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FURTHER REPORT ON
ASEPTIC AND SEPTIC SURGICAL CASES, WITH
SPECIAL REFERENCE TO INFECTION
FROM THE SKIN.

THE following report upon aseptic and septic wounds is a continuation of that which was published in the *BRITISH MEDICAL JOURNAL* on October 25th, 1890. In that report no wound was called aseptic unless its sterility had been proved by the inoculation of culture media from it. This test has been continued, and, when nothing has grown upon the cultures, the wound has been called aseptic, and, I may add, the subsequent progress of the case has left nothing to be desired.

The dangers and imperfections of treatment which permits of wound infection are self-evident. There is no plan which can allow the so-called harmless microbes to enter and at the same time keep out the harmful. Nor can we rely upon the vital resistance, phagocytic power, or microbe-destroying properties of the fluids and tissues of the body. They are factors beyond control, whilst asepticism is not.

Recent investigations show that few wounds can endure the stringent test of the inoculation of culture media. A wound which does not infect seems to be so unusual that it is worthy of being recorded.

Bloch,¹ who seems to have tested properly a great many wounds, found microbes present in almost every instance. He refers to upwards of forty-six cases, out of which only two were sterile. It must not on this account be inferred that his results were not good; but they did not come up to the highest standard. As a result of his work, this surgeon seems to take a pessimistic view of the possibility of asepsis. He thinks the skin is the source of contamination.

Halsted² has also worked in the same direction. His statements are not precise, but it is said "that test tube inoculations made by us a few days after the operations from the surface of the new cicatrix, from the fine line of granulations, from the surface of the blood clot, from the tip of the gauze plug, and from the bottom of the sinus occupied by the plug,

¹ Bloch, *Revue de Chirurgie*, 1890, p. 819.

² *The Johns Hopkins Hospital Reports*, vol. ii, No. 5, p. 298.

frequently yielded a number of colonies of pyogenic organisms." This surgeon also refers to infection from the skin, and says that, after numerous experiments, he came to the conclusion "that it is impossible to disinfect it by any of the methods which have hitherto been recommended." Mr. Watson Cheyne has also more than once attributed wound infection to the patient's skin.³

These quotations show the comparative rarity of aseptic wounds in the practice of surgeons who aim at their attainment. They also point to a source of contamination to which I propose to allude. Before doing so, brief notes will be given of some wounds which have borne the ordeal of the inoculation of culture media, and which are, therefore, called aseptic.

ASEPTIC WOUNDS.

CASE I. *Tuberculous Synovitis of Left Knee; Arthrectomy.*—The patient was an unmarried woman, aged 26, and was by no means a good subject for an operation. She says that both of her parents and five brothers and sisters had died of consumption. She herself had had strumous ophthalmia when a child and had had necrosed bone removed from her upper jaw, and from her hand. Six years ago (aged 20) her right hip was affected, and it is clear that after much suppuration the head of the femur had disappeared. It is eighteen months since the last sinus healed. The left knee, for which she seeks advice, was injured by a fall down stairs fourteen months ago. It is now hot and tender, with marked thickening of the synovial membrane. The patient was kept at rest for three weeks, during which Dr. Clifford Beale reported that: "There is no evidence of any active mischief in the lungs, but there are signs of previous phthisis (probably quiescent), at the right apex." It ought also to be said that during this period of rest in bed the knee, which had been placed upon a splint, showed no signs of improvement, and a very suspicious pain and tenderness developed in the cervical spine. With much reluctance it was decided that something must be done for the knee, and therefore an exploratory incision was made into it along the inner side of the patella. The cartilages were very little diseased, merely eroded and vascular at a few isolated spots, but the whole synovial membrane was inflamed and thickened. The joint was therefore freely exposed by turning up a very large rectangular flap in which the patella was included, its ligament having been divided. After this all the synovial membrane was removed and the eroded cartilages gouged and scraped. The ligamentum patellæ was sutured with fishing gut, and the wound closed with silk sutures placed about half an inch apart. Before tightening the last sutures the joint was irrigated with some quarts of perchloride of mercury lotion, ३०००. The skin was rubbed with a little iodoform, and the usual dressing applied. Before this operation the patient's temperature had ranged from 97° F. to 100° F. Afterwards it ranged from 98.8° F. to 101.4° F., and on the ninth day reached 102.8° F., probably on account of an hysterical attack, to which she seemed liable. On the tenth day the wound was dressed and seemed healed throughout, except at a corner

³ *Suppuration and Septic Disease*, London, 1889, pp. 8 and 9; also *Micrococci in Relation to Wounds, Abscesses, and Septic Processes*, BRITISH MEDICAL JOURNAL, 1884, vol. ii, p. 553.

where the skin had not been quite accurately adjusted. Gelatine and agar-agar tubes were inoculated from this and other points, but remained quite sterile. The synovial membrane was tuberculous, and occasional tubercle bacilli were seen near the free surface.

Six months after the operation the patient seemed exceedingly well and fat. The knee was excellent, although the patient had not used it, having been laid up with influenza. There seemed no reason why she should not begin to get about upon it, in spite of the absence of the head of the other femur.

CASE II. Carcinoma of the Breast; Amputation; Clearing of Axilla.—The patient is a single woman, aged 41, and was sent in under my care by Dr. Stokes. She had a scirrhus cancer of the left breast, which had been growing for four years; the axillary glands were also affected. The whole breast and mammary gland, together with the pectoral fascia and several axillary glands, were removed. The wound was brought together with button and interrupted sutures, and dressed in the usual way without drainage. The skin was rubbed with a little iodoform. On the following day she complained of the pressure of the Martin's bandage, and this seemed a source of annoyance for the next week, and was afterwards found to have caused some eczema of the back and side of chest, but otherwise there was nothing to note. The dressings and sutures were removed on the tenth day, and culture tubes of gelatine and agar-agar were inoculated from the scar, but remained quite sterile. She left the hospital on the fourteenth day after the operation.

The only point that calls for remark in this case is the trouble caused by the Martin's bandage. I have now begun to omit this part of the dressing, or apply it much more lightly and to remove it earlier—on the third or fourth day. Of course, care has always been taken not to let the Martin's bandage be in actual contact with the skin.

CASE III. Senile Gangrene; Amputation of Thigh.—The patient was aged 77. He was admitted with senile gangrene of the toes of the right foot, which had come on during the cold weather. He was kept under observation for several days, during which the gangrene extended into the sole of the foot. There was also some inflammatory œdema of the lower part of the leg, and septic poisoning seemed to be in progress. There was a very feeble pulse in the popliteal artery, but none in the tibials. He suffered greatly from pain, and was delirious at night, and was rapidly losing ground. After consultation amputation was done through the lower third of the thigh. The wound was dressed in the usual way, and a small drainage tube inserted towards the inner side. No iodoform was used. The operation caused very little shock, and the wound was dressed on the fifth day, and gelatine and agar-agar tubes inoculated from the drainage tube and from the wound, but they remained sterile. Before the operation his temperature ranged between 99° F. and 100° F.; afterwards it was 99.4° for some days, and then fluctuated slightly between 98° and 99.8°. On the eighth day it reached 100.2° owing to some bladder trouble, which continued troublesome until he got up. He kicked his second dressing off on the twelfth day, but the wound was healed. It is only necessary to add that there was rather more serous discharge from this wound than is usual in aseptic cases; indeed, there was enough on the fifth day just to show through the dressings.

In other respects the case is very like one given in the previous report. In both the good results of the amputation were immediate and very striking.

CASE IV. *Lipoma of Side.*—The patient was a cook, aged 49. She had a lipoma about 4 inches long by 3 inches broad over the anterior extremities of the lower ribs of the left side. This was removed, and the wound dressed in the usual way, no drainage tube being used. The wound was dressed on the eighth day, and was quite healed. Two gelatine tubes were inoculated, the platinum wire being thrust into the line of the wound. They remained sterile.

This case possesses little interest except that its asepticity was properly tested. One other point is, perhaps, worth mentioning. On the fifth day, the patient's temperature rose to 102.8°, having previously been normal. We attributed this to an attack of acute tonsillitis, which might have been associated with the condition of the patient in the next bed, who had a very foul-smelling discharge. However, it is clear that the condition of the throat had no effect upon the healing of the wound.

CASE V. *Amputation of Breast.*—The patient was a healthy woman, aged 39, who had a hard cancer of the right breast. The whole of the mammary gland, together with the subjacent fascia, was removed on November 5th. The wound was irrigated and dressed in the usual way without drainage. The dressings were removed on November 17th, when the wound was quite healed. There was a small hæmatoma under the lower flap, which was emptied by thrusting a sharp director through one of the stitch holes, and gave no further trouble. Gelatine inoculated from this blood remained sterile, as did also that which was inoculated from the line of the wound. This patient had no abnormal temperature, and was quite comfortable throughout.

CASE VI. *Laparotomy for Hæmatosalpinx or Tubal Pregnancy.*—This case has been already reported in the BRITISH MEDICAL JOURNAL of September 26th, 1891, p. 296. It was that of a woman, aged 27, whose abdomen was opened to explore a large swelling, which was thought to be a hæmatoma connected with a tubal pregnancy. The abdomen was opened by an incision 4 inches long in the linea alba below the umbilicus, and three or four pints of blood clots were evacuated with the hand and by irrigating with warm boracic lotion, and when the supply of that failed, with hot water. A globular swelling the size of an orange was then found upon the right Fallopian tube. The tube and the tumour were removed in the usual way, and the abdomen drained with a glass tube, and the wound closed with silkworm gut sutures. The fluid which was sucked from the tube the day after the operation was inoculated into gelatine tubes, which remained quite sterile. Before the operation the temperature was 101.2°, and on the second day after, it had fallen to 98.8°. However, it is possible that if, later on, I had been able to inoculate from the superficial parts of the wound, I should have had to remove this from the aseptic category. The superficial part of the drainage opening was a few days in healing, and there was a slight rise of temperature. However, the essential part of the case was aseptic. It may be remembered that the abdomen had been washed out with hot water. This came from the ordinary hospital supply which is pumped up to the operating theatre from large boilers in the basement. To test

this water, the operation theatre basin was filled in the usual way, and the water inoculated in gelatine tubes which remained sterile.

CASE VII. *Removal of Tumour of Breast.*—The following case throws light upon the conditions of asepsis, and will be referred to again. An adenoma of some size was removed from the breast of a woman aged 30, and also the subjacent lobe of of the mammary gland. A considerable chasm was left, which was closed in the usual way without drainage, and the skin was rubbed with iodoform and a carbolic gauze dressing applied. As it was inconvenient to wait, the wound was dressed on the seventh day, and was healed except where a

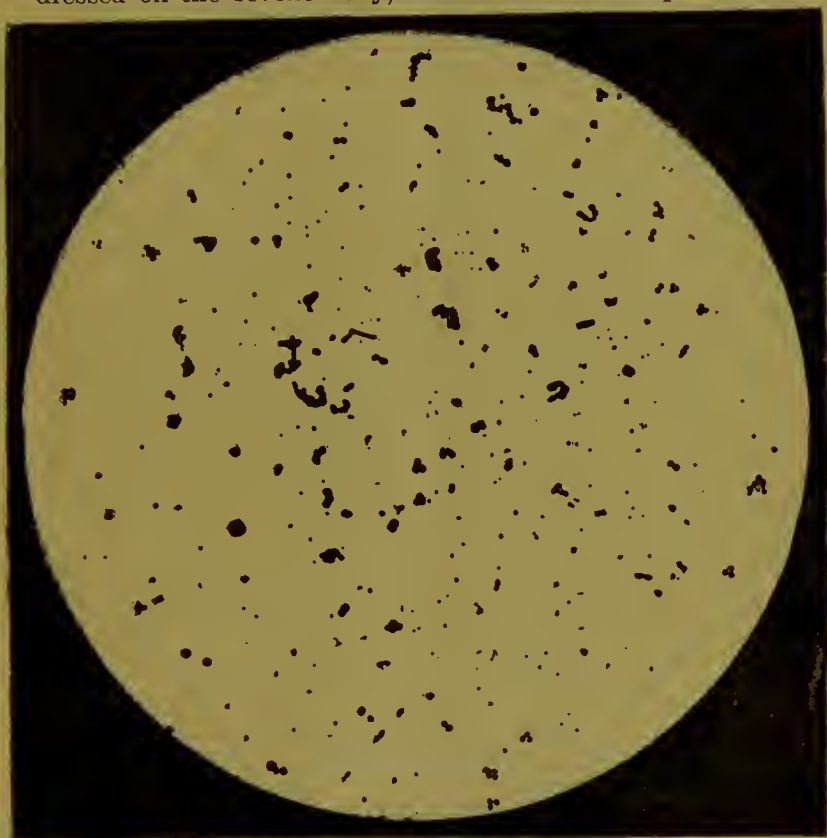


Fig. 1.—Broth culture inoculated with skin from aseptic Case VII, stained with fuchsin. From a microphotograph by Mr. Cosens.

small piece of the skin had been removed for examination. The original iodoform having disappeared, some more was dusted on and covered with a bit of alembroth wool. After this nothing more was seen of the wound, and the patient left on the fourteenth day soundly healed. Cultures inoculated on the seventh day from the unhealed part remained sterile. At the operation the bit of skin which was cut from the same place was dropped into peptone broth. This became cloudy in three days, and contained bacillus epidermidis, a streptococcus with as many as fifteen elements in a chain, staphylococcus albus, and many diplococci (see Fig. 1). In the earlier cultures the cocci preponderated, but

in later plate cultures the rapidly-growing bacillus crowded them out. Especial care had been taken in the preparation of this case. The day before the operation the patient had had a bath; the skin of the breast had been scrubbed with hot soap and water until, as the sister said, the patient almost cried; next the skin had been rubbed with carbolic lotion—1 in 20—and, finally, it had been enveloped in an antiseptic dressing for eighteen hours before the operation. At the operation it was abundantly rubbed and washed with perchloride of mercury lotion—1 in 1,000.

I need not comment upon these aseptic cases; they are but a proportion of the operations which I have done since the last report. Many others which ran the same course are excluded because of the difficulty of being present to obtain inoculations when the dressings were removed.

SEPTIC WOUNDS.

Septic wounds group themselves into two classes; each with clear characters. In the first class the depths of the wound are infected before repair has begun. In these the infection is introduced at the operation, or spreads from an undisinfected sinus or septic focus, or is admitted through a defective dressing and along drainage tubes. The local and constitutional symptoms of this "deep infection" are acute and severe, and are well known. In the second class of septic wounds the superficies of the wound becomes infected after repair has begun. The symptoms of this "superficial infection" are so trivial as to be usually ignored. About the fifth day or earlier there is a slight rise of temperature with loss of appetite, and the wound becomes uncomfortable. If blood clots or bruised and injured tissues in the depths of the wound become infected the constitutional disturbance is greater; there is pain, and the clot is disorganised and liquefied, and has to escape.

The first two septic cases exemplify infection of the depths of the wound by undisinfected sinuses; the third the effect of superficial infection when blood clot is involved; the fourth and fifth are cases of superficial infection from the skin. I have had since the last report but one case in which it seemed probable that infection occurred at the operation. It was a primary amputation through the leg. Unfortunately I was unable to inoculate cultures from it. The exact source of infection was never traced, but a few hours before I had trephined in the same theatre a case of the most septic kind of mastoid abscess, and it is possible that some sponge or appliance which had been infected from it had been inadvertently used for the amputation without having been disinfected.

Infection from Pre-existing Septic Foci.

CASE VIII. *Amputation of Thigh for Old-standing Suppurative Synovitis of Knee; Imperfect Disinfection of Sinus.*—The patient was a delicate woman, aged 35, who had suffered with her right knee for nearly thirty years. There was a sinus towards the outer side of the thigh, which had been discharging for nearly twenty years; it led upwards towards the shaft of the femur, and probably communicated with the knee-joint. The knee-joint and limb had undergone the changes which are usual when chronic suppurative arthritis is engrafted upon tuberculous disease. The joint was almost ankylosed in the flexed position, the tibia being dislocated backwards and

rotated outwards; the synovial membrane was thickened, and the muscles and bones of the limb were wasted. Amputation was performed in the usual way through the lower third of the femur, and an attempt was made to cut clear of the sinus, and its site was washed with perchloride of mercury lotion and rubbed with iodoform, and a small drainage tube left in its neighbourhood. After the operation the patient's temperature never rose above normal, and the dressing was removed on the tenth day. The wound was healed, except at the site of the drainage tube, from which a small quantity of most offensive fluid escaped. The drainage tube was withdrawn, and iodoform emulsion poured into the sinus, which was healed when the second dressing was taken off. Some of the fluid which escaped at the first dressing was inoculated into gelatine tubes, which speedily became liquefied with a foul odour. This was due to the growth of small and very short bacilli, which had all the characters of the bacterium graveolens, a variety found in the skin.⁴ Their comparative innocuousness may be attributed to the circumstance that they are merely saprophytes, and that the attempts at disinfection had probably prevented their multiplication until the reparative material was sufficiently organised to resist their inroads.

It is evident that wound infection did little to hinder the repair in this case of amputation of the thigh, but the extreme difficulty of disinfection is illustrated. That disinfection of old sinuses can be attained by the means which were used is shown by the result of a case of Syme's amputation given in the previous report; but that the process of erasing old sinuses with Volkmann's spoons, washing with perchloride of mercury lotion 1 to 1,000, and stuffing with iodoform is inefficient is, I think, shown both by the case of amputation through the thigh and by a second case of the same kind in which the failure was followed by much more serious results. The following is a very brief account of it.

CASE IX. Amputation of Thigh for Tuberculous Knee; Imperfect Disinfection.—The other case of amputation of the thigh which illustrates the difficulty of disinfection was that of a phthisical man, aged 35 years, who had advanced tuberculous disease of the left knee. The opening of an abscess had been followed by an acutely septic condition of the knee. Amputation was done through the lower third of the thigh, and great attention was given to a sinus which ran along the outer side of the femur; it was scraped with Volkmann's spoons, washed with perchloride of mercury lotion 1 to 1,000, rubbed with iodoform, and a drainage tube inserted. His temperature fell slightly after the operation, and the wound was dressed on the seventh day and the drainage tube removed, and the sinus filled with iodoform. Culture tubes inoculated from the edge of the wound grew staphylococcus albus;⁵ those from the interior grew bacilli and staphylococcus aureus. The wound seemed to be healing fairly well, but when it was dressed again on the fourteenth day the discharge was purulent and foetid, and shortly afterwards the flaps gaped.

⁴ Eisenberg's *Bakteriologische Diagnostik*. 3rd Edition. 1891. P. 108. I wish to say that I have found this admirable book of the greatest service.

⁵ Later investigations by plate cultures throw doubt upon the diagnosis of staphylococcus albus in any case.

There was ultimately good union, and the man was able to return to work.

In this case disinfection and asepsis were of the highest importance, as tissues deteriorated by continuous sapraemia are quite unable to resist septic processes. It is clear that the means which were relied upon in this and the previous case are not rigorous enough.

The only other amputation from which cultures have been inoculated and which was septic was a Syme's amputation performed upon a boy of 12 years of age. Owing to unavoidable circumstances the stump was dressed with double cyanide dressings, which, as in two other cases published in the *BRITISH MEDICAL JOURNAL*, 1890, vol. i, p. 1247, caused acute inflammation of the skin with the formation of large bullæ. The dressing had therefore to be removed, and suppuration followed. *Staphylococcus albus* and *streptococcus pyogenes* grew in the inoculated tubes. The presence of the streptococcus was associated with some suppurative lymphangitis—an affection which it is said to cause.

Superficial Infection.

CASE X. Removal of Tumour of Breast.—The following case is, I believe, a typical instance of infection of the wound by the skin. The patient was a married woman, aged 52, who had a doubtful tumour in the left breast. An incision did not clear up the doubt as to the malignancy of the tumour, and therefore it was removed without taking away the whole breast.⁶ The wound was dressed in the usual way, without drainage. The patient suffered from a neurotic affection, accompanied with pains in various parts, but for some days after the operation she did not seem to have more pain in the breast which had been operated upon than in the other. On the eleventh day the wound was painful, and her temperature, which had been normal, rose to 99.6° F., and the tongue was foul, with loss of appetite. Next day the dressings were removed. The wound was healed except a small piece at one end where a little dark treacly blood exuded. Although the skin looked natural, there was beneath it a fluctuating swelling, from which a quantity of dark fluid blood was evacuated. This collection of blood was washed out with perchloride lotion, and drained, and speedily closed without suppuration. Gelatine tubes were inoculated from the healed part of the wound, and remained sterile; others inoculated from the unhealed part and from the blood grew a coccus with the characters of *staphylococcus albus*. But neither this original culture nor broth cultures inoculated from it seemed to cause ill effects when injected into the veins of rabbits. A microbe with identical characters was grown from the next case, and seemed decidedly pathogenic for rabbits. The history of the case was as follows:

CASE XI. Radical Cure of Hernia: Skin Infection.—S. C., a married woman, aged 45, had an irreducible femoral epiplocele on the right side. The usual operation for radical cure was done on February 2nd, and on February 11th the dressings were removed. Since the operation there had been no rise of temperature or pain or discomfort. The wound was healed, except at the skin level, where the epidermis had not

⁶ This patient was well nine months after the operation, although a histological examination showed that the growth was cancerous.

grown over the subjacent reparative material. It would, I think, be incorrect to say that there was any suppuration, but the line of the wound and some of the surrounding skin were moistened with a little thin, almost transparent, fluid. The wound was redressed with iodoform and sal alembroth wool and the patient allowed to get up. It gave no further trouble. Gelatine tubes inoculated with the fluid grew that which is usually called staphylococcus albus. About 5 drops of these cultures were injected into the auricular veins of two rabbits. One died in thirty-two days and the other was killed at the end of two months, as it was evidently dying. Both of these animals passed an unusual quantity of urine and had diarrhoea. A few days before death they seemed to become paralytic. In both instances there was pneumonia and one had infarcts in its lungs, the other in the kidneys. Nothing obvious could be found in the spinal cord.

CASE XII. *Strangulated Femoral Hernia; Herniotomy and Radical Cure; Skin Infection.*—In the following case superficial infection of the wound with an ordinary skin microbe seems clearly established: E. G., aged 43, was operated upon for femoral hernia of the right side. The usual operation was done, and afterwards a radical cure was performed, the femoral canal being occluded in a satisfactory way. The wound was closed as usual without a drain and dressed with alembroth gauze wrung out in 1 in 40 carbolic lotion. There is nothing to note in the progress of the case. The wound was dressed on the ninth day, when it was found that the alembroth dressing had caused eczema about the fold of the groin, and that the wound was healed except the superficial part, which was wet with a little fluid, thin and transparent, like ordinary starch. Gelatine and agar-agar tubes were inoculated with this fluid, and resulted in the growth of a diplococcus (diplococcus albus) which I have invariably found in cultures inoculated with scrapings from the human skin.

I now propose to refer to the kind of infection which occurred in these and other cases, and endeavour to trace its source. In the cases of amputation of the thigh, it obviously came from the pre-existing septic sinuses which had not been properly disinfected. Like other surgeons,⁷ I have seldom found bacilli in wounds treated with antiseptics, but usually cocci. Recently I have met with an instance in which bacilli were present as well as cocci in a wound treated with stringent antiseptic precautions. A child of 3 had a large congenital cystic hygroma in the axilla. The axilla was opened, the pectoralis major divided, and the tumour removed with the exception of a cyst, which extended into the neck, and enveloped the axillary vessels and brachial plexus. A drainage tube was put in this, and the wound closed. The dressing was removed on the eleventh day, when the wound was healed, except at the drainage tube. There was no pus or odour, but cultures showed that the depths of the wound and the mouth of the sinus were infected with two kinds of cocci and with a bacillus. The child had no rise of temperature, and the sinus was healed on the seventeenth day, when the second dressing was removed. As we proceed with our reference to microbes of the skin, the absence of bacilli from antiseptic wounds will seem to be a rather inexplicable phenomenon.

⁷ Bloch, p. 823.

Another microbe which is common in purulent fluids was met with in a case of pelvic cellulitis, and, as it has a feature of some interest, it is now briefly mentioned. The history was of the usual kind: H. A., aged 19, had been confined of her first child three months previously. She thought she was quite well and got about on the ninth day, although she had slight pain and a vaginal discharge. However, she became ill and had to take to her bed again, and at last was admitted with a huge pelvic abscess which extended into the left thigh. This was opened and the patient soon recovered. The abscess contained a very large quantity of thin, dirty yellow, shreddy pus. Cultures inoculated from this grew beautiful chains of streptococcus pyogenes (Fig. 2). This is all in accordance

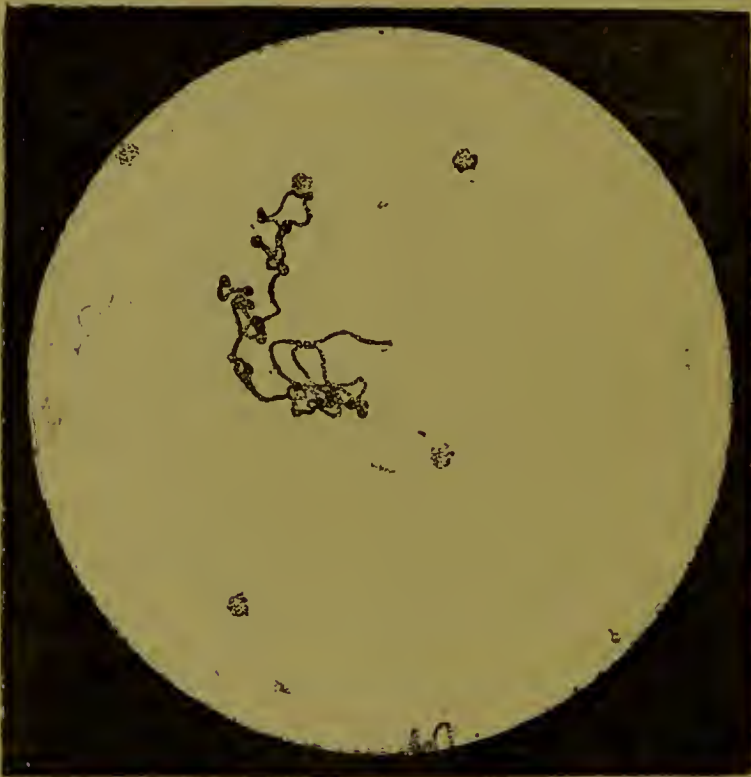


Fig. 2.—*Streptococcus pyogenes* from a case of pelvic cellulitis; grown in broth; stained with methyl blue. The larger elements of the chain contain spores.

with what is customary, and would hardly call for mention; but when Mr. Cosens magnified his photograph of the cocci by throwing it upon the screen, it was clear that each of the larger elements of the chain, or arthrospores, had a small clear point in its centre. Further examination of these with suitable powers confirmed us in our opinion that these clear points represented spores. In coming to this conclusion we were quite aware that there are many points in the life-history of *streptococcus pyogenes* which do not lend it support.

Various kinds of microbes are found in the vicinity of

wounds which have healed under one dressing and without drainage. Perhaps the commonest is a coccus which is the same size as the well-known staphylococcus aureus, and like it grows in clusters. Its growth is rapid in the usual media, and at the usual temperatures. On agar-agar it grows upon the surface and in the depths, and forms circular, heaped-up, cerate-like dots from $\frac{1}{16}$ to $\frac{1}{4}$ -in. in diameter on surface, but smaller, opaque, yellow, irregular colonies in the depths. The behaviour of this microbe to gelatine is characteristic: at 23° C. the medium is in three or four days liquefied, but at 12° to 15° C. it becomes solid again. This liquefying of the gelatine may have caused some to believe that they had to do with staphylococcus albus, but such an idea is negatived by the fact that the gelatine solidifies again at the lower temperature. The appearance of the resolidified gelatine is very typical, inasmuch as the part of it next to the air exhibits a delicate cloud like that of albumen in heated urine, whilst the rest is clear with a white precipitate at the bottom. This microbe stains with all the usual aniline dyes; it has such a tendency to form diplococci that it may be referred to as diplococcus albus. Cultures of these caused local suppuration when inoculated into rabbits, but were harmless when injected into the veins. This diplococcus is, in my experience, always present in cultures inoculated with skin scrapings, and can easily be separated by the method of plate cultures.

Often, however, cultures inoculated from antiseptic wounds contain several kinds of cocci. For instance, after operating for the radical cure of irreducible epiploceles of both right and left sides, I found the cultures which had been inoculated, when the dressings were removed on the eighth day, gave diplococcus albus on the right side, and diplococcus albus and citreus⁸ on the left.

The last-named diplococcus is constantly found in cultures infected with scrapings of normal clean skin (Fig. 3), and I have no doubt that that was its source. Indeed, I now propose to argue and adduce evidence to show that the patient's skin is the usual source of secondary superficial wound infection.

In the first place, when proper care is exercised in preparing the materials used in the performance of the operation, the sources of infection can be narrowed down to (a) the hands of the operator and of his assistants, and (b) the skin of the patient. The atmosphere is not a danger. I have left culture tubes of gelatine open for hours in operating theatres and rooms, and they have not become infected; and gelatine spread out in dishes has had the same immunity. But any danger of infection from the atmosphere has been provided for by filling the wounds with perchloride of mercury lotion, 1 in 2,000, squeezed from a sponge, or, in large and deep wounds, discharged from an irrigator.

It may be otherwise as regards the skin of the surgeon's hands and arms. A great deal has been written about the sterilisation of the hands. Halsted⁹ seems to think that their sterilisation is impossible, but Forster¹⁰ succeeded by washing the hands with soap, and soaking them in sublimate

⁸ Unna and Tommasoli, *Flora Dermatologica*, *Monatshefte für praktische Dermatologie*, No. 2, July 1839, p. 56.

⁹ *Loc. cit.*, p. 298.

¹⁰ Wie soll der Arzt seine Hände reinigen? *Centralblatt für klinische Medizin*, vol. lv, 1886, p. 207.

solution $\frac{1}{1000}$ or $\frac{1}{1000}$. Boll¹¹ was also able to sterilise the hands by washing with soft soap and hot water, with subsequent immersion in 3 per cent. carbolic lotion, followed by $\frac{1}{1000}$ perchloride of mercury lotion. The last observer cleaned the nails with 10 per cent. iodoform gauze soaked in 5 per cent. carbolic lotion. Halsted and his assistants took even greater pains to disinfect their hands, but found that after the greatest efforts the epidermis scraped from them infected gelatine tubes. This seems to be an unreasonably severe test, and beyond the needs of actual practice. I myself found that after the nails had been cut short,¹² and the hands scrubbed with soap and hot water, and dipped into $\frac{1}{1000}$ solu-

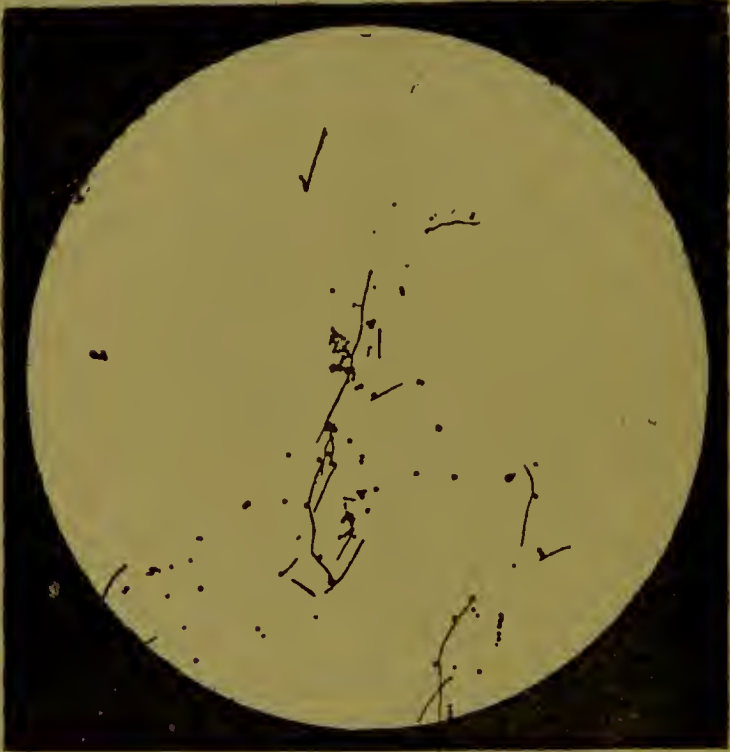


Fig. 3.—Gelatine culture inoculated with scrapings from clean normal skin, stained with fuchsin. From a microphotograph by Mr. Cosens.

tion of perchloride of mercury, the fingers could be dabbed with impunity upon plate cultures of gelatine or agar-agar; also that scrapings of the skin of the fingers gave no result; therefore, I believe that the hands can be sterilised, and afterwards kept so by occasionally dipping them into suitable antiseptics, such as solution of perchloride of mercury $\frac{1}{1000}$.

The skin of the patient is a much harder problem. The difficulty of disinfecting it has already been exemplified, and

¹¹ Franz Boll: Zur Desinfection der Hände, *Deutsche med. Wochenschrift*, 1890, No. 17. He refers to the contradictory results of Kümmell, Förster, Fürbringer, and Landsborg.

¹² I have obtained streptococci from beneath nails which seemed to have been cleaned.

is also shown by the following experiments. After having ascertained that ordinary skin contained various kinds of cocci, streptococci, and bacilli, which were not decolorised by Gram's method, I obtained some skin from two breasts which had been carefully prepared for amputation. The skin of the areola of one of these breasts was cut into sections and stained by Gram's method; its epidermis contained cocci singly and in pairs, and bacilli of various sizes. The skin of the other breast also had cocci and bacilli both in the epidermis and in the mouths of the hair follicles.

It might be argued that the microbes seen in the skin of these two breasts had been killed by the precautions which had been taken. This, however, is negatived by the case (aseptic Case VII) of removal of a chronic mammary tumour. Although in it the skin had been washed and scrubbed until the woman complained, had been washed in 5 per cent. carbolic solution, covered for eighteen hours with an antiseptic dressing, and finally washed just before the operation with perchloride of mercury lotion 1 in 1,000, nevertheless, a bit of this skin infected culture tubes with cocci, streptococci, diplococci, and bacilli such as are usually found in the skin (Fig. 1). The reason for this failure to disinfect the skin was shown in the following way:—

A cover-glass preparation of the contents of a sebaceous gland stained with fuchsin shows that sebum is a mass of cocci, diplococci, and bacilli, together with occasional epithelial cells. After an area which has numerous sebaceous glands had been washed with soap and water, then with perchloride of mercury lotion, 1 in 1,000, and lastly with absolute alcohol its glands were squeezed and cultures inoculated from its surface. The result was a plentiful growth of long and short bacilli, leptothrix, monococci, diplococci, and staphylococci. In a similar way, the properties of the sweat glands were shown. A perspiring surface was washed with soap and water, then with perchloride of mercury lotion—1 in 1,000—and afterwards with absolute alcohol. As soon as the sweat reappeared, nutrient material was inoculated with it and grew quantities of staphylococci (Fig. 4), and in old cultures some bacilli and leptothrix. Thus there was a slight difference in the first results of these experiments. Sweat glands gave a growth of cocci with few bacilli, whilst sebaceous glands gave bacilli with few cocci.

These simple observations and experiments point to an obvious cause for the infection of antiseptic wounds, and render the microbes of the skin of great importance.

The pathogenic properties of the microbes of the skin seem to be considerable. When cultures which had been inoculated with the contents of sebaceous glands were introduced into the subcutaneous tissues of mice, they killed the animals in three or four days, causing œdema, suppuration, and ulceration, with loss of hair. These cultures had the peculiar disagreeable odour possessed by the contents of sebaceous retention cysts. I also found that pure cultures of bacillus epidermidis cultivated from skin scrapings had the same effect upon mice as the mixed cultures.

It was also ascertained that a fluid composed of skin scrapings suspended in normal saline solution and injected into the auricular veins of rabbits usually causes a fatal result. Some rabbits died at once—killed, perhaps, by the coarse particles; others died some days or weeks afterwards.

A strong, healthy animal wasted and died twelve days after the injection. It had diarrhoea and its cage was constantly wet. In another the symptoms were the same, but there was also suppuration at the seat of inoculation and a considerable inflammatory œdema of its neck. After it had been killed, infarcts such as Professor Hamilton¹³ has described were found in its kidneys, and there were areas of pleuro-pneumonia in the lungs. In another animal the kidneys seemed to have escaped, but the lungs contained many infarcts.

These effects might possibly have been caused by the particles of epidermis, and therefore the experiments were repeated with gelatine cultures which had been inoculated

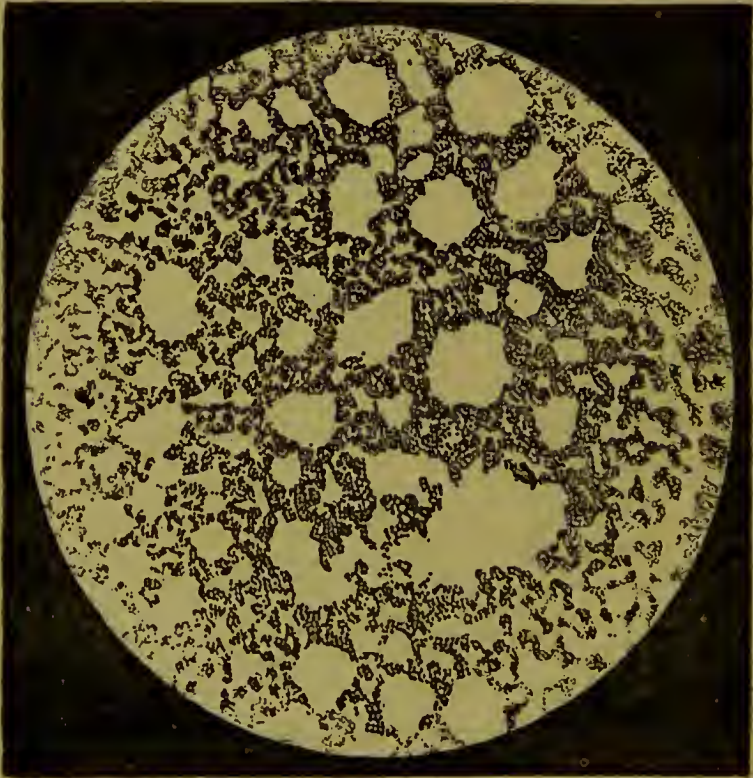


Fig. 4.—Gelatine culture inoculated from perspiring skin which had been washed with soap and water, with perchloride of mercury lotion ¹⁰⁰⁰, and with absolute alcohol. Stained with fuchsin. From a microphotograph by Mr. Cosens.

with the same kind of fluid—namely, normal saline solution mixed with skin scrapings. The gelatine was rapidly liquified, and contained a great many kinds of microbes—cocci of various sizes, diplococci, staphylococci, chains of from four to twelve cocci, some consisting of large others of small elements, numbers of very small short bacilli aggregated into small groups, a larger spore-containing bacillus with rounded ends, and leptothrix (Fig. 3). This fluid seemed more virulent than a mere solution of skin scrapings. An intravenous inocula-

¹³ *A Textbook of Pathology*, vol. 1, 1889, p. 680.

tion of from 5 to 10 drops soon made the rabbits ill; they ceased to feed and became emaciated, and their cages were constantly wet. The lungs were the organs most attacked, and in the early stages were engorged and inflamed, especially at their periphery.

Thus the skin contains microbes which are pathogenic for mice and rabbits. But it also constantly harbours staphylococcus aureus and staphylococcus albus,¹⁴ which are pathogenic for man, and Eisenberg¹⁵ gives a list of others which, if less known, are equally dangerous.

Of course the pathogenic microbes of the skin are associated with many species which are, perhaps, harmless. But it is evident that no wound treatment is ideally safe which fails to exclude them all, because, as I said in the previous report, there is no method which can exclude the harmful microbes from wounds and at the same time allow the so-called harmless to enter.

The cases given at the beginning of this report show that asepsis can be attained in spite of the difficulty which at present exists of disinfecting the patient's skin. In explaining this paradox, it is to be remembered that the wounds were dressed with iodoform and with 5 per cent. carbolic gauze wrung out in perchloride of mercury lotion 1 in 2,000. Both of these remained in contact with the skin, and doubtless kept it aseptic. Another factor in their relatively safe and rapid healing was probably the infrequent use of drainage and the accurate adjustment of the skin. The apposed skin unites as rapidly as the peritoneum would do, and thus most of the wounds were superficially healed before their depths could become infected. Advantage is taken of this peculiarity of the skin with the view of obtaining—so to say—subcutaneous repair of the depths of the wound.

The infection of wounds with skin microbes is obviously due to causes which have already been pointed out—namely, our present inability to disinfect the skin. At first I thought that iodoform rubbed into the skin, but not introduced within the wound, would do away with this danger. But although iodoform gives good results, it is far from perfect. Therefore, with the assistance of Messrs. Masterman and Maingay, I have endeavoured to test the antiseptic and disinfectant properties of iodoform. First, it was ascertained that iodoform was not infective. Dusted on the surface of broth, it floated for days at a temperature of 23° C., but soon mingled with the broth at 37° C. Tubes which had been treated in this way were good culture media for staphylococcus aureus.

Next, plate cultures of gelatine and of agar-agar were infected, some with staphylococcus aureus, others with skin microbes, such as staphylococcus albus, diplococcus albus, and diplococcus citreus. Broth cultures inoculated from these after intervals of five, ten, fifteen, and twenty minutes, were infected, as were others which were inoculated after three weeks. Iodoform did not disinfect, it merely inhibited the growth of the microbes. We obtained the same results with boracic acid and with quinine. Salicylic acid did not kill in five minutes, but was efficacious in ten. However, this drug seems too strong to apply pure to the skin. We propose to continue these experiments, and great encourage-

¹⁴ *Traité Pratique de Bacteriologie*, Macé, 1891, p. 721.

¹⁵ *Bakteriologische Diagnostik*, 1891, p. 28.

ment is derived from the circumstance that inasmuch as our present methods almost invariably prevent the growth of bacilli in wounds, so antiseptics may be found which may prevail against other varieties. The difficulty is, of course, to find one which is potent, but which will not injure the skin when left in contact with it. Sir Joseph Lister's double cyanide gauze and powder seem to be suitable, but, owing perhaps to want of skill in their use, I have had severe blistering in three cases treated with them.

The last case was a Syme's amputation, which has been mentioned at p. 1130. Its recovery was merely delayed.

Although a knowledge of the microbes of the skin is so essential in aseptic surgery, our principal surgical authors hardly mention them. Even works on bacteriology, such as those of Baumgarten, Cornil and Babes, and Flügge, briefly allude to them. Much information can, however, be obtained from scattered papers, and especially from those which Dr. Unna has written in conjunction with Von Sehlen, Gründler and Tæzner, and Tommasoli.¹⁶

In conclusion I wish to say that I owe my best thanks to my friend Mr. Cosens for all the trouble he has taken to produce the microphotographs.

¹⁶ *Flora Dermatologica, Monatshefte für praktische Dermatologic*, vol. vii, et s.