

PRELIMINARY REPORT
ON
ASEPTIC AND SEPTIC SURGICAL CASES,
INCLUDING
TRAUMATIC TETANUS, GANGRENE, AND ACUTE EPIPHYSITIS.

BY C. B. LOCKWOOD, F.R.C.S.,

Surgeon to the Great Northern Hospital; Senior Demonstrator of Anatomy and of
Operative Surgery in St. Bartholomew's Hospital.

Reprinted for the Author from the BRITISH MEDICAL JOURNAL, Oct. 25, 1890.



PRINTED AT THE OFFICE OF
THE BRITISH MEDICAL ASSOCIATION, 429, STRAND W.C.



PRELIMINARY REPORT ON
ASEPTIC AND SEPTIC SURGICAL CASES,
INCLUDING TRAUMATIC TETANUS,
GANGRENE, AND ACUTE
EPIPHYSITIS.¹

THE following gives the results of the bacteriological examination of a number of surgical cases. The work was begun to ascertain whether my methods of wound treatment excluded microbes, and to show the effects of their presence or absence upon the clinical history of the cases. Some of the traumatic infective diseases have also been investigated, and points of interest which have arisen will be mentioned.

Before proceeding it is necessary to premise that for present purposes, and from a logical and scientific standpoint, no antiseptic method is perfect which does not secure absolute sterility. Observers have been somewhat complacent upon this point. Microbes having been found in wounds treated by the best antiseptic methods, and which were said to have been pursuing a typical aseptic course,² it seems to have been inferred by some that there are harmless microbes, the presence of which is permissible in aseptic wounds. We have here, however, two distinct and separate questions; first, the possibility of excluding microbes from wounds; and, secondly, the properties of microbes. It is intended to keep these two questions apart. As regards the supposed harmlessness of microbes, it may be observed that cultures of those which Mr. Watson Cheyne³ found in typical aseptic wounds killed rabbits with considerable certainty.

I have never seen a microbe-containing *antiseptic* wound which, in my opinion, ran a perfect course.⁴ It is greatly to be questioned whether some of the microbes which have been considered innocuous, such as the rare staphylococcus cereus albus and staphylococcus cereus flavus, are as innocent as is thought.⁵ All seem prejudicial to wound healing. In the next place, it is obvious that methods of wound treatment which permit the entrance of one kind of microbe may permit the entrance of another, and I am not aware of any method which claims to exclude the harmful but not the harmless.

¹ This work was assisted with a grant from the Scientific Grants Committee of the British Medical Association. I am also greatly indebted to the Committee of the Great Northern Hospital for the use of a room and other conveniences.

² Micrococci in relation to Wounds, Abscesses, and Septic Processes, BRITISH MEDICAL JOURNAL, 1884, vol. II, p. 553, *et seq.*

³ *Loc. cit.*, p. 599.

⁴ See Cheyne, *Antiseptic Surgery*, p. 247.

⁵ See Baumgarten, *Lehrbuch der pathologischen Mykologie*, vol. I, p. 328. 1890.

It is proposed in what follows to confine the use of the word "aseptic" to wounds which contained no microbes, and to apply the word "septic" to those which did.

As evidence of the asepticity of wounds it is customary to refer to the constitutional condition of the patient, to the condition of the wound, to the microscopical characters of the wound products, and lastly, to cultures made from the wound. I do not propose to rely upon the constitutional condition of the patient as evidence of the sterility of the wound. Some septic conditions of wounds cause practically no constitutional disturbance, although they are prejudicial to healing. On the other hand, constitutional disturbance is not necessarily evidence of septicity, although it must always be a sign of great import, and be taken as throwing doubt upon inferences of asepticity drawn from other sources.

Nor has reliance been placed upon the condition of the wound as a proof of its asepticity or otherwise. Although aseptic wounds heal without the usual signs of inflammation, such as pain, heat, redness, and swelling, and without visible effusion; nevertheless, as everyone knows, the absence of those phenomena is not clear evidence of asepticity. On the other hand, the occurrence of any of the above phenomena suggests a strong probability of septicity, although in cases they may be owing to other causes, such, for instance, as chemical irritants. We may also recall that the repair of some simple fractures is attended with considerable local heat, and sometimes redness and effusion, although there may be no evidence whatever of local infection.

Therefore, inasmuch as the clinical evidence is open to objections, I have relied upon the microscopical examination of the wound products and upon the inoculation of culture media with substances from the wound. The first of these plans is of small value, because, although when many microbes are present they are easily seen, yet when few and scattered they are just as easily overlooked. Culture media, especially pepton gelatin (10 per cent.) and pepton agar-agar, are a much more delicate and reliable test; but, nevertheless, I have reason to think that there are microbes, or phases in the life of microbes, for which ordinary nutrient media are not well adapted. However, they are at present the best and most convenient test at our disposal, and I think the result will show that it is improbable that their use has introduced error into this investigation.

The ordinary tenets of antiseptic surgery have been adopted, and it has been assumed—(a) that in health the unexposed tissues are sterile; and (b) that suppuration and the other septic and infective diseases of wounds are due to microbes introduced from without. Doubtless wounds are sometimes infected through the circulation (auto-inoculation), but this seems an unusual thing, and the causes of it can usually be recognised.

It is unnecessary to dwell at length upon the methods of wound treatment and dressing. Whenever possible, the patients were prepared as if for ovariectomy. The area of operation was shaved and cleansed in the usual way, and covered with a perchloride dressing for at least twelve hours before the operation. As each operation had to be looked upon as a bacteriological experiment, most scrupulous care was taken to sterilise all sponges, ligatures, and silk. The latter was always used for stitches, and usually for tying vessels. Hæmorrhage was stopped at once, to prevent any blood extravasating into the tissues. The most perfect coaptation of the wound was attempted.

Before applying the dressing the wound was irrigated with some quarts of warm perchloride lotion, and one or more Martin's

rubber bandages were used outside the dressing to exclude air and produce equable pressure. Various materials have been tried, but it seemed as if the best dressing was the 5 per cent. carbolic gauze, well wrung out in 1 in 2000 perchloride lotion, next the wound, then plenty of alembroth wool, and a very large carbolic gauze outside dressing.

Drainage tubes have been gradually discarded because it was observed that aseptic wounds produced so little fluid that they were unnecessary. It was also thought that the tissues could, if necessary, absorb a considerable quantity of fluid, so long as it was aseptic. Drainage tubes were found objectionable in other ways, as they delayed union and necessitated a change of dressing for their removal.

ASEPTIC SURGICAL CASES.

Syme's Amputation.—Patient was a tuberculous subject, aged 21. He had tuberculous disease of the synovial membrane of the left ankle, with two suppurating sinuses leading into the joint; there was erosion of cartilage but no caries; he also had a number of suppurating glands in the neck. After the amputation great pains were taken to remove all the synovial membrane; the sinuses were erased, washed with perchloride lotion (1 in 1,000), rubbed with iodoform, and drained. The operation was done on November 28th, 1888, and dressed on December 6th, when the drainage tube and sutures were removed. Cultures inoculated at this dressing were quite sterile, and wound moisture examined microscopically contained no microbes. Dressings removed three weeks after the operation, when healing was complete. This patient was free from pain and had a normal temperature throughout. The healing was rapid for a Syme's amputation, and the case is interesting as showing that chronic septic wounds can be made aseptic. The synovial membrane had the usual giant cells, but no tubercle bacilli could be seen. Another Syme's amputation ran a similar course but I was unable to inoculate cultures from it.

*Excision and Erasion of Hip.*⁶—Boy aged 6. Head of femur removed and joint erased through an anterior incision. The joint contained turbid fluid, and the cartilage of the femur was eroded; the surrounding tissues were oedematous, with enlarged inguinal and iliac lymphatic glands. The wound was irrigated, rubbed with a drachm of iodoform, and closed with deep sutures and without drainage. Operation on March 13th, 1889; dressing removed on April 1st. Cultures from moisture at upper part of incision quite sterile.

The course of this case was as follows: The day after the operation he had a temperature of 100° F., and was sick; this was attributed to iodoform. Afterwards his temperature was normal, except on the tenth day, when it was 99.2°. He was very ill and in great pain before the operation, but afterwards became very cheerful and happy. Fifteen months after the operation he has a good and freely movable hip.

Amputation of the Thigh for Senile Gangrene.—A man aged 66 years was admitted with gangrene of the toes of the right foot, with inflammatory swelling of the foot and lower part of the leg. The internal saphenous vein was tender and inflamed, and it was plugged as far as the knee. As his temperature was from 103.4° to 102.2°, and as he was delirious and suffering great pain and losing ground, I amputated through the lower third of the femur by skin flaps and a circular incision through the muscles. His tem-

⁶ Reported in *Clin. Soc. Trans.*, 1890.

perature became normal. The wound was dressed on the fifth day, and a drainage tube and some stitches removed. This dressing was taken off on the twelfth day, when I am told that the wound was healed. Cultures from the interior of the drainage tube when it was removed remained sterile.

This case hardly calls for comment. The dressing was but little stained, and the drainage tube seemed to have been superfluous. The examination of the gangrene is given later.

Amputation of Breast and Removal of Axillary Glands.—The whole of the left mammary gland together with the subjacent fascia and some axillary glands of a woman, aged 46, were removed on November 19th, 1889. As much as possible of the wound was closed with button sutures, the axillary part being closed without drainage. The night after the operation the temperature was 99.4° F., and reached the same height on the fourth day, but with these exceptions was normal. The dressing was removed on the tenth day to take out the button sutures, the wound was healed except where it could not be brought together. There was no pus and two cultures gave no result. The antiseptic dressing was finally removed on the 17th day, when a small unhealed surface remained.

After she had recovered from the shock of the operation this patient was quite cheerful and well, with a good appetite. Professor Ogston⁷ says he has found it impossible to keep axillary wounds free from organisms. It is of course very difficult, but when no drainage tube is used, as in this case, the axillary wound is healed before microbes have time to multiply and infect it. However, the risk of the omission of drainage would be great without asepsis and pressure. A similar, but rather more severe, operation of a similar kind ran the same course, but I was unable to obtain inoculations from it.

Large Lipoma of Back.—A large lipoma was removed from the back of a woman, aged 43, leaving a wound eight inches long and of considerable width. The wound was closed without drainage. The temperature remained normal after the operation, and the dressing was removed on the ninth day, when the wound was healed. Cultures were inoculated with stitches and with some clear fluid from a vesicle near the wound, but they remained sterile.

The only complaint this patient made was about the tightness of the Martin's bandages.

Excision of Navus.—A venous nævus of some size was excised from over the middle of the left sixth and seventh ribs of a boy, aged 8. The operation was done on December 5th, 1888, and the wound dressed on December 12th. Cultures made from sutures and moisture gave no result. Drainage not employed.

This patient's temperature was normal throughout, and he seemed quite well and free from pain. The operation is such a small trial that it is hardly worth recording except that the wound was tested to ascertain its sterility.

The cases mentioned in this report are but a few of those which have been under my care. No attempt has been made to select them, and many of a like nature have been omitted because of the difficulty of being present when the wounds were dressed for the first time. When it was found that a culture inoculated from a wound remained sterile the greatest confidence was felt as to the after-progress of the case. Two days was enough to set the question at rest.

⁷ *Micrococcus Poisoning*. Alexander Ogston. *Journal of Anatomy and Physiology*, vol. xvi., p. 528.

SEPTIC CASES.

Amputation of the Thigh.—Amputation was performed through the left thigh of a healthy country labourer on account of an ossifying sarcoma of the upper end of the fibula. Two chicken bone drainage tubes were inserted, one at the outer angle of the wound and one through the posterior flap. The wound required packing the same night, and was dressed the next day (packing for thirteen hours). The drainage tubes were found blocked with clots, and were removed. After this three more dressings were required, namely, on the fifth, eighth, and twelfth days. There was no inflammation or suppuration, but a quantity of tarry-looking fluid, broken down blood clot, escaped from the wound. His temperature was 99.2° the day after the operation, and then normal until the day of the second dressing, when it was 99° in the morning and 99.8° in the evening, and 99° for some days longer. The date of the amputation was January 16th, 1889, and the stump was firmly healed on February 19th. At the second dressing cultures were inoculated from the edge of the wound and from the tarry fluid from the interior. The former remained sterile, the latter contained staphylococcus pyogenes albus. Although this wound healed well and rapidly, I was of opinion that there was not the same comfort and absence of pain as in aseptic cases. It seems probable that there was some oozing of blood after the application of the first dressing, and that the clot was liquefied by the microbes in the same way as coagulated serum or gelatine.

Amputation of Breast; Removal of Axillary Glands.—The entire mammary gland, together with the pectoral fascia and axillary lymphatic glands, were removed from a woman, aged 41 years. The wound was brought together as much as possible, and a drainage tube placed in the axilla. Catgut was used for the vessels, and sterilised silk for the skin and button sutures. The wound was dressed by the house-surgeon on the second day because discharge was through the dressing, and again on the seventh day to remove the button sutures and drainage tube. Hitherto the temperature had been about 99° , and never higher than 99.6° . On the eighth day the temperature was 101.4° , and remained rather irregular for some time after. At the second dressing cultures were made from some purulent fluid from the axilla, and from the unapproximated part of the breast wound. The latter was sterile, but the former contained encapsuled cocci, like those sometimes found in saliva, from whence they may have come. The axillary wound was some time in healing.

Removal of Fatty Tumour from Subclavian Triangle.—A large and irregular fatty tumour was removed from the left subclavian triangle of a girl, aged 17. The tumour was easily removed, with the exception of some deep finger-like processes. A drainage tube was placed in the wound, and required removal on the sixth day. There was pus in the tube, and dressing and cultures contained staphylococcus albus. The wound, which was red and inflamed, was dressed again on the tenth day, and this was replaced on the fourteenth with lead and spirit lotion. Healing was not completed until the end of the third week. The highest temperature was 99.4° , but the girl's appetite was bad, and she had some pain. It was thought that this wound became infected from the air, by the dressing being disarranged by the movements of the head. It contrasts very unfavourably with a similar one which remained aseptic after the removal of a large fatty tumour from the back. In the last case no drainage was used, and the pressure was, without doubt, more efficient.

Traumatic Tetanus.—The contagious nature of tetanus has been long suspected. Verneuil⁸ has argued that it is never spontaneous, but always due to traumatic infection, and he traces the infection to horses.⁹ This view has received great credit in France; so much so that we find a case recorded because no contact with horses could be discovered.¹⁰ Horse dung seems especially open to suspicion, and thus it is found that ordinary dust, garden earth, and surface soil play an important part in the causation of tetanus. Nicolaier (who discovered the bacillus), whilst experimenting with earth from fields, gardens, and roads upon mice, rabbits, and guinea-pigs, found that some cases died of malignant oedema and others of tetanus.¹¹ Senn,¹² who gives a good account of the history of tetanus, refers to Bononie's observations, that out of seventy persons injured by the falling of a church during an earthquake, seven were attacked by tetanus. Animals inoculated with the dust of the church died of tetanus, although those inoculated with dust from another church did not.

Kitasato¹³ was the first to obtain pure cultures of the bacillus of tetanus, and, through the kindness of Dr. Kanthack, I am indebted to this observer for some excellent pure control cultures. His method is as follows: Pus from a case of tetanus is inoculated into nutrient agar-agar prepared with 2 per cent. of grape sugar. This culture is kept at 37° C. for twenty-four hours, after which it contains a large number of microbes, including the bacillus of tetanus. This mixed culture is heated to 80° C. for half an hour in a water bath, and afterwards inoculated into nutrient gelatine, blood serum, or grape-sugar agar-agar. The cultures are then immersed in hydrogen, and kept for a week at 20° C. As the bacilli multiply they produce some gas and a penetrating odour. Old cultures keep their virulence for long periods.¹⁴

Kitasato's observations also show that the spores of the bacillus of tetanus are very tenacious of life;¹⁵ they bear a temperature of 80° C. for half an hour to an hour, but are killed by five minutes' stay in the steam steriliser at 100° C. They were still virulent after ten hours' immersion in 5 per cent. carbolic lotion, but fifteen hours killed them. A solution of perchloride of mercury (1 in 1,000), with 5 per cent. hydrochloric acid, killed them in thirty minutes, although the same strength of perchloride without the acid took three hours. As might be expected, the attenuation of tetanus has been attempted, and with some measure of success.¹⁶

The bacillus of tetanus is said to be mobile, and has three principal phases of existence¹⁷; namely, a spore stage, a bacillus stage, and a spore-bearing stage. The most characteristic is the spore-bearing, during which the bacillus is swollen and bulged, usually at one end, by the spore. At this "club" stage it stains deeply

⁸ *Comptes Rendus de l'Académie des Sciences*, 1887, p. 552 *et seq.*

⁹ *Origine et Pathogénie du Tetanos*, *Revue de Chirurgie*, 1887, p. 759.

¹⁰ *Archives Gen. de Méd.*, May 30th, 1890.

¹¹ Ueber Infectiösen Tetanus, *Deutsche medicinische Wochenschrift*, 1884, p. 842. *et seq.*

¹² *Surgical Bacteriology*, p. 152. Mr. Anderson (*Lancet*, 1888, p. 212) also has given an excellent summary of the history of tetanus.

¹³ Ueber den Tetanusreger, *Verhandlungen der Deutschen Gesellschaft für Chirurgie*, 1889, Pt. 2, p. 162.

¹⁴ Befanti and Pescarolo grew the bacillus of tetanus in small glass capsules, closed at both ends. *Centralblatt für Bakteriologie*, vol. v, p. 711.

¹⁵ *Loc. cit.*, p. 168.

¹⁶ Bossano, Atténuation du Virus Tétanique par le Passage sur le Cobaye, *Comptes Rendus de l'Académie de Sciences de Paris*, T. cvii, 1888, p. 1172. Abstract in *Centralblatt für Bakteriologie*, vol. v, p. 554.

¹⁷ Excellent photographs of the bacilli of tetanus will be found in the *Atlas der Bakterienkunde*, Fraenkel und Pfeiffer, 1890, Fig. 50.

throughout, with the exception perhaps of a single bright spot at the thick end of the club, which indicates the position of the minute commencing spore (Fig. 1 C). When the spore is fully developed or, in its turn, gives birth to a bacillus, the appearances are equally characteristic, and are very like those of a drumstick (Fig. 1 B). The spore itself has no obvious peculiarity, but is small and round, or oval, and stains with difficulty, or not at all. The bacillus of tetanus also seems to multiply by fission, forming short chains.

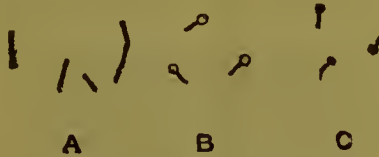


Fig. 1.—Bacilli of Tetanus $\times 900$.

When not bearing spores the bacillus of tetanus is a straight stiff rod of varying length, and with rounded ends, and which either lies apart from its fellows or is linked with two or three to form a short chain (Fig. 1 A). It is strongly anaërobic, and its growth in solid nutrient media is characteristic.¹⁸ Inoculated by a stab the bacilli begin to multiply some distance below the surface, and as they penetrate the medium produce a delicate feathery appearance (Fig. 2).

The effect of pure cultures upon animals is very typical, and throws light upon the action of the bacilli. A few hours (usually less than twenty-four) after the root of a mouse's tail has been inoculated with an appreciable quantity of pure culture, the tail becomes rigid, and either bent to one side or in a corkscrew fashion; the hind legs are next seized with spasms, and sometimes with tremors. The spasm becomes so intense that first one and then the other leg is extended, with the sole of the foot turned upwards; then the muscles of the trunk, of the forelimbs, and of the neck and head become tetanic in definite order, those nearest the point of inoculation first and afterwards those at a distance; and in about twenty-four hours the animal is dead. If the neck or fore limbs be inoculated, instead of the root of the tail, the tetanus begins in them. The period of incubation varies, being about twenty-four hours in the mouse, five days in rabbits, and may be, as cases I am about to relate show, four days in a child and sixteen in a strong man.

The first case of tetanus occurred in a healthy boy, aged 4, who ran a bit of firewood into his face close to the angle of the jaw. Mr. Godfrey informs me that the accident happened whilst the child was playing in the garden. After four days' incubation the facial muscles began to twitch, and this was followed by trismus and opisthotonos. Death ensued on the fourth day, and twelve hours before it occurred I excised a small ulcer from the point of injury. Half of this material was implanted beneath the skin of a rabbit, but only caused a small abscess. Sections of the other half were stained in carbol-fuchsin, but, as usual, no bacilli were found; only streptococcus pyogenes. Cover-glass specimens of the juice contained cocci and a very few club-shaped bacilli. No *post-mortem* examination was allowed, but a morsel of tissue was obtained from the wound. Cultures of this contained strepto-

¹⁸ I have not found it necessary to use hydrogen, but to put the culture material in very long narrow test tubes.

coccus pyogenes, and were quite inert when inoculated into mice. Some of the soil from the garden suspended in water and injected beneath the skin of two rabbits gave no result, but about a drachm of the same soil gave a rabbit typical tetanus, from which it died. The disease in this animal was accompanied with more tremor than in the mice inoculated with pure cultures. Three mice were inoculated with tenacious white material from the place where the earth had been implanted into the rabbit, and all became tetanic; one died, but the other two got slowly well. These latter were afterwards unaffected by inoculation with a pure culture.



Fig. 2. (From Fraenkel and Pfeiffer, Fig. 55.)

The commencement of this child's tetanus in the muscles nearest the wound is very significant, and betrays the closest resemblance to tetanus produced by earth or cultures.

For the second case I am indebted to Mr. Marrant Baker. The patient was a smith by trade, and was 22 years old. On May 22nd he jumped upon a box and drove a nail through his boot into the sole of his foot, causing a transitory redness and swelling. I am told that this accident happened in the outhouse of a garden in the country. After an incubation of sixteen days his neck and jaws became stiff, and this was followed by violent spasms of the limbs and

trunk, the legs and abdominal muscles being especially affected. He died from spasm of the glottis after eight days' illness. Just before death his temperature was 106.8°, and after, 108.6°. The point of inoculation was excised soon after the tetanus began, but Dr. F. W. Andrewes tells me that he could find no bacilli in it nine hours after death. Messrs. Lucas and Edwards, Mr. Baker's house-surgeons, very kindly obtained for me some blood, blood and cerebro-spinal fluid, and an inch of the upper part of the cervical spinal cord.

Neither the blood nor the mixture of cerebro-spinal fluid and blood could be seen to contain bacilli, and they were harmless when inoculated into mice. Some of the spinal cord was implanted beneath the skin of the abdomens of two rabbits, but caused nothing beyond a sore, a result with which most experimenters are familiar.¹⁹ Agar-agar tubes were inoculated with bits of the cord and incubated at 37° C. for twenty-four hours; these had numbers of the bacilli of tetanus, in the drumstick stage, in the gravy at the bottom of the tube, together with many other microbes. Two mice inoculated with these cultures died during the night, with their limbs extended as if running, and one of them with food in its mouth. In these respects they were the same as mice killed with pure cultures of tetanus.

Bits of pia mater and arachnoid were stripped off the cord and stained with carbol-fuchsin and decolorised with alcohol. The arachnoid contained numbers of saprophytes, together with bacilli in short chains, and which had the characters of non-spore-bearing bacilli of tetanus, but it also had upon it scattered "drumstick" bacilli, about which there was no doubt. It was very questionable whether the substance of the cord contained bacilli, although many sections were examined. Rosenbach,²⁰ who found bacilli of tetanus in the spinal cord of rabbits killed with tetanus, remarks upon their fewness and upon the absence of spores. He says that Nicolaier, out of many observations, only once found the bacillus in the nerves (sciatic), near the point of inoculation, and only twice in the spinal cord. These observations seem to show that tetanus may at first be a local disease, and thus they favour vigorous treatment of the point of inoculation. Punctured wounds seem most favourable for its production, as might be expected for such a strongly anaërobic bacillus.

Gangrene.—A case of amputation of the thigh for senile gangrene has already been mentioned, and the following is the result of the examination of the diseased tissues. With proper precautions gelatine and agar-agar tubes were inoculated from the gangrene of the toes, from the inflamed, dusky red, œdematous tissue of the foot, and from the thrombus in the saphenous vein, taken just below the knee. Before giving the result of this I may remark that the term "senile" gangrene is merely used to denote its appearance and to imply that the disease was in an old man—old in appearance rather than in years, for his age was only 66. The arteries of his leg were free from disease and were not plugged, and his heart and other organs seemed healthy. The causation of the gangrene was obscure, but more than a month before it began the great toe was injured by a rusty nail. The cultures from the dead tissue stank horribly, and contained putrefactive bacilli, moderate doses of

¹⁹ Rosenbach, Zur Ätiologie des Wundstarrkrampfes beim Menschen, *Archiv für klinische Chirurgie*, 1887, p. 308 *et seq.*

²⁰ *Loc. cit.*, p. 316. Rosenbach says the bacilli were typical but without spores. Perhaps this refers to the club stage. Bacilli of tetanus seem easily stained, but easily decolorised.

which were quite harmless when injected into the subcutaneous tissue of mice. The cultures from the clot in the internal saphenous vein remained sterile. Those from the inflamed, dusky red, cedematous tissue of the dorsum of the foot contained various kinds of micrococci, but no bacilli. The following kinds of micrococci were separated by plate culture, namely, streptococcus pyogenes, in chains of considerable length, staphylococcus aureus and citreus (the last is probably a more brightly coloured variety of aureus); and, lastly, a large micrococcus which grew in clusters and in chains, and was singular in its reproduction. A single full sized coccus divided into two others of unequal size and often of kidney shape, and lying with their hilums towards one another (Fig. 3); these, whilst still in that position, underwent a



Fig. 3.—Gangrene. Large cocci undergoing unequal division $\times 1200$.

further fission, so as to give rise to groups of four and sometimes eight (Fig. 3). Those which were in chains underwent fission in the direction of the chain, which thus became doubled (Fig. 3). This microbe formed a creamy white layer on agar-agar and gelatine, producing a strong smell of decayed cheese. The gelatine was slowly liquefied.²¹

As far as I am aware little has been written about the bacteriology of senile gangrene.²² In the present case it is not known what originally killed the toes, but it is clear that after their death they were a breeding ground for bacteria. Afterwards the neighbouring tissues, being feeble and unable to resist, became infected, and not only did the gangrene spread into new districts, but sapræmia also ensued, as was evidenced by the high temperature.

The finding of micrococci in the parts which seemed about to mortify is in accordance with the observations of Koch,²³ Ogston,²⁴ and Rosenbach.²⁵ Invasion by bacilli seems a rare and doubtful occurrence, except, of course, in acute spreading traumatic gangrene. The authors who have just been mentioned have proved that streptococci are the cause of inflammatory mortification.

Either the streptococcus or the staphylococcus alone can cause gangrene. Koch and Rosenbach met with the streptococcus in their researches. Ogston found streptococci in that which he calls "erysipelatoid wound gangrene," and staphylococci in "inflammatory mortification." The case I have just described contained both varieties, as did also two others. The first of these cases was that of a man, aged 61, who had mortification of the skin of the dorsum of the foot, the vitality of which had been per-

²¹ Klebs (*Die allgemeine Pathologie*, 1887, p. 311) says that staphylococci sometimes assumes sarcina forms and that they may grow in short chains. In some respects they accord with Crookshank's account of the merismopodia. *Manual of Bacteriology*, p. 194 et seq.

²² Baumgarten (*Lehrbuch der pathologischen Mykologie*, 1890, p. 743) refers to some observations of Tricomi, but only to cast doubt upon their value.

²³ *Etiology of Traumatic Infective Diseases*. Trans. by W. Watson Cheyne. New Sydenham Society, 1880, p. 40.

²⁴ *Journal of Anatomy and Physiology*. Vol. xvii., p. 37.

²⁵ *Microparasites in Disease*. Trans. by W. Watson Cheyne. New Sydenham Society, 1886, p. 428.

manently lowered by a fracture of the tibia and fibula ten years before. There was a history of a slight injury. The gangrene was followed by ulceration and by the formation of orange pus of Verneuil, and cultures showed that streptococcus pyogenes and staphylococcus albus were present, but no aureus.

The second case was one of acute inflammatory gangrene of the scrotum and skin of the penis, which followed an operation performed by one of my colleagues for the cure of hernia. The gangrene was accompanied with profound constitutional disturbance. Fluid from the wound contained streptococci, whilst streptococcus pyogenes and staphylococcus aureus grew in cultures.

The apparent absence of microbes from the clot in the saphenous vein of the first case was unexpected, the supposed septic condition of that vein was one of the reasons why amputation was performed through the thigh at such a distance from the main disease. The importance of ascertaining from future cases the exact extent of the infection of the tissues is too obvious to need pointing out. Efforts ought also to be made either to remove or sterilise the dead tissues.

Acute Epiphysitis.—In March, 1890, a youth, aged 14, was supposed to have had an attack of acute rheumatism. He came under my care three weeks after its onset, with the usual signs of acute synovitis of the hip, very ill, and with a temperature of 101°. A few days afterwards some pus was removed with an aspirator from the neighbourhood of the hip. For a day or two afterwards the local condition improved, but in the meanwhile it had been ascertained by cultures that the pus contained staphylococcus aureus. The temperature continued high (101.8°), and the boy was losing ground so rapidly that the hip-joint was explored by an anterior incision. There was pus both within and without the joint, and the upper epiphysis of the femur was only joined to the shaft by some soft inflammatory material, which was afterwards found to contain micrococci; the ligamentum teres and the acetabular cartilage were intact; but the articular cartilage of the femur had partly disappeared without any caries of the bone. The head of the femur was removed, and the wound drained and treated in the usual way. The dressing was renewed on the fifth, ninth, and fourteenth day, and then replaced with a dry dressing, under which the wound healed within six weeks after operation.

I was quite unable to ascertain how this patient got infected with staphylococcus aureus, the virulence of which was shown by its effects upon animals. Three drops of a culture a week old injected into the auricular vein of a rabbit killed it in a few minutes. Some sterilised salt solution was inoculated with a particle, and about six drops of it injected into the auricular vein of another rabbit. In ten days this animal became paraplegic, and on the twelfth it was killed. It had suppuration around the lumbar part of its spinal cord, suppurative nephritis, and retention of urine. Staphylococcus aureus was grown from the abscess round the cord, but the urine was sterile, probably because only the clear part of it and not the turbid sediment was used for inoculation. The kidneys contained quantities of micrococci.

It seems reasonable to suppose that if this hip-joint had been drained earlier the head of the femur might have been saved. A few months before, a boy, aged 7, came under my care with septic inflammation of the knee, dependent upon caries and necrosis of the tibia, at the line of the epiphysis. The fluid from the joint contained streptococci, and the joint was incised and drained. It was dressed on the seventeenth and twenty-seventh day, and the child has now

(July 14th) a good and movable joint, although there is still a sinus leading to the caries. In the case of the hip the difficulties of diagnosis delayed the treatment, but a most unfavourable opinion was formed after the discovery of the staphylococcus aureus. It is well known that that microbe is always associated with destructive inflammatory processes, especially of bones, and so it proved in this case. It will be interesting to see what will be the results of the investigation of other cases. I also found a staphylococcus aureus in a case of acute necrosis in which several bones were involved, but others have, in like cases, found it associated with other microbes, more particularly staphylococcus albus.