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**ACUTE HEMATOGENOUS OSTEOMYELITIS
OF LONG BONES**

**Senior Thesis
April 21, 1933**

Leigh H. Wemble

FOREWORD

The aim of this paper is to set down a few notes concerning Osteomyelitis of the Hemolytic variety as found in the growing long bones of children.

It is not intended to be complete in any sense of the word, but to serve as a resume of some of the current literature on the subject, condensed in brevity to the utmost. The content is in no ~~ways~~^{ways} original (though some conclusions may be) ; the reader is referred to the original articles for more accurate and complete presentation of the subject.

It is hoped that the reader may become familiar with the early clinical picture and with the mechanism of the disease process so that he may realize the importance of EARLY THOROUGH TREATMENT, and there-by avoid the production of a chronic condition.

ACUTE HEMATOGENOUS OSTEOMYELITIS

Of The Long Bones

An acute blood borne pyogenic process involving the metaphysis of growing bones, rapidly tending to involve the periosteum, cortex and medullary cavity.

Acute Osteomyelitis has long been considered one of the most formidable conditions confronting the surgeon. One which if diagnosed early and treated radically offers results approximating one hundred per cent, but if unrecognized, and therefore neglected, is capable of producing complete destruction of a bone, and very often endangering the life of its victim. The disease lends itself to treatment which promises a fairly return of function or to that which leads directly toward a state of chronic invalidism (11).

One can best understand the disease process after a review of the anatomical conditions of a growing long bone. It is composed of the shaft or diaphysis, and the ends or epiphyses, separated by a strip of cartilage, the epiphyseal cartilage, which is the site of growth. The diaphysis has been subdivided into dense cortical bone, the diaphysis proper, and the cancellous extremities termed the metaphysis. The cortex is composed of dense lamellae arranged first parallel to the surface, then in concentric circles about the Haversian canals. It is thick near the middle of the shaft, tapering to tissue paper thinness at the

epiphyseal line (where infection breaks through from the cancellous bone). The cancellous bone is made up of straight and arched trabeculae so placed to best withstand weight bearing.

The periosteum is vascular, surrounds the bone except at its articular ends and is attached to the bone by loose areolar tissue. At the epiphyseal line there is firm attachment so that the periosteum of the diaphysis is separate from that of the epiphysis. (23)

The blood supply is threefold. The nutrient artery pierces the cortex and divides in the medullary cavity to supply the bone marrow and the endosteum of the shaft, and is finally lost in branches in the metaphysis; here a capillary looping occurs with marked slowing of the stream. (14) The periosteum sends branches into the cortex through the canals of Volkmann and Haversian. (The endosteum sends similar branches to the inner cortex.) The epiphysis has another blood supply from fairly large branches which enter the spongy bone substance through the periosteum. The periosteum and the endosteum thus are intimately related to the physiological proliferation and destruction of bone by supplying nourishment. Bony tissue is very prone to become necrotic in the absence of ideal blood supply.

Focal infection with metastasis through the blood stream is the means of infection of the bone, the bacteriemia must be sufficient to produce the disease, and yet not severe enough to become a fatal septicemia. Staphylococcus aureus is the chief organism found, Streptococcus, Staphylococcus albus, and pneumococcus are also found, but not nearly so often. Superficial skin infec-

tions as boils, carbuncles, infected blisters or infected abrasions are the most usual source of Staphylococic infections and occur most often in the summer, coincident to more frequent superficial infections in playing children. The Streptococcus usually comes from the nose and throat, (which may also be a focus for the Staphylococcus and pneumococcus) occurring more often with "colds" of the winter months. Blood cultures may be negative or positive; with general septicemia or pyemia there are repeated positive blood cultures and usually early death.

This is essentially a disease of children up to the end of the bone growing age. Boys are far more frequently effected than girls, due probably to their increased activity and having more infections. The age incidence is highest between ten and fifteen years, the time of most active strenuous playing. Adults are relatively seldom effected, though the shaft may become the site of the acute process; however arthritis is the rule.

Localization of acute foci (while varying somewhat, may be taken to be) most frequently found in the upper end of the Tibia, lower Tibia, lower Femur, upper Humerus; while the upper Femur, lower Ulna and Radius are sometimes involved (12).

The role of trauma has been discounted by most teachers and experimental evidence bears this out, clinically however, traumatic history is the rule. A twisting or strain upon the epiphyseal line insufficient to cause separation would seem to be a factor in localization. For we find that in growing bones the ligaments and capsule are attached at or near the epiphysis;

trauma produces epiphyseal separation in children, rupture of the ligaments in the adult, due to the relative strength of the ligaments and bone at these two periods of life. Injury then may lead to some decrease in the defensive mechanism of that part and if infection is present, localization occurs at the site of injury.

There are other sources of Osteomyelitis besides the blood borne, as direct infection of the bone in compound fracture, and extension of infection from the surrounding soft tissue, but we are not concerned with these types in the present consideration.

First, one must have a source of infection from which the offending organism may enter the blood stream and localize in the bone. Experiments have shown the mechanics of infection and its spread (22).

With the injection of small amounts of *Staphylococcus aureus* bone abscesses were produced in young rabbits, which were killed at varying intervals to reveal the entire pathological picture. It was found that early there is localization of the organisms in the metaphysis of the growing long bones, corresponding to the slowing of the blood stream in this location. Here by a multiplication of the organisms, thrombosis of the vessels occurred with soft tissue edema which allowed further increase of organisms. Never in young animals did infection occur in the shaft, although on repeated tests organisms were found in this location, cellular elements of the blood stream are apparently active enough to combat the implantation of the infection. In adults the blood picture changes and localiza-

tion in the metaphysis does not occur, instead arthritis is the usual result of infection (14). Robertson cites the case history of a boy with local signs in the lower tibia from whom cultures were made at operation. Swabs from the medullary cavity were negative for pus and culture, while pus was found in the metaphysis (22).

Due to increase of the organisms, thrombosis of vessels, and pressure by the inflammatory process of the soft tissues present, necrosis occurs giving a localized bone abscess; with increasing size and pressure seen there is erosion through the thin cortex to a subperiosteal site in the region of the epiphysis, i.e. the metaphysis. The periosteum being attached at the epiphysis, pressure of the infection raises the periosteum progressively in the direction of the shaft. Thrombosis of the vessels in the canals of Volkmann and Haversian occur and infection travels through these canals to reach the medullary cavity. Infection continues with raising of the periosteum toward the shaft, mere necrosis of bone and further involvement of the medullary canal. Since the periosteum is a site of bone production, incident to its raising, a layer of new bone is thrown down which increases in size, forming a shell, or involucrum. After a time the enclosed infection erodes through the periosteum, involves the soft tissues, and by boring along the fascial planes soon reaches the surface and a discharging sinus results. With the rupture of the periosteum, further bone necrosis usually steps and separation of the living and non-living bone occurs by resorption of the calcium and phosphorus salts by the action of the osteoclasts, so that we have a non-living bone (sequestrum) separated from the living. Here then, we have the ultimate picture

of neglected acute Osteomyelitis, presenting a discharging sinus, involucrum and sequestrum formation.

The history of the case is by far the most important single factor in diagnosis and might be said to be sufficient alone.

The history of injury near a joint in a youngster of the growing age, especially between the ages of 10-15, with finger-point tenderness localized near a joint, with toxic symptoms, should be sufficient. Needless to say there may not be history of injury. One might well inquire into the history of boils, or other recent infections, or inspect the nose and throat for foci. "The disease is so common, the symptoms so typical, examination so definite, one is surprised that the diagnosis is ever missed--except as a lack of understanding of the symptoms (22)."

Acute Osteomyelitis should not need a close differentiation from other diseases because of its well defined picture; however there is a large group of border-line cases that require attention. Acute rheumatic fever is probably more often confused in the diagnosis than any other condition. Rheumatism is seldom monoarticular; it always involves the joint giving articular symptoms, while acute Osteomyelitis never involves the joint which with care can be moved without great discomfort. The extreme muscle spasm of rheumatism is absent, while severe toxemia is absent in rheumatic fever and prominent in acute Osteomyelitis. Infective arthritis (genococcic, pneumococcic or influenzal) shows toxemia, but all signs are articular; there is early swelling and aspiration yields purulent fluid. Cellulitis presents toxic symptoms with more general pain, tenderness, swelling and redness, signs which do not appear in Osteomyelitis till the periosteum has ruptured, three to seven

days after onset.

If the bacteremia is severe, a septicemia, the prognosis is, of course, grave. With localization of the infection and recognition, adequate early treatment yields practically one hundred per cent results in a few weeks. If untreated, or inadequately treated, involvement of the cortex and medullary cavity results, the case becomes chronic and cure is at best prolonged and difficult.

Septicemia is the thing which carries out nearly all fatal cases of acute Osteomyelitis. Secondary foci, which occur in seventy-five per cent of cases (22), must be kept in mind. Arthritis occurs from extension into the joint. Fracture occurs, but is practically limited to the chronic cases, where it is no small feature.

General hygiene to build up resistance is, of course, desirable for general bodily health, which in connection with adequate handling of apparently minor infections would seem to be of aid in combating the disease.

Symptomatically there is usually a history of injury in the region of a joint which interferes with function for a few hours or a day. Then there is a return to normal function. If a skin abrasion is present, this may fester, (usually Staphylococcus) and heal; then evidence of focal infections occur. The symptoms appear six to eight hours after onset (12) with pain in the neighborhood of the affected joint, which is finger point in localization and is always near a joint, not within it, and associated with profound toxicemia. Pressure causes the acute pain and accounts for the great toxic absorption. Early there is no loss of motion, no

joint symptoms whatever, only this constant boring dull pain. Seen there is loss of motion and the child guards this extremity; motion causes pain. The temperature, which has been mild, increases, nausea and restlessness occur. Within twelve hours the pain is so severe the child cannot sleep; there is guarded motion or no motion of the extremity. Temperature is high, 103 - 104, pulse correspondingly high 120 - 180, and respirations around 32 - 34. While the pain persists the first few days, tenderness is not so definite and may be hard to localize over the site of sprain; Cotton advocates percussion to localize tenderness. Leucocytosis is usually present, 18000 to 30,000, usually near the upper limit. There is no local change demonstrable clinically as yet. During the second twelve hours the symptoms increase and there is beginning local change in soft tissue; edema and redness appear. In twenty-four to thirty-six hours the swelling occurs and progresses toward the shaft. It is common to have, after twenty-four hours, another lesion in bony tissue with its symptoms similar to these; this occurs in seventy-five per cent of cases (22).

Early X-ray examination is of no value as far as showing pathology, indeed, a negative X-ray may be confirmatory evidence of acute Osteomyelitis. However, they are often a means of false security on the part of the doctor who does not realize that the films he has commonly seen of Osteomyelitis are of the late or chronic condition. The first X-ray evidence is a mottling of the cortex, then a proliferation of the elevated periosteum, eight to fourteen days after onset.

As the localized bone abscess ruptures through the bone, there is some relief of pain, and after the periosteum has begun

raising, the pain subsides rapidly, as do the fever and toxic symptoms. However, a dull ache persists, and as the soft parts become involved with rupture of the periosteum, limitation of motion occurs to some extent. With erosion of the skin and drainage, there are few symptoms, except aches, more or less general debility, and of course, persistent drainage. Pathological fracture may occur with the usual signs of fracture. With involvement of a joint by extension, joint symptoms are prominent. If there is an acute severe septicemia, its symptoms may mask to some extent the early symptoms of osteomyelitis, or the patient may die without their becoming present.

The general consensus of opinion for the treatment of the acute osteomyelitic process is early operation; indeed, it is advised to operate even if not positive of the diagnosis in order to safeguard the patient. There is one acceptable operation; that of exposing the bone in the effected region, and opening the cortex of the metaphysis till pus is evacuated. This may be done by drilling or chiselling. The cavity produced is filled with wet dressings (boric acid, biniodide of mercury, Eusal, Carrel-Dakin), or packs, as taken up in considering cavities of chronic osteomyelitis. If this is done early, while the infection is still localized within the metaphysis, there is very little destruction of bone, and other bony structures are not involved. Healing occurs as a simple process in a matter of weeks; usually in three or four weeks the member is as good as new. This is, of course, the ideal time for operation, before spread of infection occurs under the periosteum. There is some necrosis of bone, very little in small lesions, to sequestra

formation in larger areas which necessitate secondary operation. Usually however in this type of process the periosteum has already become involved at the time of the primary operation, so the process had become "subacute". In the older method of periosteal incision without drainage of the metaphysis, sequestrum formation was the rule, indeed, the intent of the operation was simply to limit the disease process and later remove the sequestrum.

This type of drainage is especially adapted to the so called Brodie's abscess, which is a localized bone abscess usually beginning as acute Osteomyelitis but in which the symptoms subside. The lesion is localized in the metaphysis and may remain dormant for several years; it is asymptomatic except for general ache in that region, with X-ray evidence of rarification of the metaphysis. The contents, ~~are~~ frequently sterile, is reputed to result from attenuated organisms or increased immunity on the part of the host (23a).

After the periosteum (and cortex almost simultaneously) has become involved, the process may be termed sub-acute or chronic, depending on the duration of the pathologic process. This is where treatment of a wide variety enters, which differs but little from that for the old chronic cases, and for the sake of brevity may be considered as one treatment. Review of the literature shows no method too good.

Let us first consider the operative surgical procedures alone, undertaking the dressings later. It is not to be overlooked that bone surgery carries a high potentiality of shock from bone trauma, there is less control of hemorrhage and of necessity more prolonged anesthesia than most fields of surgery. Care must be

exercised to prevent fracture of the diseased member, both during the operation and subsequently.

There is advocated an operation, which in general may be termed the same as for the acute variety, but more extensive, namely that of incision and drainage of the cortical involvement of the diaphysis and metaphysis. A more extensive procedure is that of guttering the shaft in the involved region, which is apt to leave bone deprived of its blood supply and cause sequestrum formation. While at this time there is clear X-ray evidence of pathology, still the sequestrum has not yet separated and the involucrum is at best of very poor strength. For this reason some men would rather wait till there is clear X-ray evidence of the sequestrum, for they state, it only adds a procedure to "dabble" in diseased bone which has no clear pathological boundaries. Feeling that operative procedures before sequestration has occurred either sacrifices sound bone or leaves diseased tissue, weakening the cortex while the involucrum can as yet add little for its support. Orr takes the stand that the better judgment rests with those who attempt to limit the disease process, even though it entails a subsequent operation for removal of the sequestra, he supports the limb by use of plaster cast, which also adds rest.

Entering the realm of chronic cases, we have here the addition of several factors. The virulence of the infecting organism to the host is decreased, so that there is a relative decrease of destructive powers, and while the advance of the infection is slowed or checked, still there is very little attempt on the part of the host on the offensive side.

Here we find a sequestrum that is wedge shaped (base at

the epiphysis] due to the blood supply, this has taken two to six months to form. The involucrum is rather firm and abundant; there is also a sclerotic condition of the bone surrounding the purulent cavity. While this dense type of bone offers quite a resistance to infection, it never-the-less offers an equal barrier to the healing process of the lesion, as when the cavity is drained this dense bone has very meagre powers of bone regeneration, which is no small factor in the healing process.

Treatment of this type of case varies from the conservative (incision of the involucrum and removal of the sequestrum), to the radical (total subperiosteal resection of involved bone). As is typical of medical treatment, the pendulum of enthusiasm has narrowed its swing, and for the most part, saucerization of the involved area is generally accepted as the best method of treatment for chronic Osteomyelitis. The important feature being to allow the remaining bone to be thoroughly covered with osteogenic periosteum. Too often surgeons in their enthusiasm have peeled off the periosteum generously, and thus allowed sound bone to become necrotic from absence of nourishment from its periosteum, thereby perpetuating the process of sequestra formation. The factor of proper nourishment would seem to be a very important feature in the healing of Osteomyelitis by regeneration of new bone. Nichols, in his method of approximating the periosteum after complete subperiosteal resection, has the greatest possible blood supply for a minimal amount of bone, and thus was able to get good results from regeneration of the shaft. More recently Baer calls attention to the abundance of "ooze" from his wounds, evidence of serous exudate from actively supplied granulations. Brockway in his

salt baths can lay almost exclusive results, I believe, to the use of the hypotonic solution which he uses, usually a month after operation. The limb is supported in the bath by splints, if necessary, and between baths by plaster shell. The concentration is 6 - 7 per cent and repeated cultures have been sterile. Varying depths of water allows the patient to have graded increase in weight bearing upon the extremity. This method also has a marked beneficial effect on the moral of the patient, which is no small factor in general bodily activity.

There is one factor in chronic Osteomyelitis that even yet has not been satisfactorily answered, but has had innumerable ingenious methods provided for its accomplishment; that of filling the cavity after operation. History reveals many such attempts, as does now, more "modern methods". All of these have worked for a time with success, but have sometimes failed to meet the needs. Most all dressings are anteceded by saucerization to render the cavity as shallow as possible and thus decrease the problem.

Early surgical treatment of Osteomyelitis (chronic) began with the simple soft tissue incision to facilitate "more drainage", and finally evolved into incision and sequestrectomy. No doubt patients were dismissed with "good (plentiful) drainage". Amputation has been resorted to in modern, as well as ancient, times as a curative factor, and while it may be a form of treatment worse than the disease, it is never-the-less effective.

As has been intimated, the surgical procedures are pretty much standardized, varying with the surgeon and his judgment of the extent of the pathological process of each individual case. It may be summed up by saying that the routine usually

followed is that of sequestrectomy with saucerization. As to how best to close and treat the wound once made, personal pride seems to compel every surgeon to derive a method of his own; all of which bespeaks of failure of previous methods to meet the needs and an attempt to greater success.

In 1881 Hamilton packed the cavity after sequestrectomy with sea sponges as a scaffold for growth of granulations.

1885 Keeting, of England, advocated sterilization by scraping out the marrow cavity and swabbing with carbolic and bichloride solution, with thorough drainage with a large rubber tube--and since this time there has been no end of "filling" osteomyelitic cavities with "antiseptics" (16).

1904 Nichols, of Boston, demonstrated that strong antiseptics and scraping destroyed some of the osteogenic properties of the periosteum and endosteum, so he removed all the bone and sutured the opposing periosteal surfaces together between the epiphyses, thus removing bone that might later undergo sequestration, but has the hazard of failure of complete regeneration.

Bone chips have been used, but they usually form sequestra and sluff out. The same may be said for blood clots (they also make excellent culture media for bacteria).

Various types of bone wax have been derived, which usually fail due to their irritation; generally some slowly liberated antiseptic is added, usually iodoform. Starr mentions Masetig-Moochof paste, copper amalgam, Beck's paste, Merison's paste, even plaster-of-Paris, fat and muscle flaps--the last working with the most consistent good results (23b). Bipp paste, bismuth, iodoform and paraffin base, has been used quite a gooddeal, and with good results.

Eusel and Carrel-Dakin (essentially the same, a chlorine) solution was used during the World War, and is effective in sterilizing a wound if thoroughly and efficiently applied--which happens rather seldom in speradic cases. It is irritating to the skin, and allows no support for the limb other than its inherent saucerized bone, which frequently results in fracture (7). Further, it requires constant expert hospital attention for the duration of the treatment, or till the wound is rendered sterile and may be secondarily closed.

Thorek has added a new idea by the use of his aluminum-potassium-nitrate paste, which he states promotes the growth of bacteria, thereby attenuating its virulence; and stimulating bodily defence by its irrant action tends to overcome the infection. It is not antiseptic, is non-toxic, and does not interefere with normal tissues. He has exlussive use of his method, but has had beneficial results.

Orr in 1923 introduced the vaseline pack after swabbing the wound with iodine and alcehol; he then encases the limb in plaster in which he sends the patient home after watching the post-operative course for a few days. They return in three to six weeks for a redressing and new cast; this is repeated as often as necessary till healing occurs, which he states, is quickly done without the usual large sear. The theory of this treatment is rest (which is essentially a "steal" from John Hunter, Hilton and Thomas) with aveidance of contamination of secondary infection introduced with frequent dressings. This method has the advantage of a quick hospital turnover, which is a decided economical factor; but is counter-balanced by insult to the patient's olfactory sense.

One law-suit is cited from neglect to dress a patient's wound and thus allowing pus to run out of the cast. Orr states however that these infrequent dressings yield no more, and even less pus than the daily dressings advocated by most men. He claims, and rightly so, that the effort to control infection once established is usually unsuccessful because there has been no ideal antiseptic found.

A take-off of this method is that of cutting a window in the cast and thus allowing for daily dressings without disturbance of the vaseline pack, except infrequently.

Albee is a strong supporter of Orr's method on the stand that a "bacteriophage is produced which aids very materially in the elimination of the infection. He has found this "phage" in 94 % of cases, has isolated a laboratory "phage" in an additional 3 %, and the remaining 3 % has been intractable (usually a hemolytic Streptococcus). He cites the work of D'Herelle, of Yale, and the Entomological work in Florida fruit groves with the simile "little fleas have lesser fleas upon their backs to bite them" ad infinitum. Paraffin and vaseline paste is used in varying proportions to suit the depth of the wound, usually 3 to 1, to 10 to 1 in the deep wounds. Tubes are imbedded in this tampon which is liquid on application and solidifies in situ to fit the wound snugly. Post-operatively he introduces 10 cc. of bacteriophage from the laboratory culture of the case, or of a laboratory strain, once or twice weekly through a plaster cast. New tampons and casts are applied every eight weeks as needed. Care must be exercised so that the tubes do not become a source of infection into the wound. He uses no antiseptics as he feels that this only

inhibits the formation or working of the "phage"

Baer has introduced the "viable antiseptic" for treatment of chronic Osteomyelitis, as a result of his observations in the war of neglected soldiers found on the field, whose wounds were in good condition in spite of the habitation there-in of innumerable maggots. Similar observations had been made by Pare' (1509-90), Fabricius (1634), Zachmann (1704) and by Zacharius during the Civil War (5). He uses the classical operation of saucerization, without antiseptics of any kind, either pre- or post-operatively, packs the wound for 24 - 48 hours with vaseline to control hemorrhage, then introduces sterile maggots into the cavity and covers the wound with a tight fitting screen. This is not always easy, as the profuse serous discharge from the wound loosens the adhesive and liberates the maggots. Owing to the life cycle of the "beasts", their useful span of life being five days, redressings are necessary each five days. He finds that after several dressings the length of duration of the maggots in the wound is shortened. Other authors using this method claim death of the maggots is due to inadequate drainage which is profuse after each implantation, and to the use of too many maggots,^{and} that they will continue to live the full five days if these factors are taken care of properly. (17) Slight constitutional symptoms occur often the third or fourth day after implantation, such as fever 101 - 103, especially if insufficient drainage is present. One patient had extensive damage of tendons (18), while another author reports a "wild" strain of maggots which caused extensive destruction of sound tissue before they could be removed. (5) This occurred due to the difficulty of securing laboratory maggots

which were of necessity collected upon some exposed meat--the offenders were never identified. The type of maggots used in the treatment satisfactorily are: *Phormia regina*, *sucilia sericata*, *Lucia caesar* (5) and *Calliphora erythrocephella* (15a). The production of a suitable sterile maggot in sufficient quantities was at first quite a problem, but has become of relative minor import of late. (17) One case of tetanus resulted fatally, so that the routine administration of tetanus antitoxin is advised.

According to Baer the maggots act as scavengers, devouring only the necrotic tissue. There are small pieces of sequestrum constantly removed; there is absence of purulent odor and free pus is never present, as the maggots devour the bacteria. Fine looking granulations are produced which quickly fill in the cavity, so that as in the Carrel-Dakin management, secondary closure may be accomplished. Maggots eat only liquid food which is produced in the wound by bacterial action on the necrotic material. The bacterial count becomes markedly lowered, there is apparently less toxic absorption, the wound secretion rapidly changes from acid to alkaline, there is no odor, the resulting scar is soft, the X-ray shows smooth even calcification of the bone, as contrasted with the blotchy type of "packs". Maggots have a scavenger action, promote secretion from the wound, and according to Livingstone (15b) induces the formation an "active principle". Needless to say this requires hospitalization and a constant, suitable supply of maggots, all of which ^{are} expensive.

Livingstone, after observing dead maggots in a wound with apparently equally good results, began investigations and

found that macerated maggots produced equally good results. Filtered extract of the macerated maggots worked just as well. As a result of his observations he concluded that there was some "active principle" responsible for the results; he is continuing work along this line (15b).

It is interesting to note that both Albee and Livingstone have apparently approached one another in their observations on "bacteriophage" and "active principle" derived from two entirely different sources. No doubt it is along this line that future treatment will ensue.

After a resume of the current literature considering the accepted pathological picture, it is interesting further to note that for the most part surgical technique at operation is relatively the same, with the aim of removing all necrotic bone, and all infected tissue(4,10,2,15,19,21,22,24). Treatment being successful to a varying degree depending on the age of the patient, the size and chronicity of the infection, previous operations, the lymphatic and vascular conditions, and on the technical ability of the operator, rather than upon the particular "method" used. All authors report good results--those most frequently quoted being Orr, with modifications, and Baer.

In closing I would like to make a plea for diagnosis and treatment of the acute case, both for the benefit of the patient and the conscious of the physician in attendance. Caldwell states that operation during the first 48 hours results in a mortality of not over one per cent, and disability of less than three months; secondary operations are reduced 50 % and

complications nil. That in Louisiana figures show (of 700 cases) a mortality of 4 %, with the estimation that 20 % of cases have disability of three to six months. And of the remaining 80 %, 25 % recover in one to five years with numerous operations, 75 % recover after months and years with deformity or permanent disability. This is due to the fact that 75 % of cases are diagnosed as rheumatism. Briefly he states, there is justification for operation when there is:

History of:

Acute illness, with chill
 Trauma, nearly always present
 Predisposing infection, skin or tonsils
 Pain, intense, throbbing, toothache, heat no value
 Temperature, immediate rise and very high 103
 Pulse, very rapid 120 - 180
 Prostration, very great

Examination shows:

Location, one focus (others may arise) not in joint,
 usually tibia or femur
 Appearance, negative early
 Tender, none over joint, acute over bone
 Fluid, none in joint
 Motion, with care there is no pain.

If the physician (when called) will treat his acute Osteomyelitic cases as he does his acute appendicitic patient, better results will be obtained, and chronic Osteomyelitis will not be so common.

Case A, from Starr, in Lewis's Surgery

A. Age 12, admitted May 22, 1922.

History: For several months prior to admission she had suffered from boils in various parts of her body. Three weeks prior to admission she developed an infection of the finger, right index. The infection was severe and subsequent investigation after her admission showed it to be an osteomyelitis of the terminal phalanx. A week before admission she had a chill, felt miserable and ached all over. The next day complained of pain in the lower end of the right thigh and limped when she walked. The pain was severe, so that she was unable to sleep at night. Her temperature was elevated and she was delirious at times. Three days after the onset of pain in the leg her physician noted that the affected area was swollen. These symptoms continued and increased in severity up to the time of her admission.

Examination on admission revealed; Temperature 102.5, W. B. C. 25,000; 88 % polys. Pulse 136. She appeared ill and was in evident pain. Scattered over the body were numerous scars, the result of previous boils. The lower end of the thigh was swollen, and the knee held flexed at an angle of 150 %. Extension beyond this angle was impossible on account of pain, but there was considerable range of flexion from this position without pain. The knee joint was not swollen nor did it contain any fluid. The swollen lower end of the thigh was red, especially on the inner side. It was exquisitely tender, the point of maximum tenderness being over the inner condyle of the femur. This also was the point of maximum swelling and redness. The terminal phalanx of the right index finger was swollen, red and tender, and a sinus discharged from the dorsum just proximal to the nail. Fluctuation over the swollen thigh was not made out.

Diagnosis: Osteomyelitis of the lower end of the femur.
Operation (within a few hours of admission): An incision made over the inner condyle of the femur, the vastus internus was split to expose the periosteum. An incision of the periosteum a subperiosteal abscess was opened from which about three ounces of pus drained. The cortex was stripped of periosteum for a considerable distance. A rubber tube inserted for drainage and the wound partially closed with silk worm. The sinus in the terminal phalanx was explored. The greater part of this bone was found to be separated as a sequestrum. It was removed.

Blood cultures on admission grew *Staphylococcus aureus* in all tubes, and cultures from operative wound yielded same organism.

Following operation, the temperature fell steadily, reaching normal on the fourth day. It remained normal during the remainder of her stay in the hospital except for a period during the fourth week when drainage evidently was impaired. The finger healed quickly. The wound on the thigh continued to discharge till Sept. 1922. By that time a sequestrum was evident in X-ray film. On Sept. 25, 1922 this was removed by a simple operation which enlarged the sinus sufficiently to permit picking out the sequestrum. Obliteration of the cavity was not necessary. She was discharged after this operation with the wound still open. She was re-admitted Dec 28, 1923 with the sinus still discharging. X-ray showed a sequestrum. This was removed by operation on Dec. 29, 1923. The sinus had healed two months later. A recurrent abscess was opened by a simple incision on March 8, 1924 and healed quickly after drainage. There has been no further trouble. Examined some time after healing, the leg showed no deformity, the movements of the knee were free and normal in range, and function of the leg was normal.

This case illustrates the onset, latent treatment, which was prolonged, and the results after all the necrotic material had been removed.

Case 1, Cassegrain.

M. D. age 17, white, male, entered Jan. 4, 1925 complaining of running sore over right collar bone.
 Present illness: Five and one half months ago, one afternoon he was taken suddenly ill with chills, high fever and extreme pain in the right side of his neck just above the collar bone. The day before he had played baseball nearly all day, under a hot sun, and had been struck in the neck with a foul ball. Six days after onset of trouble a large abscess of the neck was incised and drained. He left the hospital in nine days and he had felt fairly well since his discharge, except the wound had not healed, has been draining ever since and that on two occasions small particles of bone escaped from the wound. Culture at time of operation showed *Staphylococcus aureus*.
 Physical examination was negative except for the sinus. X-ray report described osteomyelitis of entire right clavicle. On Jan. 15, 1925 operation was performed under local anesthesia. The periosteum was thickened, bone was removed entirely without the periosteum. Iodoform pack inserted and incision closed.

Uneventful convalescence with slight fever of 100 on the first day post operatively. Discharged from the hospital eight days later and healed in sixteen days. One and a half years later X-ray of clavicle showed complete regeneration.

Case 3. Brockway.

Age 16, male had acute osteomyelitis of left femur which was treated by Baer's maggot method. The wound was still draining when he suddenly began to have pain in the right hip with chill and high fever. The X-ray film showed an area of rarefaction just below the epiphyseal line of the capital epiphysis. There was also destruction of the lateral cortex of the femur beginning just below the great trochanter and extending down the shaft for a distance of three or four inches. Six days after the clinical onset a femoral osteotomy was done and the neck of the femur drained by making a large drillhole upward into the neck, starting below the trochanter in order not to contaminate the hip joint. The wound was packed with vaseline gauze and a long leg plaster spica applied. The spica was left on for three weeks during which time the temperature went up to 100 % daily. Light cuff traction to knee and ankle was then applied and daily "pool" treatment started. The temperature dropped to normal in a few days and the discharge rapidly decreased. X-rays of hip two months later showed definite bone regeneration and the wound healed except for a small point which was covered by excess granulations and was draining hardly at all. The patient at this time had no pain or motion in any direction.

Case from Orr.

Age 6, came 250 miles by train and admitted on Sept 1, 1926 with a temperature of 105, pulse 140, respirations 32, white blood count 28,000.

There had been pain in left knee and thigh for three days previously. Hot packs did not allay discomfort but during the past 24 hours the least movement of the lower extremity caused severe pain. The temperature taken twelve hours before admission was 106 % and had been 104 on the previous day.

The lower one third of the thigh was swollen and tender. There was a definite redness radiating to the outer side of the front lower portion of the thigh. Movement of the knee or hip caused severe pain. The child was negative as to other physical findings, except a mild furunculosis on the back of the neck, and an infection of one finger.

X-ray findings were negative as to any bone lesion.

The child was taken to the operating room with the diagnosis of acute Osteomyelitis of the lower third of femur. Operation by Orr and Thomas. An incision was made laterally just behind the quadriceps group about six inches long. The skin, muscles and periosteum were reflected in one mass and a small chisel hole made in the cortex of the metaphysis just proximal to the epiphyseal line. Immediately a yellow, creamy pus welled out. The opening in the bone was extended toward the diaphysis to about three by a half inches, so that the entire lower third of the femur was well drained. The pus exuded freely and was apparently under pressure. Very little exploration of the medullary cavity was done and the wound was filled to the depth of the medulla with a vaseline gauze pack, and vaseline covering placed over the entire area. A double plaster-of-Paris spica cast was applied. In twelve hours the temperature had dropped to 99°; it went up in the morning to 101, but was down in the evening. The temperature ranged within these limits for three days, after which it remained under 99.6. After this he had a normal temperature except once or twice rising to 99.

At the end of six weeks the cast was removed and the dressings taken out. There the wound had filled in to practically one half of the previous depth and was covered from the base with healthy granulations. A new single spica cast was put on and worn for a month longer, then on removal the wound was found to be healed, with the dressings pushed entirely out of the wound and the serum which had come from the wound, entirely dried.

This wound which had gaped open originally about two inches, closed to less than one half inch at the widest portion of the scar. He was placed in a caliper brace and physiotherapy, massage, and active and passive motion instituted. Since he has been up and around he has had no temperature, and on Jan. 10, 1927 was apparently entirely well.

Case 11 Kulowski

Gerald T. age 7, diagnosis, Osteomyelitis of lower end of right femur, four months duration. Complains of pain, swelling and deformity of right knee.

5-27-29 Orr drainage, hip spica applied, uneventful recovery.
 6-20-29 New cast, condition good.
 7-29-29 Cast changed to long leg cast.
 9-2-29 Fell and broke cast about week ago. Very profuse drainage since. New long leg cast applied.
 10-17-29 Still much drainage. Granulations are not healthy as they should be to promote healing. Long leg cast applied.

Pt improved but a small sinus persisted until 4-14-30 at which time a sequestrum was demonstrated by X-ray.
 4-14-30 Second Orr drainage; uneventful recovery.
 4-30-30 Cast changed from spica to long leg cast.

Patient went on this way for several months until the long leg cast was changed to a spica and he was told to remain in bed. There has been considerable improvement.
 2-18-31 Wound practically healed.
 Patient began to improve steadily following adequate immobilization.

Case I Buchman

A. H. , age 10, white male, complained on admission to the hospital of pain, deformity and inability to use his lower limbs and a discharging sinus of both legs, of nine months duration. The onset was characterized by high fever, pain, and swelling of the right leg. Two weeks there-after, two sinuses appeared with a profuse discharge of pus. A few weeks later, the left leg was similarly involved with like consequences, and after several months, pain appeared in his right arm, subsiding again in a few weeks.

Examination revealed that the patient was in a very poor general condition, underweight, undernourished, and totally disabled. He presented marked flexion adduction deformities of both hips with great loss of motion at these joints. There were flexion deformities, partial subluxation, and limitation of motion of both knees. The feet were in marked equinus and immobile. There were in addition, discharging sinuses in both legs and several healed bed sores over the sacrum, back and about the greater trochanters. Roentgenographic examination showed an extensive osteomyelitic condition involving both tibiae, the right fibula and a destructive arthritis of the right knee joint.

In view of the poor general condition, the patient was given supportive measures and after a month's care, he improved considerably. Because the extent of the involvement of both tibia was similar, it was decided to treat the left limb by the Orr method and the right limb by the maggot technique. A saucerization and Orr dressing were therefore performed on the left tibia on March 20, 1931. On April 13, 1931 a similar procedure was carried out on the right tibia, but the Orr

dressing was omitted. After a period of six weeks, during which four maggot dressings were applied, the wound was entirely healed save for a very small area which was slowly being epithelized. On June 24, 1931, the right fibula was saucerized, and after a period of two months during which eight maggot dressings were applied, this wound also healed save for a small area lacking epithelium. At the end of nine weeks this wound was completely healed. On the left side the control side, a number of Orr dressings were performed but after a period of six and one half months a discharging sinus still presisted.

A comparison of both limbs at this time showed that on the side treated with maggots, both operative wounds were perfectly healed, the scars were excellent, and have remained so to date. Furthermore, the wounds had filled up to the level of the surrounding tissues. On the control side, there was a presistant sinus after six and a half months of treatment, and the scar was considerably depressed. Comparative X-ray studies showed that the limb treated with maggots presented an evenly calcified bone scar of excellent texture and appearance, while on the control side, the bone deposition was irregular with areas of sclerosis, rarefaction, and evidence of remaining osteomyelitic activity.

It was therefore decided to re-operate upon the control side and institute the maggot treatment.

On Oct. 2, 1931, the left tibia was explored and saucerized. Operation revealed several areas of granulation tissue and a perforation of the posterior cortex which was not found at the previous operation. Since the second operation, eleven maggot dressings have been done and the wound is now completely healed after a period of ten weeks. X-ray examination revealed satisfactory healing. The bone regeneration was homogeneous, smoothly and evenly calcified.

During the course of these events, a sinus appeared over the right humerus and a roetgenographic study revealed an extensive chronic osteomyelitic process with sequestrum formation. This area was saucerized on Sept. 4, 1931 and the maggot treatment was instituted. Fifteen maggot dressings were applied, and now, after a period of fourteen weeks, the wound is practically healed. X-ray examination at this time shows a homogeneously calcified bony regeneration.

These cases are cited primarily to show the acute onset, but also to illustrate the effect of proper surgical technique at operation and subsequent dressings of various kinds.

L. H. W.

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