is often done by medication on the table or at the close of the operation. An hour or two later the demand for stimulation may be greater. Should proctoclysis, however, have been employed, the blood-vessels will have been partially, at least, supplied with fluid, and this later post-operative critical period will then not be so apt to follow.

Irrigation.—At the present day there is considerable difference of opinion concerning the advisability of employing peritoneal irrigation. Surgeons are, perhaps, equally divided in their opinions on this important question. The modern tendency, however, seems to be toward omitting this step, at least as a routine procedure. Of course, in certain cases, its employment must evidently be

beneficial, as when there are present in the peritoneal cavity particles of foreign material or irritating liquids—as, for example, partially digested food, fecal matter, masses of blood, or the contents of an abscess. Under such circumstances, removal of these irritating substances is indicated, and this can best be accomplished by free flushing of the cavity with hot salt solution. The presence of such substances is most deleterious, and all arguments as to the danger of spreading the infection by means of the irrigating fluid must be ignored. Such conditions are apt to follow gastric or intestinal perforations, ruptured pyosalpinx and ovarian cysts, and traumatic lacerations of blood-vessels, liver, or spleen. Under these circumstances irrigation is distinctly indicated.

The situation, however, is very different when there has been no such escape of foreign material into the peritoneal cavity. Its own exudate, the result of the septic inflammation, constitutes then the only abnormal material present. This exudate may be scanty, as in "dry" peritonitis, or it may consist of turbid serum or pus more or less abundant in quantity. Two important questions then present themselves: Is it beneficial to wash away as much of this secretion as is possible, or shall we allow as much of it as will not escape of its own accord through the wound, to remain in the peritoneal cavity? In this latter case, Nature must be trusted to dispose of it as she will. These are questions which at present are engaging the attention of many abdominal surgeons. The pathologists are also trying to aid in the solution. So far, the answers received are by no means satisfactory to all surgeons, and as a consequence there are radical differences of opinion. Before the problem is solved, one must first learn whether the action of this peritoneal secretion be mainly injurious or mainly beneficial. If a satisfactory conclusion with regard to this point could be reached, the indications as regards drainage would be clear.

The advantages of irrigation are: (1) Efficient removal of foreign material—on this point surgeons are practically agreed; (2) the safer and more prompt elimination of the bacteria and their septic products. That the removal, in a large measure, of the peritoneal exudate can thus be accomplished is self-evident. The advocates of irrigation claim that it is advantageous to remove from the abdomen the bulk of the exudate, and that also, by the dilution of what remains, the osmotic current is directed away from the peritoneal cavity. They maintain—and experiments in a measure support their claim—that fluids are absorbed from the peritoneal cavity by osmosis, rather than by way of the lymphatics, and that, consequently, less burden is thrown on the kidneys, liver, etc., if the concentration of the peritoneal fluid be reduced. On the other hand, the opponents of irrigation maintain, in the first place, that infection is more widely disseminated by its use, and that bacteria are carried in profusion into regions where formerly their growth had been limited; and, in the second place, that irrigation is immediately followed by a severe blood infection, the bacteria in the blood-vessels greatly increasing in number in a very few minutes. This latter point seems to be well-established, and it accounts for many cases of what was formerly called "secondary shock"—a condition which, as we now know, is caused by an overpowering toxæmia.

For purposes of irrigation, various solutions have been employed. Many of them have possessed irritant as well as antiseptic qualities. All have practically been abandoned, just as has been the case in other branches of surgery, in favor of bland solutions, non-irritating, and resembling blood serum in their constitution. Salt solution, in physiological strength, has been very generally adopted. Ringer's solution has also been employed, because of its supposedly less irritating qualities. The solution should have a temperature slightly above blood heat (102° to 108° F.). It should be delivered from the nozzle with moderate force, and the stream should be fairly large, so that the cleansing process may be effected as rapidly and as thoroughly as possible. As a matter of course complete cleansing is impossible, and too much time should not be expended on this detail of the operation. Either the rubber hose itself may be employed, or there may be attached to it either a long glass nozzle, perforated with numerous openings, or one of the double-current irrigating nozzles devised for this purpose. The latter nozzle permits both an entering and an emerging stream. The latter stream should wash outward toward the opening in the abdominal wall, and not away from it. For this reason the entering stream should first be delivered as far away from the seat of the lesion as is possible and the most distant areas should be first made clean. It is especially wise to cleanse thoroughly the flanks and the spaces below the diaphragm. The exudate, through the action of the force of gravity, is apt to collect in the loins. The under surface of the diaphragm absorbs bacteria with great rapidity, and this is the most dangerous region in the abdominal cavity in which to allow septic material to collect. Our endeavor, therefore, should be to wash away from this region, toward the pelvis, especially if the abdominal incision be situated below the umbilicus. The pelvis is at the other end of the scale so far as danger of absorption is concerned. It is better able to take care of septic material than is any other part of the cavity. Should the incision be situated above the umbilicus, a secondary opening, either in the loin or above the symphysis pubis, can always be made for drainage. The cleansing should be as thorough as the limit of time allows, for it is unwise to consume more than a few minutes in this process. If the irrigation be carried out simultaneously with the other steps of the operation, but little additional time is needed. It must be borne in mind that complete cleansing is impossible.

The beneficial effect of the hot solution is at once felt, and the heart is stimulated. The extremities become warmer. Some of the fluid is at once absorbed into the blood-vessels, and the beneficial effect is shown in an improved circulation. As a rule, replenishment of the fluid which has been lost through vomiting is badly needed. Further to supply this want it is beneficial, at the close of the operation, to allow a litre or more of the solution to remain in the peritoneal cavity. In the course of ten or fifteen minutes this will have been absorbed. The stream should be allowed to flow until the sutures have been inserted and the wound is ready for the dressing. By conducting the process in this manner, no time will be wasted, the peritoneal surfaces will be kept moist, and the vessels will be kept supplied with artificial serum. The argument has

also been advanced that the solution which remains in the cavity will prevent the adhesion of peritoneal surfaces. This is probably fallacious reasoning.

Drainage.—Drainage is another of the modern problems which provokes discussion, and about which there is still considerable difference of opinion. Surgeons are not by any means in agreement, either as to the principles or as to the practice of drainage; indeed, their views are often radically different. In America, at least, the tendency is toward less and less drainage. Many of the German surgeons, however, still cling to the tamponade of gauze. The insertion of bare gauze into the peritoneal cavity, unless in exceptional cases, is no longer popular in this country, and is now but rarely employed. Of course, when necrotic tissue remains, or when a sloughing process is likely to follow, a light tamponade of gauze is often necessary—as, for example, when the inflamed appendix has not been removed. A few operators are now entirely omitting peritoneal drainage, and they claim that no disaster has followed. In many cases this may be a safe practice, but it is never wise to conclude that sloughing or suppuration will not follow in the neighborhood of the septic lesion, even if this has been apparently removed. It is but seldom that any harm can result from the presence, for thirty-six hours, of a smooth and slender drain, and at the end of this period it can generally be determined whether or not its further employment is necessary. It is therefore unwise entirely to omit drainage, and the great majority of surgeons habitually employ, for a short period at least, drainage of some sort.

Methods of drainage differ. As a rule, drains should be slender and their external coats smooth. Multiple drainage from several openings is apt to be, not only useless, but also injurious. As regards drainage material, perforated rubber tubes (perhaps split longitudinally) and cigarette drains (a strip of gauze or lamp wick covered throughout its entire length by rubber tissue) are the most extensively employed, and give the most satisfactory results. These different drains should not, however, be indiscriminately selected. If the secretion consists of thin fluid, such as turbid serum, the cigarette drain will usually suffice. It should generally be removed from the peritoneal cavity at the end of thirty-six hours, unless the discharge in the mean time has changed into thick pus. The abdominal wall, however, should usually be drained for a day or two longer; and this is accomplished either by not completely extracting the cigarette or by substituting in its place another cigarette or a strip of rubber tissue or protective. The cigarette drain can be extracted without pain provided that the end of the gauze has not projected beyond its rubber cover, and provided no disturbance of the intestinal coils accompanies its removal. Instead of the cigarette a small rubber tube, perhaps split longitudinally, can be employed. Some operators consider that a stout strip of rubber tissue or protective may be substituted and, in many cases, this slight form of drainage seems to be efficient as well as sufficient. The inexperienced surgeon, however, had better employ the larger drain. A large personal experience is needed in order to decide wisely in what cases drainage can be safely omitted. In cases of doubt, it is always better to drain.

If, however, the peritoneal exudate be pus, or if a deep foul abscess has been opened, a soft-rubber tube is the best form of drainage. If the walls of the abscess cavity be covered with necrotic tissue, a strip of gauze may be loosely packed in the cavity and its end brought out through a drainage tube. In this manner bare gauze will not rest against the intestinal coils at any point, but will be in direct contact with the walls of the sloughing cavity. The strip can be gradually extracted, a piece two or three inches long being drawn out on the third and each of the succeeding days up to the sixth or seventh, by which time the cavity will have cleared up and further drainage will no longer be needed. As a rule, plain sterile gauze or lampwick is best for this purpose, but, if circumstances point to the probability that the gauze must remain undisturbed for several days, iodoform gauze may be substituted. Among the conditions which indicate the impropriety of early removal of gauze, is the existence of a foul abscess located at some distance from the abdominal wound. Such a cavity must probably be drained for many days. Early removal of the drainage would probably be followed by the so-called pocketing of pus and the formation of a local deeply situated abscess, the recognition and localization of which might be very difficult. This state of affairs might be expected to follow the removal of a sloughing appendix from Douglas' cul-de-sac. Removal of the gauze at an earlier period than the third or fourth day would be unwise, for its replacement, prior to the formation of a canal with uncollapsible walls, would be a most hazardous and uncertain procedure. At the end of four or five days, however, the drain can be safely removed and a new strip of gauze or a tube substituted.

It is sometimes wise, for purposes of more direct drainage, to make a secondary opening—as, for example, above the pubis, posteriorly in the loin, or through the vaginal vault. Through such an opening, a tube, strip of gauze, or both combined, may pass directly into the infected region. In patients with very thick abdominal walls and heavy muscles, it is at times of advantage to employ a glass drainage tube (2 cm. in diameter). Through this may run a strip of gauze which can be easily replaced when it becomes foul. It has been asserted that a glass tube is more likely than one of rubber to cause a fecal fistula. It is doubtful, however, whether this assertion is correct. The main objection to a drainage tube of any kind is the tendency, which it apparently has, to cause ulceration of the wall of the bowel at the spot against which it rests. This results eventually in a perforation, with a fecal fistula. For this reason, a tube should never remain, in exactly the same position, longer than forty-eight hours. A slight change in its relationship, effected by rotating it or by withdrawing it for a short distance, will largely obviate the danger of its producing a fecal fistula. A tube split longitudinally is also less likely to cause ulceration. The formation of a perforation is sometimes rightly attributed to the negligence of the surgeon, who has permitted the employment of a tube the end or the side openings of which had not been properly polished—such rough places in the glass are always a source of danger. Care should be taken that all edges be made as smooth and rounded as possible.

Drainage of the peritoneal cavity for a period longer than thirty-six or forty-

eight hours is rarely practicable. A small local area can be drained almost indefinitely, but all true peritoneal drainage soon ceases. It was long a fallacy that, because abundant purulent secretion would continue to flow from the drain for days or weeks, the presence of the tube was necessary to carry away the poisonous products from the peritoneal cavity. Under this impression the surgeon was formerly in the habit of sucking out periodically, with a syringe, the fluid which had collected in the drainage tube. It is now recognized that this theory of benefit being derived from prolonged peritoneal drainage is false. The drain is a foreign body. Its presence is resented, and the peritoneal surfaces in its immediate neighborhood continue to secrete fluid in abundance simply in order to wash out the foreign body. Such irritation is not only useless but harmful. It is a purely local drainage, the tube having been, by adherent peritoneal surfaces, shut completely off from the general cavity. It is unwise, therefore, to allow a peritoneal drain to remain longer than two days, for it has a decided tendency to cause intestinal stasis, if not obstruction. If, however, the tube or gauze has been employed for the drainage of a sloughing cavity, its presence is needed until the sloughing process has ceased and the reparative process has begun.

Evisceration, or the deliberate removal of the bulk of the intestinal coils from the abdominal cavity for a brief time, is rarely indicated. Indeed, all efforts should be made to prevent the escape of the intestines from their cavity. In past years, evisceration was often employed for purposes of more thorough cleansing. It was then thought that the more thorough was the cleansing of the peritoneal cavity, the better were the chances for recovery. With this object in view even rubbing the peritoneal surfaces with gauze was sometimes practised. This latter procedure is distinctly objectionable. It is of the greatest importance that the endothelial covering should not be disturbed, and consequently it is now generally believed that there should be as little handling of the intestines as possible. Even if the fingers be covered with rubber gloves all manipulation should be as gentle as possible. Evisceration undoubtedly causes shock. Heat is abstracted, and surfaces become more or less dry in spite of protection by hot moist towels, etc. The intestinal coils are much distended and their return into the abdomen is accomplished with difficulty. This may be very great, demanding deeper anæsthesia, the loss of many precious minutes, and much handling. If the intestines should have freely escaped, despite our best efforts to restrain them, this troublesome complication may face us. There is not sufficient room in the abdomen for these distended organs. The time and manipulations needed for their replacement will greatly increase the shock of the operation. To avoid this and to make possible an easy and gentle replacement it is sometimes necessary to make a small incision in the wall of the ileum and allow gas and intestinal contents to escape.

Temporary Enterostomy.—An opening such as has just been described, made for the purpose of causing the collapse of the distended intestines, is termed a temporary enterostomy. The incision should be made parallel to the long axis of the bowel. A length of 2 cm. ($\frac{3}{4}$ inch) is generally sufficient. A certain

amount of gas and much fluid will at once escape. The inexperienced, however, will be surprised at the slight amount of collapse produced. The opening will drain the contents of a portion of bowel not much longer than two feet, and the distention of the remaining coils will be unaffected. In order to empty these a milking process may be employed, but this is more objectionable and less effectual than Monk's device of threading the intestines over a stiff tube of rubber, glass, or silver. Several feet of bowel can thus be emptied. Of course, in these manipulations, in order to prevent infection from the escaping gas and feces, the intestinal coil which is to be opened must be well drawn out of the wound and away from the other coils, which must be thoroughly protected by warm moist towels. The patient should be turned on the side toward the operator. If the ileostomy be made merely for the purpose of temporarily emptying the bowel, the opening should be at once closed by a row of Lembert sutures of fine silk. After the necessary washing has been done, the bowel is returned.

It may be deemed best, however, to make a permanent enterostomy. Some surgeons have great faith in the efficacy of one or more such openings. The main advantage is the resulting relief of the enormous intestinal distention which commonly exists, and the removal of the decomposing contents. The thoracic organs are relieved from pressure and intestinal absorption is diminished. If desired, the bowel can be washed out, and nutritive fluids poured in through the intestinal opening. The immediate disadvantages are the additional time necessary for the establishment of the fistula and the additional wound, with the increased traumatism. The later risks are those attending any intestinal operation —accidents, it is true, but occurrences, nevertheless, which must be taken into consideration; and then, besides, there are the disagreeable features of an artificial anus and the additional dressings which it requires. Of equal importance is the secondary operation for closure which is generally necessary, and which often, in order to prevent inanition, must be performed on a weak patient. If, however, the cæcum had been selected,—and it is the part which ordinarily should be selected for the enterostomy,—this danger of malnutrition is little to be feared. Such a fistula will sometimes close spontaneously. It is believed by some surgeons, however, that through an opening situated so low down the small intestine cannot be satisfactorily emptied; and, to secure this desirable result, it has been suggested that an additional opening be made in the jejunum, so that effective irrigation may be practised. Multiple openings have even been practised. Except under most unusual circumstances, more than one enterostomy does not seem justifiable, and this should be made in the cæcum or lower ileum. It is not a procedure, however, which can be generally recommended. The majority of surgeons do not favor its employment.

A permanent enterostomy is best made by inserting a tube into the intestinal opening. Several tubes have been devised for this purpose. The best is one or other of the variously shaped Mixter tubes. This is fastened into the bowel by means of a purse-string suture, and the adjacent surfaces of visceral and parietal peritoneum are united by sutures.

The injection of sulphate of magnesia in concentrated solution into the upper

part of the small intestine by means of a hypodermic needle has been employed by some operators with apparent benefit. It is doubtful, however, whether in the ordinary case this is an advisable procedure.

Multiple drainage openings are, as a rule, inadvisable; they may, however, be required in cases where there are separate individual collections of pus. It was formerly the practice of some surgeons to employ such openings for intermittent or continuous peritoneal irrigation. This is a dangerous practice, however, and has been practically abandoned.

The Ochsner Method.—The principles on which this method is based were first promulgated by A. J. Ochsner, and consequently it is generally known as his plan of treatment. It is true that, for some time, all of its details had been in more or less general use, and many surgeons were independently arriving at somewhat similar conclusions; but Ochsner deserves all credit for his original combination of these details and for his bold advocacy of their wide range of applicability. When first introduced, the method was violently assailed. It was met by a storm of criticism, and extreme positions were taken on each side of the question. Perhaps extravagant claims were made by its enthusiastic advocates; but, on the other hand, its opponents put forward, with great fervor, arguments and statistics to prove that the method was most dangerous, and that, if it were generally adopted, the mortality of appendicitis would be greatly increased. Many of its opponents, however, do not seem to have given the method a fair trial, and the greatest difference of opinion still exists, as regards both its real value and its range of applicability. It is undoubtedly a measure which has worked harm as well as good. The excellent results which have been reported as due to the Ochsner method have encouraged timid or ignorant practitioners to postpone, in a most unjustifiable manner, needful operations. These men have entirely misunderstood Ochsner's recommendations as to the range of applicability of his method. Through their ignorance or obstinacy they have allowed patients, who could certainly have been saved by an early operation, to drift into a state which is practically hopeless. As an excuse for adopting such a course they point to the excellent results which have been secured by the starvation method. It seems at times as if they wilfully twisted Ochsner's own expressions; for certainly no man is more earnest than he in his advocacy of early operation. He believes, as do all surgeons, that extension of the infection can be prevented by early removal of the appendix. This is true as long as the infection is confined to the appendix. When, however, it has spread beyond the limits of this structure and has involved the neighboring peritoneum, he advocates delay and the employment of his method of treatment until the infective process shall have located itself and the spreading peritonitis shall have subsided.

It should be said, on the other hand, that the influence which Ochsner's method has exerted is in many respects beneficial. Apart from their direct bearing on the individual case, the results of the practice of this method have distinctly shown that many a case of peritonitis can be saved without the performance of an immediate operation, and that, if this be delayed for some hours

or even days, the patient may be placed in a stronger position to resist the fresh access of sepsis which is so apt to follow every septic operation. This delay will often allow the blood to marshal its forces into better battle array, and will enable the intestines to recover some of the tone which has been temporarily, at least, weakened by the blow of the enemy. The pulse will become fuller, the abdominal distention will become less marked, and the whole aspect of the patient will improve. The demonstration of such a rally, temporary though it may be, is perhaps the best evidence of the benefits which have been derived from the practice of the Ochsner method. The lesson thus taught is gradually, though far too slowly, influencing the practitioner to abandon the employment of cathartics, and to trust to starvation. Ochsner thus expresses his views:— "This form of treatment cannot supplant the operative treatment of acute appendicitis, but it can and should be used to reduce the mortality by changing the class of cases in which the mortality is greatest into another class in which the mortality is very small after operation. It will take patients who are sure to die in the hands of the average surgeon, and will place them in a condition in which any surgeon with reasonable skill, and clean hands, can make a safe operation." He believes that the distribution and extension of the infection are accomplished by the peristaltic action of the small intestine; and the inhibition of this movement constitutes the most important detail of his treatment. He also believes that the spread of the peritonitis can gradually be stopped, and that the extensive inflammation which already exists will gradually subside, provided that the intestinal peristalsis can be arrested. It is his endeavor, while the diffuse inflammation is gradually subsiding, to confine the septic process to the immediate neighborhood of the original lesion. He claims that, in the great majority of cases, it is possible to do this. As a rule, at the later date,—that is, in five or six days,—the local abscess must be opened and the appendix removed. The operation, under these circumstances, is comparatively simple, and the risk attending it is very trifling in comparison with the risk of removing the appendix from an abdomen whose peritoneum is the seat of a diffuse inflammation. It is especially in this class of cases that the operative mortality is so great, and the advocates of the Ochsner method claim that its adoption in the treatment of these patients has saved many lives. As a rule, the patient does not escape without abscess formation, but occasionally even this will be absorbed, and no operation will be needed. There seems to be no doubt but that pus can be absorbed, even in large quantities, by the peritoneum.

The two important features of the method are: first, absolute starvation; second, the removal from the small intestine of all particles of food or any other material which might produce peristalsis. The administration of food of any kind, or of cathartics, should be absolutely prohibited. Even tea, broth, or acid or aromatic drinks of any kind are forbidden. Vomiting, in order to rid the stomach and intestines of irritating contents, is encouraged. No attempt should be made to stop the emesis, except, perhaps, by the employment of lavage. Reverse peristalsis will often completely empty the small intestine. Should there be persistent nausea or gagging, or much abdominal distention, gastric lavage

should be employed. It should be repeated at intervals until the stomach and small intestines are emptied. Peristalsis will then subside. The blood-vessels should be supplied with water. Large enemata should, however, never be employed. They are most dangerous, because of their excitation of peristalsis. Small enemata of four or five ounces may be administered, but the drop method of proctoclysis is distinctly preferable. The chances for localization of the septic process and subsidence of the diffuse inflammation are much greater, if, from the commencement of the attack, no food or drugs have been administered. Castor oil is especially prejudicial to a happy outcome.

The weakest point in the argument in favor of the method is the indefiniteness of what is termed the early stage of appendicitis. The boundary line between this stage and the next can rarely be defined. On the average, the early stage terminates at the end of the first thirty-six hours, but, unfortunately, there are many exceptions to any such rule, and the early stage may either not be recognized or be only of a few hours' duration. No surgeon, even he with the widest experience and keenest judgment, can determine with certainty whether or not the disease is limited to the appendix.

The views as to the relative value of this method differ so widely that it is not easy to express any definite opinion. The surgeon of experience must rely on his own observations. The tyro, however, is lacking in personal experience, and he must therefore be guided by what he has seen and read. He should be familiar with both sides of the question. When the applicability of the method for advanced cases of appendicitis and for diffuse peritonitis was first urged by Ochsner, the mortality of these operations was very great—for the appendicitis cases, fifteen per cent; for the peritonitis cases, from forty to fifty per cent, although some operators reported a much smaller mortality. There can be little doubt but that, up to the year 1902, Ochsner's treatment of these cases was more successful in saving life than was operation. In the last three or four years, however, the mortality of operation has been gradually decreasing, and at the present day it is not greater than eight or ten per cent for the grave class of appendicitis cases and perhaps ten or fifteen per cent for those of peritonitis. Far better results than this have been reported, but these figures represent approximately the death-rate of the average surgeon. The arguments, therefore, for the adoption of the Ochsner method are less forcible at the present day than they were eight or ten years ago. It is doubtful whether its general adoption will give as good results as will operation when performed by a skilful surgeon. When the services, however, of a clever surgeon cannot be obtained, its employment is probably preferable to a bungling operation. There exist good reasons why the method should be adopted in certain selected cases. What is this type of case in which its adoption, if not absolutely indicated, should at least be considered? The most important is the elderly patient with grave symptoms. The mortality attending immediate operation on this class of patient is great, and if, in addition, he be handicapped by diseased liver or kidneys, the risk of operation is enormous. Peritonitis in this class of patients, especially if they have led dissipated lives, is, under any form of treatment, a very fatal disease.

Immediate operation, however, is attended with a greater mortality than is treatment according to the Ochsner method. At the opposite end of the scale are children or young healthy adults. For these, operation is indicated at every stage of the disease. Between these two extremes, are the debatable cases, and they are decidedly in the majority. Each surgeon must here decide for himself. If lacking in experience, he must be influenced by the views of the men in whom he has confidence. It should be understood, however, that the majority of surgeons favor immediate operation in all these patients. Should he operate, he will be supported by the weight of surgical opinion. Should he not operate, and the patient die, he may not only blame himself for his adoption of the conservative course, but may also subject himself to the adverse criticism of his colleagues and the patient's friends. His choice of method should also be influenced by his own skill and experience. If he knows that he can complete the operation within twenty minutes, he should be more inclined to advise operative interference. A fair statement of views entertained by surgeons as to the general applicability of the method in cases of advanced appendicitis and peritonitis, would seem to be as follows:—

(*a*) The majority of surgeons (probably seventy per cent) are opposed to its adoption.

(*b*) A minority of perhaps fifteen per cent favor its universal adoption.

(*c*) Another minority of perhaps fifteen per cent favor its adoption in selected cases only.

After-Treatment.—While the technical features of the operation itself are of the greater importance, yet the final result is more or less influenced by the subsequent management of the patient. Special attention should be paid to the replenishment of the blood-vessels with fluid, to the condition of the gastro-intestinal tract, to the maintenance of mental quietude, and to posture. The patient, at the close of the operation, is apt to be in a more or less collapsed condition, but at a later period (varying from thirty minutes to five hours) this state of collapse is apt to be still greater. The nervous shock of the operation is partly responsible, but this later grave condition, which appears after the patient has been returned to bed, is mainly due to the increase in the number of bacteria in the blood, as the result of change in the osmotic current and of the exposure of new areas to infection. "Secondary shock" was the name sometimes applied to this condition, and it was frequently the forerunner of death. In anticipation of its possible occurrence, the nervous system should be quieted by a hypodermic injection of morphine (gr. $\frac{1}{8}$ to gr. $\frac{1}{4}$) given at the close of the operation. The heart should be strengthened to withstand the toxic action of the bacteria, and the patient should be immediately placed in Fowler's position. The most reliable and comfortable means of quieting the nervous system and improving the circulation, is supplying the blood-vessels with a fluid as nearly resembling serum as possible. This should be supplied in a slow and gentle manner. If the condition of shock is well-marked, it may be necessary to inject 1,200 c.c. at once into a vein. As a temporary stimulant to tide over a crisis, it is vastly superior to any other. A slow and continuous supply of water is, however, of

more permanent benefit. Hypodermoclysis of the same amount is often an advantageous method of administration, but even this may be too rapid, and, besides, the process is one which generally causes discomfort and mental distress to the patient. The rectum is the preferable route. The ordinary enema of from eight to ten ounces is certainly effectual, but less so than the continuous current which flows in drop by drop, and is as slowly absorbed. This method of proctoclysis should be at once begun, as soon as the patient is placed in bed. Orders for its preparation should have been given in advance, so that there may be no delay in its administration. Its intermittent use should be continued for two or three days, or at least until the patient's stomach is sufficiently quiet to retain liquids. Started immediately after the completion of the operation, the procedure should be continuously employed for two, three, or four hours. It can then be discontinued for an hour or two, to be again resumed and continued for a couple of hours. This intermittent proctoclysis should be maintained for at least twenty-four hours, there being perhaps twelve hours for rest and twelve hours during which the current is kept flowing into the intestinal canal. On the second day the periods of rest may be prolonged, and, as soon as water can be retained by the stomach, the procedure may be discontinued. The effect of this rectal sipping of salt solution is not only markedly beneficial to the heart, but it also restores tone to the intestines, quiets spasm, and diminishes the paretic condition. Under its influence the heart-beat becomes stronger, the pulse fuller, the tongue moister, and the skin less dusky. Often, on the second or third day, flatus will quietly pass along through the bowel and be properly expelled. As a rule, neither cathartics nor purgative enemata are needed.

TUBERCULOUS PERITONITIS.

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Historical Remarks.—The chronic forms of peritonitis have been known to the profession for many hundred years. Hippocrates resorted to the use of a hot iron to puncture the abdomen for the removal of fluid in cases of ascites. Celsus also recommended the withdrawal of the fluid from the abdomen for the relief of this condition, and some of the cases so treated recovered and remained well. Marcello Donato, of Mantua, about the year 1600, is said to have been the first to discriminate between general and localized ascitic accumulations. It was about the same time that Santoro, a professor at Padua, invented an instrument which was a forerunner of our present trocar and cannula, and was then substituted for the instruments previously used in the withdrawal of fluids from the abdomen. It remained, however, for Louis, of Paris, in 1825, to give expression to the thought that the chronic forms of peritonitis are usually of tuberculous character. Henoch,[1]* in 1855, described cases of chronic contraction of the omentum associated with a large amount of fluid in the abdomen and the presence of pseudomembranes upon the peritoneum. These patients were, without doubt, suffering from tuberculous peritonitis. It was in 1862 that Spencer Wells, operating upon a case which he had diagnosticated as ovarian cyst, found, to his astonishment, in an abdomen filled with ascitic fluid, widespread nodular growths upon the peritoneum. After he had cleansed the abdominal cavity and had closed the wound, the patient, to his surprise, not only made an operative but indeed a permanent recovery. That the true character of tuberculous peritonitis was not recognized even as recently as 1882 is evidenced in the article written by Heineke [2] on "Surgical Diseases of the Abdomen," in Billroth and Pitha's "System of Surgery." His statement is, that "chronic tuberculous peritonitis is to be assumed to exist when, in addition to the ascitic accumulation, tuberculosis of other organs or caseous foci in some other parts of the body can be found." Evidently the experience of Spencer Wells had made but little impression upon the medical profession. It remained for Koenig [3] in 1884 to appreciate this condition and, as a result of his investigations, deliberately to recommend for it surgical treatment. In the description of his cases he discriminated, for the first time, between the ascitic collections in the abdomen of tuberculous origin and those arising from other causes. He demonstrated also that this condition could occur as an ascites or in the form of multiple cysts, and that there need not necessarily be other evident

* These numbers refer to the corresponding numbers in the Bibliography at the end of the article.

tuberculous foci in the body. This paper attracted the attention of the entire profession and his prediction that tuberculosis localized here would prove as amenable to surgical treatment as had other forms of surgical tuberculosis, has been abundantly verified. In the same year Dr. C. B. Adams, of Framingham, Mass., performed one of the first operations in this country for tuberculous peritonitis.

Etiology and Pathogenesis.—The frequency with which tuberculous peritonitis occurs is variously stated. Altschul,[4] at the International Congress on Tuberculosis held in Washington in the autumn of 1908, stated that, in 10,322 autopsies, tuberculous peritonitis was found 299 times—a trifle under 3 per cent. In 2,230 autopsies performed at the Charité in Berlin, Koenig reported that there were 107 cases, or nearly 5 per cent. Cummings, of Philadelphia, found it 92 times in 3,495 autopsies—that is, in 2.7 per cent. Sick, of Hamburg, and Muenstermann, of Muenster, reported the lowest percentages—namely, 1.8 per cent and 1.6 per cent respectively. The highest rate was recorded by Borschke, of Vienna,—namely, 5.3 per cent. Bircher,[5] who collected the statistics of 19,184 autopsies from nine different sources, found tuberculous peritonitis in 671,—an average, therefore, of 3.5 per cent.

The occurrence of tuberculous peritonitis as a primary affection has been questioned. That it is very rare is without doubt true. A few undisputed cases, however, are on record. Benndorf[6] reported a case in which he found tubercles disseminated throughout the entire peritoneum, yet, after a careful search of the rest of the body at the autopsy, he was unable to discover any other foci of the disease. Meissner[7] reported a similar case. Cummings[8] found, in the 92 cases referred to, 3 which were primary. Of the 46 cases of peritoneal tuberculosis reported by Muenstermann,[9] 2 were primary. In 4,250 autopsies reported by Borschke, of Vienna, 226 cases of peritoneal tuberculosis were disclosed, and in but two instances was the disease primary. It is apparent, therefore, that the study of large numbers of cases of tuberculous peritonitis leads to the conclusion that in about 2 per cent the disease is found to be a primary affection.

On the other hand, there is usually evidence of coincident tuberculous disease of other organs. This occurs most frequently in the lungs, which Koenig found involved in 92 per cent of his cases, Sick in 85 per cent, and Cummings in 84 per cent. The intestines were likewise affected with tuberculosis in 74 per cent of Koenig's cases and in 65 per cent of those of Sick, while Cummings discovered this complication in but 32 per cent. Additionally, these same observers found the Fallopian tubes and the ovaries, the pleura, the kidneys, the liver, lymph nodes in various localities, the spleen, and the mesentery frequently involved in a tuberculous process. General tuberculosis was discovered by Koenig in 10 per cent of the bodies examined on the autopsy table.

We are therefore confronted, in the study of tuberculous peritonitis, by a condition which, in exceptional cases, is limited to the peritoneal cavity and may not only involve at the same time other important structures, but may be merely one of the manifestations of a general tuberculosis. This deeply concerns

us, whether we view this pathological condition from a clinical, a therapeutic, or a prognostic standpoint.

There are, however, other features to be discussed in considering the etiology and pathogenesis. The statements thus far made represent the findings at the autopsy table. Naturally, these do not present a correct view of the situation as we encounter it *in vivo*. It is rather surprising that even 2 per cent of the cases have proceeded to a fatal issue without provoking, or being associated with, tuberculous manifestations in other parts of the body. It is obviously unfair to assume that tuberculous peritonitis as seen by the surgeon presents the same picture as that which is unfolded to the pathological anatomist. The disease is brought to the attention of the former, if not at its inception, at least usually at an early stage; while the latter has occasion to witness only the widespread devastation caused by the dissemination of tubercles.

It is interesting to note that the Mayo brothers,[10] of Rochester, Minnesota, were able to report that in 5,687 patients upon whom intra-abdominal operations had been performed during the ten years terminating October 1st, 1904, 184 (or about 3 per cent) gave evidence of tuberculous disease. Localized intestinal tuberculosis occurred 21 times; in 13 of these cases they were able to demonstrate that this was the primary tuberculous lesion, whereas in the other 8 they were uncertain as to this point. During the same period, in 1,888 cases in which they had removed the appendix this organ was found to be involved in a tuberculous process 29 times. They frequently found caseous lymph nodes in the meso-appendix. Geographical location apparently exerts an influence in the dissemination and appearance of tuberculous disease. The Mayos state that, living as they do in an agricultural community, pulmonary tuberculosis is comparatively infrequent, while abdominal, bone, joint, and lymphatic affections of this character are quite common.

It is stated that, in the United States, 60 per cent of all cadavers show evidence of healed or active tuberculosis, while in Germany the percentage is said to be as high as 86 per cent. Nothnagel[11] calls attention to this discrepancy and refers to the report of 4,250 autopsies by Borschke, in 1,393 of which tuberculous lesions were found, and, of this number, 226 (*i.e.*, over 16 per cent) showed involvement of the peritoneum. It is claimed, furthermore, that tuberculous peritonitis occurs more frequently in Vienna than in any other part of the globe.

Heredity is undoubtedly an important etiological factor. Shattuck[12] found such a history in 20 per cent of his cases, Rotch[13] in 30 per cent, Haene in 35 per cent, and Lauper[14] in 40 per cent. In this connection it should be stated that congenital cases have been placed on record. The earliest report is that of Manclair and Alglave.[15] In this report there is narrated the case of a child who, when three days old, was seized with vomiting, and died on the sixth day. The autopsy showed advanced tuberculous peritonitis associated with intestinal obstruction. The mesenteric lymph nodes contained many bacilli and giant cells. Another case is reported by Brouardel. In this instance the child died when ten weeks old. In each of these cases the mother had a tuberculous condition of the genitalia.

Age is without doubt an important factor. Lauper[14] states that tuberculous peritonitis occurs most frequently in the second half of the second decennium. Rotch[13] has prepared a paper based upon the cases admitted into the Children's Hospital of Boston between the years 1884 and 1902—in all, 69 cases. He states that the disease occurs in infancy or childhood, but does so much more frequently during the latter period. He has observed that the occurrence of tuberculous peritonitis in infancy is usually a manifestation of general tuberculosis, but he states that "it is this chronic tuberculous peritonitis, occurring in individuals most frequently from one and a half to four years of age, which can be treated as a disease *per se*, and which gives us the largest percentage of recoveries from tuberculous peritonitis by means of laparotomy."

The youngest patient operated upon by the writer was twenty-two months of age. The disease had existed at least six months and the child was extremely weak and emaciated, but made a good recovery after operation. He is now nine years of age and a splendid specimen of youthful vigor.

In determining the influence of age on the development of tuberculous peritonitis it is interesting to compare two tables—one American and the other German. The first table represents the experience of the Massachusetts General Hospital, and is derived from two separate papers, the first of which is by Shattuck[12] and covers the 98 cases which were treated during the ten years terminating in 1900. The second table, which is by Stone,[16] takes up the cases in the same hospital (122 in all) which were under treatment between 1900 and 1907; the two sets of cases making a total of 220. In 178 the disease occurred before the thirtieth year of life, and in only 42 at an age later than thirty. In 29 it appeared between the first and tenth years, in 60 between the tenth and twentieth, and in 89 from the twentieth to the thirtieth years. Evidently, tuberculous peritonitis occurred most frequently in the third decade, while, in more than 80 per cent of all of the cases treated in the Massachusetts General Hospital during these seventeen years, the patients had not attained the thirtieth year of life.

On the other hand, of 164 personal cases reported by Nothnagel[11] from his own clinic none occurred before the tenth year of life. Of the remainder, 28 occurred between the tenth and the twentieth years, 37 between the twentieth and thirtieth, 50 from the thirtieth to the fortieth, 31 from the fortieth to the fiftieth, 12 from the fiftieth to the sixtieth, and 6 from the sixtieth to the seventieth years. It appears, therefore, that, in 99 of his 164 cases (or in 60 per cent), the disease occurred later than the thirtieth year of life; and the fourth decade seems to have been the one during which it appeared most frequently. In a paper published by Vierordt not a single case under twenty years of age is mentioned. Ochsner[17] states that, of 32 cases operated upon by him and reported in 1902 to the American Surgical Association, 20 were less than thirty years of age, and only 12 older. One-third of his patients were not twenty years of age. It would seem, from the foregoing, that the disease appears at an earlier period of life in this country than abroad. An exception to this, however, is to be found in the experience of the surgical clinic of Goettingen. Of 40 cases

reported by Dr. Karl Thoenes,[18] 28 (or 70 per cent) were under twenty years of age. However, after reviewing the statistics of all countries, I believe that it is fair to conclude that tuberculous peritonitis occurs most frequently from the twentieth to the fortieth year of life.

The study of the relation of sex to tuberculous peritonitis is likewise interesting. Mayo[10] states that, in his experience, the disease occurs four times as frequently in the female as in the male. Of Ochsner's 32 cases,[17] 24 were women; of the 40 cases operated on by Thoenes, 25 were women; 16 of the 22 cases operated upon by Lauper[14] were women. However, of the 164 cases reported by Nothnagel, 101 were men and 63 were women. Of 69 cases reported by Rotch, 39 were boys and 30 girls. Of 122 patients forming the basis of the paper by Stone, 62 were males and 60 females; while, in the paper prepared by Shattuck, 67 were women and 31 men. Nothnagel states that 90 per cent of all the patients operated upon for tuberculous peritonitis are women, and he seeks to explain this on the ground that in many instances an erroneous diagnosis had been made, the symptoms present having been referred to some diseased condition of the female sexual apparatus. For this reason, early operations are more frequently performed upon women.

On the other hand, at the autopsy table a large proportion of the subjects presenting tuberculous invasion of the peritoneum have been males. Bircher,[5] collecting the statistics of various hospitals, found that, in 452 autopsies where death was caused by tuberculous peritonitis, 338 (or 74 per cent) were males as against 124 (or 26 per cent) females. Bybee[19] reported that, in 872 autopsies made at the Cook County Hospital of Chicago, tuberculous peritonitis was found in 30, 28 of these being in males and but 2 in females. Vierordt found 80 per cent in males, Sick 83.1 per cent, and Cummings 66.3 per cent. If all of these figures be summarized it would appear that, on the autopsy table, the disease is found three times as frequently in males as in females.

Occasionally traumatism has been the provoking cause of tuberculous peritonitis. Bircher[5] mentions one case in which the disease appeared fifteen days after the receipt of an injury and was apparently precipitated by the rupture of tuberculous mesenteric lymph nodes. Heintze[20] reports three cases of acute traumatic peritonitis of a tuberculous nature. In one of our own cases a young woman sustained a fall while riding a bicycle, striking upon her chest and abdomen. Tuberculous pleurisy, as well as tuberculous peritonitis, followed; the latter running a furious course and causing her death in six weeks. In all of the reported cases due to traumatism the course has been a very acute one.

Without doubt the tubercle bacillus is the essential cause of tuberculosis. It is a matter of great interest to determine, if possible, the port of entry in those cases in which it is responsible for the development of tuberculous peritonitis. Three methods of invasion are possible: by way of the blood stream, by way of the lymphatic channels, and by direct extension from a contiguous focus. The tubercle bacillus only exceptionally finds its way to the peritoneum by way of the circulation, and then only, as a rule, in those cases in which we are evidently dealing with a general miliary tuberculosis. Many of the German observers

are inclined to designate this class of cases as "peritoneal tuberculosis" rather than as "tuberculous peritonitis," because of the absence of inflammatory manifestations. The lymphatic route is of much greater importance in the pathogenesis of tuberculous peritonitis, by reason of the fact that the peritoneum, mesentery, and intestinal walls are richly supplied with lymphatics.

The question has recently been raised by Koch as to whether human and bovine tuberculosis are dependent upon the same bacillus. While he insists that they are separate and distinct, Von Behring holds that they are identical. Raw [21] takes the ground that they are distinct varieties of an original species, each capable of producing distinctly characteristic lesions in the human body. He believes that, particularly during the milk-drinking period of early life, the bovine tubercle bacillus is capable of producing certain lesions. In 100 carefully conducted autopsies on children dying of tuberculosis, many of them ordinary cases of phthisis and several of them abdominal and meningeal forms, he found that 38 showed tuberculous intestinal ulcers with caseating mesenteric lymph nodes, and that 23 had caseating mesenteric lymph nodes without intestinal ulcers. He concludes that the human tubercle bacilli, whether introduced primarily with food or swallowed secondarily with the sputum in those suffering from phthisis, will cause intestinal ulcers, and that bovine tubercle bacilli ingested with milk will rapidly pass through the intestines leaving no trace behind, attack the mesenteric lymph nodes, and then spread to the lungs and be distributed all over the body. There are a few recorded cases in which the perforation of a tuberculous gastric ulcer has been responsible for the occurrence of tuberculous peritonitis.

In a recent address Prof. A. E. Calmette,[22] of France, takes the ground that the respiratory tract is so strongly guarded that only in exceptional cases can there be direct admission of tubercle bacilli through this route. On the other hand, he maintains that the most frequent source of invasion is through the intestinal tract. This, he holds, is the result of the ingestion, not only of milk from tuberculous cows, but also of food contaminated either directly or indirectly by means of tuberculous sputum. The bacilli penetrate the intestinal walls, enter the blood- or the lymph-circulation, and, being thus transported, produce tuberculous disease in various localities of the body. The intestinal mucosa can give transit to tubercle bacilli and yet not show afterward any trace of their passage. In his research work he has produced, in this way, tuberculous disease of the pleura, of the joints, and of the genito-urinary apparatus. Pulmonary tuberculosis, therefore, is, according to Calmette, a secondary manifestation, the primary invasion taking place by way of the intestinal tract. If this view is correct it seems surprising that we do not find tuberculous peritonitis more frequently as an early evidence of tuberculous disease in the human body.

Murphy,[23] on the other hand, while regarding the intestinal tract as the usual route through which the infection travels in its course to the peritoneum, holds that, in the female, the genital tract is more often the portal of entry. There is very strong ground for questioning this claim. When tuberculosis attacks the female genitalia the Fallopian tubes are usually the site of the

greatest activity of the disease. The fundus of the uterus is affected to a much less degree, the cervix rarely, and the vagina only occasionally. All of this would seem to argue against tuberculous peritonitis being due to an ascending genital invasion. On the other hand, experimental study has shown that there is a peritoneal current which flows toward the Fallopian tubes, and it is assumed that the frequent involvement of these tubes is secondary to the peritoneal disease rather than the primary affection. Furthermore, Baumgartner, as a result of inoculation of the genital tract of the rabbit at different levels, found that, while tuberculosis might spread by continuity to other structures in the genital tract, its tendency was to travel downward rather than upward. His conclusion is: "Since tuberculous infection of the genital apparatus in the female is most frequent in its upper extremity and there is little evidence of an ascending affection, it seems reasonable to assume that the Fallopian tube may be readily infected from the peritoneal cavity." Out of 194 cases of tuberculous disease of the female genitalia reported by Mayer the tuberculous process implicated the peritoneum in 110. On the other hand, the literature of the subject contains the records of a large number of autopsies upon female patients in whose Fallopian tubes, notwithstanding the fact that they had succumbed to tuberculous peritonitis, no evidence of tuberculous disease was discovered. Biggs [24] reports the case of a child, twenty months old, in whom a post-mortem examination disclosed coincident tuberculous disease of the peritoneum, tubes, and uterus in association with tuberculous ulceration of the bowels, which latter lesion was evidently the primary focus of the disease. Tubal infection with tuberculosis, through sexual intercourse with a tuberculous man, no doubt does occur. Gelpke [25] records the case of a woman, of healthy parentage, who became infected by a tuberculous husband who died before their child was born. The child lived about a year and died of tuberculous meningitis. Soon after the birth of the child the mother developed tuberculous peritonitis, the disease beginning apparently in the left Fallopian tube. She never had had any previous tuberculous invasion of her lymph nodes, lungs, or intestines. This question must remain for the present *sub judice*. There can, however, be no doubt that when invasion of the Fallopian tubes has occurred, whether this be a primary or a secondary manifestation, toxins as well as tubercle bacilli may be produced, and the latter may multiply so rapidly in them that, for the time being, these structures become the actual storm centre, and their removal becomes imperative.

Pathological Anatomy.—Pathologists and clinicians seem to differ as to a classification of the forms of tuberculous peritonitis. The former group the cases according to the findings on the post-mortem table, while the latter—be they internists or surgeons—are governed in their division by the symptomatology. It is a question whether one can create sharp lines of division. But few cases will absolutely fit into a given group, be that based upon its pathological or on its clinical picture. As stated before, Kauffmann [26] makes two divisions. To the first he gives the name "tuberculosis of the peritoneum," to the second, that of "tuberculous peritonitis." Under the former head are included those

cases in which the disease progresses without any evident inflammatory manifestations, and in which, nevertheless, there are found at autopsy gray tuberculous nodules that are widely distributed over the peritoneum and intraperitoneal organs. Naturally, this variety is discovered more frequently by the pathologist than by the clinician, and it may therefore be excluded from our present consideration. Tuberculous peritonitis is usually divided into three groups:—The first and most frequently encountered is the ascitic variety of the disease; the second is the adhesive, and the third the caseous. In the ascitic variety there is usually, in the free peritoneal cavity, a large accumulation of fluid, which varies in character, being at times clear yellow, serous or sero-fibrinous, occasionally hemorrhagic, and rarely purulent. The amount of effusion varies. It may be slight in some cases and very abundant in others. Occasionally tubercle bacilli are found in this exudate. However, it is not always possible, even in cases in which tuberculous peritonitis is positively present, to demonstrate the presence of the bacilli. Tubercles are usually found upon the peritoneum in great abundance. They vary in size from the smallest millet seed to quite large caseous nodules. Very frequently the intestines are covered with a fibrinous exudate, which may lead to the formation of adhesions between the intestines or between these structures and the abdominal wall. The parietal peritoneum is usually infiltrated with numerous small gray transparent nodules and the resulting thickening is constant and quite characteristic. The mesentery and omentum are likewise involved, and the latter is particularly changed, being converted into a dense, hard, contracted mass which is beset with tubercles and is drawn to the upper part of the abdomen where it strongly simulates a tumor. The fibrinous exudate leads to plastic formation, and adhesions result, not only between the intestines but also between them and the other intra-abdominal structures. Fixed spaces are thus created in which fluid collects or is held imprisoned. In this way what appear to be distinctly localized collections of fluid are formed in the abdomen,—a condition which has frequently been mistaken for intra-abdominal cystic tumors. Cirrhotic changes in the liver and spleen are frequently associated with tuberculous disease of the peritoneum. The tendency to the formation of a plastic exudate with adhesions has often led to the encapsuling of tuberculous masses, and without doubt it is in this way that sometimes the process is arrested. On the other hand, the tuberculous process may advance to a stage of caseation with subsequent purulent accumulation, or it may lead to ulceration and perforation. As a result of this process, not only may a fistulous communication between various intestinal loops be established, but surface destruction may also occur and a perforation in the neighborhood of the umbilicus follow, as a result of which a fecal fistula is established at this point. Again, the adhesions may lead to intestinal constriction—serious enough, in some cases, to constitute complete obstruction of the bowels. The mesenteric and the retroperitoneal lymph nodes may become extensively involved, in which case they appear as large tuberculous tumors. In the female the Fallopian tubes and ovaries may be invaded either primarily or secondarily. The caseous variety of the disease, when advancing to the

suppurative stage, frequently becomes contaminated with other infectious organisms, and we have then to deal with a mixed infection. Most surgeons make a special group of such cases.

It must be emphasized, however, as stated before, that these various pathological conditions present no fixed border line, and a division into specific groups is more artificial than real. There are, no doubt, varying degrees of intensity, some cases being mild, presenting few tubercles and little exudate, and characterized by only slight involvement of the peritoneum. Such cases often proceed to a spontaneous cure. In a more severe variety the peritoneal invasion is of a more serious nature; the effusion becomes more abundant and fibrinous, and is apt to form a plastic exudate. In this class of cases the omentum presents the characteristic contraction and the appearance as if it were the seat of a tumor. Then again, in some cases, the exudate is encapsuled, the tuberculous process being limited and the disease showing a tendency to recovery. In the severest type of cases there is caseation associated with mixed infection and resulting sepsis. In the mild cases bacilli have either been found in small numbers or not at all. On the other hand, in the caseous variety, associated with mixed infection, cultures have shown the presence of micro-organisms of the most virulent type.

Most surgeons classify the cases as ascitic or dry. The difference between the two groups is rather clinical than pathological, for it is evident that with any of the pathological varieties there may be present a greater or a smaller amount of effusion or none at all.

Bruns[27] was the first to describe cases in which the earliest evidence of a tuberculous invasion of the peritoneum was found in the hernial sac. Subsequently Roth and Petit furnished confirmatory contributions. Of the twenty-two cases reported by Roth,[28] fourteen involved the sac alone; in three the process was limited to the contents of the sac; and in the remaining five both the sac and the contents showed evidence of tuberculosis. In nine hundred herniæ reported by Petit fifteen were tuberculous; in five of them there was evidence of inherited tuberculosis. It is fair to assume that in all of these cases the tuberculous process was not limited to the hernial sac, but was of such a mild type or so little advanced as not to give evidence of a general tuberculous peritonitis. The claim, however, has been advanced that hernia predisposes to tuberculosis. Reference has already been made to the coincident involvement of other organs with tuberculosis and the marked infrequency with which a tuberculous process remains restricted to the peritoneum without involvement of other structures.

Symptomatology.—In all forms of tuberculous peritonitis the early manifestations are indefinite. The experience gained at the clinic of Kocher, in Berne, as related by Lauper,[14] presents a good clinical picture. He states that there is a prodromal period which in more than one-half of the cases covers many months, or possibly an entire year. During this period there are gradual loss of appetite, languor, malaise, and vague abdominal complaints with irregularity in the action of the bowels. At the conclusion of this period, in nearly

all of the cases, there occurs a sudden outbreak of acute manifestations. This is characterized by severe abdominal pain referred to the region of the umbilicus, by sudden appearance of fever, and by increased loss of appetite, often associated with vomiting or distress at the pit of the stomach. In at least one-third of the cases the vomiting is severe. About one-half of the patients complain of some form of urinary disturbance. Some suffer from painful urination, while others complain of pain at the completion of the urinary act, together with the usual distressing symptoms of cystitis. Menstrual irregularities are present in one-half of the cases occurring in women. In some, menstruation is profuse, in others irregular and associated with dysmenorrhœa. About two-thirds of the patients have some form of disturbance of the bowel function. In perhaps one-half of this number diarrhœa and constipation alternate, the one with the other. A smaller number suffer from constipation alone, and this is found to be particularly true in children. Only in occasional instances is there persistent diarrhœa. This may be associated with colic. Maylard [29] makes the statement that when general emaciation, anorexia, diarrhœa, furred tongue, evening rise of temperature, etc., are known to exist prior to the manifestations of any positive abdominal symptoms it is more than likely that ulceration of the bowels has been the cause of the tuberculous peritonitis. He states, furthermore, that the recurrence of intermittent attacks of pain before the appearance of local signs in the abdomen indicates either a tuberculous implication of the intestines or the presence of adhesions resulting from an antecedent attack of tuberculous peritonitis. The temperature may remain unaffected, but in severe forms it is always elevated, and in suppurating cases it assumes a hectic type. About four-fifths of all patients suffer from abdominal pain, which is usually quite general. It may be associated with areas of tenderness, and, where the female genitalia are primarily or coincidently affected, the tenderness is particularly evident in the neighborhood of the Fallopian tubes.

The most constant local manifestation is increase in the size of the abdomen. This is usually dependent upon the presence of ascites, but the effusion is not the only cause of this enlargement. In the dry cases it is usually due to the presence of tympanites. Sometimes the ascitic fluid is so limited in amount that it can be recognized only by having the patient stand and lean forward.

Thomayer [30] calls attention to the manner in which the omentum and mesentery are retracted. The omentum, after being drawn to the upper part of the abdomen, is carried to the left side because of the retraction of the mesentery. Consequently there appears, in tuberculous peritonitis, a firm tumor located largely in the left upper quadrant of the abdomen, while the intestines collect in the right lower quadrant where a tympanitic area is present. Further physical examination, particularly in the adhesive type, may reveal the presence of localized collections of fluid suggesting the presence of intra-abdominal cysts. In other cases, there are sometimes found masses of doughy consistence due to the enlargement of mesenteric or retroperitoneal lymph nodes, possibly in a state of caseation.

Dyspnœa is a frequent complaint, and is usually dependent upon the in-

creased size of the abdomen. Emaciation is most constant, being present in about eighty per cent of all cases, and, in an advanced stage of the disease, it is associated with exhaustion.

The clinical course is exceedingly variable. Cases may proceed to a fatal termination unrecognized. Gelpke [25] refers to the case of an insane man who shoveled snow the day before he died. The autopsy revealed an old caseous form of tuberculous peritonitis. On the other hand, in the acute miliary form the progress may be exceedingly rapid, the cachexia being pronounced and death occurring at an early date. As has been stated, in chronic cases it often occurs that the acute symptoms are preceded, during a long period of time, by disorders of an ill-defined nature. In a large number of these cases no distressing symptoms whatsoever are evident, and the first abnormal manifestation which calls attention to the patient is the sudden or gradual increase in the size of the abdomen.

The experience of the Berne clinic, as reported by Lauper,[14]—viz., that the disease frequently presents an inactive prodromal period, followed by acute manifestations,—is confirmed by Gelpke [25] and also by the experience of the Massachusetts General Hospital, as appears in the papers of both Shattuck [12] and Stone.[16] This was the course observed in about one-third of their patients. In over one-half of their cases, as soon as the tuberculous peritonitis had reached such a degree of development that one could make a positive diagnosis, there was found undoubted evidence of tuberculous disease in other parts of the body. Usually this was manifested by the presence of an abnormal condition at the apices of the lungs, by the existence of a pleurisy, or by the fact that there was enlargement of several lymph nodes. Symptoms of obstruction of the bowels were noted by these observers particularly in the adhesive variety of the disease. This was made manifest not only by such symptoms as vomiting or constipation or the inability to expel gases, but objectively by the character of the distention of the abdomen. In about one-third of the cases there was free ascites,—*i.e.*, the fluid shifted with the movements of the body.

Blood examinations were made in 96 of the 122 cases reported by Stone. In 58 a leucocyte count of 10,000 or less was observed, in 21 the leucocytosis ranged from 10,000 to 14,000, in the remaining 17 it varied from 14,000 to 40,000. In the case in which the highest count was made there was no fluid, but there were numerous intestinal ulcerations. In a case presenting a leucocyte count of 28,000 there was a rapidly developing abscess. In one of 27,000 there had been an acute attack of vomiting and diarrhœa. In one case in which there was a leucocytosis of 22,000, there was but little fluid in the abdomen but marked tenderness about the Fallopian tubes; while in another which had the same count the stools contained blood. In a case with a leucocyte count of 21,000 the right tube was filled with foul pus, and the same was true in two other cases —one with a leucocyte count of 20,000 and the other with a count of 18,000. These observations led Stone[16] to conclude that a high leucocyte count, associated with tuberculous peritonitis, indicates the presence of sepsis in some form, and that in non-septic cases the tuberculous process is attended with a low count.

In about one-half of the cases occurring in women there were found either fixation of the uterus and a dense mass in the Douglas cul-de-sac or parametric changes associated with diseased adnexa.

Examination of the urine occasionally discloses the presence of albumin. In about one-fifth of all cases there is an increase in indican. Very rarely, tubercle bacilli are found in the urine. They are, however, quite frequently discovered in the stools.

In a case reported by Gelpke,[25] in which there was found, in the upper part of the abdomen, a collection of pus which broke spontaneously through the navel, a post-mortem examination showed that the disease had been dependent upon the presence of two irregular perforating tuberculous ulcers at the pyloric end of the stomach. Similar cases have been reported by Strappler[30] and Cone.[31]

Diagnosis.—The diagnosis of tuberculous peritonitis is not always easily made. It is essential to study the previous history of the patient. Evidence of pre-existing tuberculous disease in other parts of the body may be of marked service, not only in determining the nature of a doubtful case, but also as indicating the site of the primary tuberculous focus. It becomes necessary, therefore, to investigate the cause of such existing symptoms as cough, diarrhœa, menstrual derangements, or manifestations suggesting pelvic disease. During the latent period which so frequently precedes the outbreak of acute symptoms it will usually be impossible to make a diagnosis, because of the absence of any characteristic signs. Not until the abdomen presents positive evidence of invasion would one be justified in suggesting a diagnosis of tuberculous peritonitis. Nor is its differentiation even then a simple matter.

The first case successfully operated upon by Spencer Wells, to which reference has already been made, was in a woman who was thought to have an ovarian cyst. This mistake frequently occurs, especially when the ascitic fluid becomes encysted. Other forms of abdominal tumors have been presumed to exist until an incision of the abdomen has disclosed tuberculous peritonitis. Gelpke[25] reports the case of a twelve-year-old boy in whom a tumor the size of a fist had formed below the umbilicus. Sarcoma was suspected; but the tumor was found to be made up of a mass of tuberculous omentum and intestines. In another instance Gelpke had diagnosticated myoma of the uterus, but a tuberculous tumor was found in that case also. Briddon[32] records a case of tuberculous peritonitis in which the diagnosis had seemed to rest between a tumor of the omentum and an enlarged floating kidney. Holmes[33] and Eisendrath[34] report instances in which this condition had been diagnosticated as hydronephrosis. Treves,[35] in an interesting paper, mentions the fact that tuberculous peritonitis has mimicked cyst of the liver, tuberculous kidney, appendicular abscess, internal hernia, and fibroma and sarcoma of the abdominal wall. One of our own cases, which occurred in a man sixty years of age, presented a history of having had early in life pulmonary hemorrhages, and, upon physical examination of the chest, the existence of an old but latent tuberculous process was recognized at the apex of one of his lungs. There were marked ascites, moderate fever, and alternating diarrhœa and constipation. The omentum was retracted and drawn to

the upper portion of the abdomen. After an incision had been made and a vent had been provided for the ascitic accumulation, innumerable nodules, apparently tuberculous in character, were found covering the parietal peritoneum and the intestines as well as structures—such as the gall-bladder and the stomach—in the upper part of the abdomen. A piece of omentum having been cut out and subjected to microscopic examination it was ascertained that the case was one of peritoneal carcinosis. The subsequent clinical course verified the diagnosis. In this class of cases a positive diagnosis can be made only by the pathologist.

As a rule, the tubercles are found to be miliary in size. Thoenes[18] reports an unusual case in which the nodules were as large as hazelnuts. The macroscopic diagnosis was sarcoma. Miscroscopic examination, however, showed the condition to be tuberculous.

Tuberculous retroperitoneal lymph nodes have also been mistaken for malignant tumors of the stomach, intestines, gall-bladder, and kidneys. The Thomayer[36] sign (page 536) may be helpful, as most of the malignant tumors in the upper part of the abdomen are found to the right of the median line, while the tuberculous omentum, when contracted, occupies a site to the left.

Tuberculous ascites is usually of more rapid development than is an ovarian tumor. Cirrhosis of the liver, as has been stated, may appear as a complication of tuberculous peritonitis. When occurring as a result of the ordinary form of cirrhosis the ascitic accumulation is of darker color than that found in tuberculous conditions, the color being brown in the cirrhotic disturbance and usually light yellow in tuberculous peritonitis. Moreover, in the latter affection the ascitic effusion may be bloody or purulent. However, it is essential, in differentiating between these two conditions, that a careful survey of the history and the entire clinical picture be made.

Occasionally the disease has been mistaken for typhoid fever. In one of our own cases this question was raised, and a differentiation was made by injecting tuberculin hypodermically. The reaction following its use was exceedingly violent and almost proved fatal to the patient. In the end, however, it was helpful, as she proceeded to recovery without operation. The ascitic fluid has been used to inoculate animals for the purpose of diagnosis. Such a series of investigations was instituted by Gelpke,[25] but it was found that, even in cases which were undoubtedly tuberculous, injections into guinea-pigs and rabbits were more often negative than positive in their results. Borchgrevink found that inoculations with material taken from excised tuberculous masses were more apt to yield positive results. Out of eleven cases operated upon, there were five in which the character of the disease was positively demonstrated by inoculation. The ascitic fluid, after being withdrawn, has frequently been used for the production of growths upon agar or in bouillon, but, even when the material used was taken from subjects who subsequently succumbed to the disease, the result frequently proved negative.

Recently tuberculin has been used in various ways for the purpose of making a positive diagnosis. In our experience we have occasionally obtained positive reactions after employing the method of Calmette. Stone[16] injected tuberculin

in thirty-one of his Massachusetts General Hospital cases. Five did not react; two were doubtful; and in one there was no report. Two of the five not reacting were found to have extensive peritonitis. In the other cases no operation was performed.

Prognosis.—In an address delivered before the Chicago Surgical Society in October, 1903, Murphy[23] quoted the opinions of many surgeons,—mostly German, however,—to the effect that at that date unfavorable views were held by them as to the result of the surgical treatment of tuberculous peritonitis.

Czerny,[52] discussing the surgical procedure recommended by Koenig, expressed himself thus: "As tuberculous peritonitis never occurs as a primary affection, this manifestation is but a new station in the route of the disease to Golgotha; and the usefulness of an operation so little radical as this is not to be understood." Fortunately, few surgeons prognosticate so gloomy a future for those suffering from this diseased condition.

It is without doubt very difficult to express an opinion in general terms as to the prognosis when the peritoneum is involved in a tuberculous process. The general as well as the local conditions existing in each individual case are to be carefully considered. Since the affection usually occurs as a secondary manifestation, the location and extent of the primary focus are important. Not less so, however, is the coincident involvement of other organs, as well as the general condition of the patient and the degree of resistance which he is able to offer.

If we can be certain that the tuberculous invasion of the peritoneum is the primary disturbance and that it is still a localized process, the outcome should be most promising. This is apparent in those cases in which it has been unexpectedly discovered in patients during the progress of an operation for the cure of hernia. Moreover, it is now known that in certain mild forms the disease may even heal spontaneously.

When Koenig, in 1884, proposed, as a cure for tuberculous peritonitis, that an incision be made into the abdomen, his suggestion was based upon the satisfactory results which had followed a similar procedure in the withdrawal of fluids from the pleural and synovial cavities when affected with tuberculous disease. In none of these instances did the effusion contain great numbers of tubercle bacilli, and yet removal of the fluid usually was followed by a cure. It was soon discovered that the presence or absence of an effusion in the peritoneal cavity seriously influenced the outcome of the surgical treatment of tuberculous peritonitis. The cases in which no fluid is present are by most authorities regarded as presenting a poorer prognosis than those which are associated with pronounced ascites. As was stated under the head of etiology the percentage of recoveries after operation is larger in children than it is in adults. The exception to this rule, however, will be found in infants, in whom, as stated previously, tuberculous invasion of the peritoneum is but a part of a general tuberculosis and hence presents an almost hopeless prognosis.

In the case—that of a child only twenty-two months old—operated upon by the writer, there was scarcely any ascitic fluid, but large masses of diseased lymph nodes were present in the abdomen. His recovery from a most unpromising condi-

tion was, in a large measure, attributable to the post-operative treatment. Every advantage was given him in the way of change of climate, excellent nursing, and close attention to his physical wants. There is no doubt that the prognosis in all cases might be materially improved if the same hygienic, dietetic, and other measures regarded as essential for the treatment of pulmonary tuberculosis could be enjoyed by those suffering from tuberculous peritonitis.

Certain specific symptoms are to be considered in connection with the prognosis. A persistently high temperature is suggestive of a mixed infection and hence forebodes an unfavorable outcome. Diarrhœa associated with mucous or bloody stools implies intestinal involvement, and hence is to be regarded as a serious manifestation. Marked emaciation indicates a weakened resistance and a poor prospect of recovery.

The possibility of tuberculous disease being awakened in other organs or structures while the process is active in the peritoneum is not to be forgotten. Not infrequently tuberculous meningitis has been lighted up under these conditions. Symptoms of intestinal obstruction were reported by Johnson [37] as having resulted, in a given case, from the deposition of tubercles in certain tributaries of the superior mesenteric vein.

In forecasting the future of patients who have recovered from tuberculous peritonitis one must not lose sight of the fact that the resulting adhesions may at some time become responsible for partial or complete obstruction of the bowels. Experience has taught that the younger the patient the more apt are the exudates to be entirely absorbed and the less the danger of trouble from subsequent adhesions.

Treatment.—*General Measures.*—As long ago as 1864, Bamberger spoke of the spontaneous cure of certain forms of chronic peritonitis which evidently were of tuberculous character, and he emphasized the importance of hygiene and diet in their medical treatment. Rest in bed in the recumbent posture, to favor the absorption of fluid, and breathing pure air (to be secured by having the windows left widely open or, better still, by subjecting the patient to what is known as the out-door treatment) are essential. The appetite is to be stimulated and nutritious food is to be given in abundance. A healthful climate or residence in the mountains or at the seashore is to be advised. In a word, every effort must be made to improve the general health of the patient and to increase his powers of resistance. Recently Borchgrevink [38] has put forth the claim that a larger percentage of the cases of tuberculous peritonitis can be cured by hygienic and medical than by surgical means, and Fenger [39] has asserted "that nature cures tuberculosis of the peritoneum better than does the surgeon." In a table which has been prepared by Bircher [5] and which includes two hundred and thirty-four cases thus treated in eight large hospitals in Europe and the United States, it is set forth that one hundred were cured. These observations have led to a careful review, on the part of many investigators, of the treatment of this disease, and at the present time our ideas are undergoing revision. A broader view of the indications for treatment is being taken.

It is essential, as has been previously stated, that it be determined, if possible, whether the disease be primary or whether its appearance in the abdomen be secondary to another tuberculous lesion, and, if so, where the original focus may be located. If perchance it be seated in the intestines and if the presence of tuberculous ulceration be surmised, the use of some iodine preparation internally has been advised by Yeo [40] and Miserocchi,[41] who hold that, just as it can be demonstrated that this drug is eliminated in the excretions of the body, it is also probably secreted in the peritoneal cavity in quantities sufficient to act as an antitoxin or to serve as a bactericide. As much if not more benefit is secured from the administration of some creosote preparation. Our own preference is for guaiacol, which has apparently been of great service in relieving the intestinal symptoms as well as in influencing favorably the general condition of the patient. In this class of cases the regulation of the diet is particularly essential; the latter should be of a bland and non-irritating character.

External Applications.—Various applications to the abdomen have been advised, but they are of doubtful utility. Knox [42] has seen marked improvement attend firmly strapping the abdomen—a procedure which he employed for a double purpose. In the first place, it secures rest by furnishing mechanical support to the abdomen and at the same time restricting its movements; and, in the second place, it causes an exaggeration of the thoracic movements and induces aspiration, whereby lymphatic absorption may be increased and the removal of the fluid favored.

Caesar [43] reports the case of a child seven years of age whose abdomen was so distended that she could not see her toes, but who, under rest in bed and the local application of mercurial inunction and a firm flannel bandage, was able, in the course of a month, to run about. Except for the presence of some enlarged lymph nodes, the child appeared to be quite well.

Serum Treatment.—Reference has been made to the use of tuberculin for diagnostic purposes. It has also been used therapeutically. Two methods have been employed. In the first, one of the many sera has been made use of, while in the second a vaccine has been employed. A comprehensive review of this subject appears in Maylard's work, in the chapter on Abdominal Tuberculosis, which was written by Hunter.

Van Huellen and Sonnenberg [44] have called attention to the wisdom of using the anti-tuberculous serum of Marmorek when surgical procedures have failed to eradicate localized tuberculous processes. The claim is made that, from the use of this serum, there occurs an improvement in the general as well as in the local condition. Two cases of tuberculous peritonitis were treated by these writers with this serum. In one of the patients, whose condition was most unpromising, a complete cure, as it seemed, had been effected. The other patient, though improved, was still under treatment at the time of the publication of the paper.

Hunter reaches the conclusion that as yet the serum treatment for tuberculous disease cannot be recommended. He draws attention to the difference between the toxin of diphtheria and that of tuberculosis. The former is a diffusible

toxin produced by a micro-organism which is always local in its growth; while the latter is endogenous and is probably liberated only when the bacillus dies or comes in intimate contact with some tissue cell which it proceeds to destroy. According to his belief, the problem in tuberculosis will be to find an antibacterial rather than an antitoxic substance.

A vaccine is defined by Wright [45] as "any chemical substance which, when introduced into the organism, causes there an elaboration of protective substances." The vaccine is derived from the bacteria themselves. Upon entering the body it unites with the natural antibacterial substances existing in the blood. The tubercle bacilli are acted upon mainly by opsonins. The opsonic index, which, in this instance, is the measure of the capacity of the blood-serum to aid white corpuscles to take up tubercle bacilli, forms some measure of the resistance which our tissues are able to offer to this organism. The tubercle bacilli grow best in people having a low opsonic index. In treating a tuberculous lesion it is essential to increase the opsonic content of the blood, and the vaccine used for the purpose must be antibacterial. Koch's "old" tuberculin is of little use, as it contains only soluble products of the bacilli and gives no immunity as regards the action of the more important endogenous toxins. This immunity is conferred by Koch's "new" tuberculin, or "tuberculin R," which is made from the disintegrated bacilli themselves. It consists of 10 milligrammes of the dried tubercle bacilli in 1 c.c. of a forty-per-cent solution of glycerin in water. The doses range from $\frac{1}{3000}$ to $\frac{1}{600}$ mg. The treatment demands much time, and the estimation of the opsonic index requires special education.

Riviere,[46] at the annual meeting of the British Medical Association in 1907, discussed the value of tuberculin in the treatment of tuberculous peritonitis in children. Under its use nearly all of his patients improved rapidly. One child, who was going down hill for many months under medical treatment, was regarded as being beyond help. Immediately after the tuberculin treatment was begun, she became cheerful and her weight increased (from October to the following July) from twenty-five to forty-two pounds. In another article [47] upon the same subject Riviere takes up the question of dosage, together with other details of treatment. He considers the proper dose, for a child one year of age, to be from $\frac{1}{12000}$ to $\frac{1}{8000}$ mg.; for one five years old, $\frac{1}{4000}$ mg.; and for a child of ten or twelve, $\frac{1}{3000}$ mg. The injections are repeated at intervals of two weeks. He believes it to be essential, even in administering the average dose, to watch the opsonic index.

Treatment by Means of the X-ray, etc.—In a recent and very exhaustive review of the subject Bircher [5] reports the result of his experience with the *x*-ray in the treatment of tuberculous peritonitis. He refers to the use, first made by Finsen, of concentrated rays of sunlight, and later of the electric light, to destroy bacterial life in the treatment of tuberculosis. Since 1898 Bircher has used the Roentgen rays, either alone or in connection with operative procedures, in the treatment of various forms of tuberculous peritonitis. Others had used it before with varying results. At first, Bircher resorted to it only in inoperable cases, and in many of these the results were remarkable. He used an instrument having 110 volts

and two to three ampères, with a maximum spark-gap of 500 mm. He used hard or medium-hard tubes. The treatments were given daily for from three to four weeks, in sessions of fifteen to thirty minutes, depending upon the character of the tube and the endurance of the patient. If no improvement followed, the treatment was interrupted for two weeks and then resumed. If, after this resumption of the treatment, no improvement occurred, it was altogether discontinued. Of sixteen cases not cured by a single laparotomy, seven were cured by the use of the *x*-ray; five were improved; and four died. Patients reacted differently to the Roentgen rays. For example, in one case an operation had failed to give relief. The *x*-ray used for twelve weeks apparently did not improve the situation. Then there followed a second operation, at which a ventral hernia resulting from the first operation was cured, and after this the patient made a complete recovery from her tuberculous disease. In another case, the *x*-ray failing to give the desired relief, an operation was performed. No improvement followed this procedure, but, after a second course of seventeen days with the *x*-rays, a marked improvement took place, and the patient was ultimately cured without further operation. In a patient suffering from the adhesive variety of tuberculous peritonitis, operative treatment had been attended with no benefit, but the employment of the *x*-ray was followed by great improvement. In cases in which the disease was either so mild as not to justify an operation or so severe as not to warrant it, fifty per cent were cured by this agent. In some instances in which the *x*-ray was used with benefit and then discontinued, the patient subsequently went on to a complete cure. Bircher mentions other instances in which direct benefit attended the use of the Roentgen rays. Seemingly he has established, for this therapeutic agent, a definite place in the treatment of tuberculous peritonitis. In the adhesive or plastic varieties of the disease, in which a surgical procedure offers but little encouragement, the use of Roentgen rays is indicated as preliminary to, or in many cases in place of, a surgical operation. It is also to be advised for those patients who are extremely cachectic, and in whom, consequently, surgical intervention would hardly be warranted. It is suitable also for the milder forms of tuberculous peritonitis. Subsequently to the operation the Roentgen rays may be used to advantage in all cases in which the fluid that reappears after the operation shows no disposition to disappear, even after the lapse of two weeks. The procedure may be employed in any case in which there is evidence of recurrence. It can be alternated with the high-frequency current.

In some of our own cases we have employed the Roentgen-ray treatment in association with a surgical operation, and the plan has proved of substantial value. It has been our practice to give one *x*-ray treatment weekly, a very hard tube being employed and the rays being allowed to pass through a leather filter. On the other days of the week, or on alternate days, high-frequency treatments are given, a vacuum tube being used for the purpose.

Operative Treatment.—The earliest and simplest of all surgical procedures is that of tapping the abdomen. Obviously its application was limited to the ascitic cases. More recently, after the withdrawal of the fluid with a trocar

and cannula, various drugs, the normal salt solution, and air or oxygen have been introduced into the peritoneal cavity. About 1890, and for a number of succeeding years, this practice was strongly recommended by certain French, Italian, and Vienna surgeons, and a number of cures were placed on record. Mader, of Vienna, reports four cases, of which he cured three by simple tapping, and Mosetig-Moorhof,[48] Nolen,[49] and Duran eight cases, in which, after the fluid had been withdrawn, the abdomen was inflated with sterilized air, with the result of curing seven. Seganti[50] claims to have cured twelve cases by tapping and irrigating with normal salt solution; while Riva,[51] another Italian surgeon, reports eleven cures by tapping and then using sterile water, instead of the normal salt solution. Of ten cases which had been treated by the same method, Baylas reports six cured and four improved. The total number of cases recorded as having been treated along these lines is, up to the present time, forty-eight, of which forty-one are said to have been cured.

Carvi reports that he had under treatment, for two months, a patient from whom he withdrew daily from five hundred to one thousand grammes of fluid with a trocar and cannula, and in the end the patient recovered.

The treatment by tapping is based on the assumption that the most important step is the withdrawal of the ascitic fluid. This assumption is not altogether warranted. Moreover, this method is not entirely free from danger, as the risk of damaging the intestines is considerable. That tapping very frequently is of no avail is evidenced by the fact that many patients who have been previously so treated, subsequently require radical operation. Thoenes, in a series of thirty-one cases in which he performed laparotomy, states that eight had been tapped. In view of the splendid results obtained by aspiration in tuberculous pleurisy, this necessary conclusion is very disappointing.

The recurrence of ascitic accumulations has led to the recommendation of continuous drainage for the cure of obstinate cases. This procedure has also been undertaken in advanced conditions. Ochsner[17] reports that he operated upon a married woman, twenty-six years of age, whose ovaries, tubes, and uterus were embedded in a mass of tuberculous tissue so extensive as to render the removal of these organs a hopeless undertaking. The cæcum, small intestines, and omentum were also matted together. Both the visceral and the parietal peritoneum were thickly studded with miliary tubercles. Ascitic fluid filled the remaining abdominal space. Ochsner inserted a drainage tube with the hope of giving the patient temporary relief, and then closed the abdominal wound around the tube. The patient made a slow recovery, being able to leave the hospital in six weeks. In reporting the case, eleven years after the operation, he was able to state that "the patient is a strong healthy woman and has given birth to two healthy children."

At the International Congress held in Berlin in 1890, Koenig[53] reported upon 131 cases subjected to operation during the six years which had elapsed since he first recommended surgical treatment. The operative mortality was 3 per cent. One hundred and seven of the cases, or 81 per cent, terminated favorably. Of these, 23 were improved and 84 (or 64 per cent) recovered. Of the latter num-

ber, 54 had been under observation for more than two years after operation, 30 of whom were known to have remained perfectly well. It can therefore be said of these cases that at least 25 per cent had been permanently cured.

Based upon their surgical treatment, these cases made three groups. Those of the first group were treated by simple incision. In the cases of the second group the abdomen was first opened and then, after all of the fluid which possibly could be removed had been withdrawn, various drugs or medicated solutions were introduced into the peritoneal cavity. In the third group such diseased organs as the ovaries, tubes, appendix, or intestines, were removed.

Among the various bactericidal drugs that had been introduced into the peritoneal cavity were solutions of salicylic acid, thymol, corrosive sublimate, and carbolic acid. In eighty of the cases iodoform had either been dusted into the abdomen or rubbed into some of the diseased structures. In fifty cases no antibacterial agent was used and apparently the largest percentage of cures followed this line of procedure. Cures occurred in each of the varieties, as well as at different stages of advancement of the disease. It is therefore permissible to say that, to each of these methods of treatment, cures of the various forms of tuberculous peritonitis may be credited.

At the conclusion of his paper Koenig, after considering the factors which had been responsible for these results, states that we are in the presence of a riddle which he is unable to solve, and he expresses the hope that, with frequent incision of the abdomen and energetic and scientific investigation, its solution may some day be reached. Since that date no field of surgery has been more earnestly subjected to investigation than has this, and yet we are by no means prepared to give a satisfactory explanation. A careful survey of the subject during the quarter of a century which has elapsed since Koenig placed the diagnosis of tuberculous peritonitis upon a more secure basis, and suggested for this diseased process surgical relief, justifies the assertion that, in properly selected cases, operative measures have cured many cases previously regarded as incurable. Watson Cheyne,[54] in his Harveian Lectures delivered in 1899, makes this statement in speaking of the operative treatment of tuberculous peritonitis: "All, even the gravest forms, show some good results, and there is no form in which we can say that laparotomy is absolutely useless." While in most cases we can judge of the patient's recovery after operation only by the subsequent clinical course of the case, in many instances true anatomical cures have been demonstrated—that is to say, the disappearance of the tubercles has been proven by a laparotomy performed later for the relief of some other condition.

Various explanations of this happy termination of the surgical procedures instituted have been offered. It has been attributed to the admission of sunlight; to the antagonism produced by the admission of bacteria introduced at the time of the operation; to the irritation resulting from the manipulations incident to the operation; to the alteration effected in the circulation, as a result of which the pressure upon the blood-vessels and lymphatics is relieved, the activity of the circulation is increased, and the process of absorption is greatly

favored; to the production of adhesions and the consequent isolation of tuberculous masses; and, finally, to the stimulating effect of the exposure of the peritoneum to the air.

It has been noticed that in those patients from whose abdominal cavities a large amount of ascitic fluid has been removed, the results of the operation are apt to be particularly favorable. Espenscheid[60] reports that he had 62 per cent of operative cures in his ascitic cases as against 18 per cent in the dry ones. The experience of other surgeons is given by Murphy in the address referred to above. He presents the following statistics: "Margarucci, 250 operations in Italy, with 85 per cent cures; Von Krencki, 266 operations, with 71.5 per cent cures in the ascitic, 61.6 per cent in the adhesive, and 75 per cent in the encysted cases; Thomas, 346 operations, with 73 per cent cures in the ascitic, and 57 per cent for both the encysted and the dry; Roersch, 358 operations, with 70 per cent recoveries; Addosides, 405 operations, with 75 per cent recoveries; and Hall, of Cincinnati, 110 cases, of which only 4 occurred in males (and in them he attributed the source of the disease to the appendix) and 106 in females (in whom he found this structure responsible for the condition in but 8). Ninety-four of Hall's cases (or 89 per cent) are reported to have made symptomatic cures. The claim put forth, therefore, that by incision the ascitic has been converted into the dry form, and that this is a step toward repair, can hardly be accepted, as the dry cases are generally regarded as presenting a more unfavorable prognosis."

Various explanations have been offered to account for the more favorable outcome of operations in the ascitic cases. It has been claimed, for instance, that the exudate possesses certain poisonous properties which are removed by means of laparotomy. Wright and Douglas[55] found that the ascitic accumulation is sometimes poorer in protective substances than the patient's blood, and they therefore assume that the evacuation of the old and stagnant lymph and the transudation of new and potent lymph from the blood-vessels furnishes the probable explanation of the benefits attending the removal of the ascitic fluid in tuberculous peritonitis.

The bacteriological study of the ascitic fluid has been of much interest. Recent ascitic accumulations have been found usually free from tubercle bacilli. Lauper[14] claims to have positively found them in cases of nine months' and thirty months' standing, as well as in an exceptional case of two months' duration, in which there was a coincident double pleurisy. Mayo[10] states that, where the disease has been of tubal origin, ascitic effusion separates the fimbriated extremity from the surrounding tissue, and that after the fluid has been removed adhesions form at the end of the tube preventing re-infection of the peritoneum and limiting the process to the pelvis.

Gatti,[56] as a result of carefully conducted animal experimentation, has demonstrated that, after the performance of a laparotomy, there collects in the abdomen a bloody serum which possesses bactericidal and antitoxic properties, and that to the presence of this serum the cure is to be attributed. Watson Cheyne[54] also accepts this view. In animals in which he had provoked experi-

mental tuberculous peritonitis Gatti found that, if the effusion was removed from the abdomen at an early period after its formation, the animals died; whereas, if it was allowed to remain undisturbed or was removed at a late period, the animals recovered. It also appeared, as a result of his studies, that the presence of caseous tubercles in animals always foretold a fatal termination. It has been demonstrated that this condition is by no means so generally fatal in the human race.

In considering the treatment of tuberculous peritonitis it is essential to decide how long medical and hygienic measures are to be continued and when the opportune time has arrived for surgical intervention. To a certain extent this decision is influenced by the conditions existing in each individual case. The rapidity with which the disease is progressing, the general health and vigor of the patient, and the condition of the other organs of the body are important factors in determining this question. As long as there is any evident improvement medical treatment should be continued. If, however, after a reasonable period of time has elapsed, the fever has not abated, if emaciation is progressing, if the patient's strength is failing, and if the ascitic effusion shows no indication of disappearing, operative intervention is indicated—provided, of course, the patient possesses the necessary degree of vigor. Should the patient improve for a time, and should then a halt occur in his improvement, this course of events may likewise be regarded as an indication for operation. On the other hand, if the lungs or the intestines be markedly involved, an operation offers but slight prospect of effecting an improvement. However, it has occurred to us, as it has to other surgeons, that the coincident involvement of the pleura, as evidenced by an effusion in one or both cavities of the chest, is, not only no bar to operation, but rather an inducement to operate; for the pleural effusion has disappeared after a laparotomy and has not recurred.

Shattuck [12] states that if, after a lapse of six weeks, there has been no evident improvement, the time for operation has arrived. Cheyne [54] fixes this same period for the acute forms, but a longer one for chronic cases. To early operations Gelpke [25] takes exception, and he reaches this conclusion as a result of his own as well as the experience of many of the German clinics—those, for example, of Lindner and of Kocher; the Frauenklinik of Bonn; the Heidelberg Clinic; Runge's and Braun's clinics at Goettingen; and the Frauenklinik of Tuebingen.

Lindner reported upon 47 operated cases in which the duration of the disease could be determined. There were 34 recoveries. Of those patients who recovered it was known that tuberculous peritonitis had existed in 11 for less than six months, and in 23 for a longer period. Of the 13 who died, it was known that in 4 it had been present for less than six weeks, and in 4 for two to three months prior to the operation. The remaining 3 patients were operated upon when the disease was more than three months old.

In the clinic of Kocher, at Berne, the period of existence of the disease before operation was known in 14 cases. Of these patients 10 were cured, 9 of them having suffered for periods varying from six months to four and one-half years, while in only one had the disease been present for only seven weeks.

This patient had marked ascites as well as a double pleurisy. The 4 who died included one case of three weeks' and another of five or six weeks' duration. In the remaining 2 the disease had been present six months. In one of these patients the serum found was turbid and curdy, and the intestines were matted together, while in the other the serum was bloody, many large caseous masses were present, and the intestines were matted together. The latter patient also had pulmonary tuberculosis.

The Frauenklinik of Bonn had a record of 16 cases with a known duration. Of these patients 11 died and only 5 made a recovery. In one of the latter patients the disease had been present three months, in two others it had been present four months, in the fourth patient it had been present six months and in the fifth nine months. Of the 11 who died, 6 had suffered from tuberculous peritonitis for less than three months and none longer than six months. Some of them were advanced in years and others had pulmonary complications.

At the Heidelberg clinic there were 24 cures out of 36 cases with a known history. In 5 of the latter the disease had existed less than three months, in 2 for a period of three months, in 1 four months, and in the remaining 16 for periods longer than six months. Of the 12 patients who died 9 had been afflicted with tuberculous peritonitis for a period shorter than two months. In the others it had existed three months; one of the patients dying of hemorrhage due to hæmophilia, while each of the remaining two had pulmonary tuberculosis.

From Runge's clinic at Goettingen there are reported 16 cases, with 8 recoveries and 8 deaths. Of the 8 who died after the operation, the disease is said to have been present in 7 for a period of seven weeks or less, and in the eighth for only three months; while, of the 8 who recovered, only 2 were operated upon early.

From the clinic of Braun at Goettingen there are reported 28 cases in which the duration is recorded. Seventeen of these patients recovered. One of the latter was a boy of twelve who was enormously ascitic, although the disease had existed but six and one-half weeks. Two others had a history of about two months' illness. In 7 the disease had existed for from three to four months; in 4, from six to seven months; in 2, for one year; and in 1, for from two to three years. In the 9 who died the disease was known to have existed in no case longer than seven weeks, and in some for only about two weeks.

The Frauenklinik of Tuebingen was able to report on 27 operative cases in which the duration of the disease was known. Of these patients, 11 were cured and 16 died. Of those cured, 5 had tuberculous peritonitis for four months or less, while in the remaining 6 the duration of the disease was given as ranging from seven and one-half to eighteen months. Of the 16 who died, 10 were known to have had the disease for a period of two months or less, and in but 4 had it been present for from six months to a year.

The experiences narrated in the preceding paragraphs apparently justify the conclusion that early operation for tuberculous peritonitis is contra-indicated.

It seems certain that the best results are obtained when the manifestations have become stationary, and that they are never so good if surgical treatment be instituted while the process is acute. Nature should be given an opportunity to erect her own protective barriers. These results are entirely in accord with those obtained by Gatti[56] in his animal experimentation, to which reference has previously been made.

Technique of the Operation.—The usual incision is through the abdominal wall, although Condamin and Lohlein recommend operating through the vaginal vault. They claim, in favor of this procedure, that there is less danger of infection, that there is no liability to the production of a ventral hernia, that there is less shock, and that recovery follows more promptly. Seven cases were operated upon by them, with four recoveries. Baumgart[57] has expressed the same view with regard to this procedure; and yet it has few advocates.

The abdominal incision is usually carried through the median line. Care should be exercised, in cases in which adhesions are present, to avoid damaging the intestines, and the aim should be, in every case, to enter the free peritoneal cavity. Stone[16] mentions three cases as having sustained rupture of the intestines in the course of operation. Many surgeons have had similar experiences.

The operation originally suggested by Koenig[3] consisted in making a simple incision, evacuating the fluid, and closing the abdomen without drainage. Soon afterward, however, many additions to this simple procedure were suggested. The abdominal cavity was flushed with medicated solutions, normal salt solution, and sterile water. Mikulicz was the first to attribute to iodoform bactericidal properties in tuberculous affections and to apply this drug to the affected areas in tuberculous peritonitis. For a number of years the majority of surgeons followed this practice, but experience has shown that the cases do fully as well, if not better, without the use of irrigation or the introduction of drugs into the abdomen. Drainage was also practised for a time by many surgeons in the ascitic cases; but this procedure is not without its dangers. It favors septic infection and may lead to intestinal ulceration and the subsequent production of a fecal fistula, or be responsible for a lasting tuberculous sinus. For these reasons the use of drains has been practically abandoned, except in such rare instances as the case of Ochsner,[17] previously mentioned.

Surgeons are divided in their views as to the necessity of instituting simple or extensive procedures to obtain a cure. W. J. Mayo[10] expresses himself as being in favor of radical procedures. He states that cases treated by incision alone at his hands frequently did not remain well; that they returned to him suffering either from relapse of the peritoneal affection or from some other form of tuberculous infection. Some returned as many as four or five times. Failure to cure by simple laparotomy induced him to undertake extensive operations—in some cases even hysterectomy. The subsequent examination of the organs removed did not justify these extreme measures. This has also been the experience of the German surgeons. In many cases the tuberculous process causes extensive matting together of the pelvic organs and they become so buried in a mass of exudate as to be practically unrecognizable. To attempt their enuclea-

tion would be to incur great risk of rupturing intestines, not to speak of the ultimate formation of incurable fistulæ.

Murphy [23] was perhaps the first American surgeon to lay stress upon the association of tuberculous peritonitis and salpingitis. He emphasized the fact that repeatedly he had found tuberculous ulcerations of the mucous surfaces lining the Fallopian tubes, in which channels practically a form of lupus had been established. He became a strong advocate of the genital origin of tuberculous peritonitis in woman and of the necessity of performing salpingectomy for its cure.

Mayo [10] states that in twenty-six cases he has been able to enucleate tuberculous Fallopian tubes coexisting with tuberculous peritonitis, and that each time he found the site of the most extensive peritoneal involvement to be nearest them. It is held that sterility is the rule after tubal tuberculosis.

Gelpke [25] sums up his experience with this condition as follows:—One married woman remained sterile; two who were unmarried became amenorrhœic; and three, in whom presumably this form of disease existed, continued to menstruate normally. Hegar calls attention to the fact that infantile genitalia are frequently found in women who, in their childhood, had tuberculous peritonitis.

The surgeons who are opposed to the efforts at radical removal of the structures involved in the tuberculous process, maintain that, since simple laparotomy has led so frequently to permanent cures in cases where the peritoneum was found studded with myriads of tubercles and the omentum converted into a hard tuberculous mass, there is no reason to doubt the recuperative power of nature to overcome a relatively insignificant condition like a tubal invasion.

Between the conflicting and extreme views held, on the one hand, by those who are advocates of a simple surgical procedure, and, on the other, by those who favor an attempt to remove radically what is apparently the primary focus, there must be a middle course. After one has entered the abdominal cavity and has given vent to the ascitic accumulation, one should inspect the appendicular region, in the male, and this region as well as the Fallopian tubes, in the female. If it be found possible, without risk of damaging the intestines or other structures, to remove these diseased parts,—the fact of their being diseased having first been established,—this should unquestionably be done. If, however, they are found to be firmly embedded, and if, consequently, their removal would prove a matter of great difficulty, it is undoubtedly wiser not to attempt their enucleation. Fatal septic peritonitis has been awakened in many cases by such efforts, while, in those who recovered from the operation, fecal fistulæ, as has already been stated, have frequently been established, and these fistulæ either terminated in a fatal issue or became the source of much discomfort and annoyance. The dry variety of tuberculous peritonitis is particularly favorable to the formation of such fistulæ. That they are easily produced is evident from the facts that Albert caused one by simply scraping the peritoneum and Koenig another by merely rubbing iodoform into an infected area.

The recurrence, after operation, of manifestations which indicate beyond a doubt that the pathological process is still active, does not necessarily imply that the case is beyond aid. It is here that the Roentgen-ray treatment, asso-

ciated with hygienic measures, proves helpful. The failure to cure a given case by a single operation does not preclude further operative procedures, provided the patient's condition warrants them. D'Urso[58] operated upon one case four times in the course of nine months, and in the end a perfect recovery rewarded his efforts. Galvani[59] is a most earnest advocate of this procedure. Murphy[23] has collected the records of seventy recurrent operations. In one case it was noted that, at the first operation, the abdominal end of one Fallopian tube and the neighboring peritoneum were studded with tubercles, and that, at the second operation, the same condition was present on the opposite side, while the first was found to have healed completely.

Subsequent laparotomies performed for other conditions furnish an opportunity for studying the results of the surgical treatment of tuberculous peritonitis. Israel found that nodules of the size of cherry pits had disappeared thirty-six days after the operation. Catinari found the peritoneum perfectly smooth two months after the first operation; Herzfeld[61] found two cases cured—one eight months, the other four and one-half years afterward, and Thoenes[18] three cases cured, four, eight, and eleven years respectively after the operation. Jordan[62] collected ten cases in which an absolute anatomical cure could thus be demonstrated, and in addition four instances of patients dying of other conditions, in whom the tuberculous peritonitis was found healed at the autopsy.

The prospect for a cure, in the adhesive variety of tuberculous peritonitis, is not so promising. It is in these cases, particularly, that great care should be exercised not to injure the walls of the intestines. Localized accumulations of fluid may be emptied, but no attempt should be made to remove the cyst walls.

Any form of tuberculous invasion of the peritoneum may develop a mixed infection and become septic. When this state of affairs exists surgery is usually of doubtful utility. Some surgeons have expressed the opinion that medical treatment along the lines previously indicated affords a better outlook than does surgical intervention. If operation be undertaken the procedure should be an extremely conservative one. The danger of damage to the intestine must never be lost sight of, and no attempt to remove septic masses should be made if, in the endeavor to accomplish this, the separation of these masses is not very easily accomplished. Even the introduction of drainage, in this class of cases, may be followed by serious consequences. Murphy[23] reports the case of a young woman whose disorder had been diagnosticated as typhoid fever. Below the level of the umbilicus, the abdomen was dull; nodular masses could be felt in the cul-de-sac. Upon opening the abdomen he entered a pus cavity. No intestines were in sight. He removed the Fallopian tubes and placed both gauze and tube drainage, which were removed on the fourth day. The fever disappeared after the operation, but soon returned, and the patient died some weeks later. Murphy is of the opinion that, had he not drained, the patient might have recovered.

When, in the course of an operation upon a patient belonging to this class of cases, the intestines are ruptured, the suture of the rent is usually of little avail. In the course of a few days the line breaks down and the faeces are dis-

charged freely through the wound, or a general peritonitis follows. Enterectomy has been performed under these conditions, and while, in rare cases, it has been helpful, most surgeons have found it useless.

Occasionally patients have been operated upon at a time when the disease had already advanced too far to warrant the use of a general anæsthetic. Abbe[63] presented to the New York Surgical Society, at its meeting on Feb. 24th, 1897, a woman, twenty-five years of age, upon whom he had operated eight months before for tuberculous peritonitis. The disease had existed six months at the time of operation. She had been tapped twice. She had become quite emaciated and had a cough; her respirations were labored and rapid; there was pleural effusion, and the abdomen was greatly distended with ascitic fluid. An incision, three inches in length, was made under cocaine anæsthesia, the ascitic effusion was evacuated, and the abdomen was flushed with a saline solution. Her convalescence advanced rapidly and apparently her recovery was complete. She had gained twenty-five pounds in weight.

Tuberculous sinuses have always offered an obstinate resistance to treatment. Recently Beck[64] has suggested a new method for curing them. It consists in the injection of the sinuses with a paste which is composed of bismuth suspended in vaseline, and which may be rendered firmer by the addition of other ingredients. In the early treatment he recommends that 33 parts of bismuth be added to 67 parts of vaseline, brought to a melting point, and then gently injected after the mouth of the sinus has been purified with 95-per-cent alcohol. For use at a later period he advises that the preparation be made of 30 parts of bismuth, 5 parts each of white wax and paraffin (120° melting point), and 60 parts of vaseline. These mixtures are not permanent and must be warmed each time before they are used. The injections are repeated as often as the conditions present in each case may indicate. An ordinary glass urethral syringe is used for these injections.

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ABDOMINAL HERNIA.

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General Considerations.

In a wide sense the word "hernia" includes protrusions of all organs from their cavities, as of the brain from the skull, of the lung from the chest, and of the synovial membranes from a joint.

The hernias of the abdomen are so distinct a class of affections as almost to monopolize the use of the term.

In physical characteristics the abdomen differs from all other cavities of the body. Its walls are more flexible and elastic, its contents more movable, and its natural orifices more numerous and less protected. It is opened more often by accident or design, and as a result weak points in its contour are left, and it is, to a greater extent than other cavities, subject to yielding of its walls under internal pressure. Its circumference and its floor, as well as its roof, are not only passively movable, but in constant active motion. The largest blood-vessels, as well as the largest digestive canals, pass through one or more of these constantly moving walls, which at the same time hold back the air- and fluid-containing hollow viscera from making their escape.

A difficult mechanical problem is presented in making these various outlets and inlets of the closed abdomen ample in size, flexible in movement, and safe against escape under pneumatic and hydrostatic pressure. Yet this is what nature accomplishes in connection with the diaphragm, the duodenal fossa, the urachus, the pelvic floor, the inguinal canals, and the outlets of the femoral vessels.

It should rather excite our wonder that failure to withstand the strains upon the abdomen do not more often cause giving way of its walls, than that yielding is only occasionally met with.

It is becoming more apparent that either congenital deficiency or the effects of wounds is present in a large proportion of all hernias of the abdomen, so that we may well say that the normal, well-developed abdomen (Fig. 196) rarely fails in its function of retaining its contents perfectly. The large part played by congenital defect (Fig. 197), and the relatively small part by trauma are matters which are now well understood; but this is less true of the rarer forms of hernia—ventral, diaphragmatic, lumbar, ischiatic, etc.—than of the commoner inguinal and femoral varieties.

The fluid- and air-filled viscera of the abdomen behave like free air or fluid, exerting their hydrostatic and pneumatic pressure almost equally in all directions. Hence they tend to protrude through nearly every side and corner

of the belly—upward through its roof, the diaphragm; downward through its floor, the pelvis; backward through the loin; forward between the recti or through the umbilicus; along the line of all its natural orifices, and into all the folds and loops of its mesenteric attachments. This gives rise to a large variety of anatomical forms of hernia, many of which are of minor clinical importance because rarely seen, while others are so common as to make up nearly all related clinical experience.

The main value of a study of the rare and obscure forms, especially of internal or concealed varieties, is to aid in the differential diagnosis of general abdominal surgical troubles. Certain of these internal or concealed hernias—as those of the duodenal fossa, foramen of Winslow, obturator hernia, etc.—are very rarely discovered except through some accident or by reason of strangulation.

The commoner hernias—inguinal, femoral, umbilical, ventral—have in

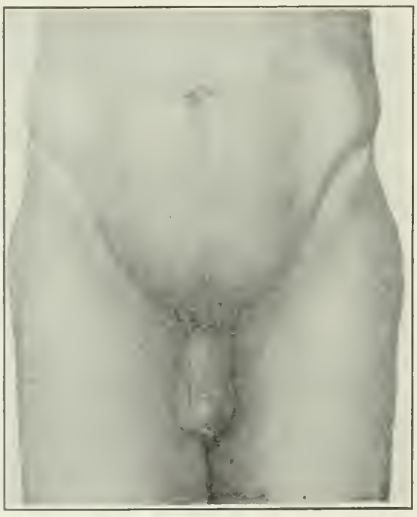

Fig. 196.

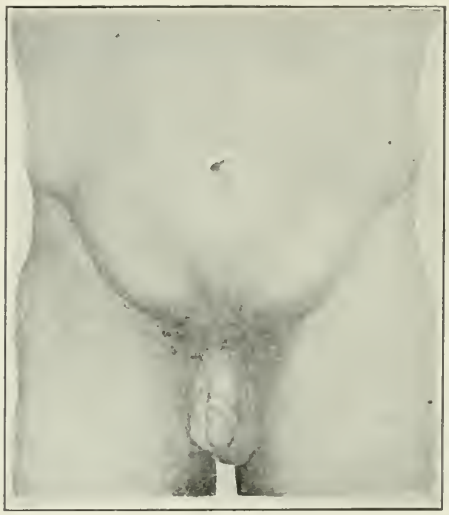

Fig. 197.

Fig. 196.—Normal Contour of Abdominal Wall. (*From Petrequin.*)
Fig. 197.—Weak Abdominal Wall. (*From Petrequin.*)

recent years received so much attention that their management has become a highly developed specialty in surgery. The operative cure of hernia has been entirely revolutionized since 1889, the date of Bassini's first paper, so that data and statistics only one or two decades old are entirely valueless, as are most of the methods of an earlier date. It is impossible to give too much attention to the etiology, pathology, and treatment of these very prevalent affections, mainly because their frequency is of an economic importance now recognized by all employers of labor, including nearly every department of Government activity. At least one in every fifteen or twenty of all males in every community is ineligible—by having hernia—for service in Army, Navy, Police, or Fire Department. Insurance companies demand that proper trusses be used by all applicants. Civil and military departments usually accept candidates

after radical-cure operations, and in America the army medical bureaus have detailed specialists in certain hospitals to operate upon the large number of cases in which this condition appears after enlistment.

Certain associated complications or accidents, especially of abdominal hernia, have given rise to such practical discriminations as irreducible hernia, incarcerated hernia, inflamed hernia, and strangulated hernia.

Irreducibility of the first kind is due to adhesion of the contents of the sac to each other, or to the sac itself, and often to both combined. Instances of this nature are usually best relieved by prompt operative procedure.

In incarcerated hernia irreducibility is dependent on occlusion of the bowel by fecal matter or foreign agents such as pits and seeds of fruit and other undigestible material. In these cases irreducibility can frequently be overcome by dislodging the obstructing agents by means of properly exercised manipulation. If this fails, however, operative interference will be required to effect a cure.

The designation, inflamed hernia, is applied commonly to hernia when contents or sac, or sometimes both together, are inflamed, because of a direct injury or the violence due to unwise manipulation for the purpose of reduction. Operative practice for effecting a final cure is required sooner or later in this class of cases; but, when practicable, mitigation or relief of the inflammatory feature should precede operation.

Strangulated hernia is a common designation of a very important physical condition of the bowel, which, after brief and cautious and unsuccessful taxis, should, when advisable, be treated by operation for radical cure, as will hereafter be expressed.

Types of Abdominal Hernia.

Inguinal Hernia.—The topographical anatomy of the inguino-abdominal region is beautifully illustrated in several modern atlases, notably the stereoscopic photographs of Enderlen and Gasser and the works of Petrequin, Guyon, Paulet, and Koeberle. However, no artificial pictures of anatomy can fit one for surgical effort in any degree comparable to that which can be secured by frequent dissection of the parts in question. We may follow Gilis in dividing the groin into two opposing regions united (or separated) by the fold of Poupart's ligament. These two planes are:—

1. The inguino-abdominal region.
2. The inguino-crural region.

The inguino-abdominal plane is a triangle whose base is Poupart's ligament, inner side the linea alba, and upper limit a horizontal line between the two anterior superior spines of the ilia. The abdominal wall in this region is made up of the following superposed tissues: (*a*) Skin; (*b*) Superficial and deep fasciæ, or subcutaneous tissue; (*c*) Aponeurosis of external oblique muscle; (*d*) Striated muscular tissue (internal oblique and transversalis muscles) and conjoined tendon; (*e*) Transversalis fascia; (*f*) Subperitoneal tissue; (*g*) Peritoneum. Each of these deserves separate consideration in the study of hernia.

Skin.—The skin of the inguinal region is softer, thinner, and more freely movable than that above. It is thickly supplied with hair follicles and sebaceous glands. The use of truss-pads produces, in the groin, atrophic, depressed, or discolored patches which are of diagnostic value. This is sometimes of importance when an old hernia is suspected as an element in obscure abdominal disease.

Superficial Fascia.—The panniculus of the groin is divided to some extent into two layers by fibrous lamellæ, which are occasionally so firm as to cause the inexperienced operator to mistake them for the deep aponeurosis. The fibrous formations in this subcutaneous fat are well developed over Poupart's

Fig. 198.

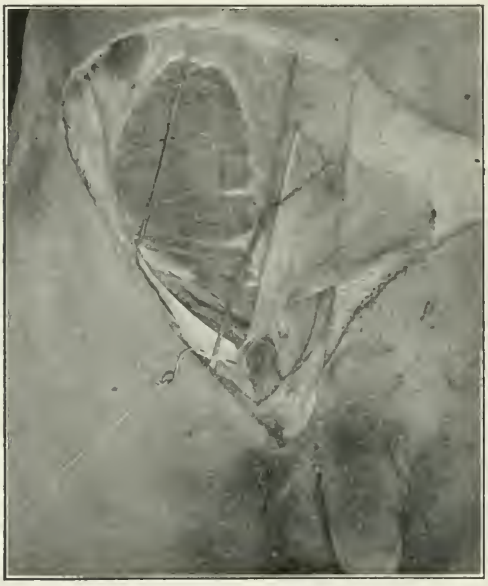

Fig. 199.

Fig. 198.—Dissection Showing External Oblique Muscle and Situation of External Ring; the superficial epigastric vessels have not been divided. (*From Enderlen and Gasser.*)

Fig. 199.—Dissection Showing the External Oblique Muscle Everted so as to expose to view the internal oblique, the cremaster, the cord, the ring, and the interior of the inguinal canal. (*From Enderlen and Gasser.*)

ligament and retain the skin in a deep groove at the inguino-femoral fold, no matter how great the obesity. These fibres are by some writers given the name "suspensory ligament of the groin." The deeper of the layers of the superficial fascia of these parts has fibrous bands attached to the cribriform fascia, external ring, and anterior rectus sheath. Some yellow elastic fibres are present in the central or suprapubic portions and these merge with the coverings of the cord or tunica propria and also spread out as they descend into the scrotum, so as to form the true suspensory apparatus of the sac, and join in continuity with the dartos. Velpeau, from studies in comparative anatomy, asserts that this structure is the analogue of a muscle found in some mammals, and he names it the *ventrier*. It is called by Sappey the "suspensory of the scrotum."

Thompson names the whole cellular space "fascia femoralis abdominalis," and the condensed part at the ring "fibrous cover of the external ring" (intercolumnar fascia). The inguinal region contains numerous superficial and deep lymph nodes which are of great importance in a diagnostic sense. Its vessels are the superficial epigastric vein and artery, which lie some distance apart. Branches from the circumflex ilii and external pubic vessels also cross the groin and lower iliac fossa.

External Oblique.—The aponeurosis of this muscle is made up of coarse fibres which mainly run parallel to Poupart's ligament and of which the latter is the lowest part. This forms the aponeurotic insertion of the external oblique muscle and transmits its powerful contractile force to the pelvis, groin, and middle line. But this aponeurosis is so flat and broad that it constitutes here

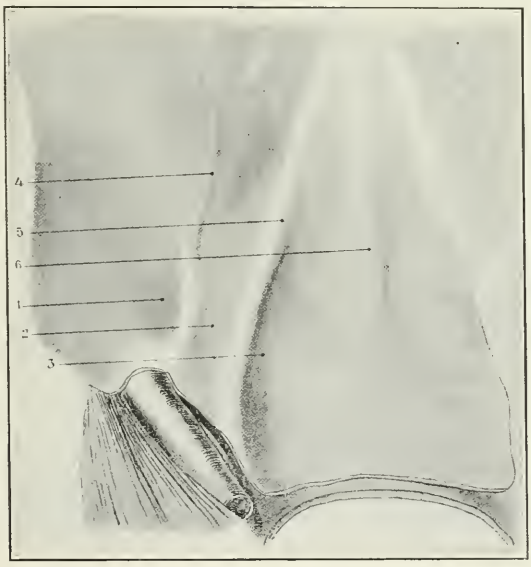

FIG. 200.—The Three Inguinal Fossæ. 1, External fossa; 2, middle fossa; 3, internal fossa; 4, deep epigastric vessels; 5, umbilical artery; 6, urachus. (*From Petrequin.*)

the most important factor of the anterior abdominal wall; also it overlies the other layers of the abdominal wall. This layer has, therefore, both an active and a passive function, according to the state of the part. The opposite muscles interlace or reinforce each other—markedly so at the pubis.

The External Ring.—The lower and inner bundles of the aponeurosis (pillars), as they approach their insertion on each side of the pubis, diverge so as to leave a triangular opening—the external abdominal ring. (Figs. 198 and 199.) These (one on each side) are 2 or 2.5 cm. in length and 1 or 1.5 in width.

The Red Muscle or Roof of the Canal.—The two striated muscles (internal oblique and transversalis), with one insertion (the conjoined tendon), are exposed when the aponeurosis of the external oblique is divided. Only the lower fibres of these muscles come into this field. They are inserted, as the conjoined tendon, into the crest of the pubis and the pectineal line, and, when

deficient, the posterior wall of the canal at this situation is much weakened. This is probably a congenital defect in many even of the acquired direct inguinal hernias. Looped fibres of this red muscle, descending along the cord, are called the cremaster muscle, and are much hypertrophied in large hernias.

Transversalis Fascia.—This layer lies beneath the abdominal muscles, and attains its greatest thickness in the lower abdomen and the inguinal region. Gilis has shown that this fascia is distinct from the conjoined tendon. It is the structure which forms the true internal inguinal ring, and as such deserves special attention in plastic operations for the repair of hernia. A better idea of this layer can be had by a posterior or internal view of its openings. Looking from the inner ring toward the pubis one sees, in Hesselbach's triangle, a "weak spot," which is the point of protrusion of some hernias. At the inner border, toward Hesselbach's ligament, the fibrous margins of the ring are much more firm. When the ring is enlarged by hernial protrusion it yields principally on its inner or pubic side, thus shortening the canal.

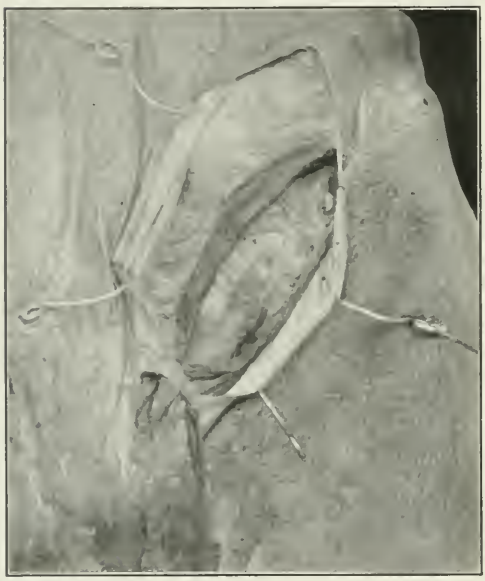

Fig. 201.—Dissection Showing the Deepest Layers of the Abdominal Wall or the Transversalis Fascia. Deep-red muscle retracted. (*From Endcrlen and Gasser.*)

Subserous Fat.—This fat contains three areas of different densities: that about the internal ring; the epigastric area; and the prevesical area.

1. About the Internal Ring.—This region has the peritoneum closely united to the fascia, but lobules of fat protrude with the cord in some cases and need attention lest they prevent firm closure by operation.

2. Epigastric Area.—This region has a very loose investment of adipose tisues in which the deep epigastric artery finds its way internally to the ring. In men it is 5 cm. outside the pubis, in women about 4 cm. from the same point. This epigastric area of the subserous fat also carries two other important structures, viz., the vas deferens and the spermatic vessels which here come together to form the cord.

3. Prevesical Area.—This large space, composed of loose tissues, lies below the reflected peritoneum rather than in front of it. It is surgically important from the fact that, in hernia of the bladder, the peritoneum usually is left behind, forming the so-called sliding hernia or one without a sac.

Peritoneum.—To study this layer properly the abdomen should be opened. A false or imperfect idea of its anatomy is obtained in hernia operations, which often are planned to deal mainly with the muscles, sometimes only those in

front of the cord. The most important information obtained from an internal examination of the peritoneal side is that it is not flat or uniform, but contains three depressions. These are termed the internal, middle, and external inguinal fossæ. (Fig. 200.) The internal fossa is bounded by the middle line or urachus and the umbilical artery. The middle fossa lies between the umbilical artery and the epigastric vessels. The external fossa lies outside the deep epigastric vessels. It contains the vestiges of the processus vaginalis of the cord and, in congenital hernias, communicates freely with the tunica vaginalis. Hesselbach's triangle includes the space lying between the deep epigastric artery,

Fig. 202.

Fig. 203.

Fig. 202.—Photograph of a Section of the Trunk of a Four-Months Fœtus. The picture represents the pelvic region as seen from a point within the abdominal cavity and well above the pelvis. The testes appear here as abdominal organs. Between them, and extending downward (in the picture), may be seen the bladder. The divided rectum and the umbilical arteries are also visible. (*From Enderlen and Gasser.*)

Fig. 203.—Photograph of a Section of the Trunk of an Eight-Months Fœtus. The view represents the left side of the pelvis as it appears when looked at from within the abdominal cavity. The testis, epididymis, and gubernaculum are visible. (*From Enderlen and Gasser.*)

the rectus muscle, and Poupart's ligament, and the *point faible* (or weak spot) of the French writers lies at its lower extremity.

If the peritoneum be reflected from the inguinal region we see a light, translucent, elastic layer composed of vertical fibres lying behind the red muscles (the internal oblique and the transversalis muscles). This is the transversalis fascia. (Fig. 201.) The testicle in its descent gives rise to the internal ring, not so much by perforating the fascia as by carrying it along as it advances, so that its fibres may be said to form a complete tube or pouch (tunica propria) along the cord and around the lower end of the testis. A similar investment attends the femoral vessels into that canal. Thompson thinks that

this process is reflected from the surface of the great vessels to form the septum crurale. In the inguinal canal this fascia, as shown by the photograph (Fig. 201), fills the whole space between the cord and the exit and the pubis. Its lower insertion, between the femoral vein and the pubis, is into Gimbernat's ligament and the pectineal line within, and is continuous with the pelvic fascia without.

Hesselbach's Ligament.—Looked at from within the border of the internal ring Hesselbach's ligament is seen to be a firm and crescent-shaped structure. (See Figs. 202 and 203.) It may be seen very distinctly if the peritoneum is

Fig. 204.

Fig. 205.

Fig. 204.—Photograph of a Horizontal Section of the Trunk of a Nine-Months Fœtus. The picture represents a view of the pelvis as seen from within the abdominal cavity. The urachus and umbilical vessels are twisted. The sigmoid flexure is in place. Both testes have entered the inguinal canals and have descended almost to a point beyond the inner ring on each side. (*From Enderlen and Gasser.*)

Fig. 205.—Photographic View of Congenital Hernias (Double) at Birth. In the dissection the anterior abdominal wall has been pulled down far enough to expose the pelvis. Both vaginal processes are open. (*From Enderlen and Gasser.*)

removed. The fibres form almost a "Z," the upper limb of which is Douglas' arch or ligament and the oblique line Hesselbach's ligament. At the outer side of this ligament the cord, vessels, nerves, and vas deferens unite to pass into the canal as one bundle. The dissection, in operations for the radical cure of a hernia, should be carried down to this point, in order thoroughly to obliterate the sac. When this is done, congenital sacs, as well as ordinary ones, can be ligated, inasmuch as the cord is extraperitoneal above this point. Hesselbach's ligament merges laterally into the general surface of the transversalis fascia, especially toward the symphysis, and passes without a break into Poupart's ligament. The inguinal canal and its con-

tents—the spermatic cord covered by cremaster muscle and a fibrous sheath described above—have four principal vessels: (1) the artery of the vas deferens; (2) the spermatic artery; (3) the anterior group of veins and lymphatics; (4) the posterior group. A small branch on the fibrous covering of the cord is called by Bouveret the "funicular artery." The vas deferens is plainly distinguished from the other vessels of the cord by its thick walls, which give it the appearance of a solid cord. The spermatic cord, as a whole, often contains masses of adipose tissue and varices, which in the aggregate are large enough to interfere with efforts to close the canal by sutures. The removal

Fig. 206. Fig. 207.

Fig. 206.—Photograph of the Pelvic and Lower Abdominal Region of a Child (not over One Year Old), with Single Congenital Hernia Discovered at the Time of Birth. On the left side of the picture (the child's right side) a persistent processus vaginalis may be seen; on the opposite side (the child's left side) the processus is closed. (*From Enderlen and Gasser.*)

Fig. 207.—Photograph of the Inner Aspect of the Lower Abdominal Wall of an Adult in whom there Existed a Large Double Hernia. Note the fact that on the left side the bowel is incarcerated. (*From Enderlen and Gasser.*)

of the sac, together with these lobules of fat and the varices, usually reduces the cord to manageable size.

In women the canal transmits the round ligament—a structure much smaller than the spermatic cord. Its vessels are seldom enlarged or of material importance.

Form and Dimensions of the Inguinal Canal.—The canal, as a whole, is of triangular section, having an inferior, a posterior, and an anterior wall. For part of its course the cord lies between the transversalis muscle and the fascia, so that these layers may be said to be of the walls of the canal. Further down, the cord passes beneath the internal oblique and transversalis muscles, these structures being sometimes called the roof of the canal. At the lowest portion

of the canal its anterior and posterior walls are respectively the external oblique aponeurosis and the conjoined tendon, and the floor of Poupart's ligament and crest of the pubis. The length of the canal, as obtained by Blaise in a series of measurements, varies from 4 to 4.4 cm. ($1\frac{3}{4}$ inch). Gilis, however, places it at from 5 to 6 cm. ($2\frac{1}{2}$ inches). As observed in hernia operations, the canal departs very widely, in its dimensions, from the normal averages, being larger in diameter in certain cases, while in others its length is shortened or even abolished.

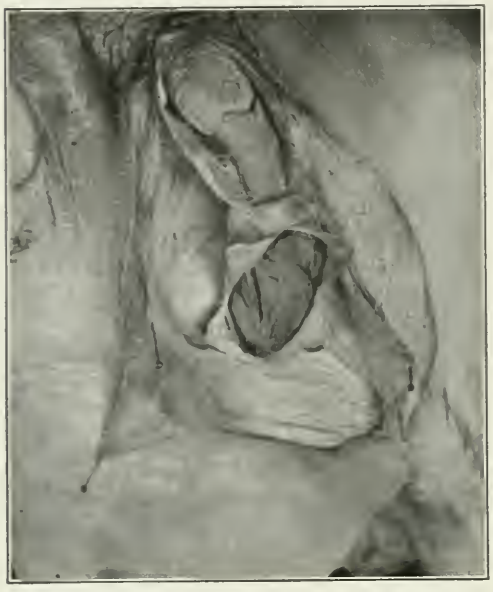

Fig. 208.—Photograph Showing a Dissection of a Large Inguino-Scrotal Hernia. The intestine lies in the tunica vaginalis in direct contact with the testicle. (*From Enderlen and Gasser.*)

The physiological function of the complex planes of tissue, above described, may well be reviewed before we consider the etiology and treatment of hernia. As these planes are mostly active muscular layers we should consider any method of support or operative mending imperfect which does not secure their physiological action as an element in repair. The obliquity of the canal is an important source of its strength, and should be preserved or restored. Muscular and tendinous fibres should be preserved, as nearly as possible, in their natural relation, and should not be too much disabled by operative efforts.

Congenital Abnormities and Arrested Development in Inguinal Hernia.—The rôle of congenital defect, as a factor in inguinal hernia, is so prominent that it is cited by some observers as a universal cause, to the exclusion of all others. This is perhaps an extreme view, as it would deny the existence of really acquired hernias, even when they appear in late life, but would assume that at least a congenital predisposition was present in these cases. Many observers are now sceptical about the so-called traumatic hernias frequently met with in industrial employees, especially as a basis for personal-injury suits-at-law. On this side of the Atlantic it may be said that statistics prove that a large percentage of the hernias acquired in adult life occur in persons who had ruptures in childhood. The affection is also markedly hereditary.

True congenital hernia is best understood by a study of the abdomen from within, that is, by looking at its orifices from the peritoneal side, and by dissections of fœtuses at various stages of development. A very accurate idea of the anatomy at this period of life may be obtained by a study of the accompanying figures, which have been copied from a series of stereoscopic photographs representing dissections made by Enderlen and Gasser. (Figs. 202–209.) Fig. 202 represents a horizontal section of a four-months fœtus, and shows the

testes as true intra-abdominal organs. In the eight-months fœtus (Fig. 203) the testis has partly begun its descent, but is still within the abdomen. In Fig. 204 the organs have passed on almost into the canals, leaving the processus vaginalis open on each side. In Fig. 205 they have passed entirely through. Fig. 206 shows a child, in its first year, in whom the processus vaginalis is completely closed upon one side, while, upon the other, it is still open—a condition which forms at least a potential hernia. Fig. 207 shows both sides widely open, forming two hernias, one of which has its contents unreduced. Figs. 208 and 209 show, respectively, a dissection and the external appearance of a scrotal hernia.

Fig. 209.—Large Scrotal Hernia. (*Author's Case.*)

Pathological Changes in Hernia.

As distinguished from the normal anatomy, the pathological anatomy of hernia shows marked alterations in the structure and relations of the parts.

Hernial Opening or Ring.—Every hernia has an opening which is either a congenital abnormity or an acquired defect. The classification of hernias is based upon the location of these openings or "rings." Thus, in the inguinal canal we have inguinal hernias, in the femoral canal femoral, and still others named in a similar manner after the localities where they occur—as, for example, umbilical, ventral, ischiatic, obturator, diaphragmatic, semilunar, incisional, etc.

The Hernial Sac.—The hernial sac consists of a peritoneal pouch escaping at the ring. It usually carries a connective-tissue investment and hence may have layers of fat and some vessels outside its wall. These may make the sac somewhat difficult to identify upon inspection or by dissection. In some cases the translucency of the sac wall is such that it may be difficult or impossible to distinguish, by mere inspection, the external fat from fatty contents, *i.e.*, omentum. In case the latter is adherent to the inner surface, as in certain femoral and umbilical hernias, and if, at the same time, the external layer of adipose tissue is thick, the sac cannot be isolated or safely incised except by seeking a new point remote from the adhesion.

Every hernial sac has a body, a neck, and a fundus, but extraordinary varia-

tions occur in the form and size. Very small or recent hernias, such as the shallow, direct inguinal, may have no permanent sac, the peritoneal pouch appearing only when the hernia protrudes and returning with it. Many sacs are composed of thin, flexible peritoneum, while others acquire hypertrophied, inelastic walls from continued irritation or vascular and trophic disturbances. The neck of an inguinal or a femoral sac is often a condensed fibrous ring, easily seen, when it is drawn down in operating, to be the narrowest portion and to be marked by a hard white line on the inner aspect. This inelastic band marks the point of compression in a strangulated hernia. On account of the pressure of pads or through other irritating influences a sac may be obliterated by adhesive inflammation at its proximal part; and when this happens there is left a cavity which becomes distended with serous fluid. In this way cysts or hydroceles of the cord or of the canal of Nuck are formed. The same irritations cause the hernial contents to become adherent, thus rendering the hernia wholly or partly irreducible. For the same reason deformities of an hour-glass form are not uncommon, and the presence of these may convey to the observer the impression that there are several rings, one below or distal to another, with dilated pouches between. These rings look as if they represented each a former neck of the sac which had been pushed or dragged farther down, allowing a new one to form above. A very important variation is represented by the formation of diverticula, which give the appearance of double or multiple sacs. The importance of these diverticula lies in the fact that, in operation for the radical cure of hernia, a failure may be expected if any of them are overlooked.

The occasional absence of a sac in a hernia is a phenomenon which, although at first puzzling, may easily be explained. In abdominal wounds which open adjoining cavities, as the pleura or pericardium, hernia of the intestines takes place without any peritoneal covering. I have seen two such cases in Cook County Hospital, and in both of them nearly all the intestines were found in one pleural cavity, from traumatic diaphragmatic hernia. In one of these cases the opening had been established by a stab wound, and in the other there had occurred a traumatic rupture of the diaphragm.

Another instance of absence of sac is seen in those forms of inguinal or femoral hernia which are called "sliding hernia," or "hernia *par glissement*." The colon on either side may slide into such an inguinal or femoral canal by escaping from its own mesocolon, and hence be devoid of peritoneum wholly or in part. The ease with which the peritoneum is lifted from the large intestine at its posterior wall, or its absence there (left side), is well shown by the old operation of lumbar colostomy, which was done without opening the general peritoneal cavity. Again, when the bladder enters the hernia, it almost never has a sac. For this reason inexperienced operators may open it, mistaking it for the sac itself.

Contents of the Hernial Sac.—The omentum, often in the form of slender processes, is apt to find its way into the smallest hernial opening. Next in frequency, owing to its mobility and small size, comes the small intestine. The large bowel, the sigmoid, the cæcum with the appendix, and occasionally

the transverse colon, also sometimes form a part of the contents of the sac. The bladder, uterus, tubes, and ovaries are met with only in comparatively rare instances. In hernia of the diaphragm the stomach and even the liver may be found. Organs that remain for a long period in a hernial sac become altered in appearance. The omentum is condensed and œdematous and the intestine may become grooved and marked by hour-glass contractions at the points where pressure is exerted. Sometimes these structures are surrounded by serous exudate. Masses of adipose tissue in the canal sometimes cause an appearance of hernia when none really exists. The condition is aptly termed "hernia adiposa." It is more often an accompaniment of a true hernia than an independent condition. Such lobular masses are developed from the properitoneal fat. They are usually of small dimensions, but they may occasionally attain the size of a hen's egg. Such masses of adipose tissue require careful removal in operations for radical cure, as their presence tends to prevent good closure by suture of the canal. Each lobular mass of fat may possibly enclose a complete sac and hernia; hence care is needed in examining and removing them. In the prevesical space and in lumbar hernia the masses of adipose tissue are usually dense and thick.

General Symptoms and Diagnosis of Hernia.

Reducible Hernia.—Reducible hernias cause tumors at one or other of the natural or false orifices; and these tumors, unlike all the other forms, appear and disappear with change of posture or on pressure. The characteristic of reducibility is a cardinal diagnostic point in all hernias. It is true that certain other swellings—for example, funicular hydroceles or psoas abscesses pointing below Poupart's ligament—may give rise to enlargements and impulses which simulate hernias. These usually have additional signs, local or general, which make the differential diagnosis positive on thorough examination. General symptoms due to bowel disturbance or to interference with the bladder, tubes, or ovaries, may be present in greater or less degree. There are usually few general symptoms other than a sense of weight or dragging, even in the largest hernia when perfectly reducible. Inspection and palpation show, not only large or small tumors which can be pushed back into the abdomen, but enlarged orifices or rings which are felt with the fingers after reduction. The exact contents of the hernia can rarely be made out with certainty by external palpation.

Irreducible Hernia.—The diagnosis of an irreducible hernia may be a more difficult matter, especially if it is located in the inguinal or femoral canal and if inflammation be present. The painful tumor may then, if no intestinal symptoms are present, be mistaken for adenitis, and the disease may go on to gangrene and abscess formation before the truth is ascertained. In inflamed bubonocele the inguinal canal is occupied in part by a tender structure, which fact can be determined by carrying the finger into the canal. If an inflamed node overlie the canal the node can be caught between the underlying fingers and the thumb of either hand, thus rendering possible an immediate diagnosis

between these conditions. If the part involved consists simply of omentum, unaccompanied by intestine, no serious results may follow, but if the bladder, a part of the colon, or one wall of the small intestine, is perforated, there results at this point a fistula. Often one encounters irreducible and incarcerated hernias of large size which do not undergo strangulation. These are not amenable to trusses and they tend to grow larger. They are constantly in danger of a sudden increase and strangulation. To a greater degree than is true of reducible hernias they cause constipation, irregular peristalsis, and mild or severe chronic bowel obstruction, with indicanuria and a low grade of toxæmia. On account of their being a menace to life and health they should be treated by surgical interference.

Inflamed and Strangulated Hernia.—Strangulation and inflammation of a hernia are often coincident lesions. They may be entirely independent, the one of the other, or they may mutually aggravate each other. Strangulation means interference with the vascular circulation, so that gangrene of the intestines or omentum, as well as mechanical obstruction, more or less rapidly supervenes. If, under sudden abdominal pressure, a larger amount or a new portion of intestine is forced into a hernia it will be retained there by its own elastic distention and by the pressure of the rings. When this occurs, a sudden onset of pain is often felt at the point of obstruction, and there follows an attack of colic, due to reversed peristalsis. The symptoms may vary somewhat according to the part of the intestine involved, but in general they are those of acute intestinal obstruction, as described in another article in the present volume. Vomiting (which in time becomes fecal), obstipation, collapse, and signs of impending peritonitis rapidly appear. In a few hours, in most cases, the patient's condition assumes a dangerous aspect. Unless early reduction is obtained by taxis, gangrene and perforation occur in the sac and the patient suffers from septic intoxication and also from a severe grade of shock, which is due, not so much at first to the peritonitis, as to the intensity of the local inflammatory reaction. Early operation is required if reduction is not secured. After the lapse of only a few hours gangrenous contents of the sac may require resection of the bowel or omentum in a patient who is ill able to withstand a major operation. The combined effect of these risks is such as to give the operation a high mortality. In some hospitals it has been as high as forty or fifty per cent, due partly to the late cases, but under no circumstances is the mortality rate low. The occurrence of such cases constantly in every community is a strong argument for the general adoption of radical-cure operations, since these are quite free from risk and would forestall the occurrence of strangulation.

General Remarks on the Treatment of a Strangulated Hernia.

Wuellstein names three types of treatment that may be employed in the early stage of strangulation:—(1) By medication; (2) by taxis; (3) by operation.

Treatment by Medication.—Little confidence should be placed in local or

general medication in strangulation, yet as good authorities as Gussenbauer and also Finkelstein report benefit from spraying or washing the hernial tumor with ether and from applying ice locally, to reduce congestion and as an aid to taxis. Other measures that may be employed in preparation for, or as an aid in, taxis, are the rubber bandages, which, in the case of large tumors, should be applied around the tumor or over the hands of the operator, to assist his muscular efforts. The bandages so employed should be specially made; they should be thin and long, about half the weight and strength of the ordinary Martin or Esmarch bandages.

The posture of the patient may assist reduction, or it may even accomplish it alone through the action of the force of gravity. Thus, if the hernia is near the pelvis, the hips may be elevated, by which means the blood current and the fecal flow will be diverted from the parts. The dependent viscera also tend to gravitate toward the diaphragm, away from the inguinal canal. An extreme use of this adjuvant to reduction is practised by completely inverting the patient, either by standing him upon his head or by suspending him by his feet or flexed knees. A person who is not too heavy may be suspended by fixing his knees across another person's shoulders, so that he hangs head downward upon his back. If the supporting person now walks or jars his burden by stepping backward and forward, the hernia will occasionally undergo a spontaneous reduction. These crude methods are not to be advised except in emergencies, when suitable tilting appliances are not at hand. The foregoing measures, when employed, should be briefly and cautiously applied, so that no sacrifice of a better opportunity will occur.

Treatment by Taxis.—In most cases taxis or direct external force must be resorted to before an incarcerated or strangulated hernia can be reduced. Taxis is not so simple and innocent a procedure as might be inferred. Efforts at taxis may defeat their own aim by reason of being incorrectly applied. A certain manipulation is required for the successful reduction of a hernia, and this manipulation is learned more particularly in reducing the same kind of a hernia on successive occasions. In general, it is important to learn the fact that reduction by taxis is not a process of pushing in. Inward or backward pressure toward the ring is generally the least likely of all efforts to reduce the strangulation. The effective motion is one which may be described as a pulling away, combined with a squeezing together of the mass laterally. The whole mass should be grasped by the hand with as smooth a hold as possible. If it is large, it should be held by the palms rather than with the fingers. If it is extra large, the light rubber bandages should be employed for the purpose of assisting the hands. The mass being held in this way, it should be pulled gently away, as if to draw down more hernial contents. This tends to unfold and disengage rather than to cause further kinking of the bowel. At the same time steady but light compression laterally of the whole mass should be made. This tends to empty the blood-vessels and to expel whatever may be contained in the lumen of the intestine. It is rare that reduction is immediately accomplished. The greatest hope of eventual success comes from continuous appli-

cation of the force just described, especially the compressing force, until the vascular distention is reduced. The value of the rubber bandage as a means of relieving the surgeon's muscles, will be apparent. General anæsthesia is usually needed in the severe cases, especially if the abdomen is rigid. After a few moments of steady compression the direction of the pull can be varied somewhat, with the object of finding, experimentally, the direction of the canal. In successful cases the first encouraging sign is generally a gurgle felt or heard—this noise signifying that something has passed back into the abdomen; and this something is more likely to be the air or fluid in the intestine than the latter structure itself. It is, however, a very favorable sign, especially if repeated in the course of a few moments. After several repetitions of this gurgle of reduction it will usually be noted that the tumor decreases in size, and not uncommonly it slips back at last suddenly, like an ordinary reducible hernia. Such taxis requires great gentleness and skill, that can be acquired only by practice.

Treatment by Operation.—Patients under the influence of an anæsthetic should be so prepared that, if taxis fails, immediate operation may be done. Herniotomy for strangulation was formerly done in a way very different from that employed in the operation for a radical cure. Very small incisions were made, and anything like a free dissection of the serous canals or the abdominal wall was avoided. Exactly the opposite should be our present practice. All idea of avoiding the peritoneum is now given up, and the free incisions which usually characterize the radical method of cure should be employed here. Especially should we avoid the methods of cutting the rings with long herniotomy directors and probe-pointed knives passed up through narrow orifices. We should be prepared in all cases to examine the tissues we cut and, if the patient is in good condition, to finish the operation in precisely the same manner as we would one for a radical cure of hernia. If, however, the patient's condition is not good, and if it be found that the intestine needs operative repair, all the more imperative will be the duty to make a free incision, in order that we may get proper access to the field of work and to the coils of intestine.

The resection of a gangrenous intestine or the repair of other lesions (as of bladder, tube, ovary, etc.) differs in no way from similar operations for other affections. (See the articles on "Surgical Diseases and Wounds of the Intestines, Bladder," etc., in this and the following volume.)

The repair of the abdominal wall after herniotomy approaches most nearly the ideal standard when it is accomplished by one of the operations later to be described. Should the patient be too profoundly under the influence of shock, or if the local infection is too intense, owing to the presence of a gangrenous sac, pus, etc., the wound may be packed lightly, as in septic laparotomies, or hurriedly closed in part of its course while a light tamponade is employed for the remainder of the wound.

The repeated occurrence of strangulated hernia and the numerous deaths caused by it, even in patients wearing trusses, should warn us that new additions are needed to diminish or abolish the death rate. This brings us at

once to a consideration of the value of curative operations and the risks which attend them.

The rare danger of operation for the radical cure of hernia is to be balanced against the certain risk of strangulation. When the radical operation had been perfected to such a degree that its risk *per se* was *nil*, it became a safer method of treatment to advise, in healthy subjects, than the use of trusses. As many deaths are caused annually by strangulation, a heavy responsibility rests upon the physician who fails to advise curative treatment by means of an operation. Any one of large experience in medical practice is able to recall instances of fatal strangulation and of narrow escapes after desperate operations. An earlier radical operation would have obviated these complications without special danger to the patient.

It is true that only a few years ago the best surgical text-books were correct in stating that curative operations were attended by some risk and many relapses. This made it questionable whether a patient's welfare was best subserved by operation or by conservatism. Only a slight operative mortality would at that time be sufficient to turn the balance in favor of non-operative measures, except when the latter had been tried and had been found unsuccessful. These statistical arguments are now reversed by the long series of successful cases without any mortality, which many of the best clinics report, and by the comparative rarity of recurrence. The improved statistics in radical cure are due mainly to improved technique, but also partly to a better selection of cases. Modern reports are based upon large series of moderate-sized, uncomplicated hernias. The older statistics were made to include a greater proportion of large, adherent, or in some way complicated hernias, upon which it became absolutely necessary to operate by reason of the failure of other methods of treatment. Even now complicated or giant hernias give operative risk and should, so far as prognosis is concerned, be classified separately. We may, therefore, group operative cases in the following manner:—

(1) Small or medium-sized reducible hernias.—Rare mortality.

(2) Very large and incarcerated hernias.—Slight mortality.

(3) Strangulated hernias.—Large mortality.

Classes 1, 2, and 3 should be kept distinct for statistical purposes. The last two comprise cases which often, despite the obvious risk, demand operation for the purpose of relieving or preventing still greater danger. Their very existence is a self-reproach, since, if they had been cured by operation at an earlier period, these hernias would not have become large or dangerous.

History of the Different Methods of Effecting a Radical Cure.—The very ancient origin of the cure of hernia by operation is well known. Both cutting operations and spring trusses were employed at the earliest historical period of medical science. The operation for inguinal rupture was rather common in mediæval times, especially in France. Castration on the affected side was found to favor an easy solution of the problem of closing the ring, and this practice became so common that it was interdicted by statute on grounds of public policy.

In the period just before and just after the dawn of Listerism operations for the cure of hernia were devised by many clinicians, and it would be easy to find, in the treatises of from twenty to fifty years ago, accounts of scores of these methods, many of which bear the names of distinguished surgeons and are characterized by much ingenuity. Thus, in treatises which are still on our shelves, we may find the descriptions of operations known as the Wood, Wutzer, Heaton, McDowell, Ball, Nussbaum, Barker, Baxter, Czerny, and Woelfler operations, —not to mention a score of others,—all possessing more or less merit and many of them still somewhat generally used. The drawbacks to all these methods are their comparative inefficiency and the greater risk that attends them. After abdominal surgery underwent its brilliant development, during the decade from 1880 to 1890, a new hernia era became possible and was indeed inevitable—an era in which all previous fear from opening the peritoneal cavity was abolished. This fear had been the most serious drawback to the development of a radical method of curing hernia, for it prevented free dissection of the structures involved and promoted half-way measures and makeshifts. The Wood and Wutzer operations avoided opening the skin by invaginating it with wire or silk sutures. Other methods—known as "sewing the pillars," etc.—contemplated only the closure of the external ring. None of them sought to repair the breach in the wall from its deepest layers outward, nor to make a very high extirpation of the sac. The canal, in these methods, was not widely opened; hence no true plastic operations could be done on its interior.

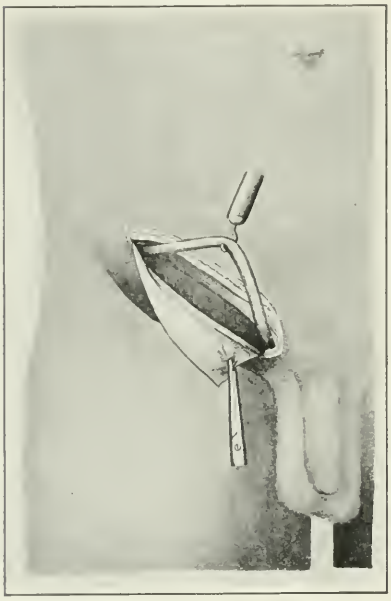

Fig. 210.—Bassini's Operation. Step 1 and step 2 completed. (*From Bouveret.*)

These more or less faulty methods were substituted, in 1889, by what are properly known as open operations, *i.e.*, open dissections of the canal for the purpose of repairing the deep or inmost layers of the abdominal wall. The general adoption of this principle followed the publication of Bassini's first paper, in which were reported several hundred cases that had been treated by his now well-known method. It is true that he credits Macewen, of Glasgow, Scotland, with being the originator of several of his important steps. Previous to both of these, Henry O. Marcy, of Boston, Mass., had practised and published an open operation which contains the essential features of both the Scotch and the Italian methods and includes the use, for the first time, of the buried tendon suture. European and American surgeons almost immediately adopted the Bassini technique or Marcy's and Macewen's technique, as modified by Bassini. Its employment became general, and it still remains the most

frequently used method in Europe. In America also it meets with considerable favor, but it is not used quite so generally as abroad.

Nearly every later operation follows, of necessity, in the general lines of the Marcy-Macewen-Bassini technique. They differ from the Bassini method as much as from its predecessors, but, on account of the wide use and great prestige of the Italian's method, all later operations are often classed as modifications of it. Thus we read of the Bassini-Fournel operation in France—a procedure which is identical with the Andrews operation, but was published some years later; of the Bassini-Girard method in Switzerland—the same operation, probably independently devised; of the Bassini-Andrews method—also the same as the two last-mentioned, and published some years in advance of either.

Other divergent methods, such as Kocher's *Verlagerungsmethode*, Phelps' method of employing wire coils, and Willy Meyer's use of filigree, are relatively little used, or are used only in exceptional cases.

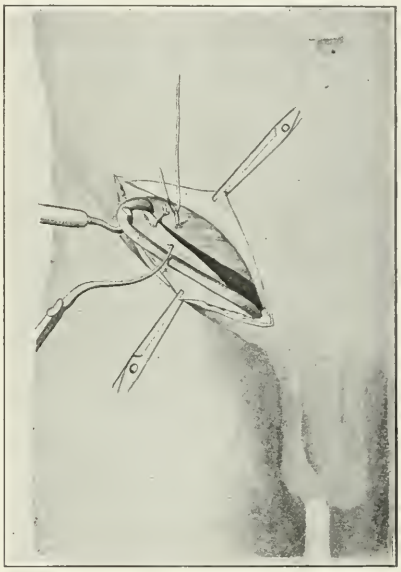

Fig. 211.—Bassini's Operation. Step 3. Deep suture placed, while the cord is temporarily raised. (*From Bouveret.*)

Technique of Bassini's Method: Step 1.—The canal in this operation is split along its whole length, after the skin has been divided, so as to afford access to the internal ring. Step 2.—The hernial sac is next sought and freed until it can be separated from the margins of the inner ring, and even a little higher up or deeper down; no portion even of the neck of the sac being permitted to remain behind. After the sac has been opened and its interior has been inspected, it is extirpated, if empty, by transfixing and ligating its neck at the highest possible point. The aim should be to leave no portion long enough to form even a dimple or funnel leading into the false opening. (Fig. 210.)

Step 3.—The next and most important step is the plastic obliteration of the false opening by means of a row of stitches which shall close the deep layers or posterior wall of the canal, at the spot where the false opening was barely large enough to transmit the cord. The latter should be relieved of all masses of adipose tissue, in order to reduce its size. The position and number of these deep stitches depend upon the size of the ring and the direction of the enlargement. They usually seem to restore the anatomy of the canal in the most effective manner when they are inserted internally to the deep ring, that is, between it and the pubis. The dilatation or stretching of the ring rarely or never takes place in an outward direction, but practically always inward. In Bassini's operation the cord is lifted out of the way and the stitches are placed behind it. (Fig. 211.) The needle is passed through the internal oblique and transversalis

and an effort is made to include also the transversalis fascia, which actually forms the internal ring. Followers of Bassini are apt to forget the importance which he attaches to this step, and to include muscle only in this stitch. Bassini, in operating, pushes a flat director into the inner ring next the peritoneum. With this he lifts all the structures except peritoneum, to insure their being caught by the needle. The needle is next carried down behind the shelving edge of Poupart's ligament (seen on its inner aspect in the lower side of the canal) and brought out through the ligament. The needle being passed from within outward, the vessels are not endangered. If the reversed direction is used in passing the stitch, extreme care must be taken to prevent the needle point from injuring the femoral vein and artery. This accident has been reported several times. It can be avoided by placing the finger between the vessels and the ligament. The latter may then be pulled forward a little; after which the needle point is caught on the finger tip and guided into the canal. In doing this the operator rests the back of the finger upon the great vessels and is thus able to feel distinctly their pulsation. From two to five interrupted stitches are placed in this manner in the posterior wall of the canal, the cord being held temporarily to one side. The lowest of these stitches should be placed very near the pubic end and should include Gimbernat's ligament, if the deep hernial opening extends to its margin. The uppermost stitch should narrow the ring around the cord as much as possible without constricting its vessels. Bassini leaves the director above-mentioned in the inner ring, until this upper stitch is tied. It is then withdrawn, a little extra space being thus left for the cord. In doubtful cases the spermatic artery may be palpated before and after tying the upper stitch. If tying it stops the pulsation in this small vessel the stitch should be discarded. The occasional loss of a testis from gangrene after a hernia operation points to the need of care against too tight closure around the cord. At the same time it is important to narrow the ring as much as practicable, in order that the exit of the hernia may the more effectually be blocked. (Fig. 212.)

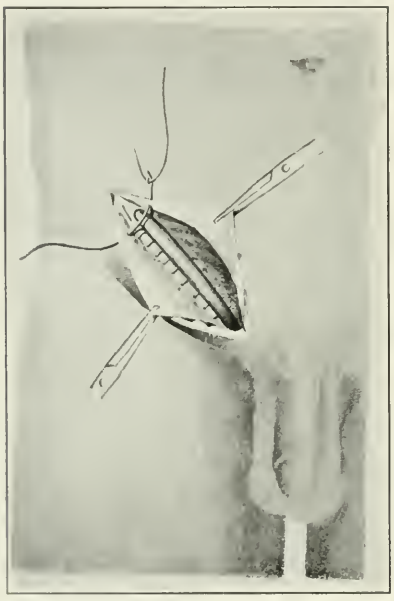

Fig. 212.—Bassini's Operation. Step 4. The cord is replaced upon the repaired posterior wall. (*From Bouveret.*)

Step 4.—The next step in the Bassini method is the reuniting of the external oblique aponeurosis over the new canal or the reconstructed old canal. This may be done with continuous or with interrupted stitches. I have observed, in Professor Bassini's own work, that he places two interrupted stitches at each end, the intervening edges being brought together by a continuous suture.

Step 5.—The final step is the closure of the skin. Bassini himself uses the form of suture shown in Fig. 231. This and all the deep sutures are of braided silk thread previously sterilized by boiling in glycerin. Most American and European operators use absorbable stitch material for the buried suture. Chromicized catgut is to be preferred. Plain catgut is not durable enough, as it lasts only a few days before it undergoes absorption; it is sometimes a cause of failure if used in herniotomy. Kangaroo tendon, the usefulness of which was discovered by Henry O. Marcy, is an ideal, durable animal ligature. It resists absorption longer than chromicized gut does—in some cases for as long a time as from four to eight weeks. I have used this exclusively for the deeper fascial suture in over fourteen hundred herniotomies. Dr. W. B. Coley reports a large number of cases (2,500) in which he has used it successfully in the Hospital for Ruptured and Crippled, New York City. The material is less well known in Europe than in America.

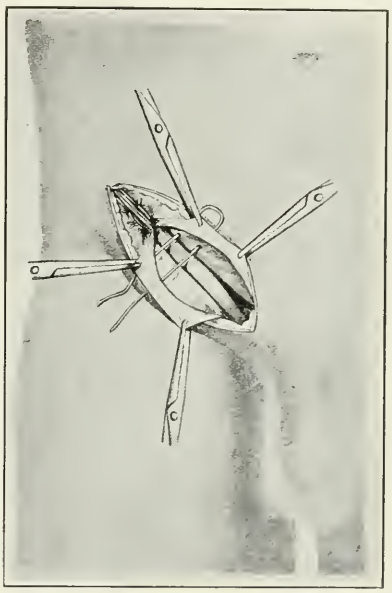

Fig. 213.—Method of Lucas-Championnière. This perhaps is the earliest suggestion of an overlapping method, but is more probably a crumpling up and everting of layers. A similar mattress stitch was used by Macewen. Both methods were employed before that of Bassini. (*From Bouveret, after Lucas-Championnière.*)

Merits and Demerits of the Marcy-Macewen-Bassini Operation.—The method just described is deservedly popular, safe, and rational, as well as easy of execution. Analyzing the elements which contribute to this success we are impressed with the vital importance of two steps, viz., the high extirpation of the sac (a step which was not original with Bassini) and, as a corollary, the open dissection quite up to the peritoneal layer. It was the failure to make this open dissection which marred the work of the earlier operators. They failed to perform a true plastic operation and tried to substitute various kinds of blind suturing. The failure to extirpate the sac high up caused numerous relapses or partial relapses, as when a serotal hernia returned (or remained) as a bubonocele. Probably the simple removal of this sac would alone be sufficient to cure many small hernias without any suturing of the canal. As the muscles and the fascia are denuded by stripping out the sac, they would often fall together as well without stitches as with them, and might unite firmly under the pressure of bandages. Dr. A. J. Ochsner, of Chicago, has demonstrated that this is true in femoral hernia. It may be equally true of small oblique inguinal hernias. When, however, the rings are greatly enlarged, even the Bassini suture is difficult to place and of doubtful permanence. The inner margin of the dilated orifice then extends from Hesselbach's ligament (outer border of conjoined tendon) almost or quite to the rectus muscle. The internal and external

rings are dragged into line so as to form an antero-posterior opening. On account of the absence or displacement of the conjoined tendon, the outer edge of the rectus sheath or muscle must be utilized in making the deep stitch. This drags the rectus outward and Poupart's ligament upward and inward, and even then one does not secure a good posterior wall for the canal. The principal element of a successful plastic operation—namely, a well-nourished flap, without tension—is wanting. Exactly the reverse conditions are found, viz., a thin and poorly nourished flap under severe tension. These defects in the Bassini method obviously have impressed all operators when they encountered large rings. The need of something to supplement the defective anatomy is then at

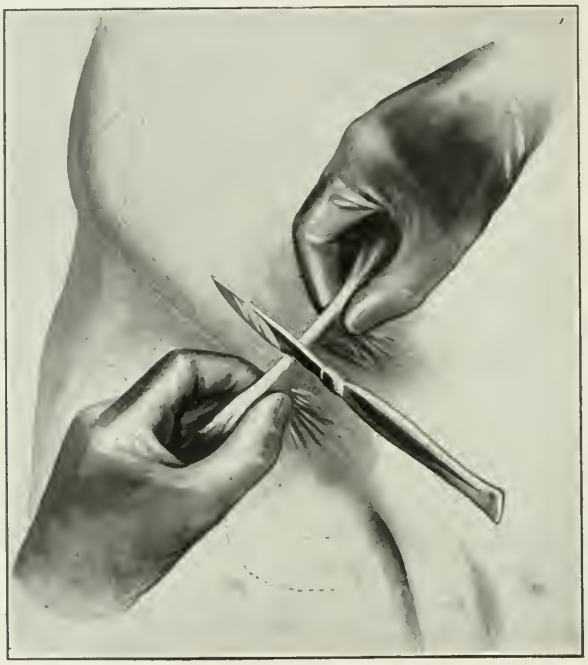

FIG. 214.—The Andrews Operation. Step 1. The skin is pinched up while the incision is being made. (*Original.*)

once evident. An ideal method would be one which supplied a well-nourished flap of such ample size that it could be brought over the weak spot without tension.

It is extremely interesting to note the unanimity with which this need has been felt—a unanimity manifested by the large number of the ingenious methods which have been suggested for the purpose. To enumerate a few of these: Halsted divided the rectus sheath and spread the muscular bundles out by attaching them to Poupart's ligament; Woelfler everted the anterior sheath of the same muscle, thus making a kind of trap-door flap which closed the rings when it was sutured over them; the anterior part of the fascia lata has been turned upward to form the same sort of flap; the tensor vaginæ femoris muscle has been dissected loose and turned upward to fill the canal; the scrotal skin and even the testicle have been invaginated to plug up the canal (measures

which constitute in a certain sense a flap method); bone grafts (Weir), sponge grafts, and wire filigree have been inserted to meet the same indications. In this category should also be placed the obsolete method of McBurney, who packed the hernial canal wide open, forcing it to heal by granulation so as to develop a large mass of scar tissue. These methods all introduce elements of risk and uncertainty, and none of them is now largely employed. It remained for the method of imbrication of Andrews to supply, in the treatment of inguinal hernia, the step needed to secure the object of all these difficult and ingenious methods without in any way adding to the severity of the herniotomy or to the length of time required for its performance. This method was published

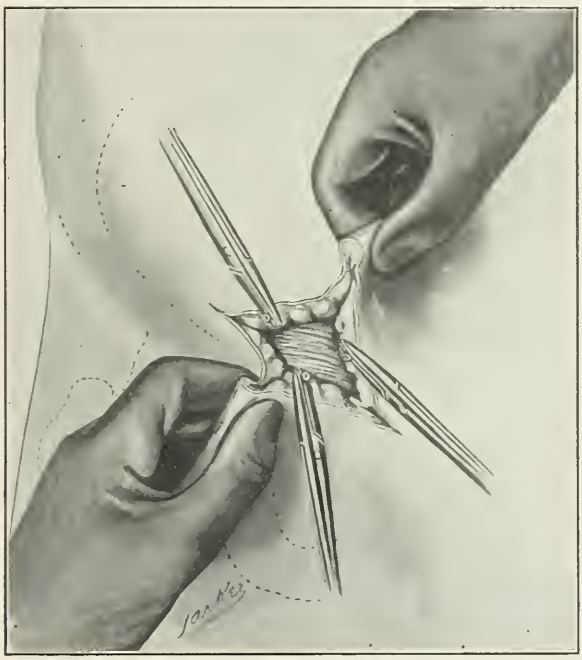

FIG. 215.—The Andrews Operation. Step 1 continued. The skin flaps are held while the artery forceps are applied one after the other. (*Original.*)

in 1895 and subsequently by Girard, in Berne, in 1898, and by Professor Fournel, in Paris, in 1900, each writer apparently being unaware of the other's work. Lucas-Championnière had still earlier suggested doubling up of the abdominal layers (Fig. 213), as had also Macewen, but this was more by everting than by overlapping the cut edges, and did not constitute true imbrication.

The Andrews Operation for the Cure of Inguinal Hernia.—Two types of imbrication or overlapping—a posterior, behind the cord, and an anterior, in front of the cord—are described in the original publication (*Chicago Medical Recorder*, July, 1895).

Posterior imbrication appeals to those who like the Bassini method; anterior imbrication, to those who object to "transplanting the cord." Anterior imbrication leaves the cord behind the deep suture line. Of late, the tendency

has been rather toward the anterior operation, and in this movement Dr. Ferguson, of Chicago, has been a pioneer. Dr. Coley, of New York, informs us that he uses both types, but rather more often the posterior-stitch method. The minor details described below may vary with different operators, but they should never vary with the same operator. Speed and smoothness come from uniformity of procedure, and such uniformity should be cultivated. In this way each operation becomes a rehearsal for the next.

Step 1. Skin Incision.—The incision should be made 2 or 3 cm. above Poupart's ligament, and it should run in a direction parallel to the inner two-thirds of this ligament. In adults its length should be from 15 to 18 cm. (6 inches to $7\frac{1}{2}$ inches). The operator should pinch up a fold of skin transversely to the groin with the left hand, and an assistant should hold the same fold at a point 3 or 4 cm. (about an inch and a half) distant. Raise this fold to a

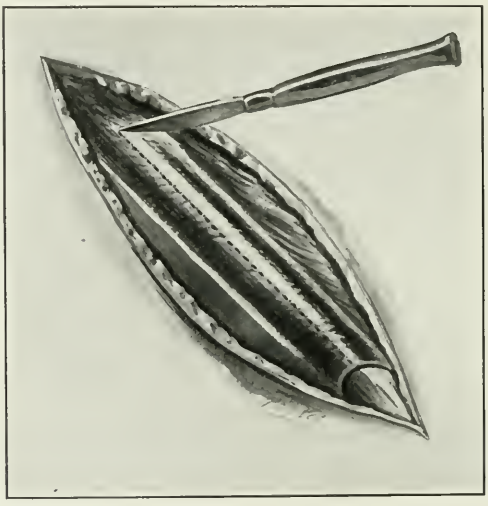

Fig. 216.—The Andrews Operation. Step 2. Dividing the external oblique. (*Original.*)

height of from 7 to 10 cm. (two and a half to three and a half inches) and cut through it to its very base by one stroke of a large, keen-edged scalpel. (Fig. 214.) Continue holding up the pinched-up margins, relaxing slightly until the epigastric and other vessels are seen and secured. Then drop the skin and pick up every smallest bleeding point. (Fig. 215.) Do not allow even droplets of blood to continue running. Expose the external ring and aponeurosis cleanly.

Step 2.—Opening the Inguinal Canal.—Do not insert a director and split the ring up from below, but split the external oblique aponeurosis the length of the canal by one straight cut from above between its fibres. (Fig. 216.) Evert the lower segment and run the scalpel handle along its inner aspect, exposing freely the shelving inner edge of Poupart's ligament.

Step 3.—Removing the Sac.—Either lift up the cord as a whole on the finger, which requires some blunt dissection, or let it lie adherent to the surrounding parts, according as you wish to repair the ring behind or in front of

the cord. In either case remove, by tying them off above the ring, any masses of adipose tissue that may be situated high up. Do not remove any veins or cremaster fibres. With a small, keen-edged knife cut a buttonhole in the fascia propria of the cord, until you see the pearly-white sac-wall. (Fig. 217.) The steps of this procedure are like those of a hydrocele dissection. Seize this wall

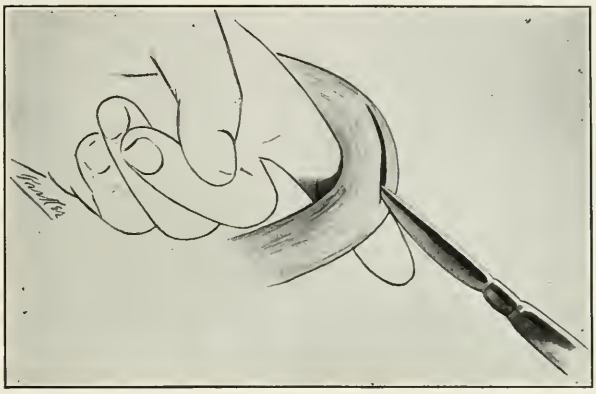

Fig. 217.—The Andrews Operation. Step 3. Dividing the cord layers in order to find the sac. (*Original.*)

with blunt forceps and strip it rapidly out by pushing away the cord elements with dry gauze. (Fig. 218.) Now and then one encounters strong adhesions which require nicking or cutting. In congenital hernias do not take time to sew a process of the sac around the cord. Follow well up into the abdomen

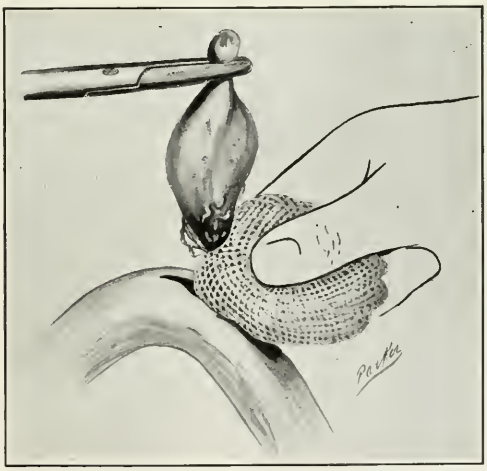

Fig. 218.—The Andrews Operation. Step 3 continued. Gauze sponge used for stripping the coverings from the sac. (*Original.*)

until a point is found where the cord and sac diverge. At this point the sac-neck can be ligated without the danger of inclosing the vas or any vessels.

In scrotal hernias strip out the sac, if it is easily separable. If it is not easily separable, cut it off in the canal, and return the scrotal part to the scrotum, either with a gauze drain through the lower end of the scrotal skin or

else (Eisendrath) everted as in a hydrocele "bottle" operation. Pull the testes freely up into the wound wherever this may be found necessary. In a number of cases it has been found that the scrotal sac is the seat of a hydrocele. Some of these require subsequent tapping, but in many other instances the hydrocele causes no trouble. With the finger separate the parietal peritoneum, throughout a zone 2 or 3 cm. broad, all around the ring, so that it shall not be attached to the muscles and may be drawn down freely. Open the sac widely at its fundus and look very carefully over its interior for adherent omentum or bowel, especially at its neck. (Fig. 219.) Keep this opening under the eye up to the moment of ligating, and watch carefully that nothing slips into it. For narrow sacs a simple ligature, and for large ones a suture ligature or a purse-string closure are best. The Macewen pad, consisting of the folded-up sac, possesses neither great fault nor abundant merit. We sometimes use it in atypical

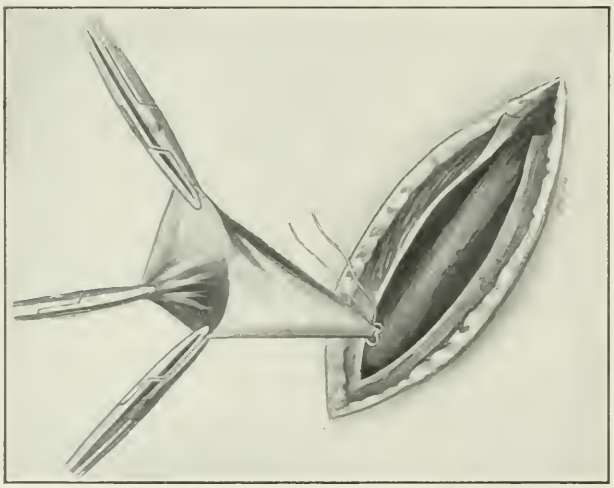

Fig. 219.—The Andrews Operation. Further continuation of step 3. Sac deligated. The fundus is open for inspection. (*Original.*)

large hernias for the purpose of increasing for a time the amount of new deposit at the weak point, but we are somewhat sceptical as to its permanent value. On account of the loosening of the surrounding peritoneum, the cut-off sac will retract well beyond the muscles. If the stump lies visible in the ring, it is too long and will form a funnel or dimple inside, and tend to bring on another protrusion. (Fig. 220.) If the stump does not disappear wholly, remove more of it. In the progress of step 3 one sometimes encounters abnormal conditions of the cord, such as thrombosis of the spermatic vein and cysts of the spermatic cord (Fig. 221) or the round ligament. Cases like these are reported by Ransohoff, of Cincinnati (*Annals of Surgery,* Aug., 1909).

Step 4. Deep Suture.—The manner of procedure, in this step, differs according to whether an anterior or a posterior imbrication is the kind of operation preferred.

(*a*) In anterior imbrication place from two to five strong stitches in such

a manner as to unite the conjoined tendon and muscles, together with the upper segment of the external oblique, firmly down to Poupart's ligament, all in front of the cord, which is thus pushed backward and toward the pubis. The lower flap of the external oblique is left free for step 5.

(*b*) In posterior imbrication lift up the cord on a loop of tape, or on Andrews' hernia-retractor (Fig. 222) which holds the wound open and has an adjustable hook upon which the cord may be suspended. Pass the deep stitch behind the cord by first lifting Poupart's ligament on the left forefinger and pushing the needle from outside the fascia behind it. The needle point is guided by the forefinger and cannot then injure the vessels. It is vitally important, in direct hernias and in the case of large rings, to get the first deep stitch as near the

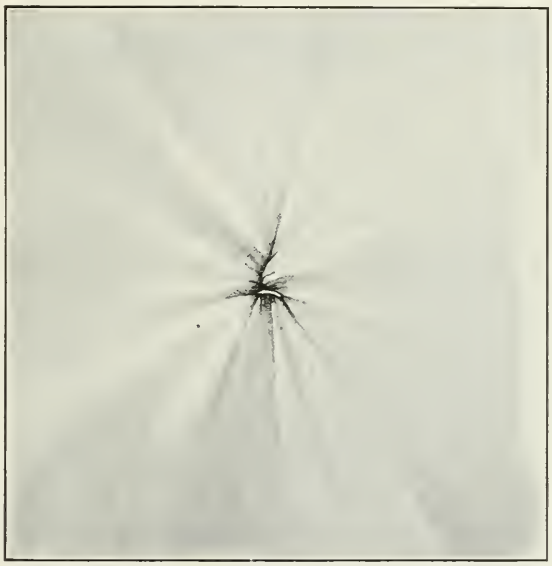

Fig. 220.—Dimple or Funnel of Peritoneum Seen from Inside when the Sac is not Extirpated entirely from the ring. This error in technique, in the Andrews Operation, causes a tendency to relapse after herniotomy. (*Original.*)

pubic end of the ligament as possible. It often includes a little of Gimbernat's ligament. Dr. Malcolm Harris first called my attention to the importance of this, and one cannot commend too much the thorough way in which he clears the structures and fortifies this weak end of the suture line by placing (according to his method) the first wire suture almost against the symphysis. From its entrance point the needle is guided by the forefinger into the canal. It is then picked up and the opposing muscle entered from within outward. The lowest or first stitch in large rings should include a little of the rectus muscle, the sheath being split open to allow this. In small rings this is not necessary. Do not resort to the Woelfler method of everting a trap-door flap of rectus sheath, or for that matter to any other mutilating flap method. The imbrication is of itself a perfect flap transplantation, and will fill the largest rings without great tension.

After the transversalis fascia and conjoined tendon or muscles have been

transfixed, we have what would be a Bassini stitch in mattress form. To this we now add the margin of the external oblique, either in the same loop or by passing the needle, which has already pierced the deep muscle, downward and forward through Poupart's ligament and back to catch the external oblique. The needle is next passed out just in front of Poupart's ligament, so that it emerges about 5 mm. in front of where it entered, and surrounds the ligament. It is thus a mattress stitch with the knot just inside the skin and fat of the groin. From two to five such deep stitches are used. It is a mistake to place them very near together, or to tie them very tightly. The uppermost or outermost stitch should narrow the ring snugly around the cord. Tie this one first

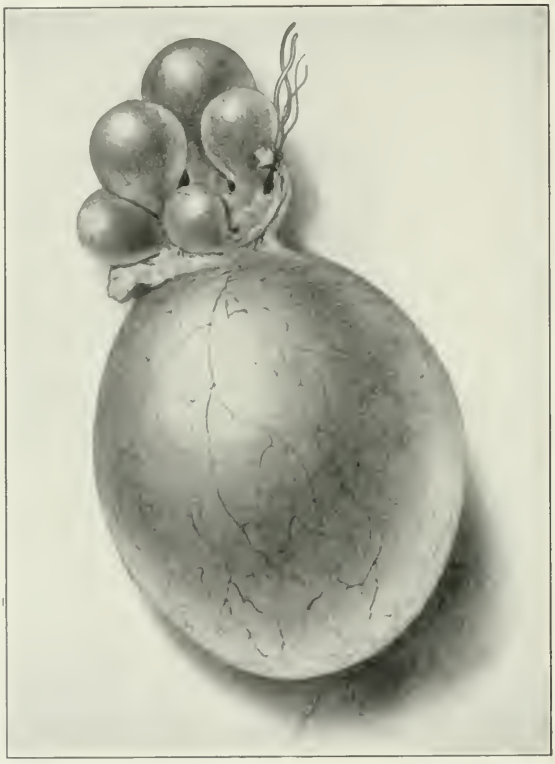

Fig. 221.—Cyst of the Cord. (*From Ransohoff*, in *Annals of Surgery*, Aug., 1909.)

and watch the effect on the spermatic artery. Commonly this vessel can be felt pulsating before and after the stitch has been tied. If in doubt, discard the upper stitch.

Step 5. Second Deep Suture.—Lap the lower segment of the external oblique upward across the upper. In case the cord has been raised, it goes between these layers. (Fig. 225.) They overlap to the extent of about 3 cm. (a little over one inch) at the external ring, thus strengthening and narrowing this dilated orifice. Suture them in this position tightly enough, by means of a lock-stitch running seam, to cause part of the strain to bear down on the deeper stitches. It will then be seen that the strength of the abdominal wall

has been doubled by redoubling its thickness; also, that these overlapped surfaces are more sure to unite firmly than is the case when one of the edge-to-edge methods is employed. (Figs. 225, 226, 227, 228.)

Step 6. Skin Closure.—After the bleeding has been very thoroughly arrested, sew the edges of the skin together with a trocar-pointed needle held in the fingers; or, if that method be preferred, apply metal clips. (Fig. 229.) The following form of buttonhole continuous suture will please those who have not yet employed it:—After the first knot has been tied, thrust the needle through both flaps at points about 1 cm. (nearly half an inch) from their edges. With the skin thus transfixed, wind the slack of the thread twice around the point of the needle, instead of once, as in the ordinary lock-stitch. (Figs. 230 and 231.)

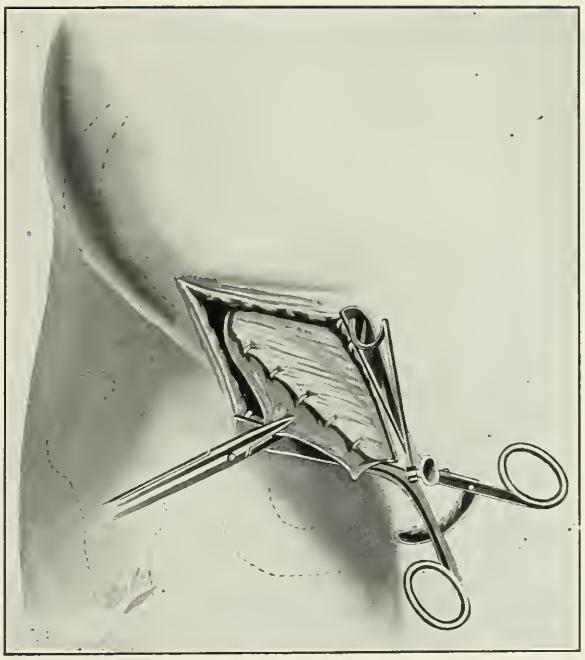

Fig. 222.—The Andrews Operation. Step 4. Anterior imbrication. (*Original.*)

Then draw the thread up until it is just tight between the stitches, but does not pucker. There is no back-slip, and each stitch holds by friction. The following stitches are applied in the same manner. This gives a ridge-shaped suture-line like a double row of stitches.

It is not usual to drain these wounds, except in rare cases in which there has been much dissection and in which oozing persists. In such cases it is well to insert a small drain through an independent buttonhole—not through the angle of the incision. In young children seal the wound with collodion or with compound tincture of benzoin. (Fig. 232.) Firmly bandage both groins with wide spica bandages. In young and restless patients it is sometimes well to pad the hips, trunk, and thighs with antiseptic cotton, and to

apply a light plaster-of-Paris or starch bandage from the chest down to the knees. (Fig. 233.) There is usually no advantage in redressing these cases. They are well on the eighth, ninth, or tenth day, and then should be allowed to be up and take ordinary exercise at once. Let no binder or truss be used after the patient is discharged from treatment.

Femoral Hernia.—The inguino-crural triangle is separated from the inguino-abdominal, as above stated, by Poupart's ligament. In its upper part, which lies along the course of the great blood-vessels, are found the femoral or crural hernias.

The etiology of femoral hernia is less perfectly understood than that of inguinal hernia. The part played by a congenital defect of the sac or ring is

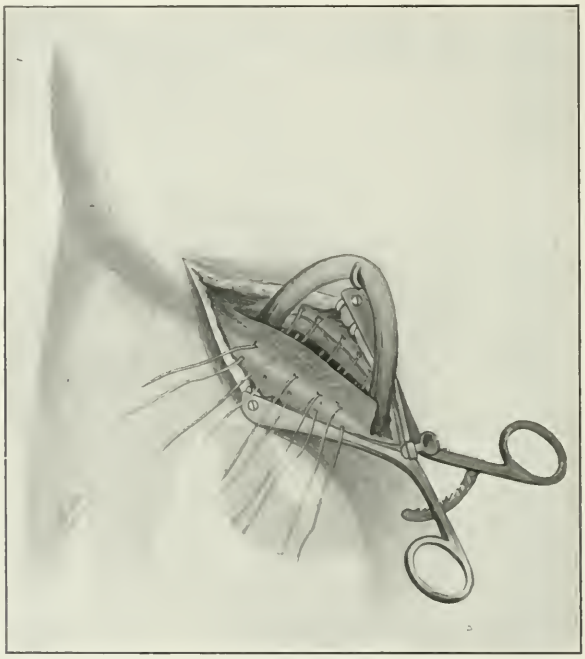

Fig. 223.—The Andrews Operation. The drawing shows the manner of using the hernia retractor in posterior imbrication. (*Original.*)

not commonly recognized. Some modern writers, as Wuellstein, deny that femoral hernia is ever congenital or that it occurs in early life. On the other hand, many observations give weight to the claim that abnormal peritoneal tubes or pouches do sometimes appear along the track of the vessels, and that these abnormalities are congenital mesoblastic prolongations in fœtal life. The occurrence of a scrotal femoral hernia, or the finding of the broad ligament in a femoral canal, points to the probable participation of an embryological factor in the production of some of these hernias.

Anatomy.—The anatomical layers are the same externally in this form as in inguinal hernia, namely, skin and external fasciæ. Lymph nodes are more numerous, as are also venous branches in the subcutaneous fat. The deep fascia, in this space the fascia lata, is perforated by the saphenous opening or

ring, the concave margin of which (the falciform process) is crossed at its lower part by the long saphenous vein as it enters the saphenous opening. (Fig. 234.) The fascia lata in front and Poupart's ligament are connected by fascial processes with the pectineal fascia and muscle and the ileo-psoas muscle behind. These fascial planes guard the great vessels, the external iliac vein and artery, as they lie in Scarpa's triangle, and tend to prevent the occurrence of hernia, either inside or outside the vein and artery, as the latter descend into the groin. These fascial bands merge with Gimbernat's ligament on the inner side, practically closing the space up to the sheath of the vein. A similar band, which closes the space outside the femoral artery at its passage under Poupart's ligament, goes to the ileopectineal eminence; it is called the ileopectineal ligament.

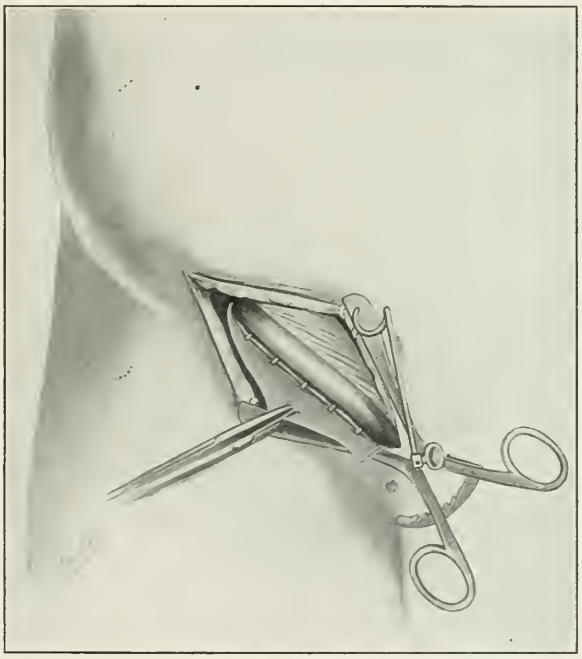

Fig. 224.—The Andrews Operation. The cord is here shown to have been restored to its natural position. (*Original.*)

On neither side does adequate space for a canal exist normally, there being only sufficient room for one or two lymph nodes, called "Rosenmueller's glands."

The space in question, bounded by Poupart's ligament in front and the pectineal ridge and muscle behind, is sometimes called the "lacuna muscularis." In addition to the great vessels it also transmits the psoas and iliacus musculotendon and the anterior crural nerve. It is filled also by loose adipose tissue and is closed by peritoneum, which, in normal subjects, is slightly hollowed or depressed, forming the fovea femoralis, which is analogous to the fovea inguinalis or slight dimple opposite the inguinal ring. This depression forms the starting point of a femoral hernia.

Pathology.—The peritoneum is forced into the femoral canal and thus forms

a sac in the direction of the saphenous opening, out of which it passes to form a tumor under the skin. (Fig. 235.) The hernia, when complete, has two rings—an inner small one at Poupart's ligament, and an outer larger one at the saphenous ring,—a space or canal connecting the two. This canal has for its outer wall the sheath of the femoral vessels, and the deep epigastric artery lies ordinarily to its outer side. On account of the great irregularity in the disposition of this and the obturator vessels, warning should be given against using any deep-cutting instrument, such as the probe-pointed herniotomy knife and the hernia director. Open dissection should supersede the older blind methods with their attendant danger of hemorrhage.

The walls of this canal and of the rings are incapable of great enlargement.

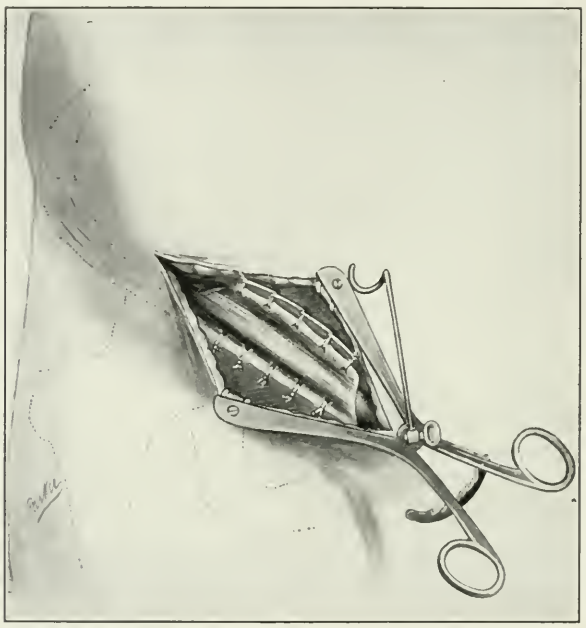

Fig. 225.—The Andrews Operation. Step 5. Second buried suture; layers overlapped. Note the close resemblance of the Fournel method to this procedure. (*Original.*)

Hence femoral hernias seldom attain large size, and as a consequence they are quite often overlooked. The rigid, small, and hard rings also cause strangulation to be more frequent than is the case in inguinal hernia. The very small femoral hernias present difficulties in diagnosis and may, if buried in the subcutaneous fat, be overlooked altogether. In case only omentum is in the sac, and if this becomes strangulated, the condition may easily be mistaken for an inflamed lymph node. In case of a strangulated intestine the obstruction may be attributed to the wrong cause, and so the hernia may remain undetected until it is too late to afford relief.

A double femoral hernia may occur in the same individual. (See Fig. 236.)

Diagnosis.—The differential diagnosis of femoral from inguinal hernia is made by the location of the former below Poupart's ligament; but, as the ex-

ternal tumor sometimes presses upward in front of the inguinal canal, it may occasionally be impossible to decide which variety is present until the skin has been opened. Other conditions to be differentiated from femoral hernia are normal and inflamed lymph nodes. One reason for this similarity between the two conditions is to be found in the fact that many of the femoral sacs are small and have a globular form. Large varices about the ring, due to saccular dilatation of the long saphenous vein, present the appearance of tumors which sometimes almost perfectly simulate hernial protrusions. These are reducible, reappear when the patient assumes the erect position, and give an impulse when he coughs. It may be possible to make the differential diagnosis by occluding the external iliac vein with firm pressure on the abdominal wall, which prevents reflux of the blood into the varix. The bruit of blood passing through a large vessel may also be heard with the stethoscope. In addition, the presence of associated varices will call attention to the same condition at the ring. Another test is to observe the difference in the sensations experienced on palpation when the supposed hernia is forced into the sac by straining or by coughing. A true hernia gives the sensation of a solid body sliding under the fingers, while the varix fills up with fluid only.

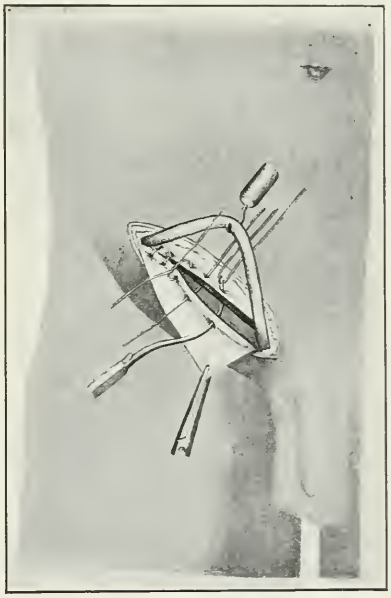

Fig. 226.—The Bassini-Fournel Operation, Identical with the Girard and the Andrews Operations. (*From Bouveret.*)

Psoas or lumbar abscesses point in this region, the pus following the psoas fascia along the muscle and making its exit just below Poupart's ligament. In cold abscesses the tumor is painless and exactly simulates femoral hernia on inspection and palpation. As they may disappear on pressure or on change of posture, they are not rarely mistaken for irreducible hernia. Several cases have come under our observation in which trusses were placed upon such swellings. The differential diagnosis can always be made by testing the extension of the hip. Limitation of extension is an early and marked symptom in lumbar abscesses due to spondylitis or other causes associated with the psoas and iliacus muscles.

Atypical Forms of Femoral Hernia.—While the ordinary route of a femoral hernia is internal to the great vessels, the bowel may exceptionally pass down externally to the sheath of the femoral artery. This anomalous form has been called "external femoral hernia" by Bahr (1898), and cases have been reported by McIlvane, Narrath, Fabricius, Cloquet, and Axhausen. The route of these hernias is between the ileopectineal ligament (see above) and the femoral artery, at which point the anatomical studies of Leinhart show that a weak place exists.

The very oblique direction of this ligament from Poupart's ligament backward leaves a triangular space, wider in front, which is somewhat unsupported in the immediate vicinity of the vessel sheath. (Fig. 237.) Hesselbach, Sr., describes bands which pass from the anterior iliacus sheath to the transversalis fascia and crural arch, forming a sort of guide or septum leading toward this weak point. "External femoral hernia" may occur in three forms corresponding to the routes taken by the escaping bowel: (1) Outside the great vessels; (2) alongside the deep epigastric vessels; (3) alongside the muscle behind the vessels. (Fig. 238.) Maydl also describes a still rarer form which makes its way inside the vessel sheaths.

Treatment of Femoral Hernia.—Operative treatment is more imperative in

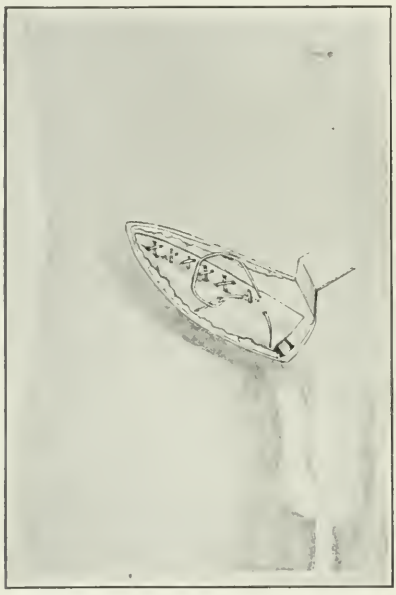

Fig. 227.

Fig. 228.

Fig. 227.—The Bassini-Fournel Operation. The drawing shows the external oblique aponeurosis overlapped. (*From Bouveret.*)

Fig. 228.—Anterior Position of Cord outside of all Fasciæ. This has been advocated by Postemski and Halsted. (*Original.*)

femoral than in inguinal hernia because the liability to strangulation is greater, because the lesion itself is small and is therefore likely to be underrated as regards its importance, and because the results obtained by the use of trusses are so imperfect.

Sprengel reviews fifty varieties of operation for this affection published since 1879. According to Goebel all the known methods may be arranged in the following five groups:—

1. Sac Extirpation—by ligation, by burying the stump, and by skin invagination. (Socin.)

2. Suture Methods for Rings—

(*a*) Without reconstructing canal, by uniting Poupart's to Cooper's ligament. (Czerny, Billroth, Schede, Bottini, von Frey, Quarnesi.)

(*b*) Under special canal closure (Kuester, Bassini)—

(1) With purse-string (Triconi); (2) with displacement of sac stump (Berger, Parry, O'Hara, Rotter, Kocher); (3) with abdomen or inguinal canal opened for high removal of sac (Tuffier, Ruggi, Nasi, Buonomocci, Cushing, Edebohls, Reed, Lawson Tait).

(*c*) By direct union of Poupart's ligament to pubes (Roux's wire nails, Nicoll, Covazzani).

(*d*) With division of Poupart's ligament (Fabricius, Delagenière).

3. Plastic operations to implant muscular tissue. (Lotheissen, Cadivella, Parlovecchio.)

4. Plastic flaps. (Talzer.) Fibrous or musculo-tendinous flaps. (Watson-

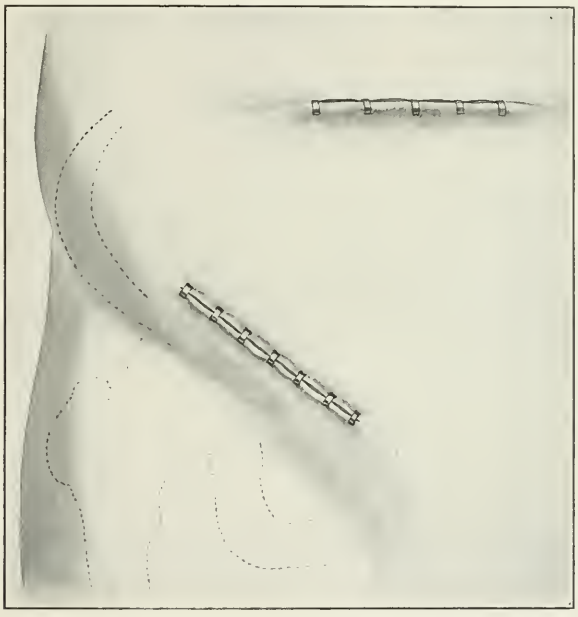

Fig. 229.—The External Wound Closed by Metal Clips which give a ridge-shaped suture line. (*Original.*)

Cheyne, McArdale, Maunsell Moulin, Swartz.) Periosteal flaps. (von Mikulicz.) Osteoplastic flaps. (Trendelenburg, Korte.)

5. Heteroplastic. (Talzer, Schwarz, Thiriar.)

It is not possible to state which of these divergent methods has become best established. Nearly all mutilating flap operations or heteroplastic methods have been abandoned for simple suture at the rings after high extirpation of the sac. Oehsner asserts that sac extirpation alone, without suture, will cure all cases. There is good evidence in favor of this belief, since femoral rings are small and the sac denudation would leave surfaces well fitted to unite. All operations have the first step in common.

Step 1. Skin Incision.—Many authorities advise making a skin opening, over the ring, in the long axis of the thigh. An incision parallel to Poupart's

ligament is, we believe, to be preferred. It gives access to the inguinal canal if such a step is desired.

Step 2.—The sac lies underneath the skin and fasciæ and is often embedded in a firm layer of fat. The greatest care is needed to avoid injuring its contents if irreducible. A very thick wall should at once excite suspicion that it may be a sliding hernia of the bladder or colon, in which case no sac will be present. These viscera slide into the hernia below the peritoneal reflection and are often opened, by mistake, for the sac. When the sac has been identified and explored it should be detached, by blunt dissection, throughout the whole length of the canal, drawn down and amputated, or dealt with from above by opening the inguinal canal or abdomen.

Step 3.—The closure of the deep ring is theoretically possible by suturing Poupart's ligament to Cooper's ligament and the pectineal fascia. This is a step which seems unsatisfactory on account of the disparity between the struct-

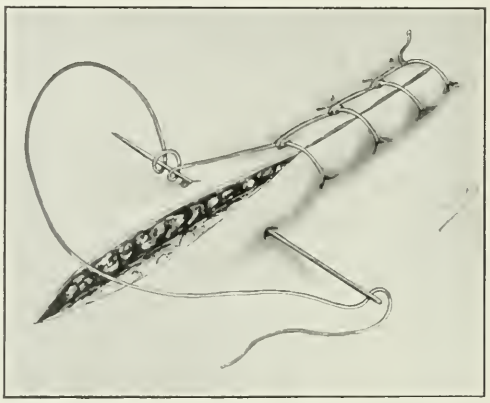

Fig. 230.—The Andrews Operation. Step 6. Method of closing the skin wound by double-locked buttonhole stitches. Note the fact that the slack thread is wound twice around the trocar needle point, causing each segment to remain taut like an interrupted suture. (*Original.*)

ures united. It can be accomplished by two or three mattress stitches extending from the pubis to the sheath of the vein. Extreme caution is to be observed not to prick the latter with the needle.

Step 4.—The outer ring or saphenous opening is also narrowed by suturing the falciform process across and overlapping the fascia lata, great care being taken not to wound or constrict the long saphenous vein.

Operating Through the Inguinal Canal.—In Frank's method the sac is drawn out through the inguinal ring, ligated, and resected, the ends of the ligature being drawn out through the muscles at a point some distance above and then tied at this point. The tendency to hernia is then corrected by suturing the posterior margin of Poupart's ligament to the pectineal fascia and the periosteum of the horizontal branch of the pubis; after which, four threads are passed through the triangular ligament, so as to draw it up to the muscles above.

Roux's Nail Operation.—Roux fastens with a double-pointed nail the edge of Poupart's ligament to the horizontal ramus of the pubis as a radical means

of curing femoral hernia. Since 1904 Hochenegg, in the Vienna Clinic, has applied this technique in thirty-eight cases of femoral hernia, all but eight of them women; general anæsthesia being used in thirty-three. The ultimate outcome—the interval of time since the operation ranging from six months to four years—is known in twenty-eight cases. The results have been satisfactory in every respect, even in one case in which the nail was felt to be loose. The outcome, he believes, compares favorably with that obtained by other methods, while the simplicity of the operation commends it for certain cases.

Post-operative Complications.—Aside from stitch abscesses, which are now

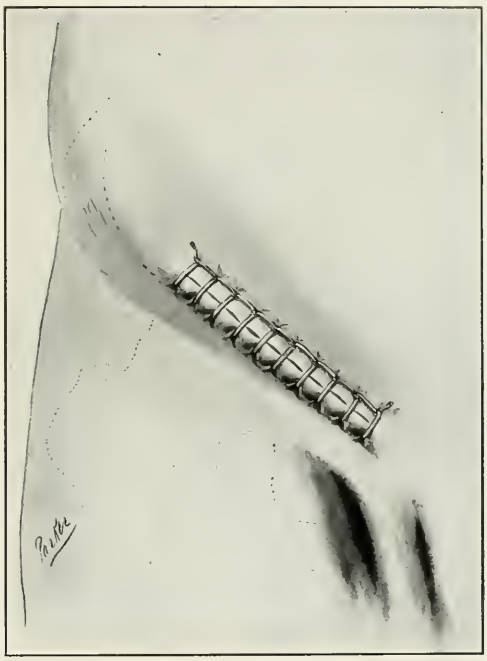

Fig. 231.—The Andrews Operation Completed. The skin remains in a ridge-shaped line like that which results from the use of the clips. If plain catgut is used this ridge flattens out in from five to seven days. (*Original.*)

relatively rare in hernia work, certain other causes of failure or relapse occasionally may be encountered.

Post-operative Desmoid.—One of the most interesting and rarest of these complications is chronic inflammatory induration of the abdominal wall, a lesion which occasionally follows herniotomy. This was first noted by Grasser, who reported two cases, and later by Schaffer, Baker, Frank, and Kreuter. I have seen two instances of this rare disease in about fifteen hundred herniotomies. In one case a massive swelling, which presented the appearance of a sarcoma, persisted for six months after inguinal herniotomy. This was nearly painless and was not accompanied by fever. The mass was explored for concealed stitch abscess, but with negative results, and finally it disappeared by resolution. In a second case, seen during the last year, a tumor as large as a man's fist was located in the groin. This tumor made its appearance three weeks after operation and

continued to exist for four months without pus formation. These masses seem to me to resemble the so-called "Holzphlegmone" or ligneous abscesses of the neck—an obscure affection of a chronic inflammatory type, sometimes called "cancroid" or cancer-like, but always ending in recovery. Schaffer observes that they are of the same type as the desmoids of the abdominal wall (see page 83 of the present volume) and have their origin at some point in the immediate vicinity of a buried ligature, especially at the neck of the sac. No treatment is known to hasten the disappearance of these masses. They may last months or even years, but eventually they disappear spontaneously.

Cysts, Hydroceles, and Hæmatoceles After Herniotomy.—When an adherent sac has been dissected from the femoral or scrotal tissues, the cavity thus left may become filled with bloody or serous exudate, and a post-operative tumor

Fig. 232.—Method of Sealing Herniotomy Wounds in Young Subjects with Strips of Fabric saturated with flexible collodion or with compound tincture of benzoin. (*Original.*)

may be the result. Cysts may also form from some portion of the sac, in a scrotal hernia, having been left behind. Such complications are not the rule, and they may be avoided by using temporary drains or by exerting firm pressure with bandages. The scrotal part of an inguinal hernia may be left, as is done in the Kocher or the O'Hara operation, or it may be removed entirely, as is easily done in most cases, by blunt dissection. In very adherent sacs and in congenital hernias one is compelled to leave it behind. To prevent the formation of a hydrocele I usually invert it ("bottle operation"), or insert an iodoform gauze strip through the bottom of the sac to cause adhesive obliteration. Even if this is not done it is rather exceptional to have cystic swelling occur.

Varicocele occasionally seems to be produced or increased by herniotomy. This is due to interference with the venous circulation. Too tight closure of the internal ring should be avoided. When varices exist on the cord it is often best to remove them high up during the herniotomy.

Femoral Hernia Following Inguinal Herniotomy, and Inguinal Hernia Following Femoral Herniotomy.—Such an occurrence is not at all uncommon. Probably most of these cases were not caused by the operation. It is well to note, however, that the closure of one orifice tends somewhat to draw apart the other, especially in methods which deform or displace Poupart's ligament, which forms the upper boundary of the femoral and the lower of the inguinal canal.

Palliative Treatment of Inguinal and Femoral Hernia.—The use of trusses, pads, and bandages in inguinal and femoral hernia becomes necessary in adults as a temporary measure, and, in young children, as a possible curative measure in suitable cases. In congenital hernia the closure of the vaginal process may be completed shortly after birth instead of earlier. This is assisted by the use

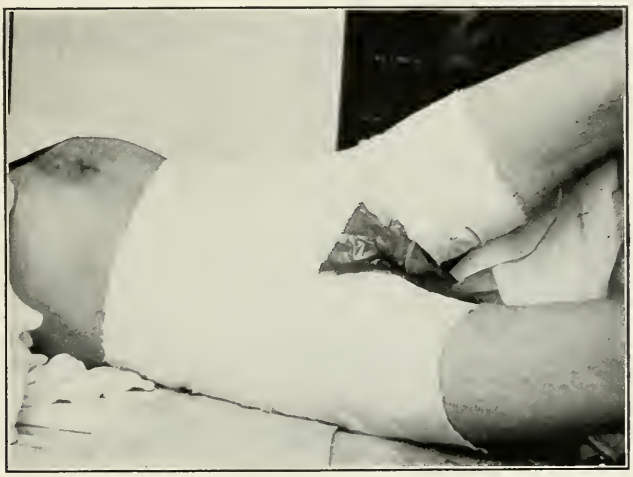

Fig. 233.—Dressing Suitable for Application after Herniotomy (double or single). Rubber or gutta-percha tissue is placed over gauze to shield it from fluids escaping from the urinary tract. In young and restless subjects the outer bandages may consist of plaster of Paris or of silicate of sodium. (*Original.*)

of some support, but, in many cases, it tends to take place without any assistance. As the early natural time of closure passes, the chances of spontaneous healing grow less. In the first year, or even in the first two years, of life many hernias disappear. Some of them re-appear in later childhood or in adult life. A large number of so-called acquired hernias are merely relapses of former congenital ones. This will be found to be markedly true when the facts relating to the personal and the family history are accurately obtained. Less importance, therefore, should be attached to natural cures than was formerly done. It is true, nevertheless, that a considerable number of hernias do disappear in early life, either with or without the use of supports.

In infancy the best support is the "yarn truss," a large soft hank of wool yarn tied like a figure-of-eight or spica upon the groin. In the opinion of Drs. Walls, Abt, and other pediatrists this gives better average results than does a spring truss. Spring trusses for use in infants should be waterproofed by

having their springs and pads enclosed in celluloid, vulcanite, or rubber. They may be kept on the patient constantly, even during bathing.

For adults spring trusses take the place of all other belts or binders, except in certain atypical or very large hernias. Occasionally an irreducible hernia of large size, as in the scrotum, may require, to prevent further enlargement, a special form of sac or support modelled to its particular shape.

Spring trusses are furnished by most manufacturers upon the following specifications:—(1) Measurement around the hips, below crests of ilia (Fig. 239); (2) side—right, left, or double; (3) kind—inguinal, femoral, scrotal; (4) size of ring; (5) location of ring, direct, indirect; (6) kind of pad—hard, soft,

Fig. 234.—The Femoral Canal. The dissection shows the saphenous vein joining the femoral vein below Poupart's ligament. (*From Enderlen and Gasser.*)

water pad, air pad; (7) tension of spring—light, strong; (8) form of spring —cross-body, direct, etc. (Figs. 240 and 241.)

Direct truss springs apply their pressure upon the side encircled by the spring itself. Cross-body trusses pass over the pubes and apply their pressure by pads on the opposite side.

Trusses become a source of trouble and even of danger when the hernia tends to escape in spite of their support. This is often an indication that some hernial contents remain incarcerated after apparent reduction. Such hernias should be cured by operation. In other instances, after several failures to adjust the truss properly, some slight alteration or readjustment of the apparatus will make it satisfactory.

Umbilical Hernia.—The congenital element in umbilical hernia is now believed—just as it is in the inguinal form of the disease—to be predominant. In other words, even the hernias which appear later in life probably have a small

rudimentary or potential pouch from birth. Clinically, it is practicable to classify ruptures at the navel into: (1) Congenital funicular hernia of the cord; (2) infantile hernias, which develop shortly after birth; (3) acquired hernias which appear in adult life.

Under normal conditions the umbilical ring closes at birth, the obliteration of the ductus omphalo-entericus takes place normally, and the visceral or peritoneal cavity closes perfectly, with no pouch left in the fœtal end of the umbilical cord. If such a pouch does remain from fœtal life it is enclosed only by the dilated network of cord vessels and the thin layers of Wharton's jelly and the amnion. (Figs. 242 and 243.)

The opening at the umbilicus may be excessively large and the tumor thin-

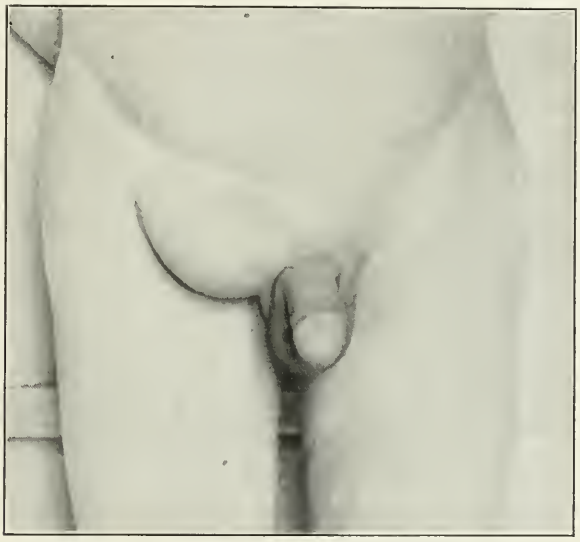

Fig. 235.—Femoral Hernia. (*Original.*)

walled and translucent at birth, or it may be small and dense. Such congenital sacs are analogous to the conditions observed in spina bifida, cleft palate, and other failures of coalescence in fœtal life. So great is the defect in some cases that nearly all the hollow viscera and the liver, spleen, and even the pancreas may be contained in the hernial tumor. Great danger of ulceration and fatal infection is present in the large thin-walled sacs. The smaller varieties, in which the hernia is covered with natural skin, are usually reducible by direct pressure. Most of the infantile and acquired umbilical hernias are of this kind, and attain large size only when left unsupported for long periods.

Strangulated Umbilical Hernia.—Two extremes in size of umbilical hernia are especially dangerous when strangulation takes place. The very small globular sacs, which represent one extreme, are often hidden in the panniculus and can be discovered only by palpation. When strangulation occurs in such cases an error of diagnosis is likely to be made, and the truth is generally not revealed until it is too late to save the patient's life by operation. The other

extreme—or a very large sac—presents another danger, due to the complex multiple form of the protruding mass. Numerous septa divide its interior into a series of separate compartments or lobules of one sac. One or more of these may be strangulated and not others. We have seen one pocket of such a hernia containing adherent normal intestine, and another adjoining with gangrenous bowel. This leads to great difficulties and dangers in performing herniotomy.

As the patients who have these enormous sacs are often in a septic condition and weakened by obesity and senility, it is best, in certain cases, to do the slightest operation which will relieve the obstruction, if possible, under gas or local anæsthesia. The radical operation may be done later.

Treatment.—Under mechanical treatment, if begun early, exceptionally good results are obtained in young children. It is as if Nature needed only a

FIG. 236.—Dissection of Pelvis from within; the peritoneum has been removed. This specimen shows double femoral hernia and double external femoral hernia in the same individual. (*From Enderlen and Gasser.*)

little more time to complete a closure already begun. Belts, trusses, and pads are of far less utility than broad adhesive straps, which should be placed transversely across the navel in such a manner as to draw the lateral margins of the opening together. Plaster strips are also valuable as a protection when the tumor is thin-walled and in danger of ulceration. The ring itself may be covered by a pad of small size which should be held in place by straps of adhesive plaster, or the latter may be used alone if the crumpled sac forms its own pad. To support the first straps, additional ones may be laid over them either obliquely or in the same direction. (Fig. 244.)

The Radical Operation for Umbilical Hernia.—Two rather opposite types of operation have come into general use for umbilical hernia—those which depend

upon plastic restoration by bringing the separated recti muscles once more into apposition, and those which utilize the thin fibrous edges of the ring without further dissection. Keen, of Philadelphia, first advocated excision of the navel as a step in radical cure. This was adopted by Lucas-Championnière, Kocher, and many others. Many operators—Pfannenstiel, Grasser, Wuellstein, and others—devised methods of mobilizing and replacing the displaced recti so as to bring them edge to edge over the ring. These muscles have even been divided transversely and crossed like a letter X to strengthen the wall at the weak point. Hartmann caused the ends of the cut muscles to overlap. Heinrich and also Cahen made rectangular flaps of one rectus and then, having turned them laterally, sewed them into slits of corresponding size in the other rectus. Goldspohn, of Chicago, devised a method by means of which the recti were forced against each other and anchored in this position by a deep quilted suture.

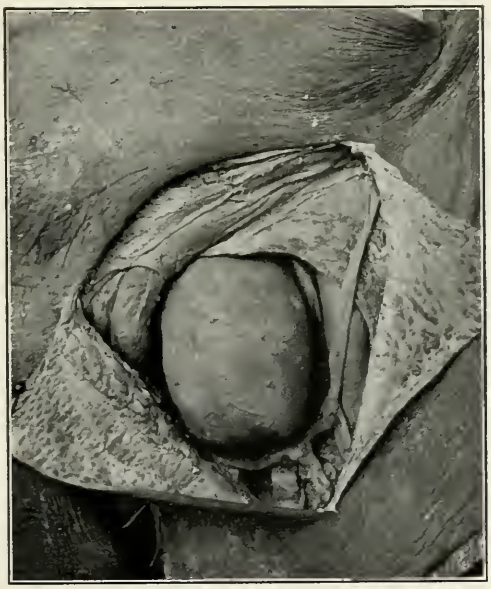

FIG. 237.—Dissection of a Large Femoral Hernia, showing its close relation with Poupart's ligament, the femoral artery, and the femoral and saphenous veins. (*From Enderlen and Gasser.*)

Of the other types of operation, W. J. Mayo's method of closure by means of a transverse or horizontal line of division with overlapped edges,* is the most popular in America. (Figs. 245, 246, and 247.) The valuable feature of this method is to be found in the fact, hitherto little appreciated, that the direction of the greatest relaxation in the pendulous abdomen is from above downward, not circumferentially. This is exactly the opposite of the prevailing belief with regard to this condition. Yet if we apply the test of drawing the edges together, it will always be found easier to approximate the margins of the ring from above downward than laterally. This is sufficient evidence that they will unite

* The imbrication method, which Mayo was the first to employ in operations for the cure of umbilical hernia.

better in that position. Theoretically, the normal anatomical conditions are not restored, but rather deformed by this step, since the diastasis of the recti is not relieved but increased. In practice the operation has given excellent results.

The skin incision should be made in either a transverse or a vertical direction, according to the type of operation, and should be elliptical, so as to excise the umbilicus and most of the tumor if the latter happen to be large. Efforts to cut down upon the sac and dissect it from its overlying skin are dangerous in large obstructed hernias, on account of the close union between the peritoneum and the skin. The sac will usually be torn or cut in attempting this, and the dissection will prove bloody and tedious. It is much easier to cut down to the fascial margins of the ring on each side, so as to remove the entire mass, skin and sac included. Not infrequently the omentum is so adherent to the sac

Fig. 238.—External or Premuscular Femoral Hernia. (*Original.*)

lining that it must be amputated at the ring. The peritoneum may next be detached and sutured as in an ordinary laparotomy.

In case closure of the gap in the recti is attempted, these muscles must be mobilized by opening their sheaths a long distance above and below. In fact, they are often separated throughout nearly their whole length. A deep fascial suture is next inserted, thus securing a strong support from the posterior rectus. Then the muscles themselves are brought together by means of a deep or quilted suture and the edges of the sheath of the anterior rectus are united by a separate line of stitches in front. The tension on all these layers is extreme and the operation often proves unsatisfactory on this account. It is as if the whole stretching of the abdomen had been in the longitudinal rather than in the equatorial direction, and the stitches seem scarcely able to bear the strain of reducing the circumference. The opposite technique of longitudinal rather than equatorial direction of closure has become popular because of the ease with which it may be executed and the certainty of the result.

The form of the ring is always circular. Its edges can be made to overlap by the introduction of three or four deep mattress stitches, which carry the upper border behind the lower a distance of from two to four centimetres. The free overlapping lower edge is next sutured to the front of the upper segment. The two segments thus imbricated constitute a wall of double thickness, and,

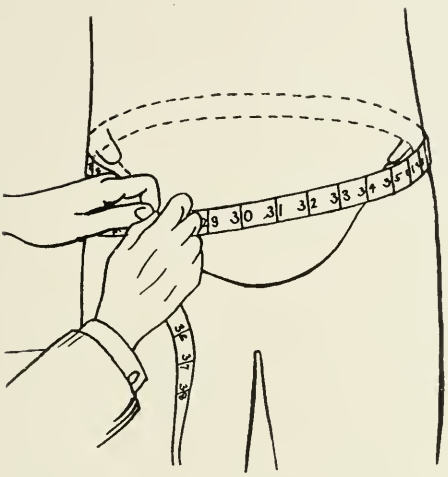

Fig. 239.

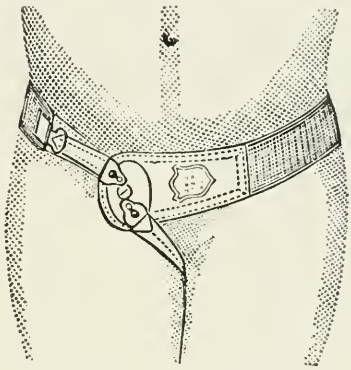

Fig. 240.

Fig. 239.—Line of Measurement to be Employed in Ordering a Spring Truss.
Fig. 240.—Elastic Belt Truss.

inasmuch as one line of sutures supports the other, failure of union is unlikely to occur.

Ventral Hernia.—Hernial protrusions through breaches in the musculature appear, not only after wounds but also spontaneously, at various parts of the abdominal wall. Diastasis of the recti above or below the navel causes hernias at the linea alba. In the lower abdomen these hernias may be large and saucer-

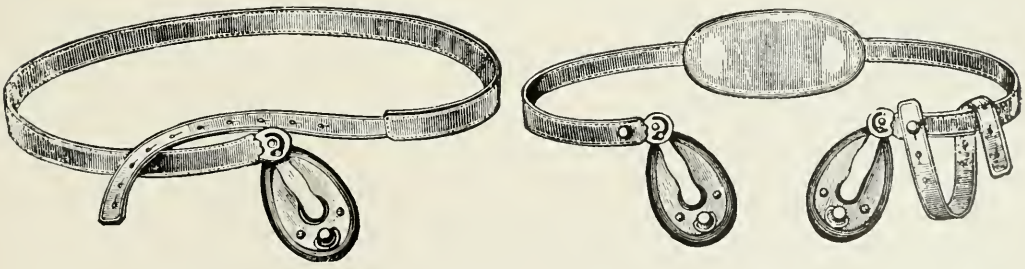

Fig. 241.—Single and Double Hard-Pad American Spring Trusses.

shaped or dome-shaped; they amount to little more than a pouched condition of the abdominal wall below the navel, and they do not endanger life by strangulation. If bandages are worn, such hernias cause little discomfort, and they may not require other treatment. In the upper abdomen the hernias of the linea alba are a type by themselves, having a peculiar history and requiring

operative cure. They are aptly called "epigastric hernias." They appear in the middle line, about three inches above the navel, as globular sacs, often buried in the superficial fat so as to be detected only by palpation. When irreducible they give no impulse and are easily mistaken for small lipomas or other external solid tumors. In general, small globular masses in this location may be looked upon with some degree of suspicion, especially if they are accompanied by deep pain or digestive trouble. In some instances they contain, not only omentum, but also small segments of the wall of the small intestine, the colon, or the stomach, and they cause pain and other disturbances which might easily be mistaken for manifestations of gastric ulcer or of gall-stone disease or for an acute indigestion. In other cases the hernial tumors are reducible and the usual impulse at the ring can be felt.

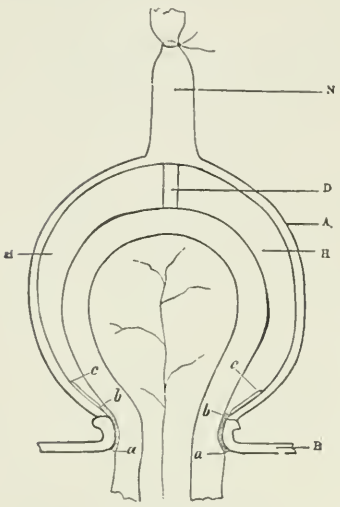

FIG. 242.—Schematic Section of a Congenital Umbilical Hernia.

a a, Ring; *B*, abdominal wall; *bc*, adhesions and new vessels from the lining of the amniotic cavity; *H*, sac cavity; *A*, amniotic cavity; *D*, omphalo-mesenteric duct; *N*, umbilical cord.

ETIOLOGY.—A very common cause of ventral hernia is found in wounds, particularly operative wounds in the abdominal wall. Formerly this complication was more frequent than it is at present. Layer-by-layer closure of laparotomy wounds has largely taken the place of the single line of deep through-and-through stitches which formerly were so commonly employed. The old method permitted gaping of the strong fascial layers, even when the skin and peritoneum appeared, at the time of the operation, to have been brought together smoothly. The integrity of the wall against hernial protrusion depends solely upon the strength of these fasciæ, and, when there has been neglect in approximating nicely the edges of the divided fascia, the skin and peritoneum alone cannot resist the development of a hernia.

The most common cause of ventral hernia, at present, is infection, which causes stitch abscesses and, as a corollary, necessitates drainage. Many operations upon internal pus collections are of such a nature as to compel the use of large drains, thus preventing primary union of the whole or a part of the wound. In many cases only a small part of the stitches become infected to such a degree as to destroy union, but in other cases the greatest care cannot prevent all parts of the suture line from undergoing suppuration and delayed union. Healing by granulation leaves large hard cicatrices which seem amply strong enough to prevent hernia, but which, in the course of a few months or years, become attenuated and then stretch to an almost unlimited degree. One may therefore infer in a general way, from the size and massiveness of the scar, just how great will be the subsequent hernial protrusion. These cicatrices occasionally stretch to a balloon-like degree of thinness (as, for example, after certain appendix operations) so that the coils of intestine can be seen outlined through their walls. More

commonly the hernial protrusion lies between two layers of the muscles or outside the muscles in the subcutaneous fat. Such hernias have sacs which may be bottle-like, with narrow orifices passing through the muscles. Ventral hernias occur in the site of laparotomy wounds at the middle line, in the region of the appendix, in the epigastric and gall-tract regions, and in the lumbar region, at the site of the incision made for a kidney operation. They also may appear at the site of any wound or laceration due to an injury or a stab or bullet wound.

In the Mercy Hospital Clinic I recently had under my care a patient who, in consequence of a crushing injury of the chest and abdomen, had experienced a false hernia of the colon and part of the liver, complicating a hernia of the lung. Recovery took place in due time, and, after the final healing, a true ventral hernia persisted in the right hypochondrium.

Treatment.—Palliation by bandages, belts, and spring trusses may prevent increase in the size of the protrusion. In many cases the prophylactic use of such supports fails to prevent hernia from appearing, but it may restrain the tumor from assuming large proportions.

Operations upon ventral hernia vary with the locality, the degree of the

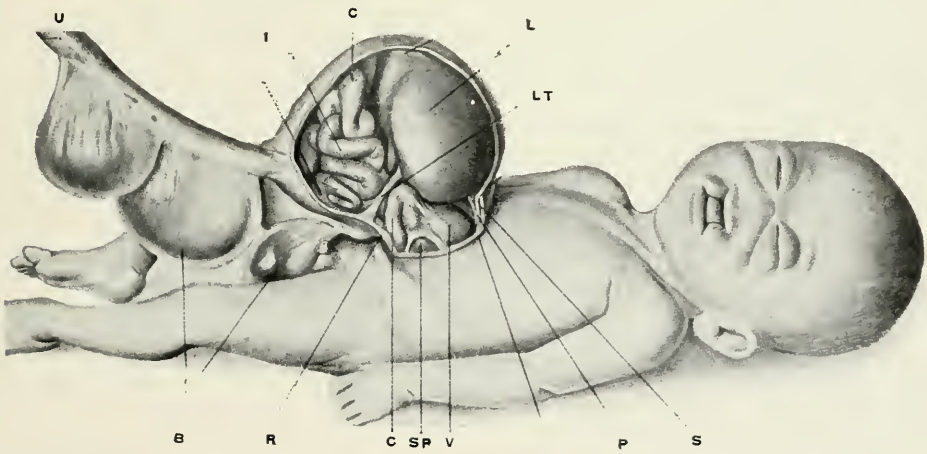

Fig. 243.—Diagram Showing a Congenital Hernia of the Navel and Cord. The sac contains both hollow and solid viscera. (From Wilms.)
U, Umbilical cord; *I*, intestine; *L*, liver; *L T*, round ligament; *V*, stomach; *C*, colon; *R*, ring.

deformity, and the amount of destruction of tissue which has taken place about the false opening. In many cases dangerous adhesions exist between the viscera and the interior of the sac. In other cases destructive cutting of muscles or their motor nerves has caused large breaches in the smooth contour of the abdominal wall which can never be restored by merely suturing the layers. In such cases it may be better to resort to flap methods, as by imbrication of rectangular flaps of the rectus sheath, and to make an anatomical dissection having for its purpose to free the various planes of fascia, in order that afterward they may be restored to their normal relations.

The treatment of epigastric hernia should be by operation. The small sac

should be removed and the minute opening or ring should be closed by one or more stitches. In operations upon these small hernias the same care should be exercised not to wound any hernial contents, as is observed in operations upon the larger hernias.

It is not possible to plan any one operative method which, with slight modifications, may be adopted for ventral hernias in various parts of the abdomen. In a large proportion of hernias due to post-operative suppuration and characterized by scars which have formed adhesions in many different directions, I find it much easier to enter the abdomen from one side rather than through the scar or sac. I make an elliptical incision around the whole cicatricial area, and then, after the necessary dissection, I remove the entire mass, thus making it possible to secure a linear wound when the opposite edges are brought together and sutured. After removal has been accomplished I open the abdomen at a point to one side of the ring. If it be found that the omentum is adherent, the portion which is adherent may be freed or cut off. When the bowel is found to be adherent to the sac the separation calls for the most careful dissection. Herein

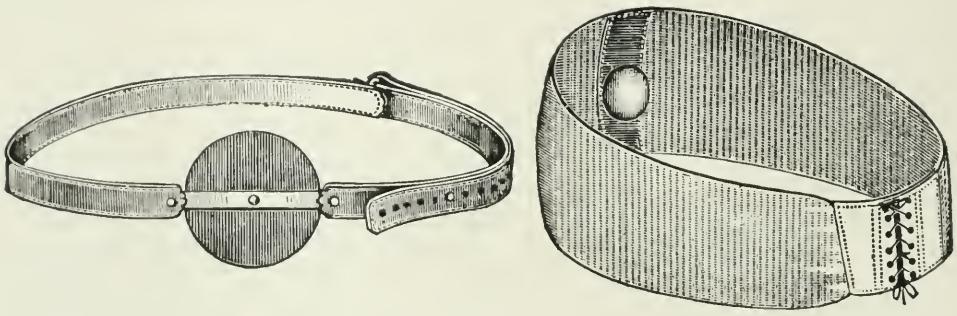

Fig. 244.—Two Different Patterns of Spring Trusses for Use in Umbilical Hernia.

lies the advantage of the lateral incision, enabling us to make this dissection from the peritoneal side. In a ventral hernia the sac cannot, if much scar tissue is present, be stripped from the overlying skin as it can in the case of a femoral or an inguinal hernia. Rather than attempt this it is safer, after entering the abdomen, to cut around the ring margins a little to one side and allow the sac and overlying cicatrix to be removed in one piece. Of course, some ventral hernias have small rings and bottle-shaped sacs which can be treated by enucleation and ligation at the neck. When the ring is large, the peritoneum should be closed by a line of buried sutures, and, for some distance from the margins of the ring, it should be undermined or detached, in order to give it elasticity and to favor the plastic work outside. After the margins of the ring have been drawn together in the direction of least tension they should be united by sutures. If the layers of tissue are intact, the wound may be closed by tiers of buried stitches in the same manner as is done in an ordinary laparotomy. In fact, the ideal operation is one which can be managed in this way. Where loss of muscle and fascia makes this impracticable the thin edges of the ring may be made to overlap to the extent of about one-half the diameter of the

opening, or as much as is possible under moderate tension. A number of mattress stitches are made to hold the deeper segment at a semicircular line inside the opposing edge. The overlapping margin of the outer layer is then sutured firmly so that it shall bear its share of the tension of the wound. If the fascial part of the incision, as mentioned above, is somewhat to one side of the skin incision, this relation of the parts favors union with a minimum of adhesion between layers.

Obturator Hernia.—The obturator foramen is closed by a strong septum, the obturator membrane, which is usually in two layers separated by light areolar tissue. The obturator internus and externus muscles, which spring from the inner and outer surfaces of this membrane, pass toward the trochanter major as external rotators of the femur. The obturator canal or sulcus permits the passage of the obturator nerve, artery, and vein in the order named, from

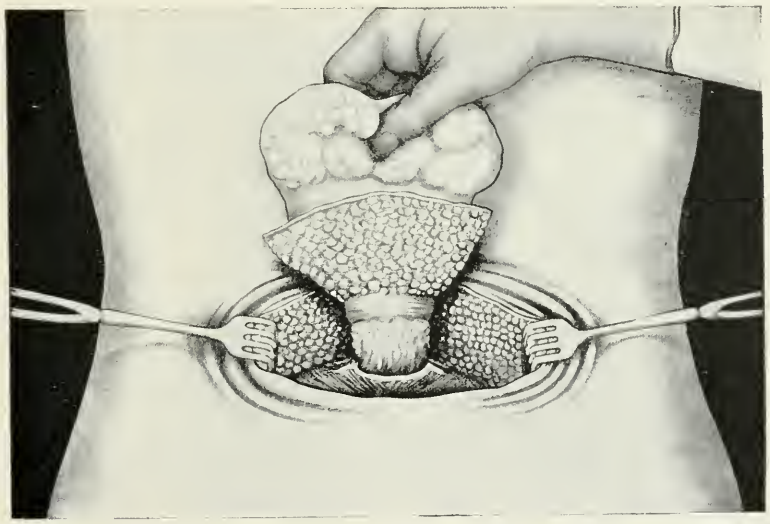

Fig. 245.—The Drawing Shows the First Stage of Mayo's Transverse Suturing of the Umbilical Ring by the Imbrication Method. (From Bryant's "Operative Surgery," Appleton & Co., New York, 1905.)

above downward. This canal is normally less than 2 cm. in length and only large enough to transmit the nerve and vessels in their course through the obturator membranes beneath the horizontal ramus of the pubis.

Hernias through the obturator foramen appear in the front of the thigh not far from the location of the femoral artery, but at a somewhat greater depth or more posteriorly. There exists some evidence in favor of the belief that they may sometimes be of congenital origin, but clinically they are not often seen in children. Men are less often affected than women, and, in the cases belonging to the latter sex, it appears from the reports that the patients were of an advanced age, several of them beyond the sixtieth year of life. This may be explained by the facts that the pelvis is wider in women, that the bones are more tilted, and that atrophy and the deposit of fat are often observed in advanced age. Obturator hernias may be double or single and may contain either

omentum or intestine. Cases are reported in which the hernial sac contained the tubes, ovaries, or the bladder.

Diagnosis.—On account of the small and deeply buried sac the diagnosis of obturator hernia may be difficult or impossible except when strangulation occurs. Palpation may give negative results except when made bimanually through the vagina or the rectum. With the bladder and rectum previously emptied it is possible to detect a cord-like mass leading downward to the obturator foramen. Another sign that is usually present is retraction of, or slight loss of power to extend, the thigh. This is also a symptom of psoas and iliac abscess.

The Howship-Romberg Sign.—One trustworthy symptom of obturator hernia is the Howship-Romberg sign. It consists of neuralgias and paræsthesias of the obturator nerve. This symptom is especially marked when the hernia is under great pressure or is strangulated. The pain is referred along the inner

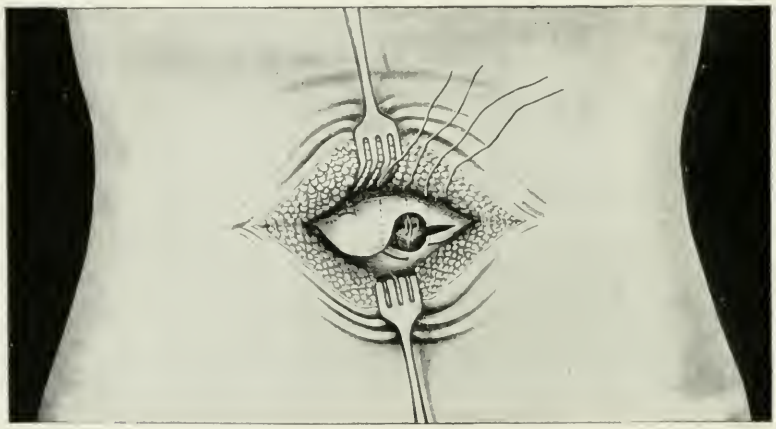

Fig. 246.—The Drawing Shows the Second Stage of Mayo's Transverse Suturing of the Umbilical Ring by the Imbrication Method. (From Bryant's "Operative Surgery," Appleton & Co., New York, 1905.)

aspect of the thigh to the knee or to a point a little below the knee, and sometimes to the region of the hip-joint—*i.e.*, to the parts which are supplied by the obturator nerve. Pain may be accompanied by numbness, prickling and formication, and occasionally by hyperæsthesia and even muscular paralysis.

The differentiation of obturator hernia from a femoral hernia and from psoas abscess depends upon the exact localization, the tumor in the obturator variety coming from underneath the pectineus muscles and fascia rather than in front of them. Many cases have been diagnosed only after strangulation has persisted for some time. In a case of bowel obstruction of unknown origin a careful examination for obturator hernia should be made, and the condition excluded in arriving at a diagnosis.

Treatment.—The treatment of obturator hernia has given a high mortality —about forty per cent, according to the statistics of H. Schmidt. This is due to the late stage of the disease and the fact that the subjects were mostly aged

feeble women. Few or no cases have been operated upon except for strangulation. Under non-operative treatment the results have been much worse, according to Schmidt—that is, fifty-six cases with a mortality of one hundred per cent. The operation of choice should in some cases, especially those in which the diagnosis is in doubt, be a laparotomy from above. The strangulated bowel can then be dealt with in whatever manner its condition calls for. For direct operations upon the hernia a vertical incision is made over the saphenous opening. The inner margin of the pectineus muscle is drawn outward after the fascia lata has been divided. It is sometimes better to divide the pectineus longitudinally by blunt separation of its fibres or to cut its origin partly from the bone. The sac is found between the ileo-psoas and the adductor brevis

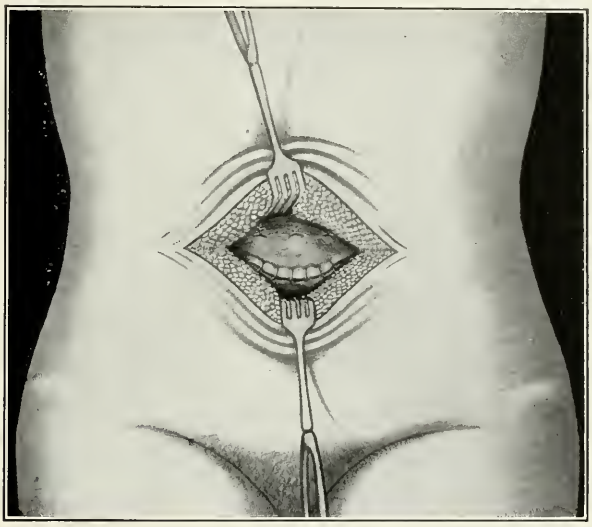

Fig. 247.—The Third Stage of Mayo's Transverse Suturing of the Umbilical Ring by the Imbrication Method. (From Bryant's "Operative Surgery," Appleton & Co., New York, 1905.)

muscles, it having passed above the obturator externus muscle. More rarely it passes behind and below this tendon. The exploration and extirpation of the sac in this narrow space, without injuring the vessels and nerves which lie against it, is a difficult operation. The location of the vessels may be made out by palpation, and, by the aid of this knowledge, one may divide the constriction without injuring them. The outward direction of the cut aids greatly in warding off the possibility of this accident. On account of the danger of such a complication it is doubtless wiser to resort to a laparotomy, as mentioned above. Riedel advised the securing of a freer opening by resecting the pubic ramus, which forms the upper boundary of the ring. Bardenheuer closes the gap which such an operation produces by utilizing a flap of the pectineus muscle or by making an osteoperiosteal flap of the bone itself.

Ischiatic or Sciatic Hernia.—The sciatic notch is crossed by the great sacro-sciatic ligament in such a manner as to form the greater sciatic foramen, an opening which is partly filled by the pyriformis muscle. Two spaces are left—

one above this muscle and one below it. The upper space affords a passage to the superior gluteal vessels and nerve, and the lower one transmits the ischiatic vessels and nerves and the internal pudic vessels and nerves. These spaces above and below the pyriformis muscle are the sites of two types of sciatic hernia named by Garré "hernia suprapyriformis" and "hernia infrapyriformis." In both forms the hernial tumor protrudes underneath the gluteus maximus and is therefore deeply buried. A third form of sciatic hernia is found at the lesser sciatic foramen, through which pass the obturator internus muscle and its nerve and also the internal pudic nerves and vessels. This third type is also called "hernia spinotuberosa" and is the least common form. (Fig. 248.)

Most of the sciatic hernias have occurred in women past middle life. In addition to the pain which usually accompanies all hernias, there is one other sign of diagnostic value, viz., the presence of a tumor, which is located beneath the gluteal muscles on one side and which in most cases disappears on pressure. Sometimes these hernial tumors are very large and they may extend to the anal region and even to the coccyx. The differential diagnosis is to be made from an aneurysm of the gluteal artery, from a cold abscess, and from a neoplasm (for example, a teratoma) located behind the sacrum.

The treatment of sciatic hernia by any form of truss is not practicable. Few operations have been performed except in the emergency of strangulation. When one operates, the best course is to make the incision between the tuberosity of the ischium and the coccyx, in a direction parallel to the lower border of the gluteus maximus. This muscle should be bisected by a second upward cut, the two together forming a T-shaped incision. The gluteus medius must next be exposed and divided high enough to enable the operator to reach the space above or below the pyriformis muscle, according to the type of the hernia. The large size of the vessels encountered makes this operation often bloody and difficult. After a wide exposure and careful hæmostasis it is usually possible to isolate and remove the sac, and to place stitches in the muscular and ligamentous margin of the ring.

Perineal Hernia.—Hernias in the perineum in men and women occur both independently and in association with prolapse of various organs (the anus, uterus, bladder, etc.). At the points where the natural outlets of these viscera (rectum, vagina, etc.) pass through the pelvic floor or partition, an opportunity is afforded for the development of a hernia. A possible congenital element is suggested by Ebner, who cites the facts that the pouch of Douglas (recto-vaginal pouch) and the recto-vesical pouch are relatively deeper in the fœtus and in infancy than they are in adults, and that they may even form diverticula, as in the case of infantile or congenital inguinal hernias. The natural pelvic orifices (urethral, vaginal, rectal) are perforations through the urogenital diaphragm, which latter may be defined as a central ligamentous septum of the pelvic floor, the lateral halves of which are composed of muscular tissue—*i.e.*, the two levator ani muscles. The physiological outlets for the viscera also afford passage to the vessels and nerves, and the remaining space is filled with layers of adipose tissue. Probably age and sedentary life cause some atrophy of

these structures. They may also be weakened by scar tissue from rectal operations and from perineal lacerations in confinement, and by the more horizontal direction assumed by the levator ani after repeated pregnancies.

Perineal hernias usually are central,—that is, infrapubic,—but they may, under certain circumstances, occupy lateral positions in one or the other of the ischiorectal fossæ. This occurs when the sac is forced through the fibres of the levator ani near the tuber ischii, instead of between the two muscles. This is termed by Borsche "hernia endopelvina." It is an incomplete perineal hernia and may escape posteriorly so as to simulate sciatic hernia, as in cases reported by Garré. Again, when the protrusion is very close to the symphysis it may enter the labium majus and be mistaken for complete inguinal hernia.

Central perineal hernias usually appear, as their name indicates, in the

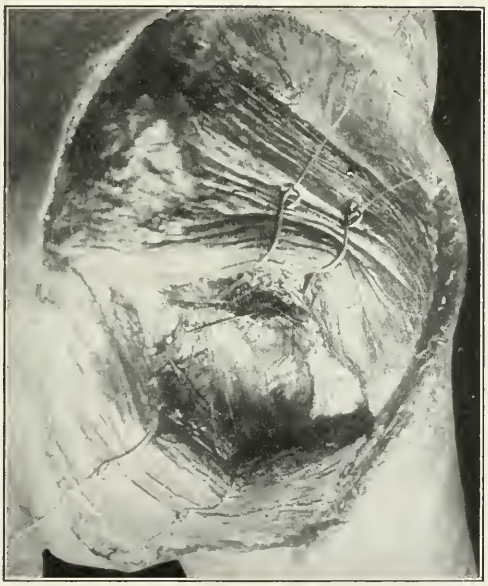

Fig. 248.—Dissection of the Gluteal Region, Showing an Ischiatic Hernia Escaping underneath the Gluteus Maximus, between the Pyriformis and Obturator Muscles. (*From Gasser.*)

perineum, and are easily diagnosed, especially in males, from the presence of a reducible tumor of moderate size. The large hernias are commonly associated with some form of prolapse occurring behind, in front of, or to one side of, a prolapsed rectum, vagina, or bladder. Grave accidents have followed the careless incision or attempted removal of hernial masses pressing upon these structures, in the erroneous belief that the masses in question were polypi or other growths.

In general, the treatment of perineal hernia by trusses or supports is unsatisfactory. A cure of the condition by operation is attempted generally in connection with plastic operations on the perineum or rectum, and is only an incident or step in this work.

Lumbar Hernia.—Hernia in the loin or lumbar muscles is one of the rarest

forms of rupture, appearing only about once in four or five thousand cases of hernia examined. Paul Berger, in 16,800 hernias of 10,000 patients examined in the Paris hospitals, reported only two instances of lumbar hernia. Few observers have seen more than one or two cases, a number of these being reported as cured by operation by Grasser, Brown, Wolff, Hein, de Quervain, Macready, and others in Europe, also by Bull and Dowd in America.

There appears to exist, in the anatomical arrangement of the lumbar and abdominal muscles, a certain predisposition to the formation of a weak point below the twelfth rib. When the latissimus dorsi is drawn backward the origin of the internal oblique and the border of the serratus posticus inferior are seen to be separated by a space covered with fascia. This space is rhomboidal in shape, bounded by the erector spinæ behind, by the external oblique in front, and, as already stated, by the twelfth rib or the serratus above, and by the internal oblique muscle below. Its floor is identical with the deep layer of the lumbar fascia—the fascia lumbo-costalis of Kocher. This space is covered by the latissimus dorsi muscle. Pettit's triangle, especially its upper angle, is also believed to be a weak point in the lumbar region. Although this has been disputed by Braun, Dowd's successful operation, in a case of lumbar hernia, was performed at this point. (Fig. 249.)

Lumbar hernia may be either congenital or acquired. In fœtal life or in early infancy atrophy of the muscles of the loin may occur from nerve injury or from poliomyelitis, causing a yielding and displacement of their margins. In adults the occurrence of lumbar hernia has been known to follow traumatism by direct blows, by falls causing intra-abdominal pressure, by the strains of coughing and of parturition, etc. The symptoms commonly observed at the time have been a sensation as of tearing felt at the moment of protrusion. There have also been reported cases in which the hernia has taken place in the scar tissue resulting from a cold abscess or a perinephritic abscess. The hernia may be double, as reported by Fedorows. In most cases a hernial sac has been found, but in 1889 Hutchinson reported an instance of a traumatic lumbar hernia, the size of an orange, in which a sac was wholly lacking.

It is usually easy to determine the presence of a lumbar hernia, but not so easy to determine its exact point of exit or the location of the inner orifice. In forty-nine cases Jeannel found only nine which had been examined by autopsy or by operation. In four cases only was the exact location determined, and, of these, one was found at Pettit's triangle and three at the superior trigonum lumbale.

The treatment of lumbar hernia may be like that of any ventral hernia, viz., by means of trusses, provided the hernia is reducible. Many cases have been observed only after strangulation had occurred, and they have been treated by herniotomy. The operation is not difficult and, in good subjects, is reasonably safe. It consists (according to Dowd) in placing a double row of sutures in the margins of the muscles after the sac has been extirpated down to the orifice in the lumbar fascia. Kuester, in cases where the defect was very large, employed a special flap. He accomplished this by lifting up a large flap of skin,

muscle, and periosteum from the crest of the ilium, rotating it, and then stitching it over the ring.

The Internal Hernias of the Abdomen.—The term retroperitoneal or internal hernia is applied to those cases in which the viscera become entangled in their own internal recesses, without giving rise to any visible external tumor of the abdominal wall. Invagination and intussusception are not included here, nor are cases in which coils of small intestine become strangulated by sliding under bands of old adhesions or into apertures in their own mesentery. There exist, along the course of the intestines themselves, several natural openings into which loops of bowel, especially of the small intestine, may slip and become strangulated. It is usually when they are in a state of strangulation that these hernias are observed; hence their importance is chiefly as possible

FIG. 249.—Dissection of Right Lumbar Region, Showing Hernial Protrusion, Triangular Space below the Twelfth Rib, the Latissimus Dorsi, and the External and Internal Oblique Muscles. (*From Enderlen.*)

factors in acute intestinal obstruction. It is rare, in cases of this nature, that a diagnosis of the true state of affairs has been made except at operation or at autopsy. The chief locations of an internal hernia are: (1) the foramen of Winslow; (2) the ligament of Treitz (duodeno-jejunal fossa); (3) under the colon (ileocæcal, ileoappendicular, etc.); (4) between the coils of the sigmoid flexure (intersigmoid).

(1) *Hernia at the Foramen of Winslow.*—A few cases only—about twenty, according to Moynihan—have been put on record. It is difficult for the small intestine to reach this foramen, which is located above the colon and duodenum and behind the common duct. When the mesentery is abnormally long or is continuous with the mesocolon, so that the latter is long and the colon not fixed to the posterior wall, or when the foramen of Winslow is abnormally large, conditions

may favor the passage of the bowel through this orifice into the lesser peritoneal cavity. Jeanbrau and Riche assert that, when this takes place, there is formed a palpable tumor which is more dull on percussion than the rest of the abdomen. This early tumefaction is important for the diagnosis. It may be directly in the centre or more toward the right, and its centre may coincide with the umbilicus, or it may lie considerably above it, but always below the costal arch. In none of the cases on record was the trouble diagnosed early. In some it was overlooked even at the laparotomy. The small intestine is generally involved. The stomach is forced forward and the afferent loops of intestine are distended and held immovable under the liver, high up to the right. No hernial sac is visible except in the rare cases in which the intestine has slipped between the two sheets of the great omentum. When the finger is able to trace the course of the incarcerated intestine, the pulsation of the large hepatic artery can be perceived. In the eleven cases in which an operation was undertaken it was found, in all but four instances, to be too late to save the patient. An incision into the intestine should be made to evacuate its contents; after which the reduction of the hernia is easy. Between the vena cava and the duodenum there is a sheet of loose cellular tissue through which it is easy to expose the lower part of the foramen of Winslow after the anterior sheet of the lesser omentum has been incised over the upper duodenum, in a direction parallel to its longitudinal axis.

The treatment of this condition is by open laparotomy, and there is presented to the surgeon a grave and almost insoluble problem as to how best to relieve the constriction. Our experience with gall-tract surgery has made us familiar with this orifice, as it is usually explored with the finger when an examination of the common duct is made. The anterior margin of the ring is formed by the gastrohepatic ligament, which carries the common duct, the portal vein, and the hepatic artery. Posteriorly we find the vena cava in close relation. Dividing the ring by cutting or tearing would seem to be impossible. Although Jeanbrau and Riche worked out, on a cadaver, a method of accomplishing this by mobilizing the structures in the ligament it has never been done on the living subject, and probably could not be done without causing death. It would be safer, as advised by Moynihan, to open the lesser peritoneum and drain the distended bowel to facilitate reduction, or to make a lateral anastomosis outside the obstruction and operate later for the hernia.

(2) *Duodenal Hernia.*—Duodenal hernia, or paraduodenal hernia, appears at the point of exit of the jejunum from beneath the transverse colon. Since 1857, when Treitz first described this condition, numerous other cases have been reported.

The duodenum is not provided with a mesentery and is the least movable part of the small intestine. Emerging at the ligament of Treitz it becomes an intraperitoneal organ where it joins the jejunum. At this point of emergence, the duodeno-jejunal angle, several small fossæ are seen when the transverse colon is drawn upward and the field is well exposed. The two main depressions are located, one upon the right and the other upon the left side of the jejunum,

and they are the starting points, respectively, of a right-sided and a left-sided duodenal hernia; in other words, these depressions are located to the right or to the left of the bowel wall at the insertion of the transverse mesocolon. Upon the left side there are habitually two smaller fossæ—an anterior and a posterior fossa—which form depressions in the peritoneal fold of the mesocolon. Through these fossæ, when enlarged, the hernial sac may extend on either side of the bowel, so as to reach the region of the pancreas or even that of the left kidney. The orifice may gradually become enlarged so as to allow an extension of the hernial mass retroperitoneally as far as the spleen, the descending colon, or the bifurcation of the aorta. In such cases a tumor usually may be felt by anterior palpation, but the diagnosis has seldom been made except by opening the abdomen.

Duodenal hernia was believed by Treitz always to be acquired, while Landzert asserts that it is always of congenital origin. Its sudden appearance in adult life points to a probable traumatic origin, as happens in a ventral hernia. Vautrin has reported two cases, in one of which he ascribes the trouble to an old scoliosis.

The infliction, as regards the symptoms and the position of the tumor, is in many respects like the hernia at Winslow's foramen. The more left-sided and lower location would usually distinguish it from the latter variety of hernia. The operative indications are the same, except that more liberty in dividing the constriction may be allowed. This orifice transmits the mesenteric vessels and nerves as well as the duodenum and hernia, but it may be divided with comparative safety on three sides. Hence there is no special difficulty about relieving the strangulation and permitting reduction of the hernial mass.

(3) *Retrocæcal Hernia.*—Retrocæcal varieties of retroperitoneal or internal hernia are of two forms—a superior, just above the ileocæcal valve, and a lower or inferior, just below that junction or at the mesoappendix. The location of the sac is between the layers of the mesocolon and between the colon and lumbar muscles. The weak point, through which a hernia occasionally protrudes, is just at the angle above or at that below the rectangular insertion of the ileum into the side of the cæcum. From this location the hernia tends to follow the direction of the large bowel toward its hepatic flexure. The condition may resemble an intussusception at the valve, but the tumor is more immovable and more deeply located.

(4) *Intersigmoid Hernia.*—The sigmoid has a long mesocolon, which, when lifted, is seen to be fan-shaped, with a central depression at the junction of its root with the posterior abdominal wall. This is surrounded by the main trunk of the sigmoid artery. Hernias through this weak point pass into a tunnel-shaped channel that leads upward behind the peritoneum, in close relation with the superior hemorrhoidal and colica sinistra arteries.

The treatment of retrocæcal and retrosigmoid hernias, if strangulated, meets the same operative difficulties as are encountered when the hernia is located at the foramen of Winslow. The vascular ring is almost complete and free division of the constricting bands is impossible. Extirpation of the sac is practically impossible in its inaccessible location. It must be left *in situ*, with the possi-

bility of its forming a cyst. The ring itself may be closed by sutures if great care is taken to avoid the encircling artery.

Hernias of the Diaphragm.—Something over five hundred cases of hernia of the diaphragm are now on record, and almost two-thirds of them were congenital. Thoma collected 433 cases, of which only 181 were acquired; the remainder (252) were congenital. In 248 cases Lacher found that a sac was reported only 24 times. These diaphragmatic hernias have also been classified as true hernias—*i.e.*, hernias having peritoneal sacs, while false hernias merely consist of openings in the diaphragm through which the viscera escaped. The former, the true hernias, constitute only one-tenth of the whole number reported. (Figs. 250 and 251.)

Congenital absence or weakening of the central tendinous portion of the

Fig. 250.—Diaphragmatic Hernia Exposed to View by Dissection of the Pleural and Peritoneal Cavities. This is a "true hernia," *i.e.*, it has a hernial sac. (*From Enderlen and Gasser.*)

diaphragm allows the escape of intestine and stomach, especially on the left side, into one or both pleural cavities. In acquired hernia the conditions are the same, the cause being a wound or rupture of the diaphragm. In some congenital cases the hernia has a true sac, especially at the œsophageal or the parasternal opening. As might be expected from its location the stomach is most frequently found in the hernial sac. Rochard, in 330 cases, found that the different abdominal organs formed a part of the hernia in the following order of frequency:—

Stomach	187	Duodenum	48
Colon	17	Cæcum	35
Intestine	133	Pancreas	12
Spleen	78	Left kidney	2
Liver	60	Right kidney	1

In 266 cases of hernia of the diaphragm in which several organs were involved Lager found that the stomach was in the hernia in 161 cases and the colon in 145, while in 53 cases in which only one organ was involved the stomach was implicated in 27, the colon in 13, the small intestine in 6, and the omentum only once.

In the case of a severe trauma, which causes a large tear through the diaphragm, the stomach, lying against this opening, is the first organ to escape; it is forced directly into the pleural cavity by the difference of pressure in the two cavities. In a case operated upon by me in 1909 the colon escaped transpleurally into the open air underneath the liver, the chest being torn open above so as to expose the dome of the diaphragm. In spite of the facts that the lung also prolapsed and that half a dozen ribs were fractured, the patient made a good

Fig. 251.—Dissection Exposing to View a "False" Diaphragmatic Hernia, or one without Hernial Sac. Nearly all of the small intestines have escaped into the left pleural cavity. (*From Enderlen and Gasser.*)

recovery. The wound in the diaphragm was sutured from above. Suppuration ensued in the chest and the patient had a recurrence of ventral hernia after leaving the hospital. In the preceding year I reported two other cases of diaphragmatic hernia which had come under my care in the Cook County Hospital. In one of these—a case of stab wound, recovery took place; in the other a traumatic rupture of the diaphragm was discovered at the autopsy. When the stomach enters the chest cavity, it is apt to drag after it consecutively the colon, the jejunum and small intestine, the spleen, and the omentum. In small wounds the omentum may be first to enter the opening. It contracts adhesions at this point and afterward acts as a wedge to dilate the orifice. Then, later, it drags first the colon and afterward the stomach by its lower border, thus inverting and twisting its pyloric end. Repetto, by experiments on dogs, proved that the

tendency of the omentum to seek these openings was constant. At the end of eight days it was always found adherent to the borders of the orifice. Cranwell reports a case in which this omental outpost preceded the prolapse of the colon, thus creating a kind of sac around the hernia. The organs of the chest are correspondingly compromised, as the pleural cavity is encroached upon, causing dyspnœa and heart embarrassment. The herniated bowel may also be compromised and perforation ensue, as in Strupler's case, with septic pneumothorax and empyema. In other cases no strangulation occurs and few symptoms are noted. Gomez describes a case of stab wound of the diaphragm with few symptoms at the time. After remaining well and continuing at work for a period of six months the man was suddenly attacked with intestinal obstruction and died quickly from strangulated hernia at the diaphragm.

Symptoms.—In the majority of cases there are noticed some symptoms of the hernia, either of abdominal or of thoracic origin. Pains located in the epigastrium and left hypochondrium and radiating toward the shoulder, and digestive troubles are the symptoms usually noted. There may be tympanitic resonance over the left chest, and there is usually dextrocardia. Herz observed a case of hernia of the diaphragm in which the descending colon, especially the splenic flexure, rose during inspiration and sank during expiration. He regards this symptom of paradoxical respiration as important for the differentiation of hernia from eventration of the diaphragm. The patient was a man of thirty, who had always been healthy until two years previously, when he noticed that he was becoming corpulent, that he perspired more freely than had been his habit, and that he suffered occasionally from dyspnœa on exertion. One day he experienced great dyspnœa while walking, and coughed considerably. These symptoms becoming more severe, he entered the hospital, complaining of a sense of oppression in the chest, especially at the lower third of the sternum. The case proved to be one of congenital hernia of the diaphragm with a large defect. The stomach was in its normal place.

Diagnosis.—In making a differential diagnosis it will be found helpful to employ insufflation with the stomach tube, and also to resort to the use of radiography after the patient has ingested bismuth.

Treatment.—The treatment of diaphragmatic hernia does not include the use of trusses or bandages and must be mainly operative. In many cases the associated injuries also call for operation. In one instance, for example, I sutured a stab wound of the stomach and a similar wound of the diaphragm and intercostal space. Some stomach contents had soiled both peritoneum and pleura, and a secondary empyema required operation later. When one operates solely for the hernia the important question is whether to make a transpleural or a transperitoneal operation. Familiarity with abdominal work has led many operators to attempt the repair of these wounds from below. Thus, Heidenhain advises the abdominal route for simple hernias and the transpleural for strangulated cases. Wahringer collected twenty-six cases of which twenty-two were operated upon by the abdominal and four by the pleural route. The fear of opening the pleura without the aid afforded by the pneumatic

cabinet has deterred operators in general from opening the chest in these cases. In only ten instances was the diagnosis made before operation. As no one operator has a large series of cases, it is important to determine, if possible, which method of procedure has the greater advantages. I believe that the transpleural route should be the one of choice in all cases requiring operation at all. The dangers of pneumothorax have been greatly overestimated and are largely illusory. The chest can be opened upon either side, as a rule, without much collapse of the lung. I have repeatedly seen it thrusting itself out of a wound at each respiration, and not at all collapsed. Temporary collapse, however, does not cause as much shock and dyspnœa as was formerly believed. It is difficult or impossible to place stitches in the higher part of the diaphragm from the abdominal side, and practically impossible to detach adherent omentum or viscera from below. Cordier reports a case of failure, with fatal result, from an

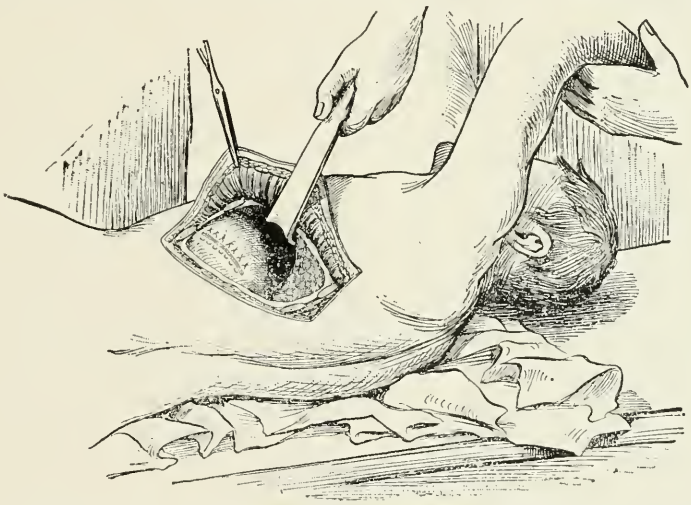

Fig. 252.—Operation for Diaphragmatic Hernia by the Transpleural Route. (*From Cranwell.*)

attempt to do this. All the steps are simplified and made safe when the pleural cavity is opened, as the dome of the diaphragm rises and reaches almost to the parietal pleura. Lejars advises the pleural route in irreducible hernia because the abdominal route gives so many failures. Cranwell confirms this and strongly advocates the pleural route, citing cases of failure from operation below; many of these attempts having been made by good operators, like Abel, Martin, Schwartz, and Rochard. Like the French, the Italian surgeons were early advocates of the transpleural route and obtained brilliant results thereby. Postempski, Nine, and Sorrentino have practised and advocated operating through the chest wall. In fifty-two transpleural operations collected by Neugebauer the mortality was only 9.6 per cent, while in ten laparotomies for the same affection the mortality was 50 per cent.

Technique of the Transpleural Operation for Diaphragmatic Hernia.—The patient should lie in the reversed Trendelenburg or Fowler position, as in Crile's operation about the neck. The use of the pneumatic compensating suit of Crile

or constant watching of the blood-pressure is not required. The incision should extend from the eighth rib and should be curved with its convexity downward. The ends of the incision should be nearly vertical and the eighth and ninth ribs should be resected at these points. (Fig. 252.) The pleura may then be opened and any adhesions broken up sufficiently to gain access to the cupola of the diaphragm. This lies very near the chest wall and can easily be repaired. If necessary, in order to reduce the contents, the hernial opening may be enlarged. The ring should then be closed with durable catgut, tendon, or other suture material. Cranwell used fine silk to unite the two layers of the diaphragm separately. The pleura should next be cleaned and dried locally by sponging with soft pads, and the external wound should be closed without drainage if the wound has been a clean one.

(The employment of local anæsthesia in hernia operations is considered on page 255 of Vol. IV.—Diaphragmatic hernia is also discussed in Dr. J. C. Reeve's article in the earlier part of the present volume.)

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INFLAMMATORY AND OTHER DISEASES OF THE VERMIFORM APPENDIX.

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I. ANATOMY AND PHYSIOLOGY OF THE APPENDIX.

Anatomy.—The appendix vermiformis lies in the right iliac fossa of the abdomen. If a line be drawn from the right anterior superior spinous process of the ilium to the umbilicus, and if a point then be taken on this line two inches from the spinous process, it will be found to correspond approximately to the base of the appendix. In structure the appendix is similar to the rest of the intestinal canal in that it has four coats—mucous, submucous, muscular, and serous. The mucous follicles are shallower than those in the large intestine, and there is relatively a very large amount of lymphoid tissue. This is one reason for the proneness of this organ to attacks of inflammation. The muscular coat has the usual two layers—a circular internal and a longitudinal external. The latter differs from that of the colon in that it is a uniform sheet instead of being in three bands (taeniæ coli). The fact that the longitudinal muscular coat of the appendix is continuous with these three bands is an important point to remember in locating the base of the appendix. If any one of these taeniæ be followed down it will be found to lead to the beginning of the appendix. In early middle life the inner coats of the appendix begin to atrophy, fat and connective tissue being deposited in the submucous and muscular coats and the organ as a whole undergoing considerable diminution in size. The lumen of the appendix is normally continuous with that of the cæcum, the point of communication varying in size between a pin point and a No. 7 French sound. It is often protected by a fold of mucous membrane, the function of which is doubtful. This has been described by Gerlach as a valve. The length of the appendix is quite variable, the usual limits being from 3 to 8 cm., and the extreme limits from 1 to 24 cm. The diameter varies from 3 to 5 mm. It reaches its maximum size about puberty. There are on record a few cases of true absence of the appendix, where no trace could be found after careful post-mortem search in subjects with no abdominal scars. They are quite rare. The appendix has also been found invaginated into the cæcal lumen.

The shape and position of the appendix are best understood by a consideration of its development. Early in the second month of intra-uterine life the intestinal canal is so arranged that on profile it presents an α-shaped loop. From the first descending limb are developed the jejunum and the major portion of the ileum; from the ascending, the terminal part of the ileum, the ileo-cæcal

junction, and the ascending and the transverse colon; while from the terminal limb come the descending colon, the sigmoid, and the rectum. The cæcum first appears, about the sixth week, as a lateral protrusion from the ascending limb of this loop. At first, it is of the same calibre throughout, but, as growth advances, the enlargement is far more marked in the proximal segment than in the distal; in other words, there are formed the cæcum proper and the greatly reduced terminal portion—the vermiform appendix. At this time (second month) the ileo-cæcal region is in the lower left quadrant of the abdominal cavity. During the third and fourth months this portion of the intestinal canal is gradually crowded forward and then upward and to the right by the more rapidly growing

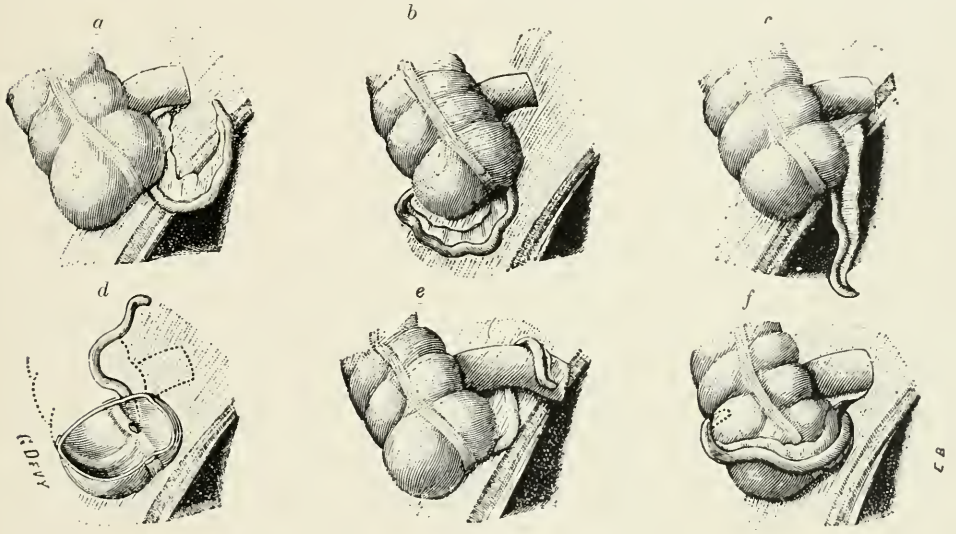

Fig. 253.—Some of the Different Positions which the Vermiform Appendix may Occupy. (From Poirier et Charpy.) *a*, Internal position, showing slight concavity of the cæcum and internal portion of the appendix, which latter may extend much farther inward, even downward into the pelvis; *b*, external position; *c*, descending position; *d*, posterior surface of the cæcum (ascending position); *e*, appendix wrapped around the ileum; *f*, appendix wrapped around the cæcum.

In the position shown in *a* the appendix arises from the inner aspect and most dependent portion of the cæcum; it also turns outward and lies more or less removed from the outer side; or, as is the case in a large majority of instances, the base of the appendix is found on the left and posterior aspect of the cæcum, perhaps extending downward a certain distance, with an inclination either outward or inward.

In about one out of fifty instances the appendix passes up behind the cæcum (extraperitoneal) for a longer or shorter distance. Sometimes, however, it passes upward (extraperitoneal) at either side of the colon, in rare instances even to the liver.

small intestine, so that it assumes a subhepatic position, the proximal part of the colon lying transversely across the upper part of the abdomen. During the remainder of fœtal life the cæcum and the ileo-colic junction migrate downward into the right iliac fossa where they are found at birth. Failure of this rotation to the subhepatic position or of the downward migration serves to explain the rather uncommon adult conditions—those, namely, in which the appendix is found either in the left iliac fossa, or well up under the liver.

The development of this part of the intestinal canal aids also in understanding the relation of the site of the base of the appendix to the cæcum and the

shape of the latter. At first of uniform calibre, the cæcum, with the more rapid growth of the proximal portion, takes on a more conical shape, either remaining straight or becoming convex, with its concavity toward the ileum. (Fig. 253.)

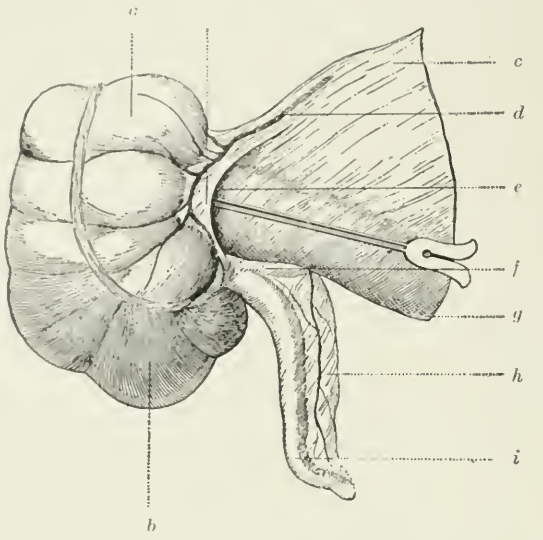

FIG. 254.—Superior Ileo-Cæcal (Anterior Ileo-Colic) Fossa, in an Adult.* (From Poirier et Charpy.) *a*, Colon; *b*, cæcum; *c*, mesentery; d, ileo-cæcal artery; *e*, superior ileo-cæcal fossa; *f*, inferior ileo-cæcal fold; *g*, ileum; *h*, meso-appendix; *i*, vermiform appendix.

These are the conditions usually found a short time before birth. The three longitudinal bands will be seen gradually converging to the base of the rudimentary distal portion, to form the continuous external coat of the appendix.

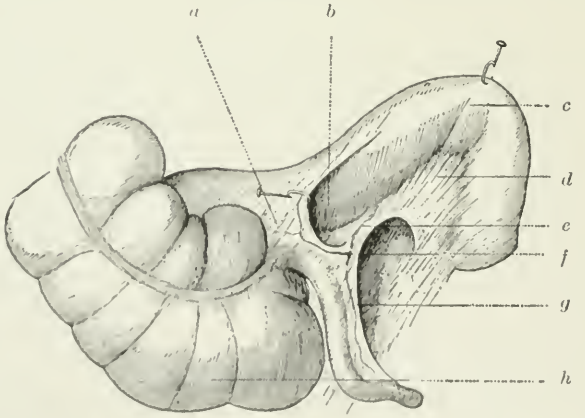

FIG. 255.—Inferior Ileo-Cæcal Fossa (Posterior Ileo-appendical Fossa), in an Adult. (From Poirier et Charpy.) *a*, Ileo-appendical fold; *b*, inferior ileo-cæcal fossa; *c*, ileum; *d*, mesentery; *e*, appendical artery; *f*, ileo-appendical artery; *g*, meso-appendix; *h*, cæcum.

The cæcum proper may then develop equally on all sides, giving rise to the more unusual adult forms—those, namely, in which the appendix is seen arising from the most dependent portion; or, as is the case in the large majority of instances,

* Ileo-colic fossa, of Lockwood. superior ileo-cæcal fossa, of Treves.

the main growth takes place on that portion which lies between the anterior and the postero-external longitudinal bands, so that the base of the appendix is found on the left and posterior aspects of the cæcum. With practically no growth of the left pouch, the appendix will be found close under the ileo-cæcal junction. Consequently, the base of the appendix may be found anywhere, on the inner or posterior wall of the cæcum, between its most dependent point and the ileo-cæcal junction.

Peritoneal Folds and Fossæ.—The ileo-cæcal artery, which is given off by the superior mesenteric, divides into two terminal branches that straddle the terminal part of the ileum. The anterior branch is the smaller and passes down over the anterior aspect of the cæcum, to a point a little below the level of the ileo-cæcal junction. The posterior branch usually divides into two, one of which passes into the inner and back part of the cæcum, while the other sup-

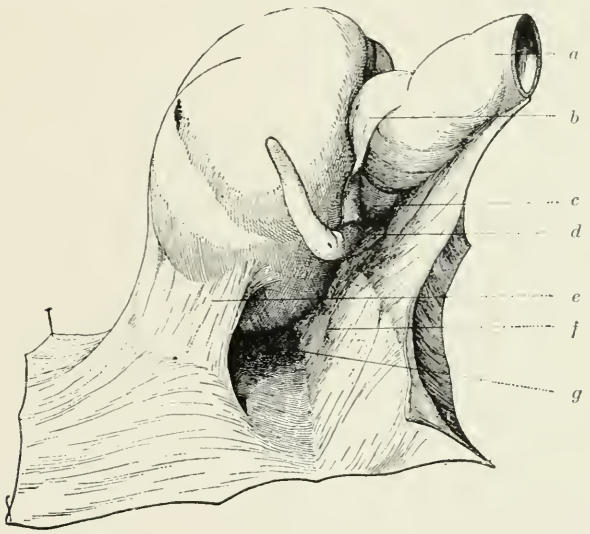

FIG. 256.—Retro-Cæcal (Subcæcal) Fossa. (From Poirier et Charpy.) *a*, Ileum; *b*, ileo-cæcal fold; *c*, inferior ileo-cæcal fossa; *d*, meso-appendix; *e*, superior cæcal fold; *f*, inferior cæcal fold; *g*, retro-cæcal (subcæcal) fossa.

plies the appendix. As these vessels pass to their termination they are enclosed in peritoneal folds called the superior and inferior vascular folds. (Figs. 254 and 255.) Of these, the superior (ventral or anterior fold) is the smaller and appears merely as a curved ridge, often containing masses of epiploic fat. The shallow fossa framed in its concavity is the superior ileo-cæcal (or ileo-colic) fossa. (Fig. 254.) In six per cent of cases this fold is the larger of the two and forms the mesentery of the appendix. (Fig. 256.) The inferior (dorsal or posterior) vascular fold is usually the larger and more important one of the two, forming the mesentery of the appendix and containing the appendicular artery. (Fig. 255.) A third fold, the intermediate or non-vascular fold (bloodless fold of Treves), is triangular, attached above to the terminal portion of the ileum and rather on its dorsal aspect, and below to the outer side of the cæcum. It usually swings around to blend with the inferior ileo-cæcal fold. (Figs. 254, 255, and 256.) Its base is free

and forms one boundary of the pocket enclosed by these two folds and the ileum, called the inferior or posterior ileo-cæcal fossa. (Fig. 255.) Occasionally this intermediate fold swings forward to blend with the superior vascular fold and to aid in the formation of the ileo-colic fossa. (Fig. 256.)

Position of the Appendix.—As a rule the terminal part of the cæcum and the appendix hang unconnected in the peritoneal cavity. Rather frequently, though, the posterior surface of the cæcum is adherent to the parietal peritoneum. If these adhesions extend farther down on the lateral aspect of the cæcum than in the middle they will enclose a shallow fossa, which can be seen with its opening looking downward when the cæcum is lifted up. This is known as the sub-cæcal or retrocæcal fossa. (Fig. 256.) If the appendix is held up vertically behind the cæcum (as the latter descends) it may be caught in these adhesions and become entirely retroperitoneal and retrocæcal. This retrocæcal position of the appendix is quite common. Sometimes the tip of the appendix remains free on the outer side of the cæcum. (Fig. 256.) Perhaps more frequently it is found to the left of the cæcum, either pointing up behind the terminal part of the ileum, toward the spleen, or downward and inward, perhaps with its tip hanging over the brim of the pelvis. Among the more uncommon positions may be mentioned these: in front of the ileo-cæcal junction, in the subcæcal fossa (8 per cent); or with its tip reaching over to the left side of the pelvis or even to the left iliac fossa (.05 per cent). The cæcum with its appendix has quite often been found in an inguinal hernial sac. The fact has already been mentioned that the appendix, through faulty development, is sometimes located under the liver or in the left iliac fossa.

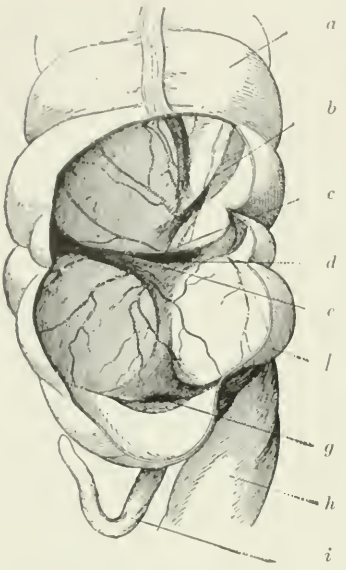

FIG. 257.—Internal Configuration of the Cæcum; specimen taken from an adult. The bowel was first inflated, then dried; and finally a part of the external wall was excised. (From Poirier et Charpy: "Traité d'Anat. Humaine," Paris, 1901.)

a, Colon; *b*, valve-like fold; *c*, ileo-colic valve; *d*, ileo-cæcal orifice; *e*, ileo-cæcal valve; *f*, internal wall of the cæcum; *g*, appendical orifice; *h*, ileum; *i*, vermiform appendix.

Vascular and Nerve Supply.—Besides the ileo-cæcal artery mentioned above, the ovarian artery is said to send a small branch to the appendix. This is not always the case. The veins draining the appendix send their blood back through the superior mesenteric to the portal vein. The nerve supply is derived from the coeliac plexus through the superior mesenteric plexus. The lymphatics drain into the mesenteric nodes and into others scattered along the inner and posterior aspects of the cæcum and ascending colon.

Meso-appendix.—The shape and the size of the mesenteriolum vary considerably. As regards its shape this structure is described as either triangular or quadrilateral. As a rule, it completely envelops the appendix. In a few

cases, however, the serous coat does not completely encircle that organ, but a portion is practically extraperitoneal. It was this anatomical arrangement which led to a most acrimonious discussion, between the years 1875 and 1885, as to whether the appendix was an intraperitoneal or an extraperitoneal organ. The meso-appendix extends most often to the tip of the appendix, though it often apparently ceases about the junction of the outer and middle thirds, or even proximal to the middle. A real mesentery is sometimes practically missing, there being no layer arrangement, but the appendix lies close along the posterior wall of the cæcum, to which it is bound by a sheet of peritoneum which passes over it. The mobility of the appendix depends largely on the length of its mesentery, as does its accessibility at the time of operation.

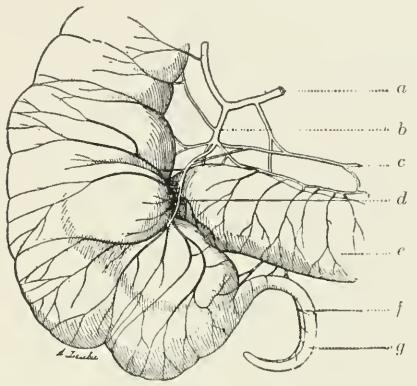

Fig. 258.—Arteries of the Cæcum, the Vermiform Appendix, and the Terminal Portion of the Ileum; view from in front. (From Poirier et Charpy.)

a, Ileo-colic artery; *b*, anterior colico-cæcal artery; *c*, ileal artery; *d*, anterior cæcal artery; *e*, ileum; *f*, appendical artery; *g*, vermiform appendix.

As the mesentery is considerably shorter than the appendix it is responsible for the curved shape of the latter. Because of this difference in length, there are sometimes produced sharp bends or twists which cause obstruction, stagnation, and the formation of so-called stones (appendicular colic.)

Physiology.—The appendix is a rudimentary organ, or a vestigial structure. Its function is not needed for the preservation of life or health, but that it is capable of exerting some influence on the intestinal digestion, can scarcely be doubted. This influence, however, must be very slight, inasmuch as the tens of thousands of patients whose appendices have been removed, cannot appreciate that any distinct deleterious effect on their digestion has followed the loss of that organ. It is very rich in lymphoid and glandular structures; indeed, it has been called the "abdominal tonsil." Its glands secrete a considerable amount of glairy mucus. It is a question whether or not this secretion has a peculiar action of its own or is merely similar to that of the contiguous mucous membrane of the cæcum. This latter pouch changes its shape during the passage of chyme, and it is possible that the appendical secretion exerts some influence on this act, as well as on the passage of fæces from the ileum through the ileo-cæcal valve. Macewen believes that the cells and nuclein of the solitary follicles may have some controlling influence on the organisms that reach the cæcum. It is known that the Bacillus coli communis effects the disintegration of some of the undigested material which finds its way into the lower part of the ileum, and it may be that the appendical secretion has some controlling influence over this germ.

II. CONGENITAL MALFORMATIONS AND NEW-GROWTHS OF THE APPENDIX.

Congenital Malformations.—Such malformations are generally but a part of some congenital defect or abnormality of the intestinal canal. There have been reported a few cases of complete transposition of the abdominal viscera, where the appendix (with cæcum) was located in the left iliac region. Minor grades of such transposition are also on record. Unusual length of the cæcum may carry the appendix far out of its normal position. For example, it may lie far up under the edge of the liver, or well down in Douglas' cul-de-sac. The ascending colon may be entirely wanting, and the cæcum may be attached to the transverse colon; the appendix, in such a case, probably lying far back

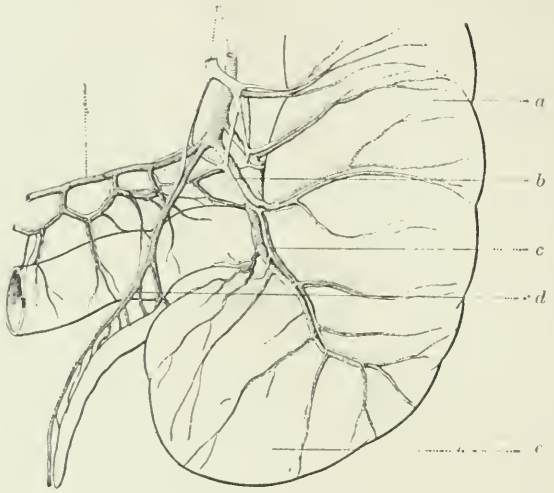

FIG. 259.—Arteries and Veins of the Cæcum and Vermiform Appendix, in an Adult; view from behind. (From Poirier et Charpy.)

a, Ascending colon; *b*, posterior colico-cæcal artery and vein; *c*, posterior cæcal artery and vein; *d*, appendicel artery and vein, *e*, cæcum.

toward the loin under the posterior part of the liver. There have been recorded a few cases in which there was entire absence of cæcum and appendix. The length and the thickness of the appendix vary greatly, and some of those cases in which the appendix is represented only by a small knob or stump which projects from the cæcum and is often without a canal, may be properly classed as abnormalities. The writer has reported a case in which the appendix had a bifid origin from the cæcum.

Intussusception.—Intussusception of the appendix into the cæcum occurs very rarely. Intussusception of the cæcum with its appendix is, however, not so uncommon.

New-Growths.—(1) BENIGN TUMORS.—Among the benign tumors of the appendix are reckoned: *a*, cysts; *b*, fibro-myomata; *c*, papillomata.

Cysts.—Cysts are nearly always the result of previous inflammation, though

possibly, in a few cases, true cyst formation may exist. Cysts, or at least circumscribed collections of clear or mucoid fluid, are not uncommon. In every hundred operations, the surgeon will probably encounter one or perhaps two cystic appendices. The distal portion alone may constitute the cyst, or the middle portion alone may be involved, or the entire appendix may have been converted into a so-called cyst. The contents are generally mucoid or muco-purulent, though occasionally the fluid may have entirely lost its mucoid characteristics and appear to be clear serum. Occasionally the fluid is tinged with blood. Such cystic conditions are termed hydrops, mucocele, or empyema. The appendical contents are prevented from emptying themselves into the cæcum by an occlusion of the lumen of the appendix at some point. This constriction may be at the cæcal attachment or, indeed, at any point of the appendical canal. It may not be perfectly tight, or its closed condition may be intermittent, allowing, at times, part of the cyst contents to escape into the cæcum. These cysts vary greatly in size. In some cases the appendix is but slightly larger than normal, in other cases it becomes enormously distended, so that the length of the organ may be as much as 18 or even 25 cm. (7 to 10 inches) and its circumference 20 to 30 cm. (8 to 12 inches). Cystic appendices the size of an orange or a Hamburg sausage, have been found both at operation and at autopsy. The amount of fluid varies from a few drachms to two and a half ounces. The neck of the cystic tumor, consisting of the narrow cicatrized basal portion of the appendix, may be but slightly narrower than the normal thickness of that portion of the appendix, or it may be constricted and shrunken to the size of a surgical probe; and, in at least one case (writer's), the large cystic appendix was completely separated from the cæcum and lay embedded in the pelvic tissue some distance from the bowel.

Fibro-myomata.—A few such tumors have been reported, but they have probably originated from the longitudinal connective-tissue bands of the large intestine and secondarily have involved the appendix.

Papillomata.—A few cases of growths of this nature are on record, but the possibility of malignancy must always be suspected.

(2) Malignant Tumors.—Primary malignant involvement of the appendix is comparatively rare. Seventy cases have been reported, but some of these must be excluded on account of unsatisfactory microscopical reports. Of course, cases of secondary involvement—as where the cæcum is the part primarily involved—are of much more frequent occurrence. In about 50 cases, however, the malignant disease has been confined to the appendix. Of these, 42 have been classed as carcinoma, 4 as endothelioma, and 4 as sarcoma. The most common forms of cancer are the spheroidal-celled and columnar-celled varieties. The malignancy of cancer of the appendix does not seem as marked as that of the same disease in other parts of the intestinal canal. The diagnosis, in several of the cases, was made only after the results of a microscopical examination had been learned, the disease having had no specially malignant effect on the patient. Frequently, the cancer has been of very slow growth. In several of the cases there was no suspicion of malignancy up to the time of

the operation, the symptoms having been merely those of subacute or chronic inflammation. Indeed, there are few special symptoms which will lead to a diagnosis of malignant disease. Many of the patients have been comparatively young, one being twelve years of age and another fifteen. It certainly appears as if the appendix were attacked by cancer less often, but at a younger age, than are the other digestive organs. The operative results for malignant diseases have been comparatively good. The mortality from the operation has been about fifteen per cent. Not a few of the cases are reported alive and well several years after the operation.

No general rules can be given with regard to the proper manner of operating upon these new-growths; the details of the procedure must be suited to meet the peculiarities of each case.

III. ETIOLOGY AND PATHOLOGY OF APPENDICITIS.

Nomenclature.—The name appendicitis was first suggested in 1886 by Fitz, of Boston, in his classic article on inflammatory diseases of the vermiform appendix. Previous to that date, the terms perityphlitis, paratyphlitis, typhlitis, and epityphlitis had been loosely and indiscriminately employed. This was a time, however, when the appendix was not recognized as the usual cause of the inflammation in the neighborhood of the cæcum. The term appendicitis is now very generally adopted, though some of the continental writers still insist on retaining the old term perityphlitis. The term epityphlitis (Fitz) is etymologically correct, but has not been favorably received or generally adopted.

Age.—Appendicitis is essentially a disease of childhood and young adult life. The abundance of lymphoid tissue in the young and their reckless manner of eating explain their greater tendency toward appendical inflammation. With advancing years, the tendency to appendicitis, or at least primary appendicitis, decreases. If a patient reaches fifty without an attack he can feel assured that he almost certainly will never have appendicitis. It is understood, however, that, if the organ has been previously inflamed, this comparative immunity does not exist. In the writer's experience of three thousand cases, about sixty per cent of the patients experienced their first attack between their tenth and thirtieth years. The ages at which the first symptom of appendicitis manifested itself are, in round numbers, as follows:—

Three Thousand Cases.

In the first year of life	3 cases.	From 30 to 35 years	9 per cent.
In the second year of life	6 "	" 35 to 40 "	6 " "
From 2 to 5 years	5 per cent.	" 40 to 45 "	5 " "
" 5 to 10 "	9 " "	" 45 to 50 "	2 " "
" 10 to 15 "	14 " "	" 50 to 55 "	1 " "
" 15 to 20 "	16 " "	" 55 to 60 "	0.5 " "
" 20 to 25 "	14 " "	" 65 to 70 "	3 cases.
" 25 to 30 "	16 " "	Over 70 years	2 "

The youngest of these cases was ten and a half months old; the oldest, seventy-three years. A dozen or more operations on patients under one year of age have been reported. One of the youngest cases ever operated upon for a perforated appendix was an infant sixty-one days old. One case of apparently prenatal appendicitis has been reported.

Sex.—It was formerly supposed that appendicitis was much more prevalent among males than among females. It is now known that the disease occurs almost as frequently, if not quite as frequently, in the female as in the male. In the writer's three thousand cases, there was a slight predominance of females. The former belief in the predominance of males was probably due to the fact that the disease was not always recognized in the female. The latter sex is apt to complain less than males, and there is often confusion between discomfort from a chronic appendicitis and that from a cystic ovary, chronic salpingitis, or a movable kidney.

Etiology.—The causation of appendicitis is so intimately associated with its pathology, that very little can be said here on the subject in addition to the very full account which will be found in the section on Pathology. It may be stated briefly, however, that the most common direct cause of appendicitis is undoubtedly intestinal indigestion. Trauma occupies quite a secondary place, as do the parasites. With the exception of the so-called concretions, it is rare to find any other foreign body within the appendix, certainly in not more than 0.5 per cent. Appendicitis is most common in spring and in summer, at which periods the digestion is apt to be impaired—in the spring, because of the winter's dissipation; in the summer, because of some indiscretion in diet. Certain appendices, because of their peculiar anatomy, are especially liable to inflammation. These peculiarities consist in their feeble blood supply, their narrow necks, and their angulations or twists because of a short mesentery. In certain families appendicitis is comparatively unknown, in others one or more members of every generation have suffered from the disease. In several instances the grandfather, the father, and several children have been thus affected. The disease is undoubtedly hereditary, in the sense that there exists, through various generations and various branches of a family, some anatomical peculiarity of the appendix which renders it extremely liable to inflammation. The mechanical friction from a movable kidney is an undoubted etiological factor in producing chronic appendicitis. The simultaneous existence of these two conditions is quite noticeable. There may be some peculiar anatomical arrangement of the mesenteries which is responsible for such a combination.

Classification of Varieties.—A logical and at the same time practical classification of the different forms of appendicular inflammation is difficult. That based on the etiology of the disease is unsatisfactory. It is of course an infectious disease, due to bacteria, but a distinction between a streptococcus appendicitis, a pneumococcus appendicitis, and a colon-bacillus appendicitis cannot be made, either anatomically or clinically. From a practical point of view the pathological classification is not satisfactory. The classification which is given under Pathology seems to be most in accordance with the pathological

changes. Another excellent classification, which is perhaps more practical than the one to which I have just referred, is that of Deaver.

DEAVER'S CLASSIFICATION.

Acute Appendicitis.

(1) Catarrhal.
(2) Interstitial.
(3) Ulcerative.
    (*a*) Non-perforative.
    (*b*) Perforative.
(4) Gangrenous.

Chronic Appendicitis.

(1) Catarrhal.

A serious objection to any of these classifications is the impossibility of differentiating, at the bedside, between the various varieties. They not only intermingle with each other, but, in one part of the appendix, one form may be predominant, while in another part a different form prevails. After removal of a diseased appendix, the scars of former attacks, representing different types of inflammation, may be distinctly seen. The steps of progression from one form to another cannot be clinically recognized. Hence the danger of naming an attack "catarrhal." The use of this term is apt to suggest the mild character of the attack, and, in consequence, a false confidence may be felt that the attack is practically innocuous. There is no surgeon living who can *know* that an ulceration is not rapidly approaching the serous coat of the organ. Clinically, the distinction between the "catarrhal" and the interstitial varieties is absolutely unreliable. Even the differentiation from the gangrenous form cannot always be assured.

It seems safer, therefore, from the clinical point of view, to abandon the pathological classification, and to describe inflammations of the appendix as:—

Acute,	Tuberculous,
Subacute,	Parasitic, and
Chronic (recurrent, relapsing, intermittent),	Typhoid.

Between the acute and chronic varieties occur various grades of severity, which may be called subacute, semi-chronic, etc. The attacks of any one of these forms may recur periodically, and the terms relapsing, recurring, and intermittent are then employed. The period between the attacks is termed the *interval*, the "*cold*" stage, "*à froid.*" Such intervals of freedom may last for days, weeks, or months; indeed, chronic appendicitis, with variable degrees of severity, may persist for years. The final outcome of a long-existing, chronic inflammation may be a gradual connective-tissue infiltration of the wall of the appendix, with contraction, shrinkage, and partial or complete obliteration of the mucous coat as well as the calibre. This is termed *appendicitis obliterans*, the result being a mere fibrous cord, with perhaps here and there a patch of mucous membrane.

Pathology.—There is probably no other organ in the body which is capa-

ble of undergoing such a variety of pathological changes as the vermiform appendix. Few organs are exposed to such a complex pathogenesis; and it is rarely that such a clear connection can be traced, as here, between the causative factors and the resulting lesions. It is a distinct advantage, then, to have fresh in mind some of the more prominent of these causative conditions before proceeding to consider the pathological changes produced.

The causes of appendicitis which have a direct bearing on the pathological changes may be divided into predisposing, exciting, and final.

The fact that obliterative processes have been found in the appendix in fifty-six per cent of persons over sixty years of age, and in thirty-two per cent of persons over twenty, would account for the circumstance that the great majority of cases of appendicitis occur in childhood and early adult life.

The vermiform appendix is a blind sac with its orifice at the upper extremity. It is relatively long and of small calibre, and possesses an orifice which, narrow at best, is still further diminished when the mucous membrane of the valve of Gerlach is swollen. For these reasons, it is easy for stagnation of the contents of the appendix to occur, and for solid irritating particles, once entered, to encounter difficulty in escaping.

The viability of the tissues, already of feeble vitality on account of the poor development of the organ, may easily suffer further from the fact that the appendicular blood-supply is furnished through a single terminal artery. For this reason, angulations, torsions, adhesions, and endovascular changes are capable of producing more serious consequences than in other tissues which possess a more varied blood-supply.

The age during which appendicitis is most common—*i.e.*, in the young—is also that in which lymphoid tissue is most abundant. The amount of lymphoid tissue in the neighborhood of Gerlach's valve and scattered throughout the wall of the appendix is very great. The significance of this fact is evident when it is recalled that lymphoid tissue throughout the body is prone to inflammation whenever subject to even slight irritation by bacteria and their toxins.

Among the exciting causes, trauma, strains, and exposure to cold act as they do in other parts of the body in producing inflammation. The causes of digestive disorders exert a still greater influence. A fact, which helps to explain the influence of constipation, is the recent discovery of an increase of virulence of the B. coli communis during that condition.

While appendicular concretions usually represent the result, rather than the cause, of primary appendicitis, they and foreign bodies are an important factor in the production of chronic recurring appendicitis, and may also provoke the acute exacerbations in this condition.

Pins, shot, pieces of lead, bones, hairs, bristles, and various seeds and enterozoa have been known to gain access to the appendix and provoke an inflammatory process by producing abrasions of the mucosa, thus promoting the invasion of infective microbes. They may also act indirectly by obstructing the lumen or by causing pressure anæmia of the appendix wall and diminishing the viability of the tissue.

Of the intestinal parasites that act as exciting causes, the oxyuris is found in some acutely inflamed appendices and may have provoked the attack. There is some reason for thinking that the presence of Ascaris lumbricoides is more often associated with gangrenous appendicitis, while the oxyuris and trichocephalus lead to chronic inflammatory conditions.

The immediate cause of appendicitis is always microbic infection. The conditions in the appendix are not only favorable for the growth of bacteria of many kinds, but also for the sudden and rapid increase of virulence of bacteria which may be innocuous, or almost so, in other portions of the intestinal tract; for the appendix resembles very closely a test tube, and the contents are very suitable media for the culture of bacteria.

The most important factor in the augmentation of the virulence of such an organism as B. coli communis in the appendix is defective drainage. When the drainage becomes impeded this organism multiplies rapidly and increases in virulence, producing a toxin of high potentiality. As a result, the mucous membrane becomes reduced in vitality and invasion of the wall of the organ is a matter of easy accomplishment.

Great interest has attached recently to the bearing of Ruffer's observations of cellular phagocytosis in the appendix on the cause of appendicitis. The phagocyting leucocytes in the intestinal wall are found to be most numerous and most active in the lymphoid areas of the cæcum and the appendix. This greater activity in the microbe-destroying process displaced by the phagocytes implies, not a greater activity on their part, but a greater need for their activity—in other words, a more vigorous invasion of the intestinal wall at these points than at any other. The obtaining of a successful foothold by the bacteria in these areas might well be explained by an exaltation of virulence which would overpower the activity of these phagocytes, or by a diminution in the substance (known as opsonin) in the serum which renders bacteria phagocytable, or by both. One or both of these conditions existing, the predilection of the appendicular mucosa for bacterial absorption would explain the greater vulnerability of the appendix over other parts of the intestinal canal to infectious processes.

Under these circumstances, not the least important part of the pathology of these forms of appendicitis is that which has to do, not only with the virulence of the inciting organisms, but also with the opsonic content of the blood serum.

The bacteria found in inflammatory conditions of the appendix are the following:—

Staphylococcus pyogenes aureus,
Streptococcus,
B. coli communis,
B. lactis aërogenes,
B. pyocyaneus,
B. fecalis alkaligenes,
B. proteus vulgaris,
Pneumococcus.

Anaërobes:
B. fragilis,
B. ramosus,
B. perfringens,
B. fusiformis,
B. furcosus.

Organisms of the latter group have been considered responsible for gangrenous conditions of the appendix and for the intoxication which occurs in appendicitis.

Streptococcus pyogenes is especially associated with all cases of very severe infection, and is the usual cause of extensive and rapidly fatal peritonitis. It is subject to marked variations in virulence.

While the B. coli communis usually occurs as a causative factor in appendicitis in connection with other organisms, it sometimes occurs alone. It undergoes marked variations in virulence and this may be exalted by association with other bacteria. The colon bacillus is usually associated with the milder type of the disease, and with those processes which have little tendency to spread, but which form localized abscesses with the production of large quantities of pus of a peculiarly fetid character.

Pneumococcus and staphylococcus have also been identified in an etiological relationship in appendicitis. The presence of B. pyocyaneus and B. proteus vulgaris is usually considered a secondary invasion of structures already diseased.

The frequent association of appendicitis with constitutional diseases has led to the view of the possible relationship between the general infections and this condition. This relationship has frequently been noticed between appendicitis and rheumatism. The association of tonsillitis, which is frequently connected with rheumatism, and appendicitis has been established. The appendix and tonsils resemble each other, not only in their anatomical peculiarities and excessive lymphoid composition, but also in their predisposition to inflammatory involvement, especially at a youthful age.

Animal experimentation has demonstrated that the lymphoid tissue of the appendix is the seat of predilection for the localization of infective organisms derived from the general inoculation.

The association between some cases of appendicitis and attacks of influenza has been firmly established. Such relationships have rarely been proven, however, by the bacterial examination of the appendicular lesion. Cases of pneumococcal, streptococcal, or staphylococcal infection of the appendix, as part of a systemic process, are well known.

Disorders of the vermiform appendix may best be considered under such headings as Appendicular Colic, Inflammation of the Appendix, Tuberculosis of the Appendix, Actinomycosis of the Appendix, Typhoid Appendicitis, and Amœbic Appendicitis.

(1) Appendicular Colic.—Appendicular colic, although it frequently occurs independently of any actively inflammatory process, is very often found to have a pathological basis as the etiological factor. While stagnation of the contents of the cæcum, associated with gaseous distention, may account for a great many of these cases, the larger number are undoubtedly caused by concretions with or without strictures of the appendix, or by parasites—most commonly Oxyuris vermicularis—within the lumen of the appendix. Adhesions between the appendix and neighboring organs, which have resulted from some previous inflammatory process, may be responsible for the attack. A slight

inflammatory process in the neighborhood of an appendix which is already bent or twisted by its short meso-appendix, may also predispose to colic. In a few cases of chronic colic, interstitial neuritis and atrophy of the nerve fibres supplying the wall of the appendix have been noted.

(2) Inflammation of the Appendix.—Like inflammation elsewhere in the body, the inflammatory manifestations in the appendix may commence acutely or chronically. If the former be the case, the acute manifestations may subside after a greater or less interval of time, and the pathological alterations may persist as a chronic inflammation. On the other hand, the condition may begin as a chronic inflammation.

An inflammation of the appendix originating as a catarrh may, in a given instance, progress to the interstitial variety. This in turn may be succeeded by ulceration, which may or may not lead to perforation of the organ. Gangrenous appendicitis may also follow in such a train of events, though it not infrequently arises in a totally different manner. Again, an appendix which for a longer or shorter period of time has been the seat of chronic inflammation, may suddenly undergo an acute exacerbation and may present the most intense degrees of acute exudative inflammation, with suppuration, ulceration, or gangrene.

The different types of appendicitis will be briefly discussed here under the following headings: Acute Catarrhal Appendicitis, Acute Exudative Appendicitis, Acute Gangrenous Appendicitis, Chronic Catarrhal and Diffuse Appendicitis, Chronic Exudative Appendicitis, Obliterative Appendicitis, and Residual Appendicitis.

Acute Catarrhal Appendicitis.—As the result of the onset of an acute catarrhal appendicitis, the mucous membrane becomes swollen, hyperæmic, and œdematous, and the appendix as a whole becomes stiffer and firmer to the touch. A rapid shedding of the epithelium of the general surface occurs, with detachment and extrusion of the epithelial lining of the crypts of Lieberkuehn. The mucous membrane is infiltrated with leucocytes, and as a result there is swelling with pressure upon and obliteration of many of the crypts. The lumen contains leucocytes, granular débris, mucus, and casts of the interior of the crypts. The blood-vessels of the mucosa and submucosa are congested. In all but the milder forms of inflammation some swelling, congestion, and serous infiltration of the lymph nodules will be observed.

The process may cease at this point and terminate in complete restoration of the mucous membrane to its former condition. But if the process continues, the leucocytic infiltration of the submucosa becomes more marked, the basement membrane may be destroyed, and the internal surface becomes ragged.

Perfect recovery by new growth of epithelium is at first possible, but the shedding may be complete over so large an area that it is impossible for the epithelium to cover again the entire surface. Under these circumstances the inner surface of the mucous membrane will then become covered with granulation tissue; and, if the opposing granulating surfaces come in contact,

fusion may be expected to take place. If the granulating area has been of limited extent, the result of the fusion will be a stricture; but, if the entire surface of the mucous membrane has been involved, obliteration of the appendicular cavity will take place. As a result of such an obliteration the possibility of future appendicular inflammation is almost entirely banished.

Acute interstitial appendicitis is the term usually applied by some authors to a type of lesions resembling those of acute catarrhal appendicitis on the one hand, and the acute suppurative form, on the other. The pathological alterations described extend to the submucous, muscular, and subserous coats, and consist of a diffuse infiltration by small round cells, with hyperplasia of, and occasional abscess-formation in, the lymphoid follicles.

Acute Exudative Appendicitis.—Acute exudative inflammation of the vermiform appendix, with a purulent exudation, occurs usually, if not always, in connection with a catarrhal appendicitis, and there is no sharp dividing line between the two. A mild infection is commonly not suppurative, while a severe infection induces suppuration, unless the virulence of the infective material is so great that a fatal toxæmia results before the tissue has time to react.

As a result of acute exudative appendicitis the appendix is swollen, irregular in diameter, tense, exceedingly hyperæmic, red, mottled with subperitoneal extravasations of blood, often presenting light-yellowish or greenish-yellow areas due to localized foci of suppuration or necrosis. If perforation be imminent the area involved is usually brownish-green in color and soft, and is usually covered by some discolored exudate. Perforations are usually small, round or irregular, with ragged edges.

The canal of the appendix contains a muco-purulent or purulent exudate, often mingled with blood. The mucosa is swollen, intensely injected, and hemorrhagic. Its surface is usually rough and may show erosions with ragged irregular margins.

Erosions are produced by the mechanical action of concretions and foreign bodies, by the direct action of septic material upon the surface of the mucosa, by the necrosis of an infected lymph follicle, or by the extension, into the lumen of the canal, of an abscess focus originating in the deeper tissues; and in any case the ulcerative process may involve a large portion of the mucosa, submucosa, muscular and serous coats, sometimes producing perforation of the appendicular wall in the latter case.

Microscopically, there is marked congestion of all the coats, with degeneration of the surface and glandular epithelium of the mucosa. All the coats are infiltrated to a greater or less extent with an exudate of serum, blood, polymorphonuclear, small round, and plasma cells. Ulcerations occur most commonly where the lymph nodes reach the surface of the mucous membrane, and are frequently bordered with granulation tissue. Purulent thrombo-arteritis and thrombo-phlebitis occur in some cases.

Abscesses may originate in the stroma or the lymph nodes, and they point either in the direction of the lumen or in that of the peritoneal surface. Often, when the muscular layer and even the submucosa show no perceptible change,

a marked inflammatory reaction is found in the serous membrane covering the appendix.

Rupture of the wall of the appendix, when produced by a perforating ulcer, by the pointing of an intramural abscess, or by necrosis following pressure by concretions, is usually gradual and is accompanied by the formation of a peritoneal exudate and adhesions.

When the rupture, however, is due to circumscribed gangrene from thrombosis or to a sharp-pointed foreign body, there may be little local exudate and few adhesions, but general peritoneal exudation at a later time.

While perforations may occur at the base of the appendix or at some intermediate point, the favorite location is at or near the tip.

Acute Gangrenous Appendicitis.—While gangrenous appendicitis may follow any of the previously described varieties of inflammation of the appendix, it is usually associated with the more severe forms or occurs as the direct result of the activity of virulent bacteria or from complete withdrawal of the blood-supply from the organ (entire or only a part) as a result of twists, angulations, or thrombosis.

The area affected is greenish-black in color, swollen, soft, and malodorous. In contradistinction to the other varieties of appendicitis, in which the organ is usually surrounded by a purulent exudate or by adhesions, an appendix which is the seat of a gangrenous or fulminating process may be found totally detached from the cæcum, free in the peritoneal cavity, with little evidence of purulent exudate. At other times, it may be found free in a circumscribed abscess. If gangrene occur as the result of infection by very virulent bacteria, or in consequence of absolute blocking of the blood-supply, the entire appendix, or a large portion of it, presents evidences of a very diffuse gangrene without manifestations of a reactive inflammation.

If gangrene follow catarrhal or interstitial inflammation with ulceration, there will be found, microscopically, the pathological picture characteristic of these conditions, together with, in addition, abundant round-cell infiltration, suppurative foci, larger and smaller areas of hemorrhage, and more or less extensive necrosis. The area of demarcation on the stump shows necrosis with the ordinary evidences of inflammation.

Chronic Catarrhal and Diffuse Appendicitis.—While cases of chronic catarrhal appendicitis in which the pathological alterations are wholly, or almost wholly, confined to the mucous membrane do occur, this is a very uncommon variety of the affection. As the result of such a process, the appendix is thicker, stiffer, and firmer than normal. The mucous membrane is of a grayish color and somewhat thickened. The crypts of Lieberkuehn are moderately distended, and the mucous membrane is covered with a layer of rather thick mucus. The calibre of the lumen may vary at different levels. In the mucosa there are a few round cells and spindle cells, and some connective-tissue hyperplasia.

A far more common form of chronic appendicitis, representing a process slightly more extensive than the preceding, is that known as chronic diffuse appendicitis. In this condition there is a fibrous-tissue transformation affecting

to a greater or less degree all the coats of the appendix. There is some sclerosis of the blood-vessels and a certain degree of congestion is also present. The mucous membrane is œdematous or atrophic, consisting merely of a layer of flattened epithelium resting directly upon a layer of dense cicatricial tissue. It may contain many lymphoid and plasma cells. The solitary follicles may be greatly swollen, but more frequently they are largely or wholly replaced by fibrous tissue.

The fibrous-tissue proliferation, while usually most pronounced in the submucosa, may be well marked in the outer layers, frequently causing an atrophy and replacement of the muscle fibres of the muscular layer. Hæmatogenous pigmentation of this sclerotic tissue is not uncommon. The color of such an appendix is less pink than normal, being more of a dull-yellowish ivory shade.

Chronic Exudative Appendicitis.—Chronic exudative appendicitis may follow any of the previously described forms of appendicitis, or may occur as such from the start. In this form of the disease there is a great tendency toward the formation of connective tissue, and as a result there are increased thickness and firmness of the organ and the formation of cicatrices, resulting in irregular contraction of the lumen and distortions.

The changes which take place in the mucous membrane in the course of a chronic catarrhal appendicitis are also observed in this form of the disease, and in addition there may be found some hyperplasia of the submucous and muscular coats. More commonly, there will be found atrophy, with replacement by cicatricial connective tissue, especially in those cases in which the mucous membrane was originally the seat of ulceration. The wall of the appendix is the seat of infiltration by small round and polymorphonuclear cells, resulting at times in immense thickening of the tissue. The purulent infiltration is sometimes diffuse, at other times it occurs as multiple foci in the wall. A purulent exudate may be found on the surface of the mucous membrane, or on the peritoneal surface as a diffuse process, or as a local abscess surrounded by adhesions. This local abscess occurs usually, though not necessarily, as a sequel to perforation of the appendix wall—the result of the pointing of an intramural abscess or of necrosis produced by foreign bodies within the appendix.

Obliterative Appendicitis.—This name is applied to the terminal process resulting from some of the previously described forms of appendicitis, when the lumen as a whole is occluded—a result which is generally due to an inflammatory involution process, but occasionally to one of a non-inflammatory nature. There may be marked thinning or atrophy of the organ, as a result of which it becomes converted into a mere filamentous thread. The centre of a cross-section is fibrous and contains little or no mucous membrane. While lymphoid elements may be present, there are no well-formed follicles. The surrounding tissue is dense and fibrous, and may contain a moderate amount of fat and hæmatogenous pigment. There are numerous nerve filaments which, when squeezed by the new connective tissue, cause considerable discomfort.

Residual Appendicitis.—Acute or chronic appendicitis very rarely results in a restitution to the normal condition. In the mildest cases there is more or

less connective-tissue hyperplasia, and as a consequence a certain amount of rigidity and enfeebled muscular power persists.

The term "residual appendicitis" is employed to designate the various deformities of the appendix which may follow acute or chronic inflammation after the active disease has subsided. The results may be hypertrophy or atrophy of the appendix, stricture or obliteration of its lumen, cystic dilatation, angulations, or twists due to adhesions or cicatricial contractions in the appendix wall.

Retention cysts are formed as a result of the collection of the normal secretion in a part of the lumen which is separated from the cæcal outlet by an obstruction. These cysts may reach a large size. Their walls are usually attenuated and transparent. As a result of pressure atrophy of the mucosa the mucous secretion finally ceases and the fluid becomes serous or watery in character.

If virulent bacteria gain a foothold in the affected portion of the appendix a purulent exudate with a resulting empyema of the appendix may occur.

(3) Tuberculosis of the Appendix.—While primary tuberculosis of the appendix is almost unknown, it is not uncommon to find tuberculous lesions of the appendix in connection with tuberculous conditions elsewhere—most commonly tuberculous enteritis and peritonitis, and pulmonary tuberculosis.

The gross lesion may present itself in the form of discrete miliary tubercles at the base of an ulcer or beneath the peritoneal coat; or a large part of the mucous membrane may be converted into a discolored mass of caseation. Histologically, these do not differ from similar lesions in other parts of the body. Tubercle bacilli may be detected if properly stained. In addition there are round-cell infiltration, giant cells, caseation, and partial or complete degeneration of the cellular exudate.

(4) Actinomycosis of the Appendix.—Actinomycosis of the appendix is the most common of the abdominal forms of infection by the Streptothrix actinomyces, though in America these cases are rarely seen. Infection with this organism results in suppuration, with the development of indurated connective tissue which contains small foci of pus. Extensive burrowing, with formation of fistulæ, is not uncommon. In the pus discharged the characteristic nodules, of the size of a pin's head and composed of Streptothrix actinomyces, may be found.

(5) Bilharzia Appendicitis.—This parasite has been reported as the cause of appendicitis in three cases.

(6) Typhoid Appendicitis.—In typhoid fever there may be changes in the wall of the appendix of a character similar to those in the wall of the small intestine—that is, hyperplasia of the lymphoid tissue, with ne osis resulting in ulceration and possibly perforation. As a result of such ulcerations, stenosis or kinking of the appendix may ensue, and this in turn may produce a condition which may be the cause of a future attack of appendicitis.

(7) Amœbic Appendicitis.—As a result of inflammation of the appendix

due to Amœba coli the mucosa is covered with the characteristic yellow gelatinous exudate and may suffer extensive areas of necrosis. The mucosa and submucosa are hyperæmic and infiltrated with abundant round cells and a few polymorphonuclear leucocytes. Amœbæ may be found in the exudate and at the base of the ulcers.

Complications and Sequelæ.—Of the complications that pertain to appendicitis, peritonitis is the most frequent. A slight degree of peritonitis is the rule in all suppurative conditions of the appendix, and if the process is local, as it is in the greater percentage of the suppurative cases, limitation by the formation of adhesions usually occurs.

If the resulting peritonitis is diffuse, many adhesions may occur and small abscesses form between the intestinal coils, or the entire peritoneal surface may be bathed in pus.

The inflammation of the peritoneal covering of the appendix may extend intraperitoneally and extraperitoneally to the retrocæcal connective tissue and to the cæcum, and may cause the formation of adhesions. The pus of the appendicular abscesses may also break through into various sections of the intestines, oftenest into the cæcum, more rarely into the ascending colon, the duodenum, the rectum, the bladder, the uterus, the vagina, or even through the abdominal wall externally. These escapes of pus may or may not be followed by a spontaneous cure, according as the pus is emptied entirely or partially.

Acute phlebitis, pylephlebitis, or thrombosis occasionally occurs as a sequel of appendicitis, and may give rise to infarction or to suppuration of the region supplied by the affected vessel; or, through the various anastomoses with vessels more directly connected with the general circulation, the inflammation may result in embolism or in a general pyæmic process.

Slight enlargement of the mesenteric lymph nodes in the locality corresponding to the ileo-cæcal region is to be expected in all active inflammations of the appendix, and, on removal of the primary focus of infection, this enlargement will generally soon subside. Suppurating lymph nodes, on the other hand, may serve as a starting-point for an extension of the inflammatory process by way of the lymphatics and thus give rise to a general septicæmia; or, by a direct and continuous spread, the inflammation may produce suppuration in the hepatic or subphrenic regions.

At times a peri-appendicular abscess may burrow upward behind the liver, either through or posterior to the diaphragm, and may finally rupture into the lung. Liver and subphrenic abscesses occasionally occur as a result of direct infection through the portal system.

Numerous diseases may complicate appendicitis, both prior to and following operation. Of these, the most common, as well as the most serious, are:—Peritonitis; pylephlebitis, and liver abscess; subphrenic abscess; intestinal obstruction: phlebitis. Rare complications or sequelæ are:—Pleurisy, suppuration of the abdominal wound, abscess of the liver, fæcal fistula, pulmonary embolus, hernia, pneumonia, hemorrhage from appendical stump, etc. Of these

different complications I will say but very little, as they are fully discussed in other articles of this series.

Peritonitis.—A certain amount of local peritonitis generally accompanies every attack of appendicitis. In the earlier stages of the disease it is apt to be only slight in degree and very limited in extent. A moderate local peritonitis may be considered, in one respect at least, as a most favorable complication, as, in the case of leakage through or perforation of the appendical wall, it forms, by its adhesive qualities, a barrier against the spread of the infection. When, however, the inflammation extends beyond the immediate neighborhood of the appendix it may be regarded as a serious complication, its seriousness depending on its extent and also on its septic virulency. The greater the area of peritoneum inflamed, the greater the danger to the patient. A peritonitis limited to the lower right abdominal quadrant renders the prognosis grave, though much less so than if it crosses the median line or extends up as far as the liver. A diffuse peritonitis is, of course, the gravest of all. The mortality of the latter is great, and, if it develops after the operation, the prognosis is almost hopeless. This difference in its fatality (before and after operation) is very noticeable. Careful watch should therefore be kept, at both the periods named, for the development of peritoneal symptoms. An increase in the abdominal distention; a paresis of intestinal peristalsis; a distribution, as distinguished from a localization, of the pain and tenderness; an increase in the pulse rate—all these are threatening symptoms. And if to these be added the regurgitation of mouthfuls of fluid from the stomach, perhaps accompanied by belching of gas, the prognosis becomes serious. One is warranted in assuming that the peritonitis has become more or less generalized if vomiting then becomes frequent and if no flatus be expelled. The abdomen soon becomes very bloated and tense. The distention may be enormous, like that of a balloon or a blown-up football, or it may be more moderate, with the abdominal wall boardlike to the touch. The pulse becomes small and rapid, the extremities become bluish, respiration is shallow, and the countenance assumes a most anxious appearance. The mind generally remains clear and the eyes are bright. Vomiting persists, the fluid ejected being at first clear yellow, later brownish, and finally often "spinach-green." The duration of the peritonitis, from its first symptom until death, is usually from thirty-six hours to three days. This limit may be very slightly extended in either direction. The temperature may increase at the onset and continue moderately elevated (101° to 103° Fahr.), or, on the other hand, there may be but little change until just before death, when it often rises to 105° or 106° F.

Pylephlebitis.—This is a not uncommon complication of suppurative or gangrenous appendicitis, or it may occur in the non-suppurative cases, should sepsis develop after the appendicectomy. Pylephlebitis may develop before or after the operation. It is one of the most fatal complications. It occurs in one per cent or two per cent of cases of acute appendicitis, and is nearly always fatal. The sepsis may not extend beyond the veins in the immediate vicinity, in which event it is apt to result in abscesses in the loin under the diaphragm.

Often, however, it extends farther, and results in one or more liver abscesses. A septic pulmonary embolism may also result. The appendical vein empties into the superior mesenteric, *via* the ileo-cæcal vein. There is thus a direct channel of communication with the portal system. Septic thrombi may form in any of these veins, and, from such thrombi, septic emboli may be carried directly to the liver. The supposedly primary thrombus is most often found in the commencement of the portal vein. This may extend in an irregular way along the vein as far as the liver. Such thrombi may be either obturating or mural. Undoubtedly, however, such a thrombus is secondary to one near the ligated veins in the meso-appendix. From this there may be direct extension, or a septic embolus may be carried by the blood-current some distance before it becomes fastened to the wall of a vein or becomes blocked by inability (on account of its size) to go further.

The appendical veins communicate also with the systemic circulation by means of the veins of Retzius—a fact which makes it possible for septic emboli to lodge in any of the blood-vessels of the body, most often in the lungs, but also in the spleen or kidney. Thus a septic pleurisy, a pneumonia, a pericarditis, or an endocarditis may arise. The symptoms are those of an increased sepsis. Often there are chills, and the temperature is apt to be very irregular; rapid shoots upward, with a precipitous fall, being not unusual. The tongue becomes very dry. The patient looks septic and rapidly becomes ill. There may be some pain in the right lumbar region, but the mind generally becomes sluggish, and but little interest is taken in the subjective symptoms. According to the location and extent of the septic phlebitis, the disease progresses. It is always a most serious complication, and, if the portal vein be involved, death usually results in two or three days after the appearance of the symptoms. Operation is of little use, unless there be separate abscess cavities, which can then be opened and drained. The main indication is to build up by every possible means the patient's strength. It is especially important to guard the digestive functions; therefore drugs should be avoided. As long as such a course is possible, abundance of water and whiskey should be administered by rectum, while the stomach is reserved for nutritious drinks. Efforts should be made to raise the opsonic index, and, if the infecting germ has been identified, the specific serums can be injected.

Liver Abscess.—As already explained, such a complication usually results from an infective embolus or thrombus which has been carried along the portal vein. It may possibly, however, be caused by infection carried along the lymphatic vessels. Though these do not connect directly with the liver, the communication may be made through the lymphatics of the abdominal wall; or, what is perhaps more common, the suppurative process may extend directly from an abscess. Whichever be the origin, such abscesses are most often multiple. The symptoms are those already described as arising when the portal veins become infected. In addition, there may be more or less jaundice. There is apt to be delirium, and the obstinate dryness of the tongue is especially noticeable. The treatment is operation, but the results are apt to be discourag-

ing, because the abscesses are generally multiple. Efforts should be made, however, to locate the collections of pus and, if possible, to open and drain them.

Symptoms.—The symptoms of appendicitis are usually easy of recognition and the diagnosis unmistakable. There is, however, no disease in the domain of surgery which at times is more treacherous, and which is more apt to deceive and surprise the surgeon. Not only is the diagnosis of the disease sometimes most difficult, but a true recognition of its severity is often impossible. There are certain cardinal symptoms—such as pain, nausea, tenderness, and muscular rigidity—which we expect to find in every case of appendicitis, but not infrequently one or more of these signs are wanting, and occasionally all three are absent. We should naturally expect that the severity of the inflammation would be in direct ratio to the severity of the symptoms. Such is apt to be the case, but there are so many exceptions to this rule that it is wiser not to feel too confident in regard to its infallibility. Pain and local tenderness are two symptoms which are practically always present in some degree in all types of appendicitis. The surgeon with delicate touch will also discover muscular rigidity or slight increase of tension. Reflex symptoms referred to some portion of the gastro-intestinal tract—such as nausea, vomiting, colic, constipation, or more rarely diarrhœa—are almost invariably present. Fever and increased pulse rate are also symptoms which, in acute appendicitis, generally develop early in the course of the attack, but the fever is apt to appear less early than do the above-mentioned symptoms and it is of less diagnostic value.

In chronic appendicitis these symptoms may be scarcely noticeable, but their persistence or occasional occurrence, in spite of proper hygiene, diet, and medication, should influence the surgeon to be constantly on the watch for their development.

IV. SYMPTOMS, COURSE OF THE DISEASE, AND DIAGNOSIS OF ACUTE APPENDICITIS.

The usual symptoms of acute appendicitis are: pain; nausea and vomiting; fever and increased pulse rate; local tenderness; muscular rigidity; blood changes; and abdominal distention. These symptoms appear, as a rule, in the order just stated. The pain usually precedes the nausea, though occasionally the nausea is the symptom first mentioned by the patient. Local tenderness during the first few hours of the attack is seldom noted. Generally from three to ten hours elapse before the existence of the tenderness can be definitely determined. Of these symptoms, probably the most variable is the fever. As a rule, these symptoms appear within the first ten hours of the attack. Their severity gives some indication of the severity of the inflammation, but we must not forget that at times we shall be completely deceived if we base our prognosis on any such premises; indeed, the pathological changes are often not fairly expressed by the symptoms. A most dangerous attack may creep on insidiously without exciting alarm and without severe symptoms. The onset

may for hours be apparently mild and almost harmless, when suddenly, without warning, the most critical symptoms may develop. No matter how slight the inflammation may appear, we must regard the appendical region as mined by the enemy and liable at any moment to explode, and that, often, when we least expect the explosion. The surgeon who scoffs at the possibility of surprises in appendicitis is either ignorant or reckless. It is an uncertain disease, and the more experienced the surgeon the more anxious he feels. In his operations he is never surprised if he finds marked disproportion between the symptoms and the pathological conditions.

In an average case of appendicitis the patient first notices general abdominal discomfort, especially marked in the region above the umbilicus. A feeling of nausea, with perhaps vomiting, soon follows, and what was at first merely discomfort becomes severe pain, apt to be of a colicky character, and more or less distributed through the abdomen. In a few hours fever develops and the pulse rate increases. The nausea, with perhaps vomiting, is apt to continue for several hours. The general colicky abdominal pain continues for six, eight, or ten hours, and then becomes more and more localized in the right inguinal fossa. About the same time this region becomes exquisitely sensitive to pressure, and the muscles of the region become more resistant to touch. For the first few hours there may be considerable restlessness. The patient may squirm and toss about, thinking that he has eaten something which has disagreed with him. He feels that if he could vomit he would be relieved, and in this purpose he may sometimes tickle his posterior pharyngeal wall with his finger. He finds, however, that this does not afford relief, and this knowledge increases his unhappiness. The pain soon becomes so severe that he finds it more comfortable to lie flat on his back, with the right or perhaps both thighs flexed on his abdomen, than to assume any other position. Intestinal peristalsis soon ceases, and the abdomen becomes distended. No gas can be expelled, and constipation becomes absolute. Blood changes develop within a few hours after the attack. The leucocytes increase rapidly to 12,000, 15,000, 20,000. As a rule, the differential count does not show much change during the first few hours of the attack.

In a mild case the above-mentioned symptoms continue for about twenty or twenty-four hours, and then begin to diminish. The nausea ceases, the pain becomes less, and the iliac region becomes less exquisitely sensitive to pressure. In a favorable case, after the expiration of forty-eight hours, there should be noticed a marked improvement. Nausea should have entirely ceased, temperature and pulse rate should be lowered, gas should have been expelled from the rectum, the abdominal distention should have largely disappeared, and the local pain and tenderness, while not abolished, should be distinctly diminished. If, in the third twenty-four hours, such amelioration of symptoms does not take place, the case is not a favorable one and should be regarded with anxiety, especially if, in the blood count, the polynuclear cells have increased in number. At this stage, or indeed at any stage, of the disease the polynuclear count is of the greatest value.

In a severe case the symptoms, in the second twenty-four hours, do not diminish. The nausea and vomiting, however, except in very severe cases, should have ceased. The pain and local tenderness, as well as the muscular rigidity, persist. The temperature and pulse rate increase rather than diminish, and the abdominal distention becomes more pronounced. If, by the third twenty-four hours, these symptoms are still on the increase the case should be considered as very grave. Probably at this time a distinct tumor will be felt in the right inguinal region. Under such conditions a cure by resolution will rarely result. If this favorable outcome were to follow, decided improvement should have shown itself, at latest, before the expiration of the third day. This improvement not having taken place, the probable course of the disease will be either toward a localized abscess or toward a general peritonitis.

(*a*) *Course of the Disease toward a Localized Abscess.*—When the course of the disease is toward a localized abscess, the abdominal distention will often gradually subside, there will be no recurrence of nausea or vomiting, and the local tenderness and pain will become less marked. A more distinct and larger tumor will, however, develop in the right inguinal region. The fever will probably persist and may assume a septic type. Such an abscess, if well walled in by inflammatory exudate, may remain more or less stationary for many days or even weeks, the pus resting perfectly tranquil, decreasing in virulency, and permitting of distinct amelioration of the symptoms. The abdomen loses its distended appearance and the bowels resume their normal functions. The temperature may even be decidedly reduced, though it is apt to continue its septic curve, with evening rise and morning remission. The blood changes, however, will be very decided, the percentage of polynuclear cells remaining high, even though the leucocytes have decreased in number. On the other hand, the abscess may increase rapidly in size and tend to "point" in one direction or another. It may burrow downward toward the pelvis or backward toward the loin, or it may "point" anteriorly just above Poupart's ligament. Instead of this frank course, the walls of the abscess may allow an intraperitoneal leakage to occur, with formation of secondary abscesses.

Secondary Abscesses.—The number and location of these will vary. The most frequent position is in the pelvis, the next most frequent toward the loin, depending more or less on the situation of the primary appendical abscess. Such secondary collections of pus, however, may form at more distant points, as in Douglas' cul-de-sac, in the left pelvic region, or near the umbilicus. Not only may there be one such distant abscess, but there may be multiple collections of pus at various points throughout the abdominal cavity. Such a condition may be termed a suppurative peritonitis. Accompanying the extension of the abscess or spread of the pus, there is generally a distinct relapse of unfavorable symptoms. These are more apt to indicate septic suppuration than peritoneal irritation. The temperature, still retaining its septic curve, reaches a greater elevation; the pulse increases in rapidity; the tongue becomes dry and coated; and occasionally there may be chills. The patient assumes a septic look, the skin is pale and sallow and perhaps, if the abscess be near the

liver, tinged with jaundice. There will be a slow increase in the abdominal distention, and the bowels will be very sluggish, with considerable stagnation of gas. Pain is rather variable. It is seldom very severe, but there is a general sense of soreness and the patient is apt to feel utterly miserable. Local tenderness is also variable. It is seldom acute, but deep pressure directly over the abscess will, as a rule, distinctly hurt the patient. The abnormality of the blood will continue or even increase.

(*b*) *Course of the Disease toward a General Peritonitis.*—If the course of the disease tends toward a general peritonitis, there will be either sudden or gradual increase in the unfavorable symptoms. The abdominal distention will increase, the pulse will become more rapid and more wiry, and nausea, with belching of gas and "secondary vomiting," will appear. The local pain and tenderness may entirely cease, and there may no longer be any general abdominal soreness and tenderness. The face assumes an anxious expression and the vomiting becomes more frequent and explosive in character; the material vomited being at first brownish, but later becoming greenish in hue ("spinach-green"). The abdomen becomes very hard, board-like, and enormously distended. Respiration becomes labored and shallow. The pulse increases in rapidity to 120, 130, 140. The extremities become cold, the finger-nails blue. The fever is very variable. As a rule, the temperature does not rise proportionately to the increase in gravity of other symptoms. It generally remains between 101° and 103° F., though just before death it may rapidly rise to 105° or 106° F. In certain cases, and these are the most unfavorable, the temperature remains low (under 100° F.) throughout the whole course of the disease; indeed, for part of the time, it may be subnormal. The comparative freedom from fever, especially if associated with a rapid pulse and a low leucocytosis, indicates a lack of resistance on the part of the patient, and the prognosis in such cases is always very grave. This is especially true if the polynuclear cells increase to 80 per cent or above. An estimate of the number of these cells serves as one of the most valuable guides that we possess,—one upon which we base our judgment either as to the presence of pus or as to the spread of the peritonitis.

While the description just given is that of the most usual type of the disease, there are, nevertheless, so many variations of type, and so many irregular symptoms in any type, that a more detailed description is necessary, both as to the mode of onset and also as to the character of some of the special symptoms. The disease is often most irregular in its development of symptoms. Frequently one or more of the most characteristic symptoms is entirely absent, and when they are present their prominence varies greatly. In many cases nausea and vomiting are the predominant symptoms, while in other cases this predominance must be accorded to pain and local tenderness. In certain severe cases the collapse may be so great that it masks all other symptoms.

The Onset.—An attack is occasionally ushered in by a chill, but this is the exception rather than the rule. Of course, the chilly sensations which usually accompany fever may be experienced. The onset may be very sudden or very

gradual. Between these two extremes, its severity varies greatly. Three grades of severity may be noted: very severe, moderately severe, and mild.

(*a*) A Very Severe Onset.—The attack may be ushered in by the most alarming symptoms. The patient is suddenly seized with intense abdominal pain, its exact location being indefinite. At the same time there may be a chill or vomiting. Signs of collapse rapidly follow: excessive pallor, an extremely anxious facial expression, a small rapid pulse, shallow respiration, and perhaps subnormal temperature. The abdomen rapidly becomes distended and vomiting continues. Such a group of symptoms indicates perforation with rapid absorption. The poison has made an unexpected assault on an unprepared peritoneum, and, for a time at least, its resisting power is overwhelmed. After a few hours it will be seen whether or not the patient is able successfully to conquer the invader. This will be shown by an improvement in the circulation, by the less distressed appearance of the patient, by an increase in the number of leucocytes, and perhaps by an elevation of temperature. If, in addition, there are signs of returning peristalsis, a cessation of vomiting, and a passing of flatus, the case may be considered as one that is progressing favorably, due allowance being made for the violence of the onset. If, on the other hand, the poison cannot successfully be resisted, the pulse remains small, rapid, and wiry; the anxious look and the distressing respiration do not disappear; the abdominal distention rapidly increases, peristalsis being paralyzed; vomiting persists and becomes more frequent and projectile in character; the finger nails become blue; and in twenty-four hours from the onset of the attack the patient's condition is most desperate. Such an attack is called "fulminating," and the prognosis is practically hopeless, no matter what treatment may be adopted.

(*b*) A Moderately Severe Onset.—The onset is less severe and more gradual. Instead of the sudden pain and nausea, these symptoms will gradually develop during a period of several hours. In fact, the pain and nausea may be so insignificant that several hours (from ten to twenty-four) may elapse before the diagnosis can be made. At the end of this period, however, the symptoms may be quite as pronounced as in those cases in which the onset is more acute. The same pathological lesions are produced, but in the one case the time for their production is an hour or two, while in the other case this period amounts to as much as from twelve to twenty-four hours.

(*c*) A Mild Onset.—The onset is mild. There is no vomiting. Nausea continues but a few hours. Abdominal distention is practically absent. The pain is not severe and local tenderness is not pronounced. There is but little elevation of temperature (100° to 100.5° F.) and the pulse remains about 90. Instead of a change for the worse at the end of twelve or eighteen hours (as in the preceding group), the severity of the symptoms does not increase, but rather begins, on the second day of the disease, to diminish. Under this heading may be mentioned what is sometimes called *appendical colic*. The normal appendix is, as a rule, practically empty. It is apt to resent the entrance of foreign matter. If there be an obstruction, due to inflammatory swelling at the appendical neck, the muscular coats will try to force the contents out into the

cæcum, and as a result considerable colic may be excited. Even without obstruction colic may be caused by the efforts of the appendix to rid itself of the presence of an extra amount of fæcal matter.

The Further Course of the Disease.—The course of the disease will vary greatly according to the amount of damage produced by the attack of inflammation. For convenience the cases may be divided into three groups.

(*a*) First Group.—When the symptoms are due to mere inflammatory or œdematous obstruction at the neck of the appendix (its narrowest point) there may be a rather sudden and decided amelioration due to the yielding of the obstruction before there has occurred any extensive inflammatory infiltration of the mucous or submucous coats. Under these circumstances there will be observed, on the second day, or, at the latest, on the third, the following change:—The pain and local tenderness rapidly diminish, the fever abates, the abdomen becomes softer, gas is expelled, and very soon a distinct improvement takes place in the patient's appearance and feelings. Two or three more days will elapse, however, before the local tenderness and pain have entirely disappeared, though these may be noticed only on bodily movement, or when the cæcum is distended with gas. On the fourth or fifth day from the commencement of the attack the patient should be practically well, the only disagreeable remnant of the attack being some sensitiveness of the cæcal region when an extra amount or an extra force of gas passes through. But if this latter symptom persists for many days careful watch should be kept of the patient, for fear that some lurking inflammation may again break out in a fresh attack, or that a chronic appendicitis may ensue.

(*b*) Second Group.—The obstruction may not yield, and there is a general infiltration of the mucous and submucous coats. In such an event symptoms will persist probably throughout the second and perhaps even the third day. The pain and local tenderness will continue, the abdominal distention does not disappear, the pulse and temperature remain moderately elevated, and the tongue remains furred. Vomiting, however, should cease. If the inflammation is limited to a mere infiltration of the appendix, the symptoms will gradually diminish on the third and fourth days of the attack. The change, however, will not take place suddenly, but the abdomen will gradually become softer, the tenderness less acute, and the pulse and temperature lower. The improvement should be progressive, and, at the end of the sixth or the seventh day, there should be no unfavorable signs remaining, except perhaps a slight local tenderness. If the symptoms persist beyond the sixth or seventh day the chances are strongly against resolution of the inflammation, and the inference is warranted that there is either a persisting subacute inflammation of the appendical walls, or an ulceration extending through the mucous membrane, or an involvement of the tissues outside of the appendix. It is impossible in most cases to determine which one of these conditions is causing the symptoms. Of course, if they be due to a simple subacute catarrhal inflammation, they are apt to be mild in character. For example, the fever is comparatively slight and there is very little abdominal distention, but a slight ache will persist, and

there will be a spot where the local tenderness is quite acute. Flatulent indigestion will also be a usual complaint. If, in addition to the inflammatory infiltration, there be actual ulceration the symptoms will depend more or less on the depth of the ulcer. If it extends through the mucous coats alone the symptoms may not be much more pronounced than they are in the cases belonging to the first group. There should be some absorption, however, and this may show itself in the increase in the polynuclear cells. If the ulcer extends down to the serous coat there is apt to be a change in the symptoms, due either to a local peritonitis or to septic inflammation of the surrounding tissues, caused by the escape, through the base of the ulcer, of bacteria or appendical contents. There may be no distinct, or at least no visible, perforation; and yet sufficient bacteria will escape to set up either a local abscess or a general peritonitis.

(*c*) Third Group.—When perforation occurs, the character and severity of the symptoms will largely depend on whether the perforation be into the general peritoneal cavity or whether the escaping poison be confined to a comparatively small area, limited by adherent structures, intestinal coils, omentum, etc., which have been more or less matted together or plastered against the appendix by the accumulation of lymph. This limiting wall may be perfect or at some one point it may be wanting. If the latter defect exist, the result will be either a secondary abscess or a spreading or general peritonitis. It is of the utmost importance, at the earliest moment after perforation has been suspected, to determine which one of these courses has been followed—that is, whether the perforation has opened into the general peritoneal cavity or into a cavity which is walled off by adherent intestines. Unfortunately, in advance of the perforation, we can never with certainty determine which of these courses will be followed. These hours of uncertainty may be most critical. If we delay operation, in the expectation that a localized abscess will form, the favorable moment for interference may slip by. Even after the occurrence of the perforation some hours may elapse before we can be sure which of the two courses has been followed. The sudden perforation of an adherent appendix is generally accompanied by pronounced symptoms, and particularly by signs of peritoneal shock. The pulse becomes small and more rapid; there is often intense pain; the patient is conscious that he is severely ill and his anxious countenance reveals the fact plainly; his face is of a gray, ashen color; his respiration is shallow, and his skin is likely to be covered with a cold sweat. Later, the increased distention of the abdomen and the occurrence of regurgitation from the stomach, followed by vomiting, indicate without question that a general peritonitis is threatened.

Such a train of symptoms, however, does not always follow. The involvement of the general peritoneum may take place more insidiously, and hours may elapse before the observer is aware that a general peritonitis is established. This is especially apt to be the case in children. The symptoms change so slowly that one is able to realize the gravity of the patient's condition only by the most watchful and painstaking observation. If adhesions have fortunately prevented the escape of appendical contents into the general peritoneal cavity, the symptoms will indicate increased sepsis rather than peritoneal irritation.

At the moment of perforation there may be slight temporary pain and shock, owing to a mild absorption; the pulse-rate may increase; and the patient may look and feel for a short time distinctly more ill. If the leakage, however, be quite limited these graver symptoms do not increase, nor is there apt to be much evidence of peritoneal inflammation. Indeed, the pain and local tenderness are often diminished because of relief of tension. The temperature and pulse, however, assume a course which indicates suppuration, and there may be chills. The temperature is apt to rise to 103° F. and over in the evening, and toward morning to drop two or three degrees. The blood changes also become more marked, the polynuclear cells showing marked increase. A tumor soon forms, or, if one has already been observed, it increases in size. Later, a distinct sense of fluctuation may be felt beneath McBurney's point, or (by rectal examination) deep in the pelvis, or posteriorly in the loin. Secondary abscesses may develop in any of these localities.

From the above descriptions it will be noted that there are three classes of cases:—

(1) Those in which the patient, under any form of treatment, will probably die; the only chance for recovery being afforded by an operation—perhaps early, perhaps later.

(2) Those in which the patient will spontaneously recover if properly treated. The duration of the disease, in these cases, is from two to five days.

(3) Those in which the patient can not recover spontaneously, but in which the prognosis, if operation be performed at the proper time, is very favorable.

If we exclude certain so-called "fulminating cases,"—cases which belong to the first class and which are so desperate as to justify an unquestionably bad prognosis,—there remains for consideration the large majority of patients, regarding whom the outcome may be either favorable or unfavorable. In a certain proportion of these cases it can be practically decided that perforation has occurred at the very onset of the disease. In the great majority of these cases, however, —cases in which the symptoms indicate the existence of only a moderate degree of inflammation,—the appearances are most deceptive. It is exactly in this class of cases that the inexperienced observer is apt to be deceived. Not only do we never know the exact nature of the lesion, but we never can foretell what mishap may occur. The change may take place either gradually or suddenly. The unfavorable symptoms may creep on almost imperceptibly, and the cases in which the change is of this character are apt, perhaps, to prove more serious than those in which the transition is more sudden. Such a rapid transition is generally apt to occur on the second day of the disease, although the cases differ greatly in this particular.

As already observed, the symptoms which occur when a favorable change is in progress, are in some respects similar to those which are caused by an unfavorable change. A drop in the temperature, with diminution of the pain and tenderness, may attract attention in either condition. In the one case it is a most favorable, in the other a most dangerous symptom. In the former case the diminution of fever and pain is more apt to be gradual, in the latter it is apt

to be sudden. One cannot, however, depend on these distinctions, and the other symptoms, such as distention, facies, and pulse, must be closely scrutinized. The inexperienced surgeon is often deceived by this apparent lull. The patient may himself feel better, owing to relief of tension. If the surgeon is not making frequent visits, the nurse may report improvement—"less pain; patient feels better." Many a life has been sacrificed through lack of careful and experienced observation at this critical moment. The putting off of the operation because of apparent improvement may render the prognosis absolutely unfavorable. Even for the experienced surgeon it is often most difficult, sometimes impossible, to determine on which route the disease is travelling. He may hesitate to operate in the face of apparent improvement. The report of a fall in temperature, and the patient's own feeling of improvement may cause him to question his better judgment. He may be persuaded to temporize for an hour or two, and this is especially apt to be the case if he sees the patient for the first time at this critical moment. Previous observations may have been unreliable. It is only by the most careful scrutiny of all the symptoms that he can, in this puzzling situation, arrive at a just decision. The polynuclear count will, at this juncture, be of the greatest value. A count of over eighty per cent should invariably decide the matter in favor of immediate operation.

Analysis of the Symptoms.—*Pain.*—Pain is very rarely absent. Some human beings, of course, are very insensitive to pain, and in such patients the pain may be insignificant. Its absence, however, should make us very suspicious that the disease is not appendicitis. It is generally the first symptom of which the patient complains. It is described in various terms. Generally it is more or less paroxysmal in character, due to gas passing through the cæcum, or to the peristaltic action of the inflamed appendix endeavoring to force out its contents past the inflammatory obstruction at its base. The exact location of the pain is apt, at first, to be indefinite. Some patients describe it as a general colicky abdominal pain; others call it a boring, burning, stabbing, or tearing pain; and still others describe it as a dull, sickening, depressing sensation. In about half the cases the locality in which pain is at first felt is in the middle of the abdomen, a short distance above the umbilicus. In some very acute cases, where there has occurred a sudden unexpected perforation, the pain may be at once felt in the right iliac region. Its severity varies. In about half the cases, the attack begins with severe pain; in others there is a more gradual development of pain. For the first hour or two the pain is of an ill-developed character, and it is not described as severe until after the lapse of a few hours. On an average, the severity of the pain reaches its maximum about the fifth or sixth hour of the disease. This, however, is very variable, as in some severe cases the attack begins with most severe pain. In favorable cases the severity of the pain diminishes during the second twenty-four hours of the attack. In unfavorable cases there is no such abatement, but intense pain persists, until either an abscess forms or a general peritonitis develops. Wherever primarily felt, it soon becomes localized in the right iliac fossa. Generally, in from five to eight hours the patient appreciates that he has more pain in his lower right abdomen

than at any other part. This knowledge, however, may be first derived from the fact that pressure by the examiner's finger causes local pain in this region. When pain has become localized in the right iliac region, it is apt to remain more or less confined to this area, and the general abdominal pain gradually becomes less prominent, or at all events it is overshadowed by the severity of the local pain. This latter persists until the inflammation undergoes resolution, or the appendix is removed by operation, or a general peritonitis develops. The disappearance of local pain, if accompanied by the general abdominal pain, is apt to be a very unfavorable symptom. If attended by an increase in the pulse-rate, by tympanites or abdominal rigidity, it is apt to mean the development of a general peritonitis. A recurrence of pain after its severity has diminished is also an unfavorable sign, as it means a relapse due to some serious cause, which most probably is either a perforation or a spread of the peri-appendical inflammation.

Nausea and Vomiting.—One or other of these symptoms is rarely absent in acute appendicitis. Vomiting occurs in certainly one-third of the acute cases, nausea in practically all. Nausea and vomiting generally follow the pain, but these three symptoms may appear simultaneously. If the nausea and vomiting precede the pain by many hours, the disease is probably not appendicitis. The nausea, which generally continues for hours, is apt to be of a most unsatisfactory character; the patient feeling that an attack of vomiting would be of no avail—a characteristic which distinguishes the nausea of this disease from an ordinary gastric nausea. It is also not like the nausea of sea-sickness. It seems to spring from a deeper area in the abdomen, and is apt to give the impression of a heavy sickening weight in a region just above the umbilicus. Vomiting may usher in the attack; but, on the other hand, it may not occur until some hours have elapsed. In very grave cases the vomiting may never cease; it recurs persistently, at half-hourly or hourly intervals, up to the moment of death or until relief is afforded by operation. In moderate cases, the vomiting is generally limited to the first few hours of the attack. Primary vomiting, unless in unfavorable cases, does not generally continue for more than three or four hours, though in some cases this limit may be extended. If it has once ceased, its recurrence is a most unfavorable sign. Secondary vomiting, occurring on the third or fourth day of the disease, is usually an indication that a general peritonitis is developing.

Local Tenderness.—Local tenderness is one of the most constant, as well as one of the most characteristic, symptoms. The time when it first appears varies. It may exist from the onset; and then again several hours may elapse before its existence can be verified. Its absence for the first twelve or fourteen hours deprives us of one of the most important symptoms, as without it we can rarely be absolutely sure of the correctness of our diagnosis. The degree of the tenderness varies. Most frequently it is very acute. The sensitiveness is so exquisite that even the weight of the sheet may cause pain. In other cases, especially when the appendix is deeply situated toward the pelvis, it is moderate in degree, considerable pressure being needed before the patient

complains. The area over which it is felt also varies somewhat in extent. Its point of maximum intensity, however, is nearly always at or near McBurney's point, beneath which lies the base of the appendix. In McBurney's own words, "the seat of the greatest pain, determined by the pressure of one finger, lies very exactly between an inch and a half and two inches from the anterior spinous process of the ilium, on a straight line drawn from this process to the umbilicus." At first, however, the local tenderness is apt to involve a space about equal to the palm of the hand; indeed, the surface of the entire right iliac fossa is tender, and often exquisitely so, to pressure. As the disease progresses the maximum tenderness is apt to become more confined to McBurney's point. The tenderness persists as long as the disease remains active and localized. It is one of our most valuable signs for formation of judgment as to the progress of the disease. Its persistence means continuance of the inflammation, its subsidence means either decrease of peritoneal inflammation or a general peritonitis —which one of these, it may be possible to decide from the variations in the other symptoms (the pulse, facial expression, tympanites, etc.). The point of maximum tenderness may not, however, be situated at, or indeed near, McBurney's point. This will generally denote an unusual situation of the appendix. The point may be found lower down toward Poupart's ligament, or even more internally under the lower part of the right rectus muscle. It may also be situated nearer the anterior iliac spine, or farther backward toward the loin. Occasionally it is noted on a level with the umbilicus. Should there be uncertainty as to the presence of local tenderness, further information may be obtained on noting the location of greatest pain when the patient coughs, during which act firm continuous pressure with the palms of the hands is exerted over the upper and left lower abdomen. Under these circumstances, local pain may be felt in the appendical region alone. This same localization of pain may also be confirmed by making with the hand energetic, quick palpations on the left side of the abdomen. It should also be noted that the downward pressure of the palpating finger may not be nearly as painful as the upward spring of the abdominal wall when pressure is removed.

Muscular Rigidity.—Muscular rigidity is perhaps the most characteristic symptom of peritoneal congestion and inflammation. Over an inflamed area of peritoneum the muscles are "on guard" against traumatism. There is a persistent contraction, and the slightest touch generally increases this tonic contraction. The right rectus muscle is especially sensitive, though the oblique muscles covering the inflamed area are also affected. This rigidity varies somewhat according to the extent of the inflammation and its proximity to the surface. It is less noticeable if the inflamed peritoneum is deeply situated, either toward the pelvis or toward the loin. Its development is generally coincident with local tenderness. Some hours usually elapse before its presence can be definitely recognized. Its situation gives some clue as to the location of the appendix.

Examination for Muscular Rigidity.—Examination for muscular rigidity as well as for local tenderness must be most carefully conducted. Delicacy

of touch is of essential importance. Any roughness, either of speech, manner, or touch, is often apt completely to mask this most valuable sign of diagnosis. Warm hands are a necessity. If the hands are cold, palpation should be made through a thin covering rather than on the bare skin. The examination should begin with a very gentle testing of the abdominal muscles of the entire abdomen; those of the upper area being examined first, while those of the right iliac fossa are reserved until the last. The palpation should be made by gentle touches with the soft parts of the fingers. In this attempt to determine the different degrees of muscular resistance every portion of the surface area should be subjected to examination. At the same time the patient should be reassured and he should be asked thoroughly to relax the abdominal muscles. Both recti muscles should be most carefully tested, in order to ascertain if there be more resistance to the touch on one side than on the other. If there be appendicitis, there will generally be found an appreciable increase in the resistance imparted to the finger as it gently taps the right muscle. This increase of resistance will extend outward toward the anterior iliac spine, and in certain cases even well over toward the right loin. In many cases the muscles of the entire right iliac fossa show a rigidity, while in others the resistance is limited to a smaller area; but most often it is the right rectus which responds most distinctly to the examining finger. The spot where resistance is encountered and where there is also tenderness may, however, be very small—perhaps limited to a circular spot 2 cm. (four-fifths inch) in diameter.

Fever.—Fever is a very variable and uncertain symptom. Generally there is a decided rise of temperature, which in a few hours reaches 101°, 102°, 103°, or even 104° F. The average temperature is from 101° to 103° F. This is generally reached within twelve hours of the commencement of the attack. Not infrequently, however, the rise is more gradual—perhaps 100.5° for the first twelve hours, 101° for the next, 102° for the next, and then a gradual subsidence, if the attack is passing off, or a still greater rise if the attack continues. In some cases there is but little fever, indeed much less than might be expected from the severity of the other symptoms and from the nature of the pathological changes of which these symptoms are the expression. A low temperature is not by any means always a favorable symptom; indeed, in certain cases it is most unfavorable, indicating, perhaps, a perforating appendicitis with but little active resistance on the part of the patient, and with an absence of adhesive peritoneal inflammation, without which no wall will be built up to surround the escaping toxic material. A sudden drop of temperature, after the inflammation is well established (say, on the second, third, or fourth day of the disease), unless accompanied by distinct amelioration of other symptoms, is generally most unfavorable, signifying a spread of the peritonitis. The young surgeon must not be deceived by such a drop and thus be led to conclude that it is a happy change; on the contrary, his suspicions should be at once aroused, and he should minutely examine for change in the other symptoms, such as an increased pulse-rate, abdominal distention, disappearance of local pain, etc. A rapid rise of temperature on the third or fourth day is always a threatening

sign. On these days there should be subsidence, and a contrary course generally means danger. If fever exists for a day or two before either pain or nausea appears, we should suspect some disease other than appendicitis.

Pulse.—The pulse is a more important guide than the temperature, but its rate is more important than its quality. Increase of pulse-rate, from the beginning to the end of the attack, is the rule. The increase, however, is not very great, and often it scarcely keeps pace with the temperature. In the average attack a pulse of from 90 to 100 is usual during the first day of the disease. On the second day, if the inflammation is progressive, a still further rise to some point between 100 and 115 is usual. The course of events during the next twenty-four hours generally determines the outcome of the disease, whether it is to be resolution of the inflammation, the formation of an abscess, or a general peritonitis. On the third day a pulse above 100 means a serious condition, and if it increases much beyond this height the condition becomes threatening. On the third day the pulse should decrease in frequency. If it increases beyond its second day's rate, the prospects for resolution are very unfavorable.

The character of the pulse, in the beginning of an ordinary attack, is simply feverish in quality. When there is more or less peritonitis, it is apt to assume the sharp, wiry, so-called peritoneal type. A rapid small pulse, without much elevation of temperature, is unfavorable. It is apt to mean considerable septic absorption, with, on the part of the patient, feeble resistance. Under these circumstances the differential blood-count will be of much corroborative value. When general peritonitis develops, the pulse generally ranges between 120 and 130 and soon rises to 140. A pulse of 130 means that the prognosis is decidedly desperate.

Facial Expression.—The anxious, so-called Hippocratic expression has for centuries been considered significant of peritoneal inflammation. This expression, however, is not always observed, nor is its appearance always significant of peritonitis. In many cases it is unquestionably a most valuable sign, and the general facial appearance which causes the observer to remark, "he looks very ill," is often an indication for operation. Other symptoms may be but slight, but the sick look of the patient must always be taken into consideration in one's estimation of the gravity of the case.

Blood-Count.—The number of leucocytes, and the differential count of the various cells are often important guides for an estimation of the gravity of the case. From the very beginning of the attack an increase in the number of white cells is the rule. There are, however, exceptions. In mild cases, there is generally, within a few hours from the commencement of the attack, a leucocytosis of from 10,000 to 12,000. The case may not be very severe even if the leucocytosis is 20,000. It means that there is an active inflammatory process, and that the patient is making a good resistance against its inroads. Even 30,000 white cells need not cause alarm; in fact, if other symptoms are severe, a high leucocytosis is a much more favorable sign than is a low count. This hyperleucocytosis may continue throughout the entire course of the disease. The differential count is of even more value than the leucocyte count; indeed, it is generally

wiser not to place much value on the leucocyte count unless the differential count can be obtained for comparison. When a polynuclear count gives eighty per cent and over, the chances are strongly in favor of suppuration. This is especially probable if the normal relationship between the numbers of different white cells and the percentage of the polynuclear cells is much disturbed. The normal leucocytosis varies, in adults, between 6,500 and 10,000. Any excess of this latter figure may be regarded as a hyperleucocytosis. The normal proportion of polynuclear cells varies, in adults, from sixty-five per cent to seventy-five per cent. In inflammatory conditions there should be a proportionate increase in both leucocytes and polynuclear cells. In inflammatory lesions with a favorable prognosis this relationship should be more or less definite—*i.e.*, according to rule. A digression from this rule in the way of excess of polynuclear cells beyond the standard increase in white cells (for example, eighty-two per cent polynuclear against 12,000 white cells) indicates a very septic process, with absorption and a rather feeble resistance on the part of the patient. In normal adults, the proportion of polynuclear to white cells varies somewhat, and this variation may be even proportionately greater when patients with different powers of resistance are attacked by inflammatory septic processes. Any standard must be approximately rather than absolutely correct. Dr. C. L. Gibson has devised an illustrative standard which is based on one thousand blood-examinations, made on cases with abdominal lesions. This standard is as yet tentative, but has already been of great service to surgeons.

According to this chart (Fig. 260), a "rising line" would indicate serious, and a "falling line" favorable, conditions. In children, however, reliance cannot be safely placed in blood-counts. The polynuclear percentage is apt to be low, and the leucocyte count very unreliable. In tuberculosis, also, it is apt to be variable. If, with a high polynuclear count (eighty per cent and over), there be combined a high leucocytosis (20,000 to 30,000), it is safe to infer, in a general way, that a strong resistance is being made against a severe septic infection. If, however, with a high polynuclear count, there be a low leucocyte count, the patient is in grave peril. As already stated, there are a few exceptions to these rules, and reliance should never be placed upon blood-counts alone. They must be regarded simply as corroborative of testimony furnished by other symptoms. At times, however, when these latter are uncertain, the blood evidences may be of the greatest value. The plan of treatment may, in exceptional cases, hinge entirely on the relationship between leucocytosis and polynuclear cells. If operation has been rejected or is inadvisable, the leucocyte and differential counts should be made frequently—at least twice a day—during the critical period of the disease. Blood-examinations are almost as important as temperature records. The following are examples of rather typical blood-counts:—

1. Woman, married, 23, housewife. Attack of appendicitis a few months ago. Present attack began on the day before admission to hospital. Acute onset. Patient prostrated, apathetic, very ill. Abdomen rigid over all. Shifting dulness in flanks. Temp. 102.8° F.; pulse 120; resp. 30. Leuc., 12,300; polyn. 88 per cent.

Low leucocyte count with high polynuclear percentage indicates a grave condition. Patient had a perforated appendix with acute diffuse septic peritonitis. Operation within forty-eight hours of onset of attack. Convalescence uninterrupted. Good recovery.

2. School boy of 14. Onset acute, with chills, fever, and vomiting. Prostrated, acutely ill. Abdomen rigid over all. Temp. 102° F.; pulse 104; resp. 24. Leuc. 31,200; polyn. 90 per cent. High leucocyte count and high polynuclear count indicate good resistance. Patient had a perforated appendix, with diffuse septic

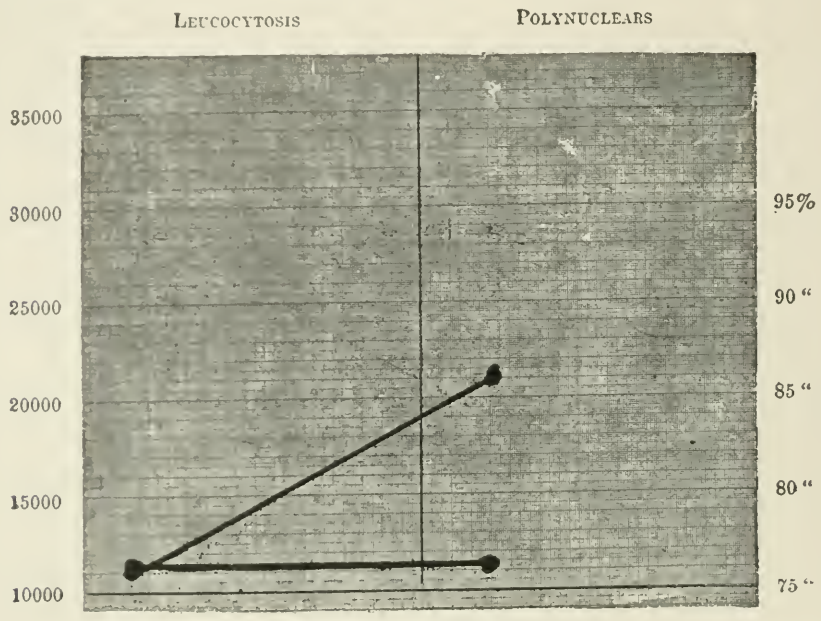

Fig. 260.—Gibson's Chart.

The chart is divided into units of one centimetre. A horizontal base-line is drawn as the starting-point of the pathological leucocytosis of ten thousand on the left-hand side, while the other or right-hand end of the base-line corresponds with the index of 75 per cent polynuclear cells, the limit more or less arbitrarily chosen. Variations in these proportions are indicated by making a dot at the proper level of the left-hand or leucocytosis side of the chart, while a similar dot at the proper level of its percentage is made on the polynuclear side of the chart. These two dots are connected by a straight line. The vertical distance between the two dots will represent the disproportion between the two counts.

For example, suppose on the left a dot indicating a leucocyte count of 11,000 and on the right a dot indicating 76 per cent polynuclear cells. The result would be indicated by a line which would be absolutely horizontal, and would be indicative of a just proportion between the two elements of the count.

If, however, with the same leucocytosis of 11,000, there were a polynuclear increase to 86 per cent, the line connecting these two points would have a steep rise from left to right, and a measurement of the vertical distance between these two points would give ten centimetres or ten units.

peritonitis. Operation within forty-eight hours of onset. Convalescence uneventful. Patient discharged cured.

3. Male, 26, peddler. Onset acute, with abdominal pain localized in right lower quadrant, and vomiting. Temp. 103.2° F.; pulse 114; resp. 28. Patient prostrated and acutely ill. Abdomen rigid below umbilicus, and there was extreme tenderness. Leuc. 28,500; polyn. 94 per cent. Operation showed the existence of an acute gangrenous appendix. Patient made an uneventful recovery and was discharged cured.

4. Male, carpenter, 22. Attack four days previously. Onset gradual, condition

growing progressively worse. Patient was prostrated; did not look very ill. Abdomen rigid and tender over McBurney's point. Temp. 99° F.; pulse 88; resp. 20. Leuc. 28,500; polyn. 94 per cent. Operation showed an acute suppurative appendix, with no free fluid. Patient made a normal recovery and was discharged cured.

5. Female, school teacher, 29. Had previous attacks of colicky pain in abdomen. Present attack was of five days' duration. Condition was slowly but steadily improving. Abdomen soft; slight tenderness and rigidity over McBurney's point. Temp. 100.5° F.; pulse 88; resp. 24. Leuc. 11,000; polyn. 85 per cent. Operation showed an acute catarrhal appendicitis which was relapsing.

Apparent exceptions to the above conclusions are shown by the two following cases:—

First case.—Maid, 22. Sudden onset on the day before she was admitted to the hospital. Vomited three times and had severe pain over McBurney's point. Walked into hospital complaining of pain in right side. Examination showed tenderness and some rigidity over McBurney's point. Temp., pulse, and resp. were normal. Leuc. 9,200; polyn. 72 per cent. Operation (thirty-six hours after onset of the attack) revealed a perforated appendix, with a considerable amount of free purulent fluid about the appendix and in the pelvis. Uneventful convalescence. Good recovery.

Second case.—Male, banker, 43, single. Attack of two days' duration. Sudden onset, with vomiting and abdominal pain. Patient prostrated and acutely ill. Abdomen distended and tympanitic over all. Leuc. 8,000; polyn. 67 per cent. Operation revealed an acute suppurative appendicitis with diffuse septic peritonitis. Patient died on the day following the operation. Low leucocyte count; low polynuclear percentage; low power of resistance.

Posture.—During the first few hours of the attack, there is often restlessness, the patient tossing about in bed. This is before the appearance of peritoneal inflammation. After a few hours, or indeed perhaps from the very beginning of the attack, the usual position adopted is the dorsal one, the patient lying perfectly flat and quiet on his back. The knees and thighs are generally flexed. He is nearly always more comfortable with the knees, especially the right one, drawn up. The greater the peritoneal involvement, the greater the tendency to assume this position, and the greater the pain caused by any bodily movement. However, there are exceptions to this rule, and certain patients are more comfortable sitting on a chair or walking about. In such cases the appendix is apt to be more deeply situated toward the right loin. Even in cases of general peritonitis, the patient may be found sitting in a chair or even walking painfully about the room.

Tumor.—In appendicitis the term "tumor" means an inflammatory mass collected around an inflamed appendix. Several hours must elapse before such an inflammatory mass can form. Before this, there may exist the sensation of a mass. If this sensation be imparted to the examining finger, it is due to the tonic spasm of the abdominal muscle which lies directly over the spot of inflammation. The muscle overlying an inflamed peritoneum acts "on guard." The portion of the muscle which responds, by tonic contraction, to the inflammation beneath it, may be of comparatively small extent, and thus gives the

impression of a distinct mass. It is generally difficult—indeed, often impossible—to distinguish such a muscle spasm from a mass of inflammatory exudate. If a tumor can be felt during the first twelve hours of the attack, it is safe to assume that it is merely a portion of muscle in a state of contraction. Indeed, it is rare for a palpable inflammatory exudate to appear within the first twenty-four hours. An inflamed appendix can, however, be recognized by palpation early in the course of the disease. To be felt by the examiner's finger, it must have a superficial situation, for, in an acute attack, deep pressure causes too much pain. Merely its tip may be felt, though occasionally its whole length can be mapped out. Under these circumstances it is, of course, thickened, stiffened, and swollen. If the acute stage persists after the expiration of twenty-four hours, an inflammatory mass will generally become palpable. It may, however, not be distinctly felt until the second or the third day. Its shape, size, and situation vary. Generally the mass is somewhat oval in shape, more or less directly under McBurney's point. If it be composed mainly of a thickened appendix and meso-appendix, it may seem about the size and shape of a man's index finger or thumb. If omentum be wrapped about it, the size may appear to be that of a hen's egg or a fat banana. Instead of being felt beneath McBurney's point, it may be situated just above Poupart's ligament, more toward the median line, under the lower part of the right rectus muscle; or it may be located farther out, above the anterior superior spine of the ilium, or still farther backward in the loin. Occasionally, also, the situation is so deep that the tumor can be felt only on rectal or vaginal examination. It is at first tender, but it may afterward lose much of its tenderness. It pursues one of two courses:—(*a*) It persists for some days, gradually becoming harder and less sensitive, and then slowly undergoes resolution. A mass of considerable size may thus, in the course of a few weeks, entirely disappear. The patient, however, in the mean time is running a great risk, for no one can know how much pus is shut up in the interior of the mass, nor at what moment it may burst through its confining walls. (*b*) Suppuration goes on. The abscess may develop with great rapidity for twelve or twenty-four hours, or a week or two may elapse before there is distinct evidence of pus. The average length of time required for the formation of pus—or at least for the formation of a quantity sufficient to be easily discoverable—is probably four or five days. An abscess of some size may develop within twelve or fifteen hours from the commencement of the attack, but generally two or three days elapse before the formation of a distinct collection of pus can be determined.

The fate of the patient, meantime, hangs in the balance. In a favorable case the omentum and intestines adhering together form a wall around the suppurating focus. This wall, however, is sometimes incomplete, and allows septic material to slip through some gap and thus infect a large area; the result of which is the formation of other abscesses, or, what is more probable, the development of a spreading peritonitis.

Abdominal Distention.—In acute appendicitis more or less tympanitic distention is present. This is due to peritoneal congestion or inflammation. It

furnishes one of our best guides for estimating the severity of the disease. The prognosis of a case in which distention is marked, is generally unfavorable. At first, the abdomen is but slightly fuller than usual, but quite soft. If the tympanites increases after the first twelve or twenty-four hours, the case is a serious one. Should the abdomen become largely distended and hard, it indicates that a considerable area of peritoneum is inflamed. It is one of our most important indications for operation. One of the most favorable symptoms is the passage of flatus from the rectum, whether spontaneously or per rectal tube. The gurgling of gas is a favorable sign; the complete absence of peristalsis an unfavorable one.

Jaundice.—Jaundice is an unfavorable symptom. It means either that the peritoneal inflammation has extended up to the gall-bladder or the gall-ducts, or that a pylephlebitis has started up, involving the portal circulation. If due to the first-mentioned cause, the jaundice may not necessarily be a very unfavorable symptom, especially if the case be one where the appendix lies high up under the liver; but, if it be due to a pylephlebitis, the prognosis is wellnigh hopeless.

Differential Diagnosis.—The diagnosis of acute appendicitis is generally attended with difficulties, but occasionally, because of some unusual position of the appendix or for other reasons, it becomes very uncertain. To differentiate appendicitis from any one, or indeed more than one, of the following diseases, is occasionally a difficult task: cholecystitis, salpingitis, extra-uterine pregnancy, renal colic, acute indigestion, gastro-enteritis, typhoid fever, pancreatitis, and diaphragmatic pleurisy.

1. *Differentiation from Cholecystitis.*—In a question of differentiation between these two conditions, the history is, of course, of great value. Many of the subjective symptoms of the two diseases are very similar—as, for example, the right-sided pain, vomiting, abdominal distention, fever, etc. The patient's description of former attacks of a similar nature may, on this account, not be of much value, unless there is a history of decided jaundice, pain in the shoulder, or local tenderness, or rigidity distinctly localized. The difference in the location of the pain, tenderness, and muscular rigidity, is usually, however, sufficiently definite to settle the question. In cholecystitis these signs are most prominent just below the free border of the ribs, at a point near the upper third of the right rectus abdominis muscle. On account of a local plastic peritonitis, however, the omentum, colon, and neighboring structures, below and around the gall-bladder, may become acutely sensitive, so that the local signs may extend well down toward the umbilical line, very much in the same area where we would expect to find them were an upturned appendix inflamed or perforated near its tip. Jaundice would of course strongly favor the diagnosis of cholecystitis, but it must not be forgotten that occasionally, in severe appendicitis, there is slight jaundice. The diagnosis must largely rest on the surgeon's skill in palpation. If an area comparatively free from tenderness or a rigidity can be demonstrated below the free border of the ribs and above the maximum area of tenderness, the inflammation probably does not involve the

gall-bladder. Accurate observation of the distress caused by deep inspiration while the palpating fingers rest on the skin over the region of the gall-bladder, will also afford valuable information. A deep inspiration under these circumstances is much more painful in cholecystitis than it would be in appendicitis. In the latter disease, the tenderness is also apt to extend more outward toward the lateral wall of the loin.

2. *Differentiation from Salpingitis or from a Pelvic Peritonitis around a Right-sided Pelvic Tumor.*—Here, again, the history of the patient is of the greatest value. An antecedent gonorrhœa, miscarriage, or pelvic inflammation will naturally turn the scale in favor of an inflammatory condition of the pelvic organs. In salpingitis the pain, sensitiveness, and rigidity are, of course, situated considerably below the anterior superior iliac spine, while an inflamed appendix may be well down in the pelvis, and not uncommonly is found adherent to a tube, ovary, or the uterus. It may even be adherent to the posterior wall of the latter organ, or to the sides of Douglas' *cul-de-sac*, or to the base of the bladder. A vaginal examination will usually clear up the difficulty. In an acute salpingitis, there is generally more or less pelvic peritonitis, and, as soon as the finger of the examiner enters the vagina, it encounters an abnormal degree of heat, and the patient complains of tenderness, which becomes very acute when the cervix or fornix is palpated. In appendicitis, on the other hand, acute sensitiveness is not generally complained of until the finger is pushed well up toward the right brim of the pelvis. In appendicitis, furthermore, abdominal palpation usually elicits more pain than does the vaginal. A bloody vaginal discharge favors the diagnosis of salpingitis. Irritability of the bladder is an unreliable symptom, as far as differentiation goes. It may exist when the inflamed appendical tip is attached to the bladder, and is of course quite common when the pelvic peritoneum is inflamed.

3. *Differentiation from Extra-uterine Pregnancy.*—The history is here of vital importance. The cessation of menstruation, the presence of signs of pregnancy, the bloody vaginal discharge, and the sudden severe pain, perhaps with pallor and collapse, are classical symptoms which denote extra-uterine fœtation and rupture. If there be felt, also, a boggy mass in Douglas' *cul-de-sac* or to the right of the uterus, the diagnosis is confirmed. Several of these symptoms, however, may be wanting, and the diagnosis must then depend on the comparative absence of local tenderness, and on the presence of an abnormal mass in the pelvis.

4. *Differentiation from Renal Calculus.*—The history of the patient is of value under these circumstances. Previous attacks of severe colicky pain, radiating from the loin down the course of the ureter, toward the bladder, with perhaps frequency of urination, pain in the head of the penis, and retraction of the right testicle, would seem to indicate clearly the passage of a stone or other foreign body down the ureter; yet it must not be forgotten that both conditions may exist simultaneously. The careful examination of the urine should never be neglected. Should there be blood and uric-acid crystals, the presumption is strongly in favor of calculus or gravel. If pus also be found,

it is still more confirmatory of irritation of the pelvis of the kidney by some foreign body. The location of the tenderness elicited by palpation also differs. In inflammatory conditions of the kidney there is apt to be a decided spot of tenderness in the loin (Guyon's point), at a spot nearer the spinal column than would probably be found in the case of an inflamed appendix which was bent decidedly upward and backward—the examination of the blood would also here prove of value. The number of leucocytes is generally greater in appendicitis. The pulse-rate is too varying to be of much value, and the same remark applies to the temperature. The latter, however, is more apt to be elevated in appendicitis, while the pulse-rate is generally slower than in a severe attack of renal colic. While abdominal distention is also found in attacks of renal colic, this symptom is apt to be more marked in cases of appendicitis.

5. *Differentiation from Pancreatitis.*—The difficulty of differentiating appendicitis from this rare affection is apt to be greatest in the subacute or chronic attacks of either of these two diseases. It is true, however, that a sudden perforation of an appendix into the general peritoneal cavity, with accompanying peritoneal shock, may give symptoms similar to those expected in an acute attack of pancreatitis. The signs of collapse—the rapid pulse; the pale, anxious countenance; the cold, clammy skin;—the abdominal distention; the sighing respiration,—all these may be present in both diseases. Under such conditions the diagnosis is wellnigh impossible. Pancreatitis is a rare disease, it is not apt to occur in children or young adults, and it is more prevalent among fat females. These facts should enter into our calculation. In pancreatitis the pain and local tenderness are situated at a higher point than would be expected in appendicitis. By bimanual examination (one hand pressing up the loin against the other hand in front) the mass of clotted blood can sometimes be recognized. This semisolid substance, however, might be confused with the exudate around an upturned appendix.

6. *Differentiation from Typhoid Fever.*—It is sometimes difficult to distinguish a mild attack of appendicitis from enteric fever. In the latter, tenderness in the right iliac fossa is not uncommon. It is, however, not acute, and is more apt to be diffuse and less localized. The history of headache and hebetude, with coated tongue, decidedly favors the diagnosis of typhoid fever. If fever has existed for some time previous to the pain, the case is probably not one of appendicitis. Nausea and vomiting are not apt to occur with typhoid fever. Abdominal distention may be present in either disease. Pulse and temperature can be disregarded. The leucocyte count is apt to be greater in appendicitis than in typhoid fever. Of course, if the Widal reaction is found, the diagnosis is practically settled; but this reaction is usually not present until the fever is well advanced. It must also be borne in mind that appendicitis sometimes complicates typhoid fever.

7. *Differentiation from Diaphragmatic Pleurisy.*—It is sometimes exceedingly difficult to distinguish between an acute appendicitis and an acute diaphragmatic pleurisy, or even a basal pneumonia. The sudden painful onset with vomiting, the inability to take a deep inspiration, and even a certain amount

of tenderness and muscular rigidity in the right hypochondriac region, are symptoms common to both diseases. It is especially in children that the diagnosis is most difficult. In a diaphragmatic pleurisy many hours may elapse before any abnormal physical sounds can be heard. To arrive, in certain cases, at a correct diagnosis, hours of observation may be necessary. These doubtful cases are among the most puzzling which the surgeon encounters. He knows that delay, should the case be one of appendicitis, may be most dangerous, and yet he dreads lest, if he do a laparotomy, he may find his diagnosis incorrect. This error has been committed many times by experienced surgeons. Much will depend on the surgeon's keenness of observation. He may notice a certain fixation of the lower ribs, or a stoppage, at this point, of the respiratory movements. If the patient be a child, he will probably be very restless and will toss about the bed more than he would were his appendix inflamed; but, even in appendicitis, the child is more apt to be restless than is the adult. If the child be inclined to assume the usual adult dorsal position, with the thigh or thighs drawn up, the chances are in favor of appendicitis. The passive flexion and extension of the thigh on the abdomen are apt to be more resisted and dreaded in appendicitis than they would be in pleurisy.

8. *Differentiation from Acute Indigestion.*—For a few hours the symptoms in acute indigestion may be not unlike those which occur at the onset of appendicitis. Pain and vomiting may be equally marked in each disease. With acute indigestion, however, there should be no local tenderness, no muscular rigidity, nor any changes in the blood. There is generally also no fever with this disorder. In acute indigestion the symptoms should begin to abate in the course of a few hours, while in appendicitis they should increase progressively.

9. *Differentiation from Gastro-Enteritis.*—The onsets of gastro-enteritis and of acute appendicitis may be very similar. The pain in gastro-enteritis, however, should not be as severe, neither should it persist for so long a time as would be expected in appendicitis. Fever may be present in both affections. There is an absence of local tenderness and muscular rigidity in gastro-enteritis, although, if the catarrhal inflammation be largely confined to the large intestine, there may be local tenderness over the cæcum and also over the course of the colon. In appendicitis diarrhœa is unusual, and mucus should not be found in the stools.

10. *Differentiation from Intestinal Obstruction.*—Intestinal obstruction may be due to bands, knots, twists, extensive plastic adhesions, hernia, intussusception, abnormal conditions of Meckel's diverticulum, etc. In obstruction, the local tenderness is generally less localized than it is in appendicitis. The pain, furthermore, is of a more colicky, spasmodic type; the wave of peristalsis can often be both felt and seen to cease at some definite point; certain distended coils can be mapped out, both by palpation and by sight; the vomiting is more persistent and more violent; the pulse is apt to be faster and the temperature lower; indican is generally found in abundance in the urine; the blood changes are less marked; and, finally, the vomiting soon becomes foul-smelling, and later fæcal.

11. *Differentiation from a Gastric or Intestinal Ulceration.*—A gastric or an intestinal ulceration, with approaching or complete perforation, may produce symptoms resembling those of appendicitis. The location of the pain and tenderness are the two most important differentiating symptoms. The history of the patient should be carefully reviewed. Vomiting may or may not be a prominent symptom in gastric perforations, but in intestinal perforations it is unexpected, unless a general peritonitis has developed. In perforations such as we are now considering there is apt to be less elevation of temperature.

12. *Differentiation from Tuberculous Peritonitis.*—Tuberculous peritonitis, if localized in the right iliac fossa, is most apt, in the male, to originate from a tuberculous appendicitis; while, in the female, it originates more often in a tuberculous salpingitis. The area of local tenderness is apt to be more extensive and the sensitiveness is less acute. Vomiting is seldom a symptom. The history of the patient is of great importance. If the case be of a subacute character, the reaction to tuberculin may be tried.

13. *Differentiation from Lead Colic.*—The history, the blue line in the gums, the absence of local pain, tenderness, and fever, the diffusiveness of the colic, are symptoms which are generally so marked as to render the diagnosis of lead colic comparatively simple.

V. SYMPTOMS, COURSE OF THE DISEASE, AND DIAGNOSIS OF CHRONIC APPENDICITIS.

The symptoms of chronic appendicitis are very similar to those of the acute form of the disease, but they are, of course, much milder in degree. Fever, however, is generally absent, and all the symptoms are very variable and much less persistent. There may be intervals of comparative freedom from even discomfort, and then again at times the discomfort may be very pronounced and considerable pain may be experienced. When this characteristic of subsidence and recurrence is prominent, the terms "relapsing" or "recurrent" are employed. There are many intermediate grades between acute and chronic appendicitis, and the relapses are apt to assume a subacute character; the appendix, in the interval, remaining in a state of chronic inflammation.

The symptoms may be described as local and general.

Local Symptoms.—*Localized Pain.*—Localized pain, or a feeling more often described as discomfort, is an almost invariable symptom of chronic appendicitis. It is more or less confined to the right iliac fossa, and is seldom described as severe. It is rather an indefinite ache or soreness, and is apt to be increased when the bowels are distended with gas. The patient is aware that he possesses a right side. He may feel that the gas sticks in his right iliac region and produces colicky pain in that part of the abdomen; or he may describe the colic as having become more or less general. Oftentimes he will press his hand against the right lower abdomen to diminish the discomfort. He fears the jolting caused by rides over rough roads or by sudden jars. He may explain

his symptoms by saying that he has a "bruised muscle," or he may call it "a stitch in his side." For intervals of weeks there may be freedom from even discomfort, and then again for weeks the miserable ache will persist. It is generally increased by indiscretions in diet or by exposure to cold. The patient, of his own accord, learns to diet himself. He soon becomes aware that certain articles of food will increase his discomfort.

Localized Tenderness.—At one time or another localized tenderness can generally be discovered. A number of examinations may, however, be necessary for its elicitation, and it may be entirely overlooked by the careless or hasty examiner. Sometimes pressure must be very deeply made before the patient complains. The tenderness can sometimes be discovered only when, during the continuance of the deep pressure, the thigh is energetically flexed and extended on the abdomen, thus making tense the psoas muscle. The tenderness may be confined to the immediate neighborhood of McBurney's point, or it may be more or less appreciable over the entire iliac area. For weeks or months one may fail to elicit this sign, and then, owing to the occurrence of an increased congestion of the appendix, the local spot of tenderness may be distinctly recognized for several successive days.

Muscular Resistance.—Muscular resistance is apt to be rather an elusive symptom, but, at one time or another in the course of the disease, a sensitive examining finger can generally appreciate a difference in tension between the right and the left rectus muscles. If the appendix be deeply situated, either toward the pelvis or toward the loin, this sign may be absent.

It must not be forgotten that, in certain cases of chronic appendicitis, local symptoms are practically absent. It must also be borne in mind that, in young healthy males, the iliac fossæ are very sensitive to pressure. The possibility of so-called appendicito-phobia must also be considered. Because of the fact that there have been numerous cases of appendicitis among the members of his own family or among his friends, perhaps with disastrous results, the patient acquires such a dread of the disease that imaginary pain and tenderness in the right iliac region may develop. It is important, in such patients, that during the examination their attention should be diverted.

General Symptoms.—The general symptoms are mainly connected with the gastro-intestinal tract. Some form of digestive disturbance practically always accompanies chronic appendicitis. On careful examination of the patient's history, it will often be learned that, on one or more previous occasions, there had been acute attacks of what at the time was considered "biliousness," or "intestinal indigestion." On careful inquiry as to the particulars of these attacks, it will often be learned that pain was a very prominent symptom, and that the vomiting continued for a longer time than would be expected, had the attack been either acute indigestion or biliousness. A history of "bilious attacks," especially in children, should always be carefully investigated, and special inquiry should be made as to the amount of pain suffered. Apart from these attacks, the digestion may have remained unimpaired. Sooner or later, however, a period arrives when the digestion, instead of returning to its normal

condition after such an attack, becomes chronically deranged. This derangement is generally of the intestinal form. Constipation is apt to be a pronounced and troublesome symptom. Flatulency is complained of; the abdomen becomes bloated after any indiscretion in diet. Attacks of colic are frequent, and there is sometimes diarrhœa. It is often difficult to determine whether the colic and flatulent dyspepsia be due to chronic appendicitis, to a chronic catarrhal enteritis, or to nervous dyspepsia. The history of the patient should be most carefully scrutinized. The presence of mucus in the stools certainly indicates the existence of a catarrh of the bowels, but this may have largely disappeared, while the appendix, on account of its lack of free drainage, may remain in a state of chronic inflammation. In other patients, it may be evident that they are suffering from both enteritis and appendicitis. The enteritis, in all of these cases, is probably curable; the reverse is true of the appendicitis. Operation should be advised in these cases, and it will often be found that the constipation, diarrhœa, or the various symptoms of nervous dyspepsia will entirely disappear soon after the removal of the appendix; a chronic dyspeptic will often be entirely restored to health. While constipation is the rule, there are nevertheless cases in which the appendicitis is the cause of an intractable mild diarrhœa. A constipation that persists after a "bilious attack," especially if accompanied by colicky pain, should always be regarded with suspicion.

Instead of the intestinal form of indigestion, the stomach may be the organ most affected. Persistent nausea may be the chief complaint. The tongue may remain coated and the breath foul. Vertigo and hiccough are unusual symptoms of chronic appendicitis.

The Onset.—The mode of onset is variable. The chronic form may result from an acute or a subacute attack; the symptoms of the latter almost, but not entirely, subsiding, while at the same time there are left an indefinite ache in the right iliac region, and some intestinal indigestion. On the other hand, the disease may develop very insidiously, the symptoms creeping on so that the patient is scarcely aware at what time his complaints began. He has merely noticed an almost imperceptible drift toward chronic intestinal indigestion, and, for weeks or months, he persists in attributing the discomfort which he experiences to this cause, until his attention is drawn to the preponderance of discomfort in the right side. The disease may go on for months or years. Between the exacerbations there may be intervals that last for weeks or months or even for years. The exacerbations are very variable in severity and may last for only a few hours, or they may continue for several weeks. The irregularity of the symptoms may be very great, or there may be but little difference from one week to another, the discomfort and flatulency being more or less constant.

The constant digestive disturbances, with a more or less persistent, nagging ache; the mental strain caused by the ever-present dread of an acute attack; and perhaps the anxiety caused by doubt as to the exact diagnosis, will often exert a deteriorating influence on the patient's general health, resulting in loss of flesh and strength, and in more or less demoralization of the nervous system.

Fever and rapidity of pulse are generally absent. During the exacerbations, however, there may be a slight febrile movement. The temperature, in these cases, should always be tested in the rectum.

Diagnosis.—The diagnosis of chronic appendicitis is often very difficult. It is especially difficult at times to differentiate it from the following diseases:—movable kidney; cholelithiasis; chronic intestinal indigestion; and chronic pancreatitis. A patient will often complain of a more or less indefinite discomfort in the right side of the abdomen. A slight tenderness may exist over an area extending from the free border of the ribs almost to Poupart's ligament, and in a backward direction as far as to the loin. This may be accompanied by digestive disturbances, colic, flatulency, etc. It is often exceedingly difficult, and occasionally impossible, to determine the exact cause of this right-sided discomfort. The patient's history must be carefully studied. Have there been marked exacerbations in the course of the disease? Did the physician in attendance make a careful examination, and was he able to locate the maximum point of tenderness? Has there been irritability of the bladder or any great variation in the amount of urine passed? This latter sign may indicate an intermittent hydronephrosis, due generally to mobility of the kidney.

Careful palpation for tenderness and muscular rigidity will generally, if repeated on several occasions, lead to a correct diagnosis. It is desirable to examine the patient during the attacks of exacerbation, if such occur. The maximum point of tenderness may then be found in one of three places—over the gall-bladder, over the appendix, or over the kidney. Jaundice is, of course, a most valuable sign, as it indicates a probable cholecystitis, as does also pain in the region of the right shoulder blade. Probably the most puzzling problem will be to distinguish between a movable kidney and an appendicitis. The former condition may often be found, as it is common in long-waisted, thin, lax women. But, merely because the kidney is distinctly movable, we must not conclude that the mobility of this organ is the cause of the soreness and discomfort. It may be quite innocent. If, when grasped between the two hands, the kidney gives no sign of excessive tenderness, we must feel sceptical as to its being the exciting cause, even if it be freely movable. If, however, when it gets dislodged and remains more or less impacted opposite or below the umbilicus, we find that pressure causes pain, then we should feel inclined to place the blame on the kidney.

Pancreatitis is a rare disease. In its chronic form it can very seldom be recognized. The pain and tenderness accompanying this disease should be located at a rather higher point in the abdomen, more in the umbilical line, than when the appendix is the seat of inflammation. The pain should also be more acute and paroxysmal in character. From chronic intestinal indigestion appendicitis can be distinguished mainly by the history, by the localization of the pain and the tenderness, and by the patient's greater indifference to careful dieting.

VI. TREATMENT OF APPENDICITIS.

A. Treatment of Acute Appendicitis.

The treatment of appendicitis is essentially surgical. This does not necessarily mean operative interference in every case, but it means that the patient, from the onset of the disease to its close, should be under the observation of one who is accustomed to study, on the operating-table, the treacherous behavior of an inflamed appendix. Not only is it important for the diagnosis, and for the decision as to the proper moment for operation, that the surgeon should be summoned at the commencement of the attack, but also, in the event that immediate operation is not necessary, that he may be in a position to advise as to the future conduct of the case. It is very foolish for any young surgeon, or any medical man, to manage a case of appendicitis (unless it be one of necessity) without the summoning of council. Should the result be unfavorable, he will subject himself to severe and perhaps justifiable criticism. The treatment should be varied according to the stage of the disease and according to the peculiarities of each individual case. Rules can be given, but it must be understood that there are exceptions to all these rules. Could the different stages of the disease be definitely recognized, the rules could be made much more precise. Unfortunately, the transition from one stage to another is often so subtle that the change cannot be recognized. In certain severe cases of perforation or sudden gangrene, there is no subtlety; the condition is unmistakable. But, in the majority of cases, the average cases, the change from the early to the later stage may be so undemonstrative as to escape observation. In the early stage the inflammation is confined to the appendix. Generally, the mucous and submucous coats alone are involved; for, as soon as the serous coat becomes infiltrated with inflammatory cells, the attack has reached the borderland between the early stage and the later or second stage. When the products of the septic inflammation have passed beyond the appendix, and have excited a local or a spreading peritonitis, or a septic infiltration of the neighboring cellular tissue, the attack is in the second stage. The indications for treatment of these two stages are not the same. The rules for treatment of the early stage are more definite than can be those for the second stage.

Treatment of the First or Earlier Stage of Appendicitis.—The "early stage" of appendicitis is a rather loose term. It really means that the inflammation is entirely confined to the appendix, that none of the appendical contents have escaped, and that there is no peritonitis or septic process beyond the appendix. In certain cases there is practically no early stage. A sudden perforation or gangrene is the announcement of the disease. In other cases, the disease never passes beyond the early stage, the inflammation involving the inner coats only of the appendix. Between these two extremes are found, perhaps, the majority of cases. In these, however, the early stage is very variable. An average duration is perhaps twenty-four hours, but often it is much shorter, and again it may be considerably longer. There is generally no exact

moment of transition from the early to the so-called later stage. A sudden, unguarded perforation will often announce its occurrence by marked symptoms, but more often there is a gradual spread of the inflammation and sepsis from the inner coats of the appendix outward, and to the neighboring tissues. When either of these events occurs, the disease may be said to have passed beyond the early stage. A case may for days linger along without passing beyond this stage. On the third, fourth, fifth, sixth, or even a later day, the conditions may be unchanged; in other words, they are exactly as one would find them in other cases at the end of a few hours after the onset of the attack. In this class of cases, where the symptoms "hang fire" after the third day, and show no progressive improvement, the removal of the appendix is indicated in preference to waiting for an interval operation. If, even in the mildest attack, there be no distinct change for the better during the third day of the disease, the outlook for the complete subsidence of the attack is not promising, and there is risk in delaying operation.

In the early stage of acute appendicitis operation is undoubtedly the wisest form of treatment. This should be the general rule, and there is no doubt but that, in the hands of skilful surgeons, the universal application of this rule gives the most favorable results. There are, however, exceptions to this rule. There may be certain conditions of the patient, certain peculiarities of the attack, or certain obstacles in the surroundings, which contra-indicate immediate operation. The great majority of surgeons have enthusiastically adopted this rule of universal operation in the early stages of the disease, and no inexperienced physician or surgeon should take upon himself, alone, the responsibility of rejection or of postponement of an operation. It is only the wise and experienced surgeon who has the slightest right to decide whether or not the operation may, in certain cases, be postponed, and even he, if he assumes this position, will, sooner or later, find himself mistaken, and will deeply regret his supposed conservatism. If the young physician or surgeon does not, in a doubtful case, demand a consultation, he will run the risk of subjecting himself to just blame, should the case result unfavorably. On the part of the physician or surgeon who first sees the case, there should be a distinct enunciation of the fact that operation is the safest treatment, and that there is risk in delay. If the patient and friends decide to reject his proposition, the responsibility rests with them, and they should be made to understand this fact clearly. Appendicitis is a most treacherous disease, and no rules can be given which will enable the observer to determine, at the outset of the disease, that its course is to be mild and to terminate in recovery. It can often be foretold that a general peritonitis will certainly ensue, but never that it will not develop. An operation in the interval between attacks is of course to be preferred to one performed during an acute attack, and it is on this account that the surgeon feels tempted to postpone operative interference; he cherishes the hope that the acute attack will disappear in the course of a week or two, and that then, at the later date, the appendix can be more safely removed during the so-called "cold stage." It is undoubtedly true that a large number, probably the majority, of cases of

acute appendicitis will successfully pass through the acute stage of the disease to complete recovery from the attack. Knowing this to be a fact, the surgeon is sometimes tempted—but only, it is true, in cases which are more or less subacute in character, where there is no vomiting, where the pulse is good, where there is no abdominal distention, and where there is only moderately pronounced evidence of inflammatory trouble in the right iliac fossa—to adopt dilatory tactics, in the hope that a spontaneous cure will take place. Out of such a clear sky, however, there may at any moment come a dangerous explosion, which completely clouds the prospects of further abatement,—in fact, may lead to a fatal outcome. This is true even in cases where the inflammation, so far as symptoms indicate, is apparently very mild and gives every evidence of an early subsidence. Fears may be lulled by the apparent insignificance of the symptoms. These, however, do not always properly represent the extent or severity of the inflammation. There may be an absence of vomiting, fever, and distention,—in brief, the signs of peritoneal involvement may be insignificant; and yet in the depths of the iliac fossa there may be an appendix all ready to undergo perforation, or perhaps an abscess formed around an appendix which is already perforated. It is apt to be the man of small experience and little wisdom who feels confident that he can guide the patient over such treacherous seas into a safe haven. The surgeon of wide experience may take chances with such cases, and, with careful observation, he may guide the patient to recovery, but it is a risky procedure, and sooner or later an unexpected peritonitis will cause him to regret his course in certain cases. Then, again, the patient's relatives and friends may object so strongly that the surgeon is prevailed upon to postpone operation. He should, however, state his opinion frankly, and then, if it be rejected, the responsibility will rest on other shoulders. Under these circumstances it will be his duty to watch the progress of the case closely, not allowing many hours to intervene between his visits, so that he may be ready once more to urge immediate interference, should more threatening symptoms develop.

As already stated, there are exceptions to the general rule of "invariable operation in the early stages of an acute appendicitis." Such exceptions may be due to the miserable condition of the patient, to the character of the attack, or to certain conditions in the circumstances or surroundings of the patient.

(1) The miserable condition of the patient.—The miserable condition of the patient may be due to some complicating disease, such as advanced tuberculosis, cancer, grave heart lesions, severe nephritis, or impaired arteries. Each case of this kind must be judged on its own merits. Which procedure offers the least risk to a patient who is in such a deteriorated condition? On the one hand, there are a half-hour's anæsthesia and an abdominal section; on the other, there is an appendix liable to excite a general fatal peritonitis. The risk of an operation on a patient suffering from any one of the above diseases may be attended by such danger that it often appears less risky to place faith in the spontaneous subsidence of the inflammation. In a case of cancer or tuberculosis it is well to consult the wishes of the patient or his family. State

the case frankly and let them share the responsibility of the decision. In the case of a patient with heart disease, the question of cardiac compensation has to be carefully weighed. A lack of proper compensation should rather influence the surgeon to avoid, if possible, the operation. If compensation is satisfactory, the dangers of anæsthesia are but slightly increased. In a case of nephritis, the anæsthesia may exert an injurious effect on the kidneys, and such cases are more liable to develop peritonitis. The dangers must be weighed, one course against the other. Age, pecuniary requirements, family history, personal history—all these must be taken into consideration in seeking a decision as to the best course to pursue.

(2) The character of the attack.—If an adult is suddenly overwhelmed at the outset of the attack, the prognosis under any method of treatment is most unfavorable. The symptoms are: the collapsed appearance of the patient, the rapid wiry pulse, the extremely anxious countenance, the cold extremities, and the distended abdomen—all of them due to grave peritoneal shock, caused by the escape and absorption of virulent germs or material from the appendix. If the operation be performed while the patient is in this state, it will almost certainly prove fatal, and will but hasten the end. Under such circumstances, a delay of some hours will often result in a slight but distinct improvement of the patient's condition. Nature's forces, which at first were staggered by the suddenness of the attack, will often become better organized for resistance. The leucocytes, at first rather low in number, rapidly increase to 30,000 or 40,000; some flatus may be expelled, the abdomen in consequence becoming less tense; the pulse loses some of its wiry character; and the patient's whole condition becomes less distressing. This favorable change is due to a general decrease of the congestion (inflammation) of the peritoneum, and also in some measure to the fact that the inflammation shows a tendency to localize itself about the appendix. Nature is doing her best to wall in the inflamed organ. The most constant and careful observation is necessary at this time in order to determine whether Nature is to be successful or not in this attempt, and also in order that the surgeon may decide when the time of selection arrives for interference. If the general symptoms gradually subside, and if at the same time a local exudate manifests itself, the operation may be postponed from hour to hour; and, if the course of the disease continues to be favorable, two or three days may with advantage be allowed to elapse before one decides that the most favorable moment for operation has arrived. By this time there will be found a perforated and perhaps gangrenous appendix, shut off from the general cavity of the peritoneum by a thick wall of inflammatory material. Drainage, unfortunately, will be necessary, but the risk attending such an operation is but slight; whereas, if it had been done in the beginning of the attack, the danger would have been very great, and drainage even then could not have been omitted. Unfortunately, the disease does not always follow this favorable course, and in children or young adults the plan of treatment just suggested should not be attempted, but in older or dissipated patients it certainly offers a better chance for recovery than does immediate operation.

During this critical period of the disease the treatment should be carried out very strictly, and the patient should be kept constantly under observation. Rest and absolute starvation are the keystones of treatment.

(3) Conditions in the circumstances or surroundings of the patient which make it preferable, even at some risk, to postpone operation.—In many cases it is manifest that the operation is of such vital importance that it must overshadow all other circumstances; but in certain cases where the attack is mild, and especially if it be a repetition of others of a similar character, the risk of postponement is not great,—provided, of course, that the medical man in attendance be an experienced observer. The mere fact that, in past years, many similar attacks have subsided spontaneously is no guarantee that the present attack will have such a successful outcome. The chances favor such a course, but, as a rule, the risk of assuming that it will be followed in this particular attack is considerable. Very probably the final outcome of the case will be complete recovery and an obliterated appendix, but in the mean time, the patient will be hanging on the verge of a precipice. The removal of the appendix during such a mild attack is practically an interval operation. Probably no drainage will be needed, and it will be not only a life-saving, but a time-saving procedure. In advising removal of the appendix in the beginning of the mild attacks, where naturally there may be some doubt as to the absolute necessity of an operation, the probability of later attacks should be borne in mind. A recurrence of the disease takes place in about seventy-five per cent of the cases. The patient's realization of this fact and of the advisability of a later interval operation will make a strong impression upon his mind in favor of the immediate removal of the appendix. In some cases he will simply need to be assured that the risk attending the operation is but slight and that in all probability no drainage will be needed.

In cases where, for one reason or another, operation in the early stage is not performed, the treatment should be carried out in the strictest manner. The same rule applies also to cases where for a time a definite diagnosis cannot be made. Skill and experience are needed quite as much under these circumstances as they would be were the operation to be performed. The treatment should consist largely in non-interference. Absolute rest of body and mind is most important. In fact, the patient must be kept in bed, lying in whatever position will be most comfortable. Nature and not the doctor should dictate this. The dorsal position will generally be preferred. If the symptoms look threatening, it is best to elevate the head of the bed moderately (ten or fifteen inches). This degree of elevation, which is usually agreeable to the patient, tends to confine the inflammatory process to the pelvis and lower abdomen. Starvation must be absolute. If the patient be kept quiet and if he be permitted to drink a moderate amount of water, starvation for three, four, or five days is borne without discomfort. Water, at first allowed in small amounts, may later be given freely. Should there be nausea and vomiting, however, water should be sparingly given. Small saline enemata (six to eight ounces) should be employed, if water cannot be freely administered. These should be

repeated every six to eight hours. Absolutely nothing but water should be permitted until the symptoms have markedly subsided. Soups, as well as tea, coffee, albumen water, and especially fruit juices, should be positively prohibited. The one object of treatment is to quiet intestinal peristalsis, and any solid, salty, acid, or aromatic substances defeat this endeavor.

Internal Medication.—If possible, no drugs should be administered for the relief of severe pain. It is a fact, however, that one is generally compelled to give a small hypodermic of codeine (gr. $\frac{1}{2}$) or of morphine (gr. $\frac{1}{8}$). The former should be first tried. Morphine is distinctly objectionable; but, if peristalsis is very vigorous or restlessness very great, its use may be indicated. No more, however, should be given than is just sufficient to quiet the intestinal movements. A benumbing dose of opium or its derivatives is absolutely contraindicated. It is objectionable for the following reasons: first, because it masks the symptoms, thus rendering diagnosis difficult. It is apt, for example, to abolish local tenderness and muscular rigidity, and it also prevents the observer from properly estimating the progress of the inflammation. In the second place, it is apt to produce paresis of the intestines and thus to encourage abdominal distention.

If the stomach is overloaded with undigested food, it is often advisable to wash it out by lavage. This should be done as gently as possible.

Cathartics, as a rule, are objectionable. There can be no doubt but that a sharp purge, *at the very commencement*, may often be of marked benefit, but, on the other hand, it may also result disastrously. It is never known which one of these results will ensue. Certainly, many a patient has been killed by an initiatory dose of castor oil or calomel. The violent peristalsis thus excited may be the last straw to cause a complete and rapid perforation. The perforation, perhaps, could not have been prevented, but, if the intestines had been kept quiet, the rupture would probably have been anticipated, and some protection would have been provided against the approaching perforation. Of course, the bowels are often overloaded, and it would certainly be of advantage to unload them; and unquestionably, by good fortune, this is often accomplished without disaster and with advantage to the patient. In a well-marked case of "catarrhal appendicitis" there is no danger; indeed, there is a positive advantage in administering a cathartic dose. But, as already stated, no man can be sure that he has to deal with a purely catarrhal inflammation, and the uncertainty and risk are entirely too great to warrant, except in rare cases, the employment of catharsis. If the rectum be overloaded, a small soapsuds enema may be administered; but it is seldom needed, for, if saline enemata are regularly given, Nature will almost invariably within twenty-four or thirty-six hours, herself unload the bowel.

Local Applications.—Shall ice-water or hot-water bags be employed? One or other is advisable. Some measure of relief will be afforded the patient and satisfaction will be given to the family. Ice is generally preferable. It seems to have some slight effect in mitigating the inflammation around the appendix, and certainly affords some relief from pain. Occasionally hot applications are

preferable. If ice gives pain it should not be employed. In any event it should be cautiously employed; it should not be allowed to cause freezing of the skin. If the area treated be kept extremely cold for a long time, sensation is more or less lost, and the surgeon is deprived of the valuable signs of local pain and tenderness. If the ice bag be employed continuously for many hours, care also should be taken that it shall not produce gangrene of the skin. If there be much general colicky pain hot-water bags and even turpentine stupes may be advantageously employed. Great confidence, however, should not be placed in the benefit to be derived from any form of local application.

Treatment of the Second or Later Stage of Appendicitis.—When the inflammation has involved the serous coat of the appendix, and is extending beyond the organ, the second or later stage may be said to have begun. As already stated, it is often impossible to tell at what exact moment this extension occurs. When, however, there are increasing abdominal distention and an increase of muscular tension in the right iliac fossa, and especially when secondary belching of gas or vomiting begins, we know that the inflammation is no longer confined to the appendix, but that the neighboring coils of intestines have become involved in peritoneal inflammation, or that a septic process is spreading in the cellular tissue. When such symptoms appear, there is always a great regret that operation had not been performed in the earlier stage of the disease. The case at once assumes a grave aspect. The mortality of the operation will now be raised from perhaps ten per cent to a percentage eight or ten times as great. The questions then arise, Will better results be obtained if operation be postponed until the disease has re-localized itself in the right iliac fossa? and What are the chances for such a localization? Opinions on these subjects are divided. They may be classed in three divisions. The great majority of surgeons are not willing to adopt a universal rule for the treatment of cases which are in the dangerous stage of the disease. Each case must be a rule unto itself. There are, however, many advocates, some of them very enthusiastic, of each one of the three following principles of treatment:—

1. Operation should be performed on practically all cases of this class.—This is the treatment adopted by the majority of surgeons. The operative mortality will be somewhere between eight per cent and ten per cent. In the practice of some surgeons, this percentage may be lowered, and in that of others it is perhaps considerably higher. Certainly, on theoretical and perhaps on practical grounds, this plan of treatment is the best. The septic inflammation has already extended beyond the appendix, and a spreading peritonitis has begun or is threatened. What will stop this spread? Will the forces of Nature call a halt? If so, how often will such a happy result occur? How can one foretell such a fortunate course? These are some of the questions which naturally suggest themselves. That the peritonitis and sepsis often spread and become universal, every surgeon, unfortunately, knows. He sees these hopeless cases so often that he dreads a moment's delay. He claims that a peritonitis limited to the lower right quadrant, or one involving even as much as half of the abdomen, can be more successfully combated by operation than one

which has become universal. There can be no question as to the justice of this claim. It is difficult to explain why the spread should not continue; and certainly no one can tell why in one case it becomes localized while in another it becomes general. There are no statistics of the slightest value as to the proportion of cases in which the process localizes itself. It seems most reasonable to block the spreading by an operation. The results of such a plan of treatment are much superior to those which follow the plan of postponing operation in the hope of localization. This, at least, is the opinion of the majority of surgeons.

2. The same plan of treatment should not be adopted for all such cases.—A selection should be made, some cases being chosen for immediate operation, while in others the question of operation is held in abeyance until the process shall have localized itself in the right iliac fossa. Among operators it has for years been a conviction that the mortality of operations performed on or about the third day of the disease is very great. It is most often about this time that the inflammation begins to spread, and the mortality of operations performed at the moment when this spreading process first begins is, certainly, very great. The operation is especially dangerous in those patients who have reached or passed middle age, or who have led dissipated lives, or who have bad livers or kidneys. It is agreed that in this class of cases it is much wiser to wait for localization of the process, and it is believed that this localization will, under proper treatment, frequently follow, and that the older the patient, the greater the probability that it will occur. Results have shown that such a postponement, in the class of patients mentioned, will give better results than the plan of immediate operation. This, at least, is the argument presented by many wise surgeons. They do not feel, however, that delay is justifiable in children or healthy young adults, in whom the risk of universal spreading of the inflammation (peritonitis) is much greater, while at the same time the risks of operation are much smaller. Between these two extremes are many intermediate cases, and it will be in the treatment of them that the wisdom of the surgeon will be shown. In many cases where the patient is young or middle-aged, the decision in each instance must be left to the individual surgeon. His decision should be based largely on his own experience. He should generally allow for a few hours' observation, with careful relative blood examinations, before he arrives at a decision. The symptoms which point to a localization of the process are: absence or decrease of stomach regurgitation, softening of the abdomen in conjunction with the passage of flatus, and the general improvement in appearance and disposition of the patient.

3. Immediate operation should not be performed, but the patient should be carefully carried along, under continuous observation, to a stage where the general symptoms will have subsided, and where a localized abscess will have formed around the diseased appendix. This event may occur on the fourth, fifth, sixth, or even a later day. A. J. Ochsner has been the prime advocate of this plan of treatment, and he has many followers. There is no question but that his views have modified the opinion of most surgeons in regard to universal

operation on patients in this stage of the disease. The advocates of this plan of treatment claim that their mortality has been reduced from eight, nine, or ten per cent to five or six per cent, by the adoption of this method. The strictest treatment, however, is necessary for successful results. The starvation must be *absolute*. The reason why so many patients come to the surgeon almost dead from a general peritonitis is that the treatment has not been thoroughly carried out. Cathartics have been administered, or the patient has been given fluid or solid nourishment, either of which measures will certainly defeat the beneficial effects of this plan of treatment. The intestines must be kept at rest. Morphine is objectionable, but small hypodermic injections of codeine may be advisable. If there be much vomiting the stomach should be washed out. This must be done very gently, the patient resting on the right side. The gastric lavage may be repeated every few hours if vomiting persists. Under this plan of treatment, the symptoms will often improve, the abdomen will become softer, flatus may be expelled, and the general rigidity and tenderness will gradually diminish. At the same time a mass will begin to appear in the right iliac fossa. This will probably be rather hard and not specially tender. It will probably enlarge slowly, in rare cases it may entirely disappear, but generally fluctuation develops in the course of a few days. At the same time, the temperature curve will assume a more distinctly septic character, with an evening elevation. As soon as the mass is distinctly felt, it can be reasonably assumed that the risk of general peritonitis is practically over. The surgeon need, therefore, not be in great haste to open the abscess. As long as the general symptoms continue to improve, the delay of a day or two, after recognition of the mass, may often be an advantage, in allowing the general congestion or inflammation to subside, and in more strongly shutting off the general cavity of the peritoneum from the localized process. It is of the utmost importance, during this period prior to operation, that most careful and frequent observation be practised, and that irritation of the digestive tract be carefully avoided. In order to prevent too active peristaltic movements or colic, the nourishment should be confined to liquids of the simplest character. Water only should be allowed as long as there remains any symptom of general congestion or inflammation of the peritoneum. Generally this restriction will be necessary for forty-eight hours or longer. Then, for another day or two, simple clear broths may be allowed. As a rule, it is wiser—for adults, at least—to abstain from milk. Milk in any form is more liable to excite the development of gas, and to act as a slight irritant. In infants and young children, however, it may be employed. Fruit juices should be especially avoided.

Treatment of the Suppurative Stage.—As soon as it is determined that suppuration has developed, the abscess should be opened at as early a date as possible. By abscess is meant a localized collection of pus. There may be a distinct tumor, which occasionally will give a wave of fluctuation, but more often the mass feels quite hard. This lack of softness and fluctuation is explained by the fact that generally a thick wall of inflammatory material encloses

the pus. The situation of the abscess varies. Often it will be felt lying more or less under McBurney's point, though it is liable to extend farther downward toward Poupart's ligament. In about fifteen per cent of the cases its situation will be toward the loin, above the crest of the ilium. Not infrequently, it will be directly under the lower third of the right rectus muscle. Occasionally its situation is deep in the pelvis, where it can be felt only on rectal or vaginal examination. In a certain number of cases no tumor can be felt. There may even be an absence of rigidity or of marked tenderness. The diagnosis of suppuration must rest upon the other symptoms—the presence of an evening rise in temperature, the more rapid pulse, the furred tongue, and the results of the blood-count. There is apt to be persistent tenderness, especially if deep palpation be made. The patient does not get well, he remains ill and feels very miserable. It is seldom that the existence of secondary abscesses can be exactly diagnosed. They may be suspected, because of different areas of tenderness, of bowel stagnation with distention, and of increased sepsis without peritonitic symptoms.

As a rule, the sooner an abscess is drained, the better the chance for recovery. As a rule, also, the formation of an abscess indicates neglect or poor judgment on the part of somebody. There are exceptions, however, to both of these generalizations. As already explained, there may be patients in whom, as a result of a more or less diffused peritonitis, the process tends to localize itself. When first the mass is recognized, the diffuse peritonitis may not have entirely disappeared, and at the same time the process of localization may not yet be complete. Under these circumstances, it may be beneficial to delay the operation a few hours or even days, as such a delay permits the general inflammation to subside, the localizing wall to become more secure, and the local septic focus to become less virulent. During this period of delay it is of the utmost importance that the closest watch be kept for the development of dangerous symptoms. It may also be wise to delay operation in those cases which have a very stormy onset, even where it is known that there is a perforated or gangrenous appendix. Under these conditions some hours are needed by Nature's forces in order that they may array themselves in the best possible order for the fight. If immediate operation be performed the additional strain of the operation and the exposure of new surfaces to absorption may turn the scale in favor of the invading poison rather than in favor of the patient. Under all other circumstances, when the abscess is completely localized its immediate opening is indicated. This is performed through one of the incisions whose description follows. When the pus has been freely evacuated, the question will then present itself: Shall the appendix always be removed? Generally, yes; always, no—is the answer. In the practice of the writer it has been found wiser, in about one per cent of his operations in suppurative cases, not to attempt the removal of the appendix at the primary operation. There are two different conditions of the diseased area which render it safer not to disturb the parts. (*a*) In the first place, the organ may be so buried in lymph, especially in long-standing cases, as to render its recognition most difficult.

To remove it under the circumstances would lay bare new areas over which the pus would flow, and as a result there would be a local and perhaps a general severe infection. If an inflammatory process has been piling layer after layer of new material around the cæcum and diseased appendix, the solid mass may reach the size of a man's fist, or even that of a cocoa-nut. To dig into this mass, when it is almost impossible to recognize the various structures, is a difficult and sometimes hazardous procedure. There is risk, not only of spreading infection, but also of injuring the different mesenteries to such an extent that the vitality of some part of the intestine will be imperilled. It is true that, in cases in which the banking up of inflammatory material has been going on for weeks, the pus has generally lost much of its virulence and consequently the danger of fresh absorption is slight; but there is much danger of damage to the peritoneal coat of the cæcum or adherent small intestine. As a result of such injury a slough in the wall of the intestine may follow, thus giving rise to a fæcal fistula.

(*b*) In cases where there is an extensive collection of virulent pus, enclosed by a rather delicate wall of adherent intestines and mesentery, it is sometimes wiser not to injure the barrier and hunt for the appendix. If it is readily seen and can be easily removed, it is nearly always wiser to do the complete operation; but, if its discovery involves exposure of fresh surfaces, the hunt should be postponed until a later period. The virulency of the pus must be decided by the symptoms of septic absorption—the fever, dry tongue, etc. When the sepsis is marked, the less the amount of injury done at the time of operation, the better are the chances for recovery. In these gravely septic patients it is not permissible to do more than to open the abscess and to supply adequate drainage. Celerity and gentleness are the keynotes of the successful operation in these patients.

The Operation.—The preparation of the room should be in accordance with the rules given on page 143, Vol. IV. An overhead light (skylight) is of the greatest advantage.

The Preparation of the Intestinal Tract.—In anticipation of any abdominal operation it is of great importance that the intestinal tract be as empty as possible. This emptiness applies to both fæces and flatus. The latter is of almost as much importance as the former. If a patient's habits are good, it is well not to alter them radically. In an attack of acute appendicitis no attention, beyond absolute starvation, should be given to the preparation of the intestinal tract. Any stimulation of peristalsis is generally objectionable. A small enema is alone permissible. Even this is often inadvisable in acute cases. In subacute cases, however, it may be indicated if the rectum is overloaded. In chronic appendicitis the intestinal tract can generally be thoroughly prepared for the operation. Light and easily digested food should be ordered for two or three days prior to the operation. During these days the bowels should be gently but freely moved, if necessary, by the use of mild cathartics. If the tongue is habitually clean and the bowels are regular, no strong cathartic is needed; but, if constipation be a habit and if the liver be sluggish, a brisk

cathartic (such as calomel, pil. cath. co., licorice powder, etc.) should be taken four hours prior to operation. On the afternoon or evening preceding the operation, a mild but effectual laxative should be taken. In addition, enemata may be needed. Any irritation, however, of the bowels, by the use of drastic cathartics or by frequent or irritating enemata, is to be avoided, as such measures are apt to increase the intestinal gases. Solid food should not be taken during the twelve hours prior to operation, but the patient should be encouraged to drink water freely, and a cup of clear broth is often advisable during this last preparatory period.

Preparation of the Skin.—The preparation of the skin may be accomplished largely before the patient reaches the operating-room, or it may be reserved until after anæsthesia is complete. Whatever method be adopted, it must be carried out thoroughly and it must be of such a nature as not to produce irritation. Any method which causes irritation sufficient to produce blisters, vesicles, or pustules, is distinctly bad. Great care should be taken to avoid this if green-soap poultices are used. The details of cleansing the skin have been fully discussed in another part of this work. (Vol. IV., article by Dr. George Ben Johnston on "Preparations for an Operation.")

The Employment of an Anæsthetic.—As a rule, a general anæsthetic should be administered. Whether this shall be gas combined with ether, pure chloroform, chloroform combined with oxygen, or pure ether, will depend on the surgeon's preference for one or other of these anæsthetics. Whether or not an anticipatory hypodermic injection of morphine be given, will also depend on the individual surgeon. Local anæsthesia by means of hypodermic injections of cocaine, eucaine, or stovaine, is rarely indicated. The operation can, unquestionably, often be performed under local anæsthesia, but all these drugs possess certain poisonous properties which are apt to upset the patient's functions quite as much as does a general anæsthetic, and moreover the nervous strain to which the conscious patient is subjected during the half-hour's operation, has a very decided depressing influence on the average American. It is very questionable whether the shock from local anæsthesia is not greater than that caused by a well-administered general anæsthetic. Spinal anæsthesia, with stovaine or possibly magnesium sulphate, is in rare cases permissible, but it should be employed in exceptional cases only—cases, for example, in which the condition of the lungs or kidneys seems absolutely to contra-indicate chloroform or ether.

The Incision.—On account of the varying positions of the appendix the surgeon should not be wedded to any one incision. In a general way, the attitude of the appendix is as follows:—

Downward and inward	22 per cent.	Outward	1 per cent.
Downward	12 per cent.	Downward and outward	0.5 per cent.
Inward	7 per cent.	In the pelvis	1.5 per cent.
Upward and inward	29 per cent.	Retrocæcal	19 per cent.
Upward and outward	8 per cent.		

The best incision is one

(*a*) which gives the readiest access to the appendix, especially to its base;
(*b*) which divides and injures the fewest muscle fibres;
(*c*) which divides and injures the fewest nerves;
(*d*) which affords the best opportunity for drainage; and
(*e*) which affords the greatest security against hernia.

No one special incision is suitable for all cases. An incision which is good for the average case, may be a poor one for some special cases. The surgeon will do better work through an incision which he has been in the habit of making, than through one with which he has had little experience. The best incisions are those which avoid division of the inner layer of the abdominal muscles. These muscles should be either split by blunt dissection or temporarily displaced. The most popular and most advantageous incisions are:

1. The McBurney or gridiron or intermuscular incision.
2. The Kammerer or Battle incision.

It is understood, of course, that a direct incision in an oblique direction through all layers of the abdominal muscles may, in exceptional cases, be advisable, but for an experienced or skilful surgeon this necessity rarely arises. With such an incision, when drainage is not required, the result will be fairly good; but, if drainage be employed, there is a considerable liability of hernia. Some surgeons still employ the old incision at the outer border of the rectus muscle, but in cases where drainage is needed, there is danger of future hernia. A better incision is one which splits in a vertical direction the right rectus muscle; but even this does not give the strongest protection against hernia. Such an incision, however, is very convenient in cases where there is a question of diagnosis between a cholecystitis and an appendicitis, or perhaps a pancreatitis. A short incision of this character can be first made at a compromise point, and then, when the exact diagnosis has been made, it can readily be extended upward or downward according to circumstances. There are other useful incisions, but, practically, they are but modifications of those already mentioned. In the large majority of cases of appendicitis, whether acute, subacute, or chronic, the choice should lie between the McBurney and the Kammerer incisions. They, undoubtedly, best fulfil the qualifications already mentioned. The choice will depend on the individual operator. One surgeon will do better work through the McBurney and another through the Kammerer incision. (See page 123 *et seq.*)

For the young or inexperienced operator the incision at the outer edge of, or through, the right rectus muscle, is perhaps the safest. He will be able more easily to recognize and handle the various structures. The incision which ranks next, so far as readiness of view and ease of access are concerned, is the Kammerer. This can be made as extensive as necessary, whereas, if the McBurney incision be employed, there are limitations to its length; and yet, even with this incision, if the sheath of the rectus muscle be opened, a large exposure can be obtained. For the inexperienced, the Kammerer incision is the easier and safer of the two. It is also to be preferred when one is dealing with a certain group of cases—cases where the diagnosis is uncertain. For

example, where there is doubt as to whether an appendicitis or a pyosalpinx will be found, the Kammerer incision affords an admirable exposure of both these conditions. In the opinion of many surgeons, however, the McBurney incision is considered the better one for the usual case of appendicitis. The closure of the wound can certainly be made very perfect, and, in case of drainage, there is probably the smallest chance for the development of hernia. Perhaps, however, more skill and delicacy of touch are needed than is the case when the Kammerer incision is employed.

Which incision is the favorite? It is difficult to answer this question. In our Eastern States the McBurney is perhaps the most popular. In the Western States it does not appear to enjoy the same popularity. In Europe many surgeons are still clinging to the incision at the outer edge of, or through, the right rectus muscle.

The length of the incision varies according to the judgment or skill of the individual operator. The main requirement is that the incision shall be sufficiently long to enable the surgeon safely to manipulate the different tissues. The inexperienced operator, other qualities being equal, needs a longer incision than does the experienced. The beginner should never handicap himself with a short incision. One operator, with a two-inch incision, will perform equally as good an operation as will another with a three-inch or even a four-inch incision. On the other hand, the incision should never be made unnecessarily long. This is especially true at the beginning of the operation. An incision of moderate length (say, two inches) should first be made. If this prove insufficient, it can be lengthened, and—more than this—its enlargement can be made in the direction where it is most needed. An appendix, or at least a part of the organ, may be situated at some distance from the normal position. If a long incision has been made, according to rule it may have to be still further lengthened, in order to bring the pelvis or loin within reach; and it will only then be seen that an inch or more at the other end might have been omitted. Of course, the advantages of a long incision are evident. The whole operative field lies exposed under the eyes of the surgeon. He is not hampered by working through a narrow opening. He can see the various steps of his operation. He can utilize both sight and touch for the recognition of different tissues or structures. He can more easily guard against the escape of pus, and, should there be deep hemorrhage, he can more easily secure the bleeding vessels. The disadvantages of the long incision are the unnecessary division of nerves and cutting of muscle fibres. The nerve injury is of great importance, so far as the strength of the abdominal wall is concerned. That part of a muscle which is deprived of its nerve supply is apt to atrophy, and there results a weakened and thinned aponeurosis, or a flabby muscle—conditions which allow either a bulging outward of that portion of the abdominal wall or the formation of a true hernia. Either of these results is a source of great discomfort to the patient, and is apt to reflect discredit on the surgeon. The cosmetic result is also not to be disregarded. Some patients, especially females, are very particular in this respect, and they are very apt to select the surgeon who has the

reputation of performing appendicectomy through a small incision. To prevent unnecessary disfigurement, the incision in the skin should never be longer than that through the muscles. The plates in books, describing operations, necessarily show the skin incision longer than the opening through the muscles. This, however, is for illustrative purposes only. The length of the incision in acute appendicitis should vary from two to four inches. A slight extension in either direction beyond these limits may be advisable. In thin patients the incision does not need to be as long as is required in cases where there is much adipose tissue in the abdominal wall. An appendix that projects itself forward can be removed through a shorter incision than is required for an appendix which occupies a post-cæcal position. An appendix which lies external to the cæcum can also be removed through a shorter incision than is required for an appendix which lies far down in the pelvis, or far backward and upward toward the loin. The length of incision required in interval operations should vary from one and a half to three inches. Slight abridgments or extensions of these limits may be advisable, according to the length, position, or adherence of the appendix. If there be a long appendix, stretching up five or six inches beyond the cæcum, and adherent throughout its entire length, it may be necessary to extend the incision farther upward and outward toward the loin. In moderately lean patients the primary incision should, as a rule, be not longer than two inches. Later, this can be lengthened, if necessary, in either direction.

McBurney's Operation.—McBurney's operation is also called the intermuscular or gridiron operation. The skin incision, which varies in length from one to three inches, is oblique, and "crosses a line drawn from the anterior iliac spine to the umbilicus, nearly at right angles, about one inch from the iliac spine, and is so situated that its upper third lies above that line." Such is McBurney's original direction. The exact location must, however, be somewhat varied according to the position of the appendix. It is often advisable to place it a half-inch or so nearer the median line, and entirely below the imaginary line from the spine to the umbilicus. On the other hand, it may be wise to start the incision well above the iliac spine. An incision corresponding in length and direction should then be made in the aponeurosis of the external oblique muscle, including some of the muscle fibres. If possible, this muscle should be divided by blunt dissection, rather than cut. The retraction of the edges of this gap exposes the internal oblique muscle, whose fibres run almost at right angles to the cut or gap in the external muscle. By blunt separation of the fibres of the internal oblique and transversalis muscles, a gap is made corresponding in length to the opening in the external oblique, but at right angles to it. This separation of the fibres can be made by the thin handle of the scalpel, the closed scissors, or a periosteal elevator. It is only in very exceptional cases that any cutting is needed. The edges of the internal oblique having been retracted, the transversalis fascia is exposed and divided, and finally the section of the peritoneum is made in the same direction. Should more operating space be required toward the median line, the sheath of the rectus muscle can be cut for a half-inch or more. This will make it possible to

draw the rectus muscle inward, and thus ample room will be secured for the most complicated operation, provided the appendix be not situated toward the loin. In the latter case the split in the muscle can be continued upward and backward to an extent sufficient to meet almost any peculiarities of the case. The wound is closed by a continuous catgut suture of the peritoneum and transversalis fascia. The separated fibres of the internal oblique muscle are then allowed to return to their natural position. They do this promptly, and in such a perfect manner that it may be difficult to recognize where the split occurred. It is better, however, not to trust to this mere approximation of the edges, but to secure their close apposition by one or two catgut stitches, which, however, are to be tied so loosely that they cannot destroy, by strangulation, any of the muscle fibres. The edges of the divided sheath of the muscle should be approximated with special care. The edges of the external oblique aponeurosis should then be held in apposition by either continuous or interrupted sutures of whatever material the operator prefers.

The Kammerer-Battle Incision.—The Kammerer-Battle incision, which is vertical, varies from two to four inches in length, and runs an inch or so internally to the right semilunar line. (See Plate L.) It extends no deeper than through the skin and lays bare the sheath of the rectus muscle, which is divided near its transverse centre, to a length corresponding to that of the skin incision. The rectus muscle is now pulled inward and strongly retracted toward the median line. The posterior sheath of the rectus and the transversalis fascia are then divided exactly opposite the line along which the anterior sheath of the muscle is divided. The peritoneum is opened in the same vertical direction. The deep epigastric artery and vein are often seen, but they should be retracted downward and not divided. The wound is closed by a continuous catgut suture that includes the peritoneum, the transversalis fascia, and the posterior sheath of the rectus. The latter muscle is then allowed to fall back into place, completely covering the line of suture. If the retraction has rendered the muscle lax, so that it does not incline to remain in place, a single light catgut stitch may be inserted. The anterior sheath of the rectus is then sutured with interrupted or continuous sutures of plain or chromicized catgut, according to the choice of the operator.

There are various other incisions which bear the names of specific surgeons. Such are, for example, the Fowler, the Sonnenberg, the Boux, the Morris, and others still; but all are practically but slight modifications of one or other of the two incisions already described, or of the straight incision along the right semilunar line.

If the incision has been wisely located the cæcum will generally be seen, when the peritoneum is opened, lying directly beneath the wound. Sometimes, however, a coil of the small intestine will be found overlapping the cæcum. When this occurs the intestine must be pushed gently toward the median line by some blunt instrument or by a soft sponge or a pad of gauze. In cases of general enteroptosis, the ascending colon may be the part of the bowel first seen.

If this be so, it should be gently manipulated upward toward its proper position. Sometimes the right lower corner of the omentum may rest across the cæcum, and when this condition exists the omentum must be pushed to one side.

Adherent Omentum.—In cases where there has been considerable inflammation around the appendix, the omentum may be found adherent to the cæcum or to the wall or floor of the right pelvis. When this condition exists the omentum must be cautiously loosened from its connections, great care being taken that pus, which has been confined by the adhesions, may not be unexpectedly released. If the peritoneum be fastened to a hard inflammatory mass, the surrounding region should be protected by strips or pads of gauze, and sponges on holders should be held in readiness to absorb any escaping pus. As a rule, the omentum can be safely loosened without fear of bleeding. After it has been separated from its attachments, however, there will generally be a few bleeding points which require ligation. If the loosened edge is much thickened, and especially if it has been fastened to the wall of an abscess, it is wiser to amputate well beyond the thickened portion. If it be but a thin, ribbon-like process, without much fat, one ligature (best of catgut) may suffice, but often the organ must be divided, for purposes of safe ligation, into three or four portions. Great care should be taken in doing this, as serious hemorrhages from ligated omental stumps have occasionally occurred. After ligation, the omental stumps can be left lying outside the abdomen, covered by a hot wet towel, until the close of the operation, or they may be at once returned and pressed out of the operative field by gauze compresses.

The Search for the Appendix.—Occasionally no search is necessary, some part (generally the tip of the organ) presenting itself as soon as the peritoneum is divided. Its mesentery can then be grasped in an artery forceps and the whole organ be gradually and gently drawn up through the wound. In acute cases, however, even when the appendix is clearly seen, it is better to protect the surrounding regions with gauze, in case of an unexpected rupture occurring during the act of extraction. Before the organ can be completely extracted, it may be necessary to ligate and divide its mesentery. It is seldom, however, that the appendix can be so easily identified; indeed, in the majority of cases, patience and skill are needed in the search. Occasionally, the difficulty of recognizing the organ is very great, and much time may be expended before it can be discovered. It is best first to exhaust the sense of sight. By drawing the edges of the wound in different directions, and at the same time gently manipulating the cæcum with a pad of gauze, one can often recognize some portion of the appendix. This should at once be seized by the fingers. When the appendix is not quickly recognized, the index finger should be inserted and should be made to explore in all directions in the hope that it may discover an inflammatory mass or abscess. If a mass of any size should be discovered, it is wise, before beginning an investigation of its nature and relations, to surround it completely with gauze. A cautious separation of the component parts of the mass will probably reveal the appendix. During this investigation great care should be taken to catch in sponges or gauze pads any escaping

septic material. The component parts of the mass can be separated, the one from the other, by the fingers, by gauze sponges, or by the closed scissors. When neither the appendix nor an inflammatory mass can be readily seen or felt, it is best, in acute cases, slightly to enlarge the wound, so that a wider view of the cæcal region may be obtained. In chronic cases, this is generally unnecessary, for a sensitive finger should nearly always recognize the appendix, even if it lie deeply in the pelvis or behind the cæcum. In the tactile search the index finger should at once be carried downward toward the pelvis, and then, skirting the right pelvic wall, it should cautiously feel its way upward to the base of the cæcum. During this manœuvre some part of the appendix can often be felt. If the effort fails, the finger may then be carried, first around the external and then around the internal wall of the cæcum. If the finger fails to identify the appendix, either below, externally, or internally, it may then be assumed that this structure probably lies beyond the cæcum. It must then be gradually raised up, so that its posterior surface may be carefully inspected or palpated. When there is difficulty in finding the appendix, it must be borne in mind that the longitudinal bands converge to form its wall. By following the anterior band, the base of the appendix should be reached. This rule is often of great service; but, unfortunately, in the most difficult cases the appendix is so much displaced and there is so much new inflammatory tissue that the rule is not always practically serviceable.

Delivery of the Appendix.—When any portion of the appendix has been recognized, it is generally not difficult to trace the proximal and distal portions. In acute cases the entire organ should be surrounded by gauze, so as, in the event of a rupture of its walls, to prevent escape of its contents. In chronic cases no such precaution is necessary. If the appendix be non-adherent, its mesentery should be seized near the tip, in an artery forceps, and drawn up as far as possible through the wound. The appendix itself should never be grasped by clamps or forceps, as such seizure may tear its coats, and allow of leakage. If it is but slightly adherent, the finger or a gauze pad can be made gently to separate the adhesions. If the base of the appendix has been first discovered, it may be necessary to pull upward, by gentle manipulation with the fingers or a gauze pad, the remainder of the organ. If it be very adherent, the course just suggested may be found inadvisable, and, instead of beginning the separation of its mesentery near the tip, one may more easily effect its detachment by beginning near the base, a series of artery clamps being applied, one after the other, to the bleeding vessels. The final separation of the appendix from its mesentery can be accomplished by a single ligature applied in such a manner as to include the entire breadth of the mesentery. It is often preferable, however, and sometimes quite important, to clamp the blood-vessels separately, the necessary number of artery forceps thus being employed to control the mesenteric hemorrhage. If the appendix be more or less non-adherent, the identification of the blood-vessels is easy; if it be adherent, it may be necessary to divide the thickened and shortened meso-appendix before clamping the vessels. But, if these can be identified and if there be sufficient

room, it is better carefully to catch each vessel and to divide the mesentery, step by step, until the appendix hangs free. Occasionally, it may be so intimately adherent to the cæcal wall, and so plastered to it by lymph, that its recognition is very difficult. Under such circumstances considerable gentle tearing of the adhesions or the enveloping sheet of peritoneum may be necessary before the organ can be enucleated. In cases where it lies high up behind the cæcum, the mesentery may be entirely absent, and under such circumstances the enveloping sheet of peritoneum must be divided and the appendix freed. When a mesentery is lacking, and where repeated attacks have produced much inflammatory exudate, a long search may be necessary before the organ can be identified and removed. This concealment may prove very troublesome, not only when the appendix lies behind the cæcum, but also when it is tucked in between the ileum and the cæcum, or indeed when it occupies almost any position, provided it is plastered closely against the cæcum, beneath layers of either fresh or old inflammatory exudate. In certain cases the appendix may be so adherent to adjacent tissues that it must be enucleated from its peritoneal coat, the latter being in whole or in part left behind, in the position in which it was found firmly adherent to neighboring structures. The organ will then be delivered without its serous coat. While such a course is not necessary, it is sometimes much wiser to resort to this manœuvre than to attempt to dig out its peritoneal covering, as this may be so intimately adherent to the cæcum, ileum, or some other portion of the intestine, that there will be danger of tearing the bowel wall or of so impairing its vitality that a fæcal fistula may later result.

Amputation of the Appendix.—The appendix should be separated from its mesentery down to its very base. All bleeding vessels in the latter should first have been secured. If clamps have been employed for this purpose, the ligation may be done at once or postponed till after the amputation of the appendix. There are numerous methods of treating the stump. The surgeon who is accustomed to one good method, and is satisfied with it, will probably get better results if he generally confines himself to this and does not try new and uncertain methods. No one method, however, can be indicated as suitable for all cases. The surgeon should be familiar with the technique of at least two methods.

(*a*) Amputation of the Appendix by Means of the Ligature and Cautery.—The appendix being held up, a catgut ligature (No. 1 is best) is tied around its base close to its origin from the cæcum. The ends left long are held by an assistant. A piece of gauze is spread over the cæcum: it completely surrounds the base of the appendix below the ligature. The appendix is clamped a half-inch or so above the ligature. It is then divided by scissors or the cautery. If scissors be used, they must immediately be cast aside as unclean. The stump now projects about a quarter of an inch above the ligature. This stump is slowly cauterized until only a very thin layer of burnt tissue projects above the ligature. It is often wise then to tie the base with another ligature in the same groove as the first, and to touch the charred stump a second time with the black cautery, which should be allowed to cool gradually. For cauterization of the stump, white or red heat should never be employed. For the

safe adoption of this method the point should be at black heat. It will be seen, upon examination of the parts, how but a tiny layer of charred tissue lies above the ligature. Instead of the heat cautery, some surgeons use carbolic acid for cauterization. To the writer this method seems inferior.

(*b*) Amputation of the Appendix by Means of the Purse-string Suture and Inversion.—The base of the appendix can be surrounded by a very fine catgut ligature or compressed between the blades of an artery clamp. A purse-string suture is next inserted in the serous coat of the cæcum, around the base of the appendix, and perhaps a third of an inch beyond it. The appendix is then cut or tied off, leakage from its distal point being prevented by the pressure of a clamp. About a quarter of an inch of stump should remain. This is held by an assistant in the grasp of one or two anatomical forceps, and, as he inverts the stump, the purse-string suture is tied, a minute dimple alone being seen afterward in the outer wall of the cæcum. One or two Lembert sutures, to pucker up the serous coat still further, may be then inserted if desired.

During the inversion process there is also a possibility of leakage if the stump has not been temporarily closed by pressure of a forceps. If the technique has been properly executed, no such accidents are possible, but there have been several cases of fatal hemorrhage from stumps treated in this manner. If the ligature and cautery method is improperly carried out, leakage may also occur from the stump, either from slipping of the ligature or from too deep cauterization. Such accidents, however, should never happen.

(*c*) Amputation of the Appendix by the Cuff Method.—A circular incision through the peritoneal coat alone of the appendix is made at a point about half an inch above its base. The cuff of serous membrane is then dissected down to the very base. Inside the cuff, and around the appendical base (minus its peritoneal coat), is tied a fine catgut ligature. Above this ligature the appendix (mucous and muscular coats) is then divided, leakage being prevented in the manner already described. The cuff is then tied or sutured over the stump, and, if desired, an additional Lembert suture may be employed.

It is difficult to express a decided opinion as to which of these methods is generally the best. The surgeon should be familiar with all of them. There are still other methods of treating the stump—as, for example, that of Dr. Deaver, who cuts off the appendix "flush with the cæcum" and then immediately closes the opening in the cæcum by two rows of sutures—the first row including the serous, muscular, and submucous coats, the second one (Lembert) the serous coat only. The two methods, however, which seem the simplest and safest are the two first described, viz., the ligature and cautery method, and the purse-string and inversion method. There is considerable difference of opinion as to which of the two is to be preferred. Theoretically, the first-mentioned is supposed to be unscientific, as it leaves a small surface uncovered by peritoneum, and possibly some protruding mucous membrane. The results, however, have been so satisfactory that many surgeons still prefer it to any other, and the results which they obtain are certainly unsurpassed. A perfectly smooth cicatrix results. The cauterization must, however, be carried out most carefully

and thoroughly. It is not suitable for cases where the appendix has a very flaring base (so-called oblique origin). The purse-string suture is in such cases more appropriate. On theoretical grounds, it is certainly the most perfect method, and the practical results have been excellent. Its dangers are: the unduly deep insertion of the needle, as it is passed in making the purse-string suture, and possibly the leakage from a blood-vessel or the wounding of such a vessel.

The Operation in Suppurative Appendicitis.—Some one of the incisions already described should be selected, and the location of the abscess should determine where it is to be made. So far as the operation is concerned, appendical abscesses should be divided into two classes: those which are adherent and those which are non-adherent to the abdominal wall.

(*a*) Adherent Abscesses.—Careful palpation, aided perhaps by percussion, will generally determine to which particular part of the painful peritoneum the abscess wall adheres. An appropriate incision should be made directly over the adherent area. The peritoneum will be found much thickened, and a considerable thickness also of inflammatory exudate, which forms the wall of the abscess, must often be perforated before pus is reached. Entrance to the abscess should be made most cautiously, for fear of wounding an adherent coil of intestine. This procedure is carried out without entering the general peritoneal cavity. The opening should be at first very small, so that any sudden gush of pus may be avoided, as the collapse of the walls of the abscess following such a gush might result in their separation from the parietal peritoneum, and possibly also in the escape of pus in this direction. The pus should be carefully caught on sponges or gauze pads. Occasionally the tension is so great that the purulent fluid may spurt out through the small opening with considerable force. After the abscess has been slowly and cautiously emptied, the opening in its wall may be enlarged and the cavity carefully sponged dry. Search is then made for the appendix. If any part of it can be seen or felt, it should be removed. If it can not be discovered, it is often best to desist from the attempt to remove it. This can be more safely accomplished at a later date, —say, in from two to four weeks,—when at the same time the abdominal muscles can be completely sutured. Irrigation of the cavity is inadvisable, as leakage into the general cavity of the peritoneum and infection may result. The abscess cavity, however, should be carefully sponged dry. In all cases drainage of the abscess cavity is advisable. For this purpose a medium-sized perforated rubber drainage tube is generally best. Two may be needed. If the cavity be very large, and especially if the appendix has not been removed, some loose packing with gauze is often of advantage. Should a fæcal fistula develop, this packing will protect the neighborhood. If the abscess has a deep location toward the loin, a counter-opening just above the crest of the ilium, near or a little back of its middle line, is often of great advantage, and may ward off the development of a secondary abscess in this region. In females, if the abscess be situated deep in the pelvis, a counter-opening through the vagina will often prove of service. The amputation of the appendix is sometimes attended

with considerable difficulty. The base of the appendix, down to its cæcal attachment, may be partially or completely gangrenous, and even the cæcal wall for some further distance may be very friable. A brittle layer of lymph, perhaps in a sloughing condition, covers the area about the appendical base. The tissues are so friable that sutures tear out. No stump can be formed. The opening in the cæcal wall left by removal of the appendix may be difficult to reach. The edges are not only friable but may be very much thickened. No rules can be given for the closure of these troublesome openings. Lembert sutures of catgut should be employed to bring together, as closely as possible, the serous surfaces. Layers of poorly nourished lymph may, however, interfere with satisfactory approximation. The adjoining tissues (mesenteries, omentum, the epiploic appendices, and the layers of lymph) may be utilized to aid in strengthening and reinforcing the suture line. If, in the event of the appendix not being removed, it is planned to do so at a later date, there is not much need for suturing the wound unless it be very extensive. A loose gauze packing, and perhaps partial approximation of the edges of the wound with a loose stitch, will suffice to restrain the intestines. If, however, the appendix has been removed, as much of the abdominal wound should be closed by suture as is considered safe by the surgeon. Generally, it can be closed quite tightly around the drainage tube. One or two provisional sutures of silk may be inserted through skin and external oblique muscle, but they should be left untied. The subsequent local treatment must vary somewhat according to the amount and virulence of the discharge. Generally, forty-eight hours can safely elapse before the dressing will have to be changed. By that time, if the discharge is moderate in amount, the tube may sometimes be entirely removed, and in its place a thin wick of gauze, that reaches down just through the abdominal wall, may be inserted. Generally, however, the discharge is so free that early removal of the tube is inadmissible. The wound should then be irrigated with normal salt solution, and the tube should, perhaps, be slightly shortened. This process should be repeated daily, the tube being shortened as rapidly as possible. If gauze has been inserted, unless the discharge is very abundant, it will adhere so closely that considerable pain will be caused by its removal. It is generally better to leave it undisturbed for about four days, and even then it may be necessary to administer gas for its extraction. When the tube or the original gauze strip has been removed, one or both of the (?) cæcal sutures may be tied and the wound completely closed, with the exception of a small crack, through which a tiny sliver of gauze or rubber tissue may be inserted.

(*b*) Non-adherent Abscesses.—The general peritoneal cavity is entered as soon as the peritoneum is incised. The abscess may be situated not far from the abdominal wall, or it may be deep down toward the pelvis or the loin. The adjacent, and perhaps overlapping, intestinal coils should be gently pushed aside, and held back by gauze pads. These should be so arranged that they will form a surrounding wall on all sides of the abscess, and thus protect the adjacent intestines and neighboring structures from the pus which may escape when the

abscess is opened. This opening should be done most carefully. The wall of the abscess will, in part at least, be formed by adherent intestinal coils and probably omentum. These should be cautiously separated, the one from the other, and sponges or gauze pads should be in readiness to absorb the pus as it escapes. The further technique of the operation is similar to that described in the preceding paragraph.

Closure of the Wound.—The first requisite of a cicatrized wound is that it be strong and sufficiently firm to resist any tendency to future hernia. It is of course assumed that the wound in clean cases will pursue an aseptic course. The cicatrix should also be as short and neat as possible. There are various methods of closing a wound, any one of which will give an excellent result. The separate suturing of the different layers is unquestionably the best method. The special technique will depend somewhat on the nature of the incision. As a rule, the peritoneum should be closed by a continuous suture of catgut. If McBurney's operation has been chosen, the incision in the internal oblique should be closed by one or two interrupted catgut sutures, loosely tied so as not to constrict the muscle fibres. The closure of its fascia is rather important, and, if the muscle be thin, this alone may be sufficient without passing the sutures through the muscle itself. The external oblique is then closed by either a continuous or an interrupted suture of catgut. By many, chromicized catgut is preferred, or at least a catgut that will last for not less than ten days. It is often of advantage, with the object of preventing "dead space" between the skin and external muscles, to grasp both of these structures in a single silk suture, which is tied on the skin surface. If Kammerer's incision has been employed the muscle is allowed, after the peritoneum and the posterior sheath of the rectus have been separately sutured, to fall back over this suture line. Its anterior sheath is then sutured by strong catgut. Finally, the suturing of the skin is made according to the choice of the operator. Whatever method be employed, the tissues should never be strangulated by sutures drawn too tightly. Space should always be allowed for swelling. It is always good policy not to leave noticeable suture marks in the skin. Deeply indented cross lines are but rarely justifiable. They indicate too tight suturing. In purulent cases it is wiser to abstain from the use of buried chromicized catgut or of any other material which is not quickly absorbed. Retention sutures of silk or silkworm gut, passed through the skin and external muscle, are a great safeguard. These should not be immediately tied, but should rather be left in position ready for use in approximating the edges of the wound when suppuration has practically ceased.

Removal of the Appendix through a Nephropexy Incision.—The combination of appendicitis and movable kidney is so common that the necessity often arises for an operation which shall relieve both conditions. The question then will be, Shall two separate incisions be made, or shall the appendix be removed through the nephropexy incision in the loin? This must be decided by the shape and size of the patient, the location and adhesions of the appendix, and the skill of the operator. The appendix can unquestionably often be removed

with safety through the posterior wound, but rarely with ease. In a certain proportion of patients it will prove to be rather a difficult, and perhaps even a dangerous, procedure. In about one patient in three the operation will be comparatively easy; in perhaps another third it will be possible but difficult; and in the remainder it will be dangerous or impossible. Belonging to this latter class are patients who have deep narrow pelves and adherent appendices which reach down toward the base of the pelvis. As a rule, the operation is much more difficult in men than in women. The removal of the appendix is performed by drawing the edges of the lower end of the nephropexy incision forward so as to expose the peritoneum on the inner side of the descending colon. An opening is made of such a size that it will admit two fingers into the peritoneal cavity. The cæcum is then dragged upward, and the operator's finger feels for the appendix. It may be necessary to draw a considerable portion of the cæcum out through the wound before the appendix can be reached. If the base be first found, and the remainder refuses to come into sight when gentle traction is employed, it is wiser to desist in the attempt to remove the organ through the lumbar incision. If, however, it comes easily into view, the details of its removal will be those already described. After the amputation of the appendix the cæcum is pushed back into place, and the peritoneal wound is sutured. The appendicectomy should of course precede the kidney fixation. The operation is one not to be attempted by the young or inexperienced operator. As a rule, it seems wiser, in the majority of cases demanding both operations, to plan an anterior incision for the appendix and a posterior one for the kidney.

After-Treatment.—General rules may be given, but the peculiarities of each case must be carefully considered. As a rule, rest in the dorsal position for the first twenty-four hours should be recommended. This does not, however, forbid a slight tilting of a shoulder or a hip, and the patient is generally most comfortable when the knees are flexed over a pillow. After twenty-four hours have elapsed the patient can generally with safety be turned on the side. There is great difference of opinion as to the length of time during which the patient should be confined to bed. The limits, in clean, non-drained cases, are from five to twenty days. Of course, some extremists extend these limits in one or the other direction. A fair, and, it seems to the writer, a wise period for confinement to bed is from twelve to fourteen days in clean cases. In cases that have been drained, a week or two, or even longer, may usually be added to these figures. It is not always necessary to confine patients to bed till the sinus be closed; but, when there is progressive healing, this will advance more rapidly if the patient remain quiet. If the sinus become sluggish and refuses to heal, a moderate amount of movement in the fresh air may increase the vital activity of the tissues. It should always be borne in mind that it is not so much the too early abandonment of the bed that is injurious, as it is the yielding to the ever-present temptation of too great activity when one is released from the confines of the sick-room. As has already been mentioned, the upright position advocated by Fowler is of the greatest benefit in suppura-

tive cases. This should be continued for four or five days, and, as a rule, it is not disliked by the patient.

Various disorders may arise during convalescence, and these we will consider briefly in the following paragraphs.

Pain.—In the majority of cases, a hypodermic injection of a small dose of codeine or morphine is indicated immediately after the operation. Codeine is preferable to morphine. After this first hypodermic it is, as a rule, wise to abstain from the use of morphine. If its administration be continued a temporary desire for the drug will be established, and, as a result, peristalsis becomes sluggish, flatulent distention is apt to be troublesome, and the digestion is often impaired. It may, however, be advisable to continue the use of codeine in small doses for several days. The administration of sodium bromide by rectal enemata is often of great benefit in nervous patients. One drachm may be given in six ounces of water, every eight or ten hours.

Disturbance of the Gastro-Intestinal Tract.—As soon as the ether vomiting has ceased water in small quantities may be allowed. The amount should be gradually increased. As a rule, it is wiser to limit the patient to water during the first twenty-four hours. If the stomach is then quiet, hot broths may be allowed. It is wiser not to give milk (except to children) until gas has been freely passed. A certain amount of intestinal paresis is always caused by the opening of the abdomen and the handling of the intestines. This persists generally for twenty-four hours and, if morphine has been given, for probably a longer time. In the ordinary case no effort should be made, for a day or two at least, to excite peristalsis, and for this reason no irritating drinks (lemonade, orangeade, etc.), should be permitted. If the patient complains of thirst or shows signs of poor circulation, small rectal enemata of salt solution (from six to eight ounces) may be advantageously given every six or seven hours. In septic cases these enemata should be begun immediately after the operation and should be regularly administered for several days. As soon as the bowels have moved, soft diet may be begun. A cathartic should be given on the third or fourth day, unless contra-indicated by some good reason—as, for example, the fear that an intestinal fistula may develop or that the peritonitis may spread. If frequent saline enemata have been employed, the bowels will often move without the use of drugs; but, if there be no fæcal movement on the third or fourth day, it is wise to administer an efficient cathartic. Calomel, in very small repeated doses, is popular and generally efficacious. An average dose is one-eighth of a grain with one grain of sodium carbonate, to be given every hour or so up to a total of ten doses; this to be followed by a saline cathartic and also, if necessary, by an enema.

Local Measures.—In non-drained cases five, six, or seven days may be allowed to elapse before the wound is examined. Should there, however, be elevation of temperature or severe pain at any time, the wound should be inspected. In cases which have been drained, the time when the wound will require to be freshly dressed must necessarily vary. If a small cigarette drain, for instance, has been employed, this may be completely removed in from

twenty-four to thirty-six hours; or the greater part of it may be then extracted and only a small portion of its length left *in situ*—just sufficient to pass through the abdominal wall. In its place, if it be entirely removed, it may be judicious to insert a tiny sliver of rubber tissue. If a considerable amount of gauze has been introduced, it is wise to wait four or five days before the attempt is made to remove it. Inasmuch as the object of introducing the gauze was probably to wall off a septic focus or to protect a weak spot of the cæcal wall, this delay is advisable. If a rubber tube has been used, this may be gradually shortened, perhaps to the extent of half an inch daily. If, however, there be much thick purulent discharge, it may be necessary to drain the cavity for a considerable period of time; irrigation with salt solution being carried on each day through a soft catheter which passes to the bottom of the wound. It is not wise, as a rule, to drain by means of a tube for longer than a fortnight, as a sinus might be thus formed which would be sluggish in healing. In most cases, after from ten to fourteen days, a small strip of gauze may advantageously be substituted for the tube. In deeply situated, large abscess cavities, however, tube drainage may be needed for a longer period than two weeks.

B. Treatment of Chronic Appendicitis.

The treatment of chronic appendicitis is removal of the appendix by means of operation. If the appendix be not removed there is the constant danger of an acute attack, which event demands operation under less favorable circumstances. The patient is resting on the verge of a precipice, and any slight indiscretion, whether of diet, of exposure to cold, or of mental strain, may precipitate an acute attack. Operation is especially urgent if the patient lives far from a surgical centre, or if he be a traveller in out-of-the-way places, or in uncivilized countries. An acute attack, under these circumstances, will be attended with the greatest discomfort and probably with great risk. Operation, during the so-called "cold stage," is advisable, not only because of the increased dangers involved by an operation during an acute attack, but also because it will rescue the patient from his condition of discomfort, poor health, and perhaps semi-invalidism. In certain cases, neither the discomfort experienced nor the risk of an acute attack is great, and yet the mental condition is one of perpetual fear and dread; and therefore, on this account alone, it may be advisable to operate, even if we do not feel absolutely certain that the appendix is the important factor in the case. The appendix is a practically useless organ, and its removal, under favorable conditions, is attended with but the slightest amount of risk. For these reasons a patient who is suspected to have chronic appendicitis will be better off if he be operated upon than if he be allowed to drift into a condition of nervous invalidism. The younger the patient, the greater the necessity for operation. The lymphoid tissue, which is so prone to inflammatory changes, is exceedingly abundant in the appendix of the young. After the age of thirty-five it begins to disappear. This fact should be kept in mind when one is considering the indications and contra-indications of opera-

tion,—for contra-indications, though rare, do exist. In the case of middle-aged people, who have for years been subject to mild attacks lasting but a day or so, and where the severity of each attack is steadily diminishing, operation may not be absolutely necessary, inasmuch as the chances of the complete obliteration of the appendix are decidedly good. It is especially in the feeble, or in patients with organic disease, that this probability should be considered. The question presents itself, Which involves the greater danger—an appendicectomy or the risk of a severe attack? If the decision should be against operation, the patient should be warned that he must submit to careful dieting, and that he must never travel out of the reach of surgical aid. In the case of tuberculosis it is often a difficult problem to decide which is the better course to adopt—an operation, or reliance on the proper hygienic and climatic surroundings. If the patient be young, and if the appendix be a source of constant irritation to mind and body, or if it disturb digestion to such a degree that it renders difficult the task of conferring upon the tissues such a measure of strength that they can successfully resist the bacilli of tuberculosis, it is undoubtedly wiser to remove the offending organ. If, on the other hand, the patient has reached middle age, if he be very feeble, or if other tuberculous foci are rapidly developing, then, under these conditions, it is generally wiser not to run the risk of an anæsthetic and of a laparotomy with its attending confinement and lowering of vitality. Of course, under these circumstances, the operation can be performed under local anæsthesia, with cocaine, eucaine, or stovaine, but even then the shock to the patient will be considerable. Spinal anæsthesia, with stovaine, is also to be considered, but its advisability is doubtful. The personal equation and the surroundings, both social and financial, must all be taken into account, and the decision must largely be based on the comparative dangers of the two plans of treatment. We must not forget that the appendix may be a focus from which may arise a general tuberculous peritonitis, and, if conditions be such that an outdoor hygienic life is not possible, then, unless some other organ be seriously diseased, the tuberculous appendix should be removed.

C. The Removal of the Appendix when not Diseased.

The removal of the appendix in all infra-umbilical laparotomies is advocated by all surgeons when, in the course of a low laparotomy, performed for other lesions, the organ is found either acutely or chronically diseased. Shall it be removed if perfectly normal? This question is answered differently by different surgeons. The patient's permission should always have been obtained in advance. Without this, the surgeon may make himself liable for damages. The social surroundings and the habits and residence of the patient should be considered in this connection. Perhaps one-third of surgeons advise the removal of the appendix whenever it can be reached readily through the abdominal wound, provided that the patient is in perfectly good condition to withstand the extra strain. The other two-thirds formulate no rule on this subject. The choice should be largely based on the personal wishes of the patient.

D. Appendicitis in Pregnancy.

When an appendicitis occurs at any stage of pregnancy it is a very troublesome complication. Its diagnosis, in far-advanced pregnancy, is not always easy. The enlarged uterus may prevent direct palpation of the appendical region. If a patient is subject to attacks of appendicitis, pregnancy rather increases this tendency. Should an attack, even if very mild, occur at any time during pregnancy, the probabilities are strong that there will be relapses before the pregnancy terminates. A susceptible appendix may be easily stirred up to fresh inflammation by the tugging of the enlarging uterus, or especially by the traumatism to which it is liable during labor. The prognosis is rendered more serious because of the pregnancy. The mortality of appendicitis during pregnancy has been more than double that of the uncomplicated disease. Operation is invariably indicated. The earlier in the pregnancy that the attack and operation occur, the better the chances of the patient. During the late months of pregnancy it is often a very difficult operation. Unless the patient is allowed to become septic, or to develop a general peritonitis, interruption of the pregnancy is the exception. In about one case in every eight or ten it is to be expected that abortion will follow the operation. If possible, it is well to avoid drainage of the abdominal wound, on account of increased liability to hernia.

E. Post-operative Disorders.

Post-operative Thrombosis (Phlebitis).—By this is meant the phlebitis which arises in patients who give no sign of sepsis. Such a phlebitis occurs, generally, between the fifth and thirteenth days after the operation. The patient may have had a perfectly reactionless convalescence—no elevation of temperature, no pain, no blood changes. Suddenly, a thrombotic plug fills an important venous trunk. There are many theories to account for this accident. Perhaps the most popular is the one which attributes the phlebitis to some mild septic infection. This does not, however, seem probable, for it is often in the most aseptic cases that this unfortunate complication occurs. It has been attributed to poor circulation, to the effect of the anæsthetic on the inner coat of the veins, to traumatism of the veins by retractors at the time of operation, etc. The most reasonable theory, perhaps, is that which maintains that a clot in the deep epigastric vein is dislodged and is carried along until it plugs an important vein. One or other of the femoral veins is the usual site of the thrombosis, the right side being involved almost twice as often as the left, and both veins being affected about once in twenty cases. This complication follows operation in from one to two per cent of the cases. It is a most unfortunate and annoying affection. The danger to life is very slight, and yet a portion of the clot may be dislodged and plug some vessel in the lung or brain, or indeed in any other organ. The occurrence of the thrombosis often springs out of a perfectly clear sky, and the patient is necessarily confined to bed for another fortnight or longer.

Among the symptoms the following should be mentioned:—There is pain along the course of the femoral, the popliteal, or the tibial vein. Most frequently tenderness in Scarpa's triangle is first noted. Occasionally, there may be a sharp sudden pain in the back of the leg. There soon follows puffiness of the foot and ankle, which soon extends to the entire lower extremity. For a few days the pain is quite severe, and the tenderness, as stated above, can be traced along the course of the femoral, the popliteal, or the posterior tibial vein. A slight rise of temperature usually accompanies the phlebitis; from 100.5° to 102° F. being quite common. Occasionally there is a chill. Enlarged veins soon become apparent on the dorsum of the foot. The acute symptoms continue for a variable length of time—in mild cases, four or five days; in severe cases, two or three weeks. The swollen cord-like femoral vein can be felt throughout its course. Around it, in Scarpa's space, is often felt an inflammatory exudate. After the acute symptoms have subsided the course of the disease varies. The circulation rapidly improves, and, in the course of a month, the pain and tenderness may have entirely disappeared, though the swelling persists, under the most favorable circumstances, for several months. The complete return of the parts to a normal condition is unusual. In the average case the pain and tenderness do not entirely disappear for two or three months, and there remains permanently some swelling of the entire lower extremity. In severe cases, a certain amount of disability is permanent, by reason of discomfort and swelling when the erect position is maintained for any length of time. In about one-third of the cases of femoral phlebitis, some permanent disability remains. In another third, there is practically complete recovery, so far as function is concerned, and the swelling, which is apt to persist, is not troublesome. In still another third of the cases discomfort, in greater or less degree, persists for the rest of the patient's life.

The treatment, as soon as symptoms threaten, should be *absolute rest* of the affected limb. This should be elevated on a pillow. Local applications are of benefit in alleviating pain. Nothing is better than lead-and-opium wash, applied to the limb with, perhaps, an ice-bag in the groin. Envelopment of the limb in cotton is of but little value.

Post-Operative Pleurisy.—A "dry," non-septic pleurisy is a not uncommon sequela of an appendicectomy. In most cases it develops soon after the operation. As a rule, it is not serious, and its duration is less than a week. A septic pleurisy may arise from a septic infarct of the lung, or by infection travelling through the lymphatic vessels, or by direct extension from a subphrenic abscess.

Post-Operative Pulmonary Thrombosis.—Pulmonary thrombosis is one of the most serious accidents which the surgeon ever encounters. Happily it is not common, but it probably results in about one-fifth of one per cent (0.02 per cent) of all abdominal operations. For one reason or another an embolus is loosened from some clot, is carried along through the inferior vena cava, and lodges in a branch of the pulmonary artery. If the circulation is completely blocked, death occurs almost immediately; if a small branch only is plugged, the symptoms are alarming, but not necessarily fatal. Sudden pallor, extreme

difficulty and shallowness of respiration, great anxiety and distress as manifested in the countenance, and interference with the circulation, are the heralding symptoms.

Post-Operative Subphrenic Abscess.—This is a not uncommon sequela of suppurative appendicitis. It occurs in about 0.5 per cent of the cases in which suppuration has occurred in the appendical region. The subphrenic abscess may be the one complication, or it may be merely one of several secondary abscesses. It nearly always develops on the right side (ninety-five per cent), rarely on the left (four per cent), and still more infrequently on both sides (1 per cent). The route along which the infection travels is usually that of the lymphatics (either intra- or extra-peritoneal). There may, however, be a direct extension of a suppurative process which has burrowed upward along the loin. Occasionally the disease is due to a general blood infection. On the right side, the abscess lies between the liver and the diaphragm. Rarely, the pus is found to have spread behind the liver, across to the left side. Its situation may be either intra- or extra-peritoneal. Subphrenic suppuration may develop at any stage of the appendicitis, either independently of or following operation. In most cases, however, it appears from six to twelve days after the operation; but several weeks may elapse before it is finally discovered.

The abscess is apt to develop rather insidiously. Occasionally there may be a chill, but, more frequently, the development of the abscess is announced by a moderate rise of the evening temperature. Pain is not apt to be a marked symptom. The patient simply becomes more septic. The temperature is sustained at a higher point, and the upward curve toward evening is more pronounced. The tongue remains dry. In a word, the patient fails to improve. In a case where, for some days, there has been steady improvement, a sudden halt in this progress, or rather a retrograde step, should make us suspect a subphrenic abscess, if at the same time it is evident that wound drainage is not faulty or that an abscess has not formed in the loin. The physical signs are apt to be indefinite. At an early stage a subphrenic abscess is difficult to diagnose. A flatness on one side, at a spot where it should not be found, may be an enlarged liver, an empyema, or an abscess between the diaphragm and the liver. Later, there may be bulging of the side. Generally, the abscess cannot be recognized without the proof furnished by the use of an aspirating syringe. Intraperitoneal aspiration is never justifiable; indeed, it is a most hazardous procedure. But the thrusting of an aspirating needle into a "flat" area above the liver is sometimes justifiable. If it enters the liver the chance of its inflicting injury is not great. If it enters the pleural cavity the risk of harm is somewhat greater. Aspiration should never be employed unless there is at hand a surgeon who can immediately follow up the aspiration with an incision; the needle, if possible, being left *in situ*. The ordinary hypodermic needle is useless; one of larger calibre should be used. Even through a needle of this size the pus may be too thick to flow, and the surgeon must never be deceived by this failure to draw pus. If the indications point to suppuration, a "dry tap" should be followed by an exploratory opening—one large enough to admit

a finger. The technique of the operation is described elsewhere. (See Dr. Ransohoff's article on "Intrathoracic Surgery," in Vol. VIII.) Other abscesses may form at any part of the abdominal cavity, or indeed—as the result of a general infection—in any part of the body. The most common situation for such abscesses, after those already described, is the pelvis. In females this cavity may be opened *per vaginam*, in males through the ischio-rectal space. Rarely does an abscess develop in the left side of the abdomen; and, if it does, it is generally toward the pelvis. Such an abscess may be evacuated by one of various incisions. An abscess may also open into the bladder. If it does, thorough counter-drainage will usually be sufficient.

Post-Operative Hemorrhage.—Bleeding from the stump is an occasional accident. It is due, however, to faulty technique, to a failure properly to apply the ligature, to cauterization of the vessel, or to wounding of the same by the needle which passes the purse-string suture. Hemorrhage due to the erosion of the larger veins is a rare occurrence, as is also secondary bleeding from separation of sloughs.

Post-Operative Fæcal Fistula.—Fæcal fistula is a complication which occurs in perhaps one per cent of patients with gangrenous or suppurative appendicitis. The fæcal leakage usually manifests itself between the third and eighth days. The amount of fæcal matter which escapes through the wound may be very small, just sufficient to stain the dressings slightly; or, on the other hand, most of the intestinal contents may escape in this manner. The cause is nearly always sloughing of the appendical stump and also, perhaps, of the adjacent cæcal wall. When the vitality of the appendical base has been partially destroyed the application of a ligature or of sutures may complete the death of the tissue, and as a result there is established an opening in the cæcal wall. As has already been stated, when the entire appendix is gangrenous the adjacent wall of the bowel is apt to participate in the sloughing process. The suturing of the opening is unsatisfactory on account of the friable character of the bowel. Then infection still further destroys the vitality, and there results, instead of agglutination of the sutured surfaces, a further sloughing process involving the cæcal wall. The duration of the fæcal fistula varies. When the leakage is slight it may cease in from ten to fourteen days. When the opening is large the leakage may continue for weeks or even months. As a rule, closure generally results, but there are cases where a permanent fistula persists. Such permanency is generally due to the eversion of a bit of mucous membrane, which prevents closure of the gap by the agglutinating power of the serous surfaces. The most common cause is the failure to remove the appendix in its entirety. A small portion of the stump has been left attached to the cæcum, and beyond the ligature or suture there remains a rim of mucous membrane which protrudes beyond the serous coat. If this has happened through some fault of technique or through the unexpected death of tissue, a permanent fistula very generally results, and an operation will be needed for its cure. The discharge from such a fistula is generally very slight, and during the greater part of the time it may consist of mucus alone. There are occasions,

however, when a small amount of fæces will form a part of the discharge. The latter may be intermittent, and for days the sinus leading to the bowel opening may apparently close, only to burst open with an extra amount of discharge a few days later. Such closures may cause slight pain and fever. Occasionally, also, a second or even a third opening may appear. The surgeon should know what are the probabilities of spontaneous closure of such a fistula. If the diminution in the amount of discharge is progressive, no anxiety need be felt as to the ultimate closure of the fistula, and, as long as this diminution continues, there is no need of an operation. If, however, there be no permanent decrease, and if at the end of three or four months the conditions have not altered, there is but little chance of closure of the fistula without resort to operation. Six months may perhaps be mentioned as the length of time during which one may properly wait for Nature to exhaust her endeavors. If no progress be recognizable during this period, it is then best to operate. The operation consists in the inversion of the pouting mucous membrane by means of a purse-string or Lembert suture. Success is very probable, but it is not wise to guarantee closure at the first attempt. Great difficulties, such as abnormal thickness of the cæcal wall, adhesions and twists of the bowel, may stand in the way of a successful suturing.

VII. APPENDICOSTOMY.

Appendicostomy is an operation devised by Robert F. Weir for the purpose of utilizing the appendix as a means of flushing the colon in the treatment of obstinate colonic ulcerations, especially those depending on processes excited by pathological amœbæ.

[For further consideration of this topic see the article, at the end of this volume, by Drs. Tuttle and Earle, on Surgery of the Anus, Rectum, etc.

List of a Few of the More Recent Publications Relating to Diseases of the Vermiform Appendix.*

Burnam (C. F.): Exhibition of Four Appendices Vermiformes Showing Unusual Pathological Conditions. (From the Service of Dr. Kelly.) Johns Hopkins Hosp. Bull., Balt., 1904, XV., 137–140.—Kramer (S. P.): Studies in the Pathogenesis of Appendicitis, Amer. Surg., Phila., 1902, XXXV., 701–707, 861.—Morris (R. T.): Exhibition of Specimens Illustrating Each Step in the Progress of Infective Appendicitis, Proc. Phila. Med. Soc., Phila., 1904, XV., 433–445.—Rolleston (H. D.): Abnormal Relation of the Vermiform Appendix

*The bibliography of the pathology and treatment of diseases of the vermiform process is very extensive, and would occupy far more space than can possibly be spared for it in the present work. We have thought it best, however, to furnish a brief list of the most important publications on the subject which have appeared in recent years. We do this on our own responsibility, as Dr. McCosh's death occurred within a very few days after he had completed the main portion of the article.—The Editors.

to the Tunica Vascularis, Leading to Appendicitis, Jour. Anat. and Physiol., Lond., 1897–8, XXXII., 64–66.—Stanton (E. M. D.): The Sequence of the Pathological Changes in Appendicitis; a study of the significance of the lesions found in different stages of appendicitis, based on the pathological findings in a series of operative cases, Jour. Am. Med. Ass., Chic., 1905, XLIV., 1849–1853.

Appendicectomy; a discussion at the meeting of the Hunterian Society, Chir. Jour., Lond., 1903–4, XXIII., 267–282.—Appendicitis at Middlesex Hospital. Statistical tables of cases of operation for appendicitis, Med. Chir. Tr., Lond., 1905, LXXXVIII, 493–498.—Barling (A. S.): Summary of Results of Forty-four Consecutive Cases of Appendicitis Treated by Operation, Med. Chir. Tr., Lond., 1905, LXXXVIII., 499.—Brewer (G. E.): Four Atypical Cases of Appendicitis, Amer. Surgery, Phila., 1898, XXVIII., 366–377.—Bruce (H. A.): Appendicitis; Some points in diagnosis and treatment, based on over 600 operations, Brit. Med. Jour., Lond., 1906, II., 1692–1696.—Clogg (H. S.) and Fairbank (H. A. T.): Appendicitis at Charing Cross Hospital; statistical tables of cases of operation during 1902–4, Med. Chir. Tr., Lond., 1905, LXXXVIII., 517–524.—Deaver (J. B.) and Ross (G. G.): A Critical Review of 416 Cases of Appendicitis Operated on in the German Hospital, Phila., in 1901, Jour. Am. Med. Ass., Chicago, 1903, 193–217.—Fitz (R. H.): Some Observations on Appendicitis, Boston Med. and Surg. Jour., 1905, CLII., 339–341.—Jones (L.): Appendicitis at St. George's Hospital. Tables showing present conditions of seventy-three patients after operations for appendicitis during the years 1900–2, Med. Chir. Tr., Lond., 1905, LXXXVIII., 535.—Lockwood (C. B.): On the Surgery of Acute Appendicitis, Lancet, Lond., 1902, II., 1608–1612.—Morris (R. T.): A Report upon 170 Cases of Appendicitis, N. Y. Med. Jour., 1900, LXXII., 1093–1095.—Appendicitis, Internat. Jour. of Surgery, N. Y., 1906, XIX., 309–312.—Murphy (John B.): Two Thousand Operations for Appendicitis, with deductions from his personal experience, Am. Jour. Med. Sci., Phila. and N. Y., 1904, N. S. CXXVIII., 187–211.—Price (J.): Progress We have Made in Surgery about the Region of the Appendix, Tr. Med. Soc. of Virg., 1901, Richmond, 1902, 265–271.—Richardson (M. H.): Appendicitis, Old Dominion Jour. of Med. and Surg., Richmond, 1902–3, I., 71–81.—Stimson (L. A.): Some Practical Deductions from Personal Experience in the Treatment of Appendicitis, Amer. Surg., Phila., 1907, XLVI., 122–130.—Syms (P.): Remarks on Appendicitis; based on an analysis of 219 cases operated on, Am. Surg., Phila., 1904, XL., 727–734.—Wyeth (J. A.): The Technic of Appendicectomy, Jour. Am. Med. Ass., Chicago, 1907, XLIX., 121–124.]

SURGICAL DISEASES AND WOUNDS OF THE INTESTINES, OMENTUM, AND MESENTERY.

By CHARLES W. OVIATT, M.D., Oshkosh, Wisconsin.

I. INTRODUCTORY REMARKS AND GENERAL DIAGNOSIS.

The intelligent study of this subject implies a familiarity with the anatomy, physiology, pathology, and embryology of the abdominal viscera, as well as a good working knowledge of the principles governing general surgery. Operations upon the intestines should not be attempted until a broad experience in general surgery has been attained.

Methods of Diagnosis.—In the diagnosis of conditions of the intestine demanding surgical intervention, inspection, palpation, percussion, and auscultation may be made use of in the external examination.

Inspection, in a patient with a thin abdominal wall, may reveal distention, either localized or general; and peristalsis, either normal or exaggerated, may also often be noted.

By means of palpation the large bowel may frequently be outlined, and the presence, characteristics, and mobility of tumors may be determined. Rectal or vaginal examinations may often be of value, and, when symptoms point to the lower abdomen, they should never be omitted.

Percussion is valuable as an aid in determining the solid, liquid, or gaseous contents of a suspicious swelling.

Auscultation may be of value in ileus; an absence of sounds being noted in the dynamic form, and an increase in mechanical ileus. Succussion sounds may be present in relaxed viscera. In an attempt to place abdominal auscultation upon a scientific basis, Dr. W. B. Cannon has made a careful study of the sounds normally heard and has described them in detail.

Distention of the colon with air or water may occasionally aid in the recognition of a pathological condition, but it has not the value that was formerly attached to it.

After a most careful history has been secured, and after every means of arriving at a diagnosis by external examination has been exhausted, it will often be impossible to determine the character or extent of an injury or a pathological process without opening the abdomen. While the hasty, reckless, and often useless "exploratory laparotomy" of the untrained is to be deplored, the most erudite and experienced surgeon often finds himself driven to this expedient. This is especially true in cases of severe injury due to external violence or to a stab or gunshot wound, when there is reason to suspect serious damage to the

viscera. It is in these cases that prompt action means so much and that an operation done by skilled hands may save a life that would otherwise be lost.

After the abdomen has been opened, the diagnosis of an injury or pathological process may be extremely simple or exceedingly difficult. While a knowledge of anatomy and of the normal relations of parts is essential, the ability to recognize tissues and structures in a distorted pathological condition is equally important. The distinction between the large and small bowel is usually sufficiently simple, but a greatly distended small intestine covered with an exudate may render the decision much more difficult. The localization of a loop of intestine that presents itself in the abdominal wound is not always easy, and to determine the proximal from the distal end may require that it

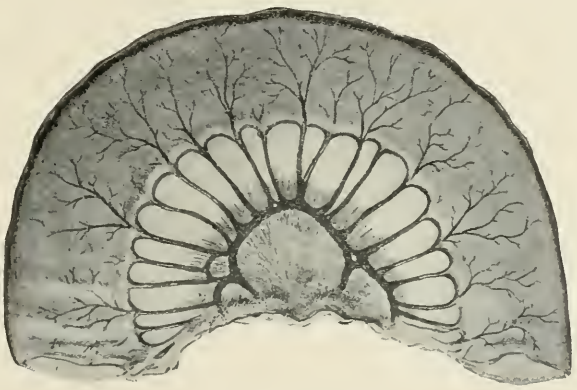

Fig. 261.—A Loop of Intestine, the Middle of which is Exactly Three Feet from the End of the Duodenum. The bowel is of large size. The mesenteric loops are primary, and the vasa recta large, long, and regular in distribution. The translucent spaces (lunettes) between the vessels are extensive. Below, the mesentery is streaked with fat. The veins, which had a distribution similar to that of the arteries, are for simplicity omitted from this and from the subsequent drawings. The subject from which the specimen was taken was a male of forty years, with rather less than the usual amount of fat. The entire length of the intestine was twenty-three feet. (From Monks, in *Annals of Surgery*, October, 1903. J. B. Lippincott Company, Philadelphia, Publishers.)

be passed through the fingers until the ileo-cæcal or the duodeno-jejunal junction is reached. Monks, who has made a most careful study of this subject, does not believe that intestinal localization will ever become exact, but he presents the following points as approximate aids:—

The diameter of the bowel is greater above; the upper part of the small intestine is normally thicker than the lower; the upper part of the bowel is more vascular and of a brighter color; valvulæ conniventes, which can always be felt and sometimes seen, are confined to the upper part of the intestine. The vessels of the mesentery are rather characteristic; at the upper part the branches of the vasa recta are given off. Lower down additional loops are added in the mesentery, and still lower down a third row of loops is added, while the vessels themselves are much smaller. At the lower end of the ileum the mesenteric vessels form merely a reticulated network. (Figs. 261, 262, 263, 264.)

The difficulties of intestinal localization are more clearly realized when we consider the variation within normal limits as regards length—viz., from fifteen

to thirty feet: the position which these organs occupy when filled or empty; and other conditions.

Moynihan says in this connection: "It is more than probable, however, that during health there is a constant journeying of the large and small intestine from one part of the abdomen to another, and that two loops of intestine which at one moment are in contact may, in a few seconds, be widely separated. This is shown during operations for gunshot wounds. Thus, in a case of bullet wound where the shot traversed the abdomen directly from front to back, a little in front of the left anterior superior spine of the ilium, the jejunum in four

Fig. 262.—A Loop of Intestine at Six Feet. As compared with that shown in the preceding figure the bowel is somewhat smaller. The vascularity of the intestine and its mesentery is less. Secondary loops are a prominent feature. The vasa recta are smaller. The lunettes are also present, but are not so large as in Fig. 261. The subject was a male, about 35 years of age, with an average amount of fat. The entire length of the intestine was twenty feet. (From Monks, in *Annals of Surgery*, October, 1903. J. B. Lippincott Company, Philadelphia, Publishers.)

places, the transverse colon in two places, and the lower end of the sigmoid were wounded."

The diagnosis of the various forms of peritoneal inflammations, injuries, and pathological conditions of the intestines will be discussed under their respective headings.

II. CONGENITAL ANOMALIES.

That congenital anomalies are not more frequent is indeed remarkable when we consider the evolution of the complicated alimentary tract from the straight primitive tube of the embryo, as is shown in Figs. 265 and 266. Failure of rotation and arrest of development account for many of the congenital anomalies which occur. That these anomalies are not without their practical bearing upon the surgery of these cases is well shown by a case reported by Mumford in which the fixed duodenum ended, not on the left side of the spinal column, but on the right. (Figs. 267 and 268.) A posterior short-loop gastro-enterostomy had been performed, and on the fifth day the patient died. At autopsy it was found that, as the stomach drained and became smaller, it pulled upon

the afferent loop until it was tightly drawn between its fixed point, the ligament of Treitz, and its retracting point, the gastro-intestinal stoma, at which point it finally gave way with a fatal result. Mumford refers to the observation of Professor Dwight of Harvard, who, contrary to Gray, Quain, and Huntington, found that the fourth portion of the duodenum is in front of the spinal column, or even slightly to the right, in from ten to twelve per cent of adult cases—a fact of some importance to the surgeon in view of the case quoted by Mumford.

Because of arrested development and non-rotation of the large or small bowel, various abnormalities of position may occur. The complicated development of the peritoneum with its various folds between the visceral and parietal

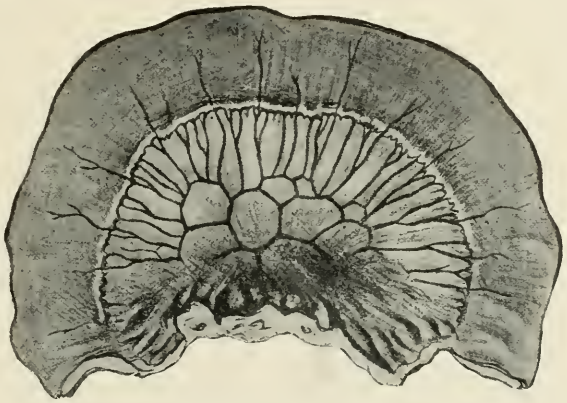

Fig. 263.—A Loop of Intestine at Twelve Feet. The vessels are smaller. The primary loops are lost in the fat, but secondary and even tertiary loops are visible. The vasa recta are shorter, more irregular, and branching. The specimen came from the same subject which furnished Fig. 261. (From Monks, in *Annals of Surgery*, October, 1903. J. B. Lippincott Company, Philadelphia, Publishers.)

layers makes possible various anomalies in the formation of mesenteries. For example, that portion of the duodenum which is usually retroperitoneal may have a mesentery, or the upper part of the jejunum may have none. A meso-colon may be expected on the left side in thirty-six per cent, on the right side in twenty-six per cent.

A rare but confusing anomaly of the intestine is the extension of the longitudinal muscular bands from the large bowel for a longer or a shorter distance upon the small intestine.

Of the various anomalies of the intestine, Meckel's diverticulum (Fig. 269) is of the most interest to the surgeon, because of its frequency and clinical importance. It is found in about two per cent of bodies examined. Originally it was described as arising always from the ileum; hence the name *diverticulum ilei*. Its usual location is on the ileum within two feet of the ileo-cæcal valve; but it may arise anywhere in the ileum or jejunum, or even in rare instances from the duodenum. It is the remnant of the omphalo-mesenteric duct. Under normal conditions the duct becomes entirely obliterated, but, with arrested development, it may assume various shapes and dimensions. In length it may vary from a slight protuberance to a tube 20 cm. long, its average length being from 2 to

5 cm. In width it may vary from a small fibrous band up to a diameter almost equal to that of the ileum. All the coats of the bowel are present and the mucosa may contain Peyer's glands. In long diverticula there may be a mesenteriolum; but, if the diverticulum is short, this is usually absent.

The diverticulum becomes of practical importance to the surgeon by causing approximately six per cent of the cases of intestinal obstruction. (Halsted.) The obstruction is usually caused by a loop of intestine becoming constricted beneath the diverticulum which has its extremity fixed. Obstruction may also be caused by inflammation of this structure (diverticulitis). Volvulus and intussusception are frequently caused by a diverticulum; or the bowel may prolapse into an open diverticulum. The diverticulum has been found in both umbilical and inguinal herniæ. Cahier, in 1906, collected thirty-six cases

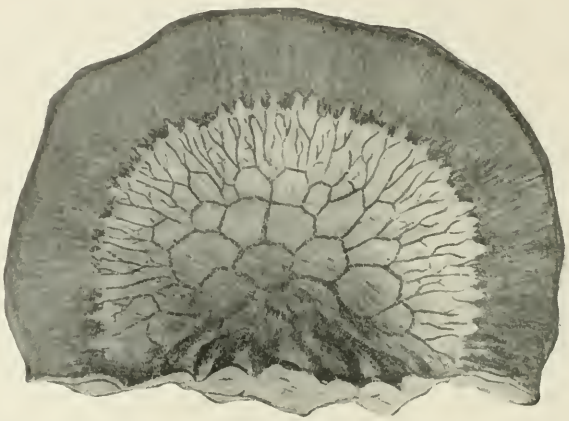

FIG. 264.—A Loop of Intestine at Seventeen Feet. The mesentery is opaque, and small tabs of fat begin to appear along the mesenteric border of the bowel. The vessels are represented by a somewhat complicated network, and are seen with difficulty in the thick fat of the mesentery. (From Monks, in *Annals of Surgery*, October, 1903. J. B. Lippincott Company, Philadelphia, Publishers.)

in which there was an inflammation of the diverticulum with symptoms markedly similar to those of appendicitis. In one of our own cases, appendicitis and diverticulitis were both present. The details of this case are, briefly, as follows:—

The patient, a male, 36 years of age, had had three well-defined attacks of appendicitis within a year. The last attack differed from the others in that there were two distinct foci of pain and tenderness, one below McBurney's point and one about 12 cm. above it, nearly on a line with the umbilicus at the outer border of the rectus muscle. He was admitted to the hospital while convalescing from the third attack. At this time the upper focus was more sensitive to the touch than the lower. The ordinary incision along the border of the rectus was made, and the appendix, in which was lodged a good-sized fecal stone, was removed. The incision was then extended to the upper seat of tenderness. At this point adhesions were encountered. They were broken up, and the presence of a Meckel's diverticulum, 8 cm. in length and about two-thirds the size of the ileum, was thus revealed. It had evidently been recently in a state of active inflammation. It was removed close to the bowel. (Fig. 269.)

Owing to the various complications and pathological conditions which this diverticulum may produce, its removal is advisable—provided the patient's condition permits the additional interference—when the structure is encountered in connection with other abdominal operations.

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III. ACQUIRED DIVERTICULA.

Acquired diverticula are divided histologically into true and false. The former have all the coats that are found in the normal intestine, while the latter are simply hernial protrusions of the mucosa through the muscularis.

Unlike those of the congenital variety, which are usually found on the convex surface of the bowel, the acquired diverticula usually occur at the mesenteric border and are frequently multiple. The descending colon and the sigmoid are the locations in which they are most often found.

According to Brewer, Wallman, in 1858, was among the first to call attention to this condition. In the same year Sydney Jones pointed out the pathological importance of acquired diverticula by reporting a case in which an intestino-vesical fistula resulted from an inflamed sigmoid diverticulum. The Mayos have recently shown the necessity of recognizing diverticulitis of the acquired type.

The recent statistics of Gardinier and Sampson are interesting in that they show the comparative frequency of diverticula. These statistics are as follows:—

Number of Autopsies	Meckel's Diverticulum.	Acquired Diverticula.	
		Small Intestine.	Large Intestine.
(1) 8,133	8	1	6
(2) 2,600	15	14	19
(3) 2,382	11	1	1
(4) 953	5	0	2
14,068	39	16	28

The large proportion found in the second series (from Johns Hopkins Hospital) is explained by the fact that they were sought for, and the result tends to show that such anomalies are not so infrequent as the usual autopsy reports would indicate.

Mayo, Wilson, and Giffin report five cases of diverticulitis and peridiverticulitis of the sigmoid. These cases had the following features in common:—The patients were over forty-five years of age, all were inclined to obesity, and except for this condition were in robust health. The onset of the symptoms

was sudden and presented the characteristics of a localized peritonitis. A tumor, of rather rapid development, was usually situated to the left of the median line, in the middle or lower portion of the abdomen. In all cases the disease originated in the descending colon and sigmoid. (Fig. 271.)

These cases have been divided by Mayo into three clinical groups: 1, those in which there develops an intraperitoneal abscess, the contents of which are

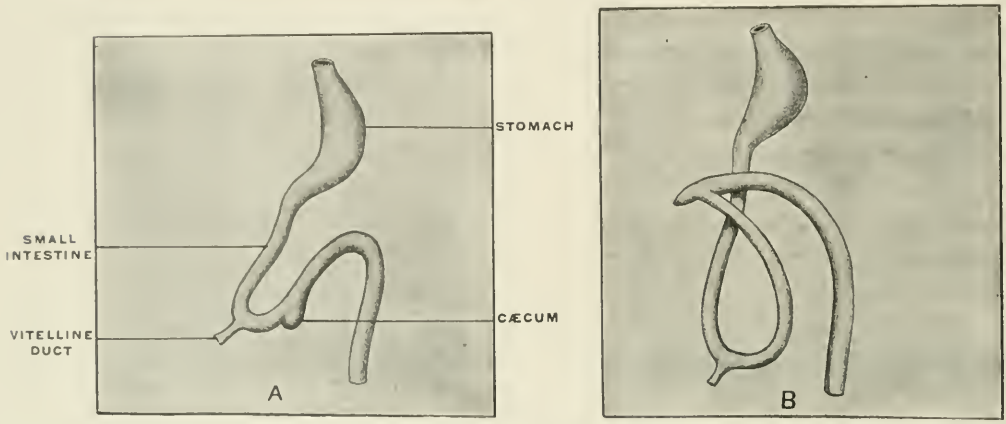

Fig. 265.—First Stage of Development of the Intestinal Canal. (From Dr. George S. Huntington, "The Anatomy of the Human Peritoneum and Abdominal Cavity." Lea Brothers, Philadelphia, 1903.)

In *A*, the intestinal canal is in the stage of umbilical loop, before rotation; in *B*, it is in the first stage of rotation, the colon crossing the duodenum.

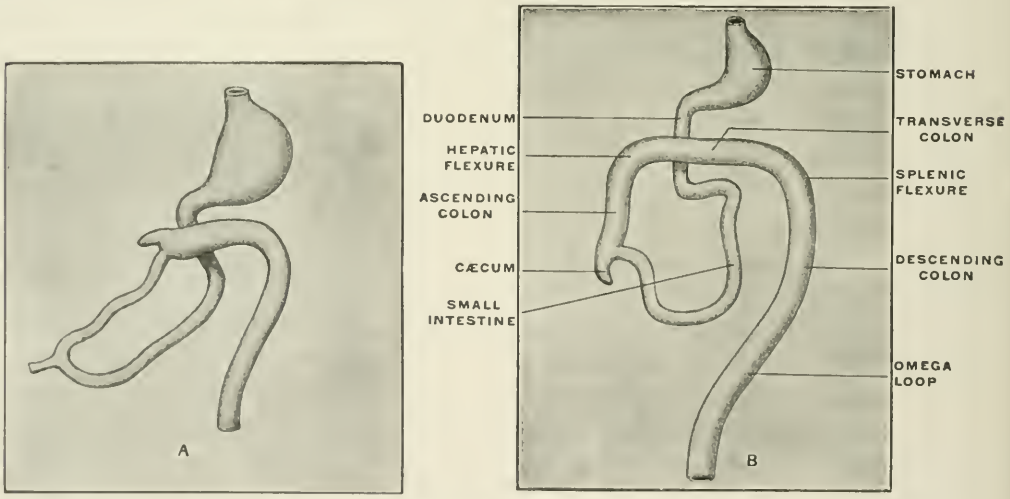

Fig. 266.—Later Stage of Development of the Intestinal Canal. (From Dr. George S. Huntington.)

In *A*, the intestinal canal is in the second stage of rotation—the rotation of the small intestine; in *B*, the schema of the intestinal canal after complete rotation and descent of the cæcum is represented.

spontaneously evacuated into a neighboring viscus or are made to escape externally by means of operation; 2, those which give rise to acute or chronic obstruction, necessitating operation; and 3, those in which the symptoms are mild and in which recovery occurs spontaneously.

Wilson recommends that the term diverticulitis should be confined to cases

of acute inflammation of the mucosa within the diverticulum, while chronic inflammation of the serosa around the diverticulum should be designated peri-diverticulitis.

In many cases the diverticula give rise to no symptoms, but when they become inflamed the conditions may resemble very closely those of an appendicitis, except as regards the location of the disease.

In the surgical treatment of these diverticula the removal of the lesion or of the segment of the bowel in which it is located may be practised, provided too much of the organ is not involved. In the cases reported by Mayo the disease was limited to portions of the intestine which varied in length from four to eight inches. If the lesion is too extensive for radical removal, or if the mesenteric vessels are too extensively involved, an enterostomy should be made.

Bibliography.—Geo. E. Brewer, in *Am. Med. Jour. Sci.*, October, 1907.—Mayo, Wilson, and Giffin, in *Surg., Gyn., and Obstet.*, July, 1907.—Gardinier and Sampson, in *Jour. of the Amer. Med. Assoc.*, May 26th, 1906.

IV. PERFORATING AND NON-PERFORATING INJURIES OF THE INTESTINE; FOREIGN BODIES.

Injuries of the Intestine.—Indirect violence from without may cause simply a contusion of the intestine or it may produce a partial or a complete rupture of the bowel. These injuries are much more likely to be overlooked than those which occur in connection with penetrating wounds of the abdomen. Symptoms commensurate with a serious injury of this character may be entirely wanting. Hemorrhage per rectum, shock, and collapse may occur, but are frequently absent. With a history of violent trauma over the abdomen, great care should be exercised to avoid overlooking such injury. As the result of a non-perforating injury of this character, diverticula may form; injury to the mucosa may be followed by ulceration with subsequent perforation; or peritonitis may develop from the migration of bacteria through the damaged bowel wall.

Perforating injuries of the intestine from within are rare and are generally unrecognized until symptoms of peritonitis (local or general) or of abscess occur. Such injuries are usually caused by the passage, through the intestinal wall, of some substance such as a fish bone, a wooden tooth-pick, etc., which has been accidentally swallowed.

Rupture of the bowel from external violence, without a penetrating wound of the abdominal wall, occurs most frequently in the region of one of the fixed points of the bowel—the ileo-cæcal junction or the duodeno-jejunal flexure,—the bowel being torn away from its attachment. Dr. E. Wyllys Andrews suggests that the bowel may be cut in two by the angle or promontory of the sacrum against which it impinges under the influence of violence exerted on the anterior abdominal wall. (Fig. 272.)

In order to estimate the probability of the intestine having been seriously injured, notwithstanding the absence of a penetrating abdominal wound, a careful history of the character of the injury should be elicited—whether it resulted from the sudden impact of a small, rapidly moving body such as a piece of wood flying from a circular saw, a fragment from a burst fly-wheel, a kick, or a blow; or whether the force applied was distributed over a larger area of the abdomen, as in crushing injuries. The rapidly moving bodies are much more

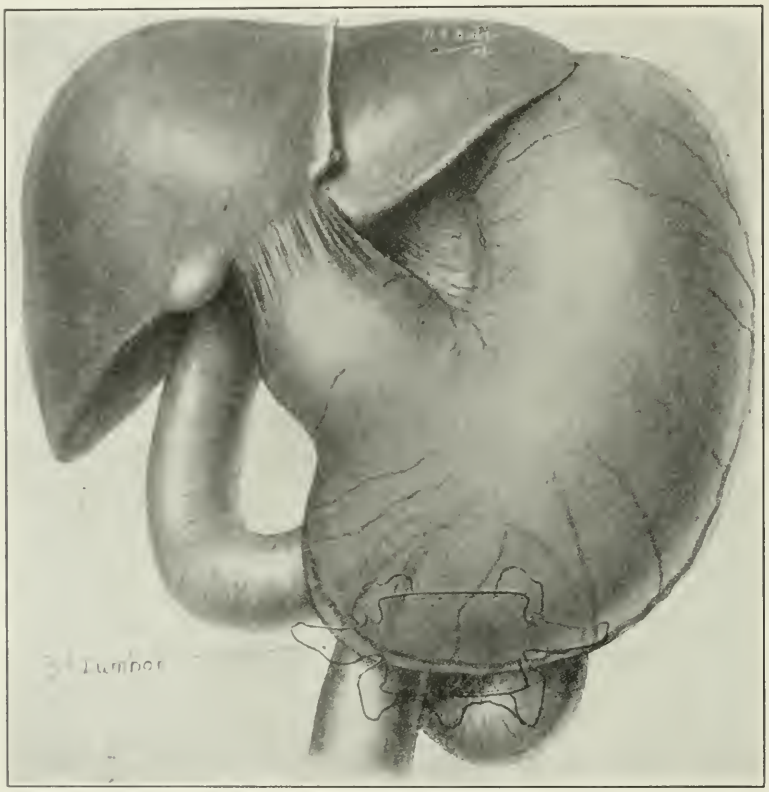

FIG. 267.—An Abnormally Short Duodenum, Rendering Inadequate and Dangerous the Operation of Posterior Gastro-Enterostomy, with the Short Loop which in those Cases is Associated with an Immobilized but Greatly Distended Stomach. A large part of the pyloric portion is greatly thickened and is held to the liver by strong and dense adhesions. (From Dr. James G. Mumford, in *Annals of Surgery*, January, 1906. J. B. Lippincott Company, Philadelphia, Publishers.)

likely to cause rupture. The integrity of the intestine may not be immediately destroyed; nevertheless, the injury may be sufficient ultimately to cause gangrene.

The small bowel is ruptured much more frequently than the large bowel. In all cases multiple rupture must be sought for.

Penetrating injuries of the intestine are more commonly caused by gunshot or stab wounds. In the latter, the wound of the bowel is more often single, while in the former multiple wounds are nearly always found. The projectile of the modern fire-arm, impelled at high velocity, does less damage to the bowel wall, but it produces more destructive effects upon the mesentery.

The diagnosis of injury to the intestine, with or without a penetrating wound of the abdomen, is necessarily obscure and difficult. The presence of free gas in the peritoneal cavity, shown by the absence of liver dulness, and formerly believed to be of diagnostic value, has been found to be often absent, and may be imitated so closely by a distended colon that this sign can no longer be relied upon. Free fluid also possesses an uncertain significance. Leucocytosis is usually late in showing itself; and similarly unreliable are the other signs or symptoms that have been presented from time to time as being char-

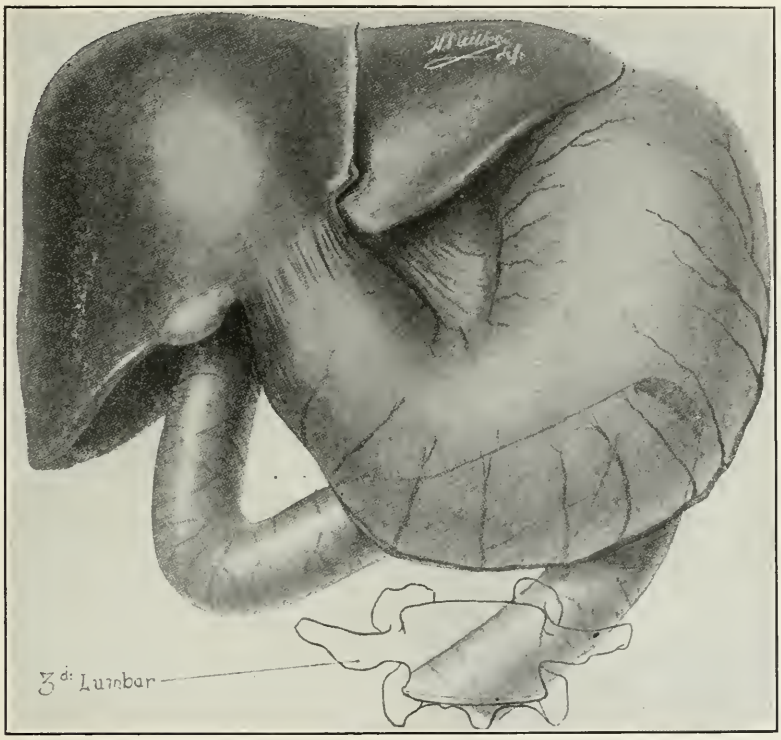

Fig. 268.—Second View of the Parts Shown in Fig. 267. At the autopsy there was found, at a point far over to the left, a large rent in the fundus of the stomach. This rent was found to be the stoma with a portion of the torn-off jejunum attached to its right-hand border. The short arm of this portion of the jejunum, measuring four inches in length, extended, in a stretched condition, to the ligament of Treitz. (From Dr. James G. Mumford, in *Annals of Surgery*, January, 1906. J. B. Lippincott Company, Philadelphia, Publishers.)

acteristic. In the absence of positive evidence, however, it is far better to give the patient the benefit of the doubt and resort to immediate exploration than to wait for symptoms of peritonitis to appear. It is estimated that, in ninety-one per cent of all penetrating wounds of the abdomen, there has been inflicted upon some abdominal viscus an injury which demands immediate operation; and in sixty-five per cent of these the intestine is the viscus injured. While there is no pathognomonic sign or group of symptoms which definitely characterizes intestinal injury, the history of trauma or the presence of a penetrating abdominal wound, taken together with evidence of shock, abdominal pain, vomit-

ing, muscular rigidity, low body-temperature, and rapid pulse, developing soon after the injury, will point to lesions sufficiently serious to require surgical intervention. Pain, rigidity, and rapid pulse are perhaps the most significant symptoms. Moynihan lays special stress on a progressive increase in the pulse rate as a diagnostic sign.

In injuries of the intestine, where operation is demanded, the earlier it is executed the lower the mortality will be. It was shown by Senn in his experimental and clinical work that success in these cases is in inverse ratio to the time allowed to elapse between the time of injury and the operation. This is em-

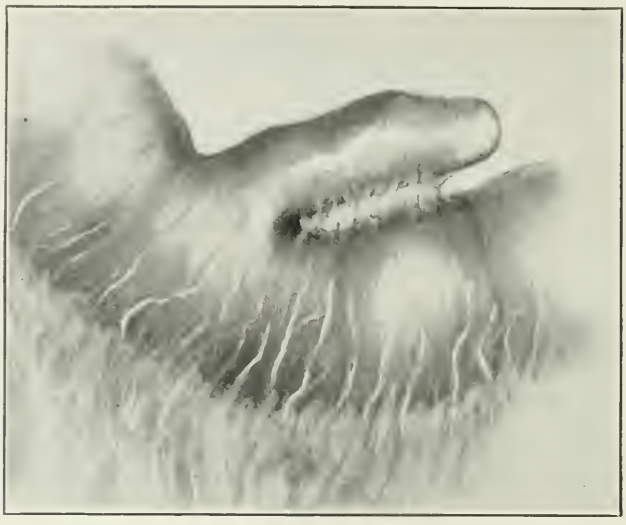

FIG. 269.—Meckel's Diverticulum. (Original.)

phasized by Coley, who found a mortality of 53.9 per cent in cases operated on within the first twelve hours and one of 77.3 per cent in cases operated on later than that.

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Foreign Bodies.—Foreign bodies may enter the intestine through the stomach, through the bile ducts, through the rectum, through an opening established by ulcerative action that has started in some other organ, or directly through the intestinal wall from the free peritoneal cavity, as a result of an abdominal operation. Mechanical devices used in intestinal repair may fail to pass *per anum* and thus act as foreign bodies. The large majority, however, gain entrance through the stomach. Coins, buttons, tooth-picks, artificial teeth, pencils, knives, pins, and needles are the most common articles found in the bowel. Any foreign body that passes the duodenum will be likely to travel the entire length of the intestinal canal without interruption, as the pyloric orifice is smaller than the intestine. Beyond the duodenum, the most common points of arrest are the ileo-cæcal valve and the anus.

Gall-stones, as foreign bodies, may enter the intestine through the bile duct. They are usually of small size and cause no symptoms. The larger gall-stones that are found within the intestine, reach there, as a rule, through an opening established by ulcerative action in the wall of the gall-bladder, one of the gall-ducts, or the diverticulum of Vater. These fistulæ may communicate with the stomach or, more rarely, with the duodenum or jejuno-ileum; but, more

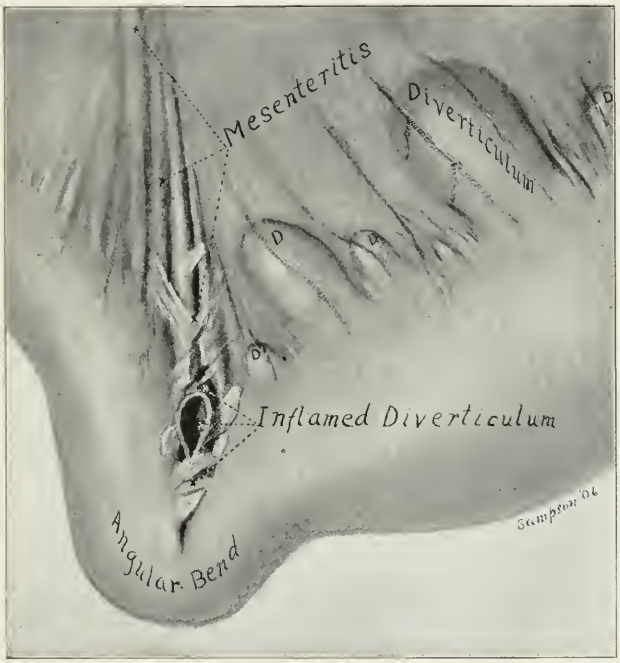

Fig. 270.—The Drawing Represents a Case of Diverticulitis, which was Associated with Local Peritonitis and Mesenteritis, and Eventually Led to the Formation of an Angular Bend in the Intestine. The parts are shown in natural size. The loop of the small intestine, which was adherent to the meso-colon, has been freed, but the act of freeing it produced a rupture of the distal portion of the inflamed diverticulum. Owing to occlusion of the base of the inflamed diverticulum, the distal portion presents the appearance of a small infected mesenteric cyst situated near the border of the intestine. (From Gardinier and Sampson, in *Journal of the American Medical Association*, May 26th, 1906.)

frequently, they communicate with the colon. In some instances they cause intestinal obstruction. Cases in which calculi from the kidney or the bladder have perforated into the intestine have been reported.

In a case which came under my care I removed from the cæcum an ordinary rubber-tipped lead pencil, seven and one-half inches in length. The pencil had been accidently swallowed, the rubber end foremost, during a fit of laughter, about ten weeks prior to the operation. A peculiar feature of the case was that the patient gave no history of swallowing the pencil until after it had been removed. He entered the hospital with pain, tenderness, and a palpable hard swelling in the region of the cæcum. The diagnosis of appendicitis was made. Through the abdominal incision a pointed foreign body could be easily felt in the cæcum and the pencil was removed through an incision about 1 cm. in length. It was lodged in the ileo-cæcal opening. (Fig. 273.) In only one instance,

so far as I have been able to learn, has a longer foreign body than the pencil above referred to, been found in the bowel. In the case of Rosati an eight-inch fork was removed from the bowel fifteen years after it had been swallowed.

The longest stiff foreign body reported as having passed through the entire gastro-intestinal canal and of having been eliminated *per anum*, is that of a six-inch piece of a clay-pipe stem, which has been reported by Hogdon. In this connection the unique case of Ruhge is worthy of mention: a piece of flexible rubber stomach tube, twenty-two and one-half inches in length, was swallowed and passed *per vias naturales* on the thirtieth day.

Mansell Moullin removed from the ileo-cæcal region, four days after the

FIG. 271.—Specimen of Sigmoid Divided Longitudinally, Showing Peridiverticulitis. (Case 4, 19,305.) Note the defective musculature and the diverticula; also, near the label needle, an inflammatory mass which has been dissected away from the surrounding tissues. (From Mayo, Wilson, and Giffin, in Supplement of *Surgery, Gynæcology, and Obstetrics*, July, 1907.)

accident, a piece of hat pin four and one-half inches long. Davies-Colley reports the removal of a packing pin (4½ in. x ⅝ in.) from the descending colon seven months after it had been swallowed.

It would seem that foreign bodies may at times pass through the gastro-intestinal tract with great rapidity. Trevor mentions an instance in which a scarf pin passed through the canal in ten hours. Williams reports an instance in which a very irregular plate of false teeth passed on the day following that on which it was swallowed.

Foreign substances accidentally left within the peritoneal cavity at the time of an abdominal operation, often migrate through the intestinal wall to be expelled *per anum*. A sudden emergency arising during the operation is most often responsible for the accident. A drainage tube or a strip of gauze may slip into the abdominal cavity during the after-treatment. Of nineteen re-

corded cases in which artery forceps were left in the abdomen, there were three in which the instrument was discharged spontaneously *per anum*. Gauze compresses thus left have repeatedly passed into the bowel to be eliminated *per anum*. As showing the frequency with which such accidents occur, Gruzdew found, in the literature for the year 1900, one hundred and eight reported cases in which foreign bodies were left in the abdominal cavity. Neugebauer in 1904 collected two hundred and thirty-six cases of this character. In one instance a forceps remained within the abdomen for ten and a half years.

I have been able to find but few recorded cases of enterotomy for the removal of foreign bodies. In 1887 Walker was able to collect but four cases of removal from the small intestine. In Walker's case an ice-cream spoon was

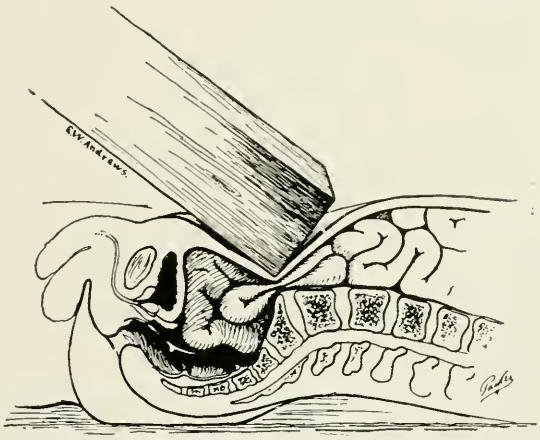

FIG. 272.—Diagram Intended to Show how the Bowel, when Driven Back upon the Promontory of the Sacrum, or the "Sacrovertebral Angle," is likely to be Subjected to a Wearing or Cutting Action on the Part of this Bony Ridge. (From Dr. E. Wyllys Andrews, in *Surgery, Gynæcology, and Obstetrics*, June, 1906.)

swallowed. This remained in the stomach for three and one-half years, after which time it passed into the bowel from which it was removed.

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V. INTESTINAL FISTULA.

An external intestinal fistula constitutes either a direct or an indirect communication between the lumen of the bowel and the external surface of the abdominal wall. Only a portion of the intestinal contents pass out through this opening. An artificial anus differs from the above in that the entire fæcal stream is discharged through the opening. A simple fæcal fistula may subsequently form an artificial anus by what is known as "spur formation"—a condition

which owes its origin to the fact that the afferent and efferent limbs of the loop that is attached to the abdominal wall change their relations; instead of forming an acute angle, they become parallel.

Congenital external intestinal fistulæ are located usually at the umbilicus and are due to the persistent patency of a Meckel's diverticulum.

An internal intestinal fistula may occur between two or more adjacent loops of intestine, or it may communicate with the stomach, gall-bladder, urinary bladder, uterus, or Fallopian tube.

An intestinal fistula may follow damage to the intestinal wall, or it may owe its origin to defective intestinal suturing or to the improper placing of a

Fig. 273.—Foreign Body (Lead Pencil) Lodged in the Intestinal Canal at the Ileo-Cæcal Valve. (Author's Case.)

drain. It may also result from the formation of an abscess, as in suppurative appendicitis, pyosalpinx, typhoid, peritoneal or intestinal tuberculosis, carcinoma, actinomycosis, and still other pathological conditions.

An intestinal fistula involving the lower portion of the small bowel or the colon, may give rise to very little disturbance of the patient's health. When, however, it is located in the upper portion of the intestinal tract it gives rise to very serious impairment of nutrition; and the external discharge, which contains active digestive ferments, gives rise to a most distressing dermatitis.

Treatment.—The ease with which a fecal fistula may be closed depends largely upon its location, the size of the opening into the bowel, the length of the sinus leading from the skin, and the presence or absence of a spur formation.

An elliptical incision should be made through the skin, fascia, and muscle down to the peritoneum. At this stage it is well to fold the skin of the ellipse over the opening and pass a mattress suture through it to prevent leakage. The peritoneum is next opened and the sinus freed from the surrounding tissues as far as to the opening into the bowel. If the opening is small and if it is on the convex surface, it may be clamped with rubber-covered forceps transversely to the long axis of the bowel and sutured in this direction. If the opening into the bowel is too large for this procedure or if it is situated at the side or near the mesenteric border, resection with end-to-end union may be necessary. In the cases where the bowel is attached directly to the abdominal wall and where a spur has been formed, making it practically an artificial anus, a heavy-bladed pair of forceps may be introduced, one blade into each arm of the loop, and then locked. This will cut away the spur and re-establish the fecal stream, after which the external opening may heal spontaneously, or may be sutured.

The use of caustics is of little value as a means of destroying the sinus, and attempts at suturing without freeing the bowel from the abdominal wall are almost certain to result in failure. In a very large proportion of these cases, however, there is a strong tendency toward spontaneous healing, and therefore operative measures should be delayed until it is certain that this will not occur.

VI. INTESTINAL ULCERS.

Peptic Ulcer of Duodenum.—Frequency.—Until recently peptic ulcer of the duodenum has been considered rare and has not been differentiated from the same lesion in the pylorus. In 1900, Weir and Foote collected cases in which an operation had been performed for acute perforation of an ulcer of this nature. In 1902 Murphy and Neff reported one and collected eighteen additional cases; and since that time hundreds have been reported. The Mayos, in December, 1906, reported two hundred and nine operations for duodenal ulcer.

The reports in regard to the relative frequency of gastric and duodenal ulcers show, as time goes on, that the one occurs almost as frequently as the other. Andral placed the proportion at 1 duodenal to 40 gastric; Burwinkel, at 1 to 12; and Trier, at 1 to 9. It is generally placed at 1 to 10. The Mayos, in an experience of 600 operations for gastric or duodenal ulcer, found 436 in the stomach, 135 in the duodenum, and 28 in which the ulcer occupied the border line of both locations. The relative frequency in these cases, therefore, was as 1 to 3.5. In the last 200 cases reported by the Mayos, 98 were duodenal and 87 gastric, with 15 in which both gastric and duodenal ulcers were present. Robson places the proportion at 1 to 2.

This rather marked increase in the frequency of duodenal ulcers is due to the fact that, in the past, the great majority of such ulcers were mistaken for ulcers of the pylorus. Duodenal ulcers are often found extending to the pyloric sphincter and these have been called gastric or pyloric. When adhesions and

other pathological changes are present it is often difficult to define the limitatation between stomach and duodenum.

Location of the Pylorus.—W. J. Mayo calls attention to a definite means of determining the location of the pylorus, and says:—"The best means of identifying it consists in the arrangement of the blood-vessels, which is quite striking. A thick-walled vein is to be seen extending from the inferior margin of the pylorus on the gastric side, upward and across about three-fourths of its extent.

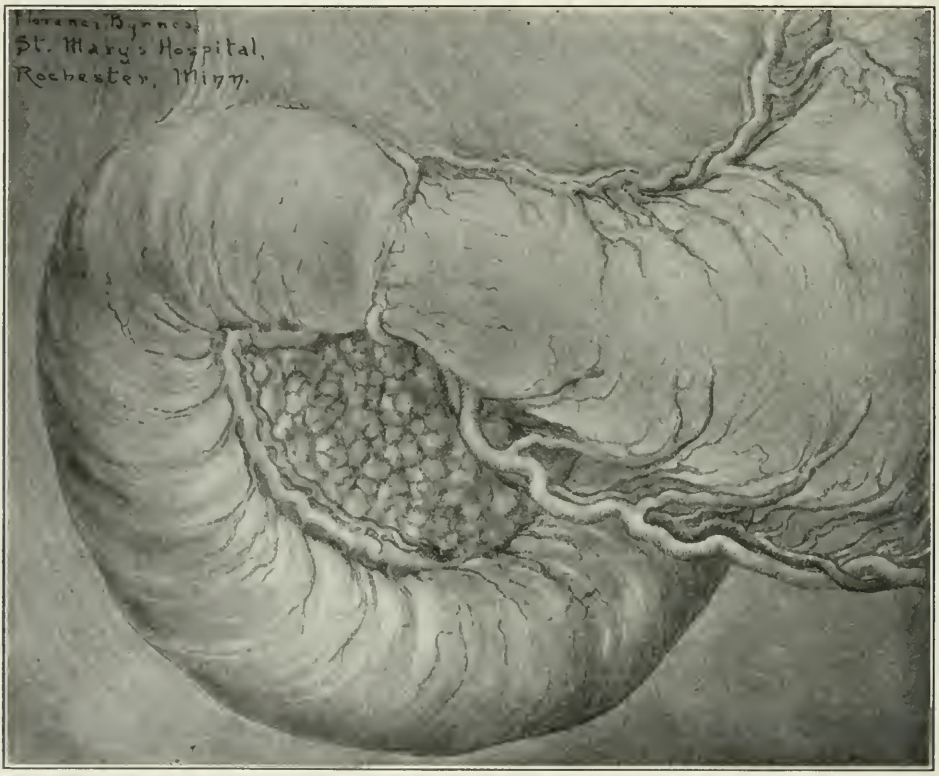


Fig. 274.—Illustration Showing Relations of Blood-vessels about Pyloric End of Stomach and Duodenum, with Special Reference to Pyloric Vein. (From Mayo, in *Annals of Surgery*, June, 1907. J. B. Lippincott Company, Philadelphia, Publishers.)

From the superior margin a similar vein extends downward until it nearly meets the one from below." (Fig. 274.)

Pathology.—Duodenal ulcers are rarely multiple. In 163 of Mayo's cases only 5 had more than one ulcer, but, in the last 200 cases, both gastric and duodenal were found 15 times. This condition is much more common in the male than in the female. Moynihan found, in 209 cases, that 76 per cent were females.

Duodenal ulceration may occur at all ages. Hahn reports a case in a baby a day and a half old; and similar cases in infants have been reported by Spiegelberg, Lister, and others. At the other extreme, Wallis reports a successful operation for this lesion in a patient ninety-two years old. The usual age is between twenty-five and forty.

Duodenal ulcers are usually located above the opening of the common bile duct. The first portion of the duodenum is involved ten times more frequently than is the second. The common situation of the ulcer is within the first two inches of the duodenum, and, in the great majority, it extends to within three-fourths of an inch of the pyloric sphincter. The deepest part of the ulcer is usually found just below the pylorus, where the acid chyme, which is ejected with considerable force from the stomach, produces an impact upon the intestinal mucous membrane.

Peptic ulcer of the duodenum has practically the same structure as the peptic ulcer of the stomach; it is circular in shape and has a terraced margin and a clean base. In all but 7 of the 163 Mayo cases the ulcer was indurated and easily located, but, in the last 100, 87 were markedly indurated.

Etiology.—The etiology of the duodenal is practically the same as that of the gastric ulcer—*i.e.*, it is caused by increased acidity. The alkaline duodenal contents do not neutralize the excessively acid chyme that passes into it from the stomach; but there is also a close relationship between ulcers of the duodenum and interference with the usual routes of elimination—the skin, the kidney, or the lung. Chlorosis, contrary to its seemingly important etiological position in relation to ulcers of the stomach, seems to play no rôle in the causation of duodenal ulcer. Cases of typhoid and tuberculous ulcers of the duodenum have been reported.

The frequency of duodenal ulcer will, in a way, be explained when we remember the observation of Ochsner, in which he found a sphincter beyond the opening of the common duct. (Fig. 275.) This sphincter contracts and so allows of a more perfect mixing of the chyme from the stomach with the pancreatic and duodenal juices. This mixing has been demonstrated by Cannon with the aid of the *x*-ray. The presence of this anatomical sphincter—the existence of which, however, is denied by Boothby—shows that there may be considerable traumatism or grinding of the food in the duodenum above the papilla of the common duct, and hence the frequent tendency to ulceration in this region. Jonas reports a case in which direct abdominal traumatism was shown to be the cause of duodenal ulcer.

Codman has called attention to an obstruction of the duodenum between the vertebra and the mesentery—*i.e.*, gastro-mesenteric ileus—as a cause of duodenal stasis, and consequently as a possible etiological factor in ulcer.

Symptoms.—The symptoms of duodenal ulceration itself are not definite; they may be absent until complications develop, or they may closely simulate either gastric ulcer or gall-bladder disease. The symptoms are latent in twenty per cent of the cases. The usual symptoms are pain and epigastric distress, gas formation, belching and eructation, vomiting, sour stomach, general weakness, and irritability. The pain, which is burning and gnawing in character, comes on in decided periods, lasting for a few days; continuous pain is a late manifestation.

An attempt to differentiate duodenal from gastric ulcer is made by a consideration of the time of onset of this pain. In gastric ulcer the pain commences

soon after eating, while in the ulcer under consideration the pain does not appear until some hours after eating—*i.e.*, until the gastric contents pass from the stomach into the duodenum. The taking of food into the stomach relieves the pain of duodenal ulcer because of the closure of the pylorus after the ingestion of food; hence frequent meals, good appetite, and increase in weight in early cases. The pain is usually worse at from two to five hours after eating.

According to Dr. Christopher Graham, the history of gas formation is almost as valuable as is that of pain, and frequently on this factor alone does a diagnosis depend. It may come on early and it always becomes prominent with the loss of motor power. It is most notable at the time when the pain is greatest. The

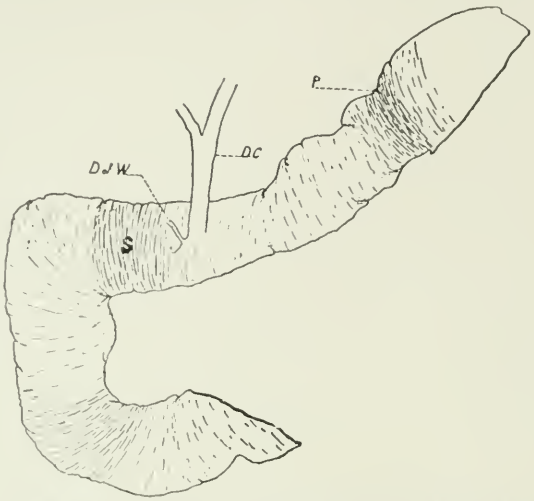


FIG. 275.—Diagram Showing the Location of the Sphincter in the Duodenum Below the Common Duct. (From Dr. A. J. Ochsner, in *Annals of Surgery*, January, 1906. J. B. Lippincott Company, Philadelphia, Publishers.) *S*, Sphincter; *P*, pylorus; *D of W*, duct of Wirsung; *D C*, common duct.

greater the acidity, the greater the pain and the more marked the gas formation. Gas is relieved, as is pain, by food, drink, an antacid, vomiting, or lavage.

Vomiting was a prominent symptom in thirty-two of Graham's forty-six cases. The regurgitation of bitter acid substance and the formation of gas are common in duodenal ulcer. In gall-stone disease the pain is sudden and severe and radiates widely; it occurs soon after the initial symptom and is independent of, and not specially modified by, the taking of food; nor is it so often traced to the latter act. No stomach symptoms are present between the short, well-defined attacks. Spasm of the diaphragm is nearly always observed. Vomiting and the bringing up of gas are present only during the attack, and relief through vomiting and gas eructation is not so certain. In duodenal ulcer, early nausea and eructation are more common than vomiting. When the latter symptom is present, the material vomited is not likely to be profuse, but is small in amount, intensely acid and bitter. It usually comes on in from two to four hours after taking food and is followed by relief in the early stages of the affection. In the more advanced cases the vomiting may be profuse.

The dyspeptic symptoms of duodenal ulcer are slight as compared with those of gastric ulcer; the appetite is good. Chronic hemorrhage is common in duo-

denal ulcer and is most frequently seen in the form of melæna. The blood may be very small in amount and may escape detection unless the test for occult blood is made. In 46 cases of duodenal ulcer Graham found 12 which gave a history of marked melæna. In 23 cases Moynihan found melæna in 3 cases, hæmatemesis in 3 cases, and both symptoms in 4 cases. Analysis of the contents of the stomach usually shows a hyperacidity.

Perforation of the duodenal ulcer, like that of the gastric ulcer, may take place in either an acute or a subacute manner. In the acute form of perforation there is a large opening with no adhesions to prevent the escape of the contents of the bowel. In the subacute form of perforation the ulcer is commonly of the chronic type, the opening being usually smaller, and surrounding the ulcer there is a localized peritonitis which prevents extensive extravasation of the contents of the duodenum. The subacute form of perforation causes an increase in the previous symptoms due to the localized peritonitis. Abscess formation may occur, and the pus may burrow a way for itself to almost any region of the abdomen or even to the thorax. Acute perforation is of frequent occurrence because of the thinness of the duodenal wall. It takes place suddenly, with intense pain, vomiting, and rigidity of the right rectus, and is followed by the typical symptoms of acute peritonitis. The exact site of the perforation may or may not be diagnosed, but this is practically of small import, as the indication is to repair the perforation wherever it may be.

Perforation of a duodenal ulcer has frequently been diagnosed as perforative appendicitis. The reason of the frequent confusion is apparent when the arrangement of the mesenteric folds is remembered. Escaping duodenal contents pass into the right renal pouch and on down to the ileo-cæcal region. The ascending colon with its mesentery serves as a dam to prevent the escape of the contents toward the median line. In cases where the dam occupies a low position, where there is no ascending meso-colon, and where the duodenal contents are profuse, the latter may pass over the colon toward the median line, but here further extension is prevented by the root of the mesentery which, by its oblique insertion, again brings the duodenal contents back to the ileo-cæcal region.

In one of my own cases a perforated duodenal ulcer was mistaken for appendicitis. Upon admission of the patient to the hospital, seventy-three hours after onset of the attack, there was evident peritonitis with muscular rigidity, and, because of the point of localized tenderness in the ileo-cæcal region, it was thought that the inflammation was of appendical origin. The right rectus was incised with the purpose of removing the appendix, but when the peritoneum was opened there followed an escape of intestinal contents. The appendix was not perforated. Its serosa was inflamed and congested, but it was plainly not the cause of the peritonitis. As the condition of the patient did not warrant an extended search for the perforation, tubular drains were inserted into the pelvis, the kidney pouch, and up to the duodenum. The patient was then put in the exaggerated Fowler position and the routine treatment for general peritonitis (Murphy) was carried out. Prompt recovery of the patient followed.

Since then, however, the symptoms of duodenal ulcer have become well-defined, and gastro-enterostomy has been advised.

The case just narrated shows not only the similarity of the symptoms to those of appendicitis, but also the fact that the perforation may be very minute, and that radical treatment such as enterorrhaphy, gastro-enterostomy, or resection may, with certain conditions, be postponed to a subsequent time.

In acute perforation, if the opening can be located and if the condition of the patient warrants, the perforation should be closed by suture. Drainage is always necessary because of the soiling from escaping intestinal contents.

Bibliography.—Weir and Foote, in Trans. of the Am. Surg. Ass'n, 1900. —Murphy and Neff, in *New York Med. Jour.*, Sept. 20th, 27th, 1902.—Mayo, in *Annals of Surgery*, June, 1907.—Ochsner, in *Annals of Surgery*, Jan., 1906; in *Jour. of Am. Med. Sci.*, July, 1906.—Jonas, in Transactions of the American Surgical Association, 1906.—Graham, in *St. Paul Medical Journal*, Sept., 1904.

Peptic Ulcer of the Jejunum.—Peptic ulcer of the jejunum is rare, usually following the operation of gastro-jejunostomy. The first case was reported by Braun in 1889. It has never been reported as following the operations of pyloroplasty or gastro-duodenostomy for benign conditions. It is generally believed to be due to the hyperacidity of the gastric juice, which, coming directly into contact with the mucosa of the jejunum, digests or erodes that membrane. In pyloroplasty or gastro-duodenostomy this acid secretion is neutralized by mixing with the bile, pancreatic juice, and other secretions. It occurs most frequently in men past middle life. The ulcers are most often located in the distal limb of the jejunal loop. The fact that this lesion almost never follows gastro-jejunostomy for gastric carcinoma, in which disease there is generally hypoacidity, would seem to substantiate the view given above.

In the great majority of the cases reported the perforation has been of the acute variety. The supposition that many such cases are not reported or that the nature of the perforation is unrecognized is quite reasonable, as is likewise the probability that cases in which acute perforation has not taken place have been attributed to other causes. These probabilities, taken in connection with the rapid increase in the number of reported cases, favor the belief that this condition may be more common than has hitherto been supposed. An estimate as to the percentage of gastro-enterostomies in which such ulceration may be expected to occur, cannot at present be made, because of the small number of cases. The risk has been placed at less than two per cent.

In respect both of its macroscopic and its microscopic appearance the ulcer is similar to the peptic ulcer which occurs in the stomach or in the duodenum. It is usually single; in only three out of twenty-four cases was it multiple, four ulcers being present in one of these instances. It may be associated with similar ulcers of the stomach or the duodenum. The usual location is at the stoma or in the jejunum, within from 1 to 7 cm. of the stoma, and generally in the distal limb of the loop. In one case the ulcer was found near the stoma of an entero-enterostomy.

Mikulicz reports the case of a child, three months of age, in whom the ulcer formed after an operation for congenital stenosis of the pylorus. On the other hand, it has been known to develop as late in life as at the age of fifty-nine years. The average age, however, is somewhat over thirty years. Ulcers of this variety occur after gastro-enterostomy with or without stenosis of the pylorus.

H. J. Patterson suggests that in most instances hyperchlorhydria is due to insufficient size or inefficient working of the anastomotic opening. Oral sepsis or long-continued indiscretion or excesses in diet may lead to septic gastritis and stasis with hyperchlorhydria.

In one case an injury done to the abdominal wall was supposed to be the cause. Direct injury by food particles, or indirect injury to the mucous membrane at the time of operation, may account for some of these cases. With arteriosclerosis of the blood-vessels of the mesentery, a very slight kinking of that structure may interfere with the blood-supply and so predispose to the formation of ulcer.

The frequent development of an ulcer after the anterior operation has been explained by an interference with the circulation of the loop as it is brought over the colon and the omentum. In Mikulicz's consideration of the subject, he states that it always followed anterior gastro-enterostomy, but, in thirty-four cases in which the location of the anastomosis is mentioned, it is found that the anterior method was employed twenty-five times, in six of which an additional entero-anastomosis was made, and that in one a previous pyloroplasty had been done, and, further, that there were nine in which posterior gastro-enterostomy was the method chosen, in only two of which cases was entero-enterostomy performed. The great majority of the cases referred to above are from the German clinics, where the anterior operation has most frequently been employed. Whether the loop of the jejunum was twisted or not, we do not know, and sufficient data are not given to warrant an opinion as to this being a possible etiological factor. But in the posterior operations there has probably been a twisted and longer loop than is customary with the more recent and more highly perfected technique, which brings the opening in the jejunum farther from the duodenum. In the posterior operation the jejunal opening is about nine inches distant from the origin of the jejunum; in the anterior operation the opening is from sixteen to twenty inches from that point. It would seem that with the no-loop and no-twist posterior gastro-jejunostomy, the danger of peptic jejunal ulcer is reduced to a minimum.

Symptoms.—The symptoms are those of gastric or duodenal ulcer. Jejunal ulcer should be considered as a possibility in every case in which there is a return of the symptoms for which the gastro-enterostomy had been performed. The symptoms may be latent and may be ushered in by an acute hemorrhage or by the occurrence of a perforation, with intense pain followed by the usual signs of peritonitis. Acute perforation and general peritonitis took place in fourteen of thirty-four cases.

The length of time between the operation and the onset of the symptoms may vary within marked limits. The presence of a symptomless period of longer

or shorter duration after the gastro-enterostomy is necessary for the purpose of excluding an uninterrupted continuation of the symptoms for which the operation was performed. In thirty-six cases in which this interval was mentioned there were:—

8 cases in which it lasted 6 months or less;
4 " " " " " between ½ and 1 year; and
10 " " " " " between 1 and 2 years.
In the remainder the symptoms returned after 2 years.

The shortest interval was ten days and the longest nine years.

Differential Diagnosis.—A differential diagnosis can rarely be made between peptic ulcer of the jejunum and a return of gastric or duodenal ulcer, closure of stoma, adhesions, kinks or other forms of incomplete obstruction, or the so-called vicious circle, as they all may give rise to similar symptoms.

In one of my own cases anterior gastro-jejunostomy was performed in 1903 for gastric ulcer with pyloric stenosis and dilatation of the stomach. This was followed by relief for two years, after which there was a gradual return and increase of stomach symptoms. Three years after the operation these symptoms demanded a second operation, at which there was found a cicatricial stenosis of the pylorus with dilatation of the stomach and practical obliteration of the gastro-intestinal stoma. A piece of linen about half an inch in length was attached to the mucous surface at the linear cicatrix which marked the site of the gastro-intestinal anastomosis. At one end of this cicatricial depression, the end toward the cardia, there was a marked induration or thickening of the jejunal wall. This mass was about one-half inch in length, one-quarter inch wide, and elevated one-eighth of an inch above the surrounding mucosa. It was fibrous in consistency, with its surface white and smooth. It extended through the jejunal wall to the greater curvature of the stomach, to which it was adherent. A second anterior gastro-enterostomy was done, and this was followed by a prompt and thus far (three years) perfect recovery. (Fig. 276.)

Bibliography.—Connell, in *Surgery, Gyn., and Obstetrics*, Jan., 1908.—Key, in *Surgery, Gyn., and Obstetrics*, for March, 1908, p. 327. (Abstract from *Nord. Med. Ark.*, Nos. 3 and 5, 1907.)

Typhoid Perforation.—The frequency of the occurrence of perforation in the ulcers of typhoid fever has been variously estimated from one per cent to eleven per cent. In 1904 Hart and Ashhurst collected 8,881 cases of typhoid fever with 225 perforations (2.54 per cent). The frequency is now generally looked upon as between 2.5 per cent and 3 per cent.

The perforation occurs usually in an ulcer which is located in the ileum. In seventy-three per cent it occurs within twelve inches of the cæcum, the large bowel being much less frequently involved. The usual sites, in the order of their frequency, are: ileum, cæcum, ascending colon, transverse colon, and sigmoid flexure. It may also occur in the appendix or in Meckel's diverticulum.

The perforations in typhoid are generally single. In two hundred and seventy-one cases multiple perforations were found thirty-five times. The perforation may be an opening no larger than the point of a pin at the base of

an ulcer, or it may be of large size, due to sloughing of the intestinal wall; or it may be cribriform in character. It may not be recognizable until after a flake of lymph has been removed, thus displaying to view a dark spot in the centre of an intensely congested area.

The perforation may be caused by a direct extension of the ulcerative process through the entire bowel wall, or it may be caused by rupture due to distention of the intestine with gas, fluid, or scybala, to straining at stool, or to a direct injury inflicted by solid food. It occurs more frequently in males than in females, and more particularly in young adults. It is more likely to take place during the third or fourth week of the attack. It may occur, however, during the second week, or indeed at any time thereafter, the danger being constant

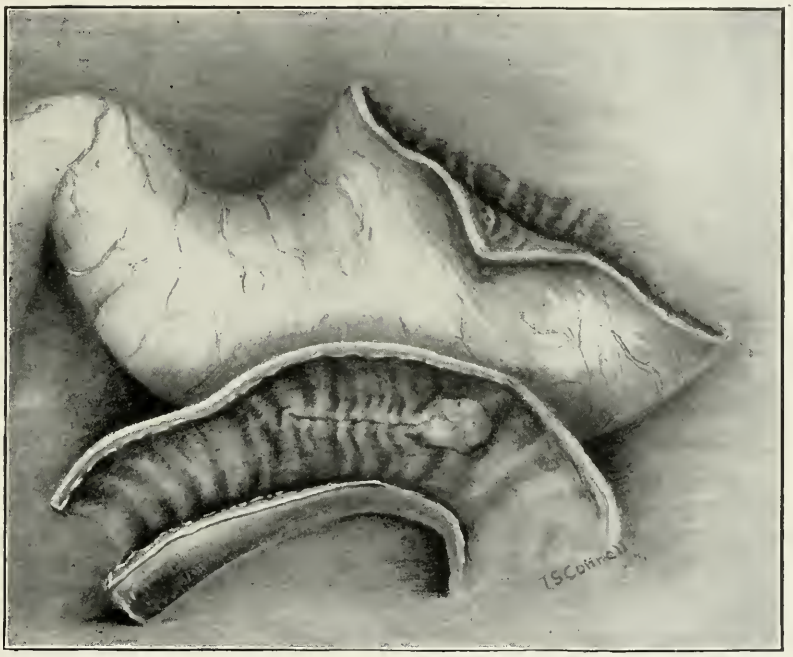


Fig. 276.—Healed Perforated Jejunal Ulcer at One Extremity of the Obliterated Stoma, after Anterior Gastro-enterostomy. (Author's Case.)

until convalescence is passed and recovery has been established. The perforation is usually situated opposite the mesentery at the fundal line, where the blood-supply is least and where the lymph follicles are situated. Perforation may rarely occur at the concave border or along the line of attachment to the mesentery. When this occurs, the contents of the bowel accumulate between the layers of the mesentery and produce a condition which simulates very closely the suppuration of a mesenteric lymph node.

Diagnosis.—The all-important point in the consideration of typhoid perforations is the diagnosis. The treatment, when indicated, is plain; the result depending largely upon the promptness with which it is carried out.

Symptoms.—The symptoms are not well-defined, but the most trustworthy is the occurrence of a sharp, sudden, severe pain, with nausea or vomiting,

muscular rigidity, and tenderness usually localized in the right lower quadrant of the abdomen. Severe, sudden pain, with nausea or vomiting, occurring during the course of typhoid fever, should always make us extremely suspicious of perforation and should demand the closest attention. Tenderness and rigidity soon follow the initial pain.

Other symptoms are unreliable. Thus, for example, there may or may not be free gas in the peritoneal cavity, with obliteration of the area of liver dulness; free fluid, also, as indicated by dulness in the flanks, may or may not be present. Collapse, as a rule, is a late symptom. After, perhaps, a primary fall, the pulse usually rises. The temperature falls and subsequently rises; abdominal respiration disappears; the blood-pressure is raised; the blood-count is usually unsatisfactory, but it may be of some assistance in differentiating a perforation from hemorrhage. Perforation may be confused with any acute abdominal emergency. In typhoid, for example, it is particularly liable to be confused with rupture of a retroperitoneal lymph node, embolism or thrombosis of mesenteric vessels, intussusception, volvulus, appendicitis, etc. Fortunately, these conditions are surgical and demand an opening of the abdomen. On the other hand, perforation may be mistaken for hemorrhage, and up to the present time operation is not generally advised in cases of intestinal hemorrhage.

Great care must be taken to exclude pneumonia, hysteria, pleurisy, retention of urine, renal or ureteral calculi, and iliac or femoral thrombosis. Of six patients who were operated upon, but in whom no perforation was found, three died.

Until the diagnosis is determined upon, opium should be withheld, for its use might possibly mask the symptoms of peritonitis.

In 1889 the operative mortality rate, in 10 cases, was 90 per cent. In the 362 cases collected by Hart and Ashhurst in 1903, the mortality rate was 74 per cent. In Allaben's 524 cases the mortality rate, up to January, 1907, was only 62 per cent. In smaller series the mortality has been reduced to less than 50 per cent—even to 21.6 per cent, according to Scott.

Hart and Ashhurst's tables show that operation during the first twelve hours after perforation gave a mortality of 73 per cent; during the second twelve hours after perforation, 73.8 per cent; during the third twelve hours after perforation, 93 per cent; and, at some period beyond thirty-six hours, 67 per cent.

Abdominal section for the purpose of suturing typhoid perforations was first suggested in Europe by Leyden and successfully carried out by Mikulicz, in 1884. I. C. Wilson, of Philadelphia, in 1896, independently urged such an operation. The first successful attempt in America is credited to Van Hook, of Chicago. Since then such operations have become the recognized line of treatment, and up to 1903 Hart and Ashhurst were able to collect three-hundred and sixty-two reported cases of operation for the repair of typhoid perforation. Allaben collected one hundred and sixty-two additional reported operations from January, 1903, to 1907.

More than one perforation should always be looked for, as multiple perforations occur in sixteen per cent of these cases, and any threatening point should be inverted. Omental grafting may be resorted to; resection of a segment of the bowel will rarely be necessary. The use of a purse-string suture will be sufficient for small perforations, while the large openings will require longitudinal or transverse suturing. Excision of the ulcer is unnecessary. Drainage, either with the cigarette drain or with a split tube containing a gauze wick, should always be resorted to.

Bibliography.—Hart and Ashhurst, in *Annals of Surgery*, January, 1904.—Allaben, in Trans. of the Amer. Med. Association, Surg. Section, 1907.

Tuberculous Ulcers.—Tuberculosis of the intestine is not infrequent. It may be either primary or secondary. In a large proportion of cases (about eighty-five per cent) it is found to involve the ileo-cæcal region. It occurs most frequently in young adult life, but may occur in very young subjects. These ulcers are usually situated in the cæcum or in the lower ileum, supposedly because the slow fecal current at this location allows the tubercle bacilli to become implanted within the mucosa. They may be found anywhere from the duodenum to the rectum. The mesenteric lymph nodes are generally involved. Tuberculosis of the intestines commonly occurs between the ages of twenty and forty years, and in one sex as often as in the other.

Since it has been demonstrated beyond a doubt that tubercle bacilli may traverse a perfectly normal intestinal wall, it is becoming a general belief that, in a large proportion of cases of pulmonary and other forms of tuberculosis, the infection atrium is seated in the intestine. In four hundred and nineteen autopsies on tuberculous subjects in Berlin, Wagner found twenty instances in which he considered the intestinal lesion to be primary.

In the secondary form of the intestinal disease the lesion is the result of a primary tuberculosis in some location other than the intestine. The secondary form is more common. In 1901 Koch had seen only two primary cases, but later he collected twenty-eight cases. Weigert is given as an authority for the statement that, in ninety per cent of the cases of tuberculosis of the lung, the disease is followed by infection of the intestine. But, recently, primary intestinal tuberculosis has been found more frequently, especially in children. A personal case of the writer's would seem to illustrate this:—

A boy, 3½ years of age, was admitted to the hospital suffering from tuberculosis of one knee-joint, the focus being in the epiphysis of the femur. An atypical excision was made and complete recovery followed. At this time there was given a history of bowel trouble coming on when the child was eighteen months old and lasting four months. Diarrhœa, with great emaciation and distention of the abdomen, was present. The child, however, seemed to make a good recovery, and remained well until the beginning of the joint trouble. About eighteen months after the joint-resection the boy was again admitted to the hospital suffering from complete intestinal obstruction of three days' duration. At operation a loop of small bowel was found attached to a healed tuberculous ulcer, thus pro-

ducing the ileus. In this instance the joint-involvement was undoubtedly secondary to a primary intestinal tuberculosis.

Another form of intestinal tuberculosis—one of more interest to the surgeon because of its amenability to radical treatment—is cæcal or ileo-cæcal tuberculosis (conglomerate tuberculosis, or chronic hyperplastic tuberculosis of the intestine). This was first described by Durante in 1890, and again in 1891 by Billroth. Since then it has been ably considered by many others. This localized tuberculosis is characterized by a marked thickening of the wall of the intestine, with some constriction of its calibre—changes which follow ulceration and cicatrization. The external wall of the cæcum is usually involved by extension from the mucosa, though the source of infection may be in the lymph nodes or in the peritoneum, from which it may invade the bowel through the serosa. Complete obstruction is rare. The cæcum or the ileo-cæcal region is usually involved, while other portions of the bowel are rarely involved. (Fig. 277.)

Extension to the cæcum is more common than extension into the ileum; there may be compensatory hypertrophy of the lower ileum. The condition may be primary or secondary, more often the former than has been supposed. Hemmeter says that tuberculosis of the cæcum, with advanced tuberculous lesions in the lungs, is very rare, but in two personal cases observed within the past year we have found advanced pulmonary tuberculous disease complicated by hyperplastic tuberculosis of the cæcum.

The symptoms are usually those of intestinal stenosis, with alternating constipation and diarrhœa and melæna. There is an evening rise of temperature.

Hemmeter presents the following schema, which is adapted from Boas for the purpose of differentiating between carcinoma and tuberculosis of the cæcum:—

Tuberculosis.	Carcinoma.
Age: between 20 and 40.	Age: rare before 40th year.
Duration: 2 to 3 years.	Duration: 8 to 9 months.
Lungs: pulmonary tuberculosis more or less evident.	Lungs: Negative.
Tumor: elongated; intestine palpable as an elongated thickened cylinder.	Tumor: sharply circumscribed; intestine not palpable.
Stenosis: always present; develops slowly, is accompanied by striking, splashing, and musical sounds.	Stenosis: develops rapidly; acoustical sounds not so pronounced.
Stools: blood and pus rare; tubercle bacilli frequently present.	Stools: blood and pus frequently observed; tubercle bacilli absent.
Fever: generally present.	Fever: exceptional.
Urine: Ehrlich's diazo-reaction positive.	Urine: Diazo-reaction negative.

The treatment consists of extirpation if practicable, care being used to extend the field of operation well beyond the diseased structures.

Bibliography.—Koch, in *Brit. Med. Jour.*, 1901.—Wagner, in *Berlin. klin. Woch.*, Jan. 30th, 1905.—Shepherd, in Trans. of Brit. Med. Assoc'n, 1906.—Ito and Ashahara, in *Deut. Zeit. f. Chir.*, May, 1906.—Crowder, in *Amer. Jour. of Med. Sc.*, June, 1900.—Hemmeter, in *Jour. of Amer. Med. Assoc'n*, Feb. 29th,

1908.—Conrath, in *Beiträge zur klin. Chir.*, 1898.—Hartman, in *Brit. Med. Jour.*, April 13th, 1907; *Revue de Chir.*, Dec., 1907.—Hoffmeister, in *Beiträge zur klin. Chir.*, XVII., 1896.

VII. ACTINOMYCOSIS OF THE CÆCUM.

In two hundred patients operated upon at Greifswald for inflammation of the cæcum, Friederich found actinomycosis in four per cent. The primary seat of the infection may be in the appendix. The disease develops slowly and

FIG. 277.—Tuberculosis of the Cæcum, with Perforation. (Natural size.) Above, is a cross-section of the ascending colon; below and to the right, is the ileum. At a point directly opposite the ileum, is a perforation of the cæcum, and just above the perforation the adipose tissue is thickened and there is a constriction of the bowel. At *a* are two enlarged and tuberculous lymph nodes. (From Cullen, in the *American Journal of the Medical Sciences*, March, 1904.)

is characterized by a hard infiltration which sooner or later involves the abdominal wall and leads to the formation of abscesses and sinuses.

Surgical intervention is rarely satisfactory, as it is impossible to remove all

of the infective material. It is claimed that better results are obtained by the use of potassium iodide in large interrupted doses. (Ochsner.)

In a preliminary report on the "Treatment of Actinomycosis and Blastomycosis with Copper Salt," Bevan recommends the use of copper sulphate in doses of one-fourth grain increased gradually to one grain three times daily. He further advises the use of a one-per-cent solution of the salt in irrigation of the sinuses and abscess cavities.

Bibliography.—Friederich, in *Deut. med. Woch.*, XXXII., 31, 1906.—Ochsner, in *Annals of Surgery*, Vol. 37.—Von Baracz, *ibidem*.—Bevan, Haines, and Smith, in *Annals of Surgery*, Vol. 41.—Bevan, in *Jour. Am. Med. Assoc.*, Nov. 11th, 1905.

VIII. PERITONEAL ADHESIONS; EMBOLISM AND THROMBOSIS OF MESENTERIC VESSELS.

Peritoneal Adhesions.—It is estimated that post-operative adhesions act directly or indirectly as a cause of ileus in seventy-eight per cent. As a preventive measure in all abdominal operations, all denuded peritoneal surfaces should, as far as possible, be covered with normal serosa or omentum, and all blood-clots should be removed from the abdominal cavity. Gentleness in manipulation and the cautious use of compresses and sponges wet with normal salt solution, instead of being used dry, aid in preventing adhesions. If capillary drainage is desired, the gauze or wick should be surrounded with gutta-percha tissue, or, better still, one may employ for the purpose rubber tubing, split on one side the entire length and the interior filled with a wick of gauze. The use of aristol, Cargile membrane (ox peritoneum), sterile oil, or other substances applied locally, have not proven of value. Extensive adhesions may be present without giving rise to symptoms unless the fecal stream should be interfered with by strangulation, stenosis, or some form of mechanical obstruction.

If surgical intervention is demanded it must be directed toward the removal of the partial or complete obstruction caused by this condition.

Embolism and Thrombosis of Mesenteric Vessels.—Interference with the circulation of the mesenteric vessels may be brought about by embolism or by thrombosis. A majority of cases occur in men between the ages of thirty and sixty. Embolism is generally due to an endocarditis, a detached fragment from a diseased valve becoming lodged in the mesenteric artery, or it may originate from any thrombosis.

Arteriosclerosis, the pressure of new-growths, or too violent manipulation of the mesentery at the time of the operation may give rise to a thrombosis. In making a posterior gastro-enterostomy one may easily catch the colica media (in the transverse meso-colon) in a suture and thus cause serious interference with the blood-supply. It has been demonstrated experimentally that the symptoms are much more abrupt and acute when the venous circulation is interfered with than when the arterial supply is cut off. The condition varies

according to the site, extent, and duration of the vascular occlusion. The bowel may be merely congested and œdematous, or it may be gangrenous, with a local or general peritonitis. The line of demarcation is usually distinct. The extent of involvement may vary from a small area to one in which the entire small bowel and part of the large intestine is involved. Gangrenous sections of the bowel, from one inch to twenty feet in length, have been observed. The mesentery is usually thickened and may be the site of a hæmatoma. In a personal case there was an embolism in both superior and inferior mesenteric vessels, as shown in Plate LII.

The cases may be divided into acute and chronic, in accordance with the varying degree and extent of the involvement. The acute cases are the more common, the onset being sudden and violent. Severe abdominal pain, with nausea and vomiting, hæmatemesis, and diarrhœa with melæna complete the picture of dynamic ileus, which ends in death in a few hours or days. In the chronic cases the onset is insidious; there are vague dyspeptic symptoms, with perhaps intermissions of varying duration.

Surgical measures are usually of no avail. If a prompt operation is made, and if the extent of bowel involved is limited and the line of demarcation distinct, an enterectomy may be done. Under these circumstances the divided bowel ends must be anchored in the abdominal wound as a temporary measure.

Bibliography.—Childe, in *Brit. Med. Jour.*, 1907, Vol. II, p. 891.—Haagn, in *Jour. of Amer. Med. Assoc.*, July, 1908, p. 136.

IX. OBSTRUCTION OF THE BOWELS.

Dynamic Ileus.—The most common cause of this condition is peritonitis, which inhibits the motor mechanism of the intestine. Abdominal traumatism may be followed by intestinal paresis, and rough manipulation of the intestine or mesentery during operation may have the same effect. Murphy classes those obstructions which are due to paralysis or absence of peristalsis, as adynamic, and under dynamic he includes those rare cases of tonic contraction of the circular muscle of the bowel, such as may occur in lead or tyrotoxicon poisoning.

Renal or biliary colic, strangulation of the omentum, and injury to the testicle or ovary may be followed by a reflex dynamic ileus. It may also follow severe spinal injury. The symptoms—pain, nausea and vomiting, distention, and rigidity—are common to all forms of peritoneal inflammation. Cathartics are absolutely contra-indicated until peristalsis is re-established. Stomach and colonic lavage may be resorted to while one is waiting to differentiate between this and some other form of obstruction.

Mechanical Ileus.—Mechanical ileus, when complete, may be divided into strangulation and obturation.

Strangulation.—Strangulation implies not only an interference with the fecal current, but also an interference with the blood-supply and the nerve-supply of the part of the bowel involved. There is, first, venous stasis, and this is followed by arterial obstruction which leads to gangrene if not relieved. A

strangulated hernia affords the most common example of this condition. Internal strangulation may take place as the result of a loop of intestine becoming caught under a peritoneal band, an appendix, or a Meckel's diverticulum, or by entering a hole or slit in the mesentery.

Volvulus.—Volvulus, which occurs in about 1 in 40 of all cases of intestinal obstruction, is a form of strangulation the result of twisting of the bowel upon its mesenteric axis. A twisting of more than two-fifths of a circle is necessary to produce obstruction and disturb the circulation of the part. It occurs most frequently in the large intestine, notably in the sigmoid flexure. In fifty-eight cases of mechanical ileus occurring in Goebel's clinic, fourteen were due to volvulus. It may be simple or compound: simple when a single loop is twisted around its mesenteric axis, compound when two or more loops are twisted around each other.

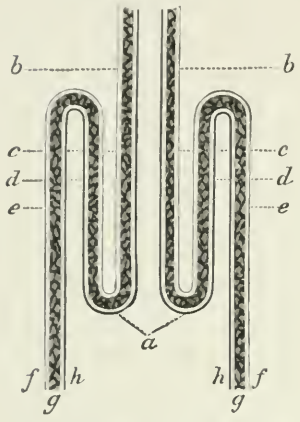


FIG. 278.—Diagrammatic Vertical Section of a Single Intestinal Intussusception. (From Bryant's "Operative Surgery," D. Appleton & Co., New York, Publishers.)

a, The apex; *b b*, the neck; *c c*, the entering layers; *d d*, the returning layers; *c* and *d*, the intussusceptum; *e e*, the intussuscipiens; *f f*, the peritoneum; *g g*, the muscular coat of the intestine; *h h*, the mucous membrane of the intestine.

Volvulus occurs more frequently in men than in women, and in the sigmoid more often than in other portions of the bowel. As regards the age at which it occurs, it may be said that it is observed more frequently in adults than in children.

Volvulus is due to causes which may be either congenital or acquired. As a congenital cause may be mentioned some abnormality of the mesentery, this structure being absent where it should normally be present, and present where normally it should be absent. Moynihan calls this an "excess or a deficiency of physiological fusion" of the primitive layers of the peritoneum. Undue elongation of the bowel or shortening of the mesentery is a most important factor. Congenital stenosis or atresia may cause a volvulus. Undue length of the loop of the sigmoid, with a constriction at its neck, is a congenital malformation which tends to produce volvulus of the sigmoid. An abnormal shortening of the root of the mesentery has allowed the formation of a volvulus of the entire small bowel. Vaughan has collected twenty-one such instances. It frequently occurs in connection with hernia; and volvulus of the small intestine has occurred during the course of typhoid fever, the symptoms in such a case resembling closely those of a perforation.

Though volvulus is a rare condition in the small intestine, Richter collected the cases which had been reported previously to 1901; he found a total of sixty-six, forty-one of which were in the ileum. Scudder recently reported an instance of volvulus of the jejunum, practically at its origin.

The symptoms are those common to other forms of intestinal obstruction. In volvulus of the sigmoid marked distention and the presence of a mass in the left side are characteristic features. A diagnosis other than that of obstruction cannot, however, always be made.

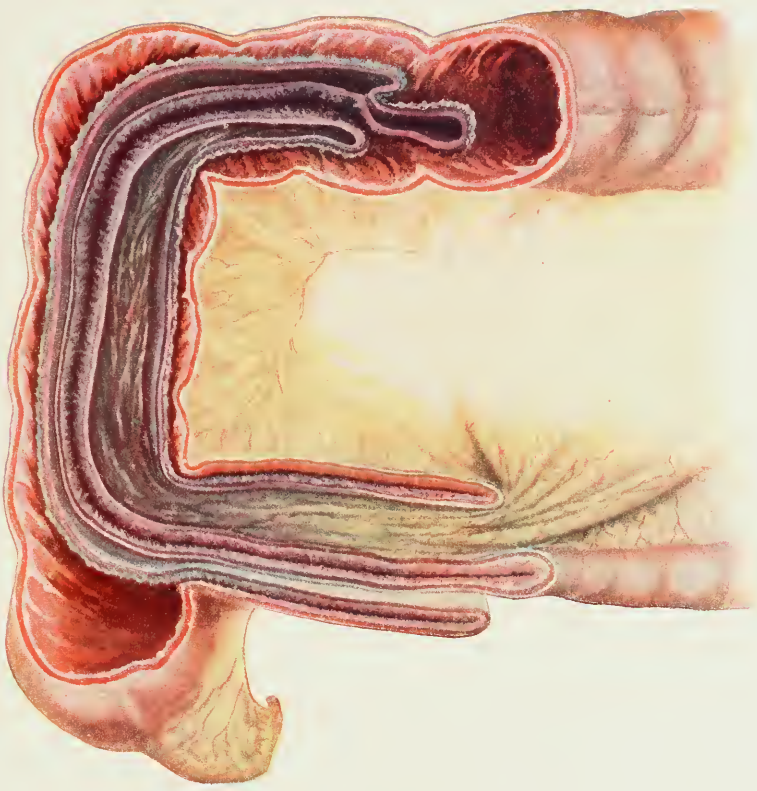
EXPLANATION OF PLATE LI.

Embolism of Both the Superior and the Inferior Mesenteric Arteries.

Fig. 1 shows gangrene of large and small bowel due to embolism of both superior and inferior mesenteric arteries.

Fig. 2 shows location of embolism in superior mesenteric artery, causing gangrene of small intestine.

Fig. 3 shows location of embolism in inferior mesenteric artery, causing gangrene of descending colon.



Sectional View of Extensive Gangrenous Intussusception, due to an Inverted Meckel's Diverticulum

From Dr. R. C. Coffey's Article in "The Annals of Surgery," January, 1907
J. B. Lippincott Company, Publishers, Philadelphia

Success in operations for volvulus, as for other conditions which produce intestinal obstruction, depends to a great degree upon the promptness with which they are carried out. The mortality following operation rises very rapidly in those done after the first forty-eight hours.

When a volvulus is exposed an attempt at detorsion should be made. If the bowel is greatly distended, this untwisting may be impossible until after

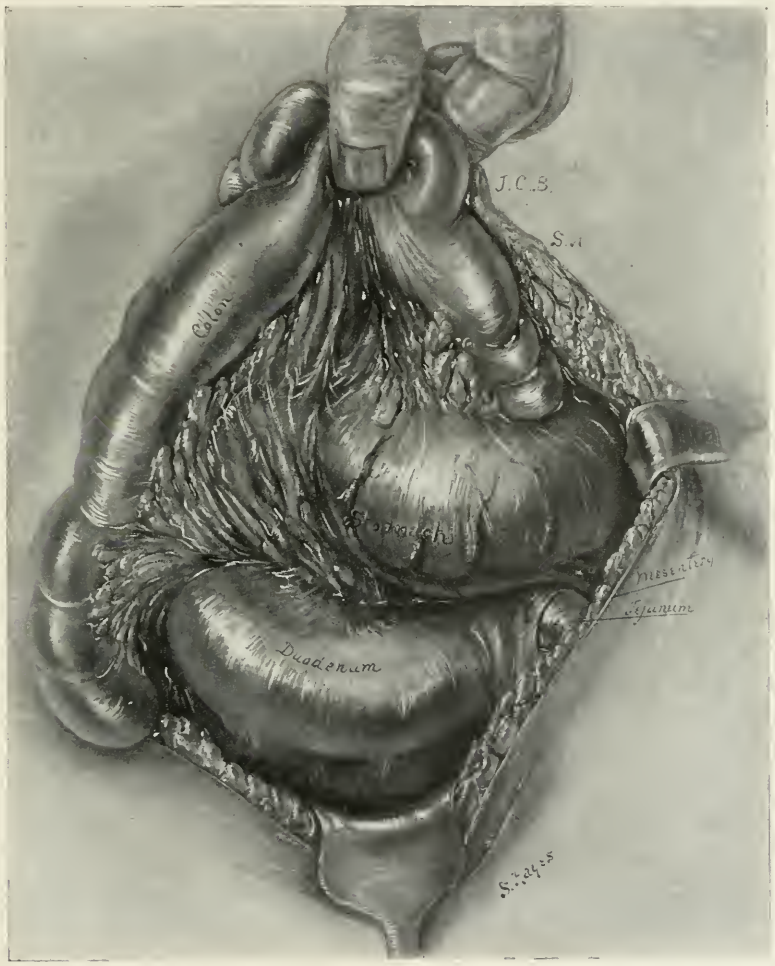


Fig. 279.—The Drawing Shows the Appearances of the Parts in an Acute Dilatation of the Stomach and Duodenum. The structures exposed to view are the stomach, the lower portion of the duodenum, the mesentery and collapsed jejunum, and the transverse colon, which latter has been lifted into view. (From Dr. Joseph C. Bloodgood, in *Annals of Surgery*, November, 1907. J. B. Lippincott Company, Philadelphia, Publishers.)

the contents of the loop have first been emptied through an incision. After detorsion, the bowel should be enveloped in a compress wrung out of hot normal salt solution until the question of viability is settled. If this question still remains in doubt after a reasonable effort in this manner has been made, an enterostomy may be performed or the suspicious loop may be surrounded by

gauze packing just within the wound, to protect the abdominal cavity in case gangrene occurs. If the bowel is already gangrenous, enterectomy will be called for, care being taken to go well beyond the damaged area. An end-to-end or lateral union may be made. If the patient's condition is such that this is not warranted, the ends may be rapidly stitched into the abdominal wound and enterorrhaphy performed later.

If the mesosigmoid is especially long, it may be sutured to the parietal peritoneum as a precaution against recurrence.

Intussusception.—Intussusception possesses the characteristics of both strangulation and obturation.

An intussusception consists of a telescoping of one part of the bowel into another,—an invagination. It is usually downward, but may be ascending. Such an invagination will be found to consist of three tubes, the outer one of

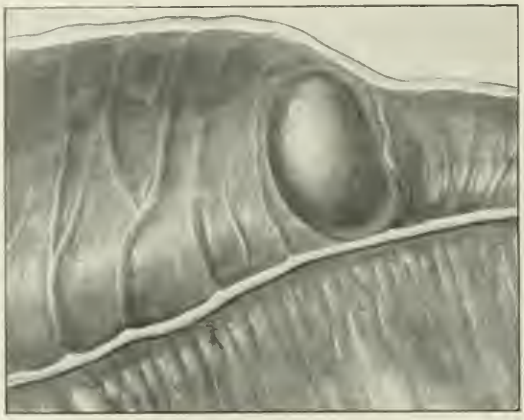


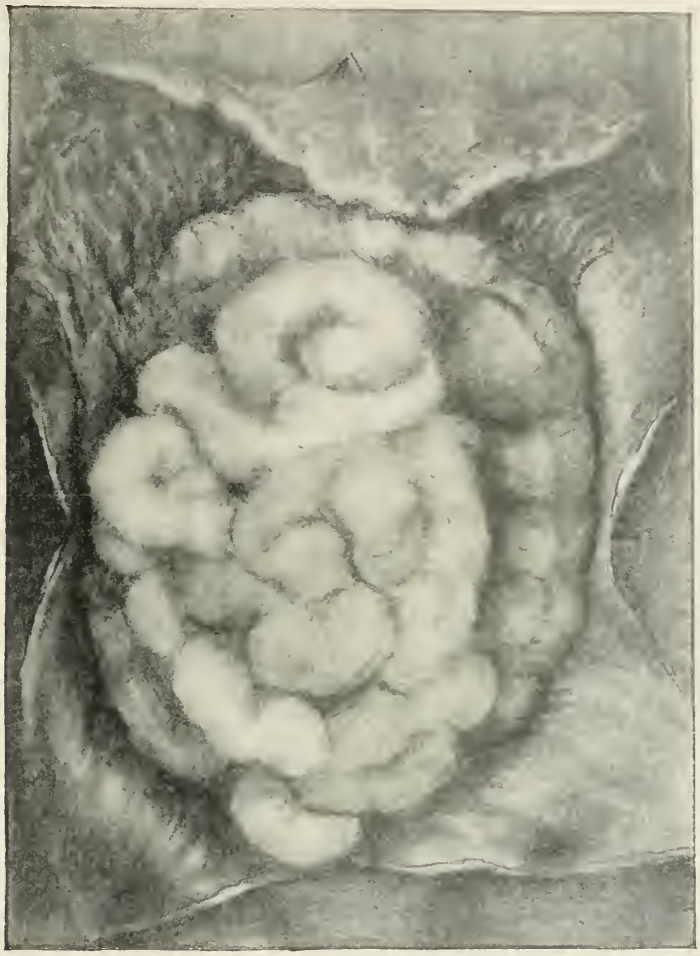
Fig. 280.—The Drawing Shows a Small Fibroid of the Ileum, Located About Four Inches above the Ileo-Cæcal Valve. The presence of this tumor produced obstruction of the bowel, which eventually led to the patient's death. The dimensions of the growth, which sprang from the mesenteric attachment, were: 3.5 cm. x 2.2 cm. x 2.5 cm. The greatest diameter ran in a transverse direction. (From Dewis, in the *Boston Medical and Surgical Journal*, October 18th, 1906.)

which is called the intussuscipiens. The intussusceptum, the part that enters, is again divided into an entering and a returning portion. The point of union of the intussuscipiens and the intussusceptum is known as the neck, and the junction between the entering and returning intussusceptum is called the head or apex. (Fig. 278, and Plate LI.)

The description given above is that of the usual condition, but a double intussusception, in which there are five tubes instead of three, does occur. In one hundred and seventy-five cases collected from the reports of Corner, Wallace, Fagge, and Clubbe, ninety-nine were double.

Triple and even quadruple invaginations have been observed. Hektoen has reported an instance of the latter in which all were of the ascending type and located in the ileum. The condition is especially frequent in children up to the fifth year. In 1,560 cases collected from the literature we find 698 occurring during the first year of life. In 244 cases, 142 of the patients were males and 102 females.

The most common location of an intussusception is at the ileo-cæcal valve,



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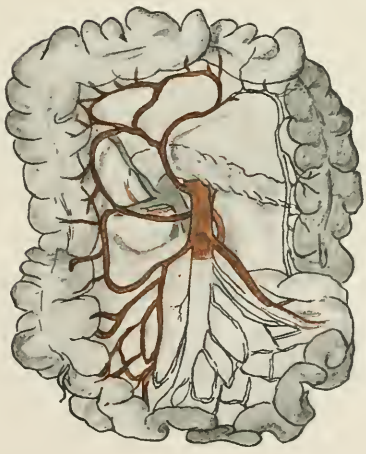

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EMBOLISM OF BOTH SUPERIOR AND INFERIOR MESENTERIC ARTERIES

(From drawings made for the author.)

and when not situated actually at the valve it is usually in its neighborhood, either above or below. When the ileum alone is involved the lesion is usually situated in the lower portion; if the large bowel is the part affected, the invagi-

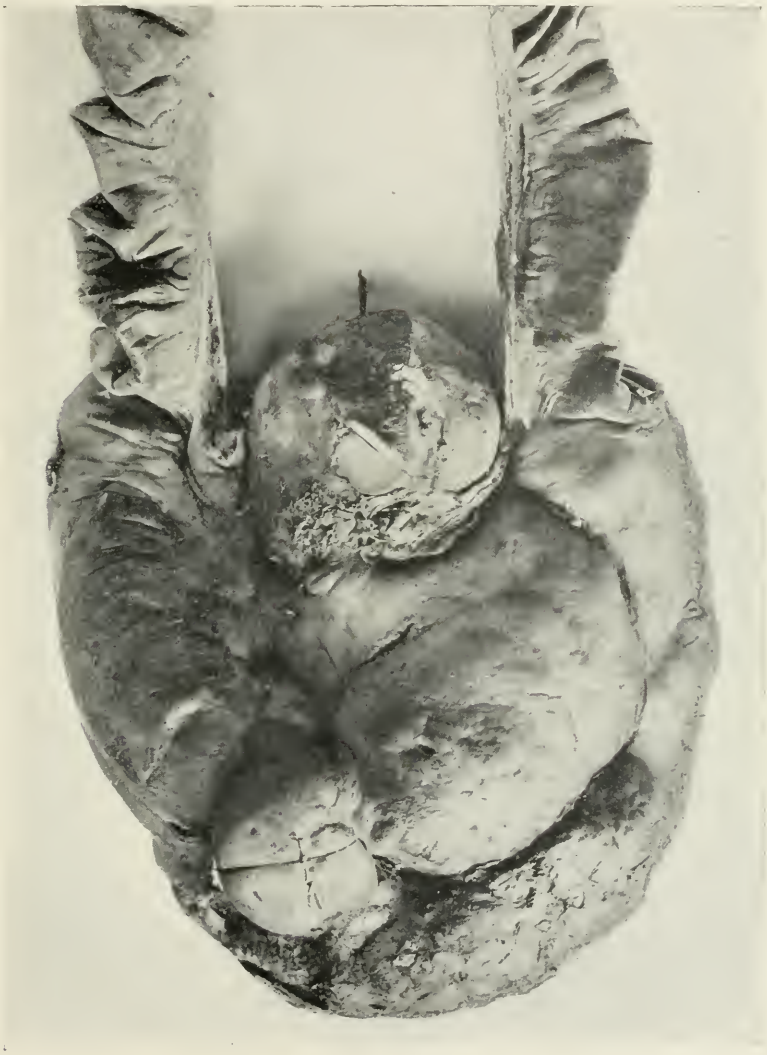


Fig. 281.—Sarcoma of the Small Intestine, in a Boy of Six. A coil of small intestine ran right through the middle of the growth. (From Gilbert Barling, in *Annals of Surgery*, February, 1907. J. B. Lippincott Company, Philadelphia, Publishers.)

nation is generally located in the sigmoid flexure. Intussusception of the rectum or of the duodenum is extremely rare.

The ileo-cæcal is the most frequent variety in infants because of the fact that the cæcum has a comparatively long mesentery in early life. Later, the cæcum becomes more firmly attached to the posterior abdominal wall. There is also a greater disproportion between the size of the ileum and that of the cæcum at this age.

Tumors, usually pedunculated and benign in character, may produce intussusception by their presence within the lumen of the bowel. Malignant disease is rarely a cause, as the thickening of the wall incident to the disease prevents folding of the organ. The invagination of a Meckel's diverticulum may act as an exciting cause. Cheyne reports no fewer than seventeen such cases in 1904, and the list has been added to more recently by Coffey and others. (Plate LII.)

The symptoms of intussusception in general are those of intestinal obstruction. The onset is acute, and is characterized by pain, vomiting, diarrhœa, and tenesmus with blood-stained mucous discharges. Pulse and temperature may be normal, and a palpable tumor may be discovered. Pain in the abdomen is usually the first symptom; it is of a diffuse character and often very severe, becoming localized later. There have been reported numerous cases in which spontaneous sloughing of the invaginated portion of the bowel, resulting in a cure, has taken place. This is said to occur less frequently in children than in adults.

Operative interference can alone be relied upon, and the character of the operation must depend upon the conditions found. In searching for the cause of the condition it is well to bear in mind the possibility of a tumor or a Meckel's diverticulum; and, if such a lesion should be found, it should be removed. It is well to bear in mind that operations upon the intestine in young children are accompanied by a very high mortality, and consequently every effort should be made, in the case of a child, to reduce the invagination without opening the lumen of the bowel.

Obturation.—Obturation is a term used for describing an obstruction of the bowel due to the presence of some neoplasm or foreign substance within its lumen. The blood-supply of the bowel is not interfered with in this condition. Gall-stones and enteroliths have frequently been reported as causes of this condition. Any foreign body of a fairly large size, that has passed through the stomach, may, either alone or in conjunction with impacted fæces, lodge at some particular point in the bowel and produce obstruction.

The symptoms are not so acute nor so pronounced as those of ileus due to strangulation. The onset is gradual, usually without severe pain and with no shock or collapse. Ordinarily, there is increased peristalsis, and later the usual symptoms of complete obstruction manifest themselves.

Treatment consists in the removal of the offending substance by operation. If no change in the structure of the intestinal wall has taken place, a simple enterotomy may be sufficient.

Chronic Intestinal Stenosis.—This condition may vary from a very slight narrowing of the intestinal lumen to an almost complete obstruction. It may exist in any portion of the large or small bowel. Adhesions, cicatrices, tuberculosis, actinomycosis, syphilitic or other granulomata, malignant or benign tumors are among the most common causes of this condition.

In 79 cases of intestinal stricture, Nikoljski found 34 cases (42 per cent) due to tuberculosis; 14 (17.2 per cent) due to carcinoma, and 12 (16 per cent) due

to syphilis. In 2 cases the stricture was caused by the presence of a benign tumor, in 2 it was due to cicatricial tissue, in 1 it followed typhoid, in 1 it resulted from a dysenteric ulceration, and in 15 it was due to unknown causes.

Fig. 282.—Torsion of the Entire Great Omentum. (From Dr. William Fuller, in *Surgery, Gynæcology, and Obstetrics*, August, 1908.)

A, Pedicle or point of constriction above the strangulated omental mass; *B*, greatly stretched adhesions twisted into a slender cord-like structure.

The symptoms of chronic intestinal stenosis are usually insidious and develop slowly, but occasionally they may be entirely absent, the condition being unsuspected until serious symptoms suddenly arise. The time of their appear-

ance and their characteristics depend upon the location of the obstruction. This is especially true in cases of circular carcinoma of the bowel. The stenosis may be multiple.

If the stenosis is located in the duodenum the symptoms will be comparatively late in presenting themselves because of the liquid character of the contents. The nature of the symptoms will depend upon whether the stenosis is located above or below the opening of the common duct. If it is located above, they will be practically the same as those in pyloric stenosis; if below, the presence of bile and pancreatic juice in the vomited matter may be of significance; but unless the stricture is very marked, this point is of little practical value. When the stenosis is situated at the papilla, the symptoms may very closely simulate those of cholelithiasis or of carcinoma of the head of the pancreas. If the stenosis is located in the upper portion of the jejuno-ileum, the

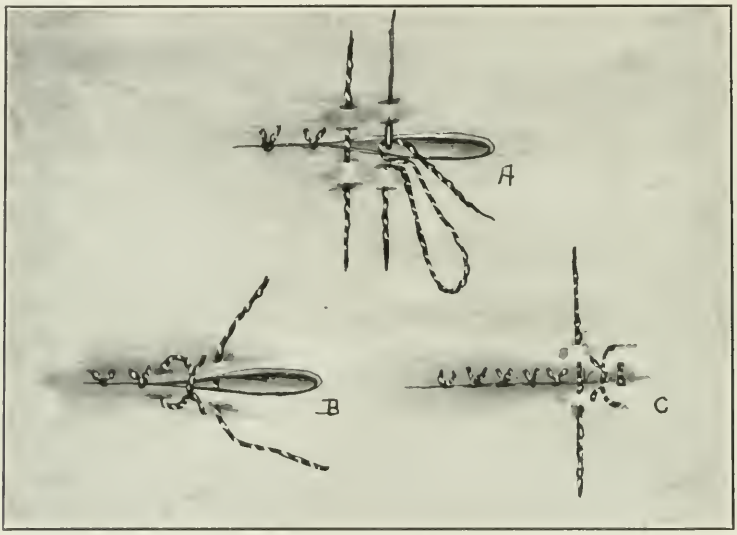


FIG. 283.—Sutures of Different Kinds. (Original.) *A*, Lembert suture; *B*, Czerny suture; *C*, Czerny-Lembert suture.

symptoms may closely resemble those of gastric disorder. They are never of a well-defined character. Those most commonly noted are indigestion, eructation of gas, bad breath, anorexia, coated tongue, sometimes constipation, vomiting, meteorism, colic, and visible peristalsis. The most important symptoms, in their bearing upon the diagnosis, are the attacks of colic and the increased peristalsis. These attacks do not present themselves until the stenosis is considerably advanced. They may last but a few minutes, or they may continue for a number of days, occasionally culminating in an acute obstruction. The attack of pain is usually accompanied by vomiting. The pain in the abdomen may be localized over the stenosis; it may also be general, or it may be located at a remote point.

In the earlier stages the attacks occur at longer intervals, the patient in the mean time being free from symptoms. As the stenosis gradually becomes more

marked the attacks occur more frequently, with symptoms which become progressively more constant, until finally the symptom-complex of complete obstruction is developed. Meteorism is not a frequent symptom, because the gas is able to force its way through even a marked stenosis. During attacks of colic there may be heard, on auscultation, a peculiar hissing sound, due apparently to the passing of gas through the stricture. The

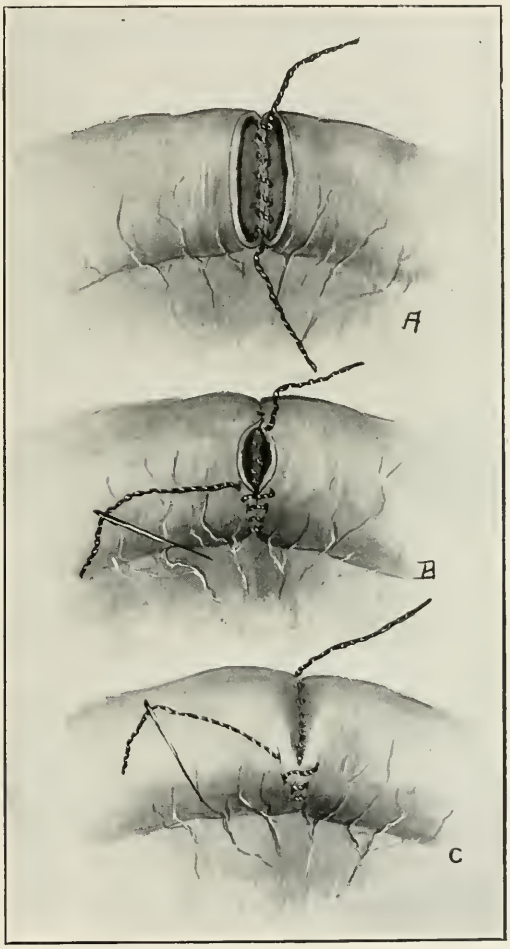


Fig. 284.—Circular Enterorrhaphy; Czerny-Lembert Method.

bowels may move normally even when the stenosis of the small intestine is marked.

In stenosis of the large bowel the symptoms are not greatly different from those noted in stricture of the small bowel, except that, because of the more solid consistency of the contents, they appear earlier. Constipation is more liable to be prominent, but this cannot be relied upon. Diarrhœa may be one of the most conspicuous features of intestinal stenosis and may be very misleading. Quite characteristic, in stenosis of the large intestine, is the alternation of attacks of constipation and diarrhœa, the diarrhœa being caused either

by an ulceration of the mucous membrane or by attacks of catarrhal inflammation due to the irritation of an accumulation of fecal material.

Bibliography.—Nikoljski, in "Volkmann's Sammlung klin. Vorträge," 1903, No. 362.

Gastro-Mesenteric Ileus.—Gastro-mesenteric ileus is a condition only recently recognized and described. In this the stomach and duodenum are greatly dilated by reason of the presence of a constriction at a point where the mesentery, together with the superior mesenteric vessels, passes in front of the duodenum. The duodenum is pinched between the tense mesentery, with its superior mesenteric vessels in front, and the aorta and vertebral column behind.

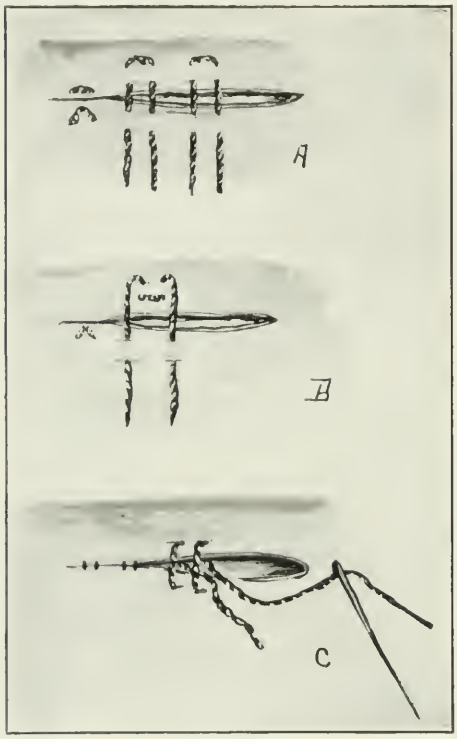


Fig. 285.—Mattress Sutures of Different Styles. *A*, Halsted's; *B*, Gould's; *C*, Connell's.

Connor found, in a record of 69 autopsies in cases of acute dilatation of the stomach, that there was also a dilatation of the duodenum in quite two-thirds of the cases. In an analysis of 120 autopsies in cases of acute dilatation of the stomach, Laffler found 27 cases of this character. In 19 of 38 cases in which the duodenum was dilated, the dilatation stopped abruptly at a point where the duodenum passed behind the root of the mesentery. This condition is favored by any cause which allows the descent of the small intestine into the true pelvis—as, for example, a long mesentery.

The symptoms which generally accompany the condition are nausea, vomiting, pain, gastric distention, constipation, severe thirst, and scanty urine, followed by collapse.

A differential diagnosis between acute dilatation of the stomach and gastro-mesenteric ileus is difficult. A distinction between this form of ileus and other forms, especially high obstruction of the small intestine, is important because of the different treatment demanded. Bloodgood emphasizes the following differential points:—In gastro-mesenteric ileus the initial pain of high intestinal occlusion is absent, being replaced by epigastric distress; in the former the collapse is gradual. The vomiting, fecal in character, is like that of intestinal occlusion. The most characteristic difference between the two conditions is the distention, which, in the former condition, is early marked; it begins at the epigastrium, extends even to the pubes, and is relieved by the use of the stomach tube. In high intestinal obstruction the distention makes its appearance later than in

gastro-mesenteric ileus and does not include the stomach or the duodenum. In dilatation of the stomach the peristalsis, when present, will be seen as a broad wave which travels from left to right, while in the other condition it will be the characteristic ladder wave. The importance of chronic obstruction of the duodenum, as an etiological factor in many gastric, duodenal, pancreatic, and hepatic conditions, has been emphasized by Codman.

The treatment consists in evacuation of the stomach contents, with lavage repeated at intervals. All foods and liquids should be withheld. The pelvis should be elevated or the patient placed in the left lateral posture to prevent traction on the stomach. If these measures fail, gastro-enterostomy may be resorted to. Bloodgood recommends duodeno-jejunostomy or gastro-jejunostomy supplemented by duodeno-jejunostomy. (Fig. 279.)

In operations for acute dilatation of the stomach the duodeno-jejunal angle should always be inspected.

Bibliography.—Bloodgood, in *Annals of Surgery*, Nov., 1907.—Laffler, *ibidem*, March and April, 1908.

X. NEOPLASMS OF THE INTESTINE.

Benign Tumors.—Benign tumors of the intestine are much less frequent than those of a malignant type. In the order of their frequency they occur as follows:—Adenomata, lipomata, myomata, fibromata, and angiomata. The lipomata, myomata, and fibromata frequently present a mixed type.

Adenomata.—Adenomata of the intestine, the most common form, are usually multiple. They may have a broad base, but more frequently they have a narrow pedicle; they vary greatly in size. They occur most frequently in the rectum and large bowel. Dewis collected 127 cases which were distributed as follows: small bowel, 14; cæcum, 2; colon and sigmoid, 30; rectum, 81. There have been reported a number of cases in which these tumors were found scattered throughout the intestine.

Lipomata.—The lipomata may be subserous or submucous; they contain more or less fibrous tissue. They are rare. In 1899 Hillier could collect but twenty-three cases, the majority of which were found in the large bowel. Dewis, in 1905, collected forty-four cases, about equally divided between the large and the small bowel.

Fibromata.—The fibromata arise from the submucosa and are frequently found in connection with lipomata. They are usually polypoid in character.

Myomata.—The myomata originate from the muscular layers, the majority from the outer longitudinal layer, but some may be traced to the circular layer, as in a case reported by Fenger.

True fibromata or myomata are rare. Dewis found only five true fibromata (Fig. 280) and forty mixed fibro-myomata.

Angiomata.—Angiomata of the intestine are extremely rare. They are so rare, indeed, that their occurrence is doubted by some authorities. Nothnagel,

however, states that true angiomata have been observed. Dewis reports three cases—two in the rectum and one in the small intestine.

Symptoms and Diagnosis.—The symptoms of benign tumors of the intestine are usually entirely wanting until their presence gives rise to some form of ileus. The diagnosis is made at the time of operation. Occasionally they may cause hemorrhage or there may be mucous discharges with tenesmus, but they give rise to nothing that is characteristic.

Treatment.—Treatment should consist in excision when the conditions plainly demand it.

Bibliography.—J. W. Dewis, in *Boston Med. and Surg. Jour.*, Oct. 18th, 1906.

Malignant Tumors.—*Sarcoma.*—Sarcoma of the intestine has been considered rare. In 13,036 autopsies held at Prague during the fifteen years prior

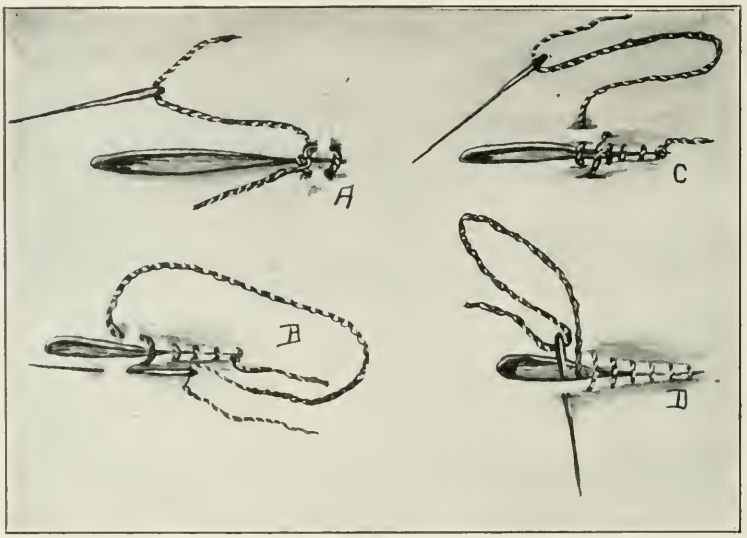


Fig. 286.—Different Kinds of Sutures. (Original.) *A*, *B*, The Cushing right-angle suture; *C*, the Dupuytren suture; *D*, the Connell suture.

to 1898, F. Smoler found 13 cases. It is estimated that carcinoma of the intestine occurs about twenty times as frequently as does sarcoma. In 178 malignant neoplasms of the intestine collected from various sources, we found 11 sarcomata. Sarcoma involves the small intestine more often than it does the large, while the opposite is true of carcinoma. The ileum is the most frequent seat of the growth, which at times is multiple. No age is exempt, but the new-growth is more frequently found in the young,—often during the first decade of life. (Fig. 281.) It occurs in males twice as frequently as in females. It is sometimes congenital. Horn reports the case of a child, three days old, in which the sarcoma had produced intussusception. The usual starting-point is the submucosa, the serosa not becoming involved until late. These new-growths are most frequently of the round-cell variety. When occurring in the rectum, they may be of the melanotic type. The mesentery and omen-

tum are rapidly invaded and metastasis occurs early, the liver and kidney being most frequently involved. The lymph nodes are involved in about one-third of the cases.

A striking clinical difference between sarcoma and carcinoma of the intestine is found in the absence of stricture in sarcoma. The neoplasm infiltrates the

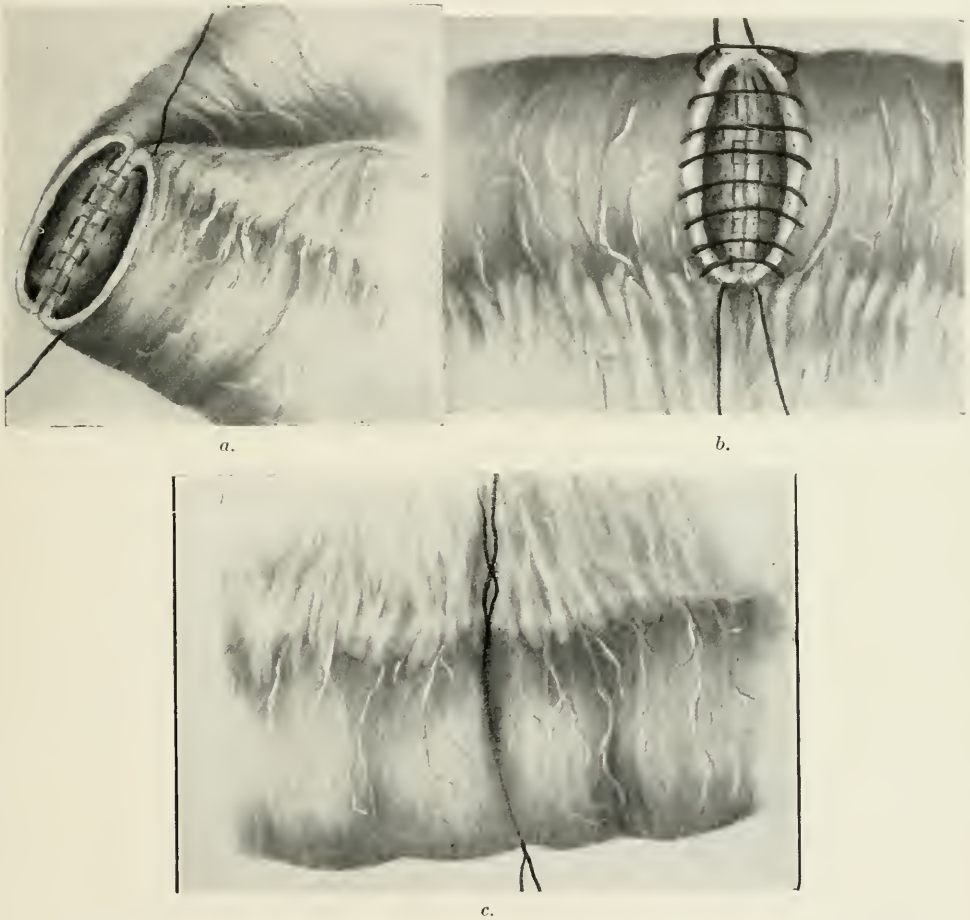


FIG. 287.—These Three Figures Represent the Three Different Stages of Dr. M. E. Connell's Method of Applying the Suture in the Operation of Circular Enterorrhaphy. (Original.)

a, The figure shows the first half completed; *b*, in this figure the second half is completed, but the stitches have not been drawn taut; *c*, the second half is drawn taut, with the ends ready for tying.

wall of the bowel in a longitudinal direction, often producing a dilatation rather than a narrowing of the lumen.

Symptoms.—The symptoms are those common to malignant disease and are often vague and indefinite.

Diagnosis.—The diagnosis must rest upon the clinical picture presented. There may be a palpable tumor, which grows rapidly and is associated with cachexia. The age of the patient and the absence of stenosis may sometimes aid in differentiating the tumor from a carcinoma.

Treatment.—If the case is seen sufficiently early, resection may be made

with a fair promise of success. Moynihan collected forty cases of sarcoma of the bowel which had been treated by operation, and in which twenty-five recovered.

Carcinoma.—In 100 cases of carcinoma of the intestine, ninety-five per cent occur in the large bowel. In 343 cases, 7 were in the duodenum, 10 in the ileum, none in the jejunum, 104 in the colon, and 162 in the rectum. From this it will be seen that over one-half of all carcinomata of the bowel occur in the rectum. Above the rectum the sigmoid is most frequently involved. Then follow, in the order of frequency, the cæcum, the splenic and hepatic flexures, and the descending colon, the transverse and the ascending portions of the colon being less often affected.

Carcinoma of the intestine is usually primary and single. It may occur,

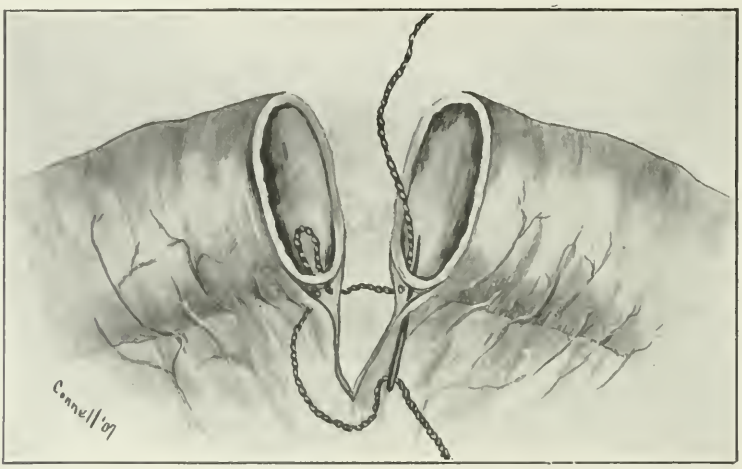


Fig. 288.—Insertion of Mesenteric Stitch which is Intended to Obliterate the Triangular Space. (F. G. Connell.)

however, by direct extension from a neighboring organ; multiple development is rare. The male sex is more frequently attacked than the female.

Carcinoma of the intestine occurs most frequently at the usual cancer age, viz., between the thirtieth and the fiftieth year; but a striking feature of cancer in this location is the fact that it often occurs at a much earlier age than cancer elsewhere.

Carcinoma of the large bowel is apparently one of the least malignant forms of the disease. The tumor usually produces a stenosis rather early. Ulceration of the mucous surface may occur early or late. Perforation does not often take place. The tumor is of slow growth and metastasis generally occurs at a late stage of the disease. Infection of the related lymph nodes or of the liver also occurs at a late stage. Extension through the intestinal wall to some structure or organ in immediate contact with the diseased part of the bowel is unusual.

Symptoms.—Symptoms are always absent for an indefinite period of time, the length of which is difficult to determine. In the small bowel the symptoms

are more obscure than in the large bowel. If the disease is located in the duodenum the symptoms may simulate those of cholelithiasis. There may be merely indefinite, so-called dyspeptic symptoms for some time; in fact, so long as the fæcal current is not interfered with, symptoms may be entirely lacking. In chronic intestinal stenosis the symptoms may persist for a considerable time. An acute ileus may occur suddenly without warning, or it may follow a chronic stenosis. Alternating constipation and diarrhœa, with the discharge of pus and blood, are very suggestive. A tumor may sometimes be palpable. Pain is not a marked symptom. When the tumor is situated low down in the bowel tenesmus may be present.

Nothnagel has called attention to a stiffening of the bowel—"Darmsteifung"—which is visible in intestinal stenosis. This condition was present in sixty

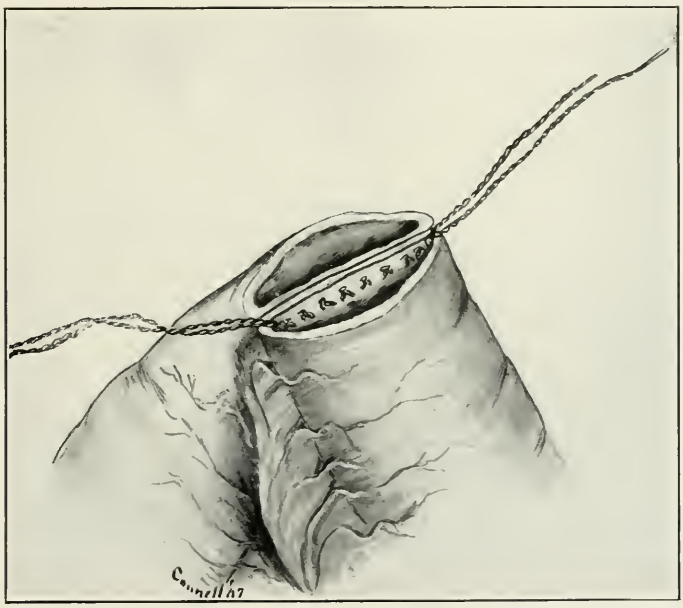


Fig. 289.—Mesenteric Stitch and Stitch at Convex Border Inserted and Tied, with the Ends Left Long for Traction. The intervening stitches are in place. (F. G. Connell.)

per cent of Mikulicz's cases. Willy Meyer has called attention to a contracture which is not objectively demonstrable, but is noticed by the patient only. The sensation, which is not always painful, is called by him "subjective stiffening" of the bowel. He considers it an important point in diagnosing carcinoma of the colon. Meteorism is likewise a symptom of intestinal stenosis; and a continuous loss of weight, not necessarily associated with cachexia, leads to a suspicion of cancer. Ascites is usually a late manifestation, occurring after the peritoneum has become involved.

A slight elevation of temperature (99° or 100° F.) is common in the early stages of carcinoma, even before there is any ulceration. Progressive loss of weight, with increasing anæmia, is very common in carcinoma of the bowel. In suspected cases it is advisable to keep a systematic record of the patient's

weight. Recurrent attacks of colic and constipation, which occur during the so-called cancer age, should always arouse suspicion when they cannot otherwise be accounted for.

Differential Diagnosis.—Sarcoma may possibly be differentiated from carcinoma by the absence of stenosis and the younger age at which it often appears; by the more rapid growth and larger size of the tumor; by the earlier development of cachexia; and by the more severe and more constant pain. A benign tumor may, at times, closely simulate a carcinoma.

In the presence of a tumor in the ileo-cæcal region it will often be a difficult matter, before an exploratory section is made, to differentiate the following conditions, the one from the other: chronic appendicitis, tuberculosis, actinomycosis, a diffuse retroperitoneal or subperitoneal cellulitis, an encapsulated exudate, a cancerous growth, or a chronic intussusception. And even after

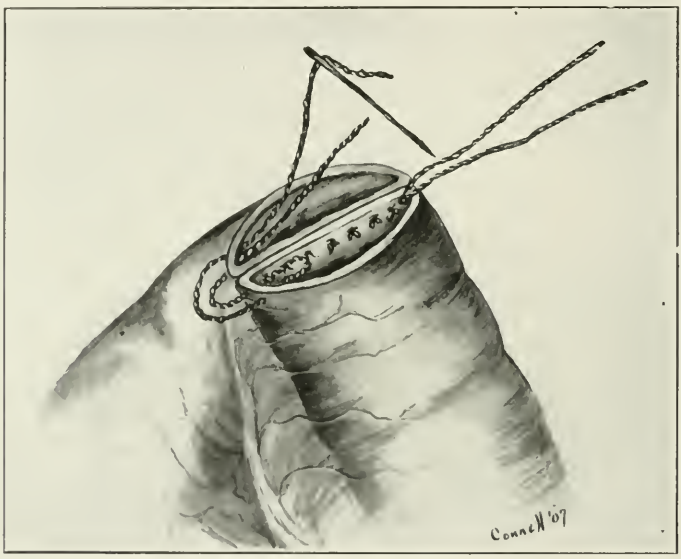


Fig. 290.—First (Posterior) Half Completed, with the First Stitch in Second (Anterior) Half Inserted, Ready for Tying. (F. G. Connell.)

the abdomen has been opened, and the suspicious part has been exposed to sight and touch, difficulty may still be experienced, except in the case of the two conditions last mentioned. An examination with the microscope will sometimes be necessary before an exact diagnosis may be arrived at.

When the tumor is in the sigmoid region, cancer may be confused at first with a sigmoiditis or with a diverticulitis, or, more rarely, with masses of fecal matter. Tumors of the hepatic flexure must be differentiated from an enlargement of the gall-bladder, as well as from a movable kidney or a tumor of that organ or of the liver. In the case of a tumor at the splenic flexure, the kidney must be kept in mind and also a possible misplacement of the spleen. Carcinoma of the duodenum or the papillæ must be differentiated from stones in the common duct.

Prognosis.—Cancer of the colon is less malignant than cancer elsewhere in

the digestive tract or in other portions of the body. Hence the necessity of an early diagnosis and removal. Carcinoma of the stomach, at the time when a palpable tumor exists, is usually inoperable. A palpable carcinoma of the colon, however, is still operable. Dr. C. H. Mayo says that the large bowel is the natural absorber of liquids, through capillaries and not through lymphatics. The large bowel is very deficient in lymphatics as compared with the small. Over one-half of those who die of cancer of the large bowel do so from obstruction, perforation, peritonitis, and liver involvement, while the lymphatic system still remains free from the disease. Cancer in this locality is distributed by continuous extension from one tissue to another, by the portal system, and by being grafted upon the moving omentum and intestines. It is also distributed to some extent by the ordinary route of the lymph channels.

Treatment.—The treatment is surgical. If a radical operation is performed

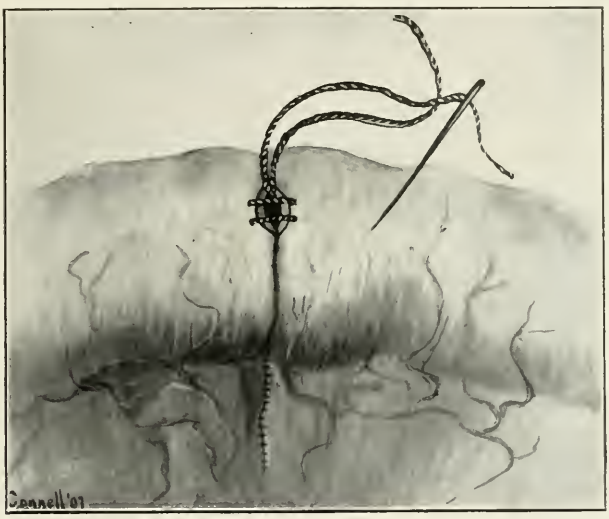


Fig. 291.—The Stitches Similar to the Ones Shown in Fig. 290 have been Inserted Throughout the Anterior Half and have All been Tied except the Last One. This stitch is in place, with the ends ready for tying. (F. G. Connell.)

early, the result will often be satisfactory. Cases in which the diagnosis is made when the abdomen is opened for other conditions, as for appendicitis, offer the best chance of a permanent cure because of the opportunity afforded for early removal.

Treatment may be either radical or palliative. The radical method consists in the complete removal of the tumor by an operation, whereas the palliative method stops short of complete removal of the growth. The latter can do no more than alleviate some of the symptoms, usually those of obstruction.

The ideal operation consists of a resection of the tumor with mesentery and lymph nodes and a liberal removal of apparently normal tissue, followed by reestablishment of the intestinal canal. In other cases anastomosis will be impossible or impracticable. Resection may be performed, but immediate union of the cut ends may seem inadvisable. Under such circumstances the open ends

of the bowel are sutured together throughout two-thirds of their circumference, exactly as in end-to-end union; the parallel pieces of bowel are next sutured together by a row of stitches at each end of the surfaces which are held in sero-serous apposition for a distance of three or four inches. In this way sero-serous apposition is obtained for about one-half of each bowel circumference. A small abdominal opening is made at a suitable point and the apposed bowel ends are drawn into this incision and secured in place; after which the larger original abdominal wound is closed. After the lapse of from ten to fourteen days a heavy forceps is inserted in the artificial anus, one blade into each portion of the bowel, and the instrument is then locked. The clamp is tightened each day until it cuts its way through the wall of the proximal and distal ends. The

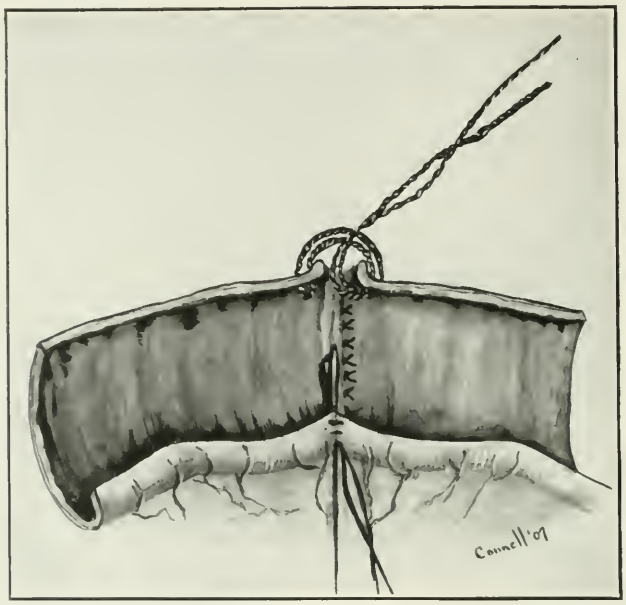


FIG. 292.—The Threaded Needle is Inserted, Eye First, Between Two Stitches, into the Lumen of the Intestine, at a Point in the Circumference About Opposite to the Stitch which is to be Tied. (F. G. Connell.)

external fistula may be closed at any time after the patency of the intestinal lumen has been demonstrated.

In cases which are not in such a condition of health as to permit resection, the operation may be carried out in two steps. In the first step a lateral anastomosis is performed without a removal of the growth; the tumor will thus be short-circuited, and the flow of intestinal contents will not pass over or through the tumor mass. At a second operation the tumor mass may be removed and the two open ends closed, the previous lateral anastomosis allowing the intestinal current to flow uninterruptedly.

The "Vorlagerungsmethode" of Mikuliez may be indicated in certain cases. According to this method the vessels supplying the tumor are ligated, the tumor itself and the lymph nodes are delivered through the abdominal wound,

and then the latter is closed. The bowel outside of the abdomen is protected by warm compresses, and after the lapse of from thirty-two to seventy-two hours, when adhesions have formed between the visceral and parietal peritoneal surfaces, so as to exclude the general peritoneal cavity, the tumor is removed by cautery without the aid of an anæsthetic. In this way there is established an artificial anus, which is subsequently closed after the division of the spur by the Mikulicz enterotribe.

In extreme cases where the least amount of operative interference is desirable, the following steps may be performed:—

(*a*) Enterostomy under local anæsthesia.

(*b*) Lateral anastomosis with or without removal of the tumor.

(*c*) If the tumor was not removed in the second, it is removed at the third step.

(*d*) Closure of the artificial anus.

As palliative operations may be mentioned: the establishment of a lateral anastomosis, to relieve the stenosis, and then closure of the abdomen, no attempt being made to remove the tumor at any time; or, in very late cases, with acute obstruction, the establishment of an artificial anus, for immediate relief.

Prognosis.—The prognosis depends upon the extent of the disease at the time of interference. In one hundred and thirty-eight patients operated upon for cancer of the large intestine, at the Mikulicz clinic, from 1891 to 1906, a very large proportion were inoperable when first seen; twelve per cent did not survive the operation; and fifty per cent were permanently cured by the operation. In fifty-six cases collected in 1903, thirteen (or twenty-three per cent) had passed the three-year limit without recurrence.

XI. DISEASES AND INJURIES OF THE OMENTUM.

Anatomy and Physiology.—The omentum is composed of white fibrous and yellow elastic connective tissue, with masses of fatty tissue, arteries, veins, lymphatics, and lymph spaces. Frequently there are areas of germinating endothelium which are supposed to be the source of many lymph corpuscles or leucocytes. This structure is limited by peritoneal reflections; it extends from the posterior abdominal wall and is attached to the greater curvature of the stomach, the transverse colon, and the gastro-hepatic ligament, from which it extends toward the pelvis. At all other points in the peritoneal cavity it is normally unattached.

In many cases the omentum does not descend toward the pelvis, but may be found drawn up under the transverse colon; it may be found in almost any part of the abdominal or pelvic cavity. The position of the omentum depends, not only on its length, but also upon the position of the greater curvature of the stomach.

Among the functions of the omentum may be mentioned: the temporary

storage of fat, blood, and lymph; the absorption of fluids, bacteria, and foreign bodies; the formation of protective adhesions; the furnishing of phagocytes; the prevention of hernial protrusion of viscera; the prevention of torsion of

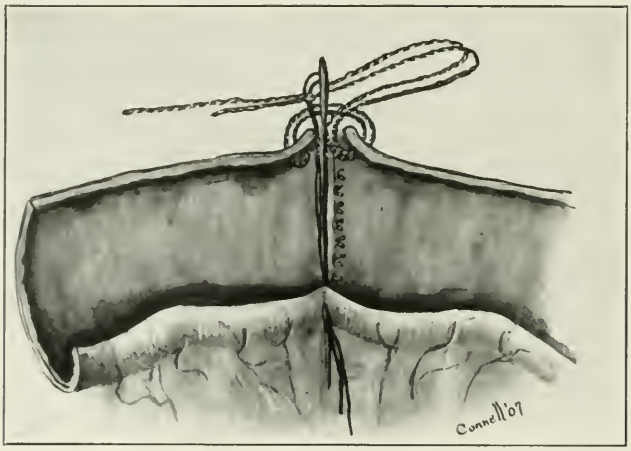


Fig. 293.—The Threaded Needle Presents Itself at the Location of the Last Stitch. The ends to be tied are inserted into the loop formed by the needle and its thread. (F. G. Connell.)

the small intestine; and the providing of a collateral circulation to tumors or viscera the blood-supply of which has been interfered with.

Pathology.—The most common pathological conditions of the omentum which demand surgical treatment are inflammation, cysts, or neoplasms. Inflammation of the omentum (epiploitis) is usually secondary to a primary

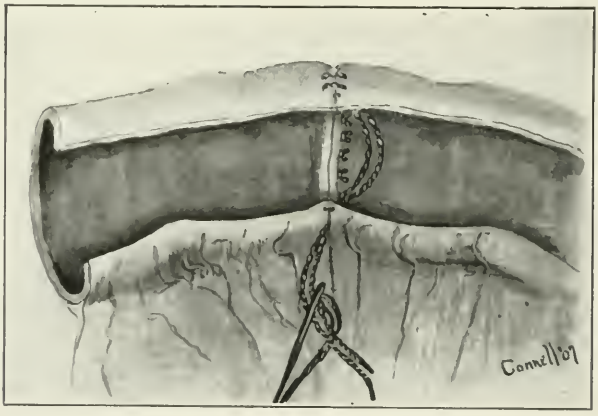


Fig. 294.—By Withdrawal of the Needle and its Loop, the Margins of the Cut at the Site of the Last Stitch are Inverted, and the Ends to be Tied are Drawn to the Outside Through the Opposite Portion of the Line of Suture. (F. G. Connell.)

inflammation elsewhere. Abscess of the omentum is usually secondary, and, because of adhesions, is not easily differentiated from other intra-abdominal abscesses.

Trauma.—Injury to the omentum most frequently occurs during operations for hernia, for appendicitis, or for other conditions in which, owing to the

fact that the omentum has become adherent, partial resection is necessary before the operation may be completed. The symptoms may be very late in making their appearance and simulate those of appendicitis with a localized swelling. Resolution may occur or the inflammation may go on to suppuration

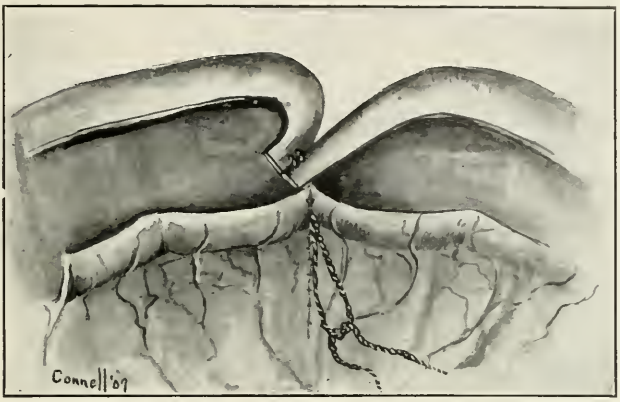


FIG. 295.—Traction on the Ends of the Suture Causes the Site of the Future Knot to Come in Contact with the Mucosa of the Opposite Side of the Bowel. The ends are tied, the knot sinks between the previously inserted stitches and is located on the mucosa. (F. G. Connell.)

and abscess-formation, with rupture either into the intestine, into the peritoneal cavity, or through the abdominal wall.

Accidental trauma may occur either with or without an abdominal wound, and may consist of a complete tear, a puncture, or a mere bruising or crushing of the structure. It is usually associated with injury to other viscera.

In resection of portions of the omentum, it is advisable to crush the line of

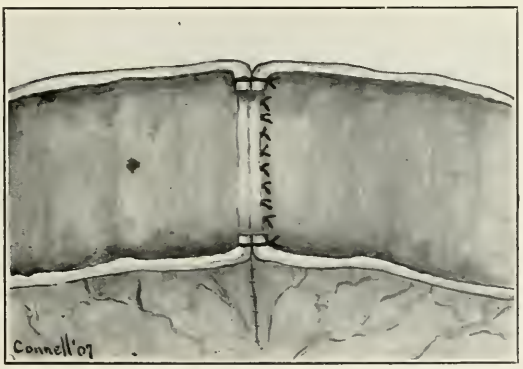


FIG. 296.—The Last Knot Has been Tied, the Bowel has Resumed its Cylindrical Contour, and the Enterorrhaphy is Complete, with all Knots in the Lumen. (F. G. Connell.)

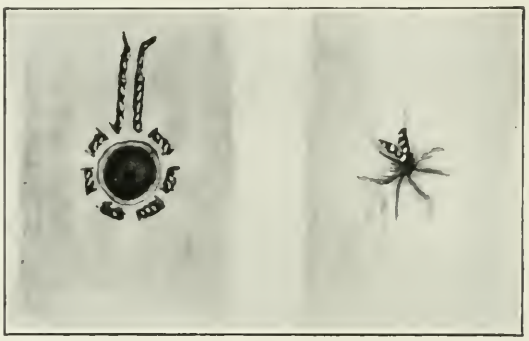
division before applying a ligature. By so doing the fat is forced away so that the ligature shall include only the dense connective tissue and the blood-vessels. The omentum should not be bunched up in one ligature and tied; it is preferable to employ a number of interlocking ligatures. Raw surfaces and stumps should be buried and covered by serous surfaces.

The omentum is very vascular and will, for that reason, withstand a severe trauma. But, because of the rather liberal blood-supply and the loose areolar tissue surrounding the blood-vessels, there is a marked tendency to the formation of a large hæmatoma.

Torsion of the Omentum.—Torsion of the entire great omentum is quite rare. The first case was published in 1882, by Oberst, and the second in 1893; since then it has been noted with increasing frequency. In 1907 Lejars collected sixty-six cases of this condition.

Before torsion may occur there must have been a preceding matting together of the omentum, or it must have become adherent to the abdominal wall. It may occur either with or without an associated hernia; in only seven of the reported cases was there an absence of hernia. The condition is usually mistaken for an appendicitis, a strangulated hernia, an intestinal obstruction, or peritonitis.

Lejars was the first to diagnose accurately such a condition before operation,



a. *b.*

Fig. 297.—Purse-String Suture. *a*, Suture in position, ready to be drawn taut; *b*, suture drawn taut and the ends tied.

and this was made largely upon the mildness of the symptoms with the presence of a palpable, doughy, non-fluctuating mass in the right iliac region.

Treatment will consist of either detorsion or amputation, usually the latter.

Accessory Omenta.—Accessory omenta do occur, and in one case reported by Cullen, the accessory structure was strangulated by twisting.

Cysts and Other Tumors of the Omentum.—R. E. Fort has collected twenty-two cases of cyst of the omentum. They are most common in female children under ten years, and are considered to be of congenital origin. Two dermoid cysts and one of traumatic origin are included in the number. Omental cysts present no characteristic symptoms.

Primary tumors of the omentum are rare. Carcinoma of this structure is never primary. Cases of fibroma, lipoma, and sarcoma have been reported.

Since 1870, according to Farrer Cobb, in the Reports of the Massachusetts General Hospital, there were fourteen tumors of the omentum, all but two being secondary. The two primary tumors were sarcoma—one a myxo-sarcoma

and the other a fibro-sarcoma. Bonamy has collected sixteen cases of primary sarcoma of the omentum, eleven of which were of the spindle-cell variety.

The symptoms of a cyst or of a tumor of the omentum are vague and are commonly due to pressure. A tumor is usually palpable and is located in the region of the umbilicus; and, if it is not adherent to the abdominal wall, it will move freely in all directions except downward. Ascites is common.

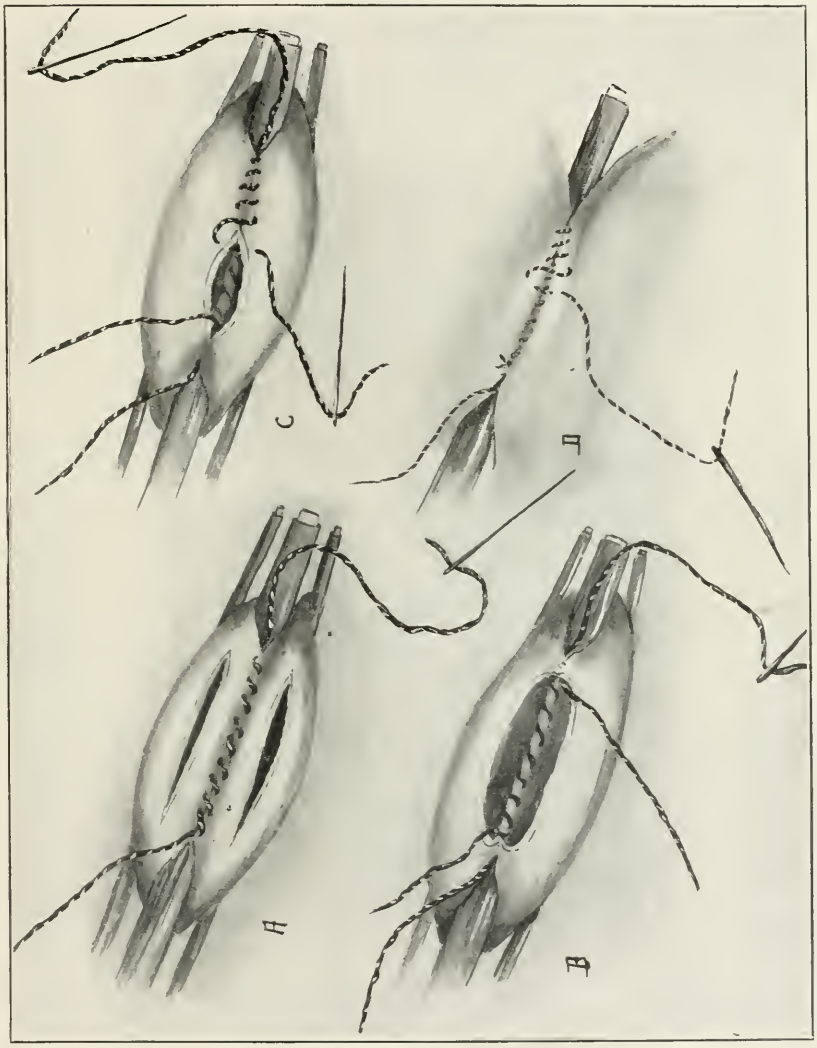


FIG. 298.—Lateral Anastomosis; Czerny-Lembert Method.

Treatment will consist of wide excision.

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XII. DISEASES AND INJURIES OF THE MESENTERY.

Slight injuries to the mesentery may result seriously by interfering with the blood supply of the intestines. In penetrating abdominal wounds, injury to the mesentery may be the most serious lesion. Hemorrhage from a divided or injured mesenteric vessel may prove rapidly fatal. This fact argues strongly for immediate operation in penetrating wounds of the abdomen.

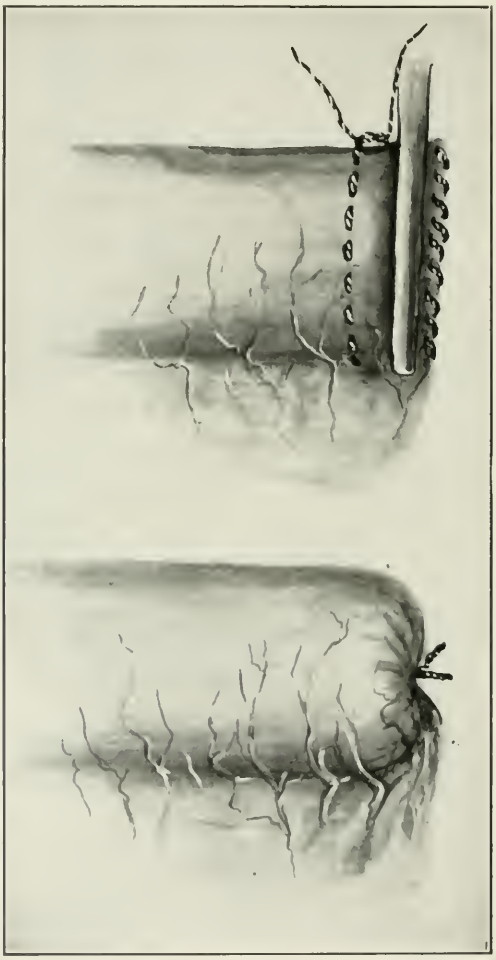


Fig. 299.—Method of Closing the Cut End of the Intestine. (Original.)

Serious injury to the mesentery may occur by contusion, without a penetrating wound. The blood-supply to the bowel may be thus sufficiently interfered with to produce subsequent gangrene. In such injuries a diagnosis is impossible before an abdominal section is made. In a patient who has received a severe blow on the abdomen and where there are distinct rigidity and pain, it is always safer to resort to abdominal section than to wait for more definite symptoms to develop.

Inflammation—mesenteritis—is frequently caused by a primary inflammation of the intestine.

Mesenteric cysts have been divided by Dowd into embryonic, hydatid, and malignant. The embryonic may originate in the intestinal wall, usually from the submucosa or the subserous layers. Or they may be snared off portions of the intestinal wall or diverticula. Cysts of the mesentery may result from the formation of a hæmatoma. They may also originate from the retroperitoneal structures or from fœtal remnants such as dermoids, remnants of the Wolffian or Muellerian ducts or bodies, Remak's diverticulum, and accessory pancreas or adrenals. They may also originate in structures originally and normally within the mesentery.

Chylous cysts are not common. Porter collected twenty such cases and, in

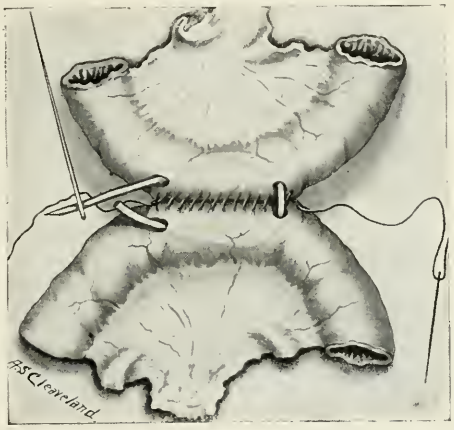


Fig. 300.—McGraw's Method of Gastro-Intestinal and Entero-Intestinal Anastomosis. The drawing shows the manner of introducing the elastic ligature into place. (From Bryant's "Operative Surgery," D. Appleton & Co., New York, Publishers.)

doing so, he noted twenty-nine cases of simple serous cysts. Chylous cysts are usually due to an accumulation of chyle in a preformed cyst.

Parasitic cysts, hydatid cysts, of the mesentery are not so rare. In 1899 no fewer than twenty-nine cases were collected, and since then many new cases have been reported. Cystic tumors occur twice as often as solid tumors.

Malignant cysts are more commonly sarcomata than carcinomata.

Non-malignant cysts may occur at any age, their size varying from those which are minute to cysts weighing as much as forty pounds. They are usually single, but may be multiple. They are apt to be confused with ovarian or broad-ligament cysts. Vaginal examinations with the patient in the Trendelenburg position will usually clear the diagnosis.

The cyst may be enucleated or attached to the abdominal wall and drained. It may, however, be so situated as to make resection of the bowel necessary. It is stated that twenty-five per cent of these cases are cured by simple aspiration.

Solid new-growths (primary) of the mesentery are not common. Secondary malignant growths may follow malignant disease of any intra-abdominal organ.

Vance reviewed the literature up to 1906 and found 27 cases of solid tumors of the mesentery that were operated upon; 33 per cent of these were malignant. The variety of tumors was as follows: Fibromata, 9; sarcomata, 7; lipomata, 2; myxo-fibromata, 2; carcinoma, 1; lymphangioma, 1; tuberculosis, 1; cholesteatoma, 1; hæmatoma, 1; myxoma, 1; large spindle-cell tumor, 1.

The ages of the patients were between four and seventy; the majority were between thirty and forty-five years. These tumors were noted in the female sex sixteen times and in the male eleven.

Bowers found lipoma the most rare of all the varieties. He collected twenty-three reported cases of fibromata and fibro-myomata of the mesentery which had been removed by operation, with seventeen recoveries and six deaths.

In Vance's 27 cases, which included all varieties of tumors, there were 16 recoveries and 11 deaths. The mortality rate in 7 sarcomata was 100 per cent, and in 9 fibromata it was 20 per cent.

Bibliography.—C. M. Dowd, in *Annals of Surgery*, Philadelphia, October, 1900.

XIII. FORMS OF CHRONIC PERITONITIS.

Actinomycosis of the peritoneum is a chronic affection secondary to intestinal or pleural actinomycosis. Until the ray-fungus is discovered in the discharges the diagnosis is rarely made. It most commonly follows intestinal actinomycosis, and the signs, symptoms, and treatment differ in no important particular from those of the intestinal lesion.

Carcinoma of the peritoneum may be localized or it may occur in the form of a general peritoneal carcinomatosis; it is secondary to primary carcinoma elsewhere, its clinical manifestations being overshadowed by those of the primary lesion.

Chronic peritonitis may be exudative or adhesive. The exudative form is markedly similar to the tuberculous form, so much so that some authorities consider them to be the same. The exudative and the adhesive forms may be combined.

The adhesive form of chronic peritonitis may be localized or diffuse. When localized it may be the result of trauma, such as is inflicted by many operations in the abdominal region. It often occurs at hernial sites or it may follow an acute or subacute peritonitis which may have originated in the female genito-urinary tract or in the gastro-intestinal tract. The female pelvic organs probably furnish the most frequent route of infection, the intestine being the next most frequent. The ileo-cæcal region, the gall-bladder, and the neighborhood of the sigmoid flexure are locations where local peritonitis very often occurs.

In certain conditions, the etiology of which is not definitely determined, a combination of the adhesive and the exudative forms may be present, and with this peculiar form of peritonitis is associated a similar inflammation of some

other serous membrane—most frequently the pericardium. To such a condition has been given the name "multiple serositis."

In diffuse adhesive peritonitis all the abdominal viscera are gathered into a mass, and this mass usually is adherent to the parietal peritoneum. There may or may not be an exudate.

The symptoms will be those of tumor and chronic intestinal stenosis. Treatment is very unsatisfactory, as breaking of the adhesions is usually followed by a recurrence.

Chronic adhesive sclerosing peritonitis, or plastic peritoneal sclerosis, is quite a rare condition. It is characterized by a marked connective-tissue in-

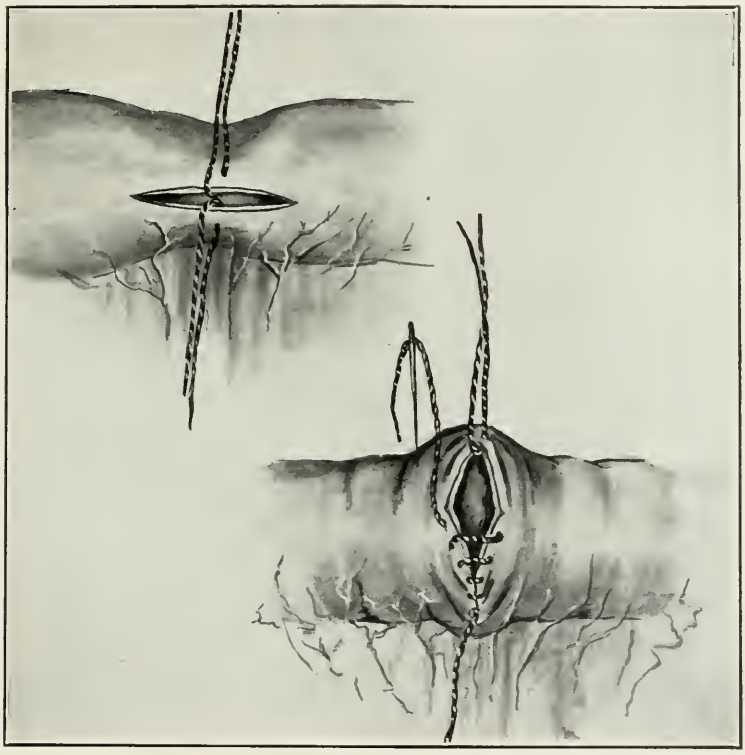


Fig. 301.—Enteroplasty. (Original.)

filtration of the peritoneum, with contraction and thickening but without any exudate or ascites. It may follow an acute peritonitis, or it may be chronic from the start. It begins usually at the customary sites of a chronic peritonitis. Wetherill reports one of the very few cases that have been observed in this country, and he states that the condition is primarily not a peritonitis at all, but a distinct affection of the subperitoneal fibrous or connective tissue. He considers the fact that it is not practicable, in an abdominal section upon a person thus affected, to secure union between the opposite edges of the thickened and shrinking peritoneum, as pathognomonic of this disease. The well-marked subendothelial connective-tissue hyperplasia is the principal patho-

logical feature of the disease, and the shrinking or contracture of the peritoneum caused by it is its leading characteristic.

A localized, encysted exudate may be very difficult to differentiate from this disease. Paracentesis abdominis will generally decide the diagnosis.

The treatment is unsatisfactory, and the condition seems to be augmented by operative interference. Medical treatment may be of some service in removing the cause of the symptoms. Where it proves of no avail, tapping of the abdominal cavity and withdrawal of the fluid will constitute the palliative surgical treatment.

XIV. OPERATIONS ON THE INTESTINES.

General Principles.—The principles governing operations for intestinal repair, in injury or in disease, are few and easily understood. The technical details necessary for the application of these principles call for exact and painstaking methods, together with a degree of surgical dexterity which is to be obtained only by experience. It is in this particular field that operations on the lower animals are of the greatest value in developing the necessary degree of skill.

The first essential in any operation upon the intestine—whether in the repair of the smallest perforation or in the excision of a portion involving the entire circumference of the bowel—is to secure a firm, water-tight approximation of the apposed serous surfaces, and the inverting of the cut edges. Many varieties of suture and mechanical aids have been devised, all of which, from the original Lembert suture to the Murphy button, are based upon this principle of the necessity of approximating serous surfaces. A point of equally great importance is the necessity of securing, by a study of the distribution of the mesenteric vessels, an adequate blood-supply for the field of union.

Strict asepsis should be maintained, and all viscera and free surfaces, except the immediate field of operation, should be protected from exposure, or from infection through escaping bowel contents, by means of compresses wrung out of warm normal salt solution. If much handling of the intestine is necessary in seeking the seat of injury or disease, it should be done with the utmost gentleness, especial care being taken to make no traction upon the mesentery.

The Various Sutures Employed.—The Lembert suture is made by inserting the needle through the two outer coats in such manner that, when the thread is tied, there will be an inversion of the cut edges and a coaptation of the serous surfaces over an extent corresponding to the distance between the needle punctures. Czerny supplemented the Lembert suture by first placing a row at the cut edges, the needle passing through all the coats of the bowel; after which he placed the sero-serous sutures. (Figs. 283 and 284.)

The Halsted quilt suture (Fig. 285, *A*) and the Cushing continuous right-angle suture (Fig. 286, *A* and *B*), are merely modifications of the same principle.

The original Connell suture (Fig. 287), devised by M. E. Connell, con-

sists of two through-and-through right-angled continuous sutures which are inserted as follows:—In enterorrhaphy the divided ends of the intestine may be held in apposition by suspension loops while the sutures are being placed or, as in lateral anastomosis, rubber-covered forceps may be used for this purpose. The needle enters at the convex margin of one end—or under one angle of the wound, if the operation of lateral anastomosis is being performed—and is made to pierce all the coats. It then passes at a right angle through all coats of the two approximated cut edges and back again, the space between any two needle punctures being about one-eighth of an inch and the punctures themselves being made at about the same distance from the cut edges. This mode of suturing is continued until the opposite extremity of the wound is reached, when the needle is made to pierce the bowel, from within outward, at a point exactly opposite that at which the first suture was introduced. The free ends of this suture are now caught with the forceps, and another needle, armed with a thread of proper length, is employed for suturing the second part.

In the second part of the operation the fresh needle is introduced, not into the same loop in which the needle used in the first part was introduced, but into the opposite one. It is made to enter this second loop at a point directly opposite that where the first suture was introduced. The needle is made to penetrate from without into the lumen of the intestine. The new suture is then carried across to the first loop in a direction parallel with the original suture. Next, the needle is introduced at a right angle with the first puncture and is carried out through all coats of the unsutured side of the bowel. It is then carried over to the opposite unsutured edge and introduced first from without inward and then from within outward; then it is once more carried to the opposite side; and this manœuvre—first over, then inward, and finally out again—is repeated until the end of the cut surface is reached, the last step being to carry the needle from within outward, on the same side with the first suture inserted, at a point exactly opposite the point of starting, and in a direction parallel with the termination of the first suture. If the forceps is now removed and the free parallel ends are drawn taut, a complete inversion of the cut edges will take place. The free arms of the suture at either pole are now tied, care being taken that puckering of the parts does not take place. The knots are drawn down between the fold of the serous surfaces. This suture makes it possible to obtain a through-and-through union, with perfect approximation of the margins of the serosa.

In our personal work we have employed this suture for over twenty years, and it has given us so much satisfaction that we prefer it to any other of which we have knowledge.

With the object of removing the theoretical objection of a perforating stitch being knotted on the serosa, F. Gregory Connell has so modified the suture that the knot is within the lumen on the mucosa. As described by him the suture may be either interrupted or continuous; the interrupted form is shown in the accompanying illustrations. (Figs. 288 to 297.)

Mechanical Substitutes for Sutures.—The numerous mechanical aids that have

been devised for approximation of the edges of an intestinal wound, have played their part in the evolution of surgery of the intestine, but the Murphy button alone has stood the test of time and is now practically the only one in general use. (Fig. 128, page 363.)

While most surgeons of experience agree that some type of suture forms a more nearly ideal method of securing intestinal union, it must be admitted that the button holds a legitimate place in the armamentarium of the surgeon. The simplicity of the contrivance and the ease with which it can be applied make its employment a much safer method than suturing in the hands of those of limited experience. In cases where a rapid completion of an operation is imperative it is often of great value, not only in other parts of the intestinal canal, but also in such locations as the sigmoid flexure and the rectum, where suturing would be especially difficult.

The mode of applying the button is so well shown by the illustration that a detailed description is unnecessary. It may be used with equal advantage

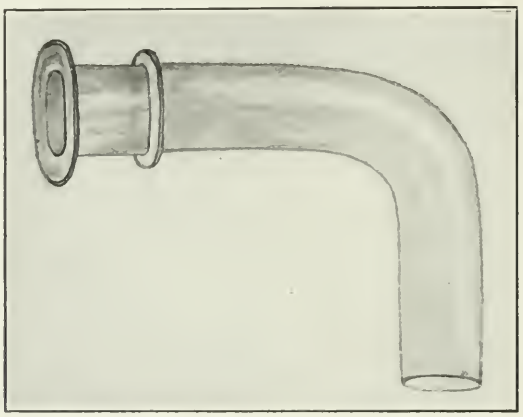


Fig. 302.—Mixter's Tube.

in end-to-end and end-to-side union and in lateral approximation. The oblong button is especially useful in lateral anastomosis.

Suture Material; Needles.—The suture material used in intestinal work may be either silk or linen. The needles are preferably the ordinary sewing needles of extra length, so that they may be comfortably handled without a needle-forceps. One great advantage of the suture method is that the material is always at hand.

Rubber-Covered Clamps.—For preventing the escape of the contents of the divided bowel during operation, the rubber-covered clamps of Murphy serve an excellent purpose, although the use of a tape passed through a non-vascular portion of the mesentery and tied over the bowel only tightly enough to prevent the escape of its contents, will be found equally efficient. The mesenteric openings should be subsequently closed by suture.

Purse-string Sutures.—Perforations that do not involve the mesenteric border may be closed by a simple purse-string suture, provided the lumen of

the bowel is not thereby reduced more than one-third. (Fig. 297.) Disease or injury involving a larger portion of the intestinal wall or compromising the blood-supply must be dealt with by resection.

Enterorrhaphy.—The repair of bowel injuries by any method of suture is known as enterorrhaphy. If the entire circumference of the bowel is incised, the repair is termed a circular enterorrhaphy. The principles governing the operation are the same as those of all other intestinal operations, a careful approximation of the edges of the serosa and the securing of an adequate blood supply being the essentials.

Resection with Lateral Anastomosis.—After a resection it is sometimes desirable, because of the unequal size of the divided ends or for other reasons, to make a side-to-side or lateral anastomosis. (Fig. 298.) The divided end of the bowel is crushed with heavy forceps or with an angiotribe, and then, while this instrument is still in position, a purse-string suture is applied about half an inch below the forceps. A ligature is tied in the groove made by the forceps and the end is inverted while the purse-string suture is drawn taut and tied. (Fig. 299.) The anastomosis is made by means of sutures or by the employment of the oblong Murphy button. When sutures are used, the opening should be made from one inch to one inch and a half in length.

Another method of making an intestinal anastomosis is that of T. A. McGraw. This method is sufficiently explained by the accompanying illustrations. (Fig. 300.) Special needles for the application of this method have been devised by McLean, Sanderson, and others. F. T. Murphy found that, by placing a knot in the suture opposite the tie ends, the elastic ligature cut its way through more rapidly. Maury utilizes a triangular ligature of twine.

The advantage claimed for the McGraw method is that, by its use, the anastomosis can be made without opening the lumen of the bowel.

End-to-Side Anastomosis.—This procedure has been recommended for use in those cases in which union between the large and small bowel is desired, or in which it is advisable to exclude a portion of intestine. The triangular space at the mesenteric border of the cut end must be carefully obliterated before the union is made. This is best done by a mattress suture so placed that the knot is on the side of the mucous membrane. The union may then be effected by the use of any one of the various suture methods or by means of the Murphy button.

Enteroplasty.—Plastic operations on the intestine are made usually for the purpose of correcting stenosis due to cicatricial contractions. A longitudinal incision through the strictured portion, with transverse suturing after the manner of the Heineke-Mikulicz pyloroplasty, is the type of operation commonly employed. (Fig. 301.)

Omental Grafting.—Omental grafting is a plastic operation which is sometimes resorted to as a means of re-enforcing a line of intestinal suture. Senn taught a method of using detached omental grafts which are to be held in place by sutures, but, when possible, it is better to slide a portion of the omentum over the line of suture. While this may still be of use where imperfect suturing is suspected, it is better to rely upon carefully placed sutures in the intestine.

Intestinal Exclusion.—Intestinal exclusion consists in excluding the fæcal current from a portion of the canal by anastomosing the bowel above with that below the excluded segment, without removing the latter. It is resorted to chiefly in cases where a malignant neoplasm, which cannot be removed, is producing obstruction. The exclusion may be partial or complete. In partial exclusion the proximal loop is divided, the ends are closed, and a lateral or end-to-side union is made with the distal loop below. In complete exclusion, both proximal and distal loops are divided and the anastomosis is made as above. This, however, is not—for obvious reasons—to be recommended.

Enterostomy.—Enterostomy consists in establishing an artificial communication between the lumen of the bowel and the abdominal wall. The fistula thus formed is named according to the portion of the bowel involved—as, for

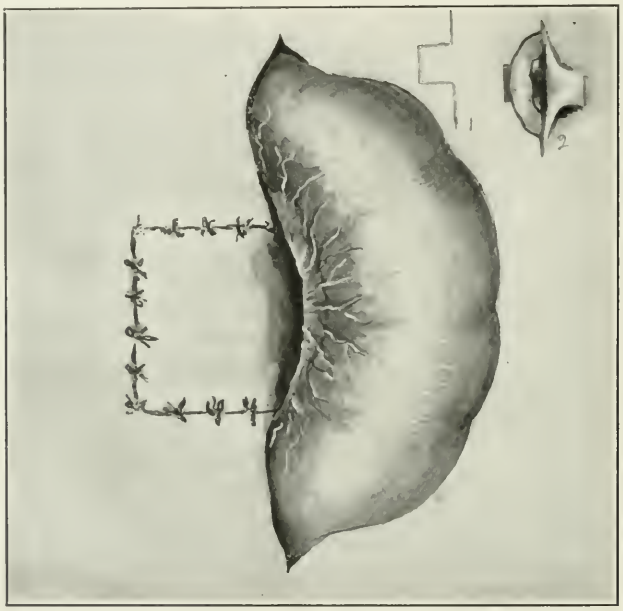


Fig. 303.—Mixter's Method of Colostomy.

example, jejunostomy, ileostomy, colostomy, or sigmoidostomy. The term enterostomy is generally limited in its application to the jejunum and ileum. The procedure is indicated as a means of relief in complete obstruction, or as a life-saving temporary measure in connection with operations upon a patient whose condition would not warrant the performance of a prolonged radical operation.

Enterostomy may be made after the manner of a colostomy (to be hereinafter described), or the tube of Mixter may be used, in which case the bowel is opened at once and the contents are conducted away without soiling the wound. (Fig. 302.) An ingenious method of accomplishing the same end is described by Stewart. One-half of a Murphy button is fastened in the bowel in the usual way, the other half being inserted and tied into the end of a rubber tube of suit-

able size. The halves of the buttons are then joined and the visceral contents are drained into a suitable receptacle.

Colostomy.—Colostomy may be performed either through the loin by a lumbar incision (the retro-peritoneal method) or by means of an incision in the inguinal region (the trans-peritoneal method). Inguinal colostomy is now more commonly employed because of the advantages to be derived from an opening into the abdomen which allows of inspection and palpation of the condition for which the operation is performed. Another reason for selecting the anterior method is the ease with which the opening in this location may be cared for by the patient. The uncertainty as to the absence of a meso-colon also favors the anterior route.

Colostomy is most commonly indicated for the relief of stenosis of the rectum, usually for inoperable malignant disease. It may be employed as a preliminary step before the removal of such obstruction, the object being to give physiological rest to a diseased part or to render irrigation possible. The colostomy may be either permanent or temporary. When the operation is performed for temporary purposes, the technique is practically the same as that described for enterostomy. If it is performed, however, as a permanent means of relief, it will be found best to adopt the following technique:

The incision is smaller than that for appendicectomy, the muscle-splitting or gridiron incision, and may be located on either the right or the left side. When it is made on the left side the sigmoid is opened and the operation is known as sigmoidostomy; but the technique is practically the same on either side. The abdominal cavity is opened, the tumor and its relations are explored, and the desired loop of bowel is brought into the incision.

It was formerly advised—in order to prevent a subsequent prolapse—that the portion of the bowel to be anchored in the incision should be the most proximal portion obtainable. But it was found that a prolapse rarely occurred even when such precautions were not taken. It is therefore now advised that the portion of bowel to be anchored in the incision should be the most distal part that can be brought into the wound. By this method a pouch is formed which acts as a reservoir or fæcal container not unlike the ampulla of the rectum. This plan, conjoined with the muscle-splitting incision intended to furnish a substitute for the anus and its sphincter, tends to render the existence of these unfortunate patients more comfortable. If the colostomy is to serve a temporary purpose, the approximated arms of the loop may be sutured together on either side for a distance of two inches before the loop is anchored. The spur thus formed may afterward be destroyed by a crushing forceps, which is to be left in position for a few hours. By the destruction of the spur the fæcal current is restored, in the same way as it is accomplished by the method of Dupuytren.

After the proper portion of bowel to be anchored to the abdominal wound has been selected, the mesentery is put upon the stretch and the bowel is brought out of the abdominal cavity. As the mesentery is being stretched, a non-vascular space is selected for the insertion of a bridge upon which the bowel

will rest. This bridge of Maydl consists of a glass rod, about the size of a lead pencil, covered with rubber tubing. In recent years various procedures have been employed to do away with the necessity of introducing this bridge. Thus, for example, it has been found that a mattress suture, passed through all the layers of the abdominal wall and through the mesentery and then tied tight, will keep the bowel in place. Mixter also described a very satisfactory method, according to which a flap of skin, formed at the time when the abdominal incision is made, is passed through the mesentery and sutured in place. It seems to retain the loop of bowel in proper position. The writer has made use of this method in a number of instances with much satisfaction. (Fig. 303.) The appendices epiploicæ should be ligated with catgut and removed.

The abdominal incision may be so diminished in size that it shall accurately enclose the projecting loop of bowel, the visceral and parietal peritoneum being united by a continuous suture. The bowel may be opened at the end of forty-eight hours by a transverse incision made with knife or cautery. If immediate opening is imperative, a purse-string suture is first placed in position, the bowel is incised, and a Mixter tube or a Murphy button is inserted in the manner described under Enterostomy. The tube is allowed to remain in place until it separates itself spontaneously by sloughing, usually about the fourth day. If a delay is permissible, the exposed loop of bowel is surrounded by a layer of rubber dam or gutta-percha tissue and a moist dressing or a dusting powder is applied.

SURGICAL DISEASES AND WOUNDS OF THE ANUS AND RECTUM.

By JAMES P. TUTTLE, M.D., New York City, and SAMUEL T. EARLE, M.D., Baltimore, Maryland.

I. ANATOMY AND PHYSIOLOGY OF THE ANUS AND RECTUM.

For want of space we must refer our readers, for the details of the anatomy and physiology of the anus and rectum, to special works under these headings. Only a few points will receive consideration here. We would call attention to the following embryological facts, which we think are important in the consideration of malformations of the rectum, viz.: during the development of the rectum from the hypoblast and mesoblast an invagination of the epiblast is steadily progressing. This invagination, which is called the "proctodæum," advances until the outer and inner layers of the mesoblast are pressed together and absorbed, and the epiblast of the proctodæum and the hypoblast of the hind-gut approach each other and form the double septum between the rectum and the proctodæum, or embryonic anus. The absorption of the septum renders the conjunction of the rectum and anus complete, and leaves a narrow zone that indicates the transition from the mucous membrane to muco-cutaneous tissue, which has been termed by Stroud the "pecten." This zone marks the lower limits of the rectum and the upper margin of the anus.

The failure of the layers of the mesoblast and hypoblast to unite at this point results in the production of two of the most common forms of malformations of the rectum. (Figs. 312 and 313.)

The Valves of Houston.—In view of the important facts which have recently been brought out by T. C. Martin, J. Rawson Pennington, and others, relative to the part taken by the pathological changes in these valves, in the production of obstipation and other kindred maladies, we wish also to speak of them in detail.

The mucous membrane of the rectum above the columns of Morgagni is thrown into irregular horizontal folds, most of which entirely disappear when the organ is distended. At from one to four points in the organ,—the number, however, varying in different cases,—these folds become more prominent when the bowel is distended, and extend out into its cavity in a crescentic form. (Fig. 304.) Houston * first described these folds as valves of the rectum. They vary in number from one to five. Ordinarily there are three—the superior, the middle,

* Dublin Hospital Reports, 1830, vol. v., p. 158.

and the inferior. The middle one is the most constant. It arises from the right anterior quadrant of the rectal wall, about 6 to 9 centimetres above the margin of the anus. It varies in height according to the depth of the peritoneal cul-de-sac, being always just below the latter. The inferior valve is located upon the left posterior quadrant, from 25 to 30 millimetres above the margin of the anus, and the superior valve is located in the same quadrant, about 8 to 11 cm. above the anus. (Fig. 304.) At the juncture of the rectum with the sigmoid flexure, opposite the third sacral vertebra, there is always a well-developed fold or valve, which more nearly occludes the calibre of the organ than does either of the others. It is situated somewhat anteriorly and

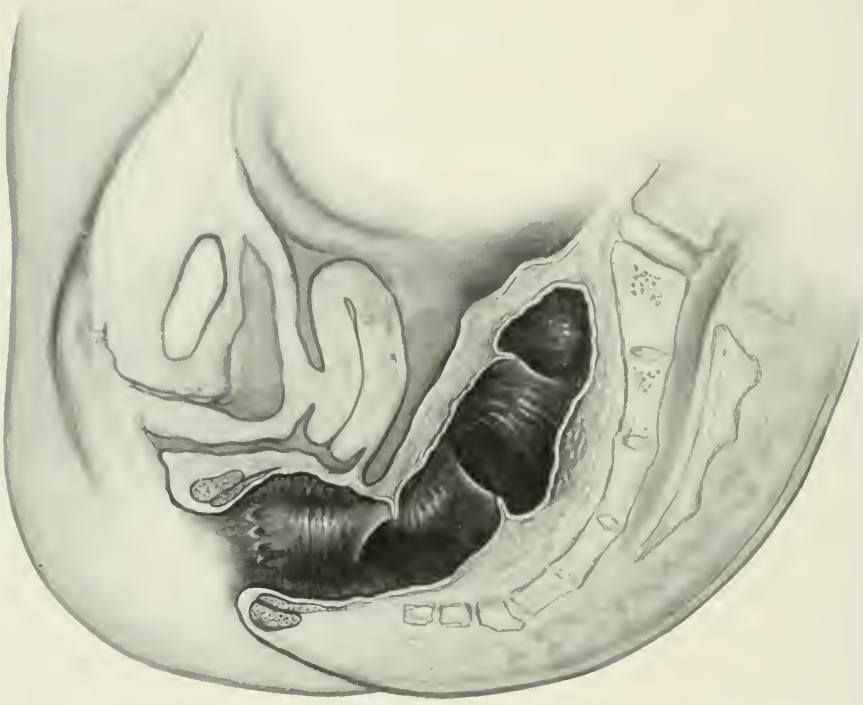


Fig. 301.—The Drawing Shows the Positions of Houston's and the Semilunar Valves.

to the right or left side according to the direction of the flexure of the sigmoid upon the rectum.

The rectal valves protrude into the cavity of the organ to various extents. They are attached to the wall of the intestine throughout one-third to one-half of its circumference; they are crescentic in shape, and present for consideration two surfaces, a free border, a base, and a central body. The superior surface of each valve appears as a smooth, inclined plane, slightly depressed in the centre, and the inferior surface corresponds to the superior, being more or less convex according to the concavity of the latter. The two surfaces are separated, the one from the other, by the tissues which intervene, viz., the mucous membrane and the tissues which compose the structure of the valve.

The free borders of the valves are crescentic in shape, clearly defined, and directed toward the cavity of the rectum. In the normal condition they are usually thin, flexible, and easily pushed aside. Owing to the arrangement of the valves at different levels, with their edges overlapping, the appearance presented, when the rectum is dilated and the examination is made through a proctoscope, is somewhat like that of a turbine wheel. The attachment of the valves to the rectal wall is not upon a horizontal plane; one end is slightly higher than the other, this arrangement furnishing a sort of inclined plane which contributes to the easy passage of the fecal material over the valves. As Houston stated in his original paper, the valves consist of two folds of mucous membrane, separated by cellular and fibrous tissue and muscular fibres.

The function of these valves is to support and let down gradually the fecal mass in its descent through the rectal canal until it reaches the anus.

The Arterial Vascular Supply.—The rectum receives its blood supply from four sources: the superior, middle, and inferior hemorrhoidal, and the middle sacral arteries. (Plate LIII.)

The Nerve-supply of the Anus and Rectum.—The anus and rectum receive their nerve-supply from both the sympathetic and the cerebro-spinal systems. The rectum is chiefly supplied by the sympathetic. The internal sphincter receives its sympathetic fibres along two paths: (*a*) through branches which pass from the second, third, and fourth lumbar sympathetic ganglia to the inferior mesenteric ganglia, thence by the hypogastric nerve to the hypogastric plexus; (*b*) through the nervi erigentes, which arise from the third and fourth sacral nerves and end in the hypogastric plexus. The cerebro-spinal nerves are supplied almost entirely to the external sphincter and the adjoining voluntary muscles and skin. This cerebro-spinal supply comes chiefly through the pudic nerve and its branches. The pudic nerve is made up principally from the third, but also in part from the second and fourth sacral nerves. The individual branches of the pudic that supply the anus, external sphincter, the adjoining muscles, and skin, are the inferior hemorrhoidal and the deep division of the anterior perineal nerve; the former distributing its branches in fan-like manner to the external sphincter and to the skin around the anus, while the latter supplies the anterior portion of the external sphincter, the levator ani, and the transversus perinei muscles. The spinal centre which controls this nerve-supply of the anus and the rectum is supposed to be located about the level of the first lumbar vertebra. This centre is practically the same as that for the genito-urinary apparatus, which accounts for the various reflexes between the two systems.

Lymphatics of the Anus and Rectum.—Quénu * has shown that the anus and rectum are supplied with three sets of lymphatics, which pursue practically the same course as do the arteries which supply these parts.

The Sigmoid Flexure or the Pelvic Colon.—The sigmoid flexure begins above, at the termination of the descending colon, near the outer border of the left psoas muscle, and embraces all that portion of the intestinal canal which lies

* Bull. de la Société d'Anatomie, Paris, 1893, p. 399.

between this point and the upper termination of the rectum, opposite the third sacral vertebra. As measured *in situ*, it is about nineteen inches in length.

Physiological Considerations.—The anus, rectum, and sigmoid, while forming a portion of the alimentary tract, take no part in the processes of digestion, except in so far as some action of this nature may be continued by a small portion of the digestive fluids which are brought down in the mass of fecal matter. The sigmoid and rectum are the receptacles for the fecal matter, but absorption is still provided for in the rectum, through the glands of Lieberkuehn.

The function of the anus is to furnish an exit for the fecal matter, and to control its discharge. In normal conditions the external sphincter muscle, which controls this exit, is in a constant state of tonic contraction, under the control of a reflex centre in the upper portion of the lumbar cord, just above the conus medullaris. The control which is exerted by this centre may be further supplemented by the higher voluntary centres in the brain. When fecal matter or flatus enters the rectum, afferent impulses ascend to the lumbar centre, which excites the dilator fibres of the internal sphincter and inhibits the tonic contraction of the external sphincter, which then in turn relaxes. The same afferent impulses which inhibit the lumbar centre that controls the external sphincter, stimulate the motor cells in the anterior horn of the gray matter of the cord, whose axones supply motor fibres to the levator muscle, which in turn contracts and pulls open the anal canal. At the same time the involuntary muscles of the rectum are stimulated by these same afferent impulses, and they in turn contract upon the contents of the rectum. These expulsive efforts are further supplemented by the action of the voluntary muscles of the abdomen and pelvis.

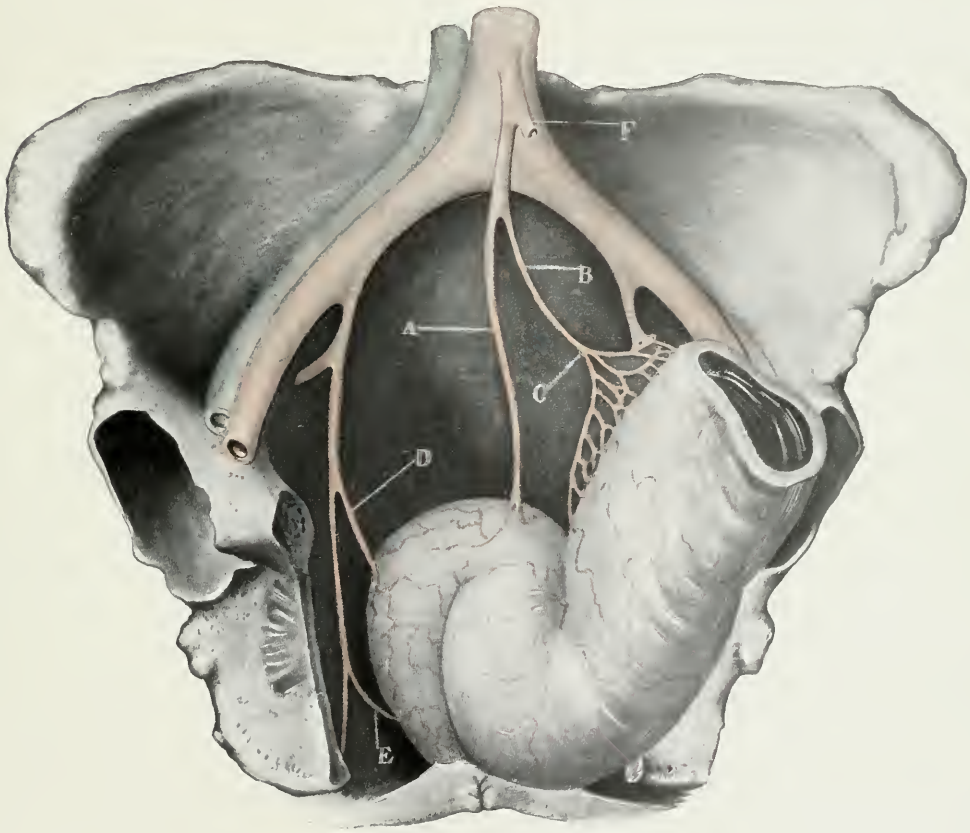
The lumbar centre that controls the external sphincter muscle is purely a reflex centre, which acts automatically when disconnected from the higher cerebral centre, as is seen under different circumstances: in disease of or injury to the cord or higher centres; or in infancy, when the connection with these higher centres is incomplete; or, again, when the influence of the higher centres is suddenly suspended, as by fear, etc. The control of the anal outlet by the external sphincter is further supplemented by the action of the internal sphincter, which, by reason of its being composed only of involuntary muscular fibres, is much slower in its action and much less responsive than the external. The assistance which it affords when the action of the external sphincter is lost, is very great.

The functions of the rectum and sigmoid are practically the same. They are both receptacles or reservoirs for the fecal material after it has passed through the intestinal canal, although the sigmoid serves this purpose principally and for a much longer time. The material is softer and more fluid in the sigmoid than in the rectum; it is also more constantly present in the former. It is not true, however, as is frequently stated, that the rectum is always empty except just before the period of defecation. It nearly always contains more or less fecal matter.

EXPLANATION OF PLATE LIII.

BLOOD-SUPPLY OF THE ANUS, RECTUM, AND SIGMOID FLEXURE.

A, Superior Hemorrhoidal Artery.
B, Sigmoidal Branch of Superior Hemorrhoidal Artery.
C, Division and Distribution of Sigmoidal Artery.
D, Middle Hemorrhoidal Artery.
E, External Hemorrhoidal Artery.
F, Colonic Branch of the Inferior Mesenteric Artery.



BLOOD-SUPPLY OF THE ANUS, RECTUM, AND SIGMOID FLEXURE

(From drawings made specially for the authors.)

II. ANAL AND RECTAL EXAMINATIONS.

General Remarks.—The necessity for making a thorough local examination in all cases presenting symptoms referable to the intestinal tract cannot be too strongly emphasized; and this admonition is especially needed by the general practitioner, who, either from the trouble which it involves, or, more often, from the unpleasantness which characterizes such an examination, is too ready to make a snap diagnosis upon the verbal statement of the patient and to prescribe at random. In doing this he not only does himself a great injustice, but falls far short of discharging his duty to the patient. Indeed, in many cases, he is guilty of criminal neglect by not availing himself of the opportunity to recognize a very simple pathological condition, which might then be easily relieved before it becomes more serious and therefore much more difficult to cure. This statement is especially true of thrombotic hemorrhoids, beginning abscesses, and malignant growths.

The history of the case should be taken. In the slight cases, it will be sufficient to ascertain all the facts which bear directly upon the condition; in the more serious ones, the individual and the hereditary history should also be ascertained. All these data, as well as those relating to the conditions found on examination of the patient, should be recorded.

Whenever a patient, who complains of any rectal trouble or of any vague symptoms which might in some way be caused by diseased conditions of the rectum or anus, comes to a physician,—whether he be a general practitioner or a rectal specialist, it matters not,—the latter should always insist upon making a thorough examination of the parts before prescribing. The symptoms of disease in this part of the body do not alone furnish information upon which we may safely base a diagnosis. It is therefore imperative that advantage should be taken of every attainable means for ascertaining the truth; and, in harmony with this idea, the family physician should be as fully equipped for making an examination of the rectum as for making one of the chest. The evacuations of the bowels should be carefully examined, a note being made of their number, their consistency, and their character—as regards the presence of mucus or of blood, and also—when the latter is present—as regards its nature (whether venous, arterial, fluid or coagulated). If there is any pain preceding, attending, or following the stool, a note should be carefully made of the location of the pain (whether at the anal margin or further up in the rectum) and of its character (whether acute or of a dull aching kind). Inquiry should be made as to any protrusion of the anal mucous membrane, and, if it be found that such a protrusion does take place, a note should be made of the times when it occurs, of the circumstances under which it takes place (as by straining at stool and even when the patient stands or walks), and of such facts as the following: whether it returns spontaneously or has to be replaced by the patient; whether it bleeds when it is outside the anus; whether it is painful; and what are its characteristics as to form and consistency.

Preliminary Preparation of the Patient.—The patient's rectum should be thoroughly emptied by one or more tepid enemas, to be taken in the knee-chest position from one to two hours before he comes to the physician's office. This length of time is allowed to intervene, in order that the small amount of water, which always remains in the rectum after the voluntary expulsion of that taken by enema, may be absorbed. Unless this small residual mass of water is gotten out of the way it will greatly annoy the physician while making the examination. If this thorough washing-out of the rectum cannot be done before the patient comes to the office, the physician should be prepared for such emergencies at his office. Notwithstanding the annoyance which such a course will (as mentioned above) cause, it will frequently be advantageous for the patient to have a stool in the physician's office; and for that reason it may be necessary to give him an enema there. Thus, for example, if there is any protrusion, a more correct opinion may be formed of its extent and character directly after the stool than at any other time.

Bodily Positions Best Suited for Rectal Examinations.—There are several positions in which a patient may be advantageously placed for examination. The left lateral, generally known as Sims' position, will usually be found the most convenient for ordinary examinations, and is attended with the least exposure of the patient's person. It is sometimes used for minor operations for hemorrhoids, and nearly always when Kraske's operation or any modification of it is performed. The extreme lithotomy position is better adapted for examining very stout patients. In certain cases, also, it will be found the most satisfactory for using the sigmoidoscope, and it is the position generally used for operating. The knee-chest position is better adapted for high examinations of the rectum with the proctoscope and sigmoidoscope. For this position no special table or chair is required; a perfectly flat table will answer every purpose. The thighs should be nearly at right angles to the pelvis, and not drawn up under the abdomen, as is apt to be done by most patients. The breast should be in immediate contact with the surface of the table, the arms to the side and the back flexed. These directions are necessary if the greatest advantage is to be derived from this position.

The author has found the squatting position (the one natural at stool) to be of special advantage for bringing down protrusions or growths, and especially for bringing within reach of the finger growths that are too high up to be reached in either of the positions previously mentioned. This position also is especially adapted for recognizing cases of prolapse of the third degree. Any good gynæcological table may be made to serve every purpose for all ordinary examinations of the rectum. The external appearance of the anus and its immediate surroundings should be carefully noted—especially the character of the skin, whether or not it is white and sodden or red and excoriated, and whether there are any scars, ulcerations, fistulous openings, or external growths. A careful search should be made for parasites and pediculi. Then the parts should be palpated, for the purpose of ascertaining whether any points of induration exist. The buttocks should next be pulled well apart and the patient directed

to strain slightly. These manœuvres will make it possible to see quite well the anal canal throughout its whole length, and thus one can frequently form quite a correct idea with regard to the presence or absence of internal hemorrhoids, of a fissure, of a polypus (if it happens to be down at the moment), and of the general condition of the mucous membrane.

Digital Examination of the Rectum.—The educated index finger is the most valuable means of diagnosis that we have for exploring the lower four inches of the rectum. When the finger is used for this purpose, it should be well lubricated, and should be introduced slowly and gently, steady but firm pressure being used to overcome the resistance of the sphincter. The finger should be directed upward and forward at first, until the internal sphincter is passed; then it should be directed backward. Failure to observe these rules will cause much pain, will induce spasm of the muscle, and will greatly discourage the patient. A twitching, tender, spasmodic sphincter indicates the existence of some acute disease near the margin; a hard, firm, resisting sphincter indicates the presence of a chronic condition, which has caused hypertrophy of the muscle; and a relaxed, flaccid sphincter justifies the suspicion that some exhausting, malignant, or constitutional disease exists. Each portion of the canal should be carefully examined as the finger is pushed slowly onward, and, when the finger has been thoroughly educated, it can recognize many conditions the existence of which could not otherwise be ascertained without putting the patient under the influence of a general anæsthetic. Among such conditions may be mentioned the internal opening of a fistula, an ulceration, fluctuation of a perineal abscess, and the presence of a foreign body which has lodged in one of the crypts or has been caught in the grasp of the muscle.

After the anal canal has been thoroughly explored, the finger should be carried beyond the internal sphincter, and swept gently around the upper surface of the rectum, when abnormalities, such as polypi, indurated internal hemorrhoids, neoplasms, strictures, procidentia, ulcerations, and inflammatory conditions, may be recognized. The condition of the prostate and the uterus with its appendages should be carefully examined regarding their relation to the rectum, and as to what influence, if any, they may have upon the symptoms of the patient who is being examined. The condition of the coccyx should also be ascertained. If the patient bears down while at the same moment the surgeon presses upward, it may be possible to push the finger another half-inch higher upward, but the ordinary limit of digital touch is placed at four and one-half inches.

The introduction of the hand into the rectum should be reserved for dire emergencies, and then it should be done only under the influence of a general anæsthetic. The procedure is attended with so much risk that it had better not be attempted, except where the hand of the operator does not exceed 20 centimetres in circumference; and it should then be done only by an experienced and skilful operator. We do not wish to encourage this procedure; there is little, if any necessity for doing it at the present day, when we have so many other better methods for making a diagnosis. I have not employed it once in my experience of thirty years of special work.

Instrumental Examination of the Rectum.—Light.—In all methods of instrumental examination of the rectum the question of light is very important. While reflected daylight is very satisfactory where sufficient can be obtained, yet its supply is so uncertain and it is subject to so many interruptions that it is much more satisfactory to rely upon artificial light, and, of the kinds available, electric light is by far the best. The methods of supplying this may be either by the employment of a head light or by the introduction of a miniature lamp into the interior of the proctoscope, the electric current being conveyed to it by insulated rods.

Specula.—Digital examination of the rectum and the information gained thereby can be materially supplemented by ocular inspection through a speculum. The lack of space will not permit of even naming the various devices which have been invented for the accomplishment of this end; they are so numerous. We cannot attempt to give, even in outline, the very interesting history of the various stages in their development. For all these details the reader is referred to the larger treatises on diseases of the anus and rectum. There is one

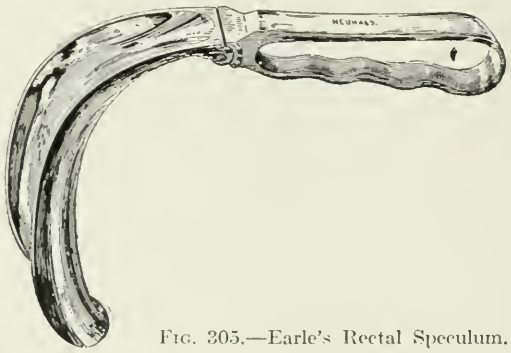


Fig. 305.—Earle's Rectal Speculum.

speculum, however, which I do not find mentioned elsewhere in the text-books, and which I think is at least as well adapted for examining the upper part of the anal canal and the lower portion of the rectum as any that I have ever seen. (J. P. T.) The speculum referred to represents a modification of Sims' vaginal speculum by Dr. Samuel T. Earle, who is associated with me in the preparation of this article. The modification has special reference to the different conditions met with in this cavity—viz., the tight sphincter and the sharp curves. The curve is greater, the sides higher, and the end more pointed than is the case in the Sims instrument; and the blade of the speculum is attached to a short handle, which may be so fixed as not to interfere with the buttocks. (Fig. 305.) I have used this instrument, which was devised about fifteen years ago, constantly, and have found it very satisfactory, especially in cases of fissure. In these cases it is necessary to introduce the instrument a distance of only about one inch in order to pull back the anal wall, on the side opposite to that on which the fissure is located, and thus to expose the lesion completely to view. This procedure causes scarcely any pain if the instrument is introduced slowly and carefully, and only sufficiently far to expose the fissure.

It is also found very useful in holding open the sphincter while the rectum is being irrigated and prepared for an operation. It may be turned in any direction, while *in situ*, and at the same time it dilates the sphincter sufficiently for all practical purposes.

The Proctoscope.—The history of the proctoscope has been clearly set forth by the author in his recent work on "Diseases of the Anus, Rectum, and Pelvic Colon." Among the many patterns of it to be found on the market, probably that devised for the author by the Electro-Surgical Instrument Company of Rochester, N. Y., is as complete and satisfactory as any, and combines practically all the recent improvements, including the pneumatic attachment. The instrument, as described in the author's recent work alluded to above, is composed of a large cylinder (*F*), from three-quarters inch to one and one-quarter inch in diameter, into one part of the circumference of which is fitted a small metallic tube, closed by a flint glass bulb at its distal end. (Fig. 306.) The electric lamp (*G*) is fitted upon a long metallic stem, and carried through this small cylinder to the end of the instrument, as is shown in the illustration.

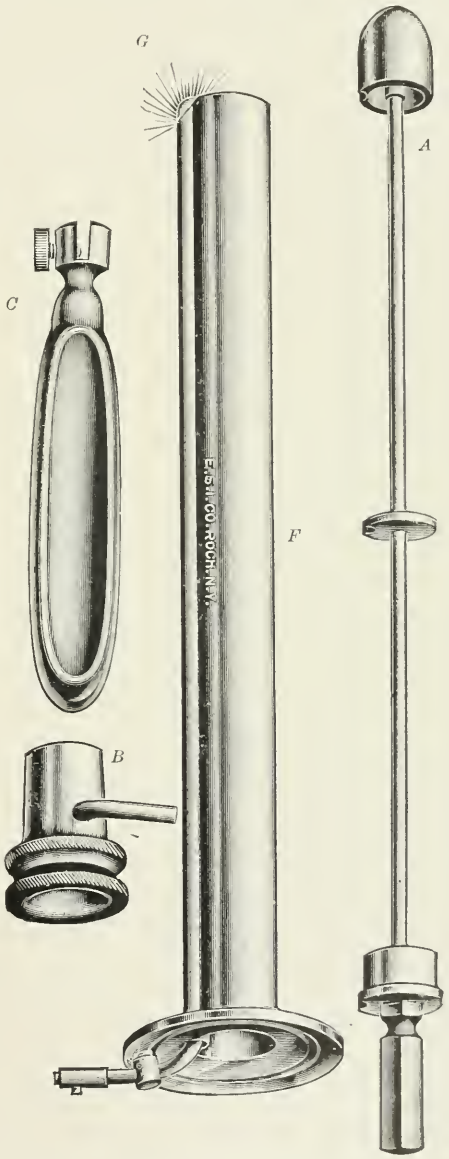


Fig. 306.—Tuttle's Pneumatic Proctoscope.

The proctoscope is introduced through the anus with the obturator (*A*) in position. As soon as the internal sphincter is passed, this obturator is withdrawn and, if the rectum does not inflate under atmospheric pressure, the bayonet-fitting plug (*B*), which contains either a plain glass window or a lens, focused to the length of the instrument to be used, is inserted in the proximal end of the instrument. This plug is ground to fit air-tight, and thus closes the instrument perfectly. The plug being inserted in the tube, a very slight pressure upon the hand-bulb will cause inflation of the rectal ampulla to such an extent that the whole rectum may be observed, and the instrument may be carried up to the promontory of the sacrum without coming in contact with the rectal wall. Further dilatation

will show the direction of the canal leading into the sigmoid, and by a little care in manipulating the instrument, and by keeping the bowel well dilated in advance, it may be carried up into this portion of the intestine without the least traumatism of the parts. If any fecal matter should obscure the light by being massed or smeared over the glass bulb, the plug may be removed, and a pledget of cotton, introduced with a long dressing forceps, will wipe this off so that the plug may be re-introduced and the examination continued with very slight delay or inconvenience.

The adjustable handle (C) fits on the rim of the instrument and thus converts it into a Kelly tube. This instrument is operated with an ordinary dry battery of four or six cells, or, better still, if one's office is equipped with the electric light, by the admirable controller furnished by the manufacturers.

The tubes are made of different lengths, varying from four to fourteen inches. The very long ones are supplied with the flexible obturator, which gives them the Mercier curve, like that which exists in the author's modification of the Kelly tubes.

The four-inch instrument enables one to examine the entire rectum, but does not give any view of the sigmoid flexure. The ten-inch tube is sufficient for any ordinary examination of the rectum and sigmoid, but one should, for purposes of convenience, also have the four-inch tube.

This instrument is most satisfactory and serves all the purposes of the Kelly tubes or any other proctoscope.

Other Instruments Required in Making Rectal Examinations.—The extent of the intestinal canal which may be seen through the rectum has been greatly increased by these modern methods of examination, but, in the large majority of instances, the field of ocular examination is limited to the sigmoid flexure. In making such an examination, however, there are other instruments which are either useful or necessary if we wish to secure satisfactory results. Among these may be mentioned, first, a silver probe, which should be from eight to ten inches long and should be furnished with a handle that is roughened on one side, so that it can be manipulated with ease, and so that the operator may always be able to tell in which direction the end is pointing. It should be made of pure silver, in order to render it flexible throughout. The rectal scoop is another very useful instrument, and may be made of steel or of copper. Applicators and dressing forceps are also required; they should be long enough to extend beyond the proctoscope and thus enable the surgeon to clear the field of observation, or to make applications to the affected parts. The handles should be bent downward, so that they shall not obscure the view. There should also be a long pair of alligator forceps (Fig. 307), for seizing and removing foreign bodies, polypi, and villous growths; and tenacula, fixation forceps, and blunt hooks for examining the crypts, pockets, and internal blind fistulæ. Bougies, which are now useful only in dilating strictures, should be made of soft rubber (as first suggested by Dr. Wales, in 1883), conical or cylindrical in shape, and provided with a narrow canal through the centre of the instrument for injecting water through it, in order to facilitate their introduction. These

bougies are made in sizes varying from one to twelve, and are ordinarily twelve inches long. The rectal *bougie à boule* is a very useful instrument for determining the length or extent of a stricture; it is made of hard rubber, or flexible wire, with tips of different sizes. It is best used through a cylindrical speculum.

The Use of Anæsthetics in Rectal Examinations and in Operations upon the Anus and Rectum.—In rectal examinations an anæsthetic is required only in hypererethistic patients who are afflicted with some disease of a very painful character; and, even under these conditions, sufficient information may, in the majority of instances, be gained from the symptoms or from a partial examination made for the purpose of determining whether or not an operation will be necessary without it. Then, if it should be found necessary to operate, the more thorough examination could be deferred until the patient is under the anæsthetic, at the time of the actual operation.

In some cases local examination fails to determine the nature and cause of the rectal disease. The pathological condition may be located above the point reached by the examination, or the manifestations may be so obscure that it is

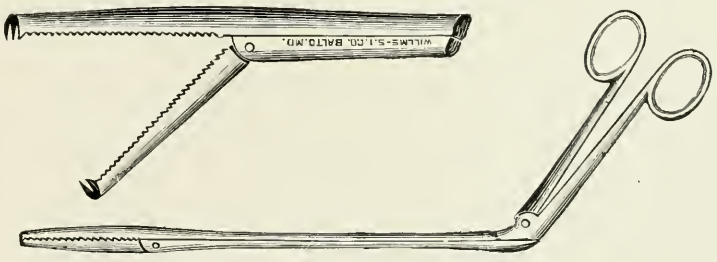


Fig. 307.—Long Pair of Alligator Forceps.

impossible to determine their exact pathology. In the case of an obscure neoplasm, one should always, whenever it is possible to do so, remove a specimen for microscopic examination.

In operations upon the anus and rectum the employment of an anæsthetic is very necessary, on account of the great sensitiveness of the anus and the adjoining tissues, due to the liberal nerve-supply of these parts. As has already been stated, it will even be found necessary, when the anal orifice is unusually irritable, to administer an anæsthetic in order to be able to make a satisfactory examination.

The choice of an anæsthetic for these cases admits of great latitude, on account of the wide range between the minor and major anal and rectal conditions which call for operative interference. Cocaine and other local anæsthetic agents, when applied directly to the mucous membrane of the rectum, not only exert little effect, but they produce in many cases alarming symptoms. They should therefore never be used in this manner. On the other hand, when they are administered hypodermatically, the results obtained are very satisfactory. By the persistent efforts of certain specialists in proctological work within the last few years, the great efficiency of local anæsthetics, when thus employed,

has been demonstrated. Even in cases where the operator is obliged to remove a considerable amount of tissue, it has been found that, by injecting the agent in close proximity to the course of the nerves supplying these parts, the requisite degree of anæsthesia is obtainable.

The local anæsthetics best adapted for this class of cases are weak solutions of cocaine, of stovaine, or of beta eucaine lactate, with the preference decidedly in favor of a solution of cocaine in the strength of from one-quarter to one-half of one per cent. Sterile water injections for purposes of local anæsthesia have also been highly recommended by Dr. Gant, in whose hands they seem to have

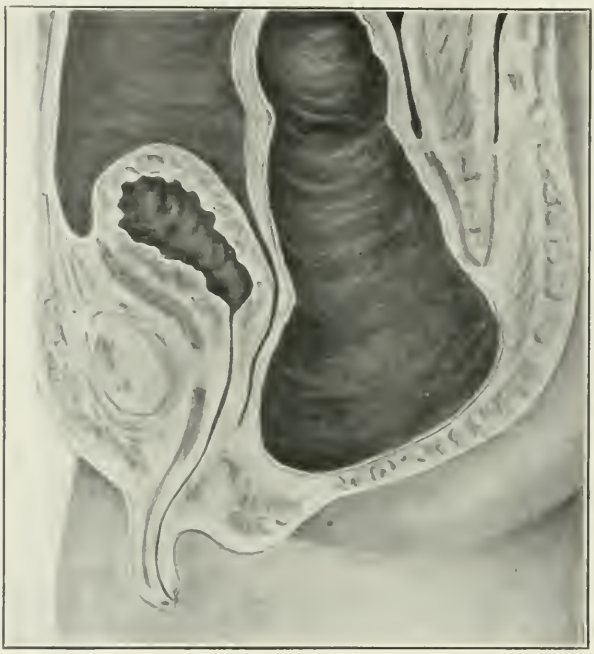


Fig. 308.—Entire Absence of the Anus.

proved very satisfactory. Most authorities object to them on account of the pain which attends their administration.

Technique of a Single-Puncture Injection for Local Anæsthesia.—The technique required in cases in which simply a moderate dilatation of the sphincter is desired is as follows:—A hypodermic needle of about two inches in length is employed, and the syringe is filled with a sterile solution of the drug to be used of the strength of one-half of one per cent. We prefer the cocaine freshly made, because it is always reliable. The needle is introduced in the median line about half an inch back of the posterior commissure of the anus and a drop or two of the solution is injected into the subcutaneous tissues, after which the right index finger is introduced into the rectum and hooked around the internal sphincter, thus dragging it down into apposition with the external. The needle is then pushed upward and forward into the sphincters one after the other, depositing about 5 minims of the solution in each muscle

at a point about half an inch in front of the posterior commissure. Afterward it is easily withdrawn sufficiently to introduce it in like manner into the muscle on the opposite side of the posterior commissure. The total quantity of solution used amounts to from 20 to 30 minims. Two or three minutes having elapsed, a duck-bill speculum is introduced into the anterior commissure of the rectum, and, with this as a point of resistance, the sphincters are gently massaged and stretched to any desirable extent.

We do not claim that, by the employment of this method, the sphincters can be divulsed or the peri-rectal tissues broken down without pain, but we do claim that with its aid the sphincters can be stretched sufficiently for all ordinary practical work. Up to the present time (1909) over one hundred cases have been thus treated by our associate, Dr. Lynch, and ourselves, with practically no failures, and the method has been demonstrated to a large number of visiting doctors, during the past six months, at the Polyclinic Hospital. The points for which we claim originality are the single puncture (which thus minimizes the dangers of infection) and the localization of the anæsthetizing agent within the area occupied by the sensitive nerves of the sphincter. After the sphincter has been stretched, the hemorrhoids or the ulcers—whichever may be the lesions that require treatment—should be anæsthetized with a mild solution (say, from $\frac{1}{8}$ to $\frac{1}{10}$ of one per cent) of the drug previously employed, as the anæsthesia produced by the first injection does not extend to the cutaneous margin of the anus anteriorly. In the case of a fissure no second puncture is necessary, as the first usually suffices, provided the injection was made in the commissure, where the fissure exists.

Fig. 309.—The Drawing Represents a Case in which the Anus is Occluded by a Membrane.

The class of cases to which this method of producing anæsthesia is applicable includes those very sensitive and painful conditions in which a satisfactory examination cannot be made without a resort to some form of anæsthetizing agency, dilatation of the sphincter, incision and dissecting out of fissures, opening up fistulous tracts, removal of polypi, removal of hemorrhoids by almost any method except Whitehead's—in fact, all minor operations upon the anus and rectum.

In the case of many of these operations it is very questionable whether it is proper or advisable to do them, with the aid of a local anæsthetic, in one's office, unless the patient is allowed to recline, for one or two hours after the operation, before being allowed to leave.

A well-grounded objection to the use of local anæsthesia in many of these operations, is based on the fact that the distention of the tissues by the injection —which distention is necessary if complete anæsthesia is to be obtained—so distorts the parts which are to be removed as well as the tissues that are to remain, that not infrequently an insufficient amount is taken away, with the result that a second operation often becomes necessary.

In the use of general anæsthetics in rectal surgery the selection of the anæsthetic to be used depends upon the length of time required for the operation and also upon the patient's condition. For operations requiring only a short time for their performance,—such, for example, as dilating the sphincter, excising a fissure, or opening up a small fistulous tract,—ethyl chloride, or nitrous oxide gas with oxygen, may be used. For operations requiring a longer period of time, sulphuric ether or chloroform may be used.

III. MALFORMATIONS OF THE ANUS AND RECTUM.

It was pointed out in the section on embryology that the anus and rectum are developed from entirely different layers of the blastoderm, and that the blood-supply comes from different sources. Arrest in the development of one, therefore, does not necessarily imply arrest in the development of the other. Malformations of either the anus or the rectum are very likely to be associated with malformations in other parts of the body which are derived from the same layer of the blastoderm. The classification which we will here make of these malformations will be based upon the differences in the origin of the anus and rectum. With the aid of this division we shall be able to follow out clearly the malformations which are due to the arrest of development in the different layers of the blastoderm.

Malformations of the Anus.

(*a*) Entire absence of the anus. (Fig. 308.)

(*b*) Abnormal narrowing of the anus.

(*c*) Partial occlusion of the anus. (Fig. 309 shows how this may occur.)

(*d*) Absolute occlusion of the anus.

(*e*) Anal opening at some abnormal point in the perineal, scrotal, or sacral region. (Fig. 310.)

Malformations of the Rectum.

(*a*) Rectum entirely absent. (Fig. 311.)

(*b*) Rectum arrested in its descent, at a point more or less removed from the anus, the anus being normal. (Figs. 312, 313, 314, and 319.)

(*c*) Rectum opening into some other viscus, with the anus present in its normal position, or absent. (Figs. 315 and 321.)

(*d*) Rectum and anus normal, except that the ureter, bladder, vagina, urethra, or uterus opens into it. (Figs. 317 and 318.)

Treatment.—Where there is complete atresia, whatever is necessary must be done at once, to afford the child any chance for life. On the other hand, in those cases in which there is an exit for the meconium and fluid feces a more conservative course may be adopted until the child has grown older and stronger and is better able to stand an operation. In such cases the opening, if small and within reach, may be dilated. The prime object, in all operations for malformations of the anus and rectum, is to give an exit to the intestinal contents, and to restore the parts as nearly as possible to their normal functional activities. Amussat, in 1835, was the first to lay down the cardinal principles which have since guided surgeons in their attempts to correct these malformations. He advised the free and wide dissection of the perineum, with removal of the coccyx, if necessary, in order to gain more room for reaching the rectum.

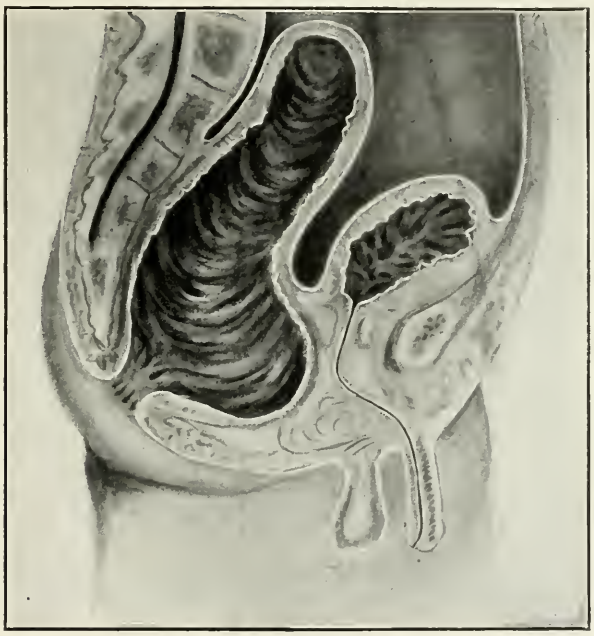


Fig. 310.—In the Case Represented in the Drawing the Anus Opened at the Tip of the Coccyx.

He also advised opening the peritoneum, when necessary, through this route. When the rectum was found, he advised that it be dissected loose from its attachments, brought down outside the wound, opened, and, after the contents had been discharged, attached (without too much tension) to the skin margin of the wound at its normal position, if possible. But, if it was found impracticable to bring it down to the normal position, then he advised attaching it to the sides of the space left by the resection of the coccyx. From Amussat's day to the present time all methods of operating upon an imperforate anus and upon malformations of the rectum have been based upon his recommendations. We shall consider the treatment of these malformations in the light of the present advances in surgery, in a general way, and shall point out their application to each particular form of malformation.

In the first place, let us consider the treatment of those forms of malformation in which there is complete occlusion. In such cases it is necessary that immediate and radical operative interference should be undertaken. The operation should be done under strict antiseptic precautions, and without the aid of a general anæsthetic, as children at this age do not bear it well.

The location of the rectum is sometimes indicated by a greenish tinge of the skin of the perineum covering the rectum, due to the green color of the meconium; there may be also a bulging of the perineum beneath the rectal pouch. With one hand on the perineum, while with the other pressure is made upon the abdomen, one may sometimes feel an impulse from the rectal pouch when the child is made to cry. Percussion may also indicate the location of

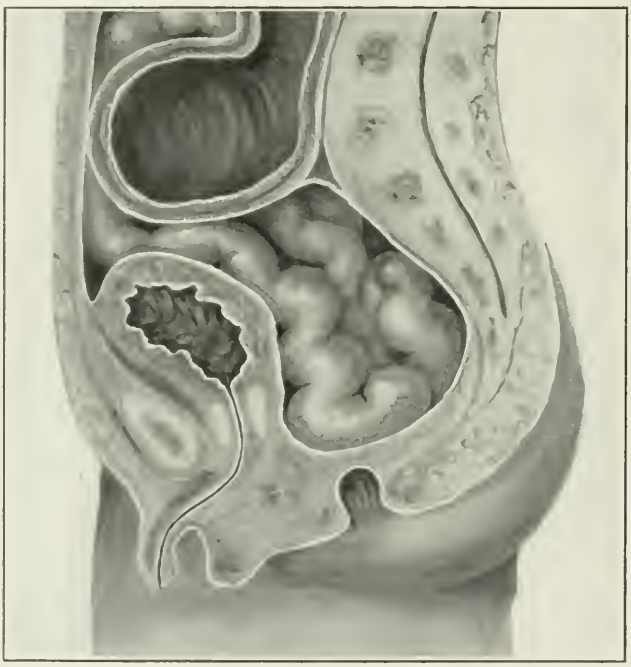


Fig. 311.—Complete Absence of the Rectum, the Colon Ending in a Large Dilatation of the Bowel at the Location of the Sigmoid.

the pouch. The introduction of a trocar or exploring needle into the perineum and backward into the hollow of the sacrum is, in the light of our present knowledge of surgery, too rash and inaccurate a procedure to be recommended. After the position of the rectal pouch has been determined as far as possible, the operation may be undertaken at once on the lines laid down by Amussat, viz., by making a straight incision from the spot where the anterior margin of the anus should be, backward to the tip of the coccyx. This incision should extend through the skin and subcutaneous tissue. If there should be a rudimentary anus, the incision should begin at its posterior margin. At the bottom of this incision we come upon the external sphincter muscle, or upon the fibrous band which takes the place of this muscle when it is lacking. This muscle or

the fibrous band should be divided by a blunt, and not by a sharp instrument, and the margins of the cut should be pulled gently apart. The dissection should then be continued upward and backward in the hollow of the sacrum, in order to avoid wounding the bladder and other pelvic organs. When the rectum is found it should be loosened from its attachments and brought out through the wound, if possible, before being opened. When it is impossible to do this, on account of the great distention of the organ, the trocar may be introduced, and the contents drawn off through its cannula. By this means the rectum will be lengthened and may then be drawn out through the wound. In either case, before the rectum is opened, the wound should be well packed with sterile gauze, which will isolate it from its surroundings. After the contents of the rectal pouch have been well drained off, the opening may then be enlarged and the mucous membrane of the same stitched to the skin surface of the wound, the serous and muscular coats being allowed to retract. The object of this step is to seal off the perineal wound from contact with the fecal discharges. If it be found impossible to draw the rectal pouch out through the wound at the point where the anus should normally be, then it may be attached at some other point of the wound, wherever it can be brought out without too much tension. The recommendation of Vincent should here be borne in mind, viz., to cut off two elliptical flaps of skin, one from each side of the site of attachment, in order to give a broader raw surface of attachment and at the same time to carry away more effectually the discharges from the intestine. When the latter has been brought down and sewed in the normal position of the anus, the posterior part of the perineal wound may be closed with deeply placed silk or chromicized catgut sutures, care being taken to draw together at this point the fibres of the external sphincter muscle.

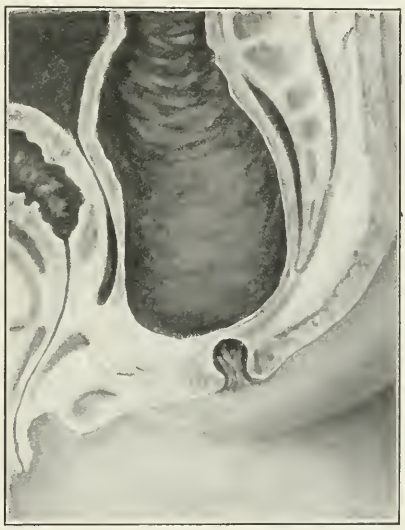


FIG. 312. — In the Case here Represented the Rectum did not quite Reach the Anus.

The sutures best adapted for attaching the intestine to the margin of the skin are those of sterilized catgut, of a fairly large size. There should be a continuous suture for each side of the rectum, but it should not extend entirely around, as that would not allow the opening to dilate sufficiently. If there is much tension on the rectal pouch, an anchor suture should be passed through the external walls of the intestine, or the mesorectum, and out through the skin, where it should be tied over a wad of gauze. The dressing should consist of soft absorbent gauze, moistened with a solution of boric acid and held in place by a napkin. The abdomen should be enclosed in a snugly fitting bandage, to control straining.

The above recommendations are applicable to all forms of imperforate ani.

Treatment Required for Cases in which the Rectum is Arrested High up in the Pelvis.—To appreciate the difficulties which one encounters in searching for the rectal pouch, it is necessary to know the measurements at the outlet of the normal infantile pelvis. The distance from one tuber ischii to the other varies from 0.5 to 2 centimetres, and does not differ materially in the sexes. In males the distance from the scrotum to the coccyx averages from 4 to 4.5 centimetres, and in girls the distance from the posterior commissure of the vagina to the coccyx varies from 3 to 4 centimetres. These measurements show that the field for operation is embraced within boundaries which give it an elliptical shape, with a maximum length of 4 centimetres and a maximum breadth of 2 centimetres. The depth of the pelvis from the tip of

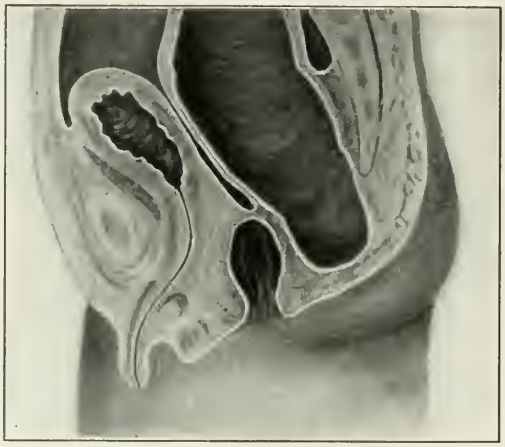


Fig. 313.—Illustrates a Case in which the Rectum Failed to Meet the Anal Pouch Descending Posteriorly to It.

the coccyx to the promontory of the sacrum is about 6 centimetres. It should be remembered that these are normal measurements, and that in the abnormal cases it will often be found that the measurements are less than those here given. The locality in which the operator is likely to gain the most space is in the hollow of the sacrum, and here the entrance to the pelvis is interfered with by the coccyx. Hence Amussat's recommendation to remove this bone. Amussat's operation, while simple, is open to certain objections, such as taking away the points of attachment of the anal and rectal muscles,—a step which removes the normal support of the lower end of the rectum and invites prolapse. A more conservative plan is that recommended by Vincent, who takes advantage of the soft condition of the coccygeal and sacral vertebræ at this early period, and splits the coccyx and the lower part of the sacrum through their centre with scissors. This affords ample room and a good view when the wound is held open by retractors.

If, in these cases, the rectal pouch is so short that it has to be attached at the coccygeal end of the wound, the operator must be careful to carry out his

dissection in such a manner that the rectum shall not remain attached to the cartilaginous sections of the sacrum and coccyx—that is, to parts which are eventually to become an osseous outlet. The succeeding steps of the operation should be as heretofore described. It would be well, when searching for the rectal pouch, to introduce a sound in the male bladder,—or in the vagina, in the case of a female,—in order to avoid wounding these organs. The fibrous band which sometimes leads from the imperforate anus to the rectal pouch, should always be watched for and followed up closely, when found, as a certain guide to the rectal pouch. If the pouch is not found in the hollow of the sacrum, the search will have to be directed forward and upward in the peritoneal cavity. It is sometimes attached to the promontory of the sacrum, or to its sides high

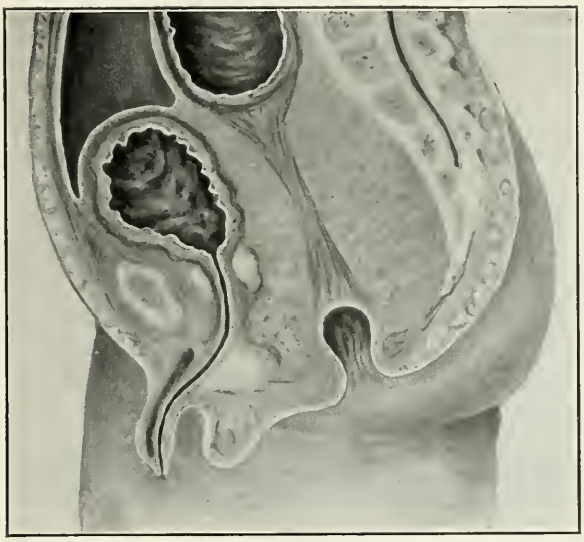


Fig. 314.—Illustrates a Case in which the Lower Rectum is Replaced by a Fibrous Cord which Connects It with the Anal Pouch.

up, in which case the rectal pouch is likely to be entirely enveloped by the peritoneal fold which attaches it to the sacrum, and the enucleation of the pouch has to be done before it can be freed and brought down. This is a difficult procedure, and the author questions whether it would not be wiser, when such a condition is recognized, either to do an inguinal colotomy or to bring down a loop of the sigmoid and attach it to the perineal wound. In all cases where the peritoneal cavity has been opened, it must be closed, or packed with sterile gauze, before the rectal pouch is opened. If the rectal pouch is too short to be brought outside of the peritoneal cavity, then this cavity should be closed, the perineal wound packed off, and inguinal colotomy done at once. (The rectal pouch may descend at a later date, when the perineal wound may be utilized.)

Treatment of the Anal Cul-de-sac.—We come now to consider the management of those cases in which the anus is fully developed and the rectum is removed to a greater or less distance, as illustrated in Fig. 313. The conditions present in these cases have already been described.

End-to-end union between the anal cul-de-sac and the rectal pouch is a very difficult thing to accomplish even under the most favorable conditions, and the results are very uncertain. In accordance with recent experience the best plan to adopt is to dissect away entirely the lining membrane of the anal cul-de-sac, including the skin around the anal margin, and then, after bringing the rectal pouch down to the margin of the skin, to open it and to suture its mucous membrane to the adjacent skin. This may be done without much dissection provided the rectal pouch is in close proximity to the anal cul-de-sac.

Colostomy in Cases of Imperforate Anus.—Besides those cases in which colostomy is imperative on account of the impossibility of attaching the rectal pouch to the perineal wound, some surgeons recommend it, as a preliminary proceeding to the perineal operation, in all cases where the rectal pouch cannot be definitely

Fig. 315.—Represents a Case in which the Anus Opens into the Vagina, the Rectum Descending Posteriorly to It.

located through the anal cul-de-sac or the perineum. The advantages, they claim, are that the results are more certain than those of a proctoplasty, that the operation is less fatal, and that it does not interfere with the establishment of the anus at its normal site when the child is older and better able to stand a serious operation. The opening established by the colostomy offers an opportunity for locating the rectal pouch, through the abdominal wound, and then, if it be found to lie within easy reach of the perineum, the abdominal wound can be promptly closed and the perineal operation done with greater certainty.

If the rectal pouch cannot be located through the abdominal wound, it should be remembered that, in infants, the sigmoid flexure is frequently found on the right side.

Treatment of Abnormal Narrowing of the Anus.—In abnormal narrowing of the anus, where the exit for the fecal matter is still fairly adequate, simple dilatation with bougies is all that may be called for until the child has developed

sufficient strength to stand a surgical operation. When the obstruction consists of a band of skin stretched across the anal opening, there can be no good reason for delay in dividing it with the scissors and dissecting out its points of attachment. The anus should then be dilated.

Treatment of Complete Occlusion of the Anus by a Membrane or Diaphragm.—These cases are among the simplest malformations of the rectum to treat. A simple crucial incision of the membrane, with subsequent dilatation, is all that is needed in most cases. Sometimes there is more than one membrane. To ascertain whether such is the case or not, the little finger should be introduced well up into the rectal pouch, after the incision has been made.

Treatment of Cases in which the Rectum opens at some Abnormal Position on the Skin.—The exit in these cases is generally sufficient to relieve the patient during early life, and there need be no immediate hurry to interfere.

Fig. 316.—Illustrates a Case in which the Rectum Opens at the Prepuce.

If the abnormal opening is not too far removed from the site of the normal anus, it and the rectal pouch should be dissected out and sutured to the skin at the site of the normal anus. Where the opening is too far removed for this procedure, a search should be made for the rectum by perineal dissection, and, if found, it should be brought down and sutured at the site of the normal anus. After this has been done successfully, the abnormal opening will gradually close. If it does not, it may be dissected out and closed at a subsequent date.

Where the abnormal opening is at the prepuce, glans penis, or scrotum, the fistulous tract is so long that obstruction is likely to occur, and therefore such a case should be operated on at once. The opening into the rectal pouch, at the normal site of the anus, should be established as soon as the child's condition will permit. In all cases of this class the fistulous tract should be cut off close

to its entrance into the rectal pouch, and a ligature should be applied to its proximal end. This end should then be invaginated into the rectum and should be retained there by Lembert sutures. After the peripheral end has been cleansed, it should be ligatured and left to atrophy. Where the abnormal opening is at some remote part of the body, it is of course improbable that the rectal pouch can be reached through the perineum. If a loop of the sigmoid or of the colon can be brought down and sutured at the anal site, it will probably serve all necessary purposes.

Treatment of Cases in which the Rectum opens into some other Viscus.—Where the rectum opens into the bladder (Fig. 321) it is a question of immediate operation; or death may be looked for in a short time from infection. From a rational

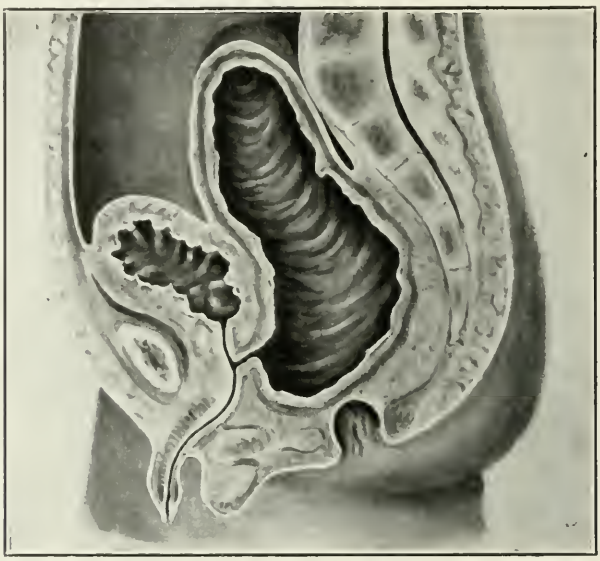


Fig. 317.—Represents a Case in which the Rectum Opens into the Urethra.

standpoint there are open to us two methods of procedure, both of which involve abdominal section. The author believes that such cases should be operated upon, at the earliest opportunity, by a full and free incision into the abdominal cavity. We are thus enabled to locate the opening into the bladder, and this information will determine what should be the subsequent steps of the operation. Where the opening into the bladder is situated high up and can be reached, it is perfectly feasible to separate the two organs at the point of communication, to invaginate the openings into each other, and to suture them, provided there is an external orifice for the escape of fecal matter. If, however, there is an imperforate anus, this condition should be remedied first, either by proctoplasty or by colotomy. Where the opening into the bladder is situated low down, in the neighborhood of the trigone and so far beyond the operator's reach that he will not be able to apply sutures with any degree of certainty, it is better to make a permanent inguinal anus and to close up the lower end of the colon entirely. Finally, where the rectum communicates with the urethra, the need for interference

is generally not so urgent. The condition is more favorable for operation, owing to the fact that the rectal pouch, in these cases, is always located lower down and nearer the pelvic floor. It is best to dissect down upon the rectal pouch, disconnect it from the urethra, and bring the orifice through which its contents are discharged into the urethra, back to the normal position of the anus, when it can be enlarged to any extent necessary and sutured to the margin of the skin in this locality. After the rectum is detached from its connection with the urethra, a simple perineal fistula is left, and this lesion heals of its own accord.

Treatment where the Rectum Opens into the Vagina.—In these cases, while the abnormal channel of communication may be free enough to allow the exit

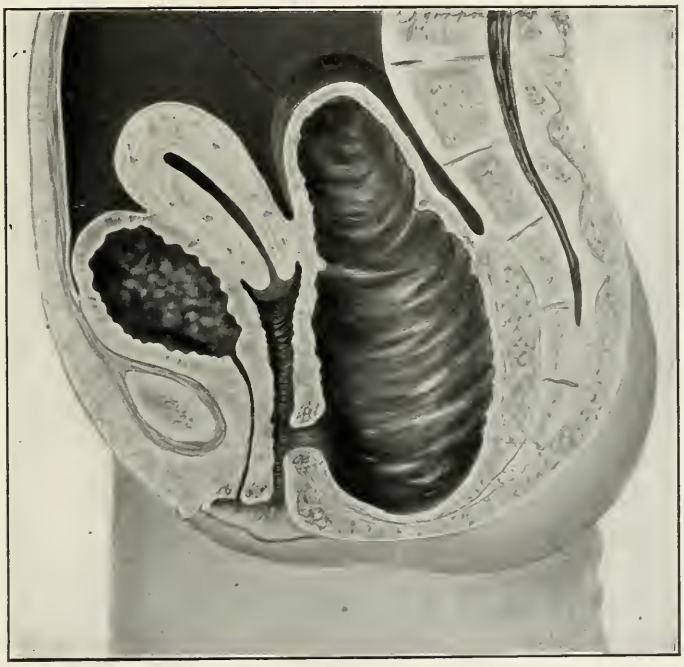


Fig. 318.—Represents a Case in which the Rectal Pouch Opens into the Vagina. The Anal pouch may or may not be present.

of meconium, the further escape of the material may be prevented by an imperforate hymen. This condition is readily diagnosed by the presence of a bulging greenish membrane between the lips of the vulva; and when the discovery is made the hymen should be incised at once. If the opening between the rectum and the vagina is not sufficiently free, it should be dilated by bougies or by a uterine dilator, or, if necessary, it should be incised. Interference should depend upon the condition of the child, all radical procedures being postponed until, by reason of its increased age and greater strength, a favorable prognosis is warranted. Fig. 320 shows the improper method of operating in these conditions.

At what age should the operation for a vaginal anus be undertaken? In the author's experience children at the age of from three to five years bear

surgical operations very well. According to Rizzoli,* whose method is generally accepted, the course to be pursued for the closure of such a vaginal anus is as follows:—An incision is made from the posterior margin of the vagina backward to the point at which the normal anus should be; the perineal tissues are next carefully dissected until the rectal pouch is reached; this pouch is then carefully loosened from its attachments all around; and the vaginal anus is dissected out intact and dragged down to the position of the normal anus, where it is permanently anchored by means of sutures. The perineal tissues in front of the intestine are then brought together by buried catgut or deep silver-wire sutures, and the mucous membrane of the vagina is carefully sutured, thus restoring completely the recto-vaginal septum and closing all communication between the

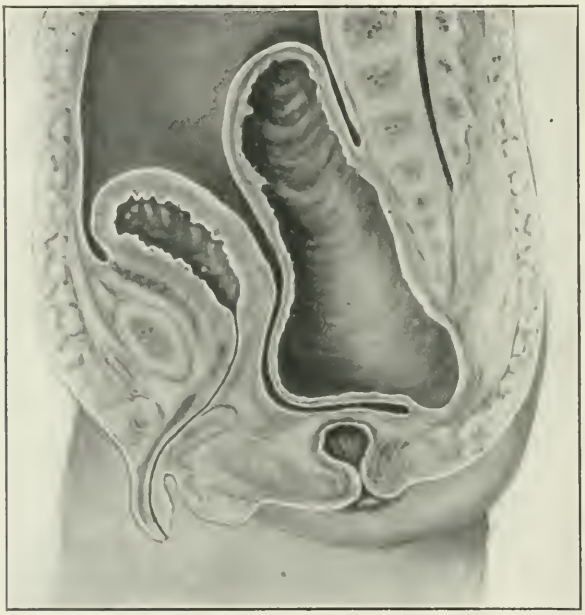


Fig. 319.—Represents a Case in which the Rectal and Anal Pouches are Separated by the Peritoneal Cul-de-Sac.

two organs. By this procedure the natural opening in the intestine is perfectly preserved, with all of its sphincteric power, and the danger from non-union or from retraction of the parts is practically obviated. It has also the great advantage of restoring the perineum and recto-vaginal septum, a matter of the utmost importance to the woman. If there should be two openings into the vagina, far apart, it is better to dissect out and use the one nearest the normal anal opening, as above described. Then dissect out and close the one farthest away.

Treatment where the Rectum Communicates with the Uterus.—These cases are so rare that no operation to correct them has ever been reported. It would seem, however, that the proper proceeding in such cases would be to establish

* Gross' "System of Surgery," vol. ii., p. 205, sixth edition.

an anus at the normal site, if possible, and to follow this by a laparotomy, by division of the canal connecting the two organs, and by inversion and suturing of the apertures in each, after the manner advised in those cases in which the rectum communicates with the bladder.

Treatment where the Rectum and Anus, although Normal in other Respects, are Rendered Abnormal by the Circumstance that the Ureters, the Uterus, or the Vagina opens into them.—In those cases in which the ureters have been found to terminate in the rectum, the bladder was found to be absent; in which instance, of course, an operation could not be thought of. In those cases in which the uterus or the vagina opens into the rectum, the same course may be pursued as in the converse conditions already described.

Fig. 320.—The Drawing Shows the Old and Unsatisfactory Method of Treating Atresia Ani Vaginalis.

IV. CONSTIPATION.

Constipation is a relative expression, inasmuch as what seems to be a perfectly normal condition in one person,—such as having one stool every second or third day,—would be quite abnormal for another, who is in the habit of having one stool in twenty-four hours, and feels very much upset in his general condition if these daily evacuations are interrupted.

Constipation is a very common complaint, one to which all classes and conditions of men, women, and children are liable, and which is the cause, as well as a symptom, of many anal and rectal pathological conditions; and we are just beginning to recognize the fact that various and serious affections may result from a prolonged retention of fecal matter in the bowel.

Constipation may be defined as an abnormal retention, and an insufficient discharge, of the waste and undigested products of our food, together with the excretory products of the intestinal tract, notwithstanding the fact that a sufficient quantity of food has been taken and properly digested.

For all practical purposes constipation may be divided into two varieties—acute and chronic.

Acute Constipation.—The causes leading to the production of the acute variety of constipation are classified by Dr. H. Illoway as follows:—(1) Direct obstruction of the lumen of the intestinal tube; (2) the pathological changes

in one or more of the tissues of the intestinal tract, impairing their capacity for the normal performance of their physiological function; (3) direct inhibition of peristaltic function through the nerve centres; (4) absence of, or impairment of, the quality of the bile; (5) inhibition of the aid afforded by the diaphragm and abdominal muscles; (6) reflex influences; and (7) a combination of the various ways already enumerated.

In addition to the above-named causes of acute constipation there are circumstances or conditions that may aggravate or increase the predisposition to it. Such are, for example, a diet that is too concentrated or too refined, an insufficient amount of fluid, want of exercise, and frequently antagonistic medication.

The rational treatment of acute constipation consists in the removal of the

Fig. 321.—Illustrates a Case in which the Rectum Opens into the Bladder.

cause as well as in the treatment of the symptoms. The cause may be remote, but it must be sought out. Thus, for instance, where the constipation is due to an intussusception or a volvulus the obstruction must be overcome before the constipation can be relieved; or, where it is brought about by the presence of false bands or by strangulation of some orifice, as in strangulated hernia, manifestly these obstructions must be relieved by surgical means before the acute constipation can be overcome.

In those cases where the obstruction and acute constipation are brought about by foreign bodies, whether formed within or introduced from without, they must be gotten rid of before the acute constipation can be relieved.

Chronic Constipation.—Although the causes of chronic constipation vary greatly in their nature, they may, as suggested by Dr. Holloway (Chap. VII., p. 56), be studied to advantage under the following heads, the arrangement of which

we have slightly modified:—(*a*) Constipation produced by well-defined morbid processes: (*b*) constipation caused by congenital malformation of a section of the large intestine, by a defective development of the intestinal tract as a whole, or by a dislocation of any part of this tract: (*c*) constipation caused by abstention from defecation on account of the pain accompanying the act: and (*d*) constipation due simply to impairment of the physiological function of defecation.

(*a*) Constipation Produced by some Well-defined Morbid Process.—As familiar examples of such well-defined disease we may refer to the presence, in the wall of the intestine, of a cancerous growth or of a mass of cicatricial tissue left by the healing of an ulcer: to the existence of an abdominal or pelvic tumor, or a retroverted uterus, in all of which conditions sufficient pressure may be exerted upon the bowel to obstruct the progress of fecal matter; and, finally, to hypertrophic thickening of Houston's valves. The latter condition undoubtedly is capable, in some cases, of producing obstipation, but we do not believe that such cases are as common as Dr. T. C. Martin would have us believe.*

(*b*) Constipation Caused by Congenital Defects of one Kind or Another.—Under this head may be mentioned such abnormalities as the following: abnormally developed colon: unduly long or unduly large sigmoid flexure: undue length of the meso-colon or meso-sigmoid: and diverticula of the large bowel. In the case of an abnormally long meso-colon or meso-sigmoid there is danger that an acute flexure of the sigmoid or colon, or an invagination of the sigmoid into the rectum, may result from these abnormal conditions.

(*c*) Constipation Caused by Abstention from Defecation on Account of the Pain Accompanying the Act.—In this class of cases it will be found that the rectum or the anus is the seat of disease of some kind—for example, hemorrhoids, ulcerated conditions of the rectum or the anus, fissures of the anus, and chronic proctitis. All physicians are familiar with the fact that these conditions favor chronic constipation. In the cases in which for any reason it is not practicable to attempt a permanent cure by operative interference, considerable temporary relief may be obtained by the administration of castor oil in half-ounce doses (to be repeated every three hours until a movement of the bowels is secured), and then afterward by the use of enemas of cotton-seed oil. Each enema should contain as much as four ounces of the oil, and the fluid should be injected while the patient is in the knee-chest position.

(*d*) Constipation due Simply to Impairment of the Physiological Function of Defecation.—It is only to this form of constipation, according to Illoway, that the term "habitual constipation" can properly be applied.

From a study of the intestinal movements it is known that, under normal conditions, the circular and longitudinal muscular fibres contract alternately. By the contraction of the circular fibres the bolus is prevented from retrograding; then, by contraction of the longitudinal fibres, the bowel is pulled up over

* The reasons why the importance of these hypertrophied valves seems to us to be overestimated by Dr. Martin are set forth in detail in the last edition of Dr. Tuttle's book on "Diseases of the Rectum, Anus," etc.

the bolus, and thus it is pushed along. Under abnormal conditions, however, this physiological order may be changed: the two sets of fibres may contract synchronously and spasmodically. Thus the progress of the fecal matter may be retarded and constipation result, as happens in spasmodic stricture of the rectum. Such a spasm of the intestinal muscles may involve any part of the intestinal tract. The writer recalls two cases, for example, in which the spasmodic contraction affected the muscles of the œsophagus. Then, again, the spasm may be limited to any section of the tract—as, for example, the rectum or the sigmoid, which are the parts concerned in the production of the form of constipation known as spastic constipation.

Under the present heading would come those cases of chronic constipation which are produced by a sphincter that is simply irritable—that is, one which is easily provoked to spasmodic action. Such spasmodic action is much more common in the sphincter ani than higher up in the rectum.

In the present group belong also those cases of chronic constipation which arise from atony of the intestine, from neglect to answer the calls of nature, from the use of food that is defective in residual matter and fats, from want of sufficient physical exercise, from prolonged mental work and worry, and from the well-marked muscular relaxation which follows the prolonged use of warm-water enemas or the too great distention of the bowel by such enemas.

Diagnosis.—The diagnosis of the mere fact of constipation is usually made without any difficulty from the statement of the patient. In some cases a digital examination may be found necessary. There is some difficulty, however, in getting at the truth when the patient complains of diarrhœa, and yet is actually constipated. The important points to be determined are: what is the cause of the difficulty, and what is its nature; that is, is it a case of habitual constipation, or is it due to one of the many pathological factors already mentioned? In order to differentiate between the different causes, one must go carefully into the history of the case, and must inquire particularly whether there has or has not been pain, and also whether or not there has been any admixture of mucus (simple mucus or mucus stained with blood) with the feces. The abdomen must be carefully examined, and so also must the rectum, both with the finger and with the proctoscope. By inflating the bowel through the pneumatic proctoscope we shall be greatly assisted in our search for facts bearing upon the nature of the affection.

Treatment.—The most common form of chronic constipation that presents itself for treatment, is that due to atony of the intestinal musculature; and the rational line of treatment, in cases of this nature, is first to remove the cause, if possible, and then to restore the lost tone of the bowel. The first indication will be met by enforcing the following rules:—The patient should have a definite hour for going to the toilet each day, whether he has the desire, or not. If he does not have the desire, he should induce it or aid it by the simplest and most ready means at his command—viz., an injection of a small quantity of cold water, which acts by stimulating the bowel to do its work. If this practice is continued for a short time, the habit will soon become

established. In the next place, he should eat such food as contains a considerable amount of cellulose—such, for example, as coarse vegetables, fruits with their skins left on, and bread made from unbolted flour. He should drink plenty of water and should take an abundance of outdoor exercise. No milk, except in very small quantities, should be allowed. To carry out the second indication, —the restoration of tone to the bowel,—resort must be had to those means which experience has shown to be most efficient, viz.: the correction of stomachic and intestinal indigestion; the use of such drugs as improve muscular tone and excite peristalsis—as, for example, nux vomica and physostigmine; massage; hydrotherapy, and electricity. Massage has the most pronounced effect in restoring the tone of the bowel, as well as in strengthening the voluntary abdominal muscles which take part in defecation. It can be carried out by the methods that are usually laid down for its use, such as kneading, rolling of a small cannon ball (three or four pounds) over the abdomen, or the Swedish exercises that have been specially arranged for developing these muscles.* Still another method is that in which massage is applied directly to the walls of the rectum by means of an oscillator or vibrator introduced into the rectum and then made to oscillate very rapidly. The results of treatment by this form of massage are reported to be most satisfactory.

Hydrotherapy plays an important part in the treatment of atonic constipation. The most common forms of administering it are the following:—Cold-water enemas used in moderate quantities, so as not to cause overdistention of the bowel, cold tub-baths, douches, and compresses; and cold moist frictions.

It is not quite certain whether the use of electricity produces any permanent beneficial effect on constipation, or not; that it is capable of provoking an evacuation of the bowel is scarcely open to doubt. The faradic current is generally used, the positive electrode being placed in the rectum, and the negative along the tract of the colon and sigmoid, over the abdomen and over the lumbar portion of the spinal cord. The treatment of that form of constipation which accompanies chronic catarrh of the large bowel, consists in the treatment of the latter disorder, as given elsewhere in this article. For spasmodic stricture of the rectum, as also for spasm of the external sphincter without local lesion, the internal use of asafœtida in large doses will probably be found the most useful of all medicines, especially as the individuals in whom the affection most frequently occurs are hysterical subjects. In cases of spasm of the external sphincter, in which the asafœtida has failed to afford relief, gradual but complete dilatation of the sphincter will be the next best means of relief at our command. In these cases also the oil clyster (from three to four ounces of olive oil or the best cotton-seed oil) should be injected warm into the rectum at night, the patient being in the knee-chest position while the injection is in progress and also for from five to ten minutes after the procedure is completed. Where the constipation is due to hypertrophy of Houston's valves, these structures should be divided, either according to Dr. Martin's method (with the knife devised by

* For a description of these, see Dr. Illoway's book.

him for the purpose) or by the application of Pennington's or Gant's clamp which causes pressure necrosis and thus effects a division of the valve.

The prolonged use of cathartics and even of laxatives, in any form of constipation, should be deprecated. In cases of impaction, or where hard scybala have formed, the administration of castor oil, to be given in half-ounce doses at intervals of three hours, until the bowels are thoroughly emptied, and then to be followed by the employment of enemas of cotton-seed oil, affords the safest and best means for obtaining prompt relief. In cases of impaction, however, the enemata should not be administered until the mass has been broken up by forceps or softened by the injection of ox-gall or, better still, hydrogen dioxide. Both the forceps and the dioxide may be applied directly to the mass through the electric proctoscope. In those cases of atonic constipation in which it is deemed necessary to give laxatives for a while, the fluid extract of cascara sagrada, a combination of the cascara with malt, or an infusion of senna leaves, will be found most efficient and the least harmful. In those cases in which the constipation is due to acute flexures of the sigmoid, or to the invagination of the sigmoid into the rectum, or to displacement of the colon,—all of which conditions are generally the result of an abnormally long meso-sigmoid or meso-colon,—temporary relief may be gotten from the introduction, once every day, of a No. 8 Wales bougie or from the inflation of the bowel with air, especially if it be done while the patient is in the knee-chest position. Both of these measures act by lifting or pushing the bowel out of the pelvis and thus straightening out the flexures. For the permanent relief of either of these conditions, when present in an aggravated form, resort must be had, sooner or later, to sigmoidopexy or colopexy. The same may be said of those cases in which the constipation is due to the presence of adhesive bands, or to undue contraction of the lumen of the bowel by scar tissue. The abdomen having been opened, the adhesive bands should be broken up or the strictured portion of the bowel excised and the healthy ends brought together by end-to-end or lateral anastomosis. In the sigmoid the latter appears to be the safer method.

V. SIMPLE AND SPECIFIC ULCERATIONS.

Simple Ulcerations.—The simple ulcerations are those which originate in traumatism or in any abrasion that secondarily becomes infected with one or more of the different species of micro-organisms which are commonly present in or around the anus and rectum. The specific ulcerations are those which are due to specific organisms—as, for example, tuberculous, syphilitic, and dysenteric ulcerations. Each of the varieties mentioned may be further subdivided according to location.

Etiology.—Simple ulcerations may be due to traumatism or to any abrasion of the surface through which infection may gain admission. When they occur around the anal margin, they may be due to herpetic or eczematous eruptions. When they occur in the rectum or sigmoid, they may be due, not only to the

causes already named, but also to catarrh of the mucous surface, to a varicose condition, to inflamed hemorrhoids, to follicular inflammation, and to the toxic action of certain drugs.

In the causation of ulcers in the region which we are now considering, some influence must be accorded to certain anatomical conditions—as, for instance, the manner of distribution of the superior hemorrhoidal veins, the absence of valves in the veins, and the existence of a feeble collateral circulation. Certain diseases, such as Bright's disease and diabetes mellitus, trophic disturbances, and marasmic conditions, favor the development of rectal and anal ulcers.

General Symptoms.—The symptoms are very similar for all varieties of ulceration; the degree of severity does not bear any relation to the size of the ulcer, but it does to its location. Those ulcers, for example, which are located nearest the sphincter produce the most distressing symptoms, regardless of their size. Diarrhœa is one of the earliest and most constant symptoms. The stools soon consist of mucus, pus, and blood, and are attended with tenesmus and a bearing-down sensation. Pain is a very indefinite and unreliable symptom, depending upon the degree of proximity of the ulcer to the external sphincter. The amount of pain bears no relation to the character of the ulcer. Incontinence may exist in a certain number of cases.

Traumatic Ulceration of the Rectum.—Traumatic ulceration of the rectum originates in an abrasion of the surface of the mucous membrane, followed by an infection through the abrasion. The appearance of an ulcer of this nature depends upon the character of the wound which gave rise to it. Its surface is covered with simple granulation tissue and is bathed with thick muco-pus.

In the treatment of these ulcers the important thing is to secure thorough drainage. This is best accomplished either by thoroughly stretching or by incising the sphincter, and by irrigations with antiseptic solutions, three or four times daily: after which the ulcer may be further cleansed with hydrogen dioxide, and stimulated with a two-per-cent solution of silver nitrate, or, in very chronic cases, with tincture of iodine. The evacuations should be regulated by gentle laxatives and made to pass painlessly by the employment of tepid-water enemata.

In the case of hemorrhoidal ulcers the treatment should be absolutely surgical; the ulcerated hemorrhoidal mass, together with any other hemorrhoids that may be present, should be removed. The resulting wounds should not be sewed up, on account of the infection already present. The clamp and cautery, by reason of their antiseptic properties, are best adapted for the treatment of these cases.

Ulceration Following Stricture.—Stricture of the rectum is sometimes accompanied by a form of ulceration that might be included with traumatic ulcerations, for doubtless the trauma from the retained and hardened fecal matter is the chief factor in its production. Nevertheless, this ulcer possesses certain features which do not characterize the traumatic ulceration. In the first place, the walls of the rectum are generally infiltrated with fibrous tissue, and this is true, not only with respect to the different layers of tissue which compose the rectal walls, but also—more particularly in the case of syphilitic strictures—with respect to

the walls of the blood-vessels that supply these structures (arteriosclerosis or endarteritis). Thus we have the circulation of the part interfered with by pressure from without as well as by a diminution of the arterial calibre; this interference with the circulation lowers the vitality and resisting power of the tissues and makes them very much more prone to ulceration. This constitutional disorder, with which strictures of the rectum are so often associated, is an additional factor that does not have to be reckoned with in simple traumatic ulcers. It, in turn, weakens the resisting power of the patient and makes the liability to ulceration in these cases more certain.

Specific Ulcerations.—Under the head of specific ulcerations of the anus, rectum, sigmoid, and colon, we shall include all those forms of ulceration which may be directly and positively traced to specific organisms. Such, for example, are the following:—Tuberculous ulcers (Fig. 322), ulcers caused by the Schistosoma hæmatobium, dysenteric ulcers, venereal ulcers, diphtheritic ulcers, carcinomatous ulcers, and ulcers due to actinomycosis.

Tuberculous Ulcers.—Tuberculosis is now known to be the cause of many forms of ulceration in this locality, the pathology of which was formerly unknown. These ulcerations may be primary or secondary, and may appear in the surrounding skin or in the muco-cutaneous, the mucous, or the cellular tissues. The disease is propagated either directly to the adjoining tissues or through the lymphatics. Its rapidity of advance is in an inverse ratio to the amount of fibrous tissue in its path. A pure cicatrix, for example, forms an impassable barrier to its progress, and may give rise to stricture.

Lupoid ulceration of the anal canal is only another form of tuberculosis. It is attended with a great deal of infiltration and is slow in its progress, but eventually it proves very destructive to the tissues.

Verrucous ulceration is still another type of tuberculous ulceration. It may extend either downward to the skin, or upward into the rectum. It is a very rare form of tuberculous disease. The chief characteristic of these ulcers is their papillary or mammillated appearance. The true nature of the ulceration has been verified by inoculation of rabbits, and by finding the tuberculosis bacilli. The ulceration develops insidiously.

The finding of the bacilli in the scrapings establishes the diagnosis.

It is interesting to note how nature, by producing an infiltration of fibrous tissue at the base and sides of the ulcer, makes provision for staying the progress of the disease.

The observance of extreme cleanliness, the use of antiseptic washes or of dusting powders, and the application of soothing ointments, constitute the treatment. All unnecessary surgical interference should be avoided, but, when this becomes necessary, the patient should be gotten out of doors as soon after the operation as his strength will permit.

In the lupoid form of ulceration curetting, followed by the use of the *x*-ray, gives the best results. General constitutional treatment should of course be given at the same time. In the verrucous form of ulceration, the same local and general measures as have been recommended for the treatment of the simple

tuberculous ulceration, may be employed to advantage. When the ulceration involves the rectum and sigmoid, the most that can be done locally is to employ antiseptic irrigations. At the same time special attention should be paid to general treatment. Several cases have been reported in which appendicostomy has given great relief.

Fig. 322.—Drawing of Tuberculous Ulceration and Stricture of the Rectum. (Tuttle on "Diseases of the Anus, Rectum, and Pelvic Colon.")

Hyperplastic Tuberculosis.—Coquet (Thèse, Paris, 1894) has described a peculiar condition of tuberculous infiltration of the intestinal walls, which he has designated by the above title. According to him it occurs most frequently in the ileo-cæcal region. It is characterized by extensive formation of fibrous and tuberculous granulation tissues in the walls of the intestine. It corresponds to a similar tuberculous process which is found in the lungs in a certain form of chronic pulmonary tuberculosis. The fibrous hyperplasia seems to take the place of caseation and necrosis. The walls of the intestine are greatly thickened and indurated. The mucous membrane is sometimes ulcerated. The chief seat of the infiltration is in the submucous and circular muscular layers.

The diagnosis is exceedingly difficult to make unless there is ulceration of the mucous surface.

Acute Tuberculous Proctitis.—This disease, which was first described by Earle in the *Maryland Medical Journal* for 1899, is characterized by swelling of the mucous membrane, by intense hyperæmia, and by the presence of numerous small ulcers. The description is based upon the findings of two necropsies, which were made under the supervision of Professor Councilman, and upon two cases observed at the bedside. For fuller details the reader is referred to the above journal.

Carcinomatous Ulceration.—Owing to the similarity of the signs and symptoms of the two diseases it is sometimes very difficult to distinguish a simple ulceration of the rectum from a beginning carcinoma of the same locality. The possibility that the latter disease may be present should always be borne in mind in the case of a patient who is suffering with diarrhœa and discharges of mucus, blood, and pus, and a thorough examination should be made to determine the truth. The trained finger will easily recognize the peculiar induration which characterizes the presence of a cancerous growth in the rectum. The ulcerations which frequently occur in connection with Bright's disease, diabetes mellitus, chronic cirrhosis of the liver, and

marasmus, possess no characteristics by means of which one might be able to distinguish them from simple ulcerations, and the manner of treating the two should be the same;—it being understood, of course, that due attention is to be paid to the complicating disease.

Ulceration of the Rectum Due to Infection by Schistosoma hæmatobium.—Dr. Leonard Blumgart, of New York (*Medical Record*, April 6th, 1907), has called attention to a very interesting form of ulceration of the rectum due to the general infection caused by the Schistosoma hæmatobium. The infection, it is now believed, takes place in one or the other of two different ways. Sonsino claims that the infection occurs through the gastro-intestinal tract by means of infected food or water; Brock, on the other hand, believes that the parasite enters the body through the skin while the patient is bathing in an infected stream. The adult worm finds its way into a small vein of the portal system, becomes encysted there, lays its eggs, and finally these burst the wall of the vessel and escape into the neighboring tissues and blood-vessels. The pathological results are induration, ulceration, and polypoid vegetations. It is only in the rectum, however, that the vegetative and ulcerative changes take place. The only symptoms which seem to be constantly produced are diarrhœa and pain. "In our case [Blumgart], the eggs were found in every stool examined." The disease is very rare in the United States, only seven cases having hitherto been reported.

Dysenteric Ulceration.—While it has been proven that the chief seat of dysteric ulceration is in the cæcum, it is unquestionably true that a very large majority of cases present typical ulcers of the rectum and sigmoid at some time in their course. This fact and the modern treatment of diseases of this nature by local measures bring dysentery within the domain of rectal surgery.

Dysentery is now admitted to be an infectious disease. There are three types of infection—the amœbic, the bacillary, and the mixed infection. The latter should probably be classed with simple ulcerations.

Bacillary Dysentery.—This form of dysentery is due to infection by the *Shiga bacillus* or one of its prototypes. The source of the bacillus is unknown.

The disease is often ushered in suddenly with a chill, rise of temperature, pain in the back, griping abdominal pains, tenesmus, and burning in the rectum. The stools are at first mushy, then liquid, and finally they are composed almost entirely of mucus and blood. Frequently there is nausea. Emaciation progresses rapidly, and collapse often comes on early in the course of the disease.

The constitutional symptoms are due to the toxins produced by the specific bacilli, and not to the bacilli themselves.

A large dose of calomel (gr. x., with sodium bicarbonate) should, if possible, be given early in the disease, and, after the lapse of six hours, it should be followed by a full dose of castor oil. When the bowels have been thoroughly evacuated, rectal irrigations of warm antiseptic solutions should be begun, and they should be repeated every four or five hours.

Shiga has obtained very good results from the serum treatment of this form of dysentery. This treatment alone, however, is not sufficient; with it must be combined rectal irrigations and constitutional measures.

Amœbic Dysentery.—This form of ulceration of the large intestine is due to infection with the Amœba dysenteriæ. It is much more insidious than the bacillary form.

Usually, in the acute cases, there are the following symptoms: a frequent desire to defecate; burning in the rectum, with tenesmus; loss of appetite; and slight elevation of temperature. As has been pointed out by Rogers and Tuttle, the amœbic infection may exist in a latent form, and may even end in death from complications, without noticeable diarrhœa. Severe constitutional complications, however, are rare.

The irregular course of the disease is one of its chief characteristics, the attack being made up of intermissions, relapses, and exacerbations.

The diagnosis can be made positive only by finding the Amœba dysenteriæ in the discharges from the bowels or—what is much more accurate—in the scrapings procured directly from the ulcers and examined immediately.

So far as treatment is concerned, it is only necessary, since the disease is primarily local, to direct all our efforts toward its eradication by local measures and by the administration of saline cathartics. Ipecac in salol-coated pills seems to produce a good effect in very acute cases, but, in our experience, it is useless in the chronic conditions. Such symptoms as may manifest themselves in addition to those of the ulceration in the large bowel, are secondary and should be treated as they arise.

High rectal irrigations of normal saline solutions, of formalin solutions (1 in 300), of a very weak solution of bichloride of mercury (1 in 10,000), or of quinia muriate (from 1 in 500 to 1 in 3,000), to be administered in alternation with similar irrigations of a silver-nitrate solution (from 1 per cent to 3 per cent), are among the best local means of treating the disease. All these solutions should be used at a temperature ranging from 80° Fahr., at the beginning, down to 60° Fahr. This is the course suggested by Tuttle, who observed that the motility of the organisms was lost—and, as it appeared, permanently—whenever the temperature was reduced below 70° Fahr. Acting in harmony with this observation Tuttle has treated successfully a number of cases with irrigations of ice water alone. Musgrave says that the cold does not destroy the amœbæ, but simply benumbs them, so that they may be more easily washed out from the intestinal canal. If it is found, however, that the cold solutions produce much pain and tenesmus, they should then be used warm, and should be introduced very slowly. The diet should be principally nitrogenous and of a mild, unirritating character, and the patient should be confined to bed. While many acute cases are permanently cured by the measures named above, this is by no means true of the chronic cases, which continue to have relapses under the most careful use of the various measures advocated—so long, at least, as they are administered through the normal channels. These same remedies, however, and especially the cold water, will give the most satisfactory and permanent results when they are administered through an artificial opening in the cæcum or the appendix, in the manner suggested by Dr. Gibson and Dr. R. F. Weir, and to be described farther on (p. 797).

Valvular Colostomy.—This operation was devised prior to appendicostomy, and, while the latter is much easier to perform and much more easily managed subsequently, yet valvular colostomy still has its own field of usefulness (*e.g.*, in cases in which the appendix is found to be impervious, or in those in which, for any other cause, this organ or structure cannot be utilized for irrigating purposes).

Gibson's method * is as follows:—An incision, one inch and a half in length, is carried through the abdominal wall parallel with Poupart's ligament on the

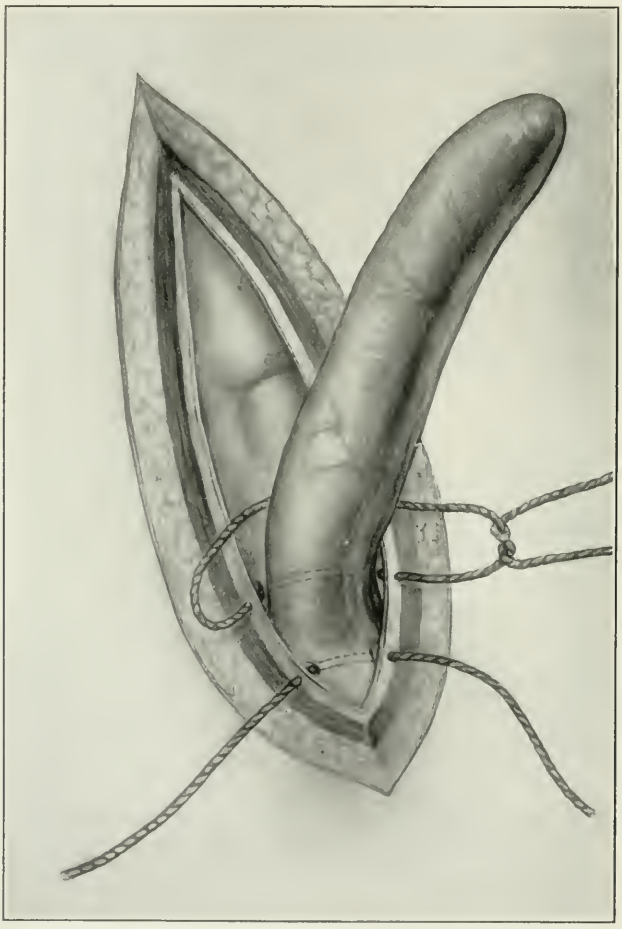


Fig. 323.—Operation of Appendicostomy; First Stage.

right side, and one inch internal to its outer part. The cæcum is found directly beneath the incision and presents itself in the opening. A point is chosen in the anterior band of the intestine and at this point an opening is made sufficiently large to admit a fair-sized soft-rubber catheter. The three tiers of sutures placed above and below this orifice serve to infold the cæcal wall. The ends of the last sutures introduced are left long, and are carried through the margins

* Boston Medical and Surgical Journal, vol. cxlvii., p. 341.

of the abdominal incision. These, when drawn tight, bring the cæcum forward into close contact with the abdominal wall, and are utilized for closing the external wound, a silkworm-gut suture being placed at each angle for reinforcement purposes.

The catheter is left in place until the seventh day, after which it is reintroduced at the time of each irrigation. These irrigations are begun about the second or third day after the operation. There is absolutely no leakage from this opening when the catheter is out, nor is there any difficulty attending its

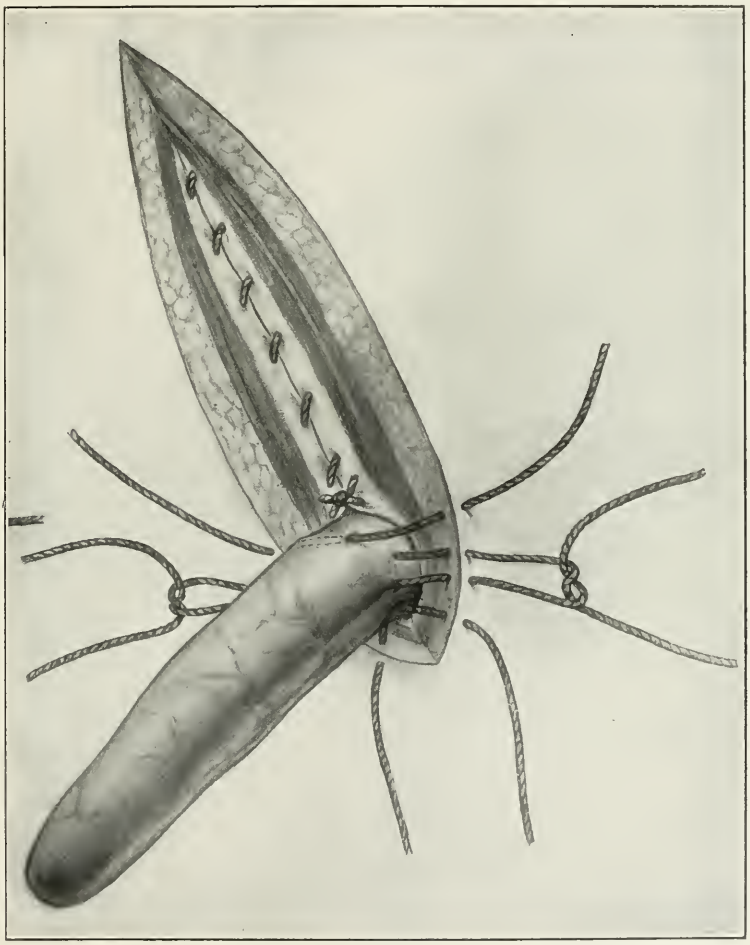


Fig. 324.—Operation of Appendicostomy; Second Stage.

reintroduction. The wound, furthermore, readily closes of itself after the use of the catheter is stopped.

Weir's Operation for Appendicostomy.—The technique of Weir's operation for appendicostomy, as recently modified by Tuttle, is thus described in a paper which he read before the Surgical Section of the New York Academy of Medicine in May, 1905:*—An incision, one inch and a half long, is made at McBurney's

* See American Journal of Surgery, June, 1905.

point, the intermuscular method being used. The appendix having been found and brought out to the surface, its artery is tied and the mesentery stripped down to its juncture with the caput coli; a suture is next passed at the lower angle of the wound, through the peritoneum, then through the muscular walls of the cæcum at its juncture with the appendix, and back through the peritoneum on the opposite side of the wound. (Fig. 323.) A second suture is then passed about half an inch above the other, through the same tissues, but on the upper side of the appendix. These two sutures having been tied, the peritoneum is closed by continuous suture and the wound in the usual manner, the skin being sutured accurately, but not too tightly. (Fig. 324.) The patulousness of the appendix should be definitely determined before closing the abdominal wound. If there is any real reason to doubt its patulousness, we believe that it is better to cut off the end and to tie in a very small catheter before closing the peritoneal cavity. There is very little risk in adopting this course, and it gives the surgeon the advantage of performing a valvular cæcostomy at once, if the appendix should prove to be impervious.* If there is no reason to suspect the perviousness of the appendix, the abdominal wound should be closed and the appendix not opened for several days. It is better to delay the irrigations for four or five days after the operation, on account of the risk of infecting the wound. It must be remembered, however, that appendicostomy does not take the place of local treatment applied to the ulcers in the rectum and sigmoid. Many of them are mixed infections and must be treated accordingly.

Ulceration due to Mixed Infections.—The character of the ulceration which results from a mixed infection is very similar to that of the bacillary type. The symptoms, as a rule, are not so acute nor so violent.

The most important pathogenic organism found in this form of ulceration is usually the colon bacillus.

Venereal Ulceration of the Anus and Rectum.—Although this form of ulceration is not very frequent in the United States as the result of direct transmission through the practice of sodomy and pederasty, yet, as a result of auto-infection, it occurs quite frequently. The chief varieties are gonorrhœal, chancroidal, and syphilitic.

Gonorrhœal Proctitis and Ulceration.—This form of the disease resembles so closely acute catarrhal proctitis, that it can be differentiated only by the presence of the causative agent, the gonococcus.

The remedial solutions which will be found the most effective are the following:—Bichloride of mercury solutions (1 in 10,000); silver nitrate solutions (one-quarter to one-half of one per cent); and solutions of argonin, argyrol, and potassium permanganate, all of which rapidly destroy the gonococci.

Chancroid of the Anus and Rectum.—This is not an infrequent affection among the lower classes, and its characteristics are very much influenced by the amount of attention which it receives. It is much more frequent in women than in men, owing to the facts that the genitalia are in closer proximity to the anus

* In a large number of cases operated upon by myself and my assistants, we have never found the procedure necessary in a single instance.—*J. P. T.*

(thus favoring auto-inoculation), that the anus probably comes in contact with the diseased male organ, and that the practice of sodomy is more frequent than that of pederasty. Chancroidal ulcerations of the anus may be secondary to chancroids elsewhere, and are generally limited to the perianal region and the anal canal. Chancroidal ulceration of the rectum is a very rare lesion and is generally the result of sodomy or pederasty. The phagedenic variety, with its persistent tendency to spread, is more likely to extend from the anal orifice up into the rectum. The treatment consists in keeping the parts thoroughly clean, in making local applications of a stimulating character, and in dusting the parts either with some mildly antiseptic powder or with one containing calomel.

Syphilitic Ulceration.—This highly infectious and insidious disease manifests itself in the skin around the anus, in the anal canal, and in the rectum, either as a primary lesion or as one of a secondary or tertiary character. The primary lesion—*i.e.*, a chancre—appears in and around the anus or in the rectum more frequently than has been supposed. It is much more common in women than in men. In whichever of these localities it may appear, its pathogenic characteristic is the induration of its base. This feature, however, is not very pronounced before the expiration of ten days or two weeks.

The differential diagnosis may be made before this by the finding of the Spirochæte pallida.

A simple hard chancre may assume a phagedenic type. The inguinal lymph nodes on both sides soon undergo enlargement, one after the other.

A patient may have a true chancre without the development of any secondary lesions, and yet, years later, he may show tertiary symptoms. Then, again, the secondary lesions may be so mild as not to attract attention. These cases indicate that the systemic resistance at the time was sufficient temporarily to overcome the virus of the disease, but not to destroy it. Then, at some later period, when the patient's vitality was depressed, it overcame the systemic resistance and developed with great intensity.

Secondary manifestations of syphilis show themselves on the skin surface, in the region of the anus, in the form of mucous patches or ulcerative conditions which are merely transformed macular, moist papules. They may also occur in the form of tubercular syphilides, due to moisture and constant contact of the parts. They first begin with an erythema between the folds of the buttocks; and this change may take place before the initial sore heals.

Secondary ulcerations in the rectum are by far the most frequent manifestations of syphilis that occur above the ano-rectal line. They may be single or multiple; they are crater-like ulcers, with clean-cut, indurated edges; in the early stages they rarely extend deeper than the submucous tissues; subsequently, they may become very extensive, and are often attended with great destruction of tissue. In these ulcerations of the rectum the sacral lymph nodes are enlarged. The walls of the rectum beneath the ulcers feel leathery and indurated. The odor is fetid and offensive, but quite different from that given off by the discharge which attends a carcinoma.

The treatment consists in keeping the parts clean, in securing good drainage,

in making local antiseptic applications, and in administering mercury internally. A large number of cases of syphilitic ulceration end in the formation of an obstinate stricture, which owes its origin to the fibrous infiltration that always attends and follows this form of ulceration.

The principal types of the rectal lesions belonging to the tertiary stage of syphilis are gummata, destructive ulcerations, ano-rectal syphilomata, and proliferating proctitis.

Gumma.—When a gumma occurs in the rectum, it takes the form of a round, elastic, and painless deposit in the submucous tissue. Later, it may involve both the mucous and muscular walls of the bowel. It may occur as a single, isolated lesion, or there may be several gummata. If breaking down and ulceration of the gumma do not occur, permanent stricture of the rectum will not result.

A dry, brittle condition of the muco-cutaneous tissues about the anus is one of the most frequent manifestations of tertiary syphilis. A very similar condition is seen in atrophic catarrh. Ulcers like those of tertiary syphilis (disintegrating gumma) may also result from traumatism and from necrosis of tissues due to endarteritis obliterans.

Ano-Rectal Syphiloma of Fournier.—Fournier* describes, under this name, a specific fibrous infiltration of the rectal walls. He states that it represents a hyperplastic proctitis, with a tendency to sclerotic change, as it is seen in the kidneys and other organs in late syphilis. It begins in the submucous tissue.

Proliferating Proctitis.—Paul Hamonic has described under the title of "De la Rectite proliférante vénérienne et non-vénérienne" (*Annales Médico-Chirurgicales Françaises et étrangères*, Vol. II., p. 3, 1886) what he considers a peculiar syphilide. It consists of a growth of fragile villous prolongations, which spring from the mucous membrane of the rectum. Kelsey and Tuttle have each reported cases of this character.

The treatment of tertiary syphilis of the anus and rectum consists in the administration of the iodides, in inunctions or hypodermic injections of mercury, and in the local application of antiseptic washes and dusting powders.

Hereditary or Congenital Syphilis of the Anus and Rectum.—Lesions of this nature are among the earliest manifestations of this form of the disease; they may occur at any time after birth, up to several years of age. There is first observed an erythema around the anal margin; the skin is slightly pigmented, red or copper-colored, but after a few days it becomes thickened, and elevated; then a thin, sero-purulent discharge is set up, which soon assumes a fetid odor.

Actinomycosis.—Actinomycosis is exceedingly rare in the region of the rectum. It may have its primary seat either in this part of the intestinal canal or in the perirectal tissues.

* "Lésions tertiaires de l'anus et rectum," Paris, 1875.

VI. FISSURE IN ANO; IRRITABLE OR INTOLERABLE ULCER OF THE ANUS.

Nature and Characteristics of the Lesion.—A fissure, as the word implies, is a crack or break in the tissues which may occur at any of the openings of the body, but in medical parlance the term is used only in connection with the anus. Technically, the fissure occurs only in the sulci between the radial folds, but it may spread vertically or laterally. It is distinct from those destructive types of ulceration which have been described in the previous section. It occurs at all ages and in all conditions of life, but is more frequent in the young. In congenital syphilis it is a very common symptom, and this disease furnishes the principal reason why fissure *in ano* is so frequent in children. There may be several fissures in atrophic catarrh, gonorrhœa, and syphilis, but the typical painful fissure, due to simple ulceration, is nearly always single.

While the shape of the ulcer does not materially influence the peculiar characteristics of a fissure *in ano,* and although the shape of the lesion is influenced almost entirely by its location between the anal folds and by the extent of surface involved in the ulceration, nevertheless the shape differs sufficiently, in different cases, to have brought about some confusion in the names applied to the disease, as appears from the titles placed at the head of this section. If it be borne in mind that the salient features of the lesion have nothing whatever to do with its shape, but are common to all shapes in which it is likely to appear, then we believe that the differences in nomenclature can be reconciled by remembering that the extent of surface involved and its location are the only two factors that cause it to vary. The two shapes which it most frequently assumes are, first, the elliptical, and, second, the irregularly circular. The elliptical shape, to which technically the name fissure is most applicable, and to which it should be restricted, results from the fact that the ulcer is confined between two anal folds. (Fig. 325.) On the other hand, the irregular circular shape is that which the ulcer assumes when it involves more than one of the anal folds; and it is to lesions of this shape that the term irritable ulcer seems most applicable. (Fig. 326.)

At the lower end of the fissure there is generally a hypertrophied tag of skin, or of mucous membrane and skin, which resembles an external pile. This is always very sensitive and painful and is called the sentinel pile.

Usual Site of the Fissure.—In the majority of instances the fissure begins just above the ano-rectal line and extends downward, and, while it may occupy any point in the anal circumference, it occurs most frequently—at least in men—at the posterior commissure. In women it occurs not only at this point, but also at the anterior commissure. It rarely occurs on either side.

Etiology.—The essential feature, in the production of fissure *in ano,* is the formation of cicatricial tissue, which, being non-elastic, does not stretch sufficiently when a constipated stool passes, and thus causes the parts to split open again and again after the fissure or ulcer heals, unless the scar tissue has been

removed. This is why palliative treatment offers so little encouragement, because, even if it prove successful in effecting the healing of the ulcer, the latter is likely to recur when the first constipated stool is passed. Surgical operations may result in the production of fissure-like ulcerations, but, not having any scar tissue, they heal up promptly and permanently. The most usual exciting cause of fissure *in ano* is the repeated passage of hard fecal masses, which tear through a crypt of Morgagni. It is the repeated recurrence of these tears that brings about the peculiar characteristics of an anal fissure, a certain amount of scar tissue forming in the repeated attempts at healing.

Polypi or polypoid hemorrhoids are frequently associated with fissures, and are situated at the upper or internal end of the fissure. They doubtless stand to each other in the relation of cause and effect, the fibrous tissue at the base of the polypus not yielding to the necessary dilatation of the parts in the passage

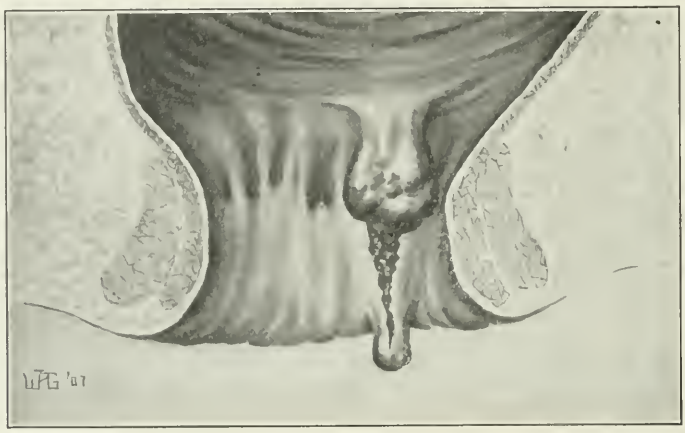


Fig. 325.—Illustrates a Fissure in Ano with an Internal Hemorrhoid Overhanging the Upper Portion.

of a constipated movement. Whatever may be the direct cause of the narrowing of the anal canal, there can be no doubt that the presence of hemorrhoids, both by narrowing the outlet of this canal and by producing changes in the connective tissue of the parts, favors the development of a fissure. The theory advanced by Ball—that typical fissures are due to the tearing of the crypts of Morgagni, through the action of small fecal masses which become lodged in the little pockets, and which then in turn are pressed upon by other hard fecal masses, thus causing the edges of the valves to tear—seems to be very reasonable, when we call to mind how frequently we find the typical fissure corresponding in general appearance and outline with the condition as depicted in Fig. 325. This theory is further supported by the frequency with which fissures occur on either side of the posterior commissure in men, and, in addition, at the anterior commissure in women, at which localities the crypts are more highly developed than elsewhere in the rectum. Moreover, the presence of two little papillæ or teats, so often seen on the mucous border of the fissure, would suggest the tearing through of the muco-cutaneous border—an occurrence

which is likely to leave little tags or teats. There are many cases, however, which cannot be accounted for by Ball's theory.

Pathology.—The pathological changes vary from a very slight tear or fissure to a deep ulceration, both of which conditions are associated with fibrous infiltration which is the essential pathological feature of fissure *in ano*. This explains the readiness with which they tear. Among the microscopic changes which M. Hartmann found in excised fissures (*op. cit.*, p. 442), the following is worthy of note:—Deep down in the smooth muscular layer, the fibres of which were more or less separated by fibrous tissue, he found that the nerve-trunks, which also were surrounded by this same tissue, showed evidences of interstitial and intrafascicular neuritis. These conditions almost certainly account for the severe and persistent pain so generally characteristic of these cases.

Symptoms.—The characteristic symptom of fissure *in ano* is the peculiar

Fig. 326.—The Drawing Represents an Irritable Ulcer of the Anus.

pain which attends it, and which continues for some time after an evacuation of the bowels. There is no disease of the anus or rectum in which, simply from the character of the symptoms, and more particularly of the pain, one may, without an actual examination, make as correct a diagnosis as in fissure *in ano*. The patient, as a rule, feels perfectly comfortable until he has a stool; and, furthermore, the pain does not ordinarily follow the stool immediately, but comes on in from fifteen to twenty minutes thereafter. This pain is of a dull, aching character, and it soon increases until it becomes almost unbearable. It maintains this degree of severity for several hours, and then it gradually subsides. In exceptional cases the pain is less pronounced; it may last for only a few minutes after the stool, to recur again at the next one; each time, however, growing more severe and lasting longer. In obtaining the history of the case, one is sometimes able to elicit from the patient the statement that he has felt a giving way or tearing of the parts during the passage of a constipated stool, and that afterward he has noted the fact that a little blood—generally only a few drops—had escaped at the anus. In other cases the patient states that

after stools he has had an itching and burning at the anal opening, and that he has a small pile which is either always swollen or becomes swollen and painful after every stool. Constipation is nearly always present, and is more likely to be the result of the pain that follows the stool than of some condition which existed prior to the formation of the fissure, although the latter may have begun with a temporary attack of constipation.

A fairly clear relationship exists between the character and severity of the pain, on the one hand, and the location and extent of the fissure. The acute pain that lasts only for a short time after defecation, is due to superficial tears in the muco-cutaneous tissues; the pain that comes on just after stool and lasts for half an hour, or more, is usually due to ulceration between the radial folds; and the dull, aching, throbbing pain, which does not develop at once after a stool, but is first observed after the lapse of some little time, and which lasts for the greater part of the day, is due to a more chronic form of fissure, one which involves the deeper tissues and is provided at its base with a sort of sentinel in the form of a tag. As a rule, the acuteness of the pain is in direct proportion to the nearness of the ulcer to the anal margin.

The reflex symptoms accompanying fissure *in ano* are often numerous and varied: the most common being frequent and painful micturition, bearing-down pains, backache, neuralgic pains running down the legs, and sometimes occipital and facial neuralgia.

Diagnosis.—While the character of the pain in certain cases may indicate fairly well the character of the trouble, yet the only definite and certain way of making a correct diagnosis is by a careful inspection of the parts. In making such an examination the physician should be very careful not to cause any more pain than is absolutely necessary. The examination can in most cases be made sufficiently satisfactory for a diagnosis without the use of a speculum,—*i.e.*, by simply directing the patient to bear down well while the buttocks are being forcibly separated. This is true especially of those cases in which the hypertrophied tag of skin bounds the lower margin of the fissure. If the examination, however, is not satisfactory, then an Earle or a Humphreys speculum (virgin size) may be introduced a short distance into the anal canal in such a manner as to push the wall opposite the fissure away from the lesion. If this is done carefully and gently, it gives rise to very little pain. The information gained from the introduction of the finger in these cases does not compensate for the amount of pain which it causes. One good view of the ulcer will enable one to know just what treatment it requires. The left lateral or the Sims position is the best one for a patient to assume for this examination. In women, when the fissure is on the anterior anal wall, the inspection can be made much more satisfactorily by introducing the finger into the vagina and turning the anterior wall of the rectum out.

Differential Diagnosis.—The condition known as hysterical or irritable rectum, and also as neuralgia of the rectum, may be mistaken for fissure. It can be readily differentiated by the absence of any fissure or local sore to account for the irritability and pain.

As the straining recommended above for bringing into view the fissure produces pain and therefore necessarily inhibits the desired effort, and inasmuch as cocaine in solution exerts very little anæsthetic effect when applied to a granulating surface, we would advise the insufflation of powdered anæsthesine on the fissure when it can be only partially seen. One may also inject hypodermatically a few drops of a weak solution of cocaine underneath the base of the fissure. In this way the desired anæsthetic effect will be obtained in a few minutes, as will be seen by the gradual relaxation of the sphincter and the complete exposure of the fissure. The examiner must bear in mind that he has to deal with one of the most exquisitely sensitive conditions which he is ever likely to meet, and, rather than take the risk of discouraging the patient from having anything done for his relief,—as he would be likely to do by subjecting him to the severe pain which attends a thorough examination,—he would do well to rest content at first with the simple discovery of the fissure, and not explore above it for complications and etiological factors. These may be looked for, and dealt with, if necessary, when the patient is under the influence of the general or local anæsthetic administered for the purpose of treating the fissure.

Treatment.—Contrary to general belief, palliative treatment of chronic cases of fissure *in ano* is time worse than lost; for not only do the local anodynes, which are necessary for the relief of the pain, increase the constipation (which in turn aggravates the most pronounced symptoms that we are trying to combat), but they leave the fibrous tissue absolutely uninfluenced. Consequently the fissure, which may possibly have undergone superficial healing under their quieting influence, will again be torn open the first time the patient has a constipated stool. In view of the fact, however, that in a certain number of cases the patient will refuse to submit to any operative measures, it is important to remember that it is possible to increase his comfort materially by keeping the evacuations soft, by restricting the number of movements to one in twenty-four hours, by making him lie down for half an hour after stool, and by applying a hot-water bag to the perineum. For the regulation of the bowels moderate doses of the fluid extract of cascara sagrada, or of the fluid extract of senna, may be administered; and the effect of these remedies may be increased by the employment of enemas of cotton-seed oil or of hot water. If there are hemorrhoids, a cold-water enema will relieve the congestion, and will serve a better purpose than the warm. The diet should consist largely of fruit and vegetables, in order to encourage the formation of soft and mushy stools. Articles with numerous small seeds, like berries, etc., should be avoided. Locally, the treatment consists, first, of an insufflation of anæsthesine directly into the fissure, for the purpose of quieting the irritability of the sphincter muscle and thus permitting the more thorough application of those remedies which induce healing. After the lapse of a few minutes a pledget of cotton soaked in pure ichthyol is applied to the fissure, which is exposed to view by holding back the opposite wall of the anal orifice with an Earle speculum. These applications should be made once every day, and, if care is taken not to introduce the speculum further than is necessary to expose the fissure, the procedure will not cause much pain.

The non-operative treatment of fissures should be undertaken only in acute and uncomplicated cases.

Operative Treatment.—The operative methods of treating fissure *in ano* include forcible dilatation, incision, and excision. At the present day probably the large majority of the cases which are treated by practitioners who are not specialists in proctology are treated by dilatation. The patients thus treated are doubtless promptly relieved of their pain and other distressing symptoms, but sooner or later very many of them experience a return of the trouble. It is for this reason that specialists do not favor this method of treating, and their judgment should carry weight, as their opportunities of seeing cases which have been treated by dilatation are numerous.

It is needless to say that, in those cases in which there is a polypus at the upper angle of the fissure, stretching alone will not cure the disease; the fissure

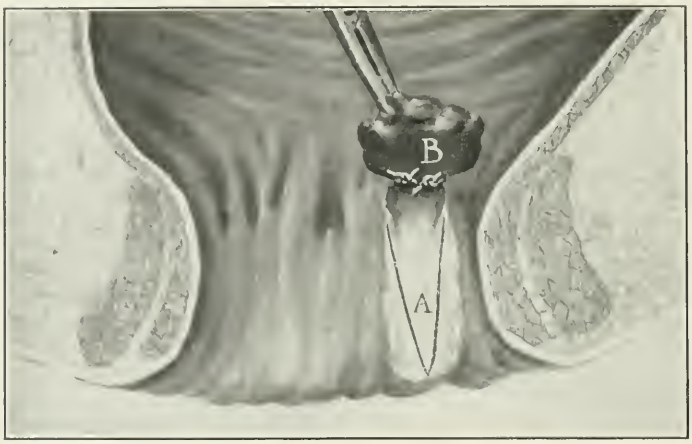


Fig. 327.—The Shape of the Incision (*A*) Required in the Case of an Anal Fissure is here Shown. At the upper end of the fissure there will be seen a hemorrhoid (*B*) to which a ligature has been applied.

will not heal permanently unless the polypus is first removed. (Fig. 325.) The same may be said of the sentinel pile at the lower angle of the fissure. When one recalls to mind what is the chief factor in the development of fissure *in ano*, —viz., the formation of scar tissue in the adjacent tissues,—there is no difficulty in understanding why the condition is likely to recur after forcible dilatation; for in this procedure the fissure is merely torn through at its base and made deeper, while the scar tissue is allowed to remain. There is a lack of agreement among writers with regard to the class of cases in which dilatation should be practised. Allingham states that it is the safest method in old people, in those affected with tuberculosis, and in persons who are very much run down. Matthews, on the other hand, says that it should not be done in such cases. In support of Matthews' position one has only to recall the acknowledged facts that old people are slow in recovering their muscular tone, and that they bear suppurative processes badly. If these facts are borne in mind, it is easy to understand how readily incontinence might follow forcible divulsion in these

cases. When the fissure is tubercuious in its nature, the better plan is not to employ either forcible dilatation or excision, but to resort to the use of the actual cautery. On the other hand, if there are multiple fissures, forcible dilatation is always advisable. In children, who usually do not bear local treatment well, this procedure is very successful, except in those cases in which the fissure is of a syphilitic nature.

Technique of the Method by Dilatation.—Forcible dilatation of the sphincter ani may be carried out in several different ways. For example, the thumbs of the operator may be introduced into the rectum while his fingers are made to clasp the tuberosities as fulera. At first, the stretching is effected by making the thumbs approach the fingers as thus placed. Then afterward, the position of the fingers having been changed to the pubis and sacrum, the stretching is done in an antero-posterior direction. Another method calls for the introduction of the fingers into the rectum, one at a time, until all four shall have been introduced. Then they, together with the hand, are gradually pushed into the canal as far as the thumb will permit. Among the different mechanical devices which may be employed for accomplishing the same end, probably the best and safest is Kelly's conical dilator. Whichever method is used, care should be taken to carry out the procedure slowly and not too forcibly, until the muscle is felt gradually to give way and yield under the pressure. Even when the greatest care and gentleness are employed, almost invariably the floor of the fissure or ulcer will be found torn through; and the good results obtained, particularly as regards the quieting of the pain, are probably due more to this tearing through of the floor of the fissure, and the fibres of the muscle beneath, than to the relaxation of the muscle brought about by stretching it. The dilatation is generally attended with some hemorrhage, but this is never alarming. The length of time during which the muscle remains relaxed and quiet varies: even an hour after the divulsion there is no gaping of the anal orifice, and the muscle will respond in a measure to stimulation. At the end of seventy-two hours sphincteric control will be restored almost completely.

If paralysis of the sphincter muscle facilitates the healing of the fissure, and if it be true, as it seems to be, that the muscle, after being dilated, very soon regains its power to contract, the question naturally suggests itself, would it not be better to introduce a plug and let it remain for forty-eight hours? Those who have tried this plan (the Lynch tube is the best for the purpose) think well of it, and affirm that the patient is much more comfortable with the plug in position.

Permanent incontinence has been known to follow forcible dilatation of the anus. Tuttle has had such a result in two cases.

Treatment of Anal Fissure by Incision.—The second method for operating for anal fissure consists in incising the ulcer or fissure through its base. This plan was first advocated by Boyer in 1788. He claimed that the fissure was due to spasm of the sphincter, and advised the complete division of the latter (as well as of the ulcer) in order to control the spasmodic contractions. He did not, however, advocate cutting the muscle through the base of the ulcer in

every instance; in some cases he divided it on either side of the rectum. He also at times introduced a plug and kept up continuous dilatation. At a later date others held that it was only necessary to divide the superficial muscular fibres directly beneath the ulcer. It is now recognized that the depth of the incision and the precise spot where it is to be made are matters of the greatest importance. It should be extended to such a depth as to put the muscle completely at rest; and it should be made through the floor of the ulcer, in order to avoid the risk of a second infection. It should be remembered, however, that these directions do not apply to ulcers which are directly over the anterior or the posterior commissure. In the latter, for example, the fibres of the external sphincter unite in a sort of tendinous prolongation which is attached to the coccyx. They do not decussate in any marked degree between the rectum and the coccyx. When the ulcer is at either commissure the V-shaped incision is the best, as it puts the muscle on both sides of the fissure at rest. (Fig. 327.)

In ordinary cases the incision should be a little longer than the fissure, and about a quarter of an inch deeper than the deepest portion of the ulcer. The incision should be made squarely across the muscle fibres, and not obliquely. The incision can be made under local anæsthesia produced by injections of a one-quarter or one-half of one-per-cent solution of cocaine (the latter strength being preferable if only a small quantity is to be used). The injection should be made directly beneath the floor and to the sides of the ulcer, care being taken to use a sufficient quantity of the solution, as there is little danger from such weak preparations. After waiting for several minutes for the injection to take effect, the operator should introduce an Earle or a Humphreys speculum, when he will have no difficulty in determining the exact size of the ulcer, and in controlling the length and depth of any incision which he may make. If, at such an examination, a polypus or a hemorrhoidal tumor (Fig. 325) is seen at the upper angle, or a sentinel pile at the lower angle, or if it is found that the edges of the ulcer are indurated, or that exuberant granulations are present, all these abnormal conditions should be removed, either by excising them or by the employment of a sharp-edged curette. As a last step, the incision should be packed lightly with sterile gauze. The patient should then, as a matter of prudence, be confined to his bed for forty-eight hours; but, if there are urgent reasons why he should be given more liberty, he may be allowed to walk about in a few hours.

Treatment of Anal Fissure by Excision.—Reference has already been made, in the paragraphs devoted to the etiology and pathology of the disease, to the fibrous infiltration of the tissues and to the tendency to the formation of scar tissue in anal fissures. Furthermore, in certain cases operative interference fails to relieve the pain, and this is especially true of cases in which forcible divulsion is employed without removing the scar tissue at the same time. These facts have been explained by the histological studies of Hartmann (already referred to on page 803), which demonstrate that such a patient is suffering, not merely from an ulceration of the anus, but from a perineuritis of the nerves located beneath the ulcer. Where this infiltration is pronounced, as in the

chronic form of ulcer, neither dilatation, nor incision, nor any method that does not remove the scar tissue, will relieve the condition. It is for these reasons that it has been found necessary to excise the ulcer with its indurated edges, and then to dissect out the scar tissue beneath. The wound which results from such an operation may either be closed by catgut sutures or be allowed to heal by granulation. If, in a case of fissure complicated with hemorrhoids, the operator decides to deal with the latter lesions by excising and suturing them, then it would be as well to close up the wound which remains after excising the fissure. It must be borne in mind, however, that we have here conditions which closely resemble those which are encountered in excising and closing up a fistulous tract. In both operations, for example, there will be an infected wound, and while the chances of primary union are rather in favor of the wound left after the excision of a fissure, yet the chances of success are not so good as they are in a clean wound. In the majority of cases in which the wound is closed after the operation, much more pain is likely to be experienced by the patient than if the wound is left open, to heal by granulation. If the open wound is washed out with a mild antiseptic solution three or four times daily, it will heal very promptly. Tuttle, in his "Diseases of the Anus, Rectum, and Pelvic Colon," reports four uncomplicated cases in which he closed the wound immediately after the completion of the operation, and in three out of the four he got primary union. The writer* has closed up the wound in many cases of this nature and he has gotten very good results in a large proportion of them; but recently he has in most cases left the wound open, principally on account of the severity of the pain which attends and follows the sewing. If the wound is left open, it should be packed lightly with sterile gauze, which should be allowed to remain in place for thirty-six hours. Then afterward the wound should be irrigated three times in twenty-four hours, and hydrogen dioxide should be introduced into it with a dropper.

The Complications of Fissure.

Inflammatory processes may follow any operation for fissure, or the wound, after having closed nicely, may be torn open by hard scybalous masses of fecal matter. Great care should therefore be taken to maintain the wound in as aseptic a condition as possible, and to keep the stools soft for some weeks after the operation. If the fissure is of a tuberculous nature, then the cutting should be done by the actual cautery.

Incontinence sometimes results from, or follows, any of the operations for fissure. It generally results from an oblique incision of the sphincter muscle—a kind of incision which should always be avoided. When it follows forcible dilatation it generally is due to too rapid or too great divulsion, or to the fact that the stretching is done in very old or very feeble people.

* S. T. E.

VII. PERIANAL AND PERIRECTAL ABSCESS.

The tissues around the anal margin and within the rectum are peculiarly susceptible to inflammation and suppuration, on account of the large amount of cellular tissue, the abundance of the blood-supply, the frequency with which abrasions are likely to occur, and the continual presence of septic organisms.

The most frequent and the most easily explained method by which infection takes place, is through an abrasion in the mucous membrane or the skin, the nature and depth of the wound having very little to do with the extent of the infection. The character of the infecting organism, especially its degree of virulence, and the resistance of the tissues, are the controlling factors. Infection frequently takes place through the presence of thrombi in the blood-vessels around the anal margin, these thrombi being so near the surface and the tension in the tissues over them being so great that small areas of pressure-necrosis are apt to make their appearance; and it is through them that infection takes place. It may also take place through sebaceous or hair follicles. In a certain number of cases in which the deeper perirectal tissues become infected, this occurrence may be explained by the assumption that the rectal wall has been perforated by some sharp-pointed foreign substance which was taken in with the food or introduced in some manner into the rectum. In such cases one would always expect to find some connection between the abscess and the primary wound on the rectal wall; yet one encounters not a few perirectal and pelvi-rectal abscesses in which no such connection with the rectum can be traced in the beginning, and whose source of infection must be explained in some other way.

The arrangement of the lymphatics, as shown in the section which treats of the anatomy of the rectum, shows that the superficial vessels of this system, which surround the anus, pass upward and forward on the perineum to join the inguinal lymph nodes, or backward to join those which are located behind the sacrum. Those lymphatics which lie at a greater depth pass through the ischio-rectal spaces to join the hypogastric lymph nodes, and those which surround the rectum pass upward and backward to join the sacral and vertebral lymph nodes. It is known that, as a rule, infection travels along lymphatic vessels, although it can and does travel along blood-vessels also. Hence a slight superficial wound on the skin or on the mucous membrane of these parts becomes the door of entrance for the infection. It is taken up by the lymphatics and passed on to the lymph nodes lying in the deeper tissues, and in these it becomes arrested, thus affording an opportunity for the organisms to multiply and to give rise to the formation of an abscess. The wound through which the infection originally gained admission, may have healed within twenty-four hours of its infliction. It is therefore easy to understand why the connection between the original wound and the abscess can rarely be traced. The same explanation holds good for the origin of the deeper-seated abscesses; and the richness of the lymphatic network in this locality, as well as the frequency with

which these vessels are injured, affords a satisfactory explanation of the large number of abscesses which occur here.

A simple and satisfactory classification of these abscesses may be made under the general heading of Circumscribed and Diffuse Inflammations, as follows:—

Circumscribed inflammations.	Superficial abscesses.	Tegumentary. Subtegumentary. Ischio-rectal (Fig. 328).
	Deep abscesses	Retro-rectal (Figs. 328 and 329). Superior pelvi-rectal. Interstitial or submucous (Fig. 329).
Diffuse inflammations		Diffuse perirectal cellulitis. Gangrenous perirectal cellulitis.

Deep Abscesses.

The distinction between the superficial and deep abscesses is to be found in the fact that the former develop in the tissues situated below the levator ani muscle, while the latter develop in the tissues located above this muscle. According to recent anatomical investigations three spaces exist above the levator ani muscle, around the rectum. The two lateral ones have been designated by Richet "the superior pelvi-rectal spaces," and the posterior one "the retro-rectal space." This latter space occupies all the region between the rectum and the anterior surfaces of the sacrum and coccyx.

The blood-vessels which ramify in the retro-rectal space come from the middle and lateral sacral arteries, with a few branches which are given off from the inferior mesenteric. The blood-vessels in the superior pelvi-rectal spaces come from the hypogastric artery and are connected with the general circulation. The lymphatics of the two spaces are also comparatively distinct.

With such distinct anatomical divisions, vascular supply, and lymphatic distribution, one can readily understand why a distinction is made between the circumscribed inflammations in these two areas, and why they should be designated retro-rectal and pelvi-rectal abscesses.

The interstitial abscesses, which represent a class apart, develop in the muscular or cellular tissues of the buttocks at points more or less distant from the rectum.

Diffuse Septic Periproctitis.

Diffuse septic periproctitis was met with quite frequently before the days of antiseptic surgery; it followed an injury to, or some operation upon, the rectum. To-day it is a rare occurrence, unless preceded by perforation of the rectal wall, and yet the walls of the rectum and anus are rarely involved in the destructive process. It is a very acute inflammation, essentially septic, and very virulent in character, and involves the perirectal tissues, especially those of the retro-rectal and ischio-rectal spaces. It may invade the pelvi-rectal spaces and even the peritoneum. The resulting peritonitis is of an intense septic type.

Idiopathic Gangrenous Periproctitis.

Under the title of idiopathic gangrenous periproctitis Furneaux Jordan* has described a very unusual type of perirectal inflammation. It consists in a slowly extending cellulitis which is not attended with much swelling or pain. It develops usually without any previous injury, although it may follow surgical operations about the rectum. It resembles very much the condition produced by urinary infiltration of the perineum. It occurs generally in high livers and drinkers, and all the cases so far reported have been in males.

Etiology.—Perianal and perirectal abscesses are always due, directly or indirectly, to infection, which may find its way to the point of abscess development, either through an abrasion of the surface or through the agency of the circulating blood, the vitality of the tissues of that locality having been lowered artificially or possessing naturally feeble powers of resistance.

Symptoms.—The symptoms and signs are similar to those attending the formation of pus elsewhere in the body, viz., fever, redness, swelling, and pain. As these abscesses are generally large, the formation of pus is very likely to be attended with constitutional symptoms, such as a distinct rigor, or at least a feeling of chilliness, a rise of temperature, accelerated pulse, and headache. If the swelling and redness are not apparent to the eye in the early stages, the induration may be readily felt. As might be expected from what has already been said of the readiness with which the infection may spread from one space to another, the inflammatory process sometimes extends around the entire anus and rectum, and through the perineum to the scrotum. Such occurrences, however, are only likely to follow in those cases in which early and free opening of the abscess cavity has been neglected, or in which, after the abscess has been opened, proper drainage and cleanliness have not been maintained.

If there has been any delay in opening the abscess, the pus is likely to be very fetid. The disgusting odor is not due, as is often supposed, to any direct connection with the rectum, but most likely to the character of one of the pus-forming organisms which are very common in this locality. The same may be said of the gas that sometimes escapes with the pus.

With the free discharge of pus from one of these abscesses, all the symptoms enumerated above subside, and as a rule permanently, unless the infection extends to one of the other cellular spaces, when they all return to a greater or less degree. Their reappearance should always excite suspicion of an extension of the infection. All the physical conditions and local symptoms of an ischio-rectal abscess may occur from hemorrhage into the spaces, without the extravasated blood becoming infected. When these local signs appear without the constitutional symptoms, one may expect to find either the lesion to which reference has just been made or a subacute tuberculous process.

Treatment.—The making of a free incision at the earliest possible moment is conceded by all surgeons to be the proper thing to do, even at the risk of an-

* British Medical Journal, January 18th, 1879, p. 73.

ticipating the formation of pus. If the abscess is located at a considerable depth in the tissues, then a one-half-of-one-per-cent solution of cocaine may be injected before the incision is made; but, if it occupies a superficial position, the cocaine may be dispensed with. The external incision should exceed in length the diameter of the abscess cavity, so as to furnish free drainage, and it should be carried well outside the sphincter muscle.

After the abscess has been opened, the finger should be introduced into the cavity, and the trabeculæ and necrotic tissue broken down. Light scraping with a dull curette may be necessary to clean out the débris, but care should be taken not to extend the scraping to healthy tissues. After the scraping,

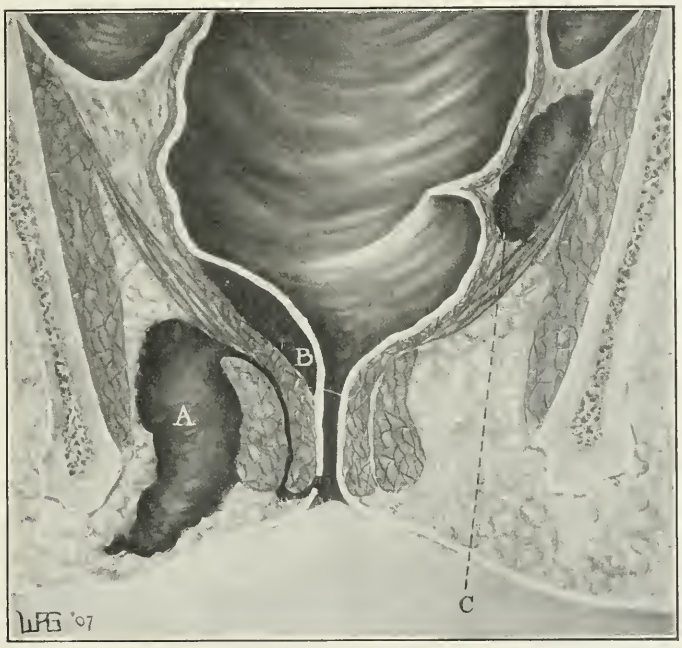


Fig. 328.—The Drawing Shows the Different Kinds of Rectal Abscess. *A*, Ischio-rectal; *B*, submucous; *C*, retro-rectal. (Earle and Tuttle.)

the cavity should be thoroughly irrigated with 1-in-1,000 solution of bichloride of mercury, or wiped out first with pure carbolic acid and then with alcohol. If there is much oozing of blood, the cavity should be tightly packed with gauze for the following twenty-four hours; after which, the gauze should be removed to allow the walls of the cavity to collapse, in order to facilitate rapid union.

Drainage may be kept up by a light tampon of gauze or by rubber tubing. Where both ischio-rectal fossæ are the seats of abscesses, that on one side may be opened by a short incision—barely long enough to drain the abscess, while that on the other side may be opened by a very free incision, which should extend as far as to the posterior commissure; and if there exists a fistulous opening into the rectum, which is likely to be the case, that also should be laid open. In every instance, great care should be taken to ascertain whether or not there

is a communication between the abscess cavity and the rectum. Unless such a channel of communication is opened, the abscess cavity and the connecting tract will not heal permanently.

When these abscesses open spontaneously into the rectum or anus they constitute what is known as blind internal fistulæ and should be treated as such.

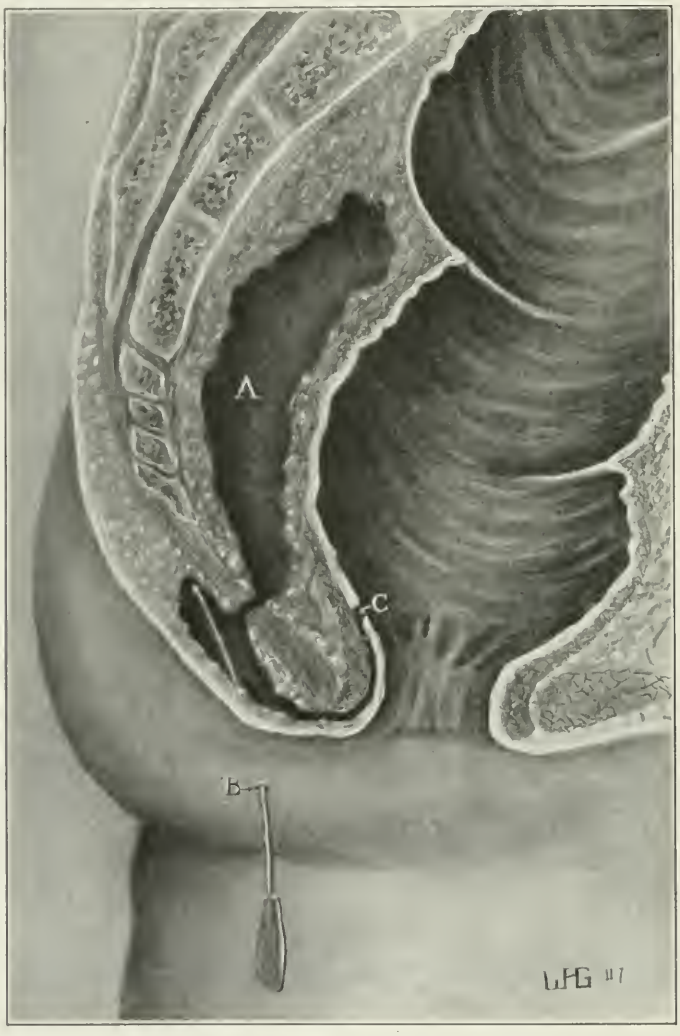


FIG. 329.—The Drawing Shows the Presence of a Retro-Rectal Abscess Above the Line of Attachment of the Levator Ani Muscle. *A*, Main cavity of the abscess; *B*, the point where a fistula leading from the abscess opens near the anal orifice; *C*, the point where a second fistula opens into the lower part of the rectum. (Earle and Tuttle.)

There is reason to believe that, when perforation into the rectum does occur, after the abscess cavity has been opened, it is due to imperfect technique in operating. Probably one of the best means of preventing this accident is to stretch the sphincter ani gently, after opening the abscess cavity. Such stretching relieves the muscular spasm, allows the gases and feces to come away un-

obstructed, and thus relieves the thin rectal wall of any undue pressure. For the same reason it is better, after stretching the sphincter, to introduce and leave in the rectum a Lynch's tube or a piece of stout rubber tubing.

VIII. THE DIFFERENT KINDS OF FISTULÆ WHICH COMMUNICATE WITH THE RECTUM OR THE ANUS.

General Remarks.—With the exception of those cases which are the result of a punctured wound that extends from the external surface to the rectal cavity, all fistulæ originate in abscess cavities or some similar foci of infection. Every recent abscess cavity, whether the opening is external to or within the rectum, forms a sinus which may heal completely in a short time; but, if it fails to do so, it is termed a fistula, even though it should have but one opening.

Fistulæ are complete and incomplete. Incomplete fistulæ are those which have but one opening. They are further subdivided into external and internal incomplete fistulæ. Complete fistulæ are those which have both an external and an internal opening. (Fig. 330.) They are also classified, in accordance with the character of the tissues in which they appear, as subcutaneous fistulæ, submuco-cutaneous fistulæ, and submucous fistulæ. (Fig. 331.) These fistulous tracts may make connection with some other canal or organ. They may also be simple, or specific, according to the character of the cause which originally gave rise to the abscess.

One cannot resist the conviction that the failure of nearly all fistulæ *in ano*—the blind external, the blind internal, and the complete—to heal spontaneously is due to the fact that they are constantly reinfected from their connection with the rectum. With regard to the blind external fistulæ we are convinced that, although it may not be practicable to demonstrate the actual channel of communication with the rectum, such a communication nevertheless really exists.

Ulceration and burrowing from the base of the mucous membrane of the diverticuli in the rectum and pelvic colon are said by Cruveilhier* and others to be the point of departure for blind internal fistulæ.

Statistics show that ano-rectal fistulæ are more prevalent in males and are observed more frequently in middle life.

The relation of tuberculosis to ano-rectal fistulæ is still an unsettled question. That a large percentage (from forty to fifty) of fistulæ are tuberculous, has been frequently demonstrated by finding the tubercle bacilli in scrapings and in the tissue removed from the fistulæ; but whether, in such cases, the fistula is the primary or the secondary focus is the point in doubt. There is a much more general agreement with regard to the percentage (from one to five) of fistulæ that occur in the tuberculous. The fact that the presence of the tubercle bacilli in fistulæ is so much more frequent than the occurrence of fistulæ in tuberculous subjects, makes it very probable that primary tuberculosis does

* "Anat. path. générale" Paris. 1849, page 549.

occur in these parts. Notwithstanding the observations of Koch to the contrary, modern observers have concluded that inoculation of the tissues in and around the rectum may take place directly through injuries and abrasions, the tubercle bacilli which are taken in with the food and passed through the alimentary canal acting the part of infective agents. If it can once be clearly established that the rectal manifestations of the tuberculosis is, in certain cases, the initial and only focus of the disease, then this fact—taken in connection with the further fact that this focus is in most cases absolutely walled off (see p. 792)—should have a most important bearing on the management of these cases.

So far as is definitely known, syphilis is related to ano-rectal fistulæ only,

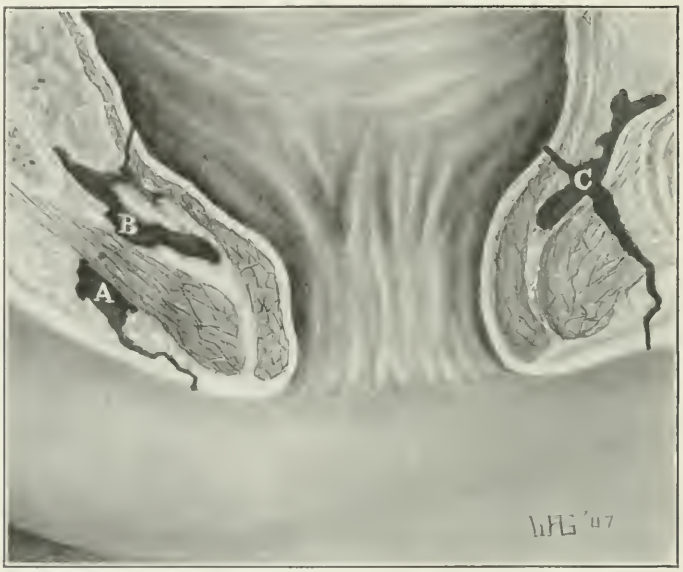


Fig. 330.—Illustrates Certain Forms of Anal Fistula. *A*, Blind external fistula; *B*, blind internal fistula; *C*, complete fistula. (Earle and Tuttle.)

or chiefly, in regard to the strictures which it may cause. In these cases the fistulæ are due to perforation of the rectal wall by ulcerative processes of a non-syphilitic nature, and then subsequently the perirectal tissues become infected with syphilis.

Ano-Rectal Fistula.—An ano-rectal fistula represents an abnormal channel of communication between the anus or the rectum and the surrounding tissues or the surface of the neighboring skin.

Symptoms and Diagnosis.—The symptoms should not include the acute manifestations which attend the formation of the abscess, but only those phenomena which are generally observed in connection with the fistula after it has formed. After the evacuation of the pus has caused a subsidence of the acute inflammatory symptoms of the abscess, the healing process, instead of progressing, as is usual under such conditions, until the cavity is entirely closed, gives place, first, to a subacute, then to a chronic form of inflammation. The pain ceases, the redness subsides, and the swelling is limited to the base of the

abscess cavity and to the immediate surroundings of the fistulous tract and opening. The discharge diminishes very much in quantity and changes from a thick creamy to a thin ichorous pus; it may cease for a few days on account of a temporary closure of the opening, and then the swelling, some redness, and the pain return, to remain until the discharge is re-established.

Upon palpation one can feel the induration at the base of the abscess cavity, along the fistulous tract, and around the opening, in which locality it is especially well marked.

The symptoms vary in certain particulars in the different varieties of fistulæ. For example, in the blind internal fistulæ they are much more obscure; the

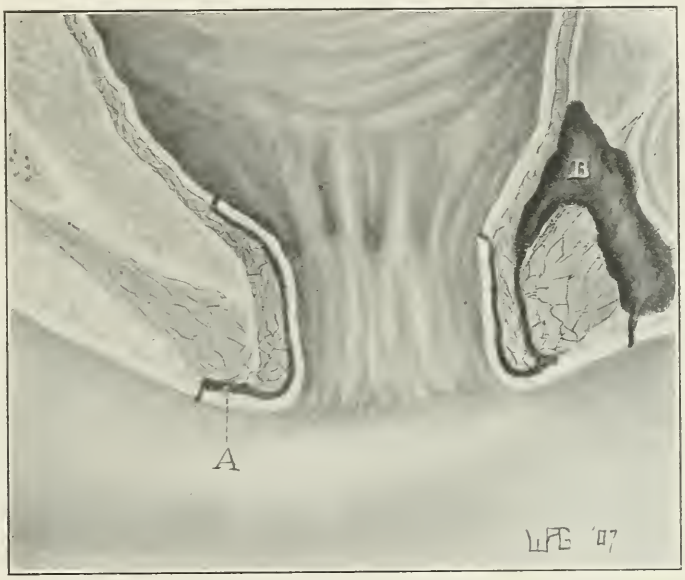


Fig. 331.—The Drawing Shows Two Different Varieties of Anal Fistula. *A*, Complete submucous fistula; *B*, complete subaponeurotic fistula. (Earle and Tuttle.)

pain is more acute; there is often spasm of the sphincter, with a sense of fulness in the rectum; and in some cases the patient experiences a slight chill. These symptoms are followed by a discharge of pus, which, however, affords only partial relief, because as a rule the opening is located above the most dependent portion of the fistulous tract, and consequently can only partially empty the latter. Usually it is possible to locate the opening simply by the sense of touch. If this fails, however, a one-bladed speculum should be introduced, when the pus can be seen coming out of the opening. A bent probe can then be introduced into the latter and the depth and direction of the tract ascertained.

In making the examination for a fistulous opening on the surface, one should very carefully inspect the parts, as such openings are sometimes very small or they are so concealed between the anal folds as to be very likely to escape recognition. In tuberculous subtegumentary fistulæ the opening may be in the midst or at the margin of a ragged ulceration. By the aid of the probe and

by palpation, however, the principal facts can generally be ascertained, but it is almost impossible to judge of the full extent of the trouble until the patient is under the influence of a general anæsthetic and the fistulous tracts, with their blind sinuses, have been laid open. It is therefore wise not to give an opinion with regard to the extent or the character of a fistula until after the operation. If it is not possible to find the internal opening with the probe that has been passed as far as it will go into the fistulous tract, while at the same time the tip of this instrument can be distinctly felt directly beneath the mucous membrane, one should lay the fistulous tract open from without up to this point, and through this widened aperture make further search, on account of the strong probability that the communication with the rectum really does exist notwithstanding our inability to find it.

If the surgeon has been unable to determine the origin of the fistula beforehand, it is very important that he should do so during the operation, as in many cases this lesion originates in some adjoining organ or canal, and it is absolutely necessary, if the operation is to be successful, to reach and remove the cause of the disease. The history, in many cases, is likely to shed much light upon the origin of the fistula.

The most important pathological factors are tuberculosis, syphilis, and carcinoma. Blind external fistulas may be due to necrosis of one of the pelvic bones. The diagnosis of any one of these diseases should be confirmed by the microscopical findings.

Prognosis.—The prognosis will depend upon the pathological nature of the fistula, the constitutional condition of the patient, and the amount of deep tissue involved. The success obtained in the cure of fistulæ is not nearly so good as is frequently represented in books; and, besides, they require the best of attention and care, after the operation, before they can be pronounced absolutely cured. In not a few cases what seems to be a perfect cure turns out to be an imperfect one. Careful watching for a period of several weeks after an apparent cure is therefore a necessity in these cases.

Treatment.—*Non-Operative Methods of Treating Ano-Rectal Fistulæ.*—By whatever method we undertake to treat this disease, it is always necessary to establish free drainage; and, in order to secure this, a slight incision, for the purpose of enlarging the fistulous opening, should always be made. Afterward, the fistulous tract should be curetted or else cauterized, and the sphincter should be dilated. These comparatively simple measures will frequently effect a cure in the case of a blind external fistula. A cure may also be effected by distending the fistulous tract with a saturated solution of silver nitrate (960 grains to the fluid ounce). Bennett states that he has successfully employed this method in quite a large number of cases of complete fistula, stretching of the sphincter being employed at the same time. Goodsall and Miles advocate it in all cases of complete fistula in which the internal opening is situated above the internal sphincter. In treating internal fistulæ without operative measures it is best to keep the stools well formed, in order to diminish the risk of infection from some part of the fluid stool passing into the fistulous

tract by way of the internal opening. The advisability of trying such conservative methods of treatment before resorting to an operation which involves the cutting of the sphincters is unquestionably wise, for even though they should fail to give permanent relief, they will certainly bring the fistula into a much better condition for a radical operation. These conservative methods should be tried for a period of from six to eight weeks; and, if by that time they have failed to effect the desired cure, one need not hesitate to resort to a radical operation.

Operative Methods of Treating Ano-Rectal Fistulæ.—The three methods that will be considered under this heading are those by incision, by excision alone, and by excision with immediate closure of the wound by suture. For any of these operations the patient should be carefully prepared after the customary methods for rectal operations, as heretofore described, and in addition the fistulous tract should be injected several times daily—for several days, if time will permit—with a fifty-per-cent solution of hydrogen dioxide. If the tract occupies a superficial position and is not too extensive, the operation may be done with the aid only of a local anæsthetic; but, inasmuch as it is almost impossible to form a correct opinion about the extent of a fistula until the direct portion of the tract has been laid open, it is far more satisfactory, in these cases, to give a general anæsthetic, unless there is some special contra-indication. After the patient is under the influence of the anæsthetic, the sphincter should be thoroughly stretched, and the rectum inspected for ulcerations and for the internal opening of the fistula. The upper part of the rectum is then packed with gauze to protect the field of operation.

Operative Technique of the Method by Incision.—When one incises a blind external fistula he should make the incision in a curving direction, parallel with, but either outside or inside the external sphincter muscle, and he should make it long enough to drain the cavity thoroughly. In the case of a complete fistula, the tract should be opened by an incision extending down to the external sphincter on the outside. Then a grooved director is passed through the remaining portion of the tract, out through the internal opening, and upon this director the tissues—including those fibres of the external sphincter which are external to the fistula—are divided at right angles to the sphincter muscle. A careful search should next be made with a fine probe for any diverticula or sinuses extending from the main tract, and, if such are found, they in turn should be laid open with the knife. All connective-tissue bands should be broken down, and the granulation tissue in the fistulous tract should be thoroughly removed by scraping with a curette. Inasmuch as we now know that many of these fistulæ are tuberculous, and as it is very difficult to make the diagnosis until after the scrapings from the tract have been properly examined, —which can be done only after the operation,—it is safer to abolish entirely a recommendation which has heretofore been considered good, viz., either to scarify through the fibrous floor of the tract in numerous places or to dissect out the scar tissue entirely. All spurting vessels should be tied and the wound should be packed tightly with sterile gauze to control the oozing and to keep the edges

of the freshly-cut wound apart. The patient is not likely to require more than one hypodermic injection of morphia (gr. $\frac{1}{4}$) to control the pain that follows the operation. The packing should be allowed to remain in the wound for not more than from thirty-six to forty-eight hours; after which it should not be replaced, but only sufficient gauze should be inserted between the edges of the wound to keep them separated and to serve the purpose of drainage. In our estimation this is a very important point, and we believe that tight packing, renewed repeatedly for several weeks, is a most fruitful cause of the incontinence of fæces which often follows these operations; this result being produced by the keeping of the cut ends of the sphincter muscle so far apart during this long period and thus allowing the intervening space to become filled with scar tissue.

After the first packing is removed the wound should be well irrigated with an antiseptic solution several times daily.

It is surprising how promptly such wounds heal. In all complete fistulæ it is very important to lay open thoroughly the entire tract as far as the internal opening, and not to make a false one at some distance from the one which already exists; for failure will surely follow such a step, owing to the fact that it will furnish a new channel through which infection may reach the tissues from the rectum. As soon as his strength will permit, the patient should be allowed to leave his bed after an operation for fistula; and, in the large majority of cases, he will be able to do this in from two to three days. While this is a matter of importance in the ordinary cases, it is still more so in patients who are tuberculous or who have a fistula which is tuberculous. The wound drains much better when the patient is in the erect position, and the good effect on the patient's general condition, as is shown by the more rapid healing of the wound, fully warrants the taking of such a step—that is, allowing him to leave his bed.

Operative Technique of the Method by Simple Excision.—This method aims at the absolute eradication of all the diseased tissues, and, if the dissection is so carefully conducted as not to destroy much of the sphincter muscle, it will generally give excellent results. It is especially applicable to old cases in which there is a large amount of cicatricial tissue. The adoption of the method is available even though the edges of the resulting wound cannot be accurately approximated by sutures. Tuttle, in his work on "Diseases of the Anus, Rectum, and Pelvic Colon," says (page 391) that he has succeeded in curing by this method a number of such cases in which simple incision had utterly failed.

Operative Technique of the Method by Excision with Immediate Suture.—This method was first originally introduced by Cassaignac in 1856, and was revived by Dr. Stephen Smith, of Bellevue Hospital, New York, in 1879. It is applicable only to cases of complete fistula, and not to those in which the fistula extends high up in the pelvi-rectal or retro-rectal space. The general and local preparation of the patient for the operation must be scrupulously carried out, and the sphincter thoroughly stretched under a general anæsthetic. A silver probe or a silver wire, having first been passed through the fistula, should be bent upon itself and held as a loop for traction purposes. The skin and mucous membrane covering the fistulous tract should be incised in a straight line from the

external to the internal opening, and dissected back a little to each side. The dissection should then be continued down and underneath the fistulous tract. While this work is proceeding, traction should be made on the bent probe or wire until the entire fistulous tract, with its infiltrated base, has been dissected free from the surrounding tissues. In carrying out the dissection one should exercise great care not to open into the fistulous tract. If such an accident should happen, the dissecting instrument should be changed at once, and the healthy tissues should be protected by sterile gauze. Having removed the entire fistulous tract, the operator should then introduce into the wound (but without tying their ends) interrupted, buried, silkworm-gut sutures as bracers; and, for the purpose of approximating the edges of the wound throughout its entire depth, he should introduce, in addition, deep mattress sutures of plain catgut. He next should bring the cut ends of the sphincter together by means of interrupted sutures. Finally, he should unite the skin edges of the wound by means of a continuous suture, and at the same time should tie the deep interrupted, silkworm-gut sutures. The final sealing of the wound is effected by means of iodoformized collodion. In order to protect the wound from infected discharges coming down from above, the mucous membrane at the upper and inner angle of the wound should be dissected up for a short distance and the edges of the flap should be rounded off, pulled down, and stitched to the skin edges of the wound, a short distance below the margin of the anus. It is also better to introduce a drainage tube into the rectum for a few days. The patient should be kept in bed absolutely for six or seven days, and his bowels should be confined for the same length of time by means of opiates. Before a movement is permitted, the rectum should first be emptied by an enema of glycerin and a solution of ox gall, and then a laxative should be given. In cases where it has been found necessary to make an extensive dissection, it is well to bind the buttocks together by means of adhesive straps, and to hold the knees together by means of a suitable bandage, in order to restrict the patient's movements and to prevent the stitches from cutting out.

If this method proves successful, a great deal of time and exhaustion are saved and much better functional results are obtained. The objection generally urged against the method is that the wound frequently fails to unite by primary union. While granting that this does sometimes occur, I maintain that even then the wound is in a better condition for prompt healing than if the open method had been used.

In the application of this principle of excision with suture to the different varieties of fistula, the chief difficulty encountered is that of distinguishing between the simple and the specific types of the disease which causes them. Failure to obtain successful results from operating upon these cases of fistula is also due in considerable measure to the fact that the internal opening of the fistula is not found.

In simple subtegumentary cases of blind internal fistula it is feasible to convert the incomplete into the complete variety by cutting down upon a probe that has been passed through the internal opening and is made to impinge upon

the floor of the fistula. After this has been done, the fistula can be given a chance to heal under stimulating and antiseptic injections; or, if this plan proves unsuccessful, the fistula can be excised in the manner described above for the complete variety. If the fistulous tract should be found to extend high up under the mucous membrane of the rectum, the following plan may be adopted for avoiding the risk of serious hemorrhage:—One blade of a pair of long pressure forceps may be introduced into the tract, while the other blade remains free in the rectum. They are then closed on the intervening mucous membrane and allowed to remain undisturbed until they have cut their way through it.

Great care should be taken to lay open all sinuses and divergent tracts. If the burrowing beneath the mucous membrane extends above the internal opening, it is not necessary to slit up the mucous membrane above the internal opening if it runs at such an angle as to drain well, and if at the same time the sphincter has been well stretched, so as to put the parts at rest. If, however, the burrowing tract involves only the mucous membrane of the lower rectum, then it would be better to open it up in all directions.

Modification of the Operative Method in Cases in which the Fistula is Found to be Tuberculous.—If the fistula is tuberculous, or even if it is merely suspected of being thus affected, a cautery knife should always be used for laying it open and also for destroying the granulation tissue which is commonly present in the fistulous tract. At the risk of repeating something which has already been stated I will call attention to the necessity of making the distinction between a tuberculous fistula and a simple fistula in a tuberculous subject. It is not advisable to undertake anything like a radical operation in a person who is tuberculous, especially while he is the subject of a febrile reaction. But when such a person has a fistula *in ano* which is draining badly, is discharging a large quantity of pus, and is causing a great deal of pain, we are perfectly justified in enlarging the external opening freely with a thermo-cautery knife, so as to drain the fistulous channel freely and to allow it to be thoroughly irrigated with antiseptic solutions. The conditions in a tuberculous fistula—*i.e.*, where the tuberculosis is localized—are entirely different. Here the chief object to be borne in mind is how to eradicate the local disease without the risk of giving rise to a general infection. That such a risk is imminent has been shown by Tuttle in his work on "Diseases of the Anus, Rectum, and Pelvic Colon," where he has reported five such cases; and Dr. Arthur Hebb, of Baltimore, has recently reported a similar case. In this connection I would refer the reader to what I have written in connection with the pathology of tuberculous abscesses, and especially to the statement that nature protects herself in these cases against infection, by throwing up barriers of fibrous tissue around these abscess cavities and their resultant fistulæ. (See page 792.) In operating on tuberculous fistulæ (or, as stated above, even on suspected cases), a thermo- or a galvano-cautery knife should always be used for cutting through the perifistulous tissues and for cauterizing the granulation tissue in the floor and walls of the fistulous tract, but *the fibrous barrier should never be burnt through or scarified.* Since I have

adopted this rule in practice I have been surprised at the rapidity with which these wounds heal.

Complex Fistulæ.—Complex fistulæ are those which have lateral burrowing tracts; they are known as water-pot fistulæ, horseshoe fistulæ, and fistulæ originating in diseased bone. They result from the fact that the abscess, being left to open spontaneously, seeks an outlet for its pus in many directions.

Goodsall pointed out, many years ago, the laws which govern the extension of ano-rectal fistulous tracts. "Those in the anterior quadrant find their way directly into the anus or rectum, the internal opening being found generally almost perpendicularly over the external opening. Those in the posterior quadrant extend circularly around the anus and generally open at some point near the posterior commissure. Subtegumentary fistulæ open at any point on the anal circumference, and may burrow subcutaneously in all directions, because there are no connective-tissue walls to obstruct them. Those situated anteriorly are likely to extend forward into the perineum and scrotum, or upward into the cruro-scrotal fold. Those situated posteriorly burrow outward into the buttocks or upward behind the coccyx and sacrum, beneath the skin."

Water-pot Fistulæ.—When a fistula has existed for some time with defective drainage, numerous tracts with separate external openings are likely to form. The fact that there are several external openings does not imply that there are a corresponding number of internal openings, although doubtless some relationship does exist between the aggregate sizes of the two sets of openings and the resisting power of the patient. Goodsall and Miles have pointed out (p. 117), "that ordinarily, in cases with numerous external openings, we shall find a large internal opening, generally between the two sphincters."

Fistulæ with More than One Internal Opening.—This variety is very much rarer than the preceding. There may be two internal openings connected with two distinct fistulæ, or there may be two or more internal openings connected with only one external opening.

Fistulæ Originating in Diseased Bone.—Necrosis of the bones of the pelvis or of the spinal vertebræ gives rise to abscesses which result in fistulæ that frequently open in the perianal region or in the rectum. Those which originate in disease of the coccyx or sacrum usually open in the posterior quadrants of the perineum and frequently involve the retro-rectal space, while those which originate in other bones of the pelvis generally open in the anterior quadrants of the perineum and into the rectum. There may be both an internal and an external opening in the same subject, and the former should always be looked for, even where the latter is present. The white, creamy character of the pus, the persistency of the discharge despite free drainage and frequent irrigations, and the history of the case, will generally indicate the source of the discharge.

As tuberculous disease is usually the main trouble in these cases, the most that can be done, as a rule, is to secure free drainage, to employ frequent irrigations, and to do whatever may be necessary to improve the patient's general condition.

Horseshoe Fistulæ.—When the fistula extends around the anterior or posterior commissure of the anus, it is called a horseshoe fistula. When a fistula of this character has resulted from true abscesses, one in each ischiorectal fossa, by an extension from one to the other, there may be an external opening on each side, with only one internal opening. Then, again, it may have several external openings, with one or two internal openings or with no internal opening. The internal opening is likely to be at the posterior commissure, just above the margin of the external sphincter. It is generally conceded that this type of fistula is rarely tuberculous; that, when it is situated posteriorly, it is generally submuscular; and that, when it is situated anteriorly, it is subtegumentary. The latter situation is necessitated by the fact that there is no deep tract of cellular tissue between the perineal body and the anus.

Treatment of Complex Ano-Rectal Fistulæ.—As different procedures are required for the different forms, we will consider them in separate paragraphs.

(*a*) *Treatment Required in Water-pot Fistulæ.*—As a general rule, it is advisable to open all of the fistulous tracts into one, the tongues of skin between the tracts being preserved to hasten cicatrization—if the patient's strength will permit such protraction of the operation. But if it be deemed best not to adopt this course, then it may be practicable to lay open the sinus from the internal to the main external opening, no attempt being made at the time to deal with the other tracts. With the lapse of time and by the aid of stimulating applications, these tracts (the primary source of infection having been removed) may heal. In many of these cases it will be found that the patient is affected with constitutional syphilis, and that consequently the employment of mercury and potassium iodide will materially increase the chances of success in treatment.

(*b*) *Treatment Required in Horseshoe Fistulæ.*—In subtegumentary cases the treatment consists in either incising every portion of the fistulous tract and establishing thorough drainage, or in excising completely the infected tissues. If the fistula, however, is of the submuscular variety, it would be unwise to lay open both arms of the tract at the same time. The better plan is first to lay open completely one portion of the tract; the treatment of the other portion being restricted for the time being to thorough drainage and the application of stimulating remedies. Then if, after the portion operated upon has healed, decided improvement shall not have taken place in the other portion, it is advisable to operate upon this also.

When a horseshoe fistula crosses the anterior commissure it may be dealt with either by the open method or by excision, with immediate suture of the edges of the wound, care being taken to preserve intact the raphe, as abscesses in the anterior quadrant of the rectum usually open low down. In the case of women care should be taken not to destroy too much of the perineal body. Where the horseshoe fistula is situated posteriorly, in which location it has only one internal opening, it is generally better to lay the entire tract open, to scrape its internal surface thoroughly or to dissect out all cicatricial tissues, and then to pack and dress the wound in the manner already recommended.

Where the fistulous tract extends entirely around the rectum and an outlet has formed, it may be found desirable, if the resulting retraction of the rectum causes inconvenience, to dissect out the cicatricial tissue, to loosen the anus and lower part of the rectum from their attachments, and then to bring these structures down to a point where they may be sutured in their normal position.

In those cases in which the complex fistula is situated superficially, excision with immediate suture may be done. Where the fistulous tract extends for a long distance out on the buttocks and possesses only one external opening, it is better, instead of laying open the entire tract, to make, at intervals of a few inches, counter-openings through which the tract may be curetted, drained, and frequently irrigated with antiseptic solutions. When the external opening is located near the anal margin, it is well to incise the tissues which intervene between the external and internal openings and to treat the fistulous tract thus laid open in the manner already described as appropriate for cases of complete fistula.

Complications Attending and Following Operations for Fistula in Ano and their Treatment.—These complications may be divided into two classes—the immediate and the secondary; the immediate occurring during the operation, the secondary after it. Among the former the one which occurs most frequently is the discharge of fecal contents over the field of operation, during the progress of an excision with immediate suture. Strange as it may seem, this annoying occurrence does not exclude the possibility of union of the edges of the wound by first intention, provided proper cleansing of the parts is done without delay. The most reasonable explanation of this is that the tissues thus soiled have already at the time of the occurrence become inured to the discharges to which they are constantly exposed. As a means of preventing such an accident the bowels should be thoroughly emptied from twelve to twenty-four hours before the operation, and in addition the rectum should be well irrigated several hours before. The bowels may be still further controlled by giving a hypodermic injection of morphia an hour before the operation, and the accident may be guarded against by thoroughly packing the rectum with gauze at the very beginning of the operation.

Hemorrhage is another complication which may attend or follow an operation. Such an occurrence, however, scarcely needs to be considered here, as it is not likely to take place if ordinary precautions are taken. At the same time it should be remembered that this accident is more likely to occur after the use of local anæsthetics, and consequently it is desirable that the patient should be kept quiet for several hours after an operation which has been performed with the aid of a local anæsthetic.

Secondary complications may occur either early or late. Among those which are likely to occur early are shock, secondary hemorrhage, retention of urine, and sepsis. In feeble and depressed subjects, shock is very likely to follow operations for deep-seated and extensive fistulæ which are attended with considerable loss of blood, or in which the thermo-cautery has been used ex-

tensively. The best way of combating shock is probably to administer morphia and nitroglycerin hypodermically.

Secondary hemorrhage is likely to be quite formidable when it takes place within the rectum. It may occur in the form of a simple but excessive oozing. When the blood escapes from a large vessel, it will be better to apply a ligature to the latter, if it can be found, even if it should be necessary to administer a general anæsthetic for this purpose. If the bleeding is due only to excessive oozing, packing, especially with gauze wrung out of very hot water, or the application of a styptic, will be likely to control it.

Retention of urine may be relieved by applying cloths wrung out of hot water to the pubes and perineum, or by the use of the catheter.

Sepsis is likely to show itself by the third day, and will probably be dependent either upon a circumscribed abscess, or upon a diffuse periproctitis, either of which conditions requires a free incision and drainage.

Among the complications which occur at a late stage, by far the most important is incontinence of feces. This result is not nearly so frequent as formerly—chiefly, we believe, because the former practice of prolonged tight packing of the fistulous tract has, in a large measure, been discontinued. The methods which are now employed in operating on extensive fistulæ are more conservative than they used to be. It is now the custom to irrigate wounds of this character quite frequently with antiseptic solutions; and, finally, operators are now careful to cut the sphincter at right angles, only once at a sitting, and to sew the cut ends together when practicable.

Fecal Incontinence.—Where the incontinence is only partial much relief may be obtained by the use of galvanism, hot fomentations, and the repeated passage of medium-sized bougies—a procedure which promotes the absorption of cicatricial tissue.

The restoration of the continuity of the sphincter muscle is by far the most satisfactory method of relieving fecal incontinence. Just how much can be accomplished by this means depends upon how much muscular tissue has been destroyed in the original operation and by the subsequent sloughing; it also depends secondarily upon the length of time which has elapsed since the first operation. The most important factor in the production of incontinence is the imperfect union of the sphincter muscle, as shown in Fig. 332. As will there be seen, the distance between the fixed portions of the muscle has been so increased that even the voluntary contraction of the muscle will not entirely close the anal orifice. It is perfectly evident, therefore, that the thing needed is to bring the cut ends of the muscle into apposition and hold them there until union shall have taken place. The lines *A*, *B*, *C* in Fig. 332 show how the V-shaped piece should be taken out in order to bring the cut ends of the sphincter into direct apposition. After the cut ends of the sphincter have been sutured together, the mucous membrane should be brought down from above over the apex of the wound, to protect it from infection by the intestinal contents. A silver-wire suture should be passed around the closed wound, to give support to those sutures which are already in place, and it should not be removed until

union shall have taken place between the ends of the muscle. The bowels should be kept confined for six or eight days, and when a movement is permitted it should be secured by an injection of oil and glycerin. The buttocks should be strapped together, and the patient confined to bed until after the bowels have been moved. If the internal sphincter has also been cut and its ends separated by the first operation, their union should be effected in the manner which has just been described (except that it is not necessary here to employ the silver-wire suture).

Where the sphincter muscle has been divided in more than one place it is advisable to perform the repair operation in two stages, three or four weeks apart. If the muscle fibres have become atrophied from long disuse, little can be accomplished by bringing the cut ends of the sphincter together. How-

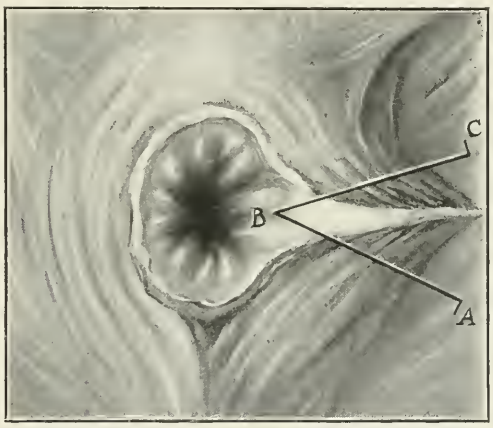


Fig. 332.—The Drawing Shows how Scar Tissue has Caused Imperfect Union of the Sphincter Muscle. The plan advocated for curing this defect calls for the removal of a V-shaped piece by two converging incisions (*A B* and *B C*). (Earle and Tuttle.)

ever, Dr. Chetwood, of New York, has succeeded, in one case of this nature, in restoring the functional activity of the anus by a most ingenious plastic operation. (See Tuttle on "Diseases of the Anus, Rectum, and Pelvic Colon," p. 417.) He made a large semicircular incision which extended from one tuberosity to the other, and the convex portion of which was directed backward toward the coccyx and a little beyond it. "The flap thus made was turned forward, and the fatty tissue dissected away until the lower end of the rectum and the edges of the glutei muscles were exposed. A ribbon-shaped piece of muscular tissue, about one-quarter of an inch in breadth and one-sixteenth of an inch in thickness, was then dissected from the gluteus muscle on each side, leaving them attached to the coccyx. The ribbon-shaped bands were made to cross each other beneath the ligamentous attachment of the anus to the coccyx (Fig. 333); they were then made to encircle the rectum, and meet anteriorly beneath the skin, the cellular tissue having been perforated by dull dissection. (Fig. 334.) At this point they were sutured with chromicized catgut. A very small remnant of the sphincter was found on each side of the rectum, and to this

the new muscular strips were attached by sutures. The original flap was then sutured back in position, and the wound closed with aseptic precautions. The patient made an uneventful recovery, and in one year from the time of the last operation the newly made sphincter exercised sufficient control on the bowel to retain its contents under all conditions." Tuttle has employed this method in five cases, in three of which the results were excellent; in the other two, however, little improvement was obtained.

Where protracted suppuration and persistent burrowing continue,—whether from general or from local conditions, it matters not,—no plastic work for the

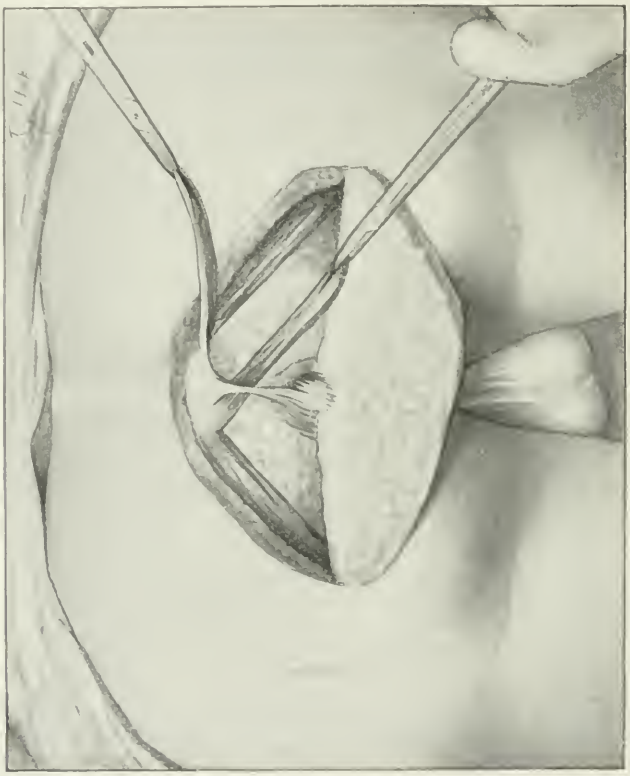


Fig. 333.—Chetwood's Operation for Fecal Incontinence. (From Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

correction of complications, especially for incontinence of feces, should be undertaken. Where the superficial edges of the wound adhere before the fistulous tract itself heals from the bottom, such adhesions should always be broken up, and the wound made to heal from the bottom.

Of all operations on the rectum, those for fistulæ call for the most persistent efforts in the after-treatment, and he who gives these cases the most care and personal attention, will be most successful in their treatment.

Anal or Rectal Urinary Fistulæ, and Perineal Urinary Fistulæ.—Under this head belong recto-ureteral, recto-urethral, recto-vesical, and perineo-urethral fistulæ.

(*a*) *Perineo-urethral Fistulæ.*—These fistulæ originate in the urinary tract, burrow backward, and open on the perineum in close proximity to the anus, thus simulating ano-rectal fistulæ. They owe their origin to some disease in the bulbous portion of the urethra or in Cowper's glands, the infection coming from a gonorrhœa, from a tuberculosis of Cowper's glands, or from traumatism. Cases of this nature really belong to the domain of genito-urinary surgery, but they are so often mistaken for ano-rectal fistulæ—owing to the fact that the external opening is located near the anus—that they quite frequently fall into the hands of the rectal surgeon, who should therefore know how to recognize their true nature and how to treat them.

The diagnosis is easily made by the use of the probe, by bimanual palpation, from the history of the case, and from the fact that urine is discharged from the fistulous opening if the fistula communicates with the urethra. The demonstration of this fact is readily made by compressing the patient's penis during the act of voiding urine; but if, for any reason, this method should fail, the administration of methylene blue to the patient will remove all doubt as to the true character of the fistula.

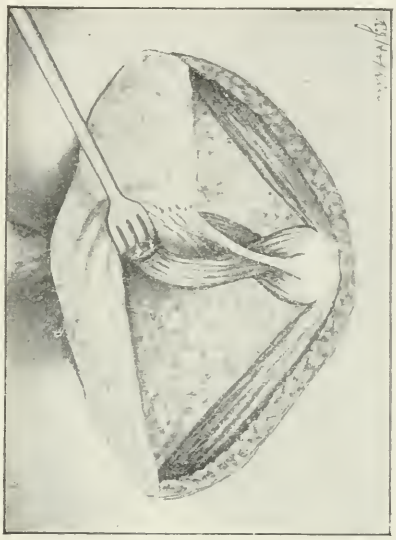


Fig. 334.—Second Stage of Chetwood's Operation. (From Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

The treatment of a urinary fistula which originates in Cowper's or the perineal glands, if tuberculous, should be laid open by means of the thermo-cautery. If this course is not adopted, then the fistula should be treated either by simple incision or by excision, with immediate suture. When the fistula communicates with the urethra it is best to give attention first to the condition of the urethra. If there is a stricture it should be dilated or incised; if there is a suppurating urethritis it should first be relieved and the urine made as bland and as unirritating as possible. After these conditions have been relieved, then attention should be given to the fistula. That portion of it which is located near the anus should be thoroughly laid open and curetted; the remaining portion, which terminates at the urethra, should be thoroughly drained, curetted, and treated from time to time with stimulating applications, care being taken not to let any of the remedy get into the urethra.

(*b*) *Recto-urethral Fistulæ.*—A fistula of this character is a much more serious condition and more difficult to cure than the preceding one. The fistulous tract connects the urethra with the rectum, and the fact that it receives its infection from both sources makes it much more difficult to heal than the common type of ano-rectal fistula. The membranous and prostatic portions of the urethra are those which are involved, and the opening in the rectum is

generally located above the internal sphincter. While the primary disease begins, as a rule, in the urethra and empties its products secondarily into the rectum at a lower point, yet, in a certain number of cases, the opening into the rectum will be found to be located at a considerably higher level than the urethral opening, and therefore it is presumably fair to infer that, in these cases, the disease began in the rectum.

As to the etiology and pathology of this variety of rectal fistulæ, we are unable to say more than that they are due either to traumatism or to some pathological process.

The most characteristic symptom of this lesion is the passage of urine through the rectum, or of fecal matter and gas with the urine. The height of the rectal opening will determine in which of these two directions the flow will take place.

As a rule, the rectal opening can be recognized by the finger placed in the rectum. With an Earle or any single-bladed speculum, introduced in such a manner as to press against the posterior wall of the rectum, the opening of the fistula may be readily seen. Then, with a sound introduced into the urethra, a small probe may be passed through the rectal opening and fistula and made to strike against the sound. The only other condition with which this is likely to be confounded is recto-vesical fistula, from which it is fairly easy to differentiate a recto-urethral fistula by the constant flow of urine which occurs in the latter lesion.

The prognosis of recto-urethral fistula is generally favorable in those cases which develop after an operation. The reverse, however, is true of those cases in which the lesion results from some pathological process.

In those cases in which the fistula develops as a result of an acute abscess, of a fairly circumscribed character, healing may sometimes be induced by simply providing free drainage and making stimulating applications. When these means fail, resort should be had to operative measures. But, before undertaking any operation, the surgeon should make sure that all obstructions to the free discharge of urine and feces through their normal passages have been removed. For the removal of such obstructions in the urethra, the reader is referred to the appropriate article in Vol. VI. When there is an irritable and tightly contracted sphincter ani muscle, it is better to incise than to dilate it, as the relaxation which follows the latter procedure is of too transitory a character. The next important thing to be done, in order to make the operation successful, is to provide for the protection of the fistulous tract, so far as possible, from the irritating discharges of urine and fecal matter. The exclusion of the urine is best effected by the continuous employment of the catheter, while the irritating effects of fecal matter may be prevented by confining the bowels for four or five successive days. It has also been recommended to do a temporary inguinal colostomy for this purpose as well as for protecting the field of operation from infection. The fistulous tract should be frequently irrigated for several days prior to the operation.

Until recently failure has attended most of the attempts which have been

made to effect a permanent closure of these fistulæ. Tuttle, in his work on "Diseases of the Anus, Rectum, and Pelvic Colon" (p. 434), has pointed out the chief cause of such failures, and at the same time he recommends measures for overcoming the defects of the treatment hitherto employed. The success of these measures is evidenced by the reports of nine successive cases in which they were employed. We give here in full his modification of the operation for the correction of urethro-rectal fistula (*op. cit.*, p. 435):

"The rectum should be incised in the middle line anteriorly, the cut being

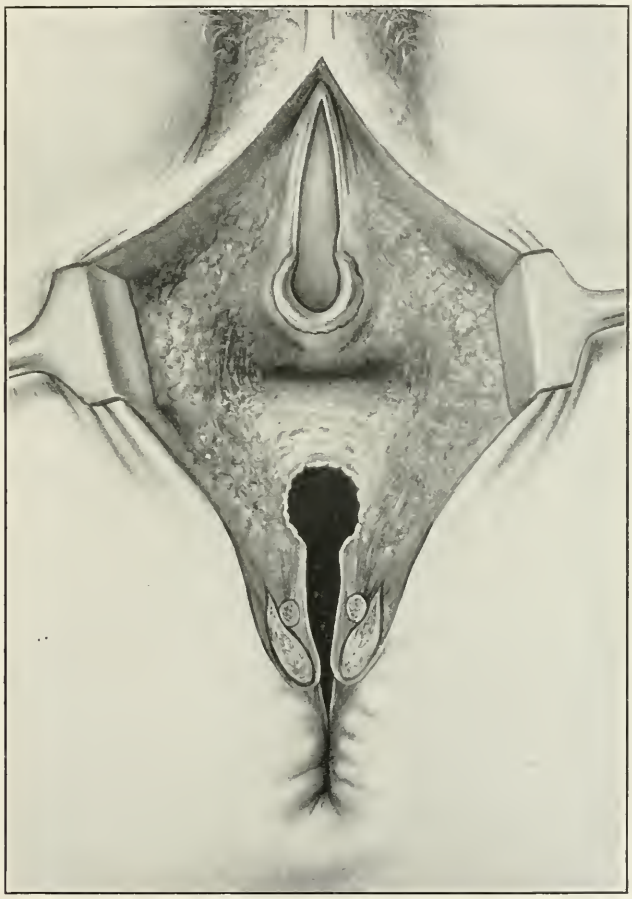


Fig. 335.—The Drawing Illustrates Tuttle's Operation for Recto-Urethral Fistula: First Stage. (Tuttle.)

carried through into the urethra and extended from the scrotal juncture of the perineum into the fistulous opening, thus dividing the urethral stricture. (Fig. 335.) The cicatricial tissue around the entire fistula should be trimmed away with scissors. The intestinal wall should then be dissected from its anterior attachments for a distance of three-quarters of an inch above the fistula, and half an inch to each side. A flap, large enough to replace that portion of the floor of this organ which had been destroyed, is next dissected from the soft tissues on either side of the urethra. A steel sound (No. 30 French)

is now introduced into the bladder, and these flaps are sutured together over it at a slight tension. Secondary flaps are then taken outside of the first flaps and entirely surrounding them, making a sort of cuff to the first area sutured. (Fig. 336.) The edges of the rectal wall are sewed together in all their thickness with chromicized catgut, down to the external sphincter muscle, at which point the mucous membrane is dissected loose, for a short distance to each side, and drawn together by stitches which do not involve the muscle. The

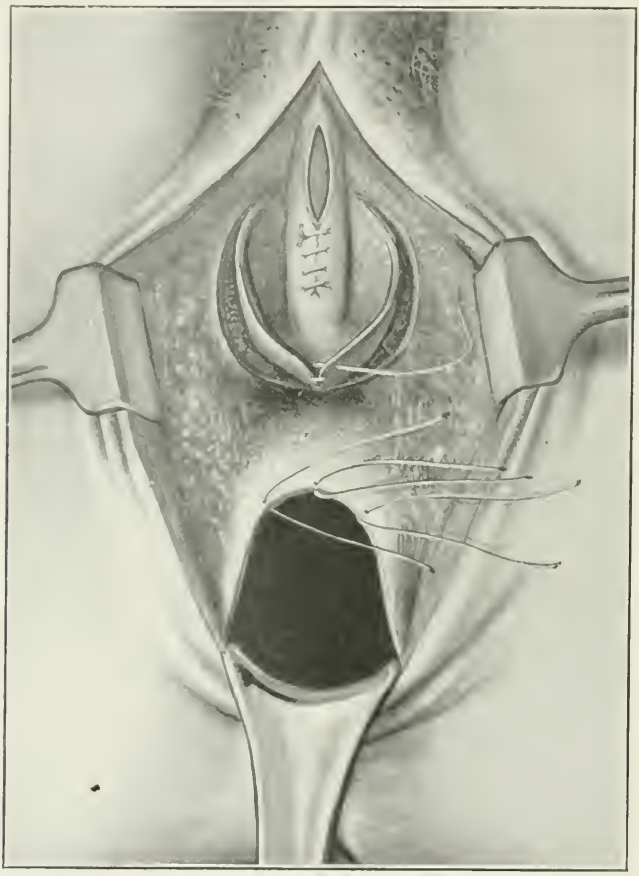


Fig. 336.—Tuttle's Operation for Recto-Urethral Fistula; Second Stage. (Tuttle.)

incision into the urethra is left unsutured beyond a point just below the site of the fistulous opening. (Fig. 337.) A No. 12 soft-rubber catheter is introduced through the meatus into the bladder and is fastened there by adhesive straps attached to the head of the penis. The anterior portion of the perineal incision is loosely packed with absorbent gauze, and a drainage tube of large size is introduced into the rectum to facilitate the escape of gas." Tuttle advises that the catheter should be retained in the bladder for from seven to ten days, but in three of his cases it was found impossible to do this; nevertheless, no serious results followed. In case the catheter should come out

before the expiration of the time, great care should be exercised in reintroducing it, lest it should reperforate the sutured wound. The instrument should be passed from the meatus out through the perineal wound, then back again through the same opening, when it is continued upward and backward against the superior wall of the urethra. If the patient is unable to bear the irritation produced by a permanent catheter, the urine, during the first five days following the operation, should be drawn off every three hours (by the surgeon, and

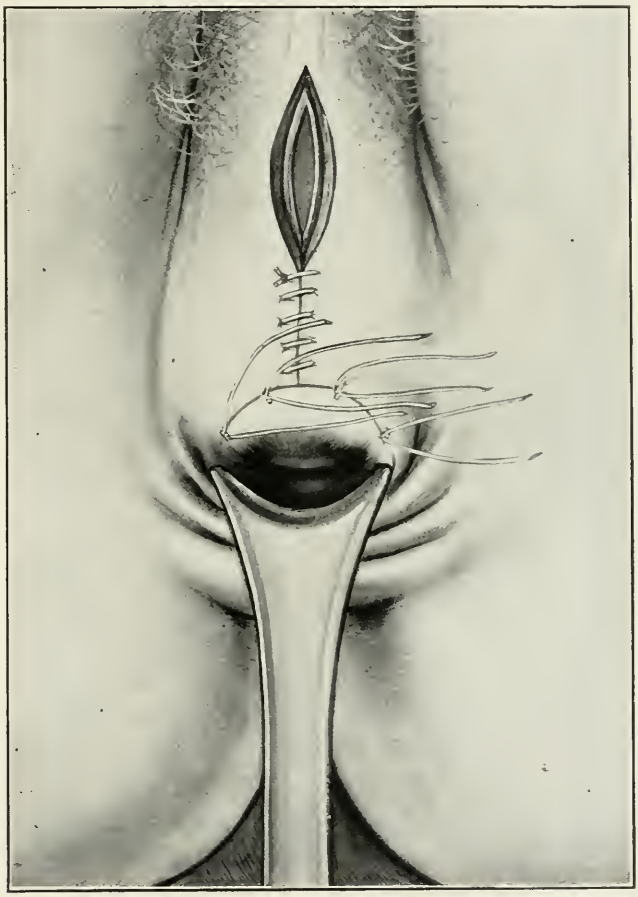


Fig. 337.—The Third Stage of Tuttle's Operation for Recto-Urethral Fistula. (Tuttle.)

not by the nurse) with a well-curved silver catheter held close to the superior wall of the urethra.

(*c*) *Recto-vesical Fistulæ.*—Recto-vesical fistulæ occur as the result of punctured wounds, of operations performed upon the bladder and rectum for malignant disease, or as the result of inflammatory processes attended with extensive destruction. Those which result from punctured wounds are likely to heal spontaneously. Recto-vesical fistulæ may be either direct or indirect. Those of the direct variety owe their origin to the fact that the walls of the two organs become agglutinated by inflammatory products, thus favoring the

establishment of a fistulous communication between the two at this point. In the case of an indirect fistula an abscess located near the two organs makes for itself an opening into each of them. Upon the recognition of the true pathology of the lesion will depend the advisability and success of radical interference.

Recto-vesical fistulæ may communicate with the small intestine as well as with the bladder. The consideration of such cases, however, does not belong in the present section.

The characteristic symptom of a recto-vesical fistula is the constant presence of urine in the rectum. Very much less frequently fecal matter and intestinal gas may be passed with the urine which comes from the bladder. This occurrence depends upon the height of the rectal opening, upon the calibre of the fistulous tract, and also upon the consistency of the fecal matter.

The history of the case may throw some light on the diagnosis, especially if the fistula is associated with malignant disease or syphilis. The location of the intestinal opening may be determined either by palpation or by the employment of the pneumatic proctoscope; and by the aid of the cystoscope the opening in the bladder may be located.

The prognosis is always grave, and the results of surgical interference are very discouraging. Extension of infection from the bladder, by way of the ureter, to the kidneys is almost certain to follow sooner or later. In the indirect variety of these fistulæ, urinary infiltration and burrowing of pus are likely to follow.

In acute cases due to traumatism or to surgical interference, continuous catheterization for a definite period and the proper regulation of the consistency of the fecal discharges may result in closure of the fistulous tract. In all cases, when possible, it is absolutely necessary to keep the fecal matter from entering the bladder. In the chronic cases, therefore, some more permanent provision—as, for instance, a temporary inguinal colostomy—must be made to prevent this accident. The adoption of this expedient, in combination with continuous catheterization, offers, on the whole, the best prospect of effecting a closure of the fistulous tract; and, if later it should become necessary to suture the fistulous openings, it will be found that the establishment of an opening in the colon and the employment of continuous catheterization increase greatly the chances of a successful issue.

When once the fecal current and the urine have been diverted from the fistulous tract, the attempt should be made to close the recto-vesical opening by paring the edges and suturing the wound. If the opening is situated high up in the bowel, the operation may be facilitated by removing the coccyx and splitting the posterior wall of the rectum. If the rectal opening, however, is situated low down, or if the case is one in which the fistula has resulted from a pelvi-rectal abscess, the anterior rectal wall should be dissected from the bladder, by lateral perineal section, as far as to a point above the fistulous tract; by which means the latter becomes converted into a recto-perineal and a vesico-perineal fistula. Then, if the rectal and vesical openings are within reach, they may be sutured. For this work Czerny's method of employing

catgut for the deep row of sutures, and silkworm gut or silk for those in the mucous membrane, should be adopted. If success has been attained in closing the fistula, the artificial anus may next be closed.

(*d*) *Recto-ureteral Fistulæ.*—The only cases in which the ureters are likely to open into the rectum are those in which the fistulous communication is the result of a malformation. Reference has already been made to these on a previous page.

Recto-genital Fistulæ.—In this class should be included the fistulæ which connect the rectum with the genital organs. They are most frequent in women, and should not include those which are due to malformations. When the lesion does occur in the male, and the fistula extends forward into the scrotum, it may be treated as an ordinary subtegumentary anal fistula. When it results from a prostatic abscess or a suppurating Cowper's gland which opens into the rectum and not into the bladder or urethra, it may be treated as a blind internal fistula.

The other fistulæ which belong to this variety all occur in women, and may be classified as follows, viz.: recto-uterine, recto-vulvar, and recto-vaginal fistulæ.

(*a*) *Recto-uterine Fistula.*—This form of fistula rarely occurs except as a congenital lesion. Dr. Tuttle (*op. cit.*, p. 447) mentions having seen such a fistula associated with a carcinoma of the uterus which involved the rectum; and Dr. Thomas Cullen, in his work on "Carcinoma of the Uterus" (p. 268), mentions a somewhat similar case.

(*b*) *Recto-vulvar Fistula.*—This form of fistula results from an injury or from infection of the glands of the labia and vagina, which are situated anteriorly to the fourchette (especially the glands of Bartholin). The writer has seen quite a number of cases of this nature. After the abscess has formed, the pus is likely, if an early incision is not made, to burrow backward and to open into the rectum or the anus. It may also burrow into the ischio-rectal fossa after it passes the transversus perinei. There may be only one opening or there may be several.

In operating upon these cases, the surgeon should take special care to preserve the perineal body. When there are no complications, excision with immediate suture may be adopted. When there are two distinct tracts, it would probably be better to operate upon only one of them at a time, at different sittings. But if they are near together and if they are of such a nature as to require only a slight dissection, they might both be operated upon at one time. Sometimes these fistulæ are incomplete and have only one opening, and when this is the case, excision and suturing may be resorted to.

(*c*) *Recto-vaginal Fistula.*—In this form of fistula there is a communication between the rectum and the vagina proper. (Fig. 338.) Such a fistula is frequently the result of a submucous rupture of the recto-vaginal septum or of sloughing of this septum from prolonged pressure of the fœtal head. Syphilitic ulceration is a frequent cause of this type of fistula, especially in cases in which there is stricture of the rectum. Tubercuious ulceration is rarely the cause of

this variety of fistula, while carcinoma of the rectum or vagina frequently is. Among other causes may be mentioned: an abscess in the septum; a foreign body in the rectum; prolonged pressure from a pessary; sloughing, following an operation for hemorrhoids; and, finally, a pelvi-rectal abscess that burrows down between the layers of this septum and opens into both the rectum and the vagina.

The diagnosis is readily made from the fact that gas and fecal matter escape into the vagina and set up a vaginitis. The offensive leucorrhœa which results from this inflammation, is one of the distressing features of the disease. The openings in the vagina and rectum can easily be seen, generally by the aid of a speculum, and by its aid also a probe may be passed through the tract.

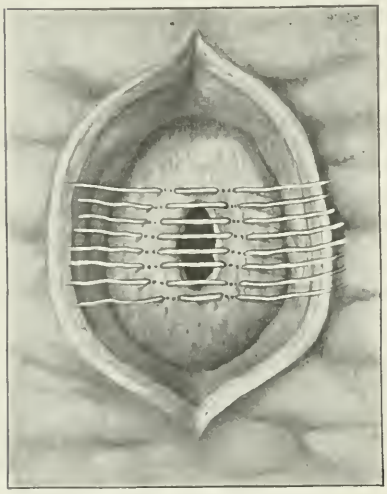


Fig. 338.—Closure of Recto-Vaginal Fistula, after the Method of Lauenstein. (Montgomery.)

So far as treatment is concerned, it may be stated that the conservative methods are attended with very little success; some surgical procedure will nearly always be found necessary. The chief difficulties which one encounters and which must be overcome are these: the prevention of the escape of gas and fecal matter through the fistulous tract, and the necessity of reaching and closing the rectal opening if it occupies a high position. The latter difficulty can be overcome only by splitting the posterior wall of the rectum and removing the coccyx, or by doing what is practically a Kraske operation. The seriousness of such an operation is out of all proportion to the gravity of the condition. When the rectal opening is small and situated low down, the surfaces around it may be freshened and united by sutures—a procedure which sometimes proves successful. But where the opening is large and is situated high up in the rectum, operations through the vagina or the perineum are more likely to be successful.

Operations upon the Vaginal Wall.—"The simplest of these is that devised by Lauenstein, which consists in denuding the fistulous tract from the vaginal surface down to the rectal mucous membrane. Stitches are then introduced from the vaginal side, embracing all the tissues of the recto-vaginal septum except the mucous membrane of the rectum, and the wound is then closed. (Fig. 338.) The sutures should be of silver wire. No effort is made to close the opening in the rectal mucous membrane. It would be well, however, after having sutured the fistula, to stretch the sphincter, introduce a rectal tube, and constipate the patient." (Tuttle, *op. cit.*, p. 452.)

Complete Excision of the Fistulous Tract Combined with Perineorrhaphy.—The technique employed by Tuttle in this operation is thus described by him (*op. cit.*, p. 453): "The sphincter muscle should be thoroughly and completely stretched; the perineum is then completely incised from the vagina into the

rectum, up to but not including the fistula. A probe is then passed through the fistula, and the latter, together with all its cicatricial tissue, is dissected out *en masse*. The mucous membrane of the rectum is trimmed off from the edges of the wound for about half an inch up to the level of the fistulous opening, and above this it is loosened from its attachments, until it can be brought down to the margin of the anus. The margins of the wound in the perineal septum are then brought together, down to and including the sphincter muscle, by means of a continuous chromicized catgut suture. Three or four deep silver-wire sutures are then passed through the perineum, after the manner of Emmet. Before the latter are fastened, the flap of mucous membrane in the

Fig. 339.—Closure of Recto-Vaginal Fistula with Impervious Layer of Mucous Membrane over the Line of Suture. (From Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

rectum is brought and sutured to the skin at the margin of the anus (Fig. 339), the wire sutures are then drawn together and made fast by twisting or by perforated shot, and finally the edges of the mucous membrane in the vagina are sutured with plain catgut and sealed over with iodoformized collodion. A small drainage tube is placed in the rectum to facilitate the escape of gas, and the patient's bowels are constipated for six or seven days. After this period, injections of oil and glycerin may be given to soften the fecal material, but under no circumstances, except in real danger to the life of the patient, should a purgative be given until the hard fecal accumulations have been removed or softened. The wire sutures are removed on the eighth day." In seven cases operated upon according to this method not a single failure has occurred.

IX. STRICTURE OF THE RECTUM.

General Remarks upon the Nature of Strictures of the Rectum.—From a clinical standpoint stricture of the rectum should include all those pathological conditions which interfere with the normal passage of feces; but, for the sake of brevity, it will be better to confine ourselves to those changes in the wall of the rectum, sigmoid, and anal outlet which produce a narrowing of their lumen, and to reserve for future detailed consideration those obstructions from without which produce similar results but have an entirely different etiology and require a different treatment.

Those conditions which arise in the walls of the rectum or anus and bring about a stenosis of its lumen, are the following: Congenital malformations, neoplasms, pelvic inflammations, spasm of the musculature, and inflammatory products.

Congenital Stricture.—Although this variety has already been considered under the head of Congenital Malformations, yet, as the condition so frequently passes unobserved until puberty or adult life, it would be well to remind our readers that it is by no means rare. Up to a certain time the symptoms may be merely those of constipation, but a constipation which steadily grows more obstinate, until finally the bowel refuses or is unable to respond successfully to laxatives or enemas. Then for the first time the physician makes a rectal examination. In the case of a congenital stricture, it will generally be found either that a fibrous band is stretched across from one side to the other, or that a thin membranous curtain projects from the entire circumference of the bowel toward the centre of the lumen. The degree of constipation resulting varies with the extent to which the band or the curtain diminishes the calibre of the canal. In either case the lesion will probably be found at about the juncture of the anal canal with the rectum; and the absence of any inflammatory infiltration, as well as the failure of the history of the case to furnish any information with regard to an earlier process of this character, justifies the assumption that the lesion is of congenital origin.

Strictures of the character described may, if not too narrow, be nicked with the knife or scissors in several places and dilated with the finger or bougie. It is far better, however,—and the resulting cure is more likely to be permanent,—to dissect out the fibrous tissue after having first dissected back flaps of mucous membrane. Then, after the strictured part has been excised, the flaps are drawn together and sutured over the wound.

Stricture from the Presence of a Neoplasm.—The new-growth, in order to produce a true stricture of the rectum, must not only grow within the rectal wall, but must also extend partially or completely around it, so as to produce a narrowing of its calibre. A growth from the rectal wall, however large it may be, and to whatever extent it may obstruct the passage of fecal matter, can be regarded only as an obstruction, and not as a stricture. It will there-

fore receive consideration under the head of Neoplasms of the Rectum. As instances of a growth of this nature, polypi and papillomata may be cited. Malignant growths, on the other hand, both obstruct the calibre of the rectum by protruding into it, and also constrict the lumen by giving rise to an infiltration of fibrous material into the surrounding walls—which fibrous material later undergoes contraction. These strictures will be considered in their proper place under the head of Malignant Neoplasms of the Rectum.

Submucous or Perirectal Stricture.—It will be well to remember that there is an abundance of fibrous tissue in the different layers of the rectal wall and between the mucous folds of Houston's valves, and that this tissue is connected directly with the fibrous meshes of the pelvic tissue, the ligaments of the bladder, the broad ligaments of the uterus, the prostate, and the fibrous sheaths of the levator ani muscle; and that consequently an inflammation in any of these surrounding structures may extend to the fibrous tissue found in the rectal walls and create there ultimately a true submucous stricture, without there having been any previous ulceration of the rectum.

Spasmodic Stricture.—That a temporary spasmodic contraction of any portion of the rectal wall may take place at any time, no one will question. But, if any one has doubts, he may easily satisfy himself on this point by the application of a faradic current, through a proctoscope, to the rectal mucous membrane, when he will see the wall contract while it is under actual observation. Furthermore, there is no longer any doubt that the same kind of contraction may be produced by the application, to the mucous surface, of any kind of irritant, or by the presence of an irritable sore. It is also an established fact that, while this spasm of the musculature is not continuous, it will nevertheless recur as often as the irritant is applied, or—in the case in which an ulcer is present—whenever the normal stimulus is in the slightest degree increased, or whenever the patient simply apprehends that such an increase may take place. Such a definition of the limits of spasmodic stricture of the rectum will be accepted generally. On the other hand, the majority of surgeons dissent from the doctrine that a permanent stenosis or narrowing of the lumen of the bowel may result from a continuous or permanent shortening of any portion of its musculature; and that, too, notwithstanding the fact that such good authorities as Cripps and Ball approve of this doctrine. It is much more likely, as we believe, that the spasmodic contraction, which, in the cases cited by Dr. Cripps, unquestionably existed in the early and active stage of the ulcer, was succeeded by the formation of a true fibrous stricture as the result of the healing and cicatricial contraction of the ulcer. In other words, the change in the pathological conditions brought about a simple substitution of the true fibrous stricture for the former spasmodic stricture.

Simple Inflammatory Stricture.—The conditions necessary to produce a stricture of this variety are a chronic inflammation of the fibrous elements of the walls of the rectum and closely adjoining structures, with or without a solution of continuity of the surface, and without regard to etiological factors. As is well known, the tendency of fibrous tissue to undergo proliferation and ulti-

mately to become hypertrophied and thickened, is very much increased in certain diseases—as, for instance, in syphilis. Hence the tendency, in the older treatises, to subdivide strictures according to the form of ulceration or inflammation which gave rise to them. We prefer to speak of all such factors as common causes, emphasizing when necessary the peculiar tendency of fibrous tissue to take on this increased growth in certain specific diseases, as well as other peculiar characteristics which attend each.

While a stricture due to simple thickening of the fibrous structures may occur at any point in the rectum, in the large majority of cases it develops at a spot within a distance of three inches from the anal margin.

In all inflammatory processes which result in stricture of the rectum, the process must involve the fibrous tissues beneath the mucosa. This important feature should always be kept in mind when one is considering the possibility that certain affections of the mucous membrane—such, for example, as catarrhal diseases and others which involve only the mucous membrane—may produce a stricture. As a matter of fact, it is practically impossible for such diseases to result in a fibrous stricture.

Wherever there has been destructive action the tissue destroyed is replaced by fibrous tissue—*i.e.*, cicatricial tissue; and when this is present in sufficient quantity and is so arranged as to involve a considerable portion of the circumference of the rectum, it produces a stricture. (Fig. 340.) Among the factors which are competent to produce such results, the following may be mentioned: all forms of trauma which cause sloughing of the rectal wall—such, for example, as prolonged pressure of the fœtal head during labor, or the retention of large foreign bodies in the rectum; phlegmonous and gangrenous ulcerations of the rectal walls; the injection of caustic or very irritating substances into the rectum; burns; and operations in which considerable areas of rectal tissue are removed, and in which healing has taken place by granulation. Some of the operations which are likely to result so disastrously are the following: resections or excisions of the rectum and operations for fistulas or for hemorrhoids, especially where Whitehead's operation has been improperly done for the latter condition, or where the hemorrhoids have been injected with a strong solution of carbolic acid. In fact, the danger that a stricture may develop subsequently should be carefully borne in mind by the surgeon when he performs any operation upon the rectum.

While we do not regard obstruction to the passage of fecal matter, whether caused by pressure from without or by the presence of a new-growth or of some foreign matter within the rectal wall, in any sense a stricture, yet it seems to us better to remind our readers once more that such obstructions do frequently interfere very materially with the passage of fecal matter, and that it is therefore important that one should be able to distinguish between such an obstruction and a true stricture. Among such obstructions may be mentioned displacements, enlargements, new-growths, and inflamed and suppurating conditions of adjacent organs. Adhesive bands formed as a result of local or general peritonitis may so constrict the upper part of the rectum or the sigmoid as almost

completely to arrest the passage of fecal matter. Inflammatory adhesions of the uterus to the rectum or the sigmoid, adhesions of the appendices epiploicæ to the abdominal walls or to each other, and inflammatory deposits resulting from a blind external fistula, may all obstruct the passage of fecal matter very seriously.

Tuberculous Stricture.—A stricture resulting from tuberculous ulceration or caused by the inflammatory products of such an ulceration is a lesion which has frequently been denied; but, since the discovery of the tubercle bacillus, pathological examinations have demonstrated both giant cells and tubercle bacilli in the scar tissue of the stricture itself. Tuttle, in his treatise (*op. cit.*, p. 469), states that, in four autopsies, he found, in each instance, an undoubted fibrous stricture existing beneath a well-developed tuberculous ulcer; and that,

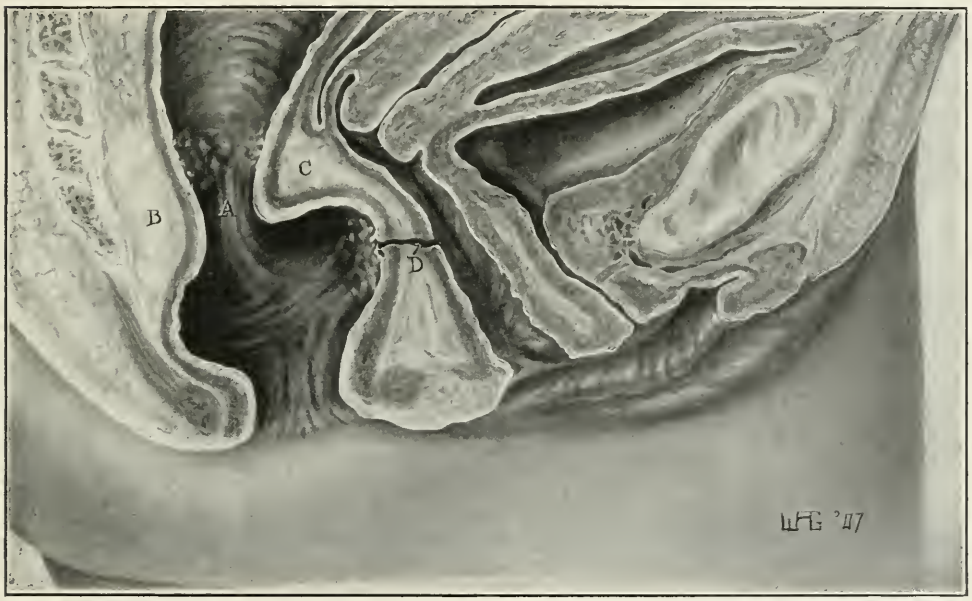


Fig. 340.—The Drawing Illustrates Two Pathological Conditions of the Rectum, viz., a Cicatricial Stricture (*A B C*) and a Recto-Vaginal Fistula (*D*). (Earle and Tuttle.)

in two of the cases, the stricture was in the pelvic colon, while in the other two it was located in the rectum. The clinical history of two of these cases corroborated the post-mortem findings, and by microscopic examination he was able to demonstrate the presence of tubercle bacilli and giant cells outside the area of ulceration. Similar findings have been made by Mitchell, Hartmann, Toupet, Sourdille, Earle, and others. With this evidence before us, we can scarcely any longer question the existence of a true fibrous stricture resulting from tuberculous ulceration.

Syphilitic Stricture.—Since the announcement of Fournier's theory, in 1875, the opinion has been quite general, up to within the last few years, "that syphilitic strictures consist of an interstitial hyperplasia, ending in a fibrous degeneration and persistent contraction of the wall of the intestine," and that

strictures of the rectum of this nature differ materially in their pathological characteristics and mode of formation from all other rectal strictures. As will be seen farther on, we take exception to this current opinion, at least in great part, and hold that strictures of the rectum due to syphilis have their beginning, as a rule, if not always, in a local ulceration of the mucous surface. We believe that, in syphilitic strictures, the formation of the fibrous tissue and its subsequent contraction proceed along the same lines as do the tissue changes in simple strictures, except as regards the formation of nodules or gummata around the blood-vessels, and the development of a distinct endarteritis—both of which lesions are impressed upon the stricture by this specific disease. While the microscopic appearances, in a sufficient number of these strictures, furnish unquestionable evidence of syphilis, yet the number of these cases does not correspond with the number of cases of stricture due to syphilis that were formerly thought to exist. In fact, at one time every case of stricture of the rectum was immediately assumed to be of a syphilitic nature. It was believed that, in some insidious manner, the constitutional effects of syphilis produced these strictures.

While we have made a partial statement of our views on this subject in the previous paragraph, yet, for the sake of clearness, we will risk some repetition. We believe that, in their first stage, these strictures begin as an ulceration of the mucous membrane of the rectum, and that this ulceration is associated with a deposit of soft embryonic tissue in the submucous layer. Then follows an infection of the tissues by colon bacilli or other organisms. The infiltration just referred to and the infection penetrate downward into the circular muscular layer. The ulcer may heal through an outgrowth of the mucous membrane over the spot, and there will then be left, to indicate the former site of the ulcer, a soft, bluish-white cicatrix. But, after the infiltration with embryonic tissue has once begun in the muscular walls of the rectum, its further progress meets with the least resistance in the direction between the circular muscular fibres. The advance continues steadily until the entire circumference of the intestine, in the vicinity of the former ulcer, becomes infiltrated. The extent of the infiltration, be it noted, bears no relation to the extent of the ulceration or to the size of the scar on the intestinal wall. In the early stages of this infiltration the infiltrated tissue is soft and dilatable, and yields quite readily to antisyphilitic treatment and to artificial dilatation; but, when once this newly-formed tissue has become organized into fibrous tissue, which soon supplants the atrophied circular muscular fibres, then anti-syphilitic medication and artificial dilatation are no longer of any permanent benefit.

It will be observed, then, that up to this point the beginning and progress of a syphilitic stricture are essentially the same as the beginning and progress of a simple fibrous stricture; the only difference being that, possibly, the tendency to the formation of fibrous tissue is greater in the former than in the latter.

We therefore assert it as our belief that all strictures of the rectum, whether syphilitic or of a simple character, have their origin in an ulceration, a trauma, or some other lesion of the mucous membrane; and that the cases in which

the lesions are due to secondary or tertiary syphilis represent the large majority of those which have heretofore been attributed to chancroids.

Pathology of Strictures of the Rectum.—There is a localized thickening of the rectal mucous membrane, and generally there is an ulceration; but, whether the latter lesion is present or not, there is always a loss of the normal elasticity of the rectal wall, which conveys to the examining finger the sensation of being dense and leathery. In cases in which the ulceration has healed, the mucous membrane is dry and has lost its smooth, glistening appearance. We have found this to be due to a loss of the goblet cells rather than to the transformation of the cylindrical epithelium into the pavement variety, as asserted by Quénu and Hartmann. Where the ulceration exists in conjunction with the stricture, which is the rule in those cases which come under the surgeon's observation, the surface of the rectum is bathed in a muco-purulent, sometimes sanious discharge. If any portion of this ulcerated surface heals, which is more likely to be the case in the lower portion, the cicatrix presents a bluish-white appearance and is very dense and hard. The infiltration and contraction may extend from the margin of the anus to the sigmoid, and sometimes may even involve the latter. In a few cases the congestion and proliferating granulations produce a greater degree of narrowing of the canal than does the actual cicatricial contraction. In one case observed by Tuttle proliferating granulations almost entirely filled the cavity of the rectum, obstructed the passage of feces, and gave rise to an abundant purulent and bloody discharge. A single ulcer, even of moderate size, may at first give rise to very slight stenosis, but, after it has healed, the subsequent degeneration and contraction of the circular muscular fibres may result in the establishment of a very decided stricture. In old cases where the stricture is quite tight there are likely to be two points of ulceration, one above and one below the stricture. That above the stricture does not generally present the characteristics of a syphilitic, but those rather of a simple necrotic ulceration, produced by irritation and by the pressure of fecal matter which collects at that point. The bowel is always dilated and its walls are thinned above the stricture. The ulcer below is of the type which produces a stricture, no matter what its origin—infectious, syphilitic, or tuberculous. A fistula is frequently found beneath the mucous membrane; it leads downward from the stricture, and frequently extends outside into the perirectal tissues. While the mucous membrane directly over the strictured portion of the bowel may not appear to the eye to be altered, yet, when manipulated, it fails to move over the subjacent tissues or moves with some degree of friction. According to Hartmann and Toupet the features which are constant in all the varieties of stricture which they describe are "the absence of ulceration at the level of the stricture and the substitution of the pavement epithelium with papillæ for cylindrical epithelium with glands." The pathological characteristics of all syphilitic strictures are endarteritis and gummatous deposits about the arteries. The nodules are also found around the veins in some cases.

The pathological changes which may, according to Heitzmann and Jeffries,

be considered as peculiar to strictures that owe their origin to tuberculous ulceration are the following: Ordinarily the entire epithelial surface of the mucous membrane is destroyed; the inflammatory infiltration extends considerably beyond the ulceration; upon the mucous membrane a number of papillæ are seen; in the submucosa there are found, in the infiltrating fibrous tissue, tuberculous follicles which show a tendency to caseous degeneration; and the blood-vessels do not show any alteration in their walls, as they do in the cases of syphilitic origin. Besides the changes just enumerated there is one other feature which may enable the surgeon to reach a positive diagnosis—viz., the finding of tubercle bacilli in the inflammatory tissues of the stricture. The failure to find them, however, does not preclude the possibility that the disease is tuberculous in its nature.

Notwithstanding the special characteristics of syphilitic and tuberculous strictures, as enumerated above, it must be borne in mind that these characteristics are not of themselves absolutely conclusive, but must, if a correct diagnosis is to be reached, be taken in conjunction with the history of the case and other conditions. Endarteritis, for example, has been known to exist in inflammatory tissues which have resulted from traumatism or from caustic applications. But if this lesion is associated with the presence of gummatous nodules in the strictured area, and if at the same time there are other evidences justifying the suspicion that the patient has syphilis, one would not hesitate to make a positive diagnosis. Furthermore, since the discovery of the Spirochæte pallida, even in the tertiary lesions of syphilis, one may now confidently rest his diagnosis upon the presence or absence of this micro-organism.

The possibility that a dysenteric ulceration may play the part of an etiological factor in stricture of the rectum has been very seriously questioned by most writers, yet quite a number of good authorities claim that it does play such a part. This wide difference of opinion is based, as we believe, on the strong probability that the cases of supposed dysentery which have resulted in stricture, were not, in reality, cases of true dysenteric ulceration. This seems the more likely when we remember that nearly all forms of ulceration of the rectum give rise to more or less tenesmus, with frequent passages of mucous or muco-purulent matter and blood.

In the "Medical and Surgical History of the Civil War" there are the reports of four cases of stricture of the rectum which resulted from gunshot wounds.

Symptoms of Strictures of the Rectum.—The primary lesion which is followed by the formation of a stricture may give rise to very few and very trifling symptoms, and then only during the acute stage. This is likely to be the case, for example, in an ulceration that has resulted from the continued pressure of the child's head during labor or from the presence of a foreign body in the rectum. Even these symptoms subside as soon as the ulcer heals. Then there follows quite a long period of rest, which varies under different conditions, and in which there are no symptoms sufficiently marked to attract the attention of the patient. During this latent period, the infiltration is going on, and the

contraction increasing. As a rule, it is not until the stenosis is well marked that the symptoms are sufficiently annoying for the patient to bring them to the attention of the surgeon. The symptoms which usually first attract the patient's attention are: a sense of heaviness in the rectal and sacral region, and a frequent desire to urinate. The latter symptom may be so pronounced as to divert both patient and doctor from the real seat of the trouble. Later, there is developed a gradually increasing tendency to constipation, with difficulty in having a stool; and afterward come the more pronounced symptoms —frequent desire to go to stool, tenesmus, purulent and bloody discharges— which are both the cause and the result of the secondary ulceration—*i.e.*, the ulceration which follows the stenosis. The increasing accumulation of fecal matter that takes place above the stricture, finally gives rise to so much irritation as to increase, at first, the normal secretions from the intestinal wall at this point. In some cases, indeed, the increase may be so great as to dissolve the surface of the fecal mass and to bring it away as a fluid stool. The continuation of this irritation and pressure finally results in ulceration. At this stage of the trouble the physician should be careful not to mistake the liquid stool or oozing for a true diarrhœa, and he can avoid this error only by making digital and instrumental examination. One of the chief dangers attending a stricture of the rectum comes from the presence of these fecal masses, as they may block the remaining portion of the lumen of the bowel so completely as to cause rupture of the intestine. When the ulceration has taken place there will be an occasional discharge of mucus and pus, often mixed with blood. This discharge is frequently passed without any fecal matter, especially early in the morning, and it is then supposed to come from the ulceration which is below the stricture. Afterward, in the course of an hour or two, there follows a stool mixed with muco-purulent matter, and then it is assumed that this muco-purulent matter comes from the ulceration above the stricture. The amount and character of the discharge will depend largely upon the character of the stricture. Thus, for instance, in a stricture due to syphilis the discharge is very abundant, always sanious, and dark in color, and it possesses a feculent odor. On the other hand, in a stricture due to tuberculous disease or to simple inflammation, the discharge is not so abundant, is rarely mixed with blood, and is of a creamy white color. Tabs of skin, commonly known as spurious condylomata and sometimes associated with papillomata, are frequently present in a case of syphilitic stricture of the rectum. Up to a recent date considerable importance was attached to the form of the stool, but now it is known that its shape can be modified by the stricture only when the latter is located immediately above the anal orifice, as it is the last constriction which gives it its shape. When the stricture involves the sphincter there is a partial loss of control (or incontinence) due to the infiltration of the sphincter with fibrous tissue. The channel then assumes a tubular form. In this condition the fluid portions of the fecal matter, together with the muco-purulent discharge, will come away involuntarily, while the solid fecal matter will be retained and will either require a great effort on the part of the patient to eject it or will have

to be brought away by artificial means. Dilatation and thinning of the wall of the bowel always occur in these cases just above the stricture, and furnish a constant source of danger from rupture.

Diagnosis of Stricture of the Rectum.—While the history of the case and the symptoms may aid very much in making the diagnosis, a digital examination, if the stricture is within reach, affords the best positive means for ascertaining the truth. But, if the stricture is located above this point, the pneumatic proctoscope (Fig. 306) will be required. With this instrument the surgeon should experience no difficulty in ascertaining the true nature of the trouble. Great care and gentleness should be exercised in making the examination, either with the finger or with the proctoscope; first, because spasmodic contraction is likely to occur, owing to the irritability of the parts, and to mislead the examiner in his judgment; and, second, because the diseased condition of the bowel makes it very liable to rupture. As a rule, one who has had experience with this method of examination, may obtain more and better information from the employment of the finger than in any other way; although he may be unable to reach the stricture itself, he will experience no special difficulty in identifying and interpreting correctly the changes which are generally found in the rectal wall below this lesion. In females much valuable information may be obtained with regard to the thickness of the stricture and also often with regard to the height to which it extends, by a combined vaginal and rectal examination. In both men and women who are not too fleshy much additional information may be gained by a bimanual examination, one finger being placed high up in the rectum, while the other hand makes firm pressure downward on the abdomen. This method of making the examination may be rendered still more perfect by putting the patient under the influence of a general anæsthetic. When the stricture cannot be reached by the finger assisted by these additional manipulations, and when the decision is made to employ instruments, we would again caution the examiner about the importance of handling them—and more particularly the long unyielding proctoscope—with very great care, for the leverage exerted, when the instrument is guided by the handle at the proximal end, is very great, and the employment of what may seem to be very little force may suffice to cause a rupture of the bowel. The same may be said of a rectal bougie, however soft and flexible, in the hands of the inexperienced. The use of this latter instrument is so very liable to lead to erroneous conclusions that little weight is now attached to it as a help to diagnosis. What we have said with regard to the danger of passing instruments into a rectum which is strictured and ulcerated, becomes doubly true if the instrument is passed when the patient is under the influence of an anæsthetic, as we shall then be deprived of the protection against inflicting a trauma which the patient's conscious sensation affords us. The pneumatic proctoscope is much less dangerous, and really gives much more information, than the ordinary proctoscope, especially if the following precautions are observed, viz.: to withdraw the obturator as soon as the proctoscope has passed the internal sphincter; not to push the instrument onward to a still higher

level except by ballooning the bowel with air ahead of the proctoscope; and to keep a close watch on that portion of the bowel which is suspected of being diseased, lest even the artificially produced distention be greater than the organ can with safety bear. By aid of this instrument one may estimate the calibre of the bowel and may often distinguish both the nature and the location of the disease itself. If the stricture is located beyond the field of vision of the pneumatic proctoscope, then the pneumatic sigmoidoscope, which is from ten to fourteen inches long, may be used for examining the bowel still higher up, and may be used with just as much safety, provided the proper care is taken. We consider the practice of introducing the whole hand into the rectum, in a case of supposed stricture, for the purpose of making a diagnosis, positively dangerous.

When all other means of making a diagnosis have failed, owing largely to the fact that the stricture is located too high up above the anal orifice for us to reach it by this route, resort may be had to laparotomy. While this may appear to be a formidable procedure for such a purpose, yet, under proper antiseptic precautions, it is justifiable. If it be decided to make such an exploratory laparotomy, the incision should be the same as that employed for a left inguinal colostomy, this incision affording the most convenient access to the sigmoid and the upper portion of the rectum.

The Differential Diagnosis between a Malignant and a Non-malignant Stricture of the Rectum.—The making of such a differential diagnosis is a matter of great importance, and, in certain cases, is attended with some difficulty. The most important differences between the two forms of disease may be summed up in the following manner:

Malignant Stricture.	*Non-Malignant Stricture.*
Generally occurs in persons thirty-five years of age and over.	*Occurs at any age.*
Runs its course ordinarily in two or three years.	*Duration, indefinite.*
Loss of flesh and strength appear early.	*Smooth, hard and elastic, but not nodular.*
Hard and nodular to the touch.	*Discharge varies according to the nature of the stricture, but has no prominent characteristics.*
Has no pedicle.	*Odor may be fecal, or feculent.*
The stenosis is produced both by the bulging of the tumor into the lumen of the bowel and by the fibrous contraction of the remaining portion of the circumference of the bowel.	
In the early stages the growth may be movable, but later it is likely to be attached to the surrounding parts.	
The odor is gangrenous.	

A microscopic examination of an excised part of the growth will be of

service in making the diagnosis, but it should not be relied upon too implicitly, as the most that can be gotten from the growth is generally a small portion of the surface, and this does not always afford a trustworthy indication of the structure of the deeper parts. For the same reason the employment of this method for differentiating between the different varieties of non-malignant strictures, so long as the obstructing mass remains *in situ*, is very unsatisfactory. The only trustworthy microscopic examination is that which is made after the extirpation of the stricture. This statement, it should be understood, does not apply to the examination of scrapings from the primary ulcer which subsequently results in the formation of the stricture.

The symptoms and the microscopical findings upon which reliance is generally placed for distinguishing between the different varieties of inflammatory stricture, are the following:—

Syphilitic strictures rarely make their appearance abruptly; they show a gradual, funnel-shaped contraction, and there is a bluish-white cicatrix around the edges of the ulcer.

The traumatic or simple inflammatory stricture generally develops abruptly, and may be limited to one side of the rectum. It usually has a smooth surface, is covered with epithelium, and in the majority of instances is near the anus.

A tuberculous stricture may occur at any point in the course of the large intestine, it is generally associated with, or is secondary to, tuberculous ulceration, the scrapings from which—if the ulcer is still in an unhealed state—will generally show the presence of tubercle bacilli and giant cells. The appearance presented by these ulcers is entirely different from that presented by a syphilitic ulcer; the mucous membrane at the edges of the ulcer being always undermined and the base being elevated, whereas in the syphilitic ulcer the edges are never undermined and the base is excavated.

While the therapeutic test may be of the greatest importance in checking the extension of the disease, it is of little importance in determining the nature of the stricture.

Treatment of Strictures of the Rectum.—If, in these cases, the patients can be seen during the existence of the primary lesion and can then be properly treated, many of them may unquestionably be prevented from having subsequently a stricture. Especially is this true of simple inflammatory and syphilitic ulcerations, and we believe that, if the practice of examining the rectum with a proctoscope were more generally adopted as a routine measure during the secondary manifestations of syphilis, or whenever symptoms of ulceration of the rectum show themselves, even if these symptoms consist only of tenesmus, pain, and a sense of weight low down in the pelvis, stricture would be much less common.

When an ulceration is found, local applications, antiseptic irrigations, and —if the ulcer be found to be syphilitic—specific medication, combined with a non-irritating diet, will generally suffice to effect a cure before the infiltration with fibrous tissue takes place.

If the stricture has already formed, the treatment will depend, in certain

respects, upon the stage of its development. If the stricture is in an early stage, before the fibrous tissue has become fully organized, much may be expected from gradual and careful dilatation with bougies, combined with antisyphilitic treatment if indicated. But when the stricture is hard, dense, and unyielding, little permanent good can be expected from either of these methods. Much can be done, however, even at this stage, for the comfort of the patient, by so regulating his diet and bowels as to give him a soft and easy stool. The diet should consist largely of vegetables and fruits, even at the risk of irritating the ulcerated surfaces above and below the stricture, if such exist. The cellulose in these articles of diet keeps the stool loose and spongy, and, notwithstanding the presence of some undigested portions, renders it much less irritating than when it is composed of hard, scybalous masses such as form after a concentrated, nitrogenous diet, especially a diet composed largely, or wholly, of milk. The latter should be positively prohibited. Where diet fails to produce a soft stool, resort must be had to laxative but not to purgative medicines. The laxatives should be of the mildest and most unirritating character. Olive oil, for example, is an excellent remedy for keeping the stools soft and mushy. It should be administered in half-ounce doses, three times daily and about three hours after a meal (that it may be less likely to undergo digestion). Small doses of castor oil or of compound licorice powder will answer, but these remedies are more irritating. Enemas, if properly administered (in the knee-chest position instead of with a long tube, which is not only useless, but positively dangerous), may be of great benefit. When diarrhœa is present it means either that there is an impaction of feces above the stricture, or that there is an ulceration. In either case the rectum must be cleared of the fecal matter by the gentlest means; and, if the diarrhœa is due to ulceration, it should be treated by antiseptic irrigations and by gently stimulating applications.

Local and Op rative Treatment.—While from an antiseptic standpoint it would be far better to heal the ulceration before undertaking any surgical procedure, yet, as the ulceration is due to the stricture, it will usually be impossible to cure the former until the latter is at least in a measure overcome. An attempt should be made to sterilize the parts by washing out the rectum before resorting to any of the methods now about to be described.

Gradual Dilatation.—Gradual dilatation is in almost universal use, notwithstanding the facts that it is not curative, that it is very dangerous, and that it has to be continued indefinitely. It should be carried out with great care, on account of the danger attending it—viz., perforation or rupture of the bowel. For this reason the selection of the proper kind of bougie and the method of introducing it are matters of great importance. The Wales bougie, we believe, combines more of the qualities required for meeting the conditions than does any other form of bougie. It is sufficiently flexible and soft not to injure the bowel, and, in addition, it is hollow, so that water or medicated solutions may be passed through it.

The mistakes which are so often made and the difficulties which one encounters in passing a bougie through a stricture when the latter is located

above the levator ani muscle, make it very necessary that we should use some more accurate and definite method of conducting the operation than that generally practised. We believe that the method recommended by Tuttle (*op. cit.*, p. 497) is the best one of which we have any knowledge. For several years he has made a practice of first passing a proctoscope up to the stricture and in this manner locating the aperture of the latter. The bougie is then passed gently through the stricture. By this plan the operator knows positively that the bougie is engaged in the stricture, he is able to determine accurately what are the proper sizes to employ, and he can in other respects direct the plan of treatment in a definite and systematic manner. Tuttle recommends a Wales bougie without a flange at its distal end; the absence of the flange making it possible for the proctoscope to be withdrawn, while the bougie is left in the stricture when such a course is deemed advisable. If bougies are used for gradual dilatation it is well to begin with small sizes and gradually to increase them up to the size which produces pain. Then, at the succeeding sitting, one should begin with the bougie which is next smaller in size than that last used. The bougies should be well lubricated with a liquid soap or with Digilube before being introduced. Oil or vaseline injures rubber and soon makes the instrument rough. The frequency with which the bougie should be introduced depends upon the amount of irritation and pain excited by it. If the irritation and pain are slight, and particularly if they have subsided by the following day, the bougies may be employed daily for a short time. Then it will be better to let several days intervene; and when the sittings are resumed, they should not occur oftener than every other day. At each sitting, before one removes the last bougie, it is a good plan to inject a warm antiseptic solution through it into the rectum, above the stricture. The patient should be kept quiet for half an hour after the treatment.

The length of time a bougie should be allowed to remain in varies with different surgeons and with the character of the stricture. The consensus of opinion is in favor of removing it immediately after it has been passed; but we think it well, in very tight strictures, to allow the bougie to remain in position for twenty-four hours, the first time it is passed, in order that it may soften the stricture by pressure and may also lessen the congestion.

Quite a number of other ingenious instruments have been devised for the dilatation of strictures. We shall have to dismiss them all with the general remark that they are dangerous and unsatisfactory. Not one of them can compare, in efficiency or safety, with the Wales bougie, when properly used.

Rapid Dilatation.—Rapid dilatation has little to recommend it. It is applicable only in constrictions which are situated low down—*i.e.*, chiefly in constrictions which follow operations. In such cases the forcible dilatation may best be done with the fingers and under the influence of one of the more transient general anæsthetics, such as nitrous oxide or ethyl chloride. For strictures which occur more than three inches above the anal margin, rapid dilatation is attended with too great a risk of a fatal rupture of the bowel for us to recommend it. Fortunately, this method is seldom employed now.

Dilatation with Electrolysis.—The method of dilating rectal strictures under the influence of a galvanic current was very much in vogue twenty years ago. The associate author became a very enthusiastic champion of the method, but, after a perfectly fair and somewhat protracted trial, he became thoroughly convinced that it exerted no permanent effect whatever. While the stricture will relax temporarily and the olive-shaped electrode will pass easily through it under the influence of the electric current, no decomposition of the organized tissue takes place, nor does the procedure seem to promote or stimulate in the least the absorption of the organized fibrous deposit.

Proctotomy.—Proctotomy consists in dividing a stricture of the rectum. Such division may be either partial or complete.

Internal or partial proctotomy consists in nicking the margin of the stricture at several points or in cutting it completely through at one point posteriorly. The latter procedure is quite dangerous, especially where the stricture is located high up in the rectum, on account of the liability to infection from want of proper drainage and of the diffuse periproctitis which results from such infection. The operation is rarely practised now on account of this danger, and it may ordinarily be regarded as bad surgery. There are a few cases, however, in which the latter statement is not true—cases, for instance, in which there is a valvular stricture at some distance above the anus. In such cases the operation may be justified, but even in these the incision should not extend back into the retrorectal space.

Complete proctotomy consists in making an incision, in the posterior median line, from the upper limit of the stricture, down through the anus and postanal tissues, nearly to the coccyx. By making the incision in the posterior median line we shall cut only a very few of the fibres of the external sphincter, and consequently the probability that incontinence will follow this operation is not so great as was formerly supposed. Occasionally, when the wound has been kept packed too tightly, or if, for any other reason, there should be a large cicatrix which separates the ends of the internal sphincter, there may follow a certain amount of incontinence. In any event, the incontinence and other inconveniences which may follow the operation are of far less importance than the dangers and discomforts which are associated with a stricture. The dangers of this operation are very similar to those of an internal proctotomy, although, on account of the better drainage, they are not nearly so great. The dangers referred to are: infection, periproctitis, and hemorrhage. The hemorrhage can be easily controlled by packing with gauze, and the sepsis and consequent proctitis may be prevented by taking the proper antiseptic precautions before the operation and providing thorough drainage afterward. After the stricture has been incised and the wound packed, it would be well to introduce a drainage tube of large size into the rectum and to push it to a point beyond the upper extremity of the incision. The tube should then be fastened so that it shall remain in this position, thus affording an outlet for gas and fluid fecal matter which otherwise would be likely to accumulate and force the packing out. The first packing may be introduced rather tightly, to control the hemor-

rhage, but subsequently it should be left very loose, simply sufficient gauze being introduced to separate the sides of the wound and to assist in keeping up free drainage. The wound should be thoroughly irrigated twice or, still better, three times daily, with an antiseptic solution.

The possibility of there being more than one stricture should always be borne in mind, and the operation should not be concluded until one is able to pass a full-sized bougie into the sigmoid. A No. 10, 11, or 12 bougie should be passed daily from this time on. After the lapse of a month or six weeks one may gradually lengthen the intervals to alternate days, and then to twice a week. In order to prevent the stricture from contracting, the passing of a bougie should be kept up for an indefinite length of time. The operation is not advisable in cases of malignant stricture. In cases in which there are fistulous tracts which extend around the stricture, opening above and below

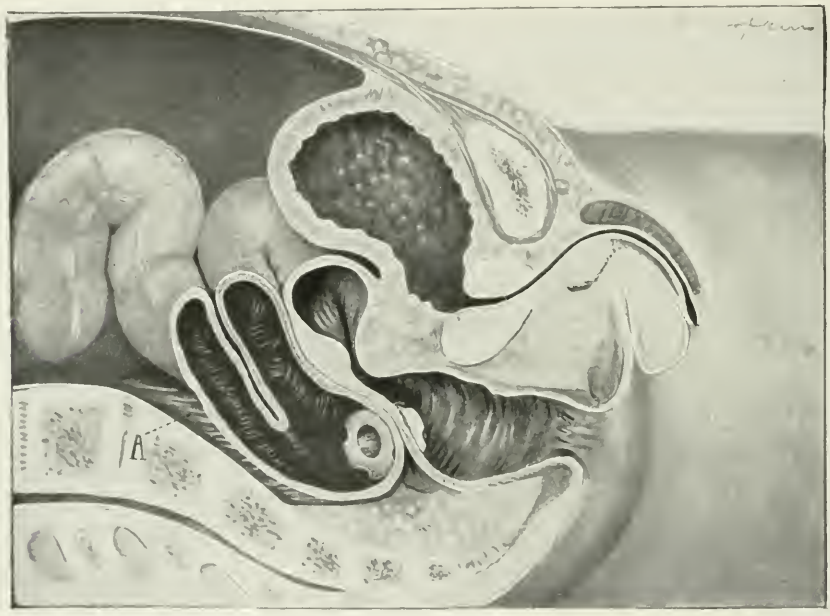


FIG. 341.—Bacon's Entero-Anastomosis for Stricture of the Rectum, First Stage. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

it, they should all be incised; by this procedure the stricture will be cut without the necessity of doing a posterior proctotomy. If not a single one of these fistulous tracts should open outside of the external sphincter, it would be better to make a free incision in the posterior median line, just as is done in posterior proctotomy, in order to furnish free drainage.

The permanent benefits of a complete proctotomy are of a very questionable character, and different operators differ very materially in their estimate of its value. So far as its immediate effects are concerned—that is, the degree of relief which it affords the patient—there can be no question; and often in the tubular forms of stricture, which extend for some distance up the rectum, no more effective remedial measure can be adopted. But it is only in a few

cases of annular and of falciform stricture, situated low down in the rectum, that one can claim for this operation absolutely curative results.

Excision.—Strictures of the rectum may be excised either by the perineal or by the sacral route.

(1) Excision by the perineal route is applicable to those cases of stricture which occur within four inches of the anal margin. If the sphincters and anus are involved, the whole anus and rectum should be dissected out above the upper level of the stricture. If the sphincters are not involved, then one of several ways may be adopted: (*a*) First, the sphincters are incised in the median line down to the coccyx; then a circular incision, extending through the entire thickness of the bowel, is made around the rectum just above the internal sphincter; the lower flaps containing the muscle having next been drawn, one to one side and one to the other, the rectum is dissected out, if possible, to a level sufficiently far above the stricture to allow the healthy and upper end of the rectum to be drawn down and stitched to the edges of the mucous membrane covering the sphincter muscle; finally, the divided ends of the muscle and the margins of the median wound are also sutured together.

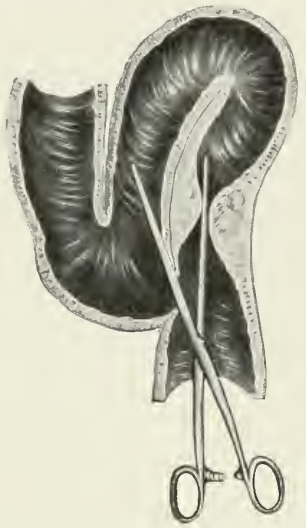


Fig. 342.—Bacon's Entero-Anastomosis, Second Stage. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

(*b*) Second, an elliptical incision embracing two-thirds of the posterior circumference of the anus and extending above the sphincters, is made, the resulting flap is dissected forward, and the rectum is amputated above the limits of the stricture. If possible, the bowel is then drawn downward and stitched to the lower flap containing the sphincters, and the latter are sutured in position. If it is found, however, that this is not practicable, the wound may be left open to heal by granulation, as in the first method, or the upper end of the bowel may be drawn down to an opening made to one side of the coccyx and an artificial anus established at this point. When the stricture is located more than four inches above the anal margin, then the sacral route will be found more satisfactory.

(*c*) The third and most satisfactory way of removing strictures in the lower four inches of the rectum is the Tuttle-Quénu method described in the section on Extirpation of the Rectum (page 908).

(2) Excision by the sacral route may be described as simply a modification of Kraske's operation for excision of the rectum. The technique of this operation is fully described in the section on Extirpation of the Rectum. Where the stricture is in the pelvic colon, it should be removed by the abdominal route, the divided ends of the bowel being reunited by means of an end-to-end anastomosis.

The results of excision have not been so gratifying as they at first promised

to be, principally on account of the great tendency of the stricture, especially in syphilitic cases, to recur. In some instances, where the stricture failed to recur, other evil results, such as rectitis, fistula, and suppuration, followed, and any one of these was sufficient to compel the patient to wear a napkin. While, therefore, the operation does not effect all that one could wish, a review of the literature shows that, in about fifty per cent of the cases, something nearly equivalent to a cure—if we disregard a certain amount of inconvenience due to the conditions just mentioned—has been attained; and this is a decided improvement over the results secured by posterior proctotomy.

Proctoplasty.—This term comprises some form of plastic operation which

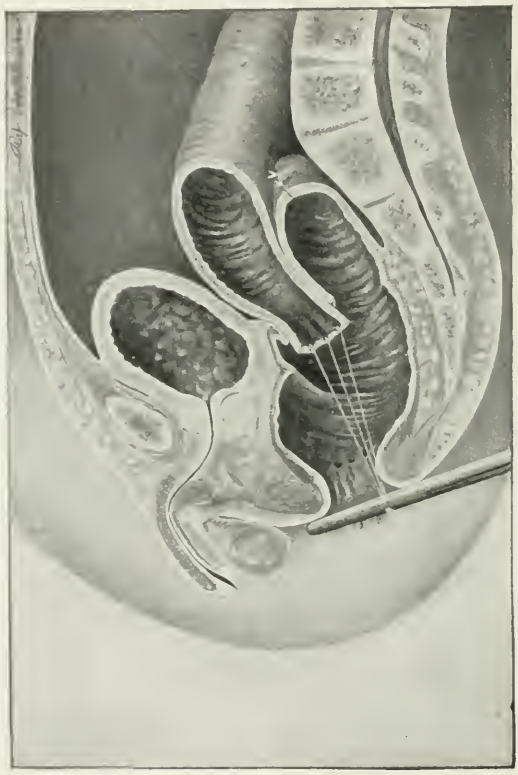


Fig. 343.—Kelly's Entero-Anastomosis, First Stage. (Tuttle, *op. cit.*)

has for its object the correction of deformities that have followed great destruction of tissue around the margin of the anus or lower portion of the rectum. Very ingenious devices have been practised, and their successful results reported by Krause of Cincinnati, Williams of Melbourne, Swartz (*Presse médicale*, 1904, p. 304), and others.

Lateral Anastomosis.—Bacon has described (*Matthew's Medical Quarterly*, Vol. I., p. 1, 1894) a very ingenious method for establishing a lateral anastomosis, between a loop of the sigmoid and the rectum, by means of a Murphy button. (Fig. 341.) This method is applicable in cases where the stricture is at the upper end of the rectum or in the lower extremity of the sig-

moid. After the button has cut its way through the bowel, a long clamp is introduced into the lower part of the rectum, and one blade of it is pushed through the stricture into the upper part of the rectum and the other through the opening made by the button into the lower leg of the anastomosing loop. (Fig. 342.) The clamp is then closed and allowed to remain until it cuts its way through the septum. By this means the calibre of the rectum will be increased to that of the combined calibres of the sigmoid and the strictured portion of the rectum. Bacon states that, when the stricture is situated low down, the operation may be done by the sacral method. Kelly, of the Johns Hopkins Hos-

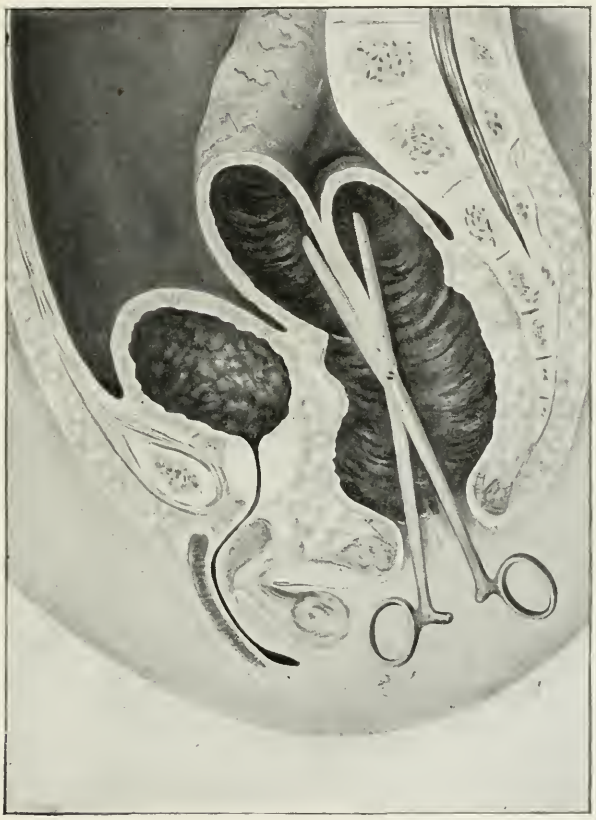


Fig. 344.—Kelly's Entero-Anastomosis, Second Stage. (Tuttle, *op. cit.*)

pital, has reported a case successfully operated upon by a somewhat similar device, but without the aid of a Murphy button or any other mechanical device. (Figs. 343 and 344; see also Colorectostomy, p. 922.) (Kelly's "Operative Gynæcology," p. 515.)

Colostomy.—Until recently colostomy for the relief of a non-malignant stricture of the rectum was done only as a last resort, as when complete obstruction was imminent or when the pain from the obstruction had become unbearable. However, since improved methods and better technique have been introduced, the operation is highly recommended in cases where the stricture is inoperable by excision or by proctotomy, and also when it has recurred

after these operations, or where complete obstruction is inevitable. Still more recently, a temporary inguinal colostomy has been recommended for cases which have not reached the extremes mentioned in the first part of this paragraph, but which require functional rest and freedom from the irritation caused by the contact of fecal matter with a badly diseased and strictured bowel. The underlying idea, in this recommendation, is that partly by the relief which will thus be afforded and partly by the benefit that may be expected to follow constitutional treatment, complete drainage, and thorough irrigation, the bowel will be restored to a fairly normal condition and the necessity for a subsequent operation will be done away with. On the other hand, should the expected benefit not be realized in full measure and should an operation become necessary, all this quieting treatment will serve to diminish greatly the danger of sepsis in connection therewith. But, if the calibre of the bowel is restored to its normal size and if the walls of the organ resume a healthy state, the artificial anus may be closed. Temporary colostomy as a palliative measure for the treatment of an ulcerated and strictured rectum or sigmoid, has furnished satisfactory results in the hands of Theim, Lowson, and Tuttle, and these results have encouraged others to try it in suitable cases.

X. PRURITUS ANI.

The exact status of pruritus ani has always been uncertain, owing to the existence of some doubt as to whether it is a disease *per se* or only a symptom. Just in proportion as our knowledge of the essential characteristics of this disorder has increased, has the former view given place to the latter, until now there are not a few who claim that there are no cases of pruritus ani essentialis, and that the few cases in which we are unable to ascertain the etiology should not be placed in this category, but should be classified simply as cases of which we are unable to discover the real cause. While unquestionably there are a few cases in which no diseased condition can be found, either in the anus or in the lower portion of the rectum, yet we also know that there are many cases which may be directly traced to diseased conditions in adjoining organs or to constitutional causes. We are therefore of the opinion that there is no such condition as pruritus ani essentialis, but that every case of pruritus, no matter how mild or how severe, can be accounted for by some functional or organic change, either localized or of a general character.

Pruritus ani may be associated with or caused by almost every known disease of the rectum or anus and by certain constitutional states; it may also be produced reflexly by diseased conditions in the genital organs. Dr. J. C. Hill, of Boston, gives the following definition: "Pruritus ani is the symptom caused by unnatural moisture or discharges which are produced either by lesions about the anus, or by congestion or some other pathological condition in the rectum or sigmoid." And we would add: by a lithæmic, uricæmic, or gouty diathesis.

Etiology.—The causes of pruritus ani may be divided into external, internal, constitutional, and reflex.

External Causes.—External causes are such as affect the external anal surface. Under this heading may be included pediculi and other parasites, eczema, dermatitis, herpes, and erythema.

The pediculi which are most likely to infest the anus are those belonging to the variety termed Pediculus inguinalis, or crab-louse. Of the other visible parasites that produce itching around the anus, the tricophyton is the one most commonly found. This parasite is the cause of eczema marginatum. It is found in the superficial layers of the epidermis, and is said to be highly contagious. A microscopic examination will always disclose its presence. The characteristic feature of the fungus is to be found in the fact that it contains very numerous spores or mycelia.

Herpes around the margin of the anus is an occasional exciting cause of pruritus ani. It is readily recognized, and its treatment calls for no special comment.

Of the local tissue changes, both external and internal, which are likely to produce pruritus ani, by far the most important, we believe, are the superficial ulcerations or abrasions of the anal canal. Next follow the catarrhal diseases of the rectum and lower portion of the sigmoid. Then, finally, come hemorrhoids and inflammation of the crypts of Morgagni. The action of all these causes in bringing about pruritus is through the irritation which they produce on the sensory nerve endings. This has been emphasized by Wallis and Hill, who lay a great deal of stress upon the irritating character of the discharges from superficial anal ulcerations, as the chief cause of pruritus; they also ascribe the same effects to irritating vaginal discharges. Thread worms, and, occasionally, lumbricoids, may produce annoying pruritus. The congestion of the rectal tissues resulting from habitual constipation may be a frequent cause. Smooth foreign bodies in the rectum and also tumors of the rectum or even of some adjoining organ may, by favoring a certain degree of constipation, act as causative factors. Dr. Cullen, of the Johns Hopkins Hospital, mentions a case of very aggravated pruritus which had lasted for some time and had resisted all forms of treatment. In this case the itching was almost immediately and permanently relieved by removing a fibroid of the uterus. The dry brittle condition of the mucous membrane over the anal orifice, which is so frequently associated with pruritus, is a result of atrophic catarrh.

Constitutional Causes.—Among the constitutional causes may be mentioned digestive derangements, uricæmic rheumatism, gout, and diabetes. Certain articles of diet, such as shell fish, strawberries, and an excess of condiments, are very prone, in certain individuals, to bring on pruritus. The same remark applies also to any articles of diet which undergo excessive fermentative changes.

Reflex Causes.—Among the reflex causes may be mentioned stone in the bladder, enlarged prostate, urethral stricture, and tumors in adjoining organs, as in Dr. Cullen's case, cited above.

Characteristics and Symptoms.—As to when or how this annoying affection begins, few patients are able to give a satisfactory account. They nearly all state that, for some time previously, they have had a sensation of uneasi-

ness in the anal region, and a disposition to scratch themselves at this point, but they are unable definitely to fix the time when this sensation changed from one of pleasure to that of an insatiable itching, which gave rise to a maddening desire to tear the parts to pieces. The incessant and intolerable itching generally comes on after the patient is comfortably settled in bed. In other cases it may come on either during the day or during the night, being excited by various, yet frequently the most trivial causes. After the itching has continued for a considerable period of time, the skin around the margin of the anus becomes thickened and at times œdematous; at other times it is raised in folds and presents a white and sodden appearance. The furrows between the folds generally split, crack, and exude a foul-smelling discharge. The surface of the transitional zone is often dry and brittle, and cracks when distended. This condition not infrequently extends a short distance into the adjoining mucous membrane. While many of these conditions may in part be the direct result of the scratching incident to the itching, they are probably due in greater part to the same pathological lesion which has caused the itching. On the other hand, we are disposed to believe that, in a certain number of cases in which the initial exciting cause has been removed, either by natural or by artificial means, the itching is still kept up by the thickened condition of the skin, which pinches and squeezes the sensory nerve endings, or also to some extent by the irritation of the skin surface which is kept up by the discharge which exudes from the cracks between the folds or from those on the marginal surface.

Treatment.—As pruritus ani is not a disease, but a symptom of some other pathological condition, permanent relief from the itching may be looked for only by relieving or removing the pathological condition, whatever that may be. While this is being done, local remedies should be used for the relief of the discomfort. If the pathological condition is one that requires removal as the only means of getting rid of it—as is often the case, for example, in hemorrhoids, condylomata, fistula, fissure, or stricture—the appropriate operation should be performed. If the affection is due to the presence of thread worms, lime water should be injected high up into the bowel and in large quantities, so that it may reach all the way round to the cæcum, the usual habitat for these organisms. When they are found in the rectum their presence in this locality is to be explained on the assumption that they have been brought down to this point by the fecal matter and the mucus. If lice are causing the trouble they can readily be gotten rid of by the liberal use of blue ointment or coal oil. In the case of the tricophyton fungus the most effective remedy to employ is an ointment containing about two per cent of salicylic acid and three per cent of Calvert's carbolic acid. When the pruritus is dependent upon reflex causes, they should be removed whenever practicable. When it is due to rheumatic and gouty conditions they should be treated, as we have been taught, by general medication.

The habits and diet of the patient should be regulated, the latter being made less stimulating and more easily digested. Evacuations should be secured regularly, but without purging.

In those cases in which the pruritus is due to catarrhal conditions of the rectum and sigmoid, these should be treated as previously directed in the section devoted to that subject. As the pruritus is nearly always increased by the warmth of the bed, it is always a good precaution to let these patients sleep between linen sheets, and the bed covering should be as light as is compatible with the comfort of the patient.

Local Therapeutic Measures.—While the pathological conditions which are the cause of the pruritus ani are being removed, local applications will have to be relied upon for the relief of the intolerable itching. Such applications have been suggested in very great variety, and we cannot attempt, within the limits of the space at our disposal, to enumerate more than a few of them. The application of as hot water as can be borne to the anus and adjoining surfaces, just before the patient retires, will frequently allay the itching and enable him to get a comfortable night's rest. The procedure may be repeated during the night, if the itching should return. If it fails to give relief, then one of the applications now about to be mentioned will have to be employed. Carbolic acid, in combination with some other agents, is probably the remedy most generally used, and the one most successful in allaying the itching. We would advise, however, that Calvert's preparation of the acid be always specified, for this purpose, as it is less irritating than any other that we have ever tried.

The following are good preparations for anointing purposes:

(1) ℞ Gum camphoræ..... ʒ i.
Spts. rectificat..... q.s.
Lanolini ..... ℥ i.
M. ft. ungt. S.: Apply before retiring and after bathing the parts in hot water.

(2) ℞ Acid. carbolic. (Calvert No. 1)..... ʒ ss.
Acid. salicylici..... ʒ ss.
Lanolini.....q.s. ad ℥ ss.
M. ft. ungt. S.: Apply to the parts after bathing them in hot water; and this may be repeated during the night.

Dr. Louis H. Adler, Jr., of Philadelphia, has reported most satisfactory results from the use of the nitrate of mercury ointment in strengths varying from 10 per cent up to full strength. Reliable authorities, however, have reported cases in which all local applications and a variety of constitutional forms of treatment have proved ineffectual in relieving the intolerable itching. In such cases heroic measures have then been resorted to for the relief of the distress, but the results have not been very satisfactory. Among such measures removal of the superficial skin for a distance of about one inch around the anal margin, as suggested by Dr. J. M. Matthews; and deep and persistent pressure upon the parts, as advised by Allingham. This is accomplished by means of a specially formed plug, which is to be introduced into the anus at bedtime, and is to be kept in position throughout the night by means of a suitable bandage. The *x*-ray and high-frequency currents are now being tried, with excellent results in some cases and absolute failure in others. Of the operative procedures which have been tried the one devised by Sir Charles Ball is the most satisfactory, and is described as follows (*British Med. Journal*, Vol. I., p. 113, January, 1905): The skin having been cleansed as completely as possible and shaved,

two curved incisions, one on each side of the affected area, are made, enclosing the entire ellipse with the exception of a narrow neck in front and one behind. These incisions are next carried down to the sphincter muscle and the flaps are raised, by careful dissection with scissors, from the surface of the muscle, around its anal margin, and up the anal canal to a line above the muco-cutaneous junction, the dissection extending around the entire circumference and all connections with the subjacent tissues being divided. The pedicles in front and behind are now undercut to a point well beyond the area of irritation, and the outer concave edges of the incision are also undercut to a distance of at least a quarter of an inch beyond the involved skin all around. Care must next be taken to stop all bleeding, and the flaps should not be replaced until it has ceased entirely, as the formation of a hæmatoma in the wound might compromise the vitality of the flaps. The flaps are finally replaced and retained by sutures, a few intervals being left between them for drainage.

Dr. Charles T. Martin, of Cleveland, Ohio, has modified Ball's operation by leaving a pedicle on the sides as well as in front and behind. The immediate result of this operation is to render the entire ellipse included between the incision, the pedicles, and outer edges, as far as they have been undercut, superficially anæsthetic, and the itching is at once relieved.

XI. HEMORRHOIDS; PILES.

Definition, Etiology, and Classification.—A hemorrhoid or pile is a collection of dilated blood-vessels, with a general increase of the connective-tissue elements and hypertrophy of the vessel walls—a true tumor formation.

The causes are predisposing and exciting. Of the former may be mentioned age, the disease being much rarer in children than in adults. It is also more frequent in men than in women. Occupation, habits, environment, and heredity, all exert some influence upon the development of the disease.

Among the predisposing causes may also be mentioned man's erect posture, the absence of valves in the portal vessels, the puncture of the muscular coat of the rectal wall by the blood-vessels, and the want of proper support for the vessels by reason of the loose attachment of the mucous membrane to the submucous coat.

Of the exciting causes probably the most frequent are constipation, excesses in alcoholism, the habit of sitting too long at stool, and the habitual use of warm-water injections, all of which determine blood to the parts. Hemorrhoids may frequently be the result of some disease of the heart, liver, or kidneys.

As to the different varieties of hemorrhoids it will be found sufficient to include them under three headings, viz., external, internal, and mixed. External hemorrhoids are those which develop from the inferior hemorrhoidal veins; internal hemorrhoids are those which develop from the superior hemorrhoidal veins; and mixed hemorrhoids are those in which both the superior and the inferior hemorrhoidal veins are affected.

External Hemorrhoids.—External hemorrhoids may be subdivided into three varieties: thrombotic, varicose, and connective-tissue hemorrhoids.

Thrombotic Hemorrhoids.—A thrombotic pile is an oval, purplish swelling which occurs at the anal margin, and is due to the formation of a thrombus in a varicose vein. This thrombus is generally caused by the rupture of the internal coat of the vein, or by a hemorrhage into the cellular tissue around the anus. It occurs suddenly, generally from straining at stool, and as a rule is attended with considerable pain. Such thrombotic piles vary in size from a pea to a walnut (Fig. 345), and are readily recognized by their color and location. This variety of hemorrhoids, if left alone, may terminate in one of three ways, viz.: the clot may become absorbed; it may become organized or calcified; or it may become infected and break down, forming an abscess.

FIG. 345.—Thrombotic Hemorrhoid. (Earle and Tuttle.)

Unless the clot is very small and painless, these hemorrhoids should invariably be opened and the clot turned out. The surface should first be made antiseptic and then a one-half of one-per-cent solution of cocaine should be injected into the skin over the tumor. A few minutes later an incision is made parallel with the radial folds, directly down to the clot, and the latter is then turned out. If the thrombus is large and is attended with a number of small ones, the tissue containing them should be dissected out. The cavity should then be packed with gauze to prevent the sides of the wound from becoming adherent and the cavity from filling with blood. The gauze should be removed in a couple of days and the wound kept perfectly clean.

Varicose External Hemorrhoids.—In this variety of hemorrhoids there is a varicose condition of the subcutaneous veins surrounding the margin of the anus. These veins become very much distended with blood whenever pressure is brought to bear on the parts, as in long standing or walking, constipation, and prolonged sitting or straining at stool.

The symptoms do not attract much attention until the hemorrhoids become inflamed, which is likely to be preceded by the formation of small, multiple thrombi. When these vessels are distended by straining there will be seen a bulging mass, of a decidedly bluish color, surrounding the anal margin.

When these hemorrhoidal tumors are not inflamed, no treatment is needed except to give the patient some general directions for the relief of the strain upon the vessel walls. If this varicose condition of the anal veins is accompanied by a tight, spasmodic stricture, the latter should be either gradually or forcibly dilated. The diet should be of such a character as to prevent constipation, and the circulation should be assisted by active, outdoor exercise. On the other hand, when hemorrhoids of this character do become inflamed,

whether they are associated with internal hemorrhoids or not, they should be removed, either jointly with the internal hemorrhoids, or separately. If the external and internal hemorrhoids are both removed at the same time, the method adopted should be either that of Whitehead or Earle's modification of the same. If they are removed separately, the internal hemorrhoids should first be removed by Earle's clamp-and-suture method, and then an incision should be made in the skin on each side of the anal margin at the most dependent part of the protrusion, the varicose vessels should be cut away with curved scissors, some of the redundant skin removed, and the wound closed by compression.

Connective-tissue External Hemorrhoids.—Connective-tissue external hemorrhoids are tags or redundant pieces of skin, combined with new connective tissue beneath. They result from repeated attacks of inflammation following thrombosis of varicose hemorrhoids, or from some chronic form of inflammation around the anal margin. Connective-tissue hemorrhoids are themselves in turn liable to become inflamed, and when this happens they should either be treated by palliative measures or be excised. When not inflamed they appear as flat folds or tags of skin. So long as they cause no inconvenience it is not necessary to interfere with them except for purposes of cleanliness or in the course of other operations.

Internal Hemorrhoids.—For all practical purposes it is sufficient to divide internal hemorrhoids into three subdivisions, viz., capillary, varicose, and thrombotic.

We wish to correct a very prevalent error with regard to the location of internal hemorrhoids. They are frequently spoken of as being high up in the rectum. They are never higher than immediately above and overhanging the upper margin of the internal sphincter.

Capillary Hemorrhoids.—Capillary hemorrhoids are raspberry-like developments, composed largely of capillaries which are very superficially located on the surface of the mucous membrane of the rectum, just within the internal sphincter. They can frequently be exposed merely by separating the buttocks and making the patient bear down; if this does not succeed in bringing them into view, they may be seen through a speculum. They bleed very freely, the blood being of a bright-red color. When they have existed for some time, the mucous membrane covering them becomes thickened, the connective-tissue elements increase, and the bleeding gradually ceases. The vessel walls then begin to dilate, the tumor increases in size, and there is developed eventually the venous or varicose variety of hemorrhoids.

Varicose and Thrombotic Internal Hemorrhoids.—The varicose and the thrombotic internal hemorrhoids are both included under the same heading, because the latter represent merely a stage in the development of the former, and are the result of the thinned and varicose condition of the vessel walls. They originate in the venous pools that connect the arterial with the venous circulation.

These hemorrhoids are due to the same causes as those which produce the

previous varieties (q.v.). They are located at the sides of the rectum, overhang the margin of the internal sphincter, and often protrude through both sphincters. They frequently occupy the entire anal circumference. They are lobulated in shape and can be readily brought into view by separating the buttocks and dragging down upon the margins of the anus, the patient being directed to bear down at the same time.

The most frequent symptoms are bleeding and protrusion. The bleeding, while it does not occur so frequently as it does from capillary hemorrhoids, is likely to be more copious. The color of the blood from hemorrhoids is always of a bright-red hue. It may sometimes be passed in a clotted state, which is due to the fact that an internal pile may continue to bleed for a while after it has been returned into the rectum. The blood which then escapes from the vessel will clot and will come away in this form with the next stool.

The protrusion does not take place until the piles have reached considerable size. At first, they protrude only at stool and go back of themselves, without assistance. As the hemorrhoids increase in size, the sphincter becomes weaker from the increased pressure and consequently less able to retain them in place. They then frequently protrude on coughing, sneezing, or after prolonged standing. If they are allowed to remain down for any length of time, they become engorged with blood and swell, and this in turn stimulates the sphincter, which still has considerable power, to increased contraction, as a result of which the hemorrhoids become strangulated.

When not inflamed or strangulated this variety of piles is not usually attended with much pain, but frequently with a sense of weight and aching in the sacral and perianal region. From distention of the walls of the vein through stasis of the local circulation, the internal coat frequently gives way and a thrombus is thus formed. This is almost sure to happen when these hemorrhoids become acutely inflamed, and is both a cause and a result of the inflammation. The clots are generally small and multiple. Internal hemorrhoids frequently give rise to reflex symptoms in the stomach and intestines, shooting pains down the limbs and in the back, constipation, and anæmia from the loss of blood.

Strangulated Hemorrhoids.—Strangulation of internal hemorrhoids may occur in one of two ways: either by the protruding tumors being strangulated by a spasmodically constricted sphincter muscle, or by the hemorrhoidal vessels becoming plugged by thrombi. It is important to differentiate between these two classes of cases of strangulated hemorrhoids, as those which belong to the former class can be promptly relieved by stretching the sphincter, whereas those which belong to the latter require more radical operative measures. Strangulation can occur only in internal and mixed hemorrhoids; no attempt should be made to replace any but the former or the internal portion of mixed hemorrhoids. Even when the strangulation and obstruction have resulted in sloughing and threatened gangrene, one should not hesitate promptly to excise the hemorrhoids—better by the thermo-cautery or electro-cautery knife, on account

of the septic conditions. The operation is attended with less risk than one would expect from the sloughing and gangrene.

Mixed Hemorrhoids.—In mixed hemorrhoids (Fig. 346) we have a combination of external and internal hemorrhoids in the same subject, and at the same time there is a breaking down of the partition line or line of demarcation between the two (viz., "Hilton's white line"), together with the establishment of free anastomosis between their respective circulations.

Fig. 346.—Mixed Hemorrhoids. (Earle and Tuttle.)

The descriptions already given of the two previous varieties will suffice for this one.

Treatment of Internal and Mixed Hemorrhoids.—In the treatment of these two varieties of hemorrhoids one may adopt either palliative or curative measures.

Palliative Treatment.—Now that hemorrhoids can be operated upon with so much safety, with such brief detention from business, and even with the aid of only local anæsthesia, there would seem to be little need for palliative treatment. There are many cases, however, in which operative measures of any kind are contra-indicated, and others in which the patient positively refuses to be operated upon. In order to meet the needs of such cases, therefore, special care should be taken in the matter of palliative measures. The principal symptoms to be met in the palliative treatment of hemorrhoids are the arrest of hemorrhage and the prevention of prolapse of the hemorrhoids. The immediate arrest of the hemorrhage may be effected without difficulty by the employment of cold, by the application of styptic or astringent remedies, and by confining the patient to the recumbent position directly after stool. To prevent a recurrence of the bleeding special attention should be paid to the diet, with a view to making the stool soft and mushy; and the patient should be advised to take plenty of outdoor exercise and to administer a cold-water enema just before the time for a stool. Resort to gentle laxatives in very moderate doses may be necessary, and it may also be well to prescribe a tonic. To diminish their tendency to prolapse the hemorrhoids should be returned immediately after the stool, and the patient should be required to lie down for half an hour or to have his stool directly before bedtime. Defecation in the recumbent posture will often entirely prevent protrusion.

Treatment by Cauterization and by the Use of Electricity and Other Means.—Cauterization of capillary hemorrhoids is another method that is used for the obliteration of hemorrhoidal tumors. It is generally done by the application of some strong chemical caustic such as nitric acid, or by the use of the thermo-cautery or the galvano-cautery. The electro-angeiotribe of Downes is especially adapted to the treatment of this variety of hemorrhoids. Electrolysis has been highly recommended, not only in capillary, but also in all forms of

internal hemorrhoids. While it has succeeded generally in controlling the hemorrhage, it does not destroy the tumor or even diminish its size to any appreciable extent. The injection of strong medicated solutions into internal hemorrhoids, for the purpose of producing coagulation necrosis or even sloughing in the tumor, is another very popular method for bringing about a diminution or destruction of these masses by the control of their blood-supply. According to Andrews' "Rectal and Anal Surgery" (p. 34) the method originated with Mitchel, of Clinton, Ill., in 1871. It remained a secret remedy, in the hands of charlatans for some years, after which the procedure was investigated and made public, in 1876, by Dr. Andrews, who also published a number of formulas which were then in use, and gave a careful review of the results obtained in over three thousand cases. The practice was then taken up by a number of regular rectal specialists, notably Kelsey, and was given a thorough trial. While nearly all of them were for some time very enthusiastic about its merits, its demerits gradually began to show themselves and to increase with the number of cases treated, until finally it was abandoned by most of them as unscientific and unsatisfactory. Nevertheless, the method still has its adherents, and it certainly possesses certain advantages which are not to be ignored in suitable cases—as, for example, where the patient is unwilling to submit to a more radical surgical operation. Carbolic acid is the chief ingredient of the solutions used for injection, and the tendency to-day is to use it in much lower percentages than formerly.

Operative Treatment.—The limited amount of space at our disposal will not permit us to describe or even to enumerate the many operative procedures which have been suggested for the relief of hemorrhoids. We shall mention some that possess special merit, and we shall describe a few that seem to us to combine the greatest number of practical features—those operations which may readily be performed by the average operator and those which are in most general use at the present time. The objects sought by all the operative methods are the following: the decrease in the size of the tumor by lessening its engorgement with blood; its atrophy by shutting off a large part of its blood-supply; or its complete removal by surgical means.

In those cases in which the sphincter ani muscle is spasmodically contracted, and in which consequently the venous circulation is seriously interfered with by strangulation, dilatation of the contracted muscle offers the best means of relieving the engorged hemorrhoids. This method is applicable to the earlier stages of the trouble, in which the hemorrhoids have just begun to protrude. Forcible dilatation is also used in all radical operations for the excision of hemorrhoids, in order to gain additional room for the application of instruments, and especially in order to afford relief from the spasmodic contractions of the muscle which follow these operations. The fingers and Kelly's graduated metallic conical dilator afford the most satisfactory means for accomplishing the desired dilatation. While a general anæsthetic is usually required for forcible dilatation of the sphincter muscle, yet this procedure may be done very satisfactorily under the influence of local anæsthesia.

It scarcely seems necessary to give here the details relating to the steps

to be taken immediately preceding an operation upon the rectum—such, for example, as the thorough emptying of the bowels, the final packing of the rectum with gauze to protect the field of operation from the intestinal discharges which come down from above, etc. As to the operations themselves we shall, as already stated, give the technical details in as concise a manner as possible.

The Ligature Operation.—The ligature operation, as devised by Mr. Salmon more than fifty years ago and performed a large number of times by Allingham, is the operation almost exclusively practised at St. Mark's Hospital, London, England, since its introduction. It has long been considered a thoroughly safe operation, and for this reason, as well as from the fact that it is easily performed, it has been very popular. The method consists in first pulling the hemorrhoids down with catch forceps; then, with a pair of scissors, the incision is begun at the base of the tumor on the skin surface and is continued up under the mass until a pedicle is formed of the mucous and submucous tissues. The artery is next felt for and the pedicle is trimmed to as narrow proportions as possible without cutting the vessel. A strong silk or linen ligature is then thrown around this and tied tightly. If the hemorrhoid is large, all that part of it which is external to the ligature is then cut off; if it is small, it is left to slough off. Dr. J. M. Matthews recommends transfixing the stump with the ligature. (Fig. 347.) Each hemorrhoid is dealt with in a similar way. The skin tabs, which are composed of the superabundant muco-cutaneous tissue around the margin of the anus, are cut off with scissors, flush with the skin, and the bleeding is controlled by compression. The wound is then dressed, and the pain is controlled by hypodermic injections of morphia or by the introduction of suppositories of opium and belladonna just after the operation.

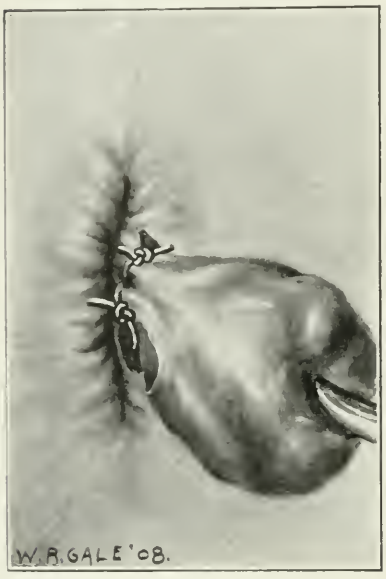


Fig. 347.—The Drawing Shows the Base or Stalk of an Internal Hemorrhoid Transfixed by a Double Ligature. (Earle and Tuttle.)

The results of this method of operating have been most satisfactory, and the death rate has been extremely low.

(As the after-treatment required is practically the same for all these rectal operations, we shall describe it farther on—see page 873.)

The Clamp-and-Cautery Operation.—This operation for the removal of hemorrhoids has been very popular ever since it was first introduced by Cussack, in 1846, and especially during the first thirty years of its use, when the methods of controlling hemorrhage were very unsatisfactory. The clamp and cautery were therefore welcomed as an infallible means, as was then believed, of controlling hemorrhage. The operation is easily performed, and the cautery both

sterilizes the wound temporarily and, by means of the eschar which it produces, seals up the capillaries and lymphatics against the absorption of septic matter. Dr. Henry Smith, who introduced it into England in 1861, and did so much to popularize it, called special attention to the importance of not catching any portion of the skin surface in the clamp, on account of the pain to which it would give rise—a precaution too little heeded by inexperienced operators at the present day. The necessary and most approved appliances for performing the operation are Kelsey's modification of Smith's clamp, Tuttle's hemorrhoidal forceps (Fig. 349), and a Paquelin cautery. The operation should be performed with the aid of a general anæsthetic, although it may be done under cocaine; the sphincter should be thoroughly stretched, and the parts prepared for the operation in the usual manner. The skin tabs are to be cut off flush with the skin. The internal hemorrhoids are brought well down by the aid of forceps, and each one is excised separately in the following manner:—The mucocutaneous base of each pile is first cut through with the scissors, so that it shall not be included in the clamp and shall not be cauterized. The clamp is next slipped over the forceps and applied beyond the point where it grasps the hemorrhoid, its heel being turned upward in its relation to the rectum. The heel of the clamp is applied to the upper part of the hemorrhoid because it holds it more securely. The toe of the clamp should fit in the groove which has been cut through the skin margin of the pile. The forceps should then be removed and the pile cut off with the scissors about one-eighth of an inch above the blades of the clamp (Fig. 348), the stump which remains being long enough to permit thorough charring (but not destruction) of the parts with the cautery—the parts, namely, which have been crushed by the clamp. After all the piles have been thus removed, one after another, the wound should be dusted with sodium bicarbonate and dressed with dry gauze. If at the conclusion of the operation the sphincter is not perfectly relaxed, a Lynch-Pennington tube may be introduced for the purpose of maintaining the dilatation of the sphincter and to provide for the free escape of gas.

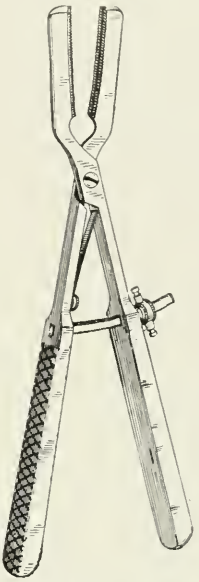


Fig. 348. — Tuttle's Hemorrhoidal Clamp.

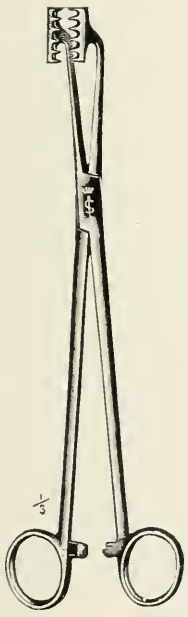


Fig. 349. — Tuttle's Hemorrhoidal Forceps.

The results from this operation have, on the whole, been very satisfactory, although there have been reported a certain number of cases of serious hemorrhage (both primary and secondary) following the operation.

The method of crushing the hemorrhoids has no special advantage over

other methods which are in much better keeping with modern surgical ideas, and it has now been relegated to the category of obsolete methods.

The electric angeiotribe, which has recently been used for removing internal hemorrhoids, represents a very happy combination of the principles involved in the clamp-and-cautery method, and we believe that it may be trusted with more confidence than the thermo-cautery as a means of controlling hemorrhage.

The Removal of Hemorrhoids by Excision.—This method, in one of the many forms which have been offered, certainly appeals to the average surgeon of the present day as the most rational manner in which to deal with these tumors. With our improved technique and with effectual means of con-

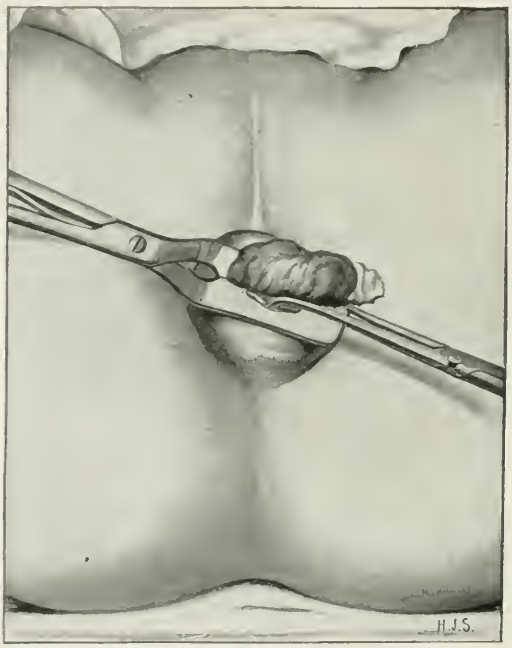


Fig. 350.—Method of Applying Clamp after Hemorrhoid is Brought Down. (Tuttle. Courtesy of D. Appleton & Co., New York.)

trolling hemorrhage, which we now have at our command, why—one naturally asks—should we apply to growths in this locality a plan of treatment different from, and more antiquated than, that which we apply to growths in other portions of the body? The answer may be found in the vastly increased number of surgeons of the present day who are using some form of excision.

The inauguration of what is known as the "Whitehead operation" by Mr. Walter Whitehead of Manchester, in 1882, was a giant stride over all other operative methods then in use. His mode of procedure is as follows: After the patient has been prepared in the usual manner, he is fully anæsthetized and placed in the lithotomy position: and then, after the sphincter has been thoroughly dilated, the hemorrhoids are pulled down and outside of the external sphincter. Beginning at the line of juncture of the skin and mucous membrane—known as Hilton's white line—the mucous membrane is divided and

dissected up around the entire circumference of the rectum, and the dissection is carried up to the beginning of the internal sphincter muscle. The mucous membrane, together with the included hemorrhoids, having been completely freed from the submucous and muscular coats, is pulled down below the margin of the skin. The mucous membrane above the hemorrhoids is now divided transversely, in successive stages, and the free margin of the severed membrane above is attached, as soon as it is divided, to the free margin of the skin below, by a suitable number of sutures. A complete ring of pile-bearing mucous membrane is thus removed. Throughout the operation bleeding vessels are dealt with by torsion or ligation. The incision around the anal margin is to be

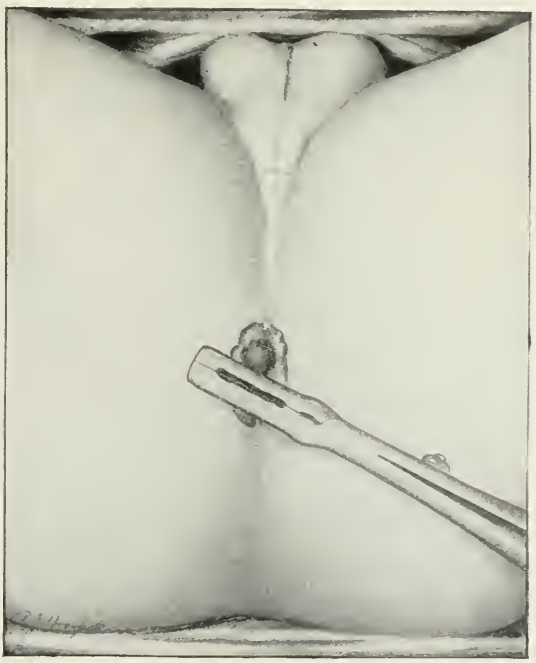


Fig. 351.—Stump of Excised Hemorrhoid held by Clamp and Ready for Applying Cautery. (Tuttle. Courtesy of D. Appleton & Co., New York.)

made entirely in the mucous membrane, and no skin, however redundant, should be sacrificed. In the three hundred cases in which, according to Dr. Whitehead's published report, he performed this operation, not a single instance of secondary hemorrhage occurred. An ice-bag is applied to the rectum for the first few days, the bowels are moved on the fourth day, the patient sits up the same day, and he resumes his work at the end of two weeks. Dr. Whitehead further claims, for this operation, that it is as free from risk as any other, that the pain following it is less severe, and that the loss of blood at the time of the operation is inconsiderable. We cannot admit that his claims for this operation have been fully borne out by the experience of other operators. It is stated by many of them, for example, that the amount of blood lost during the operation is considerable, that it takes considerable time to perform it, that there is great uncertainty of getting primary union, and that stricture and

incontinence, and also exstrophy of the mucous membrane of the rectum, as well as the reverse condition (an inversion of the skin), are likely to follow it. The two latter complications are due to inexperience and want of skill in the operator, yet they are not likely to result from any other method of operating for hemorrhoids; and the other objections are all well borne out by experience. By modifying the technique of Whitehead's operation, Tuttle has effected a great saving of time and a decided diminution in the amount of blood lost. His method "consists in making an incision through the mucous membrane at the posterior commissure of the rectum (Fig. 352); then, with blunt-pointed scissors, curved on the flat, dull dissection is made upward to the superior margin of the internal sphincter; with a boring motion, the instrument is insinuated between the mucous membrane and this muscle, and is gradually worked to one side and downward until the muco-cutaneous border of the anus is reached. (Fig. 353.) Little by little the hemorrhoidal mass is thus loosened from its muscular attachment, and peeled out of its resting place just as an orange is peeled. The same process is carried out on the other side." The incision that was begun at the posterior commissure in the lower margin of the mucous membrane is now carried entirely around the anal margin, thus leaving the hemorrhoidal area loose in the rectum. The mucous membrane is now cut longitudinally, at the posterior commissure, as high as the hemorrhoids extend. The entire mass is next caught by T-forceps and pulled down, until the upper margin of the hemorrhoids is brought down to the margin of the anus, care being taken not to subject the tissues to undue tension. The mucous membrane, with its accompaniment of hemorrhoids, is then cut off, above the level of the latter, by a series of short incisions, each of which is followed by a stitch (Fig. 354) which attaches the edge of the upper part of the mucous membrane to the muco-cutaneous edge of the wound below. This series of incisions is continued around the entire anal orifice until the hemorrhoids have all been removed; and the last one of these incisions is followed immediately by the completion of the last stage of the suturing. The steps just described leave the mucous membrane (that portion which was originally located above the hemorrhoids) attached, by a single continuous suture, to the muco-cutaneous margin of the wound below, throughout the entire circumference of the

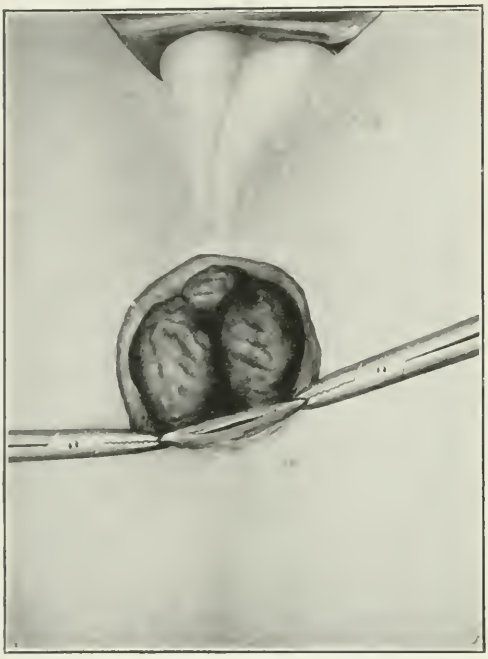


Fig. 352.—The Drawing Illustrates the First Step in Tuttle's Modification of Whitehead's Operation. (Tuttle.)

anus. (Fig. 355.) The suture used is of plain catgut, of large size. Tuttle reports the results as most satisfactory in over three hundred operations performed by this method. Any large skin tabs that may be present are cut off with the scissors, and the wound is sutured.

Instead of removing the entire pile-bearing area, as recommended by Whitehead, many operators prefer to excise the individual piles separately and to suture the edges. Gallant states (*Mathews' Medical Quarterly*, October, 1894) that Outerbridge had followed this plan with great success since 1888.

Earle (*Mathews' Medical Quarterly*, January, 1896; Parkhill, *International*

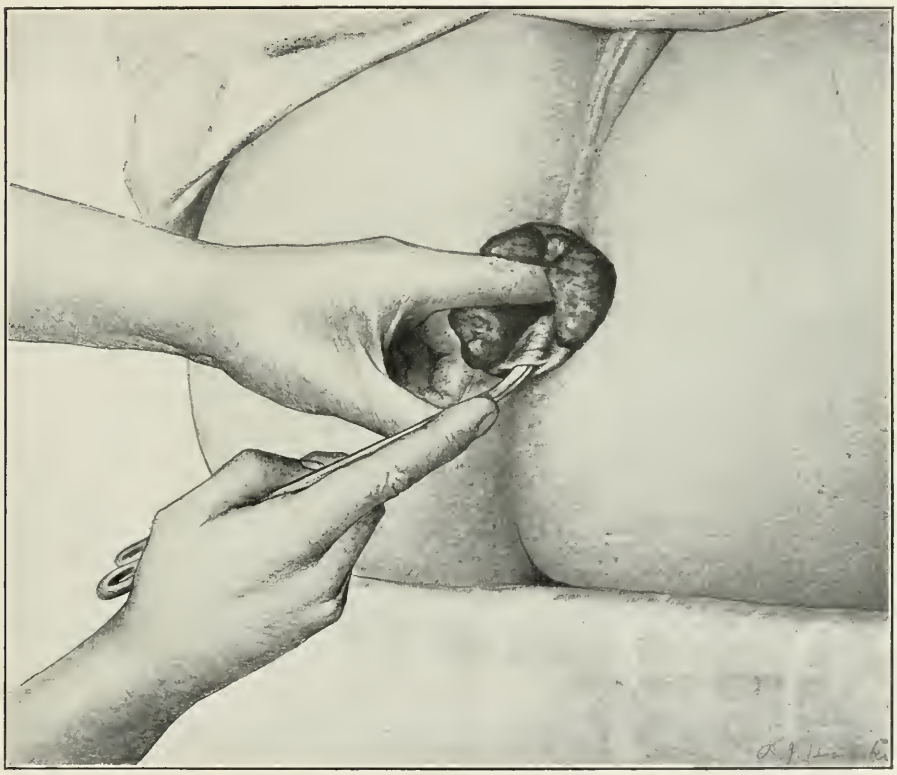


Fig. 353.—The Second Step in Tuttle's Modification of Whitehead's Operation. (Tuttle.)

Journal of Surgery, May, 1900) and Mason have each devised instruments for facilitating simple excision, and also for diminishing the danger from hemorrhage and the risk of infection in Whitehead's operation. As the same principles are embodied in each, we will introduce here an illustration of Earle's instrument and will describe his method of using it. When the hemorrhoidal tumors are isolated, each is seized in turn with clamp forceps and, having been dragged down, is clasped in the line of the long axis of the rectum by the Earle clamp. (Fig. 356.) A running suture of plain catgut No. 2 is then introduced and tied beneath the clamp at the upper end of the hemorrhoid. This will generally include the branch of the superior hemorrhoidal artery which supplies that

particular pile. That portion of the hemorrhoid which lies above the clamp is then cut off, little by little, ahead of the running suture, which is carried over and under the clamp until the entire base of the hemorrhoid is included in it. (Fig. 354.) The clamp is then loosened and withdrawn, the running suture is tightened, and thus the whole wound is closed with scarcely any loss of blood and with very little exposure of the cut surfaces to infection. If the hemorrhoids extend around the entire circumference of the rectum, then a curved clamp, a modification of Earle's by Dr. Arthur Hebb, should be employed by preference. Figs. 357 and 358 show this and his curved scissors made specially for fitting the curve of the clamp. The method of procedure, in the latter case, is

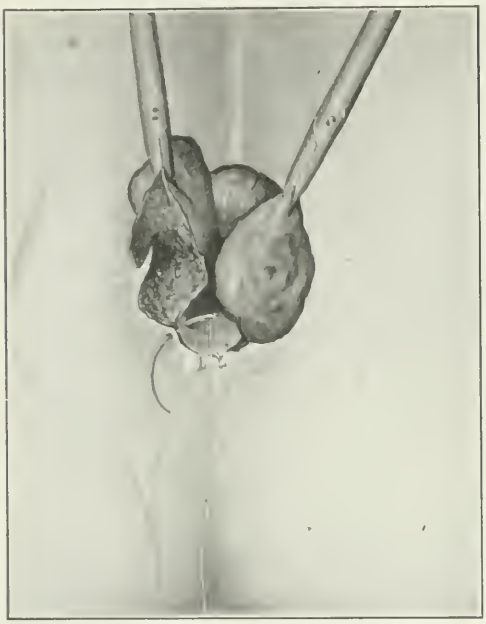


Fig. 354.

Fig. 355.

Fig. 354.—The Third Step in Tuttle's Modification of Whitehead's Operation. (Tuttle.)
Fig. 355.—Drawing Shows Tuttle's Modification of Whitehead's Operation Completed. (Tuttle: "Diseases of the Anus," etc. D. Appleton & Co., New York.)

as follows: The whole mass is seized by catch forceps at the four quadrants of the anal margin, and is then pulled down and outside of the sphincter. An incision is next made through the skin at the muco-cutaneous border, and is carried upward through the mucous membrane to a point just above the level of the internal hemorrhoids. A catgut suture is passed through the upper end of the incision in the mucous membrane, over the external sphincter, which is exposed, and out through the skin. This suture, which should now be tied, approximates the mucous and cutaneous borders of the wound. The curved clamp is next applied (Fig. 359) parallel with the circumference of the anus, the internal blade being placed just outside of Hilton's white line. In doing this, the operator should be careful to leave as broad a skin surface as possible, to prevent undue tension of the same and the resulting eversion of the mucous

membrane. The hemorrhoidal tumors are now removed above the clamp in successive stages from behind forward and toward the right. The suture is passed under the heel of the clamp, from within out, and is continued around the clamp until the point of the instrument is reached. Then the clamp is loosened and withdrawn, and the suture is drawn tight. Another segment of the hemorrhoidal area is next included in the clamp, cut off, and sutured in the same manner as the preceding one; and in turn the others are treated in a similar manner until all the hemorrhoids have been removed. (Fig. 360.)

The advantages of this operation are: the relatively short time required for its performance; the ease with which it may be done; the very small amount of blood that is lost; the small likelihood that hemorrhage or infection will occur; and the readiness with which healing takes place. It can be done either with the aid of a general anæsthetic or under the influence of local anæsthesia, and is adapted to the removal of mixed hemorrhoids.

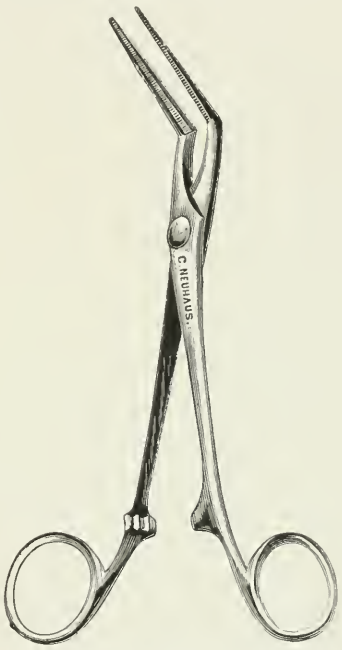


Fig. 356.—Earle's Hemorrhoidal Clamp.

Accidents and Complications Following Operations for Hemorrhoids.

Dysuria and Strangury.—One or the other of these conditions is likely to follow an operation for the cure of hemorrhoids. In most cases the only treatment called for is to apply moist heat directly over the pubis and perineum and to allow the patient to assume the normal position for relieving himself. Only in exceptional instances will it be found necessary to resort to the use of the catheter.

Infection.—Infection either by the ordinary pus organisms or by those of erysipelas or tetanus may follow operations for hemorrhoids. Such accidents are to be attributed, as a matter of course, to defect in the technique. They should be met by the usual means. For superficial infections, such as are likely to follow an infection by the ordinary pus organisms, applications of pure carbolic acid give the most satisfactory results.

After-treatment.—The after-treatment, as already stated on a previous page, is the same for cases which have been treated by excision as for those which have been treated by simple ligation. For the relief of the pain, which at first is likely to be severe, morphia should be administered in appropriate doses. A little later, however, codeine (gr. $\frac{1}{2}$) and acetanilide (gr. iij., guarded by one grain of caffeine citrate) may be substituted for the morphia. The influence of the latter remedy will probably control the action of the bowels until the fourth day, when it would be well to bring on a movement by the administration of either compound licorice powder or castor oil, to be followed by a

warm-water enema when the first impulses for an evacuation manifest themselves. The diet should be of a laxative character,—such, for example, as fruits and vegetables,—and, in order still further to insure a soft stool, it is well for the patient, on the third day, to begin taking half-ounce doses of olive oil three times daily.

It should be borne in mind, as regards the after-treatment of rectal wounds

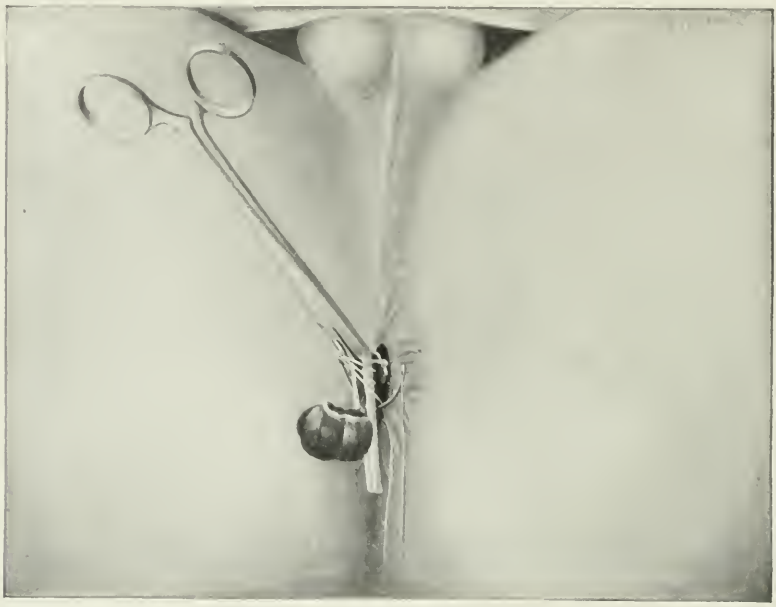


Fig. 357.—Earle's Hemorrhoidal Forceps Applied to an Isolated Hemorrhoid. (From Tuttle: "Diseases of the Anus, Rectum," etc. D. Appleton & Co., New York.)

of all kinds, that we are dealing with conditions which are different from those encountered elsewhere on the surface of the body,—conditions which are worse than those found at other orifices, mainly on account of the infected character of the discharges. These are continuously and unavoidably coming over the wound and infecting it. The best method of combating this is to control the

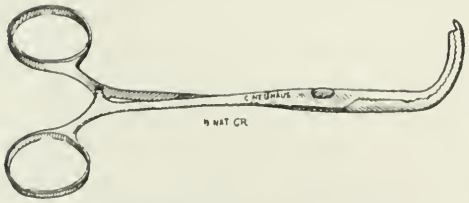


Fig. 358.—Hebb's Hemorrhoidal Clamp.

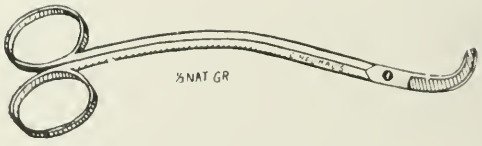


Fig. 359.—Hebb's Hemorrhoidal Scissors.

growth of the organisms which are present on the wound by frequent irrigations with antiseptic solutions, and by repeatedly changing the dressings. On the third day the patient may be allowed to walk about his room, and on the seventh day to leave his room. After the first week the anus should be gently dilated every four or five days.

XII. PROLAPSE OF THE RECTUM.

While prolapse and procidentia have the same derivation and meaning,—viz., a falling down or forward,—the former is the generic term and is applied to all degrees of falling of the rectum. Procidentia, on the other hand, is generally applied only to those cases in which all the coats of the bowel descend.

Prolapses are divided into incomplete, or partial, and complete. A partial prolapse is one in which the mucous membrane alone descends; a complete prolapse, or a procidentia recti, is one in which all the coats of the rectum take part.

Incomplete Prolapse of the Rectum.—An incomplete prolapse consists of a protrusion of the mucous membrane of the rectum through the anus.

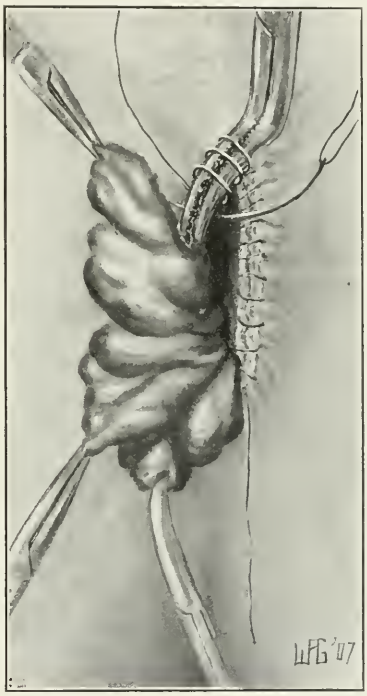


FIG. 360.—Drawing Shows the Manner of Applying the Curved Clamp and Introducing the Sutures in the Third Stage of Earle's Operation. (Tuttle: "Diseases of the Anus," etc. D. Appleton & Co., New York.)

ETIOLOGY.—This type of prolapse is due to an exaggeration of the normally loose attachment of the mucous membrane to the submucous tissue, and to the loss of elasticity in the loose fibrous and elastic tissues, which not only allow the mucous membrane to be abnormally extruded during the act of defecation, but also are incapable of drawing it back again.

It occurs frequently in acute proctitis with œdema, and also in connection with hemorrhoids and with superficial neoplasms. It is seen most frequently in young children and in the very old. It is particularly likely to occur in those conditions in which there is relaxation of the sphincter muscle together with a great reduction in the amount of the fatty tissue which normally surrounds the lower end of the rectum. These may be regarded as predisposing causes. Among the exciting causes are all those conditions which separate the mucous membrane from the muscular wall of the rectum—such, for example, as œdema, or an inflammatory effusion into the submucosa; weakness or dilatation of the sphincters; exhausting diseases, paralysis, overdistention of the rectum, and sodomy. Another series of causes includes all those conditions which induce a dragging down of the mucous membrane, such as hemorrhoids, growths attached to the mucous membrane, polyps, and hard stools. In a third series are included conditions which produce excessive straining and tenesmus—such, for example, as ulceration, foreign bodies in the rectum or bladder, cystitis, enlarged prostate, prolonged sitting and straining at stool, and excessive vomiting.

Symptoms.—The condition of prolapse comes on very gradually. In the beginning there is simply an exaggeration in the normal protrusion of the mucous membrane while at stool. At first, this protrusion returns of its own accord, but after a short time the prolapse increases, and the bowel has to be replaced. Subsequently, when the sphincter muscle becomes still more relaxed, the prolapse follows prolonged standing or walking; and, finally, the mucous membrane comes down upon the slightest provocation.

The prolapse may involve the entire circumference of the rectum or only a part of it. The surface of the prolapsed portion is smooth, unless the condition is complicated by hemorrhoids or neoplasms. The color, which at first

Fig. 361.—Earle's Operation Completed. (Original.)

is normal, soon becomes of a bright red or scarlet, as the irritation increases. When the protrusion involves the entire circumference of the rectum, the mucous membrane is arranged in longitudinal folds, which radiate from the centre to the circumference. This arrangement of the mucous membrane into folds or sulci distinguishes the incomplete from the complete form of prolapse. Large internal hemorrhoids are nearly always associated with more or less prolapse of the mucous membrane. In such instances it is easy to distinguish the hemorrhoidal tumors from the prolapsed mucous membrane.

The incomplete variety of prolapse, uncomplicated by hemorrhoids or ulceration, is not attended by much if any pain or hemorrhage. Ulceration and suppuration occur late in the disease, as a result of the friction due to the slipping of the coats of the rectum up and down.

Treatment.—Treatment consists in the removal of the exciting cause, where this can be done; and if hemorrhoids, polypi, or neoplasms are the cause

of the trouble, their removal will almost certainly result in the complete cure of this form of prolapse. When the condition occurs in children, as it often does after the exhausting and emaciating summer diarrhœas, it may frequently be corrected by careful attention to the act of defecation—for instance, by making the child have its stool in the recumbent position, especially across its mother's lap, with its feet elevated; by keeping the stool soft; by tonic treatment; and, if necessary, by strapping the buttocks with adhesive straps between the intervals of defecation. If these measures fail, the most successful and easily applied remedy is one that dates back many years. I personally saw it in use as long ago as 1868, in the hands of Dr. Nathan R. Smith, who did not speak of it as anything new, but as his chief reliance in correcting this defect in children. It consists in applying fuming nitric acid to the mucous membrane of the rectum. The child should be put, for a few moments, under the influence of a general anæsthetic—for example, ethyl chloride, nitrous oxide, or chloroform. The mucous membrane is then made to protrude, it is wiped dry of mucus, and the glass stopper of the bottle, after being moistened with the acid in such minimal quantity that it will not run down over or outside the sphincter, is applied thoroughly to the membrane. The cauterized surface should then be well anointed with vaseline, the bowel returned, and the buttocks coapted with adhesive strips. The child should remain in bed for two weeks and should be kept in the recumbent position by passing a sheet over the body and fastening it to the sides of the bed, the foot of which should be raised about four inches. The bowels should be confined for six or seven days, and, when a movement is induced, it should be by the most gentle means and with the child still maintaining the recumbent position. The rationale of this method is this: the cauterization is just sufficient to set up adhesive inflammation, which causes the mucous, submucous, and muscular coats of the rectum to become agglutinated. I have used this method of treatment for the last twenty-five years, but only on children, and I do not recall a single failure. In elderly people it is not nearly so likely to succeed, and it is therefore better in such patients to resort to some operative method—either partial or complete excision by Whitehead's method or by some modification of it—or to Van Buren's linear cauterization.

Partial excision consists in removing, by means of scissors, an elliptical portion of the mucous membrane at three or four points around the circumference of the rectum and drawing the cut edges together by means of catgut sutures, care being taken that the sutures shall extend downward and shall include the deeper tissues of the rectum; or the elliptical pieces of mucous membrane may be grasped with the hemorrhoidal clamp and removed with the cautery knife, as hemorrhoids are. The elliptical pieces removed should always be parallel with the long axis of the bowel and should not include the muco-cutaneous border.

The after-treatment following these operations for partial prolapse should be similar to that employed after an operation for hemorrhoids.

Complete Prolapse of the Rectum.—There are three degrees of complete

prolapse, all of which involve all the coats of the rectum to a greater or less degree.

First Degree.—The prolapse begins at the margin of the anus and its external surface is continuous with the skin surrounding it. (Fig. 362.)

Second Degree.—The prolapse begins above the anal canal, descends through it but does not include it, and protrudes beyond it. (Fig. 363.)

Third Degree.—The prolapse begins high up in the rectum or in the sigmoid, and extends down into the ampulla of the rectum, but does not protrude through the anal orifice. (Fig. 364.)

As will be seen, the distinguishing feature between the first and second degrees may be thus defined: the first includes the skin surface at the margin of the anus, and no sulcus is formed between the prolapse and the margin; in

Fig. 362.—Complete Procidentia of the Rectum; First Degree. (Earle and Tuttle.)

the second degree, on the other hand, the prolapse begins at the upper end of the anal canal or above it and protrudes through it, but the anal canal itself retains its position. The mucous folds or sulci, which run longitudinally in the incomplete type, run circularly in the complete types.

Etiology.—The etiology is the same as in the incomplete type, with the exception that complete prolapse is never caused by hemorrhoids or other growths that spring from the anal margin.

While both the complete and the incomplete types of prolapse generally come on gradually, yet either may, in rare instances, appear suddenly, as happens, for instance, after an accidental crushing or after an excessive straining, as in lifting some heavy object.

A neoplasm springing from the mucous membrane of the upper portion of the rectum or the lower portion of the sigmoid, and undue constriction of the rectum from any cause (*e.g.*, a stricture, the pressure exerted from without by

a malignant growth, etc.) will interfere with the free passage of fecal matter and will tend to drag down first the mucous and then the other coats of the bowel and thus produce a prolapse of the third degree. Such a prolapse is frequently found associated with an abnormally elongated meso-sigmoid or meso-rectum. The ulcerations which are so frequently associated with this form of prolapse in its chronic stage, are probably the result, and not the cause, of the affection: they are undoubtedly produced by the friction of the bowel as it slips up and down.

The extent of the prolapse varies greatly, and in fact is only limited by the length of the colon; but ordinarily it measures from three to six inches in length.

Symptoms.—In both the complete and the incomplete types the symptoms are practically the same. At first, the protrusion occurs only at stool, but,

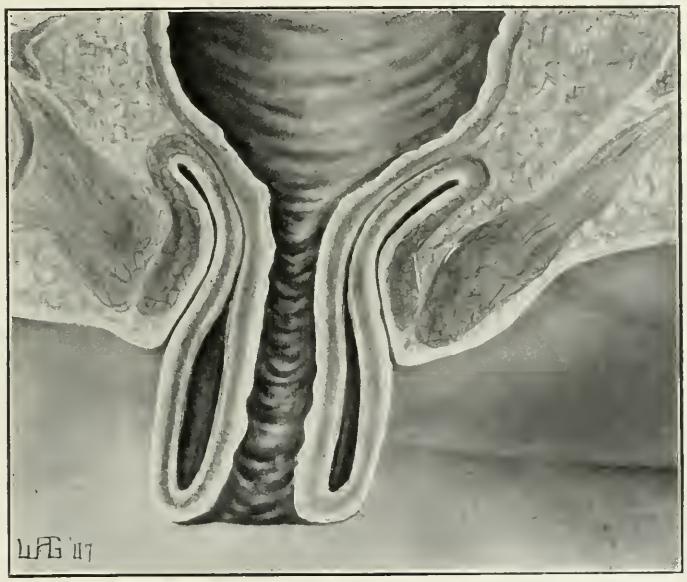


Fig. 363.—Drawing Illustrates a Case of Complete Procidentia of the Rectum; Second Degree. (Earle and Tuttle.)

later on, when the sphincters become more relaxed and the attachments stretched, it may occur upon the slightest provocation, as from standing or walking; or, in old people, in whom there is atony of the sphincters, the prolapsed bowel may remain down whenever the patient is on his feet. Constipation is the rule with these patients, until the mucous membrane of the rectum becomes excoriated or inflamed, when a teasing diarrhœa follows, which may eventually result in partial incontinence, on account of the blunting of sensibility that takes place.

The one characteristic and persistent symptom is the protrusion. The only conditions with which it is at all likely to be confounded are hemorrhoids and a protruding neoplasm, from both of which it can be readily differentiated by the circular folds into which the mucous membrane of the prolapsed rectum is thrown.

The excoriations and granulations which sometimes result from chronic prolapse may give rise to a nodular condition that may resemble epithelioma. In order to differentiate between the two diseases it may be necessary to examine a bit of the tissue with the microscope.

Both the first and the second type are likely to be complicated by rectal hernia, or archocele, and this possibility must be borne in mind in certain major

Fig. 364.—Drawing Illustrates a Complete Procidentia of the Rectum, of the Third Degree. (Earle and Tuttle.)

operations for the correction of the prolapse. In the aggravated cases, the coils of small intestine may even surround the rectum, except at its mesenteric attachment.

In a prolapse of the third degree there is an intussusception of the upper portion of the rectum, and sometimes also of the sigmoid, into the lower portion of the rectum. It does not, however, cause strangury or complete obstruction, probably on account of the great distensibility of the rectum. The bowel does not protrude from the anus in this type, and the sphincter muscle and anal canal are normal.

The symptoms of prolapse of the rectum of the third degree are very obscure. There is generally a history of constipation, but, after it has existed for some time, the constipation may alternate with diarrhœa. Whichever state exists, the patient always complains that his stool has not been satisfactory; it does not afford him the relief which is usually experienced, but leaves him with a sensation similar to that which is produced by the presence of a foreign body, and in consequence of this sensation he is often tempted to strain a great deal and to remain for an undue length of time on the closet. There is also a sense of weight and heaviness in the sacral region. At first, there is a discharge of pure mucus from the rectum, but subsequently there may be an admixture of blood, and finally it may contain pus.

These symptoms should arouse sufficient suspicion to suggest a digital examination, which should be made directly after a stool, and with the patient still in the squatting position. If the invagination does not start too high up in the rectum, the sulcus can be felt and the diagnosis confirmed by this means.

Pathology.—Briefly, and in a general way, it may be said that the organic changes which induce the prolapse consist in a weakening of the supports of the rectum. (For a detailed account of these supports the reader is referred to works on Anatomy.) Along with the weakening of the supports, there is generally an absorption of the perirectal fat in the different spaces around the rectum.

Treatment.—The first thing to be done in the treatment of complete prolapse of the rectum is to remove the exciting cause; and the next is to restore, or supplement, the rectal supports. The methods for accomplishing the first have been fully described under their proper headings. How to accomplish the second, will be discussed farther on in this article.

In the section devoted to the treatment of partial prolapse, we have already alluded to the means which we have found so effectual in children, and which is equally applicable and equally efficacious in the treatment of the first and second degrees of complete prolapse in children. When the condition is due to diarrhœa, dysentery, or rhachitis, these disorders must of course receive attention before we resort to the application of strong nitric acid. Schmey states that nearly all cases of prolapse in children may be radically cured by the administration of phosphorus in increasing doses. (Tuttle on "Diseases of the Anus, Rectum, and Pelvic Colon," page 680.) While constitutional remedies are being administered for the purpose of strengthening the rectal supports, it will be important to prevent the bowel from coming down, either during defecation or at other times. The first may be controlled by making the child have its stool in the recumbent position, by supporting the rectum with an adhesive strap placed in front of the anus, and also by drawing together the buttocks. If the bowel comes down also at other times, then the child should be confined to bed. If the rectum can be prevented from prolapsing for several weeks continuously, it is likely to become fixed, and will remain so, unless some undue force is exerted.

In adults and old people the means required for correcting the prolapse

will have to be more radical. In old people, in whom the falling down of the rectum takes place more frequently than it does in younger persons (children excepted), and in whom it is generally due to a loss of muscular tone, it would be well to try the effect of constitutional treatment in the form of arsenic and strychnia, and of strapping together the buttocks, before resorting to operative procedures. It is also of great importance to regulate the evacuations in these older patients, and to let them have their passages while they are lying down—either on a bedpan, if they are lying on the back, or upon a folded cloth, if they are lying on the side.

Great turgescence and strangulation of the prolapsed bowel may sometimes

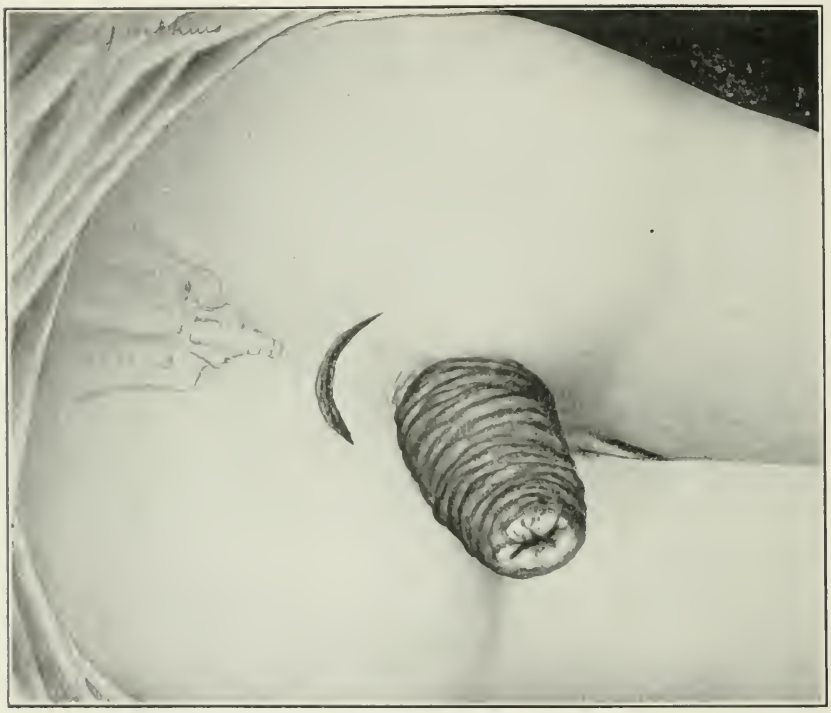


Fig. 365.—Rectopexy for Procidentia Recti; the Incision. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

occur from the great size of the protruded portion or from spasm of the sphincter. As a rule, the patient learns, under ordinary conditions, to reduce his prolapse himself, nor is it difficult for him to do so under such conditions if he takes the precaution to place himself in the knee-chest posture.

When strangulation does occur, it will be best to reduce the prolapsed bowel without the use of a general anæsthetic, if possible. If there is a great deal of congestion and œdema, firm pressure with hot cloths should be made for some time before reduction is attempted.

Efforts at reduction should be made by introducing the finger or a bougie into the lumen of the bowel at the lower end of the prolapse, and carrying it upward. Neither the finger nor the bougie should be oiled, as they will slip

over the mucous membrane instead of carrying it before them. In order to prevent this slipping, which may occur even with the unanointed finger, it will be better to wrap a piece of thin paper around the finger, and then, when the prolapse is reduced, to withdraw the finger and leave behind the piece of paper. When there is spasm of the sphincter, it is better to administer at once, without unnecessary delay, a general anæsthetic. When the protruded bowel has become gangrenous and shows a disposition to slough, great care should be taken to ascertain the depth of the slough, as it would be dangerous to reduce it if the walls of the bowel are likely to give way and establish an opening into the peritoneal cavity. In such cases immediate amputation should be resorted

Fig. 366.—Rectopexy for Procidentia Recti; the Bowel Inverted and brought through the Incision; the Sutures Passed through the Muscular Wall. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

to and the lower end of the upper segment fixed to the margin of the anus by sutures.

When the prolapsed bowel has been reduced, the buttocks should be strapped together and the patient kept in the recumbent position.

Operative Procedures.—It is evident that the method to be selected will depend upon the degree of the prolapse.

In complete prolapse of the first and second degrees we have to deal with either rupture or elongation of the bundles of connective tissue which pass from the lower end of the rectum to the coccyx, the sacrum, and the prostate (or the vagina), and at the same time also with muscular atony or relaxation.

Many methods have been devised for restoring these connective-tissue supports, and among them that of Allingham and Van Buren, which depends for its success upon the setting up of a certain amount of inflammation in the walls of the bowel for the purpose of causing them to become agglutinated with the perirectal tissues. Allingham brought this about by the application of strong nitric acid or acid nitrate of mercury. This use of nitric acid, however, did not originate with him. Van Buren, to accomplish the same purpose, recommended linear cauterization with the thermo-cautery. The subsequent treatment after the use of these means is the same as that described in the paragraph which is devoted to treatment of partial prolapse in children by one of these methods.

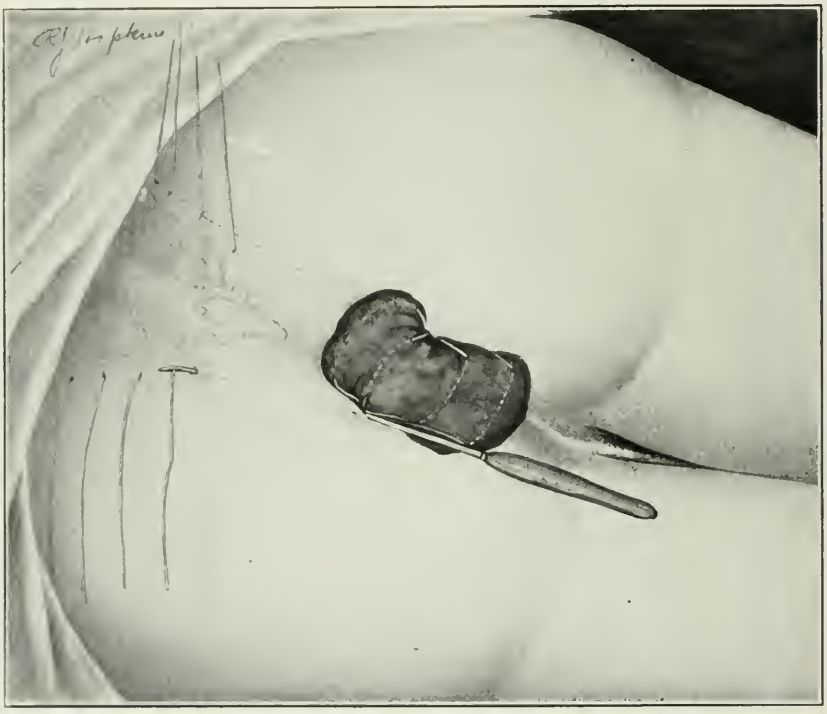


FIG. 367.—Rectopexy for Procidentia Recti; the Sutures passed from within on Each Side of the Sacrum. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

The methods just referred to are successful in the treatment of prolapse of the first degree, if used in children in the early stages of the trouble, but they do not, as a rule, answer for adults, and in the case of old people, with broken-down constitutions, the acid is likely to be positively harmful. The application of the thermo-cautery is much more successful in adults, as is also the method, advised by Dr. Henry Smith for cases in which the prolapse is of small extent, of removing folds of mucous membrane at four or five points around the circumference of the rectum, by the employment of the clamp and cautery.

In minor degrees of procidentia the condition may be relieved by Earle's modification of Whitehead's operation; but, in the average case of complete prolapse, operations limited to the mucous membrane will generally prove in-

effectual. Hence there have been recommended a number of devices which have for their object the strengthening of the deeper supports. In this category belong the methods proposed by Roberts, Dieffenbach, Lange, Verneuil, and Peters. Not one of these, however, with the exception of that recommended by Verneuil, accomplishes anything more than to narrow somewhat the anal outlet and to cause an adhesion of the lower portion of the rectum to the surrounding parts by means of an inflammatory process. Consequently it is not safe to trust any of these methods to retain a prolapse of any magnitude for longer than a brief period of time. Nearly all of those mentioned rely for their success in producing a stiffening of the rectal wall and a narrowing of the calibre

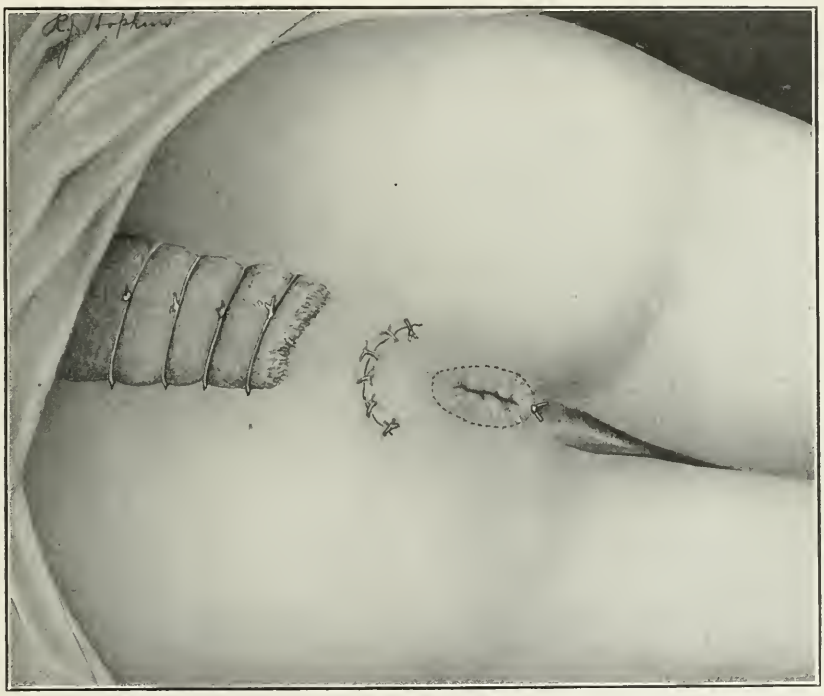


Fig. 368.—Rectopexy for Procidentia Recti; the Operation Completed. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

of the canal, upon an infolding of this wall; and the Dieffenbach-Roberts method consists merely in narrowing the lower two inches of the rectum by taking out a section of the entire thickness of the rectal wall for that distance. Verneuil simply gathered the bowel into horizontal folds, thus shortening it, and then he sutured the folded portion to the sides of the coccyx and sacrum by means of buried sutures.

Rectopexy or Suspension of the Rectum from the Sacrum.—George R. Fowler (*Medical News*, New York, February 27th, 1897) first practised suspending the rectum by sutures from the coccyx, and Tuttle has made use of the principle in the following manner:—

After the patient has been brought under the influence of a general anæs-

thetic, the prolapse is dragged down to its full extent. A curved incision, about two inches long, is made midway between the coccyx and the anus. (Fig. 365.) This is carried down to the rectal wall in the retro-rectal space. The rectum is next separated, by dull dissection, from the coccyx and sacrum posteriorly, as high up as the attachment of the meso-rectum, and on the sides as far as the attachment of the lateral ligaments. These ligaments should be carefully preserved. The anterior surface of the coccyx and sacrum should be gently curetted, to remove the fatty tissue and to freshen the surfaces. The assistant now reduces the prolapse, and, with his fingers inside the bowel, he inverts and brings it out through the incision. (Fig. 366.) The operator catches the protruded portion of the bowel and pulls it out as far as it will come. The exposed surface of the bowel is then also curetted. Silkworm-gut or silver-wire sutures are next passed transversely through the muscular layer and are made to embrace as much of the circumference of the bowel as possible; they are placed half an inch apart, and the ends are left six or eight inches long. The ends of the upper sutures are now threaded on long, curved Peaslee's needles, and each one in turn is carried up through the wound to the highest point of separation between the rectum and the sacrum, and at this point they are made to penetrate the soft tissues and are brought out through the skin on opposite sides of the sacrum. Each succeeding suture is brought out, on the skin, half an inch lower than the preceding one. (Fig. 367.) The ends are then drawn taut, and the prolapse is thus dragged up into the hollow of the sacrum. A pad of gauze is laid over the sacrum, between the sutures, and they are tied over this, to avoid their cutting into the skin. (Fig. 368.) Before the sutures are tied the wound should be freed from all clots, the oozing checked, and the external wound closed.

If the sphincters are much relaxed, a ligature of kangaroo tendon may be passed around the anus, at the upper margin of the external sphincter, and tied over the index finger after it has been introduced through the anus.

The bowels should be confined for eight days and then they should be moved by an enema. The patient should be confined to bed, and should use the bed-pan for three weeks. The anchoring sutures are left in for from ten to fourteen days.

The results secured by this operation are, according to Tuttle, most satisfactory. Indeed, so far as we know, no other operation for the relief of the first and second degrees of complete prolapse has proved equally satisfactory.

In complete prolapse of the third degree, the conditions with which we have to deal are entirely different. In these cases there is a giving way of the superior supports, or there is an abnormally long mesentery, and the correction of the prolapse consists in restoring these supports or in substituting others in their places. As in the other degrees of prolapse, the exciting cause must be relieved, and special attention should be paid to regulating the consistency and character of the stools, on account of the obstruction which this form of prolapse offers to their passage.

Temporary relief of some of the most annoying symptoms of the third

degree of prolapse may be given by the daily introduction of a Wales bougie at the time of going to stool. This procedure pushes the bowel back into position and greatly facilitates the act of having a stool.

Sigmoidopexy.—Since the abnormally long meso-rectum and meso-sigmoid actively and constantly favor the production of a prolapse of the rectum, the most rational and at the same time the most successful method of dealing with the third degree of prolapse is to attach the sigmoid to, or to suspend it from, the abdominal wall. This plan, which was first suggested by Jeannel and performed by Verneuil in 1889, is known as sigmoidopexy.

The operation consists in opening the abdomen just above the pubis, through the body of the left rectus muscle. The patient is then placed in the Trendelenburg posture and an elliptical piece of the parietal peritoneum, running upward and outward for a distance of two inches to the left from the abdominal wound, is dissected off. The sigmoid is then caught and drawn upward into the wound, until the entire prolapse is completely overcome, and until the bowel between this point and the anus is drawn comparatively taut. Fine silk sutures are now passed through the transversalis fascia on one side of the freshened surface, then through one of the longitudinal muscular bands of the sigmoid, and out through the transversalis fascia on the opposite side of the freshened surface. Three of these sutures are used for attaching the bowel to the fascia; they extend over a space about two inches in length. The wound is then closed after the usual manner. The foot of the bed should be elevated to the extent of from eight to ten inches, and this position of the bed should be maintained for five days. The bowels should be moved on the seventh day.

This operation has been done a number of times with almost unvarying success, so far as the permanent relief of the prolapse is concerned. In some cases there has remained, at the site of the adhesion, an unpleasant dragging sensation, which at times may amount even to pain. This technique is modified by different surgeons. Some attach the posterior abdominal wall; some incise the peritoneum and attach the bowel to the fascia of the iliacus muscle in the iliac fossa; and others still attach the sulco-sigmoid instead of the bowel itself to the abdominal wall. We have had no experience with these methods and therefore cannot express an opinion upon their value.

Dr. Mathews (*Journal Amer. Med. Assoc.*, 1901, Vol. I.) has reported a case of very extensive procidentia which he treated successfully by sigmoidopexy.

Sigmoidopexy is best adapted to the relief of cases which are due to an abnormally long meso-sigmoid. When the procidentia is due to stricture or to a neoplasm the cause must be removed. If the case is one in which there is a very extensive prolapse of the second degree, and in which there is reason to believe that both the upper and the lower supports of the rectum have given way, then it may be necessary to combine sigmoidopexy with rectopexy. When the prolapse cannot be reduced, or when it has become gangrenous or so inflamed that it would not be wise to attempt its reduction, the removal of the strangulated intestine would naturally suggest itself as the proper course to pursue.

Excision.—Amputation of the prolapsed bowel is undertaken only in aggravated cases of the second degree, which are too extensive to be relieved by more conservative measures—for example, in cases in which there is a neoplasm involving the entire thickness of the rectal wall; in cases in which the prolapse is associated with an organic stricture; or in those cases in which the prolapsed bowel has become strangulated and gangrenous. The probability of the existence of the rectal hernia should always be borne in mind, and should be looked for before one does an amputation. The hernial sac can be easily emptied of its intestinal contents by placing the patient in the Trendelenburg position.

Technique of the Operation of Excision.—The patient should be placed in the lithotomy position with the hips well elevated in order to throw the small intestines toward the upper part of the abdominal cavity. The rectum should be dragged down as far as it habitually prolapses and held firmly by volsella forceps. Then, after the exposed parts have been made surgically clean and dried, an incision should be made through the entire thickness of the intestine about two inches above the muco-cutaneous line, until the peritoneal cavity is opened. The serous coat of the intussuscepted portion of the bowel should next be cut through and its upper edge sutured to the peritoneal edge of the prolapsed portion. The peritoneal pouch is thus closed as the excision proceeds. The entire thickness of the intussuscepted bowel is now cut through and its muscular and mucous layers are sutured, little by little, as they are cut, to the corresponding layers of the lower section of the bowel (the intussuscipiens) at the anal margin. Chromicized catgut is preferable as suture material. In this manner the entire prolapse is excised, and an end-to-end anastomosis of the bowel is made.

After the excision is completed, if the edges of the mucous membrane are not in accurate apposition, a fine running suture of catgut, carried around the entire circumference of the bowel, should draw them closely together. A drainage tube should then be introduced into the bowel, and opium should be administered to quiet peristalsis and to confine the bowels for seven or eight days.

These cases should be watched very carefully for a year after the operation to see that stricture does not follow. The nutrition of the patient may suffer from the loss of such a large absorptive surface, to such a degree that compensation will have to be provided in the best manner that may suggest itself. When the magnitude of the operation is considered it is remarkable how free it has been from fatal results up to the present time.

Complications.—The inflammatory conditions and ulcerations which are frequently found complicating a prolapse of the rectum, and which represent either the exciting cause or the results of the irritation of the mucous surface from prolonged exposure and friction, should be treated by sponging the parts with warm antiseptic and astringent solutions and by keeping the patient for some time in the recumbent position.

To stop the hemorrhage which frequently takes place from the congested mucous surfaces, a fifty-per-cent mixture of hydrastis is the best and least

injurious application. Where there are well-defined ulcers, a strong solution (from twenty to thirty per cent) of silver nitrate, to be applied every three or four days, will answer the purpose best.

In order to keep the prolapsed portion of the bowel up, which is essential to the relief of these conditions, compresses should be applied over the anus and the buttocks should be strapped together.

Another complication is one in which unusually large areas of the intestine protrude through the anus. Several cases have been reported—one by Esmarch, for example, in which the entire large intestine, including the cæcum, protruded through the anus. Dr. Earle, in August, 1907, saw a boy, twelve years of age, who had a large prolapse of the bowel. When the abdomen was opened, there was found to be an irreducible invagination, which began at a point about four inches above the ileo-cæcal valve and involved the whole of the colon, including the sigmoid. As it was positively irreducible, the invaginated surfaces having become adherent, no other course was open but to resect the entire invaginated portion of the bowel and then to establish an end-to-end anastomosis between the ileum and the rectum. This was done by Dr. Kirby, of St. Joseph's Hospital, Baltimore, Md. The patient survived for about thirty-six hours.

Rectal hernia, already mentioned on a previous page, is one of the most frequent and serious complications of complete prolapse. Ludlow has attempted to show that the majority of cases of prolapse of the rectum are due to rectal hernia. Clinical observations have not established the truth of this assertion, yet every careful observer must have seen cases in which the cul-de-sac bulged backward into the rectal ampulla to such an extent, during straining at stool, as almost to occlude this cavity. The extensive protrusion into the rectal ampulla, without appearing outside of the anus, certainly indicates the possibility of its increasing until it overcomes the resistance of the external sphincter and causes a prolapse of the rectum. The circumference of the prolapse will be determined by the length of it, and the size of the hernial sac will in turn depend upon its circumference:—the farther it protrudes, the larger will be the sac and the more of the intestinal circumference will it involve.

The diagnosis of hernia, in a case of rectal procidentia, is made from the following symptoms and signs: the gurgling sound which is produced upon reduction of the prolapse; the tympanitic note which is elicited by percussion; and the dragging and griping sensations which are felt in the abdomen by the patient when the hernia is down. The presence of the hernia should suggest care in attempts at reduction of the prolapse, for fear of injuring the intestines.

While the contents of the hernial sac are generally composed of small intestines, it may contain portions of the sigmoid or the omentum, one of the ovaries or tubes, the uterus, the appendix, or a portion of the bladder. Any of these organs may, by becoming adherent to the sac, prevent reduction of the hernia and also furnish a serious obstacle to amputation.

The chief danger from a hernia of this nature is from strangulation and rupture of the intestinal wall. Strangulation may occur from constriction by the sphincter, the levator ani, or the longitudinal muscular fibres of the rectal wall.

The treatment of such cases consists, first, in reducing the hernia, if possible, by gentle taxis, under the influence either of a general anæsthetic or of large doses of morphia, the patient being placed in the Trendelenburg or an exaggerated knee-chest position. After the procidentia has been reduced, the operator's fingers should be carried into the rectum to reduce the hernial protrusion in the rectal ampulla. When such means fail to reduce the hernia, laparotomy should be performed at once, the adhesions broken up, and the intestines drawn into the abdominal cavity.

Advantage should be taken of such an opportunity to do a sigmoidopexy for the relief of the rectal prolapse. The intraperitoneal route also affords an opportunity for resection of any gangrenous loops of the intestine that may be present and for obliterating the hernial sac by suturing its walls.

Rupture of the hernial sac may take place through the rectal wall. It may occur spontaneously, being induced by the act of vomiting, by the patient's straining while at stool, by his lifting some heavy object, or through the efforts of the surgeon to reduce the prolapse and hernia. If the prolapse is down at the moment of rupture, the contents of the hernial sac will protrude from the body; if the rupture occurs when there is no protrusion outside of the anus, the small intestines will protrude into and fill the rectum. The presence of the small intestine in the hernial protrusion will make it easy to recognize the true state of affairs.

The symptoms develop suddenly. They are: acute pain, followed by prolapse; shock; and protrusion of the small intestines.

While the mortality in such cases is generally high, yet if the protruding intestines or other contents of the hernial sac can be reduced at once and the rent sutured, a favorable result may be looked for.

Before the attempt is made to reduce the protruded bowel the patient should be held in an exaggerated knee-chest position, or, better still, he should be suspended by the feet; for, when the body is placed in either of these positions, the bowel may recede spontaneously. Great care should be taken to ascertain positively that the intestines have been returned to the abdominal cavity, and have not merely been crowded into the rectum. If the intestines have becomes gangrenous they should be thoroughly cleansed, the protruding part excised, and the segments of the intestines that are left outside should be tied off. Laparotomy should then be performed, and an end-to-end anastomosis of the healthy intestines attempted. If the bowel is not gangrenous, laparotomy should be performed at once, the protruding intestines drawn back into the abdominal cavity, and the rent in the rectal wall sutured from the peritoneal side, if possible.

XIII. BENIGN TUMORS OF THE RECTUM.

Under this heading only those tumors will be considered which produce no constitutional disturbance beyond such as may be due to mechanical irritation and reflex manifestations.

The classification of tumors of the rectum is usually based on their histological characteristics, and the broad differentiation between benign and malignant tumors which is made on these lines, is this: that in benign tumors the cellular elements are fully developed and normally arranged, whereas in malignant tumors the cellular elements are irregularly arranged, are imperfectly developed, and are found growing outside of their normal sites. Further than this, we do not know what inherent qualities or characteristics should render one benign and the other malignant.

Under the above classification the following subdivisions naturally suggest themselves: Tumors of the connective-tissue type; tumors of the muscular-tissue type; tumors of the epithelial type; and irregular growths.

Among the benign tumors belonging to the first subdivision are: fibroma, enchondroma, lymphadenoma, lipoma, and myxoma. Myoma and fibromyoma belong to the muscular variety of tumors and both of them are benign. Those benign tumors which belong to the epithelial variety are adenoma and papilloma. Among the irregular growths the following are benign: cystomas, fungi, vegetations, and excrescences.

Fibroma.—Tumors of this type are rarely found in the anus and rectum. A fibroma in this locality originates in the connective tissue of the submucosa, and sometimes attains considerable size. It may remain in the rectal wall or it may assume the form of a polypus.

A pure fibroma is composed almost entirely of fibrous tissue, with only a few blood-vessels, but many of these tumors contain, in addition, muscular and glandular tissues. What is known as a fibrous polypus is a good example of this mixed variety. It rarely undergoes transformation, but, when it does, it degenerates into a sarcoma.

Irritation and tenesmus, with a dragging sensation when the growth is pedunculated and is grasped by the sphincter, are the usual symptoms whenever the growth attains much size.

Enchondroma.—An enchondroma is a still rarer form of the connective-tissue variety of tumor, and is composed of cartilaginous and fibrous tissues. Only a few cases of rectal enchondromata have been reported.

Lipoma.—A lipoma is a tumor composed of adipose tissue. When found in the rectum tumors of this nature ordinarily develop from the submucous layer. The growth may form a part of the rectal wall or it may simply spring from it in the form of a pedunculated tumor.

The removal of a rectal lipoma, when pedunculated, should always be preceded by ligation of the pedicle, on account of the possibility of an invagina-

tion of the peritoneum into the intestine. Where the tumor is embedded in the rectal wall, it should be removed by incising the mucous membrane over the tumor, enucleating it, and then, if possible, suturing the wound.

Myoma.—A myoma is a tumor composed of muscular tissue alone or combined with fibrous tissue. Rectal tumors of this nature are nodular in shape, and they may be either pedunculated or embedded between the submucous and muscular layers. Where the fibrous tissue is present in considerable quantity, the tumor is called a fibromyoma. Myomata are not very vascular.

When a myoma is small and embedded in the rectal wall, its hard consistency and nodular form may lead one to mistake it for a scirrhous cancer.

When the tumor is located not more than four inches above the anus, and the mucous membrane is freely movable over it, the better plan will be to remove the mass through an incision which divides the skin posterior to the rectum and extends into the muscular wall of the bowel, but does not penetrate the mucous membrane. After the growth has been removed, the edges of the wound should be accurately brought together and sutured. But if the tumor is taken out through the anus, great care should be taken to furnish free drainage.

Lymphadenoma.—The lymphadenoma, which is developed from the lymphoid tissue, is only occasionally found in the rectum. It is soft to the touch and may attain considerable size.

Rectal lymphadenomata may or may not be pedunculated. They are likely to be confounded with lymphosarcomata. It is said that they are frequently found in connection with Hodgkin's disease. They are lobulated, soft, and of a bright-red color, and they are never multiple.

The symptoms of a rectal lymphadenoma are only such as may be excited by the presence of a tumor in the rectum.

Excision of the tumor together with a broad margin of the surrounding healthy tissue is the proper treatment to adopt; for, while tumors of this nature are generally considered benign, both Stengel and Ziegler say that they are frequently malignant.

Myxoma.—A myxoma is a soft, flabby growth, either polypoid or spherical in shape, and enclosed in a thin capsule. It consists of a gelatinous mucin throughout which are scattered branched or stellate cells. It is rare for these tumors to exist as pure myxomas; they are frequently mixed with fibrous, fatty, cartilaginous, or sarcomatous tissue. According to Stengel, the vascular supply is scanty.

Adenoma.—An adenoma of the rectum is developed from the mucous and submucous coats, and as a consequence all the elements that enter into the composition of these layers are found in the tumor. A large number of rectal polypi are adenomatous in character, but all polypi in this locality are not adenomas, neither are all adenomas polypi.

The tumors may be multiple or they may occur singly. In children there are generally one or two, and these are likely to be distinctly polypoid in character, with long pedicles. In adults they are often multiple, with pedicles which are short and thick. In children the fibrous tissue is likely to predom-

inate, whereas in adults the muscular, the epithelial, and the glandular elements are apt to be in excess of the connective tissue.

Simple adenomas occur principally in childhood. The tumors vary in size from that of a very small cherry to that of a hen's egg or some larger object. The form of the pedicle varies with the size of the tumor, being, as a rule, much attenuated where the size and position of the tumor are such as to subject it to a certain amount of dragging. The firmness and vascularity of the tumor will depend upon the amount of fibrous tissue in the pedicle and body of the growth. These tumors may undergo degenerative changes, and, while they are generally benign, it is not very rare for them to assume a malignant form or to be followed, after they have been removed, either by the return of the same kind of growth or by the development of a new growth of a malignant nature.

When the pedicle is narrow it may be twisted, tied, or snared off. If the pedicle is broad or the tumor sessile, the entire mass should be removed by an incision which is carried through the mucous membrane down to the muscular layer, and should include a wide margin of healthy tissue. If any of the base of the pedicle remains it should be ligated, and the wound should be closed with catgut sutures.

Multiple Adenomata.—The rectum, the sigmoid, and sometimes the entire colon may be the seat of multiple adenomata. Their etiology, pathology, symptoms, and course differ from those of simple adenomata. Quénu and Landel (*Revue de Chirurgie*, 1889, Tom. XIX., pp. 465–494) give a most exhaustive review of this subject. They point out, not only a difference in the ages at which the two varieties of adenoma occur, but also certain differences in their histology and pathology, differences which settle definitely the question as to their being two separate varieties. Multiple adenomata constitute a disease that belongs especially to adult life. The authors above-quoted found that over fifty per cent of these cases occurred in individuals between the ages of twenty and thirty-five years. They do occur at an early age, however. One of us has seen three cases in children of three, five, and nine years, respectively.

While in multiple adenomata there is a hyperplasia of the normal glandular tissues of the bowel, the exact cause of this hyperplasia is not definitely known. It has been attributed to hereditary influence by some, to parasitic and to microbic influences by others.

From a review of the cases reported, it would appear that the rectum is the portion of the intestinal canal which is most frequently affected. The growths may vary in size from a hemp-seed to a good-sized egg, and, in conformation, from a smooth, round, shiny tumor, to a rough, and wart-like growth. Multiple adenomata are more likely to be sessile than to have pedicles. There is always more or less proctitis and colitis along with this condition. According to Quénu and Landel it is more likely that the changes in the mucous membrane are of a trophic nature than that they are due to mechanical irritation.

The symptoms observed in these cases are: at first, a slight diarrhœa,

which soon becomes very annoying; digestive disturbances; and exhaustion. The stools, which at first are simply diarrhœal in character, contain, at a later stage, mucus, with both fresh and decomposed blood. There is also tenesmus, with bearing-down pains.

The only positive and satisfactory method of making a diagnosis is by inspection through the proctoscope. With the aid of this instrument one may determine, not only the fact of the presence of these tumors (when they are not too far up in the bowel), but also their actual number, their general characteristics, and the extent of surface involved. In order to ascertain whether or not the tumors have undergone malignant transformation, it will be necessary to cut off one of them and examine its base microscopically. It must be borne in mind, however, that a negative examination in the case of one tumor does not prove that some one of the others may not have undergone a malignant change. As a rule, in about three out of four cases of multiple adenomata, malignancy is likely to show itself sooner or later in some of the growths. Ordinarily, the microscopic examination shows that these growths are composed of hypertrophied glands and connective tissue, covered with cylindrical epithelium. Neither restriction of diet nor internal medication seems to exert more than a temporary control over some of the symptoms (the diarrhœa, for instance), and it certainly exerts no influence whatever over the adenomata themselves. At the same time much may be accomplished in these cases by cold astringent lavages and internal medication, such as salicylate of bismuth, tannopin, and opium, toward quieting the tenesmus. It is usually taught, however, that the growths are best dealt with by removal, as by snaring, by ligature, and by cauterization. Before one resorts to the latter, however, it is very important to determine, if possible, the existence of malignant degeneration. If it be found to exist, no operation short of a radical removal of the affected area should be undertaken. If, however, the growths are confined to the rectum and sigmoid they may be removed, through a cylindrical proctoscope, with a wire snare or by twisting them off with forceps. Through a persistent repetition of this operation, good results have been obtained by a number of operators; and yet there are others who have found that new tumors appear in the place of those which have been removed. Where the repeated removal of the adenomata fails to give the desired relief and the patient continues to grow worse, one may choose, as a palliative measure, either one of the following operations: an inguinal colostomy, preferably on the right side, if there is reason to believe that the whole of the colon

Fig. 369.—View of the Surface of a Papilloma of the Rectum. (Earle and Tuttle.)

is studded with the growths; or, better still, an anastomosis of the ileum with the lower loop of the sigmoid flexure, after the rectum has been cleared of the adenomata. If malignant transformation has taken place in the tumors, then excision of the entire affected portion of the bowel may be resorted to. In the noted case of Lilienthal the entire colon down to the lower portion of the sigmoid was successfully removed, and the patient made a good recovery.

Papilloma: Villous Tumor.—A papilloma consists of a lobulated, spongy mass of elongated and hypertrophied villi, which may either be aggregated into a tumor-like mass, or arranged as a fringe around a part or the whole of the circumference of the rectum.

Fig. 370.—Papilloma of the Rectum; View of the Base of the Tumor after Its Removal. (Earle and Tuttle.)

Papillomata arise from the mucous membrane and from the submucous connective tissue of the rectum, and, although they are said to arise high up in the rectum, yet, of the three cases seen by Earle, all were close to the anal margin, and one formed a fringe which extended over four-fifths of the circumference of the rectum, just within the internal sphincter. These growths may drag down the mucous membrane and thus give to the tumor the appearance of being pedunculated, notwithstanding the fact that, in nearly all cases, it is attached by a broad base. (Figs. 369 and 370.) These tumors, which are red in appearance, soft, and velvety to the touch, vary in size from that of a pea to that of a small egg. Usually they do not have a spherical shape, but are simply raised a little above the surface of the mucous membrane, with the villi projecting free into the lumen of the bowel.

As shown by the schematic cut taken from Quénu and Hartmann, these tumors sometimes assume a pedunculated form.

The etiology of these growths is not understood.

The most constant and prominent symptom is the abundant discharge of clear, glairy mucus. Hemorrhages from the bowel vary considerably as regards both frequency of their occurrence and the amount of blood lost. Sometimes the latter amount is excessive. When these growths are attached low down, they generally protrude during defecation, and, even though they may be of medium size, it may be found necessary to return them. It is when they are down that they are likely to bleed profusely, and, in addition, there is likely to be a feeling of weight about the perineum and sacral region.

One characteristic feature which distinguishes simple papillomas from cylindrical epitheliomas, is the absolute absence of induration at the base of the growth or at the point where it springs from the rectal wall. (Quénu and Landel.) The chief characteristics of these growths are their soft, villous sur-

face, rather broad pedicle, and the large amount of clear mucus which is generally discharged from the rectum. They resemble very closely adeno-carcinomas of the rectum.

Allingham claims that rectal papillomata recur as carcinomas after their removal, and Quénu and Landel claim that they have observed the transformation of one of these tumors into a malignant neoplasm, without its having been operated upon.

Prompt and thorough removal is the only proper treatment for these tumors. The pedicle should be transfixed, close to its base, with a needle that is armed with a double ligature; the ligature should then be tied on both sides and the tumor cut off; or, if the pedicle is so large that it cannot be ligated, the tumor should be removed and the edges of the wound drawn together with catgut sutures. In cases in which the tumor has become malignant, resection of the bowel may be called for, or it may be necessary to adopt such other measures as will be considered under the head of Malignant Tumors.

Polypus.—This term is applied to any growth that is attached to the surface of the rectum by a pedicle which is narrower than the tumor itself.

While polypi may be found throughout the intestinal canal, they are encountered much more frequently in the rectum. They occur generally as isolated growths; yet, in adults, it is not unusual to find several in the same subject.

The tumors which most frequently take on this polypoid form are, according to their histological classification, hypertrophied solitary follicles, adenomata, fibromata, and lipomata. The most common form, especially in children, is the soft, mucous variety, which probably originates in an inflamed solitary follicle. The appearance, form, and density of polypi depend upon the type of tumor to which each belongs, and these characteristics have been given specifically under the description of each.

Treatment consists in the removal by snare, torsion, or excision after previous ligation.

Cystoma.—As the name implies, cystomata are encysted tumors, such as simple dermoid and hydatid cysts.

One rarely sees a cystic tumor of any kind growing from the walls of the rectum, although dermoids are not infrequently found embedded in the tissues of the recto-vaginal septum or of the retro-rectal space; and sometimes one of them breaks through the rectal wall and appears on the free surface of the mucous membrane as a pedunculated tumor, the pedicle being attached to the tissues in one of these spaces.

Extra-rectal Dermoids.—As stated above, dermoids may occur in either the anterior or the posterior rectal space and also just beneath the skin, between the anus and the sacrum, in which locality one of us has found them most frequently; nor are they as rare in any of these localities as in the rectal wall. These dermoids are similar to those which occur elsewhere in the body. They should be removed by dissection, under the most careful antiseptic precautions.

Postanal Dimples.—Postanal dimples occur chiefly over the region of the sacrum, coccyx, and posterior margin of the anus, and are said to be caused by imperfect union between the two lateral halves of the fœtal body. They occur as slight, fissure-like, or cylinder-like depressions in the skin, varying in depth from several inches to a mere dimple. These should be distinguished from the sinuses which occur in this region as a result of obstructed sebaceous follicles. Broken-off hairs often work their way into these dimples and look as if they were actually growing therein. They cause inflammation and abscesses, which latter may be taken for fistulæ or perirectal abscesses.

If the dimple is deep, and if it has become irritated it may be well to dissect it out and suture the edges of the wound together: but, if it is giving no trouble, it is best to let it alone and impress the patient with the importance of keeping the parts thoroughly clean and free from all collections of irritating substances.

Angeioma.—An angeioma, which is a tumor consisting of dilated venous capillaries of the submucosa, is, as a rule, congenital, and is very rarely encountered in the rectum. If it is situated low down, it may be excised, or, if high up, it may be treated by electrolysis.

Verruca.—Under the heading of verrucæ are included the warts and vegetations which are generally found around the anus in stout people. Aside from the type known as condylomata lata, which have heretofore been described under the head of specific ulcerations, these small tumors are in no sense specific. They represent a simple hypertrophy of the papillary layer of the skin.

Treatment consists in clipping them off with scissors and controlling the bleeding by hot compresses. After this has been accomplished the parts should be kept dressed with some such powder as stearate of zinc or corn starch.

Hypertrophied Anal Papillæ.—While hypertrophied anal papillæ can scarcely be called neoplasms, as they are only excessive growths of normal tissues, yet this section seems to be the proper place in which to consider them.

These papillæ are normally located upon the borders of the semilunar valves, and any one or more of them may become very much increased in size and length. In their normal state they are endowed with acute sensitiveness, and this sensitiveness is much increased when they are hypertrophied. Even in this condition they do not give rise to actual pain, but they cause considerable uneasiness and distress by exciting spasm of the sphincter and especially pruritus ani.

They look like little white teats which can be seen either by dragging down the anal canal or by employing a speculum.

If the presence of these papillæ is attended with hypertrophy of the sphincter, it would be better to use either a general or a local anæsthetic, and then, after dilating the sphincter, to snip off the growths. If the sphincter does not require dilating, then the papillæ may be snipped off with the scissors, without an anæsthetic. The bleeding from them would not be sufficient to require any treatment.

XIV. MALIGNANT TUMORS.

General Remarks.—Malignant tumors were referred to at the beginning of the previous section as including types in which the cellular elements are irregularly arranged, grow outside of their normal sites, and are imperfectly developed.

Instead of the classification that was adopted for benign tumors, where each tissue involved had its representative tumor, we shall employ, for malignant tumors of the rectum, one in which are included only carcinoma (a tumor of the epithelial type) and sarcoma (a tumor of the connective-tissue type).

Carcinoma.—From recent statistics it is estimated that, of the total number of cancers, about 6.2 per cent occur in the rectum and sigmoid. The site in which a rectal or sigmoidal cancer occurs most frequently, is the supraperitoneal portion of the bowel, in which locality it occurred in 67 per cent of the cases, and in all but 7 per cent of these the recto-sigmoidal juncture was involved at the same time. These facts have a very important bearing, for they show that a large proportion of cancers of the rectum cannot be extirpated without opening the peritoneal cavity.

Etiology.—The etiology of these cancers is not known.

The influence of heredity has not been proven, although some authorities claim that heredity has played a part in as many as 12.5 per cent of their cases. The disease occurs most frequently in the rectum in the middle or the later period of life, although Tuttle has collected seven cases in which the patient was under twenty years of age. Cancer of the rectum is more frequent in men than in women.

Four elementary types of cancer are found in the anus, rectum, and sigmoid, viz., epitheliomas, adenocarcinomas, medullary and scirrhous cancers. All of these are subject to various changes, which alter their clinical, microscopic, and histological features to such an extent that the modified growth is often described as a separate and distinct type. We shall ignore these and confine ourselves to the simple types enumerated above.

The essential elements in all carcinomas are the epithelial cells and the stroma, the former resting in alveoli which are formed by the latter. The different varieties are distinguished by the character of the cells and the amount of the stroma. The epithelial cells are of the embryonic type, and are of every shape and form; their nuclei may be single or multiple and they contain prominent nucleoli. The character of the epithelium is usually that found in the tissue in which the carcinoma develops; the shape of the individual cell, however, is governed largely by the pressure to which it is exposed. The cells in a carcinoma invade the lymph spaces and distend them, thus forming alveoli, but they do not attach themselves to the fibrous walls. This fact accounts for the spread of the disease along the lymph channels. The blood-vessels and nerves ramify in the stroma, but they do not extend into the alveoli; hence the disease seldom follows these tracts.

Epithelioma.—The term epithelioma will be limited, in this article, to the squamous variety, which occurs at the mucocutaneous margin of the anus. Histologically, the growth is characterized by the presence of cuboidal or flat epithelial cells arranged in concentric layers.

An epithelioma begins as a hard nodule in the skin or just beneath it, and it possesses an indurated base. The skin over the nodule is not movable. The tumor finally breaks down on the surface and ulcerates. This ulcer has a tendency to scab over, and, each time the scab drops off, the ulcer is found to have increased in circumference. The growth gradually tends to surround the anus and to involve the skin of the perineum and sacrum. It may, or may not, be painful. An epithelioma is distinguished from a rodent or a tubercu-lous ulcer by its nodular, indurated, and elevated base.

Malignant Adenoma; Adeno-carcinoma.—A malignant adenoma consists of tubules of irregular form, arranged in convolutions and lined by cylindrical or columnar epithelium, similar to that which lines Lieberkühn's follicles. The tubules are separated by a stroma of fibrous or myxomatous tissue.

Clinically, these tumors are comparatively soft, elevated, lobular masses. They may protrude into the rectum to such an extent as to obstruct its calibre, and are attended with an abundant discharge of mucus and blood. As a rule, they are followed by early metastasis (more commonly to the liver), and the secondary nodules possess the characteristics of the primary growth. Not only may the columnar cells of the rectum be identified in the secondary growths in the liver, but they actually develop in this new locality into gland tissue that is identical with Lieberkühn's follicles of the rectum.

Medullary Cancer.—Medullary cancer consists of a soft, pulp-like growth composed of large irregular epithelial cells which are coarsely granular and multinucleated. The stroma is scanty, fibrous in character, and filled with inflammatory corpuscles. The epithelium is arranged in an irregular manner, sometimes in nests or alveoli, which are large. The stroma is abundantly supplied with blood-vessels. Of all the forms of rectal cancer this is the most malignant.

Clinically, a medullary cancer occurs as a soft, nodular, ulcerating mass, upon a dense fibrous base. It grows rapidly and soon involves the neighboring organs. Involvement of the lymph nodes occurs earlier than in other forms of cancer, although remote metastasis is not so frequent, owing to the fact that a fatal result is likely to take place before this occurs.

Scirrhous Cancer.—Scirrhous cancer is composed of a dense, fibrous stroma, with a series of alveoli which contain atrophied or degenerated epithelial cells. This type of cancer is the least frequent and the slowest-growing of all cancers of the rectum.

Clinically, a scirrhous cancer appears as a gradually contracting stricture of the rectum. It is attended with little if any pain and only slight discharge; hemorrhage does not occur.

Unless the tumor undergoes a transformation in type, death is most likely to occur through intestinal obstruction.

Colloid Carcinoma.—Colloid carcinoma is merely a degenerative change which may take place in any one of the four types which we have just described. In a similar manner, any one of them may take on a myxomatous, mucous, or cystic degeneration.

Symptoms.—The symptoms depend upon the type of the tumor, its site in the rectum, and the stage of the disease, but, generally speaking, it is a matter of surprise, in all forms of cancer of the rectum, if located above the internal sphincter, how few and how faintly pronounced are the symptoms, even after the disease has advanced to considerable proportions. This fact seems to be

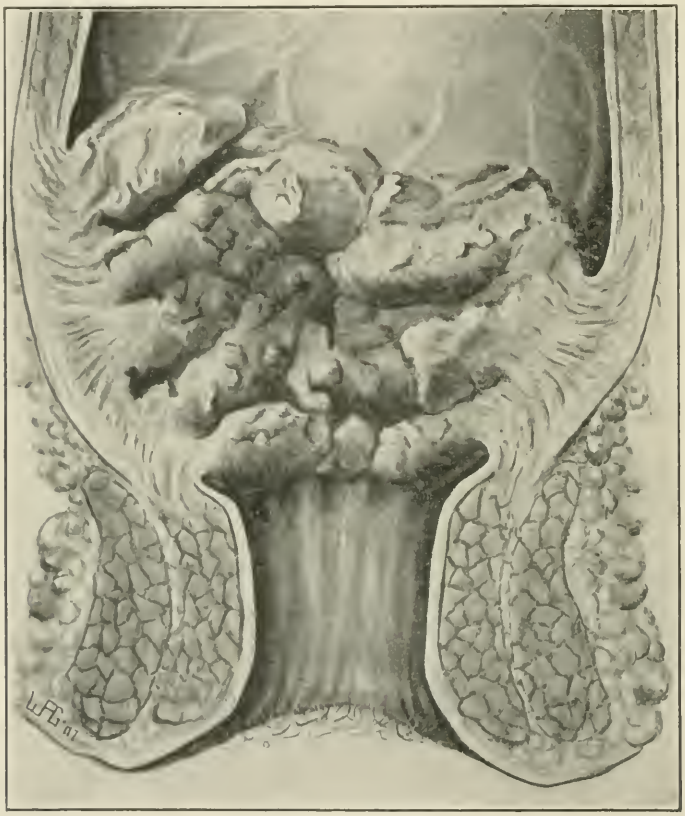


Fig. 371.—Drawing Illustrates a Case of Adeno-Carcinoma of the Rectum. (Earle and Tuttle.)

one of the chief reasons why so many cases of cancer of the rectum do not reach the surgeon until they are inoperable, and it emphasizes the necessity for the family physician to make a digital examination of the rectum as soon as his attention is called to such vague symptoms as a sense of weight and discomfort in the region of the sacrum or around the pelvis; the existence of constipation alternating with diarrhœa; the occurrence of discharges of mucus tinged or not with blood; the recurrence of bleeding on defecation, and especially the presence of dark blood in the stools; the patient's gradual loss of strength; and the existence of pain, at first vague, but afterward more pronounced.

Even by the time these symptoms attract the attention of the patient and physician, the disease is probably well developed, and it is impossible to say when it began. The lower three or four inches of the rectum should first be thoroughly examined with the finger for the presence of any growths or indurations. Then afterward, with the pneumatic proctoscope or the sigmoidoscope, the upper part of the rectum and the sigmoid should be thoroughly examined, and, if any growths at all are found, pieces of them should be pinched off with specimen forceps and examined microscopically, so that, at the earliest possible moment, the presence of a malignant growth may be recognized. As the disease advances, in the case of an adenoid or a medullary type of carcinoma, the most pronounced symptom consists of frequent calls to stool, which result in small discharges of gas, mucus, and blood, associated with an annoying tenesmus, which is not relieved by the stool or is relieved for only a short while. Pain, in these cases, is likely to be marked, although it is often vague, shooting through the pelvis or down the extremities. It is much more pronounced when the sphincters are involved than when the growth is located high up in the rectum.

Constitutional symptoms, such as loss of weight, anæmia, and increasing sallowness of the skin, begin to manifest themselves at a comparatively late stage. Local examination at this stage reveals a variety of conditions—sometimes there is a smooth, hard, lobulated mass involving the entire circumference of the rectum; at other times a similar mass is found, but it involves only a limited portion of the bowel; then again there may be a proliferating cauliflower-like growth (Fig. 371); and, finally, there may be no protrusion into the bowel, but a distinct narrowing of its calibre by an induration which extends partially or completely around the bowel, with a deep, excavating ulcer in its centre. These conditions, especially in the medullary type, are associated with a fetid, gangrenous, and disgusting odor.

In the third or degenerative stage the symptoms mentioned above are all more marked. Absolute obstruction of the intestine rarely if ever results from carcinoma of the rectum itself, which is probably due to the fact that the types of cancer which occur most frequently in the rectum (adenoid and medullary) are soft and usually undergo ulceration, especially at their most dependent portions, thus keeping the calibre of the bowel open. On the other hand, such an occurrence is always likely to take place in carcinoma of the sigmoid, because the type of tumor likely to develop here is the scirrhous, which has little tendency to ulcerate, and also because the calibre of the sigmoid is not as large as that of the rectum.

Above and below the carcinoma, the wall of the intestine is inflamed, often ulcerated, and very thin. This is more marked above the growth, and it is here that perforation or rupture is likely to take place. Inflammatory conditions around the growth, and between the rectum and adjoining organs, are frequently met with, nor need this inflammatory attachment imply that the attached organs have become involved in the malignant growth.

Carcinoma of the rectum extends by continuity, through the lymphatics,

and possibly also through the blood channels. Dr. W. S. Halsted (Trans. American Surgical Association, 1907), in speaking of the dissemination of carcinoma of the breast, quotes from Handley on "Cancer of the Breast and its Operative Treatment" (London, 1907; W. Sampson) as follows: "In showing that cancer cells in the blood excite thrombosis, and that the thrombus as it organizes usually destroys or renders them harmless, Goldman and Schmidt seem to have established a fact of primary importance, and one which is strongly opposed to the embolic theory as applied to carcinoma." We would therefore infer that in most cases of rectal cancer extension takes place unquestionably by one or both of the first two methods, while its extension by way of the blood channels is questionable. We see an excellent illustration of its extension by the lymphatics in cases of carcinoma of the anus where it travels in the line of the inguinal lymphatics, which are in the same fascial plane. Metastatic deposits, or a generalization of the cancer, may occur from either the primary or the contiguous secondary deposits. The rule, however, is that the liver is the organ that is generally affected. Whether this occurs through the blood-vessels or through the lymphatics is not positively known.

Diagnosis.—The only conditions with which carcinoma of the rectum and sigmoid is likely to be confounded are multiple adenomata, papilloma, sarcoma, proliferating proctitis, and fibrous stricture. As the first two are likely to take on malignant degeneration, or, when removed, to recur in the form of carcinoma, it would be wise to treat them as such in the beginning, although, on account of the prognosis, it would be better to differentiate between them. Where the benign is undergoing transformation into the malignant type, nothing less than complete extirpation and thorough examination of the entire growth will enable one to distinguish one from the other. The most prominent portion of these growths is the part which is most likely to be benign, while the deeper portions are most often malignant.

The diagnosis between carcinoma and proliferating proctitis is not difficult, as in the latter disease there is generally a history of syphilis, and the diseased condition is uniformly distributed throughout the rectum. Furthermore, in cancer, the granulations are soft to the touch and without induration.

Between scirrhous cancer and fibrous stricture it is almost impossible to differentiate, except by completely excising the mass and subjecting portions of it to a microscopic examination. The former disease is rare in the rectum, and the latter in the sigmoid. Scirrhus is generally nodular, whereas in fibrous stricture the surface is likely to be smooth.

Epithelioma of the anus may be mistaken for condylomata, and, where the epithelioma develops on a prolapsing hemorrhoid, it may be difficult to distinguish it from the granular condition which the hemorrhoid sometimes presents; and, besides, as Quénu and Hartmann have pointed out, one should bear in mind the resemblance between these neoplasms and the condition produced by actinomycosis. In all of these conditions involving the anal orifice a positive diagnosis may be made by a microscopic examination of a clipping of the suspected lesion. Where the malignant growth is located high up in the sig-

moid, an exploratory laparotomy may with perfect propriety be done, both for the purpose of making a positive diagnosis and for that of ascertaining the extent of the trouble. When such an exploratory laparotomy is done, the operator should be prepared to do whatever may be necessary, in the way of a radical extirpation.

Sarcoma.—In the rectum, as in other parts of the body, sarcomata arise from the connective tissue, and belong to the group of atypical tumors; which means that they do not agree, either in structure or in the character and arrangement of the cells, with any of the tissues of the adult body. Sarcoma holds the same relation to the connective tissue that carcinoma holds to the epithelial tissue. The sarcoma shows its departure from the regular type of connective tissue by the abundance of its cellular elements, and the carcinoma shows its departure from the regular type of epithelial tissue by the number and arrangement of its cells. The characteristic difference between sarcoma and the other connective-tissue tumors, is to be found in the fact that the connective tissue which forms the type of the sarcoma is represented, not by the adult, but by the embryonic form of this tissue. The different varieties of sarcoma may be said, in a general way, to represent the different phases which the embryonic connective tissue passes through in the course of its development, and the classification of the different varieties of sarcoma is based principally on the character of the cells.

Sarcomas of the rectum occur as irregular deposits beneath the mucous membrane, which, in the early stages, is movable over the growth. As regards their shape, these tumors are round or elliptical, and their surface is rough and unequal. At first, they appear as slightly elevated protrusions, then as sessile tumors, and still later they may become polypoid in shape. Sometimes they appear as a general fibrous thickening of the wall of the bowel, and in this way they may be mistaken for a simple inflammatory stricture. Subsequently the mucous surface of the tumor breaks down and ulcerates. Sarcomas may appear singly or there may be several of them. While those which involve the rectum are comparatively hard, they are not as dense as scirrhous cancers. As regards their color, they may vary from the normal color of the mucous membrane to a dark-red or a dark-gray; and when the growth is of the melanotic variety, it may appear as a black gangrenous mass.

A sarcoma may appear in any part of the rectum, and it generally terminates fatally much sooner than does a carcinoma. The lymph nodes, in many cases, but not in all, become enlarged early in the disease.

Metastasis is one of the chief characteristics of sarcomata of the rectum. The blood-vessels are very numerous and are usually in direct contact with the cells themselves.

Sarcomas of the intestine develop from the submucosa.

Etiology.—The etiology is unknown.

Symptoms.—The symptoms of sarcoma of the rectum are at first very vague. Sometimes there may be bleeding and a discharge of mucus, but the latter symptom is not so marked as it is in the case of an epithelial tumor.

Where the growth is of the melanotic variety it may be mistaken for a gangrenous hemorrhoid. The amount of pain depends upon the location of the growth; and when the disease involves the sphincter the pain will be excessive.

Prognosis.—The prognosis is very grave, as the disease tends toward a widespread metastasis and a rapidly fatal termination. Few patients survive more than one year after the operation. Earle has under observation two individuals from each of whom he removed, by complete extirpation, a spindle-cell sarcoma of the rectum. In one of these cases it is now nine years, and in the other sixteen years, since the removal of the tumor was effected, and both of the individuals, so far as can be ascertained, are entirely free from any evidences of a recurrence. While other similarly favorable reports have been published, it does not appear that in any one of these instances was the period of freedom from recurrence longer than in one of the two cases to which I have just made reference.

Treatment.—The treatment of malignant neoplasms (carcinoma and sarcoma) of the rectum is both radical and palliative. Treatment of the latter kind, however, is to be advised only after the disease has advanced beyond the state in which a radical operation can be hopefully performed. It will therefore be considered last, lest some, if they should read the description of the palliative plan first, might be tempted to try it at a time when there is yet hope for a radical cure.

In the classes of rectal tumors denominated "benign" there has never been any question as to the advisability of their removal, but in those called "malignant" some have questioned the benefit derived from a radical operation, on account of its high mortality and of the frequent recurrences. Extensive and recent statistics, however, show that in the hands of experienced operators the immediate mortality is steadily decreasing, and that the average period of life after operation is increasing. Our own statistics published in 1902 showed an immediate mortality of 18.7 per cent, while the cases operated upon since then show a mortality of only 10.8 per cent—a total mortality of 13.8 per cent in 108 cases.

As to the permanency of the cure (or the prolongation of life from that time onward), three full years of freedom from the disease being taken as evidence of a cure, Kocher, of Berne, presented the highest percentage of successes—28.5 per cent of his patients having lived beyond the allotted period. His recent statistics collected by DuPan show a number of cures based upon the same figures. The writer has recently reported the histories of one hundred cases, in forty-one per cent of which the patients had lived over three years, the average length of life of these patients (since the operation) being, up to the present time, over six years. These statistics are in keeping with the results obtained by experienced operators all over the world, and they offer encouragement to those suffering from malignant disease of the rectum.

Inasmuch as the *x*-ray, radium, serum therapy, and all other methods of treatment have failed in these cases, surgery is the only resort, and—so far as one may judge from the statistics given above—it offers results which should

appear gratifying to those for whom there is no other hope of life or comfort. Assuming then that radical removal is the proper treatment in all suitable cases, we may proceed to study what are the indications and contraindications for operation in malignant tumors of the rectum.

The main indications for operation are the existence of the tumor and a consciousness, on the part of the surgeon, of his ability to remove it without an excessive fatality. If the patient is in good physical condition, if his heart, lungs, liver, and kidneys are free from disease, neither the site, the size or the character of the tumor, nor the extent of the bowel involved, should cause one to deny, to sufferers from these diseases, the possible benefits to be derived from surgery.

The contraindications to extirpation are: immobility of the tumor; involvement of other organs, especially the bladder, liver, or bony frame of the pelvis; enlargement of remote lymph nodes; the presence of nodules in the skin; any evidence of general carcinosis; advanced lung, heart, or kidney disease; or any condition producing feeble and rapid pulse and a low power of resistance.

The type of tumor should always be considered when one is weighing the advisability of extirpation. Medullary cancer and squamous epithelioma are more unfavorable than scirrhus and simple adeno-carcinoma. Just how far these contraindications should control us can be told only by wide experience and good judgment of all the conditions in each individual case. Some of the best results from operation are often obtained from what seem to be the most hopeless cases. Immobility of the tumor, for instance, is generally considered to be the most positive contraindication to operation, and yet, this may be caused by simple inflammatory adhesions to other organs. The writer has operated upon at least ten patients in whom the tumor was practically immovable, owing to attachments to the prostate or sacrum, and in these cases he has obtained excellent results. Attachments to the prostate, the seminal vesicles, and even the uterus, though undesirable complications, are no longer considered, by the most experienced operators, as precluding extirpation. Involvement of the vaginal wall would not at first sight appear a serious complication, but experience teaches us that, where it has occurred, the probabilities of a permanent cure are very remote.

The site of the tumor may be considered a contraindication or not, according to the judgment of the surgeon. It may be stated as an axiom that the nearer the tumor is to the anus the less will be the fatality from operation and the greater the danger of recurrence; while the further the tumor is from the anus the greater will be the mortality from operation and the less the tendency to recurrence. Thus, in tumors situated high up in the rectum, the risk of operation is greater, but the chances of a permanent cure are better. In our early experience operations by the combined methods on the tumors that were situated high up proved disastrous. The same experience has fallen to the lot of nearly all operators, many of whom have abandoned the procedure altogether. Recently, however, we have had a larger proportion of successes,

the last nine cases having made good recoveries. We therefore feel more hopeful with regard to those cases in which the tumor is situated so high that its removal necessitates a resort to the abdominal or the combined operation.

The extent of the bowel involved by the tumor may be a contraindication to operation in two ways: First, the greater the tumor the longer will it have existed, and the more likely is it that other organs are involved or that metastasis has taken place; secondly, the greater the amount of bowel involved the greater will be the shock of the operation. While this feature does not constitute an absolute contraindication, many extirpations of large portions of the bowel doing better than less extensive ones, we must nevertheless bear it in mind when we give our prognosis as to the probable result of operative interference. The amount of intestine which it is practicable to remove, either by the perineal or by the combined operation, depends upon the length of the sigmoid and its mesentery in each individual case. In two cases the writer has removed portions of the rectum and sigmoid that measured respectively 39 and 44 cm., and in doing this he experienced less difficulty than he has found in removing, in other cases, portions that measured only 15 cm. in length. There is no way of telling positively in advance how much of the intestine can be brought down, but, if it is possible to get a sigmoidoscope beyond the tumor, one can determine this fairly well by the degree of mobility of the sigmoid; this mobility indicating the length of its mesentery. However, from the point of view of its value as a contraindication, the consensus of opinion is that, the greater the amount of bowel which it may be found necessary to remove, the less favorable will be the prognosis.

The age and sex of the patient are also to be considered in deciding for or against operative interference. The mortality in patients above sixty years of age is rather high (about twenty-two per cent), but the percentage of permanent cures is also high (sixty-five per cent). In patients under thirty years of age cancer has usually been considered hopeless, but, in our experience, only two out of the nine patients under thirty years of age have died—one from operation and one from recurrence. To us, therefore, the period of life from thirty to forty years has seemed the most unfavorable for operation; that from fifty to sixty, on the other hand, appearing the most favorable. As to sex, women bear the abdominal and combined operation better than men. In other respects there is practically no difference between the two sexes.

The degree of preparedness of the surgeon may be a serious contraindication to extirpation of the rectum. While every operator on the rectum must have his first operation of this nature, he should not begin with one which is especially difficult. Every minute, every drop of blood, every inch of arterial supply saved in such a serious operation is of importance, and only experience can teach one how to conserve them. Frequent practice on the cadaver is necessary to fit one to do this operation on a living subject.

Then, finally, the rights and desires of the patient are to be considered in deciding for or against operation. Every man has a right to know exactly what his condition is and what are the dangers incurred if it be left untreated;

he should also be told the probable result of operation. He can then choose for himself whether, in a desperate case, he will take his chance for life and comfort through operation. If he so decides, the surgeon should not refuse to undertake the work even though the probabilities are against a successful issue.

All these indications and contraindications having been considered, and operative interference having been determined upon, one must select the method which is best suited to each individual case. While there are a large number of methods named after individuals, there are really only five which deserve consideration, viz.: the perineal, the parasacral, the abdomino-perineal or combined, the abdominal, and the vaginal. As to the comparative value of these different operations, it is scarcely possible to make a positive statement, inasmuch as they are each applicable to different classes of cases. The perineal and vaginal operations give the lowest mortality and the parasacral the next lowest. Then comes the abdominal operation, with a somewhat higher mortality; and the combined operation follows this, with the highest mortality of all. If the conditions warrant, the preference should be given to the different operations in the order here named.

The preparation of the patient is the same for each of these operations, and may be described as follows:

Preparation of the Patient.—At least one week is required for the proper preparation of the patient for an operation of extirpation. He should be fed on a concentrated but mixed diet—such, for example, as white meats, strong broths, milk, beef juice, refined cereals, and small quantities of toasted bread. If the digestion is impaired, predigested food, such as peptonized milk and infant foods, should be given in as large quantities as the patient will bear. He should have, once every day, a saline laxative, preferably Epsom salts, in a sufficient quantity to give one or two liquid movements; he should also be given some form of intestinal antiseptic. The writer has had the best results with betanaphthol, in capsule (ten grains three times a day). Some patients cannot take this drug, and, when this is the case, salol or sulpho-carbolate of zinc may be administered in its place. The rectum should be irrigated twice a day with a mixture of hydrogen dioxide (strength, from ten to twenty per cent). Bichloride of mercury, potassium permanganate, or carbolic acid solutions, of sufficient strength to sterilize the parts, are all too irritating.

On the night previous to the operation all foods should be stopped, and large doses of deodorized tincture of opium given. The administration of this remedy should be continued for several days after the operation, in order to control peristalsis and also for its well-known influence upon peritoneal inflammations. The pubic, perineal, and sacral regions should be shaved and dressed with a bichloride dressing several hours before the operation. After the patient has been anæsthetized, the rectum should be injected with about six ounces of a fifteen-volume preparation of hydrogen dioxide. By these means one is usually able to empty the bowel and bring it to the operating table in a fairly sterile condition. There are cases, however, in which the stricture is so tight that the

intestine above it cannot be washed out and emptied. The question then arises as to what it is best to do in these cases. Personally, I prefer incising the growth posteriorly and curetting it sufficiently to allow the fecal material to pass. I have never seen any harm come from this procedure, and, if the parts are curetted and cauterized with an actual cautery, the elements of sepsis are largely obliterated and the patient experiences very little shock.

Many surgeons believe that, in these conditions—in fact, in all contemplated extirpations of the rectum—the establishment of a preliminary artificial anus constitutes the most satisfactory preparation. This procedure, as advocated by Schede, has been practised all over the world. Some make the anus in the sigmoid, others in the transverse colon, and some in the ascending colon. Some make a preliminary artificial anus, and some a permanent one. The method has some advantages, and among them may be mentioned the fact that one is able to examine the liver and the prevertebral lymph nodes and thus determine whether they have been involved by the malignant process. Still another advantage is to be found in the fact that it turns the fecal current aside and prevents infection of the operative field from this source. While these advantages cannot be denied, it must be remembered that the adoption of this course subjects the patient to two operations instead of one, and that, if the opening is made in the sigmoid, this act is very likely to interfere with the bowel being brought down, at the time of the extirpation, sufficiently far to restore the anus to its normal position. On the whole, surgeons are employing less and less this plan of making a preliminary anus. The writer has ceased to use it altogether, except in cases so debilitated that they cannot undergo a major operation. In such cases the patients sometimes improve so much, after a colostomy, that extirpation, which at first seemed impossible, becomes quite feasible. It is only in cases of this nature that we advise preliminary colostomy.

Technique of the Different Methods of Operating.—The methods of operating differ largely in their modes of gaining access to the part to be removed, and as regards the proper mode of treating the ends of the intestine after the tumor has been amputated or resected.

(*a*) The Perineal Method.—Under this heading, it has always been customary to describe the old methods of Lisfranc, Dieffenbach, Velpeau, Allingham, Depage, and Cripps. These methods, however, have all been superseded by the modified Quénu operation, which not only preserves the sphincters, but also the levator ani muscle, and enables one to remove the lymph nodes as effectually as in other operations. The technical details are as follows:

Modified Quénu Operation.—The patient is prepared in the manner described above, and is placed in the extreme lithotomy position on the operating table. A small circle of muco-cutaneous membrane is dissected up around the rectum, and a strong silk ligature is passed around the anal opening in order to prevent the escape of feces and also to remove, from the operator, the temptation to insert his finger into the infected cavity. (Fig. 372.) Some operators introduce sponges or gauze into the rectum in order to facilitate dissection. After the ligature is tied about the anal opening, the rosette-like mass

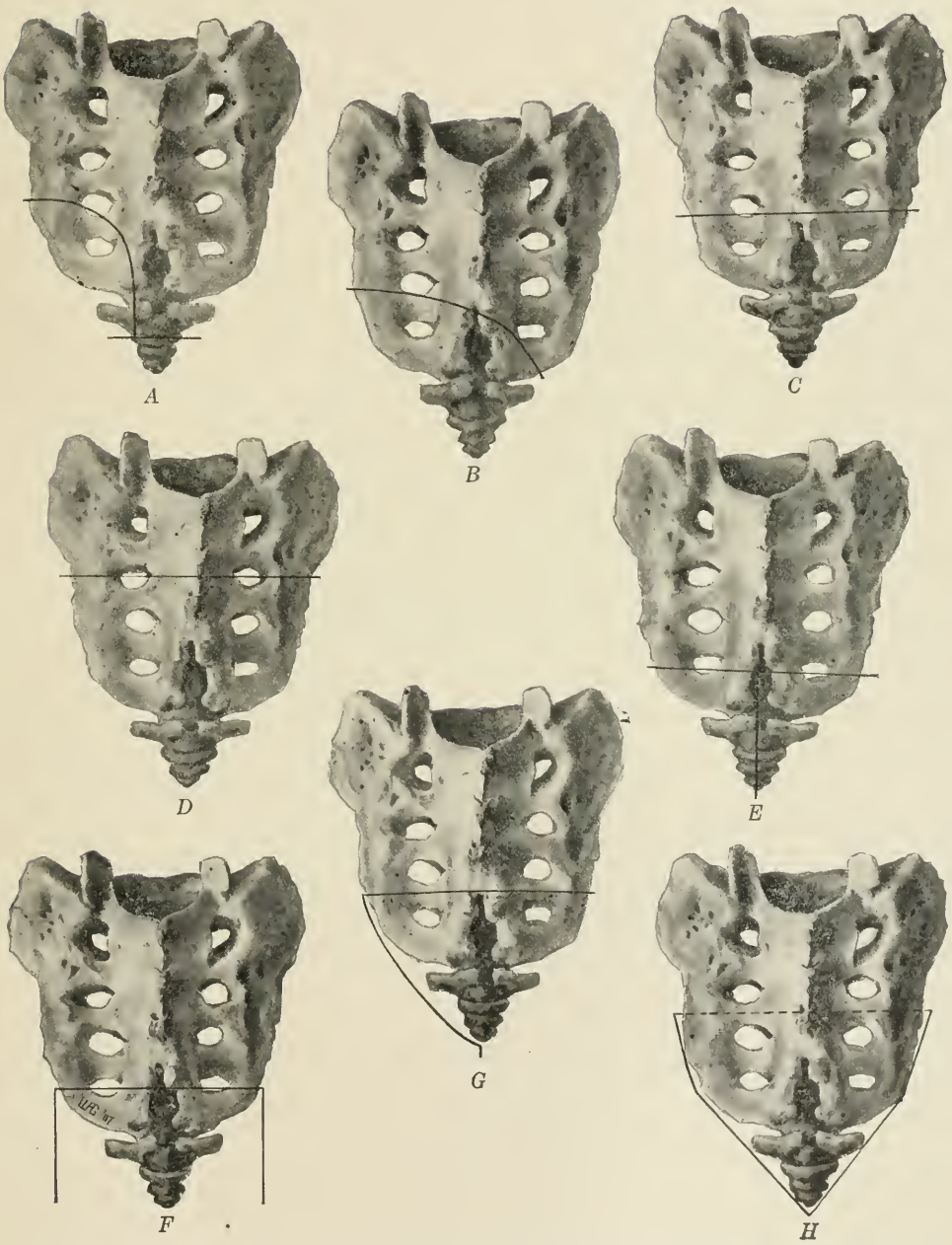


FIG. 372.—Methods of Resecting the Sacrum in Extirpation of the Rectum. *A*, Kraske's; *B*, Hochenegg's; *C*, Bardenheuer's; *D*, Rose's; *E*, von Heinecke's; *F*, Levy's; *G*, Rydygier's; *H*, Hegar's. (Earle and Tuttle.)

which projects beyond the ligature is cauterized with pure carbolic acid or with the actual cautery. The external sphincters are next dissected from their attachment to the rectum and drawn away to the sides by retractors; they are then split anteriorly to the perineal body, and posteriorly to the coccyx. (Fig. 373.) The latter incision is carried well up along the right side of the coccyx into the retrorectal space. The fingers are then carried into this space, and the rectum, with all the cellular tissue, is separated from the anterior surface of the sacrum as high up as the promontory. The mass of cellular tissue is then peeled off on each side of the rectum, from above downward, as far as to the

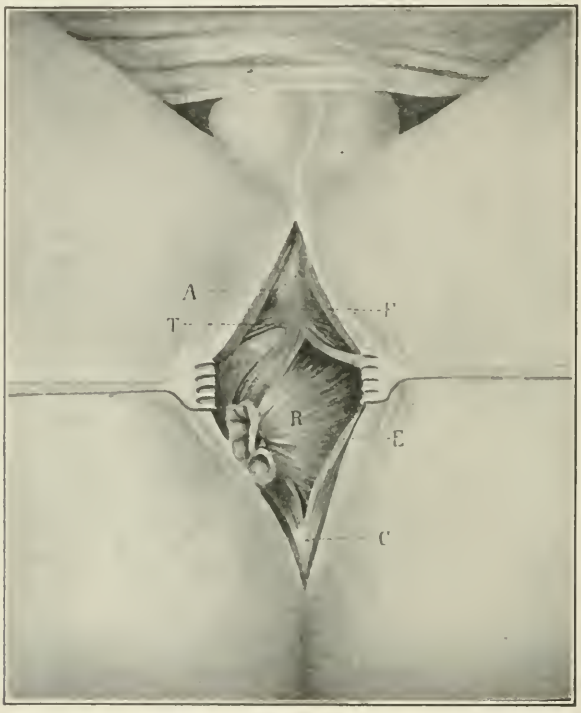


Fig. 373.—Perineal Extirpation of the Rectum. (Quénu-Tuttle Method.) *R*, Rectum; *E*, external sphincter; *C*, coccyx; *T*, transversus perinei muscles; *A*, bulbous urethra. (Tuttle.)

attachment of the levator ani muscle, which is then grasped with forceps, and cut over the finger on both sides of the rectum, thus loosening all the latter's attachments except those which bind it to the perineal body and prostate, or the vagina, in front. These tissues and the ano-bulbar rhaphe having been cut through, the rectum is freed throughout its entire circumference, and the superior pelvi-rectal space is entered. (Fig. 374.) The cellular tissue may be dissected with scissors or torn off with the fingers. Just above it, is found the peritoneal cul-de-sac, which may be stripped up in some cases, but should always be opened if the neoplasm extends above it. (Fig. 375.)

In males, before dissecting the rectum loose from its perineal attachments, one should introduce a urethral sound to serve as a guide and thus prevent

wounding the urethra. The peritoneum having been opened, it should be cut back on either side of the rectum until its attachments to the sacrum have been reached. Before the mesorectal and mesosigmoidal folds of the peritoneum are incised, the cellular tissue between these folds should be loosened from the bone, so that the blood-vessels which it carries may not be wounded in the next step of the operation, which consists in cutting the peritoneal folds that hold the bowel to the bony frame of the pelvis. Too much tension should never be put on the blood-vessels which support the rectum; and if, upon exerting gentle traction, one finds that it is the blood-vessels and not the meso-

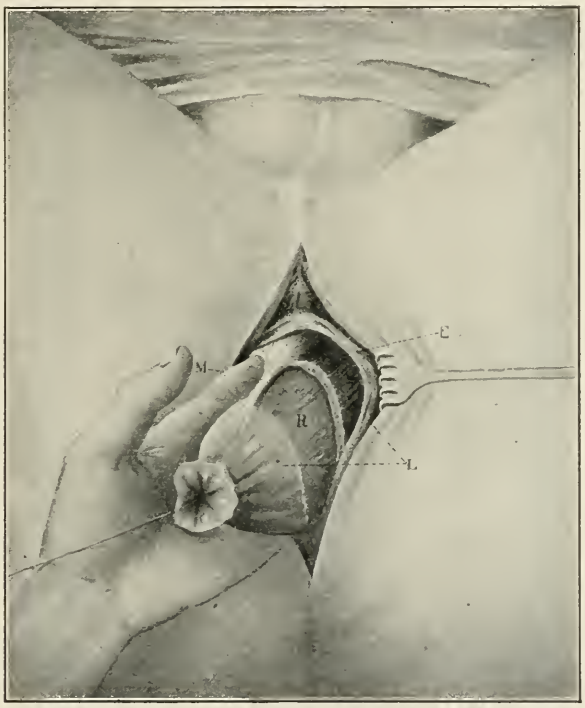


Fig. 374.—Perineal Extirpation—Loosening Rectum from Anterior Perineal Rhaphe. *L*, Levator ani; *R*, rectum; *M*, rhaphe. (Tuttle.)

rectum which prevent the bowel from coming down, he should strip the fat from the vessels and clamp the latter before cutting the folds.

When the bowel has been pulled down sufficiently to bring the tumor well outside the anus, the anterior peritoneal opening should be closed by sutures, the peritoneum being attached around the bowel well above the tumor. (Fig. 375.) The musculature of the perineum should be sewed around the bowel, layer by layer, until the external sphincter is reached. Then this should be accurately adapted around the whole intestine. When this has been done and the retrorectal space has been packed with gauze, the bowel should be amputated just below the sutures attaching the external sphincter to it. This amputation should be made little by little, the mucous membrane being

grasped by forceps and drawn outside of the wound, so as to prevent the escape of fecal matter into the latter. After the bowel has been amputated, one will usually find, in the retrorectal fat, one or two large vessels which will need ligating. One must be very careful at this point to remove all the lymph nodes that can be felt in the mass of fat and cellular tissue behind the rectum. After the bowel has been amputated, the mucous membrane should be sewed accurately to the skin which surrounded the old anal aperture. The perineal wound is closed in front, and also posteriorly, almost to the tip of the coccyx; the incision at the side of the coccyx being left open for drainage. (Fig. 376.)

On several occasions the writer has passed two silkworm-gut sutures through

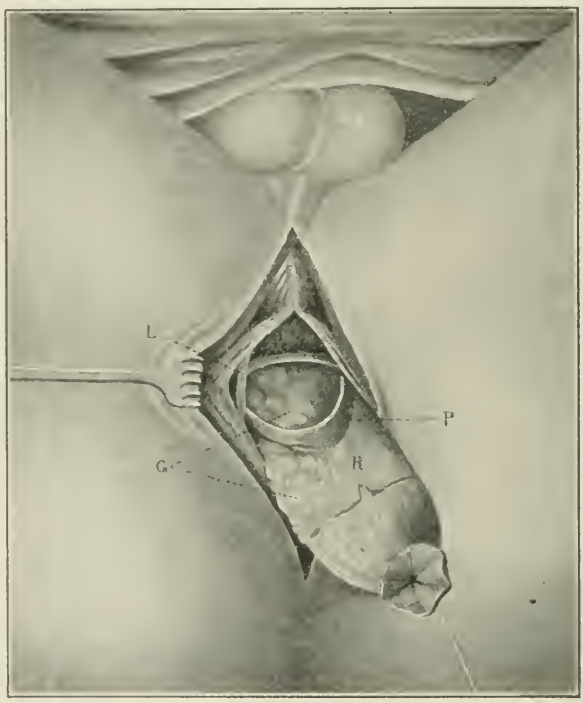


Fig. 375.—Perineal Extirpation. The peritoneal pouch laid open. (Tuttle.)

the mesorectum and muscular wall of the bowel, as high up as possible, and in such a manner as to embrace about one-third of its circumference. The ends of these sutures were then carried out on each side of the sacrum and tied over a piece of sterile gauze. By this means we are able to close up the dead space posterior to the rectum. This ought not to be done where there is much oozing. All the cases in which this procedure has been carried out in the manner described, have done well. It appears, however, that dragging the rectum back in this way sometimes produces too much tension on the anal sutures. Formerly it was supposed that a segment four or five inches in length represented the limit of extirpation by the perineal method. The writer has

removed, by this method, a segment more than fifteen inches in length, and he has cleaned out the sacral cavity as perfectly as he could have done by any other possible means. He is therefore adopting the method more and more in all operations that do not actually demand abdominal section.

(*b*) Kraske's Parasacral Method.—The term parasacral is employed to indicate any method by which access to the rectum is obtained by either permanent or temporary sacrifice of any part of the sacrum or coccyx. They are all modifications of Kraske's method, which was first introduced in 1885. Kocher's method consists in simply removing the coccyx. Kraske removes the coccyx and the left corner of the sacrum. Other operators remove more or less of this bone, as will be seen by referring to the drawings. (Fig. 372,

Fig. 376.—Perineal Extirpation. *P*, Lateral peritoneal folds; *V*, enlargement of lymph nodes between folds of mesorectum. (Tuttle.)

A–H.) Rehn, Rydygier, and Hegar do not remove the bone permanently, but leave it in a skin flap, as will be described. After the bone has been removed and suitable access has been obtained to the rectum posteriorly, these operators all employ the same method of extirpation, and it is unnecessary to go into any detailed description of this part of the operation more than once. Von Heinecke makes a T-shaped incision into the skin, carrying it through the sacrum and coccyx. Levy makes a square flap and throws it downward. The other operators nearly all use a straight incision from the anus backward and up to about the level of the third sacral foramen; they then remove the coccyx and as much of the sacrum as they believe necessary and permissible.

The tendency among surgeons of the present day is less and less toward destruction of the bone; and the writer is operating to-day by the perineal method in cases in which, five years ago, he would have thought it necessary to sacrifice a considerable portion of the bone. He has always believed, however, in the Rehn-Rydygier method, and still holds that the bone-flap method of operating is just as effectual in affording access to the rectum, and, besides, it gives more satisfactory results than do any of the methods which permanently sacrifice some part of the pelvic frame. The technique which he has employed is as follows:

Technique of the Bone-flap Operation.—The patient having been prepared

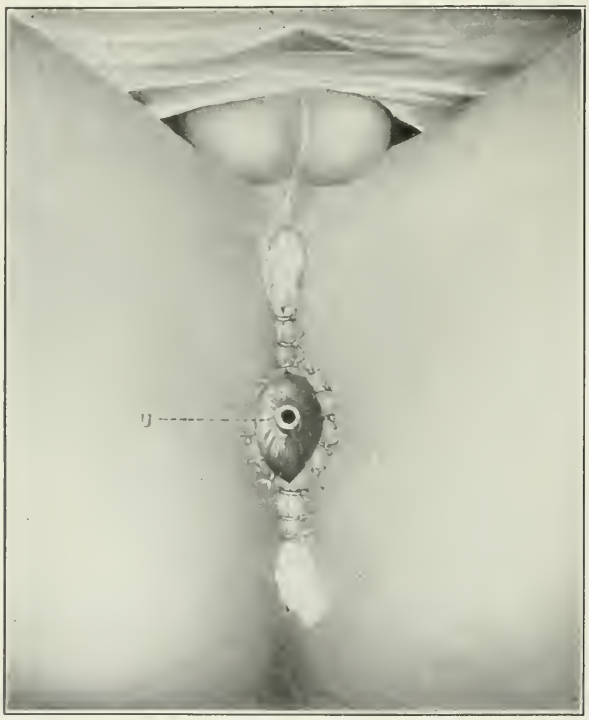


Fig. 377.—Perineal Extirpation Completed. *U*, Tampon drainage-tube in anus.

in the manner already described, the rectum is packed with gauze and the anus is closed by sutures. The patient is placed in the extreme prone position, on his left side, with the thighs flexed upon the body, and the pelvis well elevated on sand-bags. The parts having been thoroughly cleansed, an incision is made from about the level of the third sacral foramen outside of and parallel with the right border of the coccyx, down to a point about half an inch back of the anus. This incision is carried through all the tissues into the cellular mass. The hand is then introduced into the retro-rectal space and is made to separate the tissues from the sacrum. This having been done, the cavity and the wound are packed with gauze. A second incision is then made from the top of the first, across the sacrum, and down to the bone. The latter is then

cut through with a chisel, the gauze packing preventing injury to the soft parts. The flap is pulled down to the left side, where it is held by a heavy retractor. (Fig. 378.) At this point it is usually necessary to tie the middle sacral artery. As this, however, is sometimes very difficult, I have found it easier, in such cases, to crush the vessel against the bone and thus control hemorrhage. The gauze is removed and the blood-vessels which have been cut in the original incision are ligated. The flaps are then pulled to one side, and the cellular tissue is incised until the bowel itself is reached. Then the dissection is continued around its tunica until the peritoneal cul-de-sac is reached, when the latter is promptly opened. (Fig. 379.) With the aid of a large pedicle needle, one can then easily surround the bowel with a large tape and thus control the hemorrhage, if there be any, and at the same time furnish

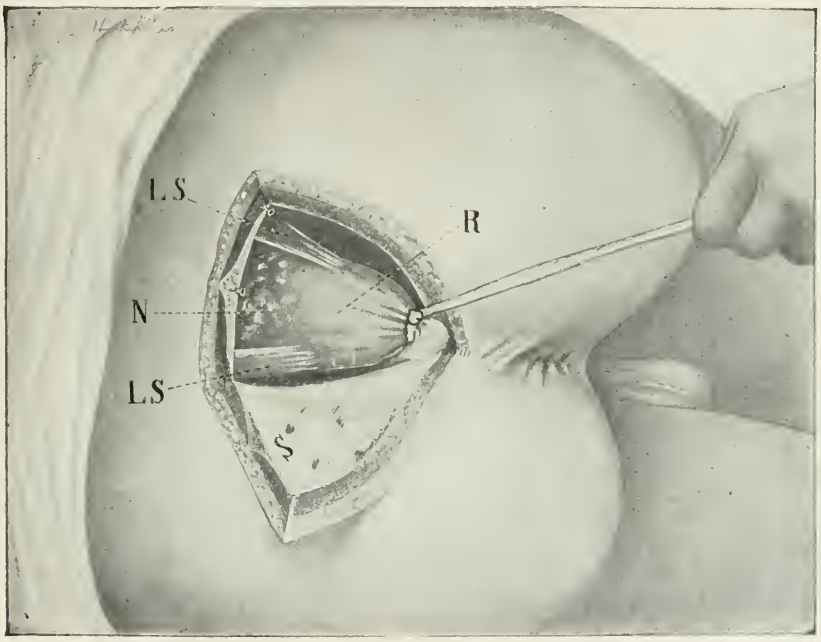


FIG. 378.—Extirpation of Rectum by Bone-flap Method. *R*, Rectum; *S*, sacrum; *LS*, lateral rectal ligaments; *N*, neoplasm. (Tuttle: "Diseases of the Anus, Rectum," etc. D. Appleton & Co., New York.)

a means of traction. (Fig. 378.) Aided by this tape attached to the bowel, the operator should proceed to separate the organ from its attachments above, always freeing the cellular tissue from the bone and lateral peritoneal folds before incising the latter, in order to get the blood-vessels out of danger. Very little hemorrhage occurs during this part of the operation if one does not cut the superior hemorrhoidal or inferior mesenteric arteries, and this will not be done if the precaution above-mentioned is taken.

After these lateral folds have been incised and the bowel has been brought down as far as possible, it may be found that the blood-vessels, in their tensely stretched condition, still hold the bowel, thus rendering it necessary to cut the latter. This should be done between two ligatures or forceps at a point just

below the sigmoidal artery, in order to preserve the anastomotic circulation in the lower end of the rectum. Then, the bowel having been well loosened above the cancerous growth, a tape or strong ligature is thrown about it, and one must then determine, without further delay, whether he will adopt resection or amputation for removal of the growth. As a general statement we would say that it is desirable to avoid sacrificing any part of the intestine which may properly be saved; but, under the circumstances which we are considering, one is not likely ever to remove too much of the organ. The wider the dissection the surer the cure. Hence, whenever it is possible, without subjecting the bowel to too great tension, and when the blood-supply is sufficient,

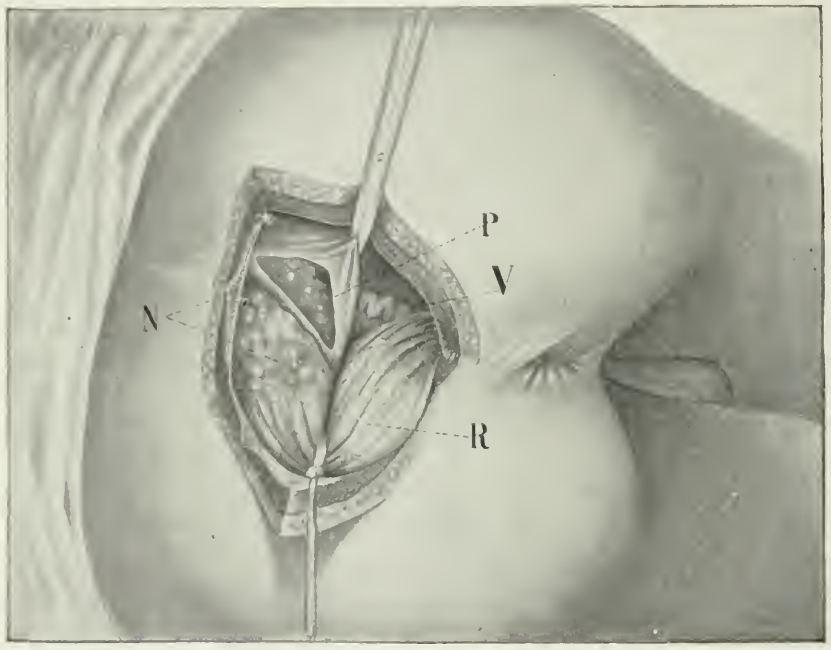


FIG. 379.—Bone-flap Extirpation. *P*, Opening of peritoneum; *V*, seminal vesicles; *N*, neoplasm; *R*, rectum, tied off. (Tuttle: "Diseases of the Anus, Rectum," etc. D. Appleton & Co., New York.)

to amputate and bring the free end of the upper section down to the margin of the anus, it is wise to do so. At this point in the operation the surgeon, having loosened the bowel sufficiently to bring it down to the anus, or to the end of the rectum which is left after a resection has been made, should close the peritoneum by sutures and should then cover the line of sutures with gauze packing. (Fig. 380.)

In cutting off the bowel above the tumor, the surgeon should be careful to do this between two ligatures, and he should then cauterize both ends with pure carbolic acid. After this has been done the lower segment can be dissected out almost without loss of blood. If the upper segment is sufficiently long to be carried down into the anal opening and sutured there, the lower segment may be everted before or after the tumor has been excised, and an end-to-end suture made outside the anus.

Another way of treating the ends, that of Hochenegg, is to dissect the mucous membrane off the lower segment, invaginate the end of the upper segment through this freshened tube, and suture it to the skin. If resection is done when the tumor is removed, the two ends may be united by end-to-end suturing (Fig. 381), by a Murphy button, or, as advised by Kocher, by uniting the ends throughout two-thirds of their circumference and leaving the posterior third open. The writer has seen only four cases in which resection has not been followed by fistula; all these, nevertheless, healed, but he has never been convinced of the wisdom of suturing the bowel half way around. If a complete circular suture is employed there will probably be a fistula, but this

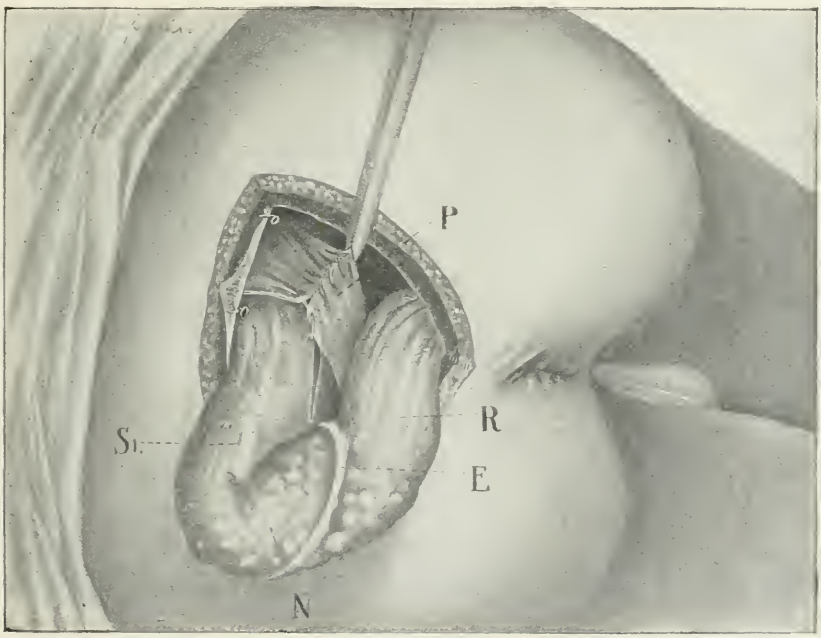


Fig. 380.—Fourth Step in Bone-flap Extirpation of the Rectum. *R*, Rectum; *E*, site of recto-vesical cul-de-sac; *Si*, sigmoid; *P*, peritoneal cavity closed by sutures. (Tuttle: "Diseases of the Rectum, Anus, and Pelvic Colon." D. Appleton & Co., New York.)

will be smaller and will be more likely to heal than if it involves one-half or two-thirds of the circumference of the bowel.

As to the use of the Murphy button in these cases, it is certainly a convenience, but not a more perfect method of securing apposition than is the plan of applying sutures. Furthermore, as in the latter plan, it is followed by the establishment of a fistula.

After the ends of the intestine have been disposed of, it is well to carry a large silk suture through the meso-rectum and to tie it to a fixed portion of the margin of the wound, thus anchoring the bowel as a whole and so preventing too much tension on the ends which have just been united. The sacral cavity is now packed with iodoform gauze, and the bone-flap is carried back into its natural position and fastened by sutures passed through the skin and perios-

teum. Some advocate the practice of not suturing the bone, but we have never found any serious objection to doing so. The skin wound is closed down to the sacro-coccygeal joint, the rest of the wound being left open for drainage. The retro-rectal space is packed with gauze and a drainage tube is inserted as in the perineal operation. (Fig. 382.) Whatever disposition is made of the ends of the intestine, the anus should be stretched before the patient is put to bed, and a large drainage tube should be carried up beyond the line of sutures in the bowel. The patient is placed in bed upon the right side, and the head of the bed is elevated, in order to prevent any concealed hemorrhage from flowing up into the peritoneal cavity. For the first twenty-four hours there is considerable oozing, but after this it is slight. The gauze is removed at the end

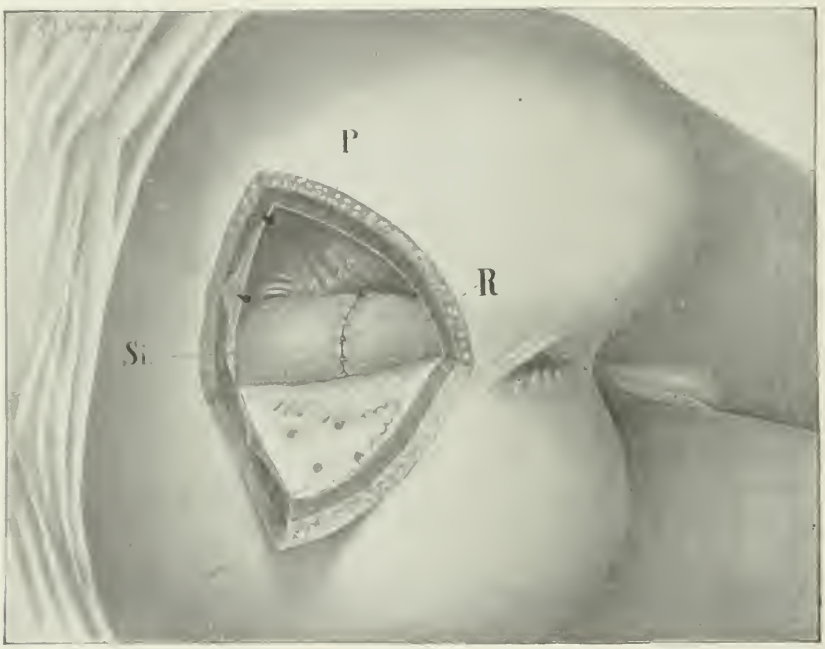


FIG. 381.—Bone-flap Extirpation of Rectum. The drawing shows new-growth resected and the two ends of the bowel united by end-to-end suturing. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

of forty-eight hours, and for it a small drainage tube is substituted. Where it is impossible to bring the bowel down to the anus, or to unite it to the lower segment of the rectum, it will be necessary to make a sacral anus—that is, to unite the proximal end of the intestine to the skin at the corner of the rectangular wound. (Fig. 383.) The main point to be borne in mind is, that one should never attempt to suture a portion of the bowel that has not a good arterial circulation, to either the anus, the rectum, or the sacral wound. In other words, unless the blood flows freely from the proximal end when it is cut, one should continue the dissection higher up until good circulation is found, even though it be necessary to bring the bowel out through the abdominal wound and make an artificial anus. Without an adequate circulation sloughing, gangrene, and death are almost sure to occur.

(*c*) Vaginal Method.—Extirpation of the rectum by way of the vagina has been practised since 1890, when it was introduced by Desguins, and it has proved a most successful operation, so far, at least, as mortality is concerned. Formerly it was employed only in the case of tumors located within the first two or three inches of the rectum; but, more recently, since these tumors have been so easily managed through the perineum, the vaginal operation is applied only to tumors located high up in the rectum and in the sigmoid. Murphy, of Chicago, was the first to give the details of this operation as it is now (with some variation) employed. His method (Figs. 384 to 388) is as follows: The patient is placed in the extreme lithotomy position, with the hips slightly elevated. The vagina is dilated with broad retractors, the cervix is drawn

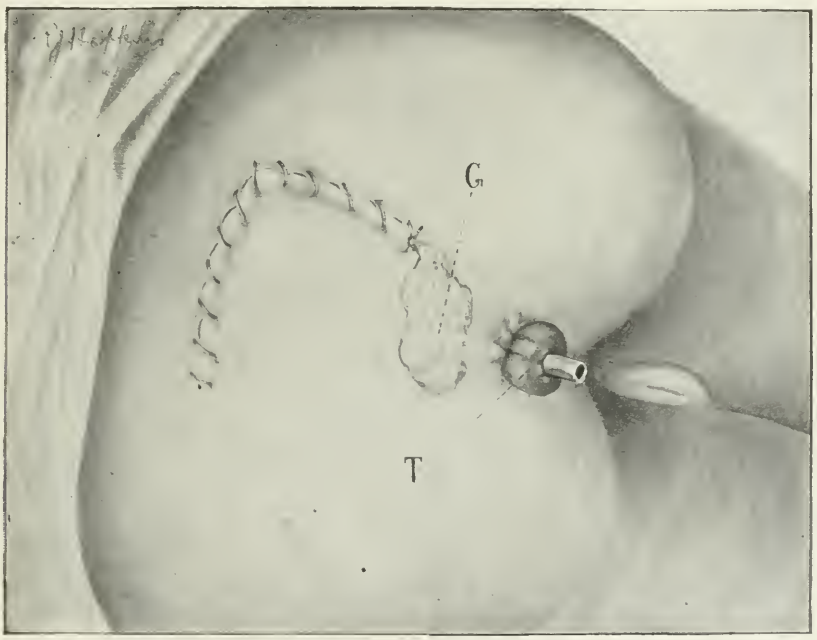


Fig. 382.—Final Step in Bone-flap Operation. *G*, Gauze draining sacral cavity; *T*, Lynch tube in anus. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon," D. Appleton & Co., New York.)

down, and Douglas' cul-de-sac is opened by a transverse incision just below the line of juncture with the cervix uteri. The contents of the cul-de-sac are displaced upward by the introduction of abdominal pads. A vertical incision is next made, in the median line, through the recto-vaginal septum down to the wall of the bowel, and including the external sphincter. (Fig. 384.) The flaps are then dissected, one from each side of the rectum, the peritoneal supports of the rectum being cut as high up as the meso-rectum on both sides. (Fig. 385.) The rectum is thus exposed in its entire length anteriorly and on the sides, which enables one to bring down the sigmoid flexure to its full extent. Murphy then divides the anterior rectal wall up as far as the lower border of the tumor, and cuts the bowel off one inch below the lower limit of the growth. (Fig. 386.) The proximal end of the bowel is then grasped with intestinal forceps, its

aperture being thus closed, and dissected out from the hollow of the sacrum as high up as the promontory or further, if the removal of the entire growth, together with any lymph nodes that may be involved, necessitates such a step. The same precautions as have been described in the previous paragraphs are observed with regard to tearing off or wounding of the superior hemorrhoidal or inferior mesenteric arteries. When the bowel has been sufficiently loosened to bring it down without tension it is amputated about one inch above the tumor and sutured to the distal end by sutures passed from within outward, so that the knots can be tied inside the bowel. (Fig. 387.) The slit in the anterior wall of the bowel is closed in a like manner. After this, the laparotomy pads are removed; the peritoneum is closed by catgut sutures; and the vaginal

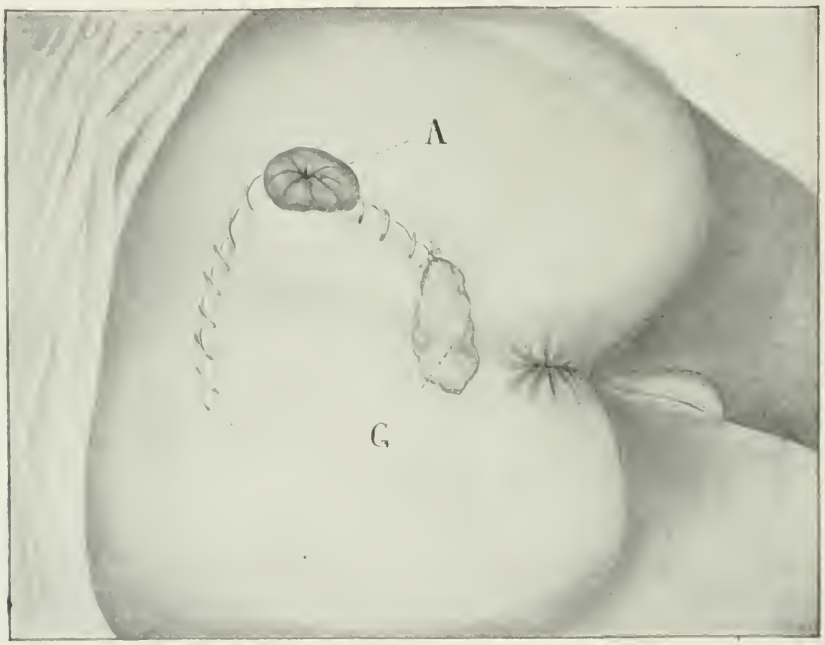


Fig. 383.—Sacral Anus, After Bone-flap Extirpation. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

wall, together with the peritoneum and external sphincters, is reunited. For this part of the operation Murphy uses silkworm-gut sutures. (Fig. 388.) A drainage tube is passed through the anus, above the point of anastomosis, and sutured in position.

Owing to the fact that a large space is left behind the bowel after the removal of the cellular tissue, fat, and lymph nodes in the hollow of the sacrum, the writer modifies Dr. Murphy's technique in the following manner: A circular incision is made behind the anus and is carried through all the tissues into the retro-rectal space. The rectum and the cellular tissues in this space are separated from the sacrum, as high up as the growth extends, by the finger or by a dull instrument. The rectum is then separated from its attachments, on both sides, by the fingers, down to the superior surface of the levator ani

muscles. This wound is packed with sterile gauze, to control hemorrhage, and the operation is then conducted, from this point onward, according to Murphy's technique, except that the bowel is not opened until it has been freed from its attachments and brought down as far as necessary, and the peritoneal cavity closed by suture. The postanal wound is left open for drainage, and through it a drainage tube filled with gauze or a cigarette drain is introduced to complete the operation.

(*d*) The Abdominal Method.—The abdominal method is applied to tumors

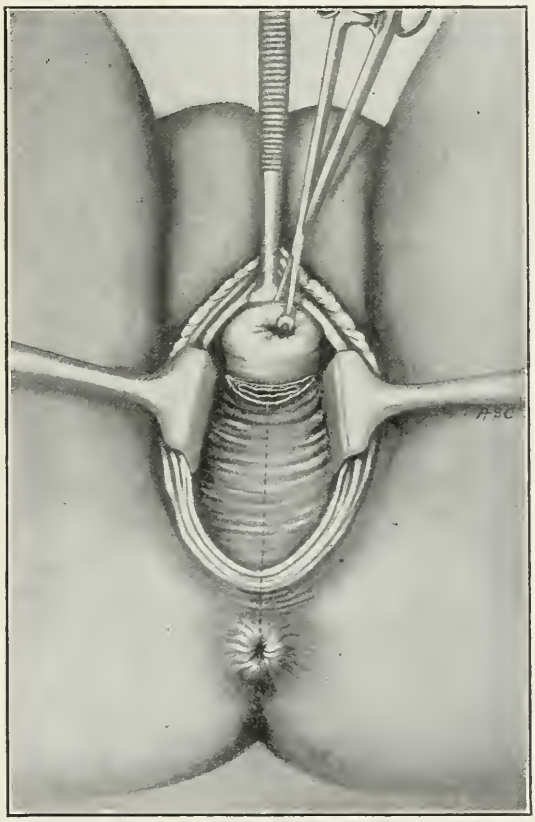


Fig. 384.—Incision in Vaginal Extirpation. (Murphy.)

which involve the upper rectum and sigmoid or the sigmoid alone. Where the growth is confined to the movable loop of the sigmoid and can be drawn outside of the abdomen, the operation resolves itself into a simple intestinal resection, with end-to-end or lateral anastomosis—an operation which has already been described on a preceding page (page 917) and therefore need not be detailed here. Owing to the dangers of anastomosis in the sigmoid one of us suggested some years ago that this operation might be done in three steps where the growth could be brought well outside the abdominal cavity, *i.e.*, pull the growth and all of the sigmoid that will come without too great tension out of the wound; fix the two legs together after the manner of Bodine; suture the

bowel to the peritoneum and skin and leave it for two or three days, then excise it thus forming an artificial anus, which can be closed according to the methods hereinafter described (Tuttle, *op. cit.*). The method has been employed a number of times and most successfully. Where the tumor is situated low down in the sigmoid, or involves the recto-sigmoidal juncture, complete abdominal resection is rather difficult. Mann, of Buffalo, claims that the procedure is feasible with the use of the Murphy button and he reports three cases which were treated by this method (with one death). My own experience, as well as that

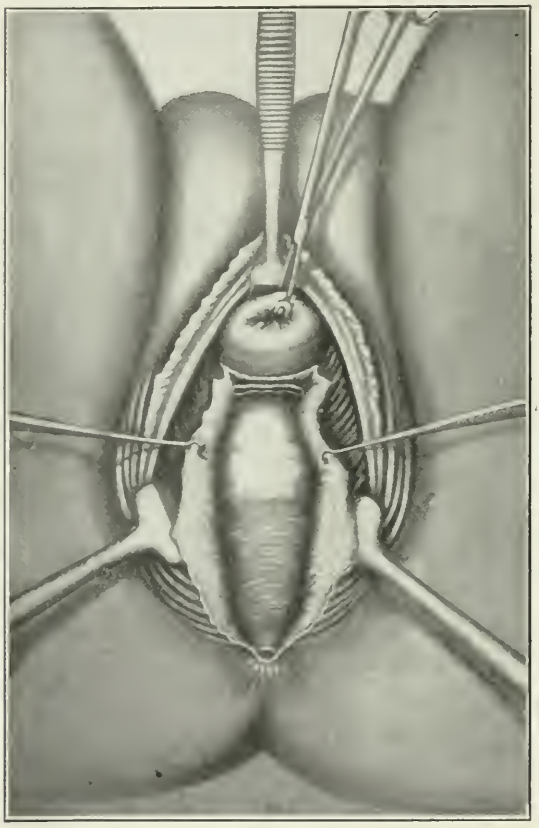


Fig. 385.—Separation of Rectum from Vaginal Walls. (Murphy.)

of Drs. Murphy, Marcy, and others, who have used the button for uniting the divided ends of the bowel where one or both of them are only partially covered with peritoneum, has been most unsatisfactory. Invariably there has been leakage, and this is almost sure to prove fatal where there is no dependent drainage. End-to-end suturing deep down in the pelvic cavity is also difficult and dangerous. We believe, therefore, that the abdominal operation should be reserved for those cases in which the bowel, on both sides of the neoplasm, is completely covered with peritoneum, or where it is advisable, on account of the condition of the patient, to make a permanent artificial anus.

Colorectostomy.—Where the tumor is confined to the lower loop of the

sigmoid, or even where it involves the recto-sigmoidal juncture, one may sometimes employ the method devised by Kelly, in 1895, and denominated colorectostomy. The technique is as follows: The abdomen having been opened, the patient is placed in the Trendelenburg posture, and all the movable contents of the pelvis are packed up in the abdominal cavity by means of gauze pads. The tumor is then loosened from its mesenteric attachments and drawn out of the abdominal cavity; the bowel is incised transversely (between two ligatures) one inch or more above the tumor; the two cut ends are cauterized

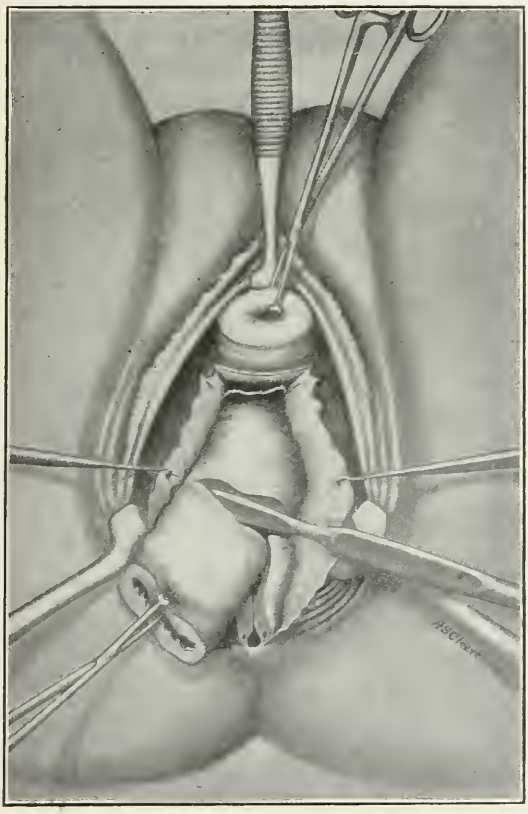


Fig. 386.—Resection of Involved Area in Vaginal Extirpation of the Rectum. (Murphy.)

with pure carbolic acid; the lower end is inverted and sutured with Lembert sutures and the upper end is wrapped in gauze after having been clamped with intestinal forceps and drawn out of the abdomen. The tumor is then excised, the bowel being cut across one inch or more below the growth. Before the bowel is divided the pelvis is well packed with sterile gauze. The upper end of the rectum thus left open is cauterized and inverted by means of a purse-string suture which passes through the peritoneum and muscular wall. Four long heavy silk ligatures are then passed through the walls of the cut end of the sigmoid, at equidistant points, and are firmly twisted together so as to form a rope; this step practically closing the aperture. A longitudinal incision,

about one inch in length, is then made in the anterior wall of the rectum; a long forceps is carried through the anus and brought out through this incision; by means of its blades the long sutures attached to the sigmoid are grasped and this organ is dragged down into the rectum, thus invaginating the edges of the wound which are covered with peritoneum and making a wide apposition between this and the peritoneal covering of the sigmoid. (Fig. 389.) The twisted sutures are caught by a pair of forceps, or wrapped around a small roll of bandage and rotated until they hold the sigmoid well in place. The clamp or the ligature on the sigmoid is now removed, and one may add a few Lem-

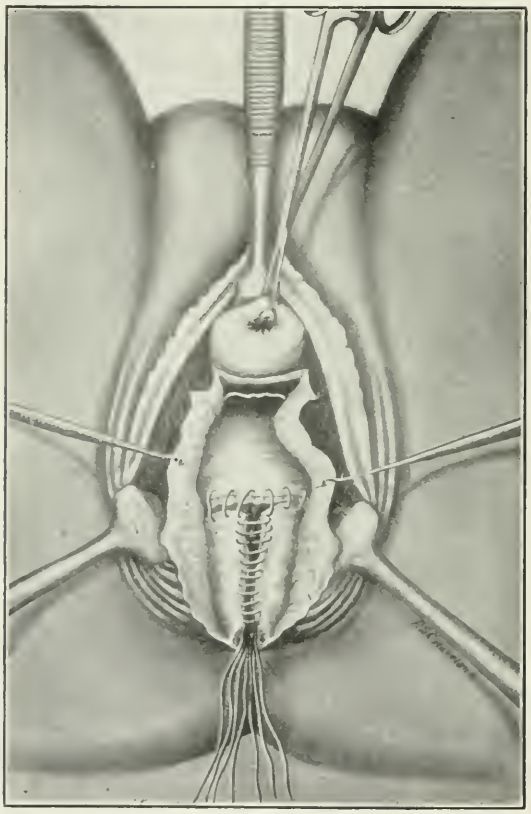


Fig. 387.—Restoration of Bowel in Vaginal Extirpation of the Rectum. (Murphy.)

bert sutures at the junction, in order more firmly to secure the colon in position. This having been accomplished, the raw surfaces in the peritoneal cavity are covered as well as possible, and the abdomen is closed. The writer has done this operation four times successfully. In one case there was a stricture at the point of exit of the colon into the rectum; this was overcome by passing a long pair of pressure forceps through the anus, with one prong in the rectal cul-de-sac and one in the sigmoid, thus cutting through the septum by pressure. (Fig. 342.) The results were all that could be desired.

(c) Combined Operation.—When the tumor is situated in the highest por-

tion of the rectum and the lower sigmoid, it is often advantageous to loosen it from its attachments through the abdominal route, and then to remove it by the anal, the perineal, or the sacral method. These procedures are termed abdomino-anal, abdomino-perineal, and abdomino-sacral extirpations. Maunsell, of Australia, was the first to advocate this method (the abdomino-anal method). He loosened the tumor from its attachments through the abdominal wound, then passed a long tape on each side of the mass, through its walls into the rectum, and then through the anus. By dragging on this tape he was able to bring the tumor outside the anus and to excise it little by little.

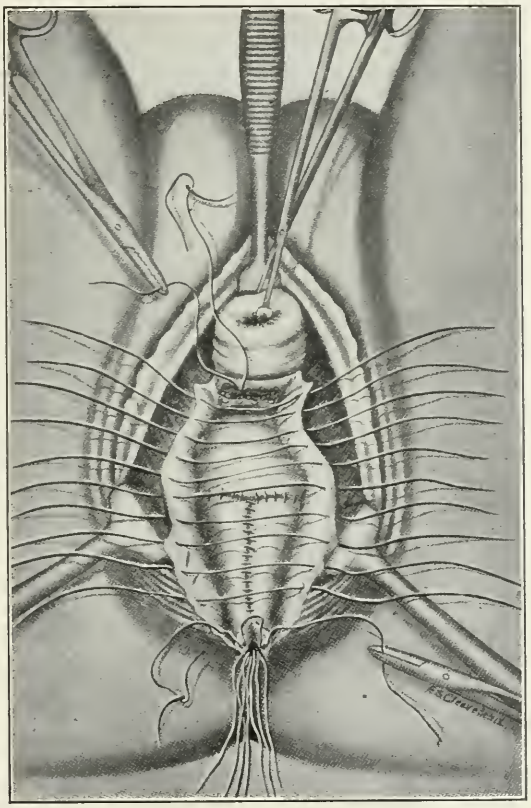


Fig. 388.—Closure of Peritoneum and Vaginal Wound after Vaginal Extirpation of the Rectum. (Murphy.)

Afterward, he effected an end-to-end union by means of sutures. He suggested that, if the tumor were very large, it would be necessary to split the anus backward, in order to allow the tumor to be drawn out. After resection has been accomplished and the parts have been sutured, the everted end of the bowel is restored to its position, the peritoneum is sutured from above, and the abdominal wound is closed.

Weir (*Journal of the American Medical Association*, 1901) has modified this operation by first removing the tumor through the abdominal wound, then everting the remaining portion of the rectum and dragging the sigmoid down

through this everted part, and finally fixing it there by needles thrust through the four walls at right angles to each other. The edges of the bowel are trimmed off even and sutured, the needles are removed, a drainage tube is inserted into the bowel, and the everted rectum is replaced in position. In this operation it is important to observe carefully the condition of the circulation in the proximal end of the bowel before one applies the sutures. Unless there are spurting arteries when the bowel is divided, one had better cut it off higher up, and even to repeat the operation until such are found; or, if spurting arte-

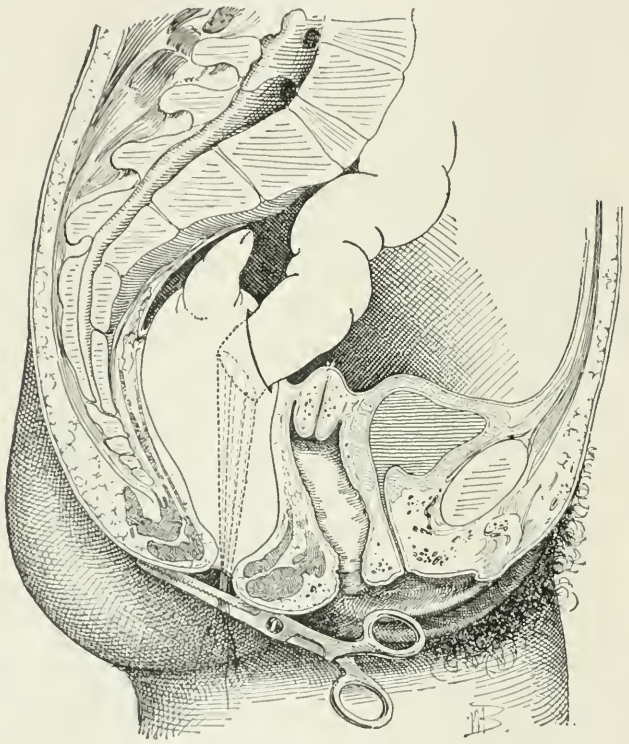


Fig. 389.—Colorectostomy, after Kelly's method.

ries cannot be found, it will be better to bring the bowel out through the abdominal wall and make an artificial anus.

The combination of the abdominal with the perineal and sacral methods (abdomino-perineal and abdomino-sacral methods) has been employed since 1884, when Czerny did it in order to extricate himself from certain difficulties in a sacral operation. Priority, in this operation, is attributed variously to Gaudier, Chaput, and Challot. Some operators loosen the bowel and the tumor as far as possible from below, and then remove them through an abdominal incision; some loosen the parts as far down as possible, through the abdominal incision, then close the abdominal wound and extirpate the bowel from below; some attempt to bring the bowel down and unite it to the anal orifice, or to the segment of the rectum which remains after resection has been

accomplished; others still (Quénu, Boeckel, Keen) prefer to make a permanent artificial anus in the left inguinal region. The writer has done the combined operation eight times. In three of these cases he employed the abdomino-sacral method, and in five others the abdomino-perineal. In the three cases in which he employed the abdomino-sacral method there was one death, and in the five in which the employed the abdomino-perineal method there were two deaths—a mortality of 37.5 per cent. In the last five cases operated upon there has not been a single death. The technique which he employs is as follows:

The abdomen is opened by a long abdominal incision, just outside of or through the left rectus muscle; the sigmoid is dragged out of the abdomen and cut across, at a point one inch above the tumor, with an electric angeiotribe, which seals up, and at the same time disinfects, both ends of the bowel. The lower segment is invaginated and secured by a purse-string suture. It is not necessary to do this to the upper end, as it need not be manipulated to any extent. The lower segment is then loosened from its mesenteric attachments, great care being taken, as the dissection advances, not to wound the internal iliac veins. The peritoneum is incised in front and at the sides, the rectum is separated from the bladder down to the prostate, and the lymph nodes in the hollow of the sacrum are removed by blunt dissection with the fingers. When the dissection has been carried downward as far as possible a ligature—if the growth is large—is carried around the bowel below the tumor, the pelvis is packed with gauze, and the tumor is removed through the opening in the abdominal wall. If the tumor, however, is not very large, the part to be resected may be crowded down into the pelvis, the abdominal wound temporarily closed, the patient put in the lithotomy position, and the tumor removed together with the necessary amount of bowel, either by the perineal method, as heretofore described, or through an incision extending along the side of the coccyx and sacrum. If a sufficient amount of the sigmoid is left above, it should be brought down and an end-to-end union effected; or it should be invaginated into the anus; but, if there is not a sufficient amount, the perineal wound is left open, the floor of the peritoneum is closed on the abdominal side, and the proximal end of the sigmoid is utilized to make an artificial anus, according to the writer's modified Bailey method. In our last five cases, all of which have recovered, we have made an artificial anus only once; in the other four cases we have been able to re-establish the fecal exit at its normal site. Theoretically, this is the most perfect operation for carcinoma of the rectum, and it has been recommended as the ideal operation by Mayo and others. Nevertheless, its high mortality has caused the majority of operators to abandon it. It is possible, however, that, with improved technique and greater skill, it will once more come into favor, for it possesses the great advantage that it enables the operator to determine accurately the intra-abdominal condition of affairs—the degree of involvement of the lymph nodes, and whether or no the liver and other organs are affected—before he undertakes the actual extirpation.

Local Excision.—There are a certain number of isolated growths of limited size, which occur on the side or in the posterior wall of the rectum, and which may be locally excised without extirpating the rectum. In not a few of the cases of this character the operation has proved successful and there has been no recurrence of the growth. Such excisions may be made through the coccygeal or the parasacral incision. The rectum is approached, as has been described, through the removal of the coccyx or by the employment of the modified Kraske method. The bowel is opened, the tumor is locally excised, the edges of the wound in the intestine are drawn together layer by layer, and the posterior wound is closed with the exception of a small aperture left for drainage. A wide margin of healthy tissue should always be taken away with the growth.

Further Remarks upon the Treatment of Malignant Tumors of the Rectum.—In the matter of treatment no distinction is made between carcinoma and sarcoma; radical extirpation being the rule in each case, whenever possible. The *x*-ray and the serum treatment offer somewhat better prospects of success in sarcoma than in carcinoma, but neither of them should ever be substituted for a radical operation, if the circumstances are such as to render the latter practicable. After the operation has been done, however, Coley's and the *x*-ray methods may both be used to advantage, as preventives against recurrence.

After one has reviewed the various methods which are employed at present for the extirpation of a malignant tumor of the rectum, it will be natural to ask, Which is the best? The only answer to this question is, The choice of a method depends upon the site of the tumor and upon the condition of the patient. The more I practise the perineal operation, the wider is the field to which I am inclined to apply it. At the present time, therefore, I would advise that, whenever a rectal tumor cannot be removed by the perineal method, it should be treated by either the abdominal or the combined method. If the surgeon has a large hand, he will not find the perineal method so easy as the parasacral, owing to the fact that the space in the pelvic outlet, especially in men, is rather narrow for work. Women bear abdominal manipulation much better than men, and consequently we do not hesitate so much about doing a combined operation in them as we do in men. At the same time, if in either sex the limits of the growth cannot be made out through the anus, the abdominal or the combined operation ought to be advised. Finally, amputation, with the restoration of the normal fecal outlet, is the method of choice whenever the operation is feasible. Resection should be done only when the growth is located more than three inches above the anal margin.

When the tumor is of the cauliflower-like type, filling up the rectum and obstructing the passage, much relief may be given by curettage and cauterization. The only danger attending this procedure is that of perforating the bowel on its peritoneal surface; the danger from hemorrhage is slight. In scraping, however, one must be careful lest an accident should occur. The

tumor may be scooped out with impunity in the posterior quadrant of the intestine. After the parts have been curetted, they may be cauterized with the electro-cautery, after the manner of O'Beirn in carcinoma of the cervix. The writer has employed this method a number of times, and, while it does not effect a cure, it gives great relief for a time by checking hemorrhage, reducing discharge, and furnishing an intestinal calibre sufficient to admit of free fecal passages.

There are a number of cases in which the passage of fecal material causes so much pain and bleeding that it is necessary to turn the fecal current aside, in order to relieve the distress of the patient. In this class of cases we may employ either inguinal colostomy or entero-anastomosis. The former operation, if properly done, is by no means the disgusting and intolerable condition described by many writers who have had little experience with it. The artificial anus can be so formed that the patient practically controls the new fecal outlet; and, in the later stages of carcinoma, it is an invaluable aid to local treatment. In those cases, however, in which there is considerable healthy bowel below the tumor, one may employ entero-anastomosis, either lateral or end-to-side, thus short-circuiting the fecal current and maintaining its normal outlet. To a very sensitive individual this operation is much more satisfactory than colostomy, and, although somewhat more difficult to perform, is very little more dangerous.

Palliative Treatment.—Notwithstanding the boldness of modern surgery and the improved skill in diagnosis, there are numerous patients affected with malignant disease of the rectum to whom we can hold out no hope of a radical cure. In these cases one must be prepared to institute such palliative treatment as will preserve life the longest and bring the greatest comfort to these miserable sufferers. The methods to be employed may be enumerated as dietary, medicinal, and local.

Dietary Treatment.—So far as control of the tumor is concerned, we have never been able to note any particular effect from special lines of diet. Recently it has been held that meat increases the tendency to cancer. It is our own impression, however, that, so long as the digestive functions remain good and the food is assimilated, it makes little difference what articles of diet are used. It is only a question of maintaining strength and resistance to infection in a general way. One would advise refraining from articles which contain much fibrous material, inasmuch as this would irritate the growth. Milk, fats, light meats, and well-cooked starches would seem to be the rational diet.

Treatment by Drugs.—No drug, so far as we are aware, has any influence in curing cancer. We have seen several cases, however, in which thyroid extract, combined with quinine, seemed to retard the growth. Whether it had any influence on the growth, or whether its beneficial influence was through the maintenance of normal metabolism, we cannot say: but it appears to be worth trying in inoperable cases. Whatever remedies aid in maintaining good physical condition and good digestion are the ones to be used. Opium is, after all, our sheet anchor in this stage of the disease, but it should not be administered

by the mouth, on account of its constipating effects and its disturbing influence upon digestion. For the relief of pain, morphine should be used sparingly at first, but with all freedom—to relieve pain, mental anxiety, and hopeless despair—after the patient reaches the bedridden stage. Other analgesics are depressing if used in quantities sufficient to be effectual.

Local Treatment.—Local treatment of inoperable cancer of the rectum consists in keeping the parts clean, in warding off sepsis, and in preventing intestinal obstruction. The first of these objects is accomplished by irrigations of boric acid, hydrogen dioxide, and potassium permanganate. When the parts are not too sensitive, a ten-per-cent preparation of hydrogen dioxide will do more to disinfect and sterilize the rectum than anything else of which I have any knowledge; but some patients are so sensitive to applications of this remedy that it is necessary to employ in its place boric or carbolic acid, or potassium permanganate, in mild solutions. These remedies should be introduced through a soft-rubber tube, with the patient in the knee-chest posture. No hard irrigators or long tubes should be used in rectums that are affected with cancer, lest perforation should occur. When there is exuberance of the growth, portions of it protruding into and obstructing the rectum, one may often widen the calibre, check the hemorrhage, and relieve the pain, by curetting the tumor and cauterizing its base with the electro-cautery. In doing this, however, the surgeon must exercise great care, so as to avoid either burning or curetting so deeply as to penetrate the peritoneal cavity and thus set up a fatal peritonitis.

The most important of the palliative remedies is the operation for colostomy. This operation is properly described under its special heading, in a later section. In all cases of malignant growth that are inoperable, this operation should be done sooner or later, nor should it be delayed too long. Whenever the patient becomes very much annoyed by frequent stools, tenesmus, and bearing-down pain, colostomy will be found to afford very decided relief, and will prevent all risk of a complete obstruction, which, in these cases, frequently comes on so insidiously that rupture or serious results from over-distention take place before the patient is referred to the surgeon for operation.

XV. SIGMOIDITIS, PERISIGMOIDITIS, AND DIVERTICULITIS.

The term sigmoiditis, first employed by Mayor, would indicate an inflammation of the sigmoid, or pelvic colon, of any kind. In proctologic literature, however, it is not usually employed in connection with specific diseases, such as syphilis, tuberculosis, typhoid fever, dysentery, etc., but is confined to the subject of simple inflammation involving the sigmoid. The first complete description of this affection was given by Mathews, of Louisville ("Diseases of the Rectum, Anus, and Sigmoid Flexure," 1892). The disease, however, had been known to some extent by proctologists for a long time, and Trastour, in an article upon "Passive Dilatation of the Sigmoid," had described it most accurately. Since Mathews wrote about the disease a number of articles on the sub-

ject have been published, and among them two very detailed theses by Catz and Patel.*

Elaborate classifications have been made by these writers, and most interesting cases have been reported to support the same. These divisions are too numerous, however, and are likely to confuse the ordinary reader. We have, therefore, adopted the following simple and brief classification:

Sigmoiditis	Catarrhal. Ulcerative. Interstitial.
Perisigmoiditis	Primary. Associated with Diverticula. Secondary.

Catarrhal Sigmoiditis.—Catarrhal sigmoiditis is frequently a part of a general enteritis or proctitis, and yet it is more often than otherwise the beginning point of such an inflammation. It occurs in both an acute and a chronic form. It attacks the sigmoid more frequently than any other part of the lower bowel because the fecal matter is more frequently arrested here, and it remains in this part longer than in any other portion of the canal.

Acute Catarrhal Sigmoiditis.—The acute disease usually follows a period of constipation or dissipation in diet. The symptoms are: some loss of appetite, flatulence, and at first a flatness on percussion over the left iliac region, together with a certain amount of pain at this point; then the pain becomes more severe and is of a griping character, and there is a frequent desire to go to stool; the passages consist at first of hard or lumpy fecal matter, but they soon assume a watery character, and eventually contain mucus, with or without blood; usually there is some elevation of temperature, and the pulse beats at a more rapid rate than normal. The inflammation subsides after a restricted diet and the administration of saline laxatives, and leaves no sequelæ of importance.

These attacks are usually of so short duration, and they are so easily managed by the general practitioner, that they rarely come under the observation of the specialist. The writer, however, has seen one case in which he was able to make a proctological examination during the acute stage. The examination was made on October 10th, 1906, twenty-four hours after the attack began. The record reads: "Temperature, 99.2° F.; pulse, 80; tongue rough; tenderness over the left iliac and the suprapubic regions; percussion gives a slightly tympanitic sound; anus is tender to the touch, but not abraded; the rectum is normal, except for the presence of a little glairy mucus at its lower segment; the mucous membrane of the sigmoid flexure and of the region where it joins the rectum shows increased redness, while that higher up is fiery red and covered, in places, with a grayish, sprue-like deposit in a bed of mucus. Although certain parts are redder than others and swollen, the rugæ being obliterated, I am unable to make out any ulcerations. An examination of the stool shows

*Catz: Gazette des Hôpitaux, No. 10, 1907, Paris.—Patel: Revue de chirurgie, Oct. and Dec., 1907, Paris.

no amœbæ or bacilli dysenteriæ." Under local applications and saline laxatives and regulated diet the symptoms disappeared in about four days, and the mucous membrane assumed its normal appearance. Tenderness over the left iliac fossa persisted for a week or more.

The attacks may be much more severe than that described above would indicate. For example, the patient is sometimes seized with a severe pain. In my experience this is more often a dull aching sensation, which extends through to the back, than the acute agony of which Catz and Lejars speak. The tongue becomes coated and red upon the tip and edges; the complexion is muddy; the temperature is elevated and the pulse is very rapid; the patient is stupid, or mentally heavy; he finds the erect posture very uncomfortable; and palpation shows a state of tension of the left rectus muscle, and the presence of a mass or tumor in the left iliac fossa, with more or less tenderness on deep pressure. Digital examination of the rectum itself reveals nothing, beyond the fact that the organ is generally ballooned. Above and in front, one can usually feel, through the rectal wall, a bosselated mass which gives one the impression of a neoplasm in the pelvis. The proctoscope, in such cases, usually demonstrates the existence of an angulation of the sigmoid, above which point there has been arrested a mass of hard, lumpy, fecal matter. Such cases have been operated on for tumor of the uterus or its adnexa, and it was on this account that Segond warned the French surgeons not to be too hasty in applying the bistoury to swellings in the left inguinal fossa.

The cause of sigmoiditis, in these cases, is the arrest of putrid, infectious fecal matter in the sigmoid, and its absorption through some traumatism or abrasion of the mucous membrane at this point. These patients may even have diarrhœa, notwithstanding the fact that the mass remains lodged in the sigmoid flexure; the current, under these circumstances, passes around or through the centre of the mass. The only way in which the condition may be accurately diagnosed is by means of a local examination with the pneumatic proctoscope. One can readily understand how such conditions as these may lead to ulceration of the sigmoid, and also how, by recurring from time to time, they may cause a chronic catarrhal condition, with plastic exudation and thickening of the wall of the bowel which will lead to a diminution of its calibre and to organic stricture.

Treatment.—The treatment of acute types of sigmoiditis consists in cleaning out the bowel by irrigations until the sigmoid is empty, and in administering afterward saline laxatives. The food should be limited as to quantity and should be restricted to white meats, rice, eggs, broths, milk in limited quantities, oil, toasted bread, coffee, and tea. Ice bags should be applied over the left inguinal region. Hydrogen dioxide, as mentioned by Cook and others, is the best solvent of the fecal mass. After the latter has been removed, the bowels should be irrigated with a mild antiseptic and astringent solution.

Chronic Catarrhal Sigmoiditis.—Chronic catarrhal sigmoiditis may result from acute sigmoiditis, or it may be part of a general catarrhal enteritis or proctitis, coming on in an insidious manner and without a well-defined history.

Patients suffering from this affection may have more or less regular movements of the bowel, but the stools are hard and lumpy, and surrounded by mucus. If the rectum and sigmoid are examined after stool, one will find these hard lumps arrested in the saccules or flexures of the sigmoid. In some cases a channel is bored through the centre of a hard fecal mass, and through this the liquid feces pass while the main mass remains adherent to the intestinal wall.

In these cases there is more or less dulness on percussion in the iliac region; the left rectus muscle is tense; there are flatulence and loss of appetite; the complexion is muddy, sometimes of a jaundiced hue; and often there is a periodical discharge of mucus, resembling the discharge observed in a crisis of mucous colitis. Trastour, who has well described the mental condition accompanying this disorder, believes that the disease is one of the chief causes of melancholia. In two of the writer's cases, in which there was acute mania associated with delusions, the mental disorder subsided in a few days, and the patients entirely recovered, after the removal of an impacted mass of feces from the sigmoid. A local examination made in these cases shows the following conditions: a pale mucous membrane throughout the rectum and sigmoid; both organs dilated or sacculated; the sigmoid is either blocked by one large fecal mass, or at least it contains, in its saccules, a number of lumps coated with mucus; there are usually small ulcers or abrasions, due to the pressure of the hard fecal masses; and the walls of the bowel are coated with thick mucus, which, after it has been allowed to remain undisturbed for a little while, is discharged in masses, often spoken of as membranes. While this form of mucous colitis may be brought about by many other causes, it is a fact that they all act through the production of fecal stasis, irritation or traumatism of the mucous membrane, infection and toxæmia. The arrest of the feces does not always occur in the sigmoid, but it takes place more often in that part of the bowel than elsewhere.

Treatment.—The treatment of chronic catarrhal sigmoiditis resolves itself into the removal of the cause of the fecal stasis, and the adoption of those measures (already enumerated on pages 788 *et seq.*) which are calculated to allay the catarrhal affection.

Interstitial Sigmoiditis.—From the foregoing paragraphs one might assume that fecal matters alone compose the tumors or swellings which are felt in these cases. These swellings, however, do not entirely disappear after the fecal mass has been removed. There remains a small sausage-shaped swelling in the lower part of the abdomen, either on the left side or just above the pubes. It can be easily felt and may persist for many months after the attack. Gradually, however, it disappears, and the patient usually resumes his average condition of health; but the attack may recur. Aporti has watched one case through three distinct attacks. There resulted, after these recurring attacks, a loss of suppleness, a thickening, and an infiltration of the bowel. Catz describes these changes as constituting a chronic perisigmoiditis. The inflammation, however, involves the entire thickness of the wall of the bowel, and is associated with a plastic deposit upon, or thickening of, the muscular and

peritoneal portions. It is an interstitial inflammation. As Catz says, it may follow an acute sigmoiditis, but usually it develops in an insidious manner and manifests itself in the form of chronic obstipation, with autotoxæmia. There is obstinate constipation. When the fecal mass is solid it is usually oval, flat, or misshapen, and contains pus and blood. As a rule, the blood is mixed with fecal matter, but sometimes it is bright red and is discharged separately from the feces. There is more or less pain in the pelvic and sacral regions, and the pain is increased when a fecal passage takes place. There is a slight rise of temperature and an increase in the pulse-rate, due to the peritoneal inflammation and the absorption of toxic matters. Palpation gives one the sensation of a sausage-shaped tumor, which is felt in the left iliac region or, in fact, in any part of the abdominal cavity. This tumor is sometimes smooth or it may be nodular, the nodules being small diverticula or hernias of the mucous membrane, which extend into and inflame the appendices epiploicæ. The condition may easily be mistaken for carcinoma of the sigmoid. The sigmoidoscope gives very little information beyond the fact that the walls of the bowel are stiff, inelastic, and painful upon pressure, and they do not dilate under atmospheric or artificial pressure. The calibre of the bowel appears to be free from any protrusion such as would suggest the presence of something growing out from the mucous or submucous coat; nor can there be seen any cicatricial tissue, such as would suggest syphilitic involvement. Nevertheless, the condition has been mistaken for scirrhous cancer of the sigmoid.

Treatment.—The treatment of this type of intestinal inflammation is essentially surgical. If one can be positively sure that a malignant growth is not present, palliative treatment might be justified; but when one realizes how serious a matter delay, under such circumstances, may be, neither the surgeon nor the patient can afford to temporize. When, therefore, a tumor of this type is discovered, even though there be a history of chronic sigmoiditis, exploratory laparotomy should be done at once, in order that the nature of this tumor may be ascertained. If it proves to be of a benign character, the decision as to what shall be done with it will depend upon the condition of the parts. It may seem necessary, for example, to remove the mass in its entirety or else to establish an artificial anus. Then, on the other hand, the condition of the parts may be such that one may feel warranted in not disturbing the continuity of the intestinal tract; the hope being entertained that nature will bring about a cure through absorption.

Perisigmoiditis; Diverticulitis.—Perisigmoiditis and diverticulitis are described as one because they are pathologically of the same nature, notwithstanding the fact that diverticula may occur in other portions of the large intestine as well as in the sigmoid. Perisigmoiditis, as the name would imply, consists in an inflammation around, or upon the outside of, the sigmoid flexure. It may be primary or secondary, and may, or may not, suppurate.

Primary perisigmoiditis has its origin in the sigmoid itself. It may be caused in a variety of ways: by an ulceration which perforates the muscular wall of the bowel; by a foreign body which produces either a simple trauma-

tism or an actual puncture; by a follicular inflammation; or by the spread of inflammation from a diverticulum in which fecal matter has become tightly lodged, and the mouth of which has subsequently been sealed by œdema of the adjacent mucous membrane. Byron Robinson (*Medical Standard*, August, 1907) holds that the perisigmoidal inflammation may be caused by a traumatism produced by the iliac and psoas muscles. He states that, under strong exercise, the muscle, in contracting, pounds upon the wall of the bowel, crushes it against the hard fecal mass within, and sets up an irritation in, or causes an actual abrasion of, both the peritoneal and the mucous surfaces. The writer has much respect for this ingenious theory. He has frequently seen such a perisigmoiditis follow horseback and bicycle riding and strenuous exercise in the field. The inflammation usually confines itself to the bowel or its mesentery, but it may extend to adjacent organs, causing adhesions and limitation of motion. It may remain stationary or the inflamed tissues may become infected and suppuration follow. Where no infection or suppuration takes place the attack will proceed as one of local peritonitis; the symptoms subsiding under physiological rest. When infection takes place, however, there will be all the symptoms of suppurative perisigmoiditis—an inflammation which is often taken for left-sided appendicitis. Except for the fact that this inflammation usually occurs on the left side, the resemblance to appendicitis is very close.

Mayo ("American Surgery") and Brewer (*Journ. Amer. Medical Association*, Oct., 1907) have each reported a number of cases of tumor and of abscess which occurred on the left side and which at first presented symptoms either of a left-sided appendicitis or of a tumor of the sigmoid, but which, upon operation, turned out to be instances of perisigmoiditis due to inflammation in the diverticula or the appendices epiploicæ. Sidney Jones, Loomis, Patel, Catz, von Eiselberg, and others have published accounts of similar cases. Recently Dr. Cullen, who has collected reports of one hundred and five clinical cases of all varieties of this disease published up to date, gives, in the London *Lancet*, an interesting review of the instances of perisigmoiditis, both suppurating and non-suppurating, said to be due to inflammation in the diverticula. Graser claims that these infections occur entirely through rupture of the diverticula into the meso-sigmoid. Inasmuch as these abscesses have been found in all parts of the circumference of the bowel, this view cannot be taken unreservedly. It is a fact, however, that most of the perforations occur in places where the intestines are covered by cellular tissue, such as the meso-sigmoid or the epiploicæ. In cases in which the parts have been laid bare by an incision before suppuration occurred, the tumors have nearly all been found to be located in the meso-sigmoid, to be of an inflammatory nature, and to have been caused by leakage from the bowel through minute diverticula. All the authors are agreed as to one point, viz., that constipation and fecal stasis in the sigmoid precede inflammations of this character.

Suppurating Perisigmoiditis.—Suppurating perisigmoiditis comes on as an acute sigmoiditis. The symptoms and signs are as follows: There is always

tension of the left rectus muscle; a history of constipation is given; there is a tumor in the abdomen, usually in the left iliac region, but it may be in the right, and it may be located as high up as the umbilicus; at first, the tumor is movable, but it soon becomes fixed; there is usually a history of chill, but this may be somewhat indefinite; if the abscess is upon the convex wall of the bowel, there will be dulness upon percussion, but, if it is in the mesentery and the bowel comes between it and the abdominal wall, there may be tympanites; the temperature is likely to be very high, and the pulse-rate soon becomes rapid, just as in appendicitis; leucocytosis is present, although it does not always mean the presence of pus, for it often exists as a result of intestinal stasis. Digital and instrumental examination of the rectum and sigmoid reveals very little. Catz says that the abscess may be absorbed, and the writer has seen one case in which this took place. The abscess may be encapsulated, but eventually it opens into the bowel, upon the skin, or into the peritoneal cavity. The writer has seen two cases in which the abscess opened into the sigmoid flexure, then refilled, and finally opened again. In one of these cases he was able to pass a uterine probe into the abscess cavity in the meso-sigmoid. The two patients were comfortable so long as the abscesses discharged freely, and on this account operation was never urged. Nearly all of the cases in which the abscess has opened through the abdominal wall, or into the sigmoid, have done well. Several instances have been reported in which there were adhesions between the diverticula and the bladder; the ultimate result in these cases being an entero-vesical fistula. The writer has never seen any cases of this nature, but he believes that they all terminate fatally.

Treatment.—The treatment of these cases depends entirely upon the fact whether or not the presence of pus has been established. Where no infection has occurred the palliative treatment is often successful. The writer has twice seen a large tumor in the left iliac fossa, evidently of perisigmoidal origin, disappear under rest and local applications. In dealing with this condition, one should always remember Segond's axiom: "Never be in a hurry to incise a swelling in the left iliac fossa." And yet, while remembering this, one should not take the chance of letting an abscess burst into the peritoneal cavity, when such evidences of pus as chills, night-sweats, high temperature, and marked leucocytosis are present. The abdomen should be opened with aseptic precautions, and, if it be found that suppuration has not taken place, then the wound may be closed with no fear of harmful results. Some have urged that one should wait until the abscess shall have become adherent to the abdominal wall and then should make an extraperitoneal opening. Such advice is misleading, because, if the abscess is on the meso-sigmoid, it will never reach the mural peritoneum, and one will therefore always have to pass through the free peritoneal cavity in order to open it. When the evidences that pus has formed are not convincing, one should first apply ice and then creolin poultices. At the same time the patient should rest in bed and should be kept on a limited but mixed diet. The sigmoid should also be irrigated regularly. If, when the abdomen is opened, it is found that the inflammation is confined to one of the

appendices epiploicæ, the inflamed mass may be ligatured and excised, the base being burned off or invaginated, just as is done in appendicostomy.

Secondary Perisigmoiditis.—The sigmoid, by reason of its mobility, is at one time or another in close relation with every organ in the abdominal cavity. It is therefore possible for it to become involved in an inflammatory process affecting some one of these organs, such involvement constituting what we have denominated as secondary perisigmoiditis. Byron Robinson, in the excellent article already referred to, says that the sigmoid is in close relation to the appendix in at least forty-eight per cent of women, and in thirty-eight per cent of men. It is in touch with the uterus and its appendages in nearly every woman. How easy, then, for an inflammation of one of the abdominal organs to extend to the sigmoid, and for adhesions to form between the two, or for a discharge to pass from one to the other. Abscesses of the ovary and Fallopian tube, of whatever type, have been known, not only to adhere to the sigmoid, but to rupture into this organ. Byron Robinson reports one case in which there were three separate openings into the sigmoid from an abscess of one of the tubes. He claims that many deaths are caused by the accidental opening of one of these fistulous tracts during the course of an operation upon the uterine adnexa, and by the neglect of the operator to close the aperture into the sigmoid. In the course of my operative work I have detached the sigmoid from every organ in the pelvic and abdominal cavities except the liver, pancreas, and right kidney.

Treatment.—The treatment of these conditions resolves itself into the treatment of the source of inflammation. At the same time, while one is engaged in relieving these abnormal conditions of certain abdominal organs, it is important to take into account the condition of the sigmoid, and to repair any openings that may have been made by cutting across fistulous tracts or by tearing through ulcerating abscesses.

XVI. COLOSTOMY.

The term "colostomy," which is derived from two Greek words (κόλον, colon; στόμα, opening), is used to describe the operation of making an opening into the colon through the abdominal wall, this opening being intended to serve as an artificial anus. This opening may be made either temporary or permanent. The procedure has for its object either to overcome some obstruction in the bowel below this point or to give functional rest and thus to relieve the diseased portion from the irritating effects of a constant flow of fecal matter over the part. It also serves as a useful preliminary to extirpation of the rectum, in cases of imperforate anus and in complicated fistulæ between the bowel and uro-genital organs. The permanent artificial anus is required in cases of inoperable stricture or of neoplasm of the bowel below this point, and it is also a necessary adjunct in operations for resection or excision of the rectum or sigmoid, where it is impossible or impracticable to re-establish the continuity of the intestinal tract.

Since the introduction (by Schede, in 1887) of colostomy as a means of temporary relief, it has been the effort of surgeons to establish a method by which the operation could be done in such a manner that the opening might be easily and safely closed after it had served its purpose. Thanks to their efforts this can now be accomplished without opening the peritoneal cavity or resecting any portion of the bowel. The term colostomy should not be restricted, by a prefix, to any special part of the abdominal wall, inasmuch as it becomes necessary, in various conditions, to open the colon at different localities. It is therefore best to speak of the operation which is almost universally done at the present time, as abdominal colostomy—in contradistinction to the lumbar method, which is now almost obsolete. Lumbar colostomy, however, still has a sufficient field of usefulness to merit description. It is applicable, for example, in incurable diseases of the sigmoid and descending colon, in which the usual opening in the inguinal region would be below the site of the disease, and also in cases in which the intestines are greatly distended—*i.e.*, in cases in which it would be much easier to find and open the colon in the lumbar region than at some other part of the abdomen.

The immediate danger from colostomy, no matter what may be the route adopted, is, in properly selected cases and under the proper antiseptic precautions, very slight.

Lumbar Colostomy.—The patient is laid upon his right side and a firm pillow is placed under the loin in order to make the flank prominent. The patient is then turned partially on his face, thus making it possible to feel the anterior border of the quadratus lumborum distinctly. An incision is made just below the border of the last rib and one inch and a half back of the anterior superior spine. This incision should extend downward and forward a distance of about five inches, and in a direction parallel with the crest of the ilium. The fibres of the muscular layers should be separated and not incised, and they should be held back by retractors. Before the transversalis fascia is divided, all bleeding vessels should be ligated. The external border of the quadratus lumborum will be exposed through the transversalis fascia. After passing through the latter the operator comes upon the bed of subserous fat, in which the kidney is embedded, and in front of which lies the colon. Blunt dissection should now be used to avoid wounding the ureter, which may be abnormally placed in this fat. Whether the colon can or cannot be reached without entering the peritoneal cavity, depends upon the length of the mesentery.

When the colon is exposed,—in a case, for example, in which its mesentery is short,—the first step consists in drawing the bowel out at least as far as to the surface of the wound and holding it there while the latter is packed with gauze. Then a silk ligature is passed first through the skin, then through the bowel, and finally through the skin on the opposite side of the wound. These sutures should be introduced at intervals of half an inch throughout the extent of the wound. The intestine should now be incised longitudinally, and the loops of the sutures that had been passed through the walls of the bowel are caught, drawn out through the wound, and cut in the middle, the ends being tied

to those which have been passed through the skin on each side. After the gas and feces have passed through the opening, the wound in the skin should be thoroughly cleansed and the edges of the intestinal wound and skin should be approximated and neatly sutured by interrupted sutures all around. The surrounding skin should then be smeared with some adhesive ointment to protect it from the fecal discharge. The stitches may be removed on or about the sixth day, and the patient allowed to sit up on the tenth day.

In order to provide a spur which shall prevent the escape of fecal matter into the lower segment, the posterior wall of the colon may be pulled well forward, in the wound, before it is stitched to the edges of the skin. A silver-wire suture is first passed through the skin and then beneath the bowel and out through the skin on the opposite side. The wire is then drawn taut and fastened to shields on each side.

In a case in which the mesentery is abnormally long and the colon cannot be reached without entering the peritoneal cavity, it is best to draw the colon out of the wound, and fix it in that position by a glass rod passing under it and from one side of the wound to the other. When this has been done, it will not be necessary to open the bowel for some hours.

Inguinal or Abdominal Colostomy.—The advantages of the inguinal or abdominal over the lumbar route are these: the operation is much more easily and quickly done; there is less danger of infecting the wound, because it is much more shallow; it affords an opportunity for exploring the abdominal cavity; an outlet in this locality is more convenient for the patient; the opening is much easier to close; and the mortality is much less. For these reasons abdominal colostomy is now employed almost exclusively, except in the instances mentioned above. Recently it has been adopted as a preliminary measure in extensive operations on the lower portion of the intestinal canal. When it is done as a temporary measure, special care should be taken to perform the operation in such a manner that the opening can be closed with the least possible danger to the patient and in the most successful manner.

Abdominal colostomy, as already intimated, may be done either as a temporary measure or for the purpose of providing a permanent artifical anus. As a temporary measure the operation is performed for the purpose of providing an outlet for fecal matter while the lower portion of the bowel is undergoing surgical or medicinal treatment, and also in cases in which it is possible to reestablish the normal fecal canal; it is performed for the purpose of establishing a permanent artificial anus when the disease in the bowel below is incurable or when it is impossible, after an operation for excision or resection, to restore the normal canal.

Temporary Colostomy.—Temporary colostomy is done for the purpose of turning aside the fecal current while treatment or some operative measure is being carried out on the intestinal tract below. The site at which the opening is made depends upon the location of the disease and also upon the treatment that is to be adopted. Thus it may become advisable to vary the location of the opening from the cæcum to the upper two-thirds of the sigmoid.

Technique of the Operation.—Several different procedures have been recommended for the performance of the operation. In one of these, for example, special importance has been attached to the formation of an efficient spur; in another, great stress is laid upon the necessity of preventing prolapse of the mucous membrane; and in a third, the operator is specially urged to construct the artificial anus in such a manner that later it may be easily closed. Instead of giving a detailed account of these different methods, we shall try to combine, in one general description, the specially good points of each.

The preparation of the patient, for each of the different methods of colostomy, is the same as for any other case of laparotomy. The location of the incision will be determined by the conditions to be met, but the left inguinal region will meet the large majority of such indications, and it is therefore the site usually selected. We will pass over the customary details which are familiar to all operators and which are recognized by them as essential points in the operation, and we will take up the consideration of some recent recommendations for the correction of what have generally been recognized as defects or shortcomings in the operation as it has been performed in the past. Such are, for example, the formation of the spur between the two legs of the loop of the colon that is brought to the surface; the production of an artificial anus that will give the greatest amount of fecal continence; the proper method for securing fixation of the bowel; the best way of doing a temporary colostomy and the best manner of closing the opening; the steps required for preventing prolapse of the mucous membrane; and the proper time and method of opening the bowel.

As regards the fixation of the bowel, Reclus first showed that it is unnecessary to suture the parietal peritoneum to the edges of the wound in the skin, a step which had up to that time been considered necessary for securing union between the edges of the wound and the bowel; and this has been verified by a number of different operators.

For making an acute spur the Maydl-Reclus method appears to us to be the simplest and most efficient. It consists in drawing the loop of the colon out through the wound, and, after pulling the bowel down from above until it is taut, making a small incision in the mesentery, care being taken to avoid blood-vessels. Then, through the opening thus made, a glass or vulcanized rubber rod, about five inches in length, is passed and its ends are made to rest on each side of the wound. This rod should remain in place for about two weeks. The protruding portions of the bowel are sutured to the skin at the two angles of the abdominal wound. This unquestionably brings the posterior wall of the bowel above the level of the abdominal wall and forms a perfectly satisfactory spur.

To prevent prolapse of the mucous membrane, the pulling down of the bowel until it is taut (in the manner described above), before passing the rod through the mesentery or fixing the organ to the abdominal wound, will be found effective.

The proper time and method for opening the bowel will depend upon the urgency of the symptoms of obstruction. If it should become necessary to open the bowel at once, or soon after it has been drawn to the surface of the wound, and before union has taken place between it and the abdominal wound, the

organ may be clasped with two pairs of intestinal compression forceps, applied about an inch apart, and an incision then made between them just large enough to introduce the end of a Paul's tube.* A piece of rubber drainage tubing is then attached to the distal end of the glass tube to draw off the gas and feces. After the tube has been secured in the bowel, the base of the protruding loop of the bowel should be sutured to the edges of the abdominal wound. If there is no urgent reason for the immediate opening of the bowel, it may remain closed for several days.

When a temporary artificial anus is to be made, the following method should be pursued:—A simple longitudinal incision is made from the superior angle of the wound to a point half an inch below the supporting rod. Tuttle recommends, in addition, that a transverse incision, involving two-thirds of the

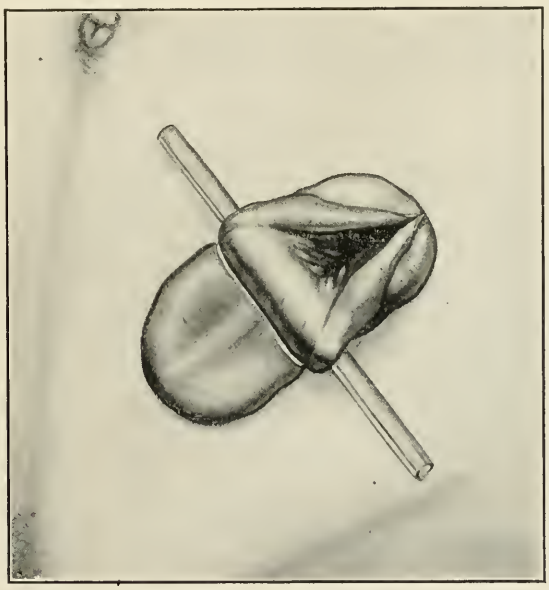


Fig. 390.—Temporary Inguinal Colostomy. (Tuttle.)

circumference of the bowel, be made at the lower end of this longitudinal incision. (Fig. 390.) In both instances the object is to preserve as much of the wall of the bowel as is possible, in order that it may be more easily restored. Tuttle claims that, in making the transverse incision, the triangular flaps roll backward and curl up, and, when the artificial anus is to be closed, the curls of the flaps can be dissected apart, unrolled, and sutured in their original places. In the latter case, or when a permanent artificial anus is to be made, or if, after providing for a temporary artificial anus, it becomes necessary to make it permanent, the entire circumference of the protruding loop of bowel can be cut through

* Under the title of "F. T. Paul's Method of Performing Colectomy" there will be found, in the British Medical Journal for May 25th, 1895, p. 1139, a reference to Paul's glass intestinal drainage tubes. The tube in question, which consists of glass, has a diameter somewhat less than that of the colon, is six or eight inches in length, and is provided with a double flange at the end which enters the bowel; the object of the flange being to secure the tube in place.

down to the mesentery, and the protruding edges may then be cut away, leaving a distinct sulcus between the upper and lower apertures. (Fig. 391.) The opening of the intestine does not require the employment of an anæsthetic, as it produces no pain unless the mesentery is cut. In the latter case a light general or a local anæsthetic will have to be employed.

Closure of a Temporary Artificial Anus.—The method of closing an artificial anus will depend altogether upon the way in which it has been made and upon the amount of the bowel which has been sacrificed in making the opening. If the method of Allingham or of Bodine (Fig. 393), for making the spur and cutting away the loop of the bowel has been employed, then the spur may be divided

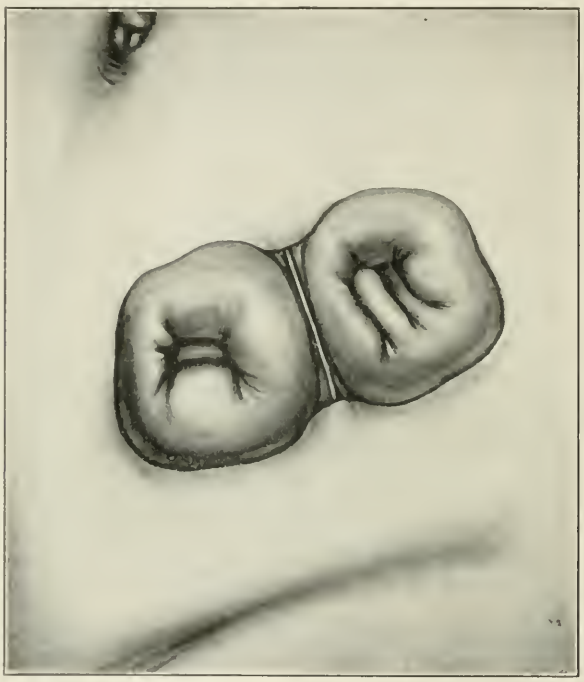


Fig. 391.—Drawing Illustrates a Case in which the Bowel is Cut through for the Purpose of Establishing a Permanent Artificial Anus. (Tuttle.)

by long pressure-forceps, and the edges of the bowel around the abdominal opening may be dissected loose and then united by Czerny-Lembert sutures; the skin and muscle layers being brought together above. The objection to this plan is that it leaves the bowel in a very distorted condition. An end-to-end anastomosis would, under these conditions, be decidedly preferable.

When the bowel has been opened first by a longitudinal incision extending down to a point half an inch below the glass rod, and then by a transverse incision bisecting the lower end of the first, Tuttle's method for closing the artificial anus (mentioned above) may be used with advantage. The T-shaped wound in the bowel is then brought together first by silk sutures passed through the mucous membrane, and then by a row of Lembert sutures placed outside

of these. (Fig. 392.) The bowel is then dissected loose from its attachment to the abdominal wall down to the peritoneal layer. This layer should be carefully stripped from the abdominal wall in the form of a band about one inch all around the artificial anus. This allows the closed bowel to drop below the level of the abdominal wall. (Fig. 396.) The opening in the latter, already freshened by dissecting loose the intestine, is then brought together by silkworm-gut sutures passed through all its layers. The bowel is thus effectually closed with very little if any diminution in its calibre and without opening the abdominal cavity; and the abdominal wall is completely restored in all its thickness. Numerous plastic methods for closure of the artificial anus have

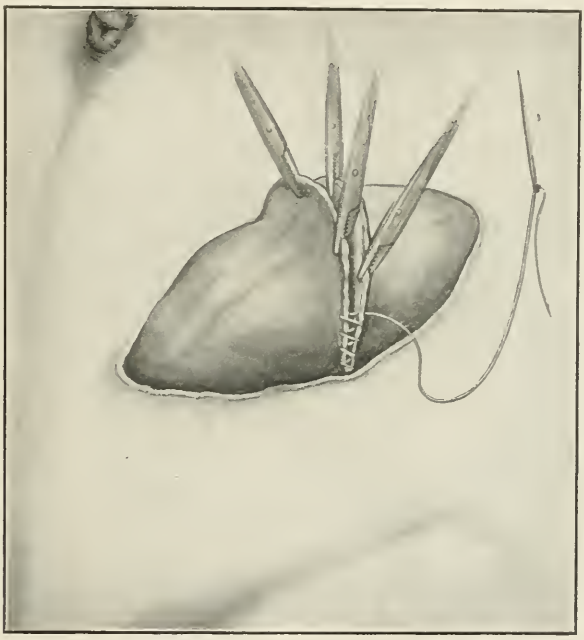


Fig. 392.—Drawing Shows Tuttle's Method of Closing a Temporary Artificial Anus. (Tuttle.)

been devised, one of which is illustrated in Figs. 394 and 395. The technique, known as that of Szymanowski, is as follows: A curved incision about three times the length of the artificial anus is made internal to the aperture and with the centre of its apex at the artificial anus. This flap of skin is dissected up for about one inch or more throughout its entire extent. A second curved incision is made on the opposite side of the artificial anus, beginning at the ends of the first incision and passing out beyond the aperture to a distance of about two inches. This flap is dissected up to the margin of the artificial anus, is then folded, hinge-like, over the artificial anus, and is sutured to the freshened surface from which the first flap has been lifted. The first flap is then dragged over the second flap and sutured to the margin of the skin from which the second flap was lifted, thus closing the artificial anus by a double layer of skin and subcutaneous tissue.

Permanent Colostomy.—The chief things required in an artificial anus which is to be of a permanent character are these: first, it should have a free outlet for the fecal matter; second, it should be so located that the patient can easily take proper care of it; third, it should be so formed that prolapse of the mucous membrane will not occur; and, last, the control of the fecal outflow should be the maximum attainable. It is generally conceded that an artificial anus in the inguinal region is more convenient for the patient than one placed anywhere else, and this locality should therefore be the one selected wherever it is practicable. A free outlet for the fecal matter may be easily obtained, in any one of the positions named, by making a free incision into the bowel; and the

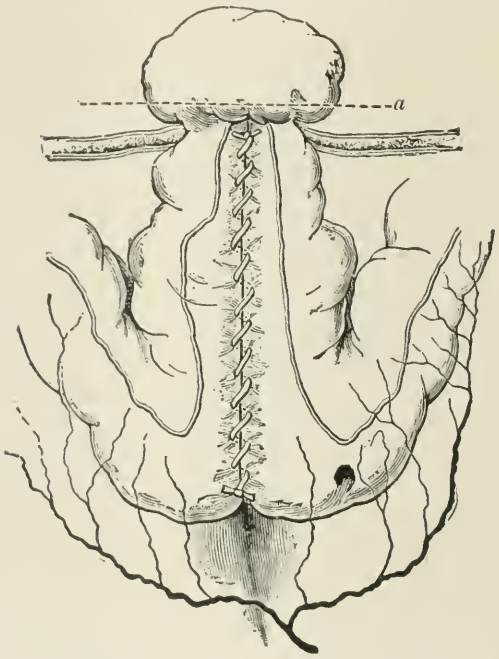


FIG. 393.—Bodine's Operation for Colostomy.

prolapse of the mucous membrane is controlled by pulling the upper segment of the bowel out, until taut, as heretofore stated.

The control of the fecal discharges is the most important part of this subject yet to be considered. The constant escape of gas and feces from an artificial anus, as experienced before the attempts to control it had been successful, brought the operation into great disrepute. Many surgical devices have been employed to effect this control, but, until recently, none of them has been found quite satisfactory. Taking advantage of his own past experience, as well as of that of workers in the same field, Tuttle has devised a method of procedure which will be found to combine the good results of all the different methods and to be eminently satisfactory. He advises that a loop of sigmoid sufficiently long to be drawn at least two inches outside of the abdominal cavity be selected, and that then a tape, or loop of large silk, be passed around it through a small

slit in the mesentery, the ends being left long and being held by artery forceps. The lower fibres of the external oblique are then pulled down, the internal oblique is split laterally for a distance of about three-quarters of an inch, and the skin is separated from the external oblique muscle for a distance of about two inches. An incision large enough to admit the bowel is next made through the skin just above Poupart's ligament. The dressing forceps is passed first through this opening and then through the opening made in the internal oblique muscle, and is made to grasp the tape or the loop of silk that has been passed around the bowel through the slit in the mesentery. By this means the bowel is drawn down through the openings and out through the lower slit in the skin.

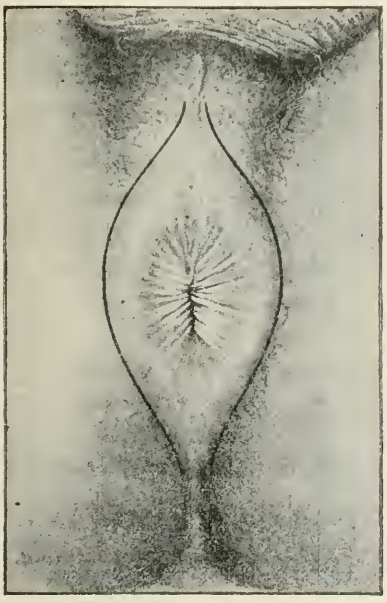


FIG. 394.

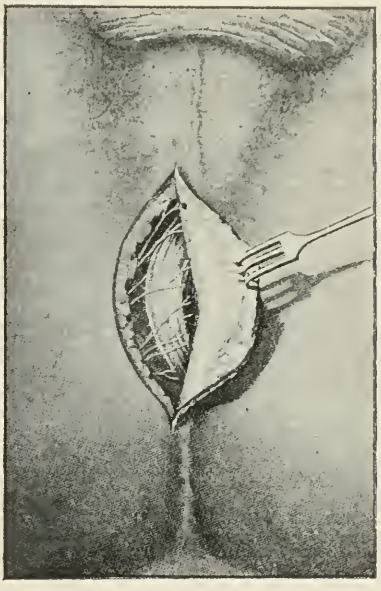


FIG. 395.

FIG. 394.—Closure of Artificial Anus by Plastic Operation; First Stage. (Earle and Tuttle.)
FIG. 395.—Closure of Artificial Anus by Plastic Operation; Second Stage. (Earle and Tuttle.)

The opening made by the incisions should be of such size that the loop of sigmoid may be drawn through easily and without subjecting it to much compression. After it has been drawn through the bowel is held in position by passing a glass rod through the slit in the mesentery and allowing it to rest at each end on the surface of the skin. The abdominal wound is closed in the usual manner. When the proper time arrives, the bowel is opened by a simple slit in the line of its longitudinal fibres. In the course of a few weeks the protruding edges of the bowel should be trimmed down flush with the skin.

The bowel is brought outside of the external oblique muscle in order that it may lie upon a resisting plane; and, if this does not suffice to effect the desired closure, a truss or compress can be placed upon it, by which means its calibre will be absolutely occluded. Tuttle has found it necessary to employ a truss in only two out of seven cases. The fact that the bowel passes through the slit

in the internal oblique muscle gives a certain amount of voluntary control over the movements.

Colostomy on the Right Side.—It is rarely necessary to make a permanent artificial anus on the right side, and even a temporary colostomy in this locality is only occasionally called for in the treatment of chronic intractable inflammations of the colon. Appendicostomy (see page 797) will doubtless supersede this operation in the large majority of such cases. Whenever it is found necessary, however, to perform a colostomy on the right side, the surgeon should bear in mind the anatomical conditions which differ from those found on the

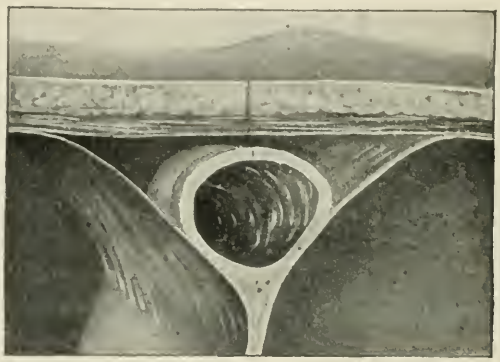


Fig. 396.—Cross Section of Parts after Extra-peritoneal Closure of Artificial Anus. (Tuttle: "Diseases of the Anus, Rectum, and Pelvic Colon." D. Appleton & Co., New York.)

left side—viz., the higher location of the colon in the pelvis, the fact that the mesentery is shorter here, and the very soft or even semifluid condition of the feces, which renders ineffectual any attempts to secure fecal continence except by Gibson's or Grant's valvular cæcostomy.

XVII. FOREIGN BODIES IN THE RECTUM AND SIGMOID.

Foreign bodies are frequently met with in the rectum and sigmoid, and there are three ways in which they may reach this part of the intestinal canal: first, by being swallowed; second, by being developed in some portion of the intestinal tract itself; and, third, by being introduced through the anus.

Medical literature abounds with instances of foreign bodies of the most varied and marvellous character that have been swallowed and subsequently found in the sigmoid or the rectum. Among such bodies may be mentioned chicken or fish bones, the outer hull of an apple seed, a plate of false teeth, etc.

There are certain disorders or conditions which predispose to the formation of foreign bodies in the intestinal canal. Among such may be mentioned altered or deficient secretions from the intestinal canal, the liver, or the pancreas. Enteroliths have their origin in small bodies which have been swallowed and around which the lime salts are deposited in the form of incrustations. Those who live in limestone regions and drink the hard alkaline water characteristic of such localities, are especially liable to have these calcareous masses form in the intestine.

For various reasons foreign bodies are frequently introduced into the rectum, and, while this is always done with the knowledge of the patient, the purpose for which the foreign object was introduced is of such a nature that he or she will not admit it until forced to do so by pain and distress.

In a certain number of cases foreign bodies are introduced into the rectum by ignorant people for the relief of certain conditions or symptoms, as for constipation, or for its reverse condition, diarrhœa. Again, the rectum has, for a long time, been made use of by thieves and criminals for the purpose of concealing stolen articles and instruments for use in crime.

Foreign bodies sometimes find their way into the rectum by accident, as by falling on pointed sticks or on the palings of a fence, and then, after penetrating the rectum, they break off and are left in the bowel.

In this section belong also those distressing cases in which foreign bodies have been introduced, by depraved individuals, for the purpose of exciting passion, and in which the object has slipped from their grasp and has passed up into the rectum.

The length of time occupied by a foreign body that has been swallowed, in passing from the stomach to the rectum, varies from twelve hours to several months.

Some remarkable cases have occurred in which large objects that have been introduced into the rectum have worked their way upward until they were beyond the reach of the hand or of instruments used for their removal.

Symptoms.—The symptoms will depend very much upon the size and shape of the foreign body. If smooth, round, and not very large, it may give rise to very few symptoms, pain and tenesmus being the chief. When the object has remained for some time in the intestine and has produced much irritation, grave constitutional symptoms, with high temperature, may supervene.

Diagnosis.—The educated touch and the proctoscope afford the only reliable means of diagnosis in these cases. The latter instrument should be used only when the foreign body has passed up beyond the reach of the finger; but then it may be used as a means, not merely for making the diagnosis, but also for removing the foreign body, which may be grasped with forceps and pulled down.

Removal by Abdominal Section.—When a large foreign body has passed beyond reach or has been arrested, in its passage from above downward, in the upper part of the sigmoid flexure, it may be advisable to open the abdominal cavity at once, to make a longitudinal incision in the bowel, and then to remove the foreign body through this aperture.

XVIII. WOUNDS, INJURIES, AND RUPTURES OF THE RECTUM.

The protected position of the anus and rectum between the folds of the buttocks guards it, as a rule, from injury. Nevertheless, there are a sufficient number of injuries of this character to make the subject worthy of our consideration. These injuries may be conveniently divided into contused, lacerated,

punctured, and incised wounds. Contusions arise from falls on the buttocks, from prolonged pressure brought about by any cause, and from excessive manipulation employed in stretching the sphincter. Laceration may be produced by a sharp foreign body in the stool, by excessive divulsion of the sphincter, and by falling or sitting down upon some sharp object. Punctured wounds result from gunshot or bayonet injuries and also from falling on sharp-pointed objects. Urethral sounds have sometimes been the cause of such accidents, but the greatest number have been occasioned by the improper use of syringe tips and rectal bougies. The writer has known of three cases in which the improper use of the Kelly tube caused perforation of the rectal wall, fecal extravasation, peritonitis, and death.

Operations for stone in the bladder or for prostatectomy, by perineal section, have frequently resulted in injury to the rectum.

Rupture of the rectum has occurred from the use of the colpeurynter in suprapubic cystotomy, and from that of a Barnes' bag to dilate a high stricture. As additional causes of this lesion the following may be mentioned: dragging upon the organ in efforts to break up attachments between it and a pelvic growth; the use of force with the nozzle of a syringe or with a rectal bougie, in pelvic operations; penetrating and punctured wounds; and excessive pressure from the use of compressed air. Rupture has occurred in several instances during attempts to reduce rectal procidentia, and it has also occurred from the introduction of the hand for diagnostic purposes.

The gravity of a wound or injury to these parts depends largely upon the site, the tissues, and the particular part of the organ involved. Where the injury is confined to the anus and rectal walls, the wounds usually heal promptly under antiseptic precautions, except in those cases in which the puncture of the rectal wall has taken place within (*i.e.*, higher up than) the anal opening and without injury to it. The majority of such cases which have been reported as terminating fatally, are due, in all probability, to improper drainage through the closed anus.

The results of gunshot wounds of the rectum, according to the records of our Civil War and of the Franco-Prussian War, show a mortality of over forty per cent. Pelvic cellulitis, septicæmia from infiltration, diffuse suppuration, and secondary hemorrhage were the chief causes of death.

Little trouble may be anticipated from minor wounds or injuries of the rectum and anus, if the cardinal principles of drainage and disinfection are strictly followed. Hemorrhage should be controlled by taking up the bleeding vessels, if possible; otherwise the bleeding should be arrested by packing, care being taken always to irrigate the rectum with hot antiseptic solutions before the packing is done. When the peritoneal cavity has been penetrated, sponging should be substituted for irrigation.

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