Observations ON TREATMENT OF GUNSHOT WOUNDS OF THE KNEE-JOINT.

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WHILE the saving of the man's life is the most urgent consideration, the preservation of a useful limb ensures his position as a competitive wage earner, and relieves the State of an additional burden. Successful surgery of the knee-joint demands the soundest judgement and most skilled and particular attention to detail.

Injuries to the knee-joint have always obtained the greatest respect from surgeons—in fact, have been regarded with great dread. Surgery of the knee-joint has always been, and is still, a serious and anxious undertaking, but the treatment of wounds of the joint along the lines which I am going to describe has, in very great measure, reduced our dread of knee-joint infections.

In fact, the knee-joint responds most satisfactorily when treated fairly and rationally. No longer, in these circumstances, do we have great fear of death from sepsis, amputation is rare, ankylosis has been reduced to a minimum, and a movable, useful knee is, in a great majority of cases, obtained.

GENERAL PROCEDURE.

A man comes into a base hospital with a gunshot wound of, or about, the knee-joint. Almost before his clothes are removed his dressing applied in the field ambulance or casualty clearing station is taken off, and the joint examined with the following points in mind.

1. *Date of Injury.*—Usually from two to seven days previously.

2. *The Amount of Effusion about the Joint.*—Be careful to determine whether the effusion is into the joint or not. Practically every injury which either penetrates or bruises the synovial membrane produces a blood-stained effusion into the joint.

3. *The nature of the wound*, whether a tunnelling, perforating, or an open, penetrating wound, and the exact site of the entrance and exit wound.

4. *Temperature and Pulse.*—(a) Usually the temperature is from 99° to 101°, with a pulse from 80 to 100; (b) a temperature over 101° and a pulse varying from 90 to 120 implies an already purulent condition of the joint or a virulent infection.

5. *The Condition of the Leg Above and Below the Knee.*—(a) Presence of wounds or foreign bodies favouring a general septic condition of the leg; (b) whether fracture or not, into or close to the joint.

6. *The Probable Nature of the Projectile.*—(a) Hand or rifle grenade fragments; (b) shrapnel bullets; (c) distorted rifle bullets or shell fragments. The difference in the infective abilities of these are not great. Jagged rough metal acts as the best carrier of infective material. (d) Undistorted rifle bullets. In only a small percentage of cases does one find an acutely infected joint following a rifle bullet wound, especially if early immobilization has been secured, whether a tunnelling, perforating, or more open wound, even when the bullet is retained in the joint.

7. *The amount and kind of interference* there has been with the joint since he was wounded, such as the dangerous policy of placing tubes into the joint following the track of the foreign body for transit to base.

8. *The Patient's General Condition.*—One must be guided by the patient's ability to stand a long convalescence in determining the treatment of already seriously septic joints, especially where combined with fracture of the bones.

9. *Splinting.*—If the knee is not efficiently fixed in a splint, this should be done at once. In most cases a long gutter "fracture" splint (Jones) is quite sufficient until after operation.

Having determined these factors, if there is effusion into the joint, it is at once tapped, the fluid withdrawn, and, if

blood-stained or perceptibly purulent, 2 drachms of either 2 per cent. formaldehyde in glycerine (made up at least twelve hours before and not more than one week old), ether and iodoform, pure ether, or 5 per cent. saline are injected into the joint at once. A tunnelling wound produced by an undistorted rifle bullet usually requires nothing more except immobilization on a Thomas's splint. The joint must not be allowed to become tense from recurring effusion.

The fluid is sent at once for a bacteriological report from a slide and from culture.

The knee is bound on a pillow and at once screened or skiaographed in planes at right angles to each other. The patient is returned to his ward and prepared for immediate operation if an open wound is present.

An acute infective condition of the knee-joint demanding immediate operation usually presents the following:

1. Wounded from two to five days.
2. The joint is swollen, red, and tender. The patient complains of a throbbing pain in the joint.
3. Temperature not always high, usually varying between 99° and 101°.
4. Pulse usually rapid.
5. The effusion is blood-stained in about 96 per cent. of cases, and in about 56 per cent. perceptibly purulent.

METHOD OF OPERATION.

Preparation of Case.

The skin is carefully shaved for 6 in. to 7 in. above and below the knee, cleaned with petrol or ether, and painted with iodine. Omnopon and scopolamine, one full dose,* is given one hour before operation. The patient is sent to the theatre on a splint. Open ether is administered in preference to chloroform, so as not to increase any tendency to acidosis. In some cases the operation can be done under local anaesthesia. The splint is removed, and the knee-joint supported in a partially flexed position on a sandbag. The area is again painted with iodine.

Operation.

The first step is excision *in toto* of the wound or wounds down to the capsule. Then with another knife and forceps the capsule is excised and this knife and forceps at once discarded. Absolutely no necrotic tissue must be left. Further treatment depends on the conditions found.

A Tunnelling Wound: No Fracture.

After total excision, including the wound of the capsule unless effusion is exceptionally foul, and after having carefully removed all particles of dirt, cloth, etc., the cavity is thoroughly irrigated with 1 per cent. saline until all blood clot and pus is cleared out, the leg being very gently flexed and extended at the same time. The capsule is stitched up with fine catgut, care being taken not to leave a knot of catgut inside the joint. A small tube is left down just to, but not into, the capsule, and the tissues may possibly be stitched about it with fine catgut.

The skin is approximated with silkworm gut and a mastisol and gauze dressing (two layers of gauze stretched taut) applied. The skin is cleaned up thoroughly away from the site of the wound and the joint injected as before.

It does not make much difference which preparation is injected, but I prefer either the saline or the glycerine and formaldehyde, and of the two, the latter, because:

- (a) It is nearer the specific gravity of normal joint serum;
- (b) It is mildly antiseptic; and
- (c) Its mechanical oily nature seems more adaptable to a movable mechanism such as the knee-joint.

The knee is immobilized in slight flexion on a gutter splint and a Thomas's splint with slight extension. If the infection is confined to the front of the joint the extension should be omitted.

Open Penetrating Wound.

Such a wound with the foreign body still in the joint is treated in exactly the same way, except that the foreign body must be carefully localized beforehand, and removed with the minimum of trauma to the joint surfaces.

* Omnopon gr. 3, scopolamine gr. 1/30.

A Wound with Localized Fracture of the Bones forming the Joint, with, possibly, the Foreign Body imbedded still in the Bone.

Such a wound is treated in exactly the same way, except that the foreign body and loose particles of bone and all soft and pulpy and possibly infected medulla must be carefully removed.

If there is much haemorrhage from the medulla, it is checked by packing the cavity with gauze wrung out of saline solution or with gauze and salt tablets.

If it involves the bone so that the capsule can be closed, this should be sutured so as to exclude the cavity in the bone from the joint. If at all possible, the synovial membrane should be closed. If it is not possible, the capsule should be carefully approximated as much as possible without tension and the wound packed with gauze and tablets, a small tube being left down just to the capsule. The plugging should be left in the bone at least five to eight days unless there are urgent reasons for removing it. The tube may be removed after two days if there is no effusion. The surface of the gauze pack and the skin around should be painted with iodine at least every second day. The superficial dressings should be changed daily at first, later only when soaked.

A Gunshot Wound of the Knee-joint where a Great Part of the Joint is Laid Open.

(a) If the patient's general condition will permit it at all, the wound is excised *in toto* exactly as in a small wound, irrigated, and possibly stitched up, leaving a small tube down to the capsule. It is preferable in all

FIG. 1.—The upper diagram shows the piece of drainage tube as cut, and the lower as bent for insertion in the wound.

such cases to leave two small tubes cut as shown in Fig. 1, which, if need be, act as a two-way catheter. In such cases it is particularly important to procure absolute fixation. If this is done, and the deep packing left *in situ* till loose, it usually happens that the rest of the joint does not become seriously infected.

(b) If the general condition is bad, temperature high (over 102°), pulse rapid (110 or over), the face flushed and anxious, complete arthrotomy, preferably subpatellar, is performed, both lateral ligaments, ligamenta mucosa, and the crucial

ligaments being also incised or cut away, and the semilunar cartilages removed.

The leg is supported, flexed to less than a right angle, on a pillow or backsplint, preferably on a splint of Captain Hepburn's type, and continuous irrigation with 5 per cent. saline started at once.

Barnard's method of draining the suprapatellar pouch and the two lateral pericondylar pouches, with their diverticula posteriorly, should never be used unless modified in the following way, when it may very rightly be tried, in the type of case in which pus of a very low degree of virulence is found in the joint, accompanied with slight rise of temperature, slow pulse, and a good general condition. In such cases tubes may be placed just down to the joint, but not traversing it. Where there is a tendency for the pus to collect in the suprapatellar pouch, a small tube about the size of a lead pencil may be inserted across the pouch, but all these tubes should be removed as early as possible.

Post-operative Treatment.—Where the small tubes are left just down to the capsule, they are wiped out or aspirated daily. The skin around the tubes is wiped with saline and then with iodine. With mastisol and gauze, the dressing is very much simplified. These tubes are removed if possible within the first forty-eight hours. The plugging is left in the cavity of the bone as long as possible until loose. Usually it can be left from five to eight days, and often longer. The joint is watched carefully for increasing effusion. If it tends to increase, and the temperature and pulse start to go up—

1. The joint is aspirated with a needle, and injected as before with the glycerine-formaldehyde, ether, or saline preparations.

2. If this be not sufficient, a large needle is inserted and the whole joint washed out with saline 1 per cent. till the saline returns clear.

3. If pus still persists in forming, two large needles

are inserted and saline is run continuously through the joint for from twelve to forty-eight hours, and repeated if necessary, care being taken not to admit air to the joint. The patient's general condition is carefully watched, as is also the area above and below the knee, lest pockets of pus form; support posteriorly by the "fracture" splint tends to prevent this. Especially are the popliteal space and the calf of the leg watched. Pressure on the large vessels and nerves about the knee is avoided. After arthrotomy continuous irrigation with 5 per cent. saline is used at first, then saline and glycerine dressing. The knee is closed down on a Thomas's splint with slight extension at the earliest moment, after the surfaces are covered with healthy granulation. If the component bones of the joint are badly comminuted, resection is performed, but it is not advisable to be in a hurry to do this until all signs of infection have cleared up, lest a fresh outburst be lighted up.

Amputation should be performed only as a last resort to save the life of the patient; then a quick circular operation should be done.

Sodium bicarbonate gr. xx every four hours and barley sugar *ad lib.* are given as routine where a septic condition may develop or is present.

SUMMARY.

The points on which I would lay most stress are:

1. That all foreign bodies, whether metal or loose bone, should be removed from the knee-joint at the earliest possible moment.

2. Perfect immobilization is absolutely necessary. Do not start passive movements too early; wait at least three weeks after the inflammation has subsided.

3. Absolutely complete excision of all necrotic or even oedematous tissue.

4. The capsule should be closed at the first operation if at all possible.

5. Antiseptics, other than the ones I have mentioned, should not be introduced into a joint.

6. Tubes should never traverse the joint surface as in Barnard's method.

7. Patients should not be moved till one is satisfied that infection has been successfully combated.

STATISTICS.

Space will not permit of complete tabulated statistics of all the cases treated in the last fifteen months, which I hope to publish later. I will simply give the results of 60 cases treated as described with what may be called the new method, and which remained entirely under my care until they were sent to England.

Death.

There was one death. In this case both the femur and tibia were badly comminuted, and the joint very purulent on admission. The patient was a cachectic, cadaverous-looking man, with no resistance, and he died in spite of early amputation.

Amputations.

There were three amputations. In two cases there was bad comminution of both tibia and femur, with the joint full of pus, and the general condition of the patient was not good on admission. In one case the amputation was done at once; in the other after five days in hospital. In the third case a hand grenade had absolutely shattered the joint and filled it with pieces of metal and dirt. Gas gangrene was present, and the leg was amputated at once.

Movement.

The results as to movement were as follows:

Ankylosis ...	...	...	...	3
Limited movement ...	...	...	...	4
Free movement ...	...	...	...	49

Fracture of one or both bones existed in 53 per cent., bloody effusion in 96 per cent., and pus perceptible to the naked eye in 56 per cent. of cases. The bacteriological reports on 42 cases showed that organisms were present in 76 per cent.

I wish to thank the nurses and officers that have assisted me during operations, and especially am I indebted to Colonel Gray, consulting surgeon, to whom the credit of the new method of treating gunshot wounds of the knee-joint is largely due, for his most valuable advice and assistance in these cases.

The notes of three cases of average severity with drawings made from the skiagrams are appended.

CASE I (FIGS. 2 AND 3).

Private M. Admitted June 3rd, 1915. Wounded four days before. On admission, temperature 100.1°, pulse 90. Knee-joint was very much distended with fluid, tender on pressure, and the patient complained of a continued throbbing pain through the joint. There was a jagged wound on the inner aspect of the knee-joint 2 in. above the articular surface of the internal condyle of the femur and on a plane about the middle of the condyle. On aspiration, the joint fluid was

FIG. 2.

FIG. 3.

deeply blood-stained. Bacteriological report was that *B. coli* and streptococci were found.

Operation.

June 4th. Temperature 100.7°; pulse 96. The wound was widely excised in a funnel-shaped manner down to the femur. The torn capsule was excised, and particles of khaki were found along the tract, even in the cavity of the femur. The hole in the condyle (about the middle of the internal condyle) was enlarged, the shrapnel bullet (distorted) removed, and all the soft, discoloured, and affected medulla removed, leaving a cavity about the size of a walnut. A double fracture was present in the internal condyle, extending into the joint, but it was fairly solid and the periosteum was intact, so the place was left. Thoroughly irrigated the joint cavity with 5 per cent. saline, sutured up the capsule with catgut, packed the cavity of bone with gauze and salt tablets, also the excised area in the tissues. Fixed a small two-way tube down just to the capsule; injected into the joint cavity 2 drachms of formaldehyde and glycerine and immobilized the leg on a Thomas's splint with a perforated zinc back piece in slight flexion and with a little extension. Packing in bone cavity was left eleven days. The packing in the tissues was left

FIG. 4.

The least movement elicited most severe pain. Bacteriologically the fluid was negative, but the effusion was deeply blood-stained.

Operation.

Local anaesthesia (novocain $\frac{1}{2}$ per cent.) was used, administering only a whiff of ether when examining the articular surfaces. The wound was widely excised; the bullet carefully extracted with forceps; the joint thoroughly irrigated with 1 per cent. saline; the capsule and tissues sutured, leaving a small tube down to the capsule; 2 drachms of formaldehyde and glycerine were injected into the joint. The joint was immobilized on a

CASE II (FIG. 4).

Private T. Admitted on May 27th, 1915. Wounded five days. On admission temperature 99°, pulse 80. A jagged entrance wound just below and external to the patella. The knee-joint was very much distended with fluid, and very painful and held in partial flexion.

severe pain. Bacteriologically the fluid was negative, but the effusion was deeply blood-stained.

Operation.

Local anaesthesia (novocain $\frac{1}{2}$ per cent.) was used, administering only a whiff of ether when examining the articular surfaces. The wound was widely excised; the bullet carefully extracted with forceps; the joint thoroughly irrigated with 1 per cent. saline; the capsule and tissues sutured, leaving a small tube down to the capsule; 2 drachms of formaldehyde and glycerine were injected into the joint. The joint was immobilized on a

Thomas's splint, with a posterior gutter splint flexed at an angle against the knee and with slight extension.

On May 29th there was very little pain, the temperature was 99° and the pulse 78.

On June 15th passive movements started, and on June 20th the case was sent to England on a posterior gutter splint.

The result was a perfectly movable knee.

CASE III (FIGS. 5 AND 6).

Private C. Admitted on June 24th, 1915. Temperature 101°, pulse 96. Two small, dirty wounds of the knee, one externally, just above the head of the fibula, and the other in the middle

FIG. 5.

FIG. 6.

line in front, just above the tubercle of the tibia. The knee-joint was very much swollen, red, and very tender, and the patient complained of a continued throbbing pain through the joint. Bacteriological examination of the fluid showed (1) staphylococcus, (2) *B. coli*. The fluid was perceptibly purulent.

Operation.

June 25th. The temperature was 101° and the pulse 100. The wounds were excised widely. The fragments of shrapnel were carefully located and extracted with forceps. A narrow grooved fracture of the external articular surface of the tibia was present. The joint cavity was very distended with a reddish-yellow fluid.

The joint was thoroughly irrigated and the capsule stitched up. A tube was left down to the capsule externally and the tissues and skin sutured about it; 2 drachms of glycerine and formaldehyde were injected in the opposite side of the joint and the joint immobilized (with slight extension) on a Thomas's splint with a posterior gutter splint slightly flexed. The tube was removed on the second day.

On June 26th the temperature was 101° and the pulse 96, and on June 29th they were 99° and 88 respectively. Passive movements were started on July 15th, and the patient went to England on a posterior gutter splint on July 21st.

The result was a freely movable knee.

HEPBURN'S KNEE SPLINT (FIG. 7).

The black strips are of heavy aluminium splinting material, measured to approximately fit the patient's limb.

The shaded strips are of the lighter aluminium material.

The strip A B on each side is put on after the splint has been moulded to the desired angle.

An additional pair of supports applied at the joints C D will increase the rigidity.

Method of splicing D-B when long strips are not available.

FIG. 7.

A small pad is placed over the strap in the popliteal space and the splint is then padded in two sections, leaving the area of the joint freely exposed.

Pad (1) C, F, E, A, and (2) D, B, K, H, G, and cover with jaconet.

The splint is moulded to the leg and thigh, and firmly bandaged.

The foot is packed into the boot part with cotton-wool.

The patient may lie on the back or on either side, and the limb can be comfortably suspended from the point C, D, B.

This splint facilitates the care of the back and the use of the bed-pan.

The tools required to make the splint are a pair of pincers, a pair of heavy shears, and a hammer.