OSTEOPLASTIC CLOSURE OF CAVITIES IN BONE.

BY

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WAR surgery has no more frequent late operation than "sequestrotomy," despite the generalized use of the radical wound excision. In a majority of cases the removal of sequestra will complete the healing of the wound, but there is a percentage in which the "bone cavity" arises as an entity of clinical importance. Cavities are, of course, left after the removal of all sequestra embedded in callus; the bone cavity is such a cavity as will not become obliterated by natural means.

The problem of closure of such cavities did not loom very large in pre-war days and tended to become less and less prominent as prompt and more radical methods of treatment were brought to bear upon the causal conditions—for example, acute infective osteomyelitis. Chronic empyema presents the same difficulties—the cavity with rigid infected walls—and modes of treatment of the one are in principle applicable to the other.

Pathology.

In the pathology of the bone cavity in war primary devitalization and septic osteomyelitis, with necrosis and caries of bone, play their part. A cavity results bounded mostly by callus, lined by a granulation layer of varying thickness. Oedema from constriction of vessels by fibrous tissue seems responsible for the pulpy thick layers occasionally found; in other instances a small sequestrum is the cause. The crux is that this granulation tissue is not invaded by bone cells in its deep layers and there is no concentric callus formation. The ingrowth of granulations must be limited largely by this, and not by vascular influences; were the ingrowth of bone to take place adequate blood supply would be assured. For the deficient bone growth sepsis must be held responsible; degeneration and absence of osteoblasts can readily be demonstrated in such cases, just as in non-union of fractures.

Baldly stated the problem is that granulations cannot fill the cavity, the bone around cannot form callus to fill it, and the walls cannot contract and obliterate it.

Methods of Treatment.

Various are the methods that have been employed in dealing with the condition. Broca's method is to remove one of the walls to permit of the surrounding soft tissues to come into contact with the remaining walls. This involves an extensive removal of bone, particularly as the tissues in the region of bad gunshot fractures are usually far from soft. Colonel Sargent has recently described a method which obviates the above disadvantage by using a muscle flap which needs a very much smaller bone removal to permit of its introduction into the cavity. Some form of filling is the alternative to the above principle of treatment. Many materials have been used—for example, blood clot, fat, bone-chips, and sponge. Moseley's wax (iodoform, spermaceti, and sesame oil), with a correct technique, achieved much success. It has recently, however, been eclipsed by bipp. The success of this preparation has been practically uniform in a certain class of case, provided always that a proper preparation of the cavity has been carried out. Neglect of this is accountable for nearly all the failures.

Two Types of Cavity.—In view of the properties of bipp, it is possible to classify bone cavities into two well-defined types (see Diagrams 1 and 2): (A) Where the sinus leading to the cavity passes through a considerable thickness of soft tissues; the necessary thickness varies with the size and shape of the opening into the cavity and the amount of scarring of the parts. (B) In subcutaneous bone—for example, the tibia, or where the superficial soft parts have been destroyed—the skin is bound down to the bony edges. Only failure can result from freeing the skin edges and suturing them over a bipp filling. The (A) cavities react readily to bipp filling—why, it is hardly necessary to discuss—overcoming of sepsis, and the stimulation of osteogenesis play a part; certainly a free growth

of granulation occurs. The question naturally arises, Cannot the cases in (B) be converted into Class A? Can we provide a durable covering for a bipp filling? The

DIAGRAM 1.—Class A.

DIAGRAM 2.—Class B.

bone cavity is an open box, can we find a lid for it? It seems to me the question might be solved by the use of a sliding skin-fat-periosteum bone flap.

OPERATIVE PROCEDURE.

The method adopted is illustrated by the following typical case:

Pte. J. (repatriated prisoner of war); wounded March 26th, 1918; admitted Lord Derby War Hospital January 24th, 1919. X ray showed sequestra in left tibia at junction of upper and middle third. An opening a quarter of an inch in diameter over the subcutaneous surface of the bone led directly to necrosed bone, and discharged intensely foul pus.

First Operation.

On February 1st a small vertical incision was made with the sinus at its middle; several large sequestra were removed, and beyond these spongy carious bone was curetted away in every direction till healthy tissue was reached. The resulting cavity was cleansed with peroxide and packed with flanne gauze. The opening in the bone measured $\frac{1}{4}$ in. by 1 in.

At the end of twenty-four hours the packing was removed and intermittent irrigation instituted; flavine and Dakin's solution on alternate days (three times and six times per diem respectively). A smear of fair thickness, examined on February 25th, showed two bacilli and two streptococci per field.

Plastic Operation.

On February 27th the cavity was first curetted again and the whole of the newly formed granulations removed; the interior was cleansed with hydrogen peroxide, dried, and packed with gauze soaked in "preparation" iodine. The skin area was again cleaned. (The use of strict aseptic technique throughout is assumed.) Next the skin incision was prolonged upwards for a short way, and converted into a J by a curved cut extending inferiorly over the posterior tibial border about one inch below the inferior border of the opening (Diagram 3). The skin and subcutaneous tissue at the lower part of the flap thus marked out were raised as far as the lower level of the opening, where a transverse incision was made in the periosteum extending to the posterior tibial border (Diagram 4). A vertical incision in

DIAGRAM 3.

DIAGRAM 4.

A, Extent of cavity. B, Opening of cavity. C, Incision in periosteum. D, Flap of periosteum. E, Cut in periosteum freeing flap. F, Bone flake.

the periosteum one inch in length was next made, extending vertically from the upper limit of the opening, and through this incision the periosteum was lifted, together with fat and skin, as far back as the tibial border, by means of a fine sharp periosteum detacher. (It is, of course, essential that the separation be carried no lower than the upper limit of the opening.) The bone slice from the cortex was next raised by a fine chisel; the cuts were made along (1) the periosteal incision below, (2) the lower level of periosteal detachment above (an oblique use of the chisel or a keyhole saw is desirable here to avoid further stripping of periosteum), (3) and then into the side of the cortex presenting at the opening; by a combination of chiselling and gentle leverage a flake of bone, $1\frac{1}{2}$ in. vertically by $\frac{1}{2}$ in. transversely, was raised, the posterior attachment being fractured. The flake was between $\frac{1}{2}$ in. and $\frac{1}{4}$ in. at

its thickest. To permit the flap thus fashioned to slip into place it was then necessary (1) to make a cut with scissors in the periosteum at the posterior border of the bone flake and to extend this cut to the upper limit of periosteal detachment; (2) to undercut the skin posteriorly (in some cases it is necessary to make lateral cuts to free the skin sufficiently to secure apposition without tension; in others a U-shaped flap is preferable). The anterior, upper, and lower borders of the opening were next levelled with a chisel to allow the flake to sit squarely in place. A further strip of skin was excised along the anterior border of the opening, so that the suture line should lie well away from the opening.

The whole area was cleansed with peroxide, haemostasis attended to, and the packing removed from the cavity, which was filled with bipp paste.

The fixation of the flap was effected by (1) interrupted fishing gut sutures through the skin; (2) a wide mattress suture passed deep to the bone flap (Diagram 5).

DIAGRAM 5.

A rubber-dam drain was inserted at the lower part of the J (in some cases a separate stab-incision is best), a flavine gauze dressing was applied, and the limb splinted.

After-Progress.

Reaction of 100.6° and 100.0° occurred on the second and third days; typical bipp sero-pus drained for two weeks. The upper end of the incision ulcerated where the stitches passed through old scar. Stitches were removed on the tenth day. The ulcerated area was dressed with flavine, brilliant green being useful occasionally as a stimulant.

In one month the bone flap was firmly fixed in place. Complete healing occurred in five weeks.

VARIATIONS.

1. *Sepsis*.—In many cases the cavity reaches the central hospital "ready made." Nevertheless, a preliminary cleansing operation with a subsequent sterilizing course is desirable. It is difficult to give any precise smear figure for the septicity margin that can be dealt with by bipp. In any case it is much lower than the smear figure for the cavity before the plastic operation, as the infected tissue is removed by the curette. In half the cases both streptococci and bacilli have been present in the smears (though never more than two or three per field in a thickish smear); one would not dream of suturing soft parts under such circumstances. The period between the two operations is usually much shorter than that in the case recorded; seven to ten days is usually sufficient. Clinical "cleanness" of appearance in these cases seems as dependable as the smear estimate, as far as ultimate results go.

2. *The Bone Flap*.—Extra vascularity can be secured by utilizing a portion of cortex into which muscle or tendon is inserted. In a case where part of the sartorius insertion was used, the bone flap oozed freely. Splinting counteracts the only disadvantage.

3. *The Size of the Opening*.—The size of the opening, not the size of the cavity, is the most important factor in this procedure. The largest opening so far dealt with has been 2 inches in length; perfectly sound union was obtained. Should one hesitate at using a bone flake longer than this, on the grounds of its nutrition, a periosteal pedicle could be made at both ends, or periosteum alone be used to cover part of the cavity.

4. *Severe Scarring of Skin with Ulceration*.—I have not encountered extensive ulceration of the skin in association with a bone cavity. It is courting disaster to attempt to form a flap out of scar tissue; the shortest plan of treatment would be wide removal of one of the walls of the cavity, but even after this one would have to be prepared for a severe reaction or worse. The flap itself should not contain any but the slightest scar.

RESULTS.

Thirteen cases have been treated in this manner—one in the humerus, one in the ilium, the rest in the tibia.

In two cases in which the cavity was very clean (and no sequestra present) the preliminary operation was dispensed with; no untoward result followed.

In six cases there was a reaction of 100° to 101°; locally, inflammatory oedema has been the utmost complication apart from stitch ulceration in old scars.

Three healed per primam with no serous discharge; the rest had the usual bipp sero-pus for periods varying from one to three weeks; one was reinjected with bipp on two occasions, the bone flap not being a good "fit"; sound healing was attained ultimately. The average time of complete healing was three and a half weeks.

In no case has necrosis of any part of the bone flap occurred. The bony union was sound in every case but one at the end of a month, as far as palpation could ascertain. In the case in which two injections of bipp were needed, union of the flap was delayed till nine weeks after the operation.

SUMMARY.

1. Bipp filling of bone cavities is in every case a successful method of treatment provided always that the preparation is thorough.

2. There are two types of cases: (A) The larger group—where a sufficient thickness of soft tissues is present to cover the opening—here simple filling is adequate. (B) Where no soft tissues can be placed over the opening, which lies flush with the skin; these cases can be treated successfully by covering the opening with a skin-bone flap and filling the cavity with bipp.

3. The advantages are:

(a) Less extensive disturbance of tissues than in any other operative procedure for closure of the cavity—no small consideration in war scars.

(b) Anatomical restoration of the bone is achieved; strengthening and not weakening results; fresh osteogenic surfaces are exposed.

(c) Good cosmetic result.

The objections are:

1. A foreign body is left in the tissues; but it (a) combats infection, (b) stimulates osteogenesis, and (c) is removed naturally when these ends have been attained.

2. *Sepsis* is neutralized by adequate preparation, careful technique, and bipp.

3. A plastic bone operation is not to be approached lightly in the presence of the slightest sepsis. But (a) the bone used is more vascular than normal; (b) the exceedingly vascular bone at muscular insertions can be used; (c) bipp smearing prevents infection.

4. *Difficulty of Raising the Flap*.—Much patience and care are needed in the use of the chisel and saw. War hospitals are not often equipped with electric saws; the two experiences I have had of the use of Albee's motor in bone grafting leave no doubt that the operation could be greatly simplified by this instrument.

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CHRONIC BONY FISTULAE.*

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CASES of chronic bony fistulae arising from a compound fracture and discharging months, or even years, after the infliction of the wound, are to be found in every large military hospital. The French authorities have established special hospitals and centres for such cases, and various kinds of special treatment, including thermal baths, radiant heat, and injections of various kinds, have been tried. But, in spite of these methods and the issue of special rules and instructions, a considerable number of such cases came under my care during the summer and autumn of 1918. During earlier periods of work in France I had treated such cases by the removal, as thoroughly as possible, of the focus of infection and of all dead or foreign material, and then disinfection of the wound by applying pure carbolic acid and tincture of iodine, plugging the whole for forty-eight hours with iodoform gauze, and then allowing the wound to granulate up.

As a rule, the cases so treated did fairly well, and probably 70 per cent., or more, were cured. The cure, however, was lengthy, and in a certain proportion of cases

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