Discussion of the treatment of hematogenous osteomyelitis

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A DISCUSSION OF THE TREATMENT OF HEMATOGENOUS OSTEOMYELITIS

BY

HENRY GRABOW

A THESIS

PRESENTED TO THE COLLEGE OF MEDICINE,
UNIVERSITY OF NEBRASKA.

OMAHA, 1940.
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INTRODUCTION

The treatment of osteomyelitis was chosen as the subject for discussion in this thesis because the disease is so common, its cure so questionable, its course so frequently chronic, and its results so disfiguring, disabling, and often discouraging. In the acute stage, the mortality is high.

It used to be said, "Once an osteomyelitis, always an osteomyelitis." Some men say that that statement is no longer true. Perhaps it isn't, but we do see all too many cases of chronic and recurring osteomyelitis supporting it.

Treatment is probably our greatest weakness concerning osteomyelitis. In the pages which follow we may be able to find out the weakness in our methods and what kind of treatment gives the best results.

We have limited this thesis to the discussion of the treatment of non-tuberculous, hematogenous osteomyelitis of the long bones. It was felt that since osteomyelitis of the long bones is most common, and the principles of treatment essentially the same, there was no need to discuss the treatment in any other specific bones.
DEFINITION

Osteomyelitis is a disease, inflammatory in nature, involving bone and having its origin practically always in the medullary tissue although at times it may originate beneath the periosteum. Also there are frequently two foci, one subperiosteal and one in the medulla. If the infection is confined to the periosteum it may be spoken of as periostitis, and where the infection is definitely within the bounds of cancellous bone, most surgeons use the term, "osteitis."

HISTORY

Evidence of osteomyelitis is found in fossil reptiles in the topmost strata of the Paleozoic and it probably helped exterminate Mesozoic reptiles and the later fossil mammals. Man has undoubtedly been afflicted with the disease for as long as he has existed. It has been discussed since the beginning of recorded surgical observations (62). Osteomyelitis was first described as a clinical entity by Chassaignac, in 1854, but it had been mentioned earlier in the United States by Nathan Smith in 1789, and by his son, Nathan R. Smith, in 1834 (145).
ANATOMY

There are certain points concerning the anatomy of bones which it is well to keep in mind in dealing with this subject. The periosteum has two surfaces, an outer fibrous one covering the bone and separating it from surrounding structures, and an inner one loosely attached to the bone by many fine strands of connective tissue. When torn away by trauma or lifted up by infection many osteogenic or bone-forming cells go with the inner layer. It is believed that these cells play a major part in the formation of new bone. The periosteum covers the shaft of the long bones and is firmly attached to the cortex at the epiphyseal line, but is not continuous with the articular cartilage. In young persons it dips down into the bone at the epiphyseal line which joins the shaft with the epiphysis. It thus serves as a barrier and delays or prevents infection from reaching the epiphysis from the diaphysis. During the growth stage the epiphyseal line is made of cartilage, from the shaft side of which the bone grows in length. In young persons, the blood supply is abundant along this line, there being numerous end arteries on either side of it. The nutrient artery of the shaft supplies one side, the other
side receives almost as much blood from a circular network or arteries just outside of, and surrounding, the articular cartilage. The blood supplied by the periosteum is of less importance than was once supposed.

**BACTERIOLOGY**

*Staphylococcus pyogenes aureus* is the cause of acute osteomyelitis in 75 to 90 per cent of cases. The rest are caused chiefly by the streptococcus, *Staphylococcus albus*, the colon bacillus, pneumococcus, and very rarely the gonococcus. Osteomyelitis due to the typhoid bacillus is sometimes a complication or sequel of typhoid fever. The organisms are usually blood borne, thus giving to the name, hematogenous osteomyelitis.

Various sources of infection resulting in osteomyelitis are infected teeth and tonsils, sinusitis, mastoiditis, boils, compound fractures, gun shot wounds, operations on bone followed by infection, and rarely, by contiguity from a neighboring joint or infected soft parts. In hematogenous osteomyelitis caused by *staphylococci*, it is well to look at the skin for the source; if caused by streptococci, look in the mouth, nose, and tonsils.
PATHOLOGY

In acute hematogenous osteomyelitis, or simply, acute osteomyelitis, is blood borne and the infection usually begins in the cancellous bone of the metaphysis bordering the epiphysis. From there it can spread to the marrow of the shaft, across the epiphyseal line into the epiphysis and joint, or peripherally along the epiphyseal line to beneath the periosteum. Contrary to what was formerly believed, the latter is the most common route which it takes. It then elevates the periosteum and extends along the surface of the cortex through which it invades Volkmann's canals and the Haversian system and reaches the medulla. Thus the medullary canal, instead of being invaded early and acting as the chief avenue of widespread infection, is often the last of the bony structures to be involved. Somewhat later pus may be found collected in pools in the medulla, in the joint, beneath the periosteum, and, when it ruptures, in the surrounding soft tissues. Extension through the epiphysis into the neighboring joint is much less common than would be expected. The joint most liable to become infected is one whose ligaments are attached on the diaphyseal side of the epiphysis. The infection
may then break into the joint by penetrating the periosteum at the epiphyseal line. The greatest destruction of bone is due to widespread embolism and thrombosis of blood vessels.

The infecting organism can be recovered from the blood in many cases. Sometimes the septicemia is overwhelming and death may occur from forty-eight to seventy-two hours after the onset of local symptoms. Usually the acute symptoms disappear in a few days, but sooner or later distance complications may arise as a result of the blood stream infection.

The osteogenic cells attached to the raised periosteum soon begin to lay down new bone and form an involucrum around the necrotic shaft. The devitalized bone separates from the living bone in a few weeks or months and forms an infected mass called a sequestrum.

The subacute stage of osteomyelitis begins as soon as the systemic reaction subsides. The patient's life is essentially out of danger, but the local pathology is all too often, very active. In it the involucrum begins to form and the sequestra to separate. There may or may not be draining sinuses present. After three or four months the involucrum is relatively thick and strong and the sequestra
pretty well separated. From this time on the disease is considered chronic.

Chronic osteomyelitis is the result of neglected or maltreated acute osteomyelitis, traumatism such as compound fractures and gun shot wounds, or may occur without preceding acute damage as in that caused by the typhoid bacillus complicating typhoid fever. It is characterized by a thick involucrum, sequestra, draining sinuses, and a bone with its structure distorted by areas of necrosis.

Occasionally the resistance of the tissues may wall the infection off and confine it to a limited area within the bone or in healing, the drainage channel may heal first and a localized vacuole may remain. Later, a wall of compact bone is built up about it producing a cavity lined with sluggish granulation tissue and containing pus from which the bacteria may disappear. This may remain in a quiescent state many years and is usually known as a Brodie's abscess.

**PREDISPOSING FACTORS**

Acute osteomyelitis is a disease of the young. Most cases occur in children from two to twelve years of age. Often there is a history of local trauma, ex-
posure to cold, or some other factor which might play a part by lowering the local resistance. Boys are affected more often than girls. The bones most often involved are the femur, tibia, and humerus. The acute infections diseases of childhood, acute or chronic infections of the teeth, tonsils, nose, ears, skin and mous membranes often immediately precede or accompany the onset of acute osteomyelitis. These infections like trauma, may reduce local resistance or give rise to infected emboli and thus aid or initiate the disease.

Acute osteomyelitis is rare in adults. They usually suffer from a chronic osteomyelitis which has never healed, have a recurrence from an old acute or chronic osteomyelitis, or the disease develops from an infected compound fracture, gun shot wound, or similar trauma.

SYMPTOMS

In acute osteomyelitis the onset is sudden. Delirium and coma may supervene before localizing signs and symptoms are evident. This is not commonly the case, but often they are desperately ill from the onset of the infection. Whether the onset is sudden or gradual, the outstanding symptom is local pain which is continu-
ous, deep, boring and severs, and the outstanding sign is exquisite tenderness on pressure over the bone, with increase in discomfort brought out by tapping along the shaft of the affected bone.

After twenty-four to forty-eight hours there will often be some edema and tenderness in the soft parts over the endoof the involved bone, and, if the patient is still not treated, suppuration may break through the periosteum into the surrounding tissues.

By this time the patient is very ill with high fever, rapid pulse, dehydration, exhaustion from pain, lack of sleep and infection. Vomiting, acidosis, delirium or coma may develop. The leukocyte count is usually very high.

In chronic osteomyelitis, the symptoms are not acute. The patient will complain of the swelling and dull pain of an unopened abscess, deformed bone, chronically draining sinus, or suffer from a pathological fracture.

A sterile abscess often gives rise to pain in the extremity. Frequently, the pain is not well localized, or is referred to an adjacent joint and the condition goes undiagnosed for months or years.
DIAGNOSIS

The early diagnosis of acute osteomyelitis is a matter of great difficulty. One of the features of the disease is that the diagnosis of acute osteomyelitis is often missed until there is positive evidence of it in the X-ray, which takes at least four to seven days.

If a child complains of pain over the end of a bone and does not want it moved or touched, if there is tenderness on deep pressure over a bone, as well as symptoms of an acute infectious process, if the onset of these signs and symptoms has been abrupt and if the evidence of infection are rapidly on the increase, a diagnosis of acute osteomyelitis should be made.

The history is frequently suggestive, but often the clinical picture is vague and inconclusive so that a diagnosis of fracture, epiphyseal separation, acute arthritis, scurvy, rheumatic fever, erysipelas, cellulitis, or lymphangitis is made and delay in treatment results.

The diagnosis of chronic osteomyelitis is easily made from the symptoms, and appearance of the limb with its scars and sinuses. However, the X-ray should be used, not only to make or confirm the diagnosis, but
also to direct treatment. This is also true in the case of chronic bone abscess in which case the lesion can but rarely be definitely diagnosed or located without it.

**COMPLICATIONS**

Septicemia or acute toxemia are the most frequent causes of death in acute osteomyelitis. Much more commonly, there is a bacteremia or pyemia. As a result there may be multiple bone and joint suppuration, suppurative pericarditis, and widespread tissue abscesses. Locally, in either the acute or chronic disease, there may be epiphyseal damage or joint involvement with growth deformity limitation of motion and an ankylosis resulting. Union of fractures is interfered with, pathological fractures frequently occur, and the characteristic scars are very easily injured.

**PROGNOSIS**

In the acute stage, the danger to life is grave. Many cases heal completely in a few weeks following primary operation. Occasionally, the disease will disappear spontaneously with conservative management alone. About one-half of the acute cases go on to chronicity. Most of these can be healed by the use of surgery and
physiotherapy.

After the acute stage, the danger to life is not great. However, many cases remain active for years no matter what is done for them. Frequently amputation is necessary, not so much as a life saving procedure, but because the patient would rather be without his limb than put up with the continual stigma of the infection. The incidence of disability, deformity, and loss of function is high. One of the worst features of this disease, is that all the lesions may heal, but recurrence is frequent. No one can make any predictions; it may recur in a few weeks or months; it may not recur for years; or it may never appear again.
TREATMENT

The only specific thing about the treatment of osteomyelitis is that it is a surgical problem, and some men don't believe that. Results have been far from satisfactory, so the procedures which have been advocated are many and varied. However, no matter what type of treatment a surgeon recommends, it is his honest desire to cure his patient, lower the mortality rate, and prevent sequestration, local metastatic extension, chronicity, and functional impairment and deformity in the shortest possible length of time and with the least expense. Therefore, he uses the type of treatment, which he believes comes the closest to fulfilling that desire.

Acute State

The local supportive measures used by various surgeons are essentially similar and used both pre and post operatively. However, the stress laid on this treatment and the time when it is most used is far from the same. Those who believe in early surgical intervention used them practically not at all, or only for a few hours before operation, while those who belong to the conservative group lay great stress on the pre operative value of this treatment, and do every-
thing in their power to increase the patient's resistance and assist him in living through and overcoming the acute, toxic stage of his disease. These men wait until the virulence of the infection has abated and the bone lesion has localized. They are not afraid to wait until there is x-ray evidence of the disease in the bone. Death, septicemia, phemia, toxemia, metastases, joint involvement and sequestration are to be feared, but they have some very good statistical evidence which shows that their waiting plus the intensive use of general or specific supportive measures, accomplishes more in preventing such complications than early surgery does. It is also to be noted that when these men do operate, they recommend the simplest type of surgery which is usually incision and drainage of the soft tissue or subperiosteal abscess. They prefer to wait until sequestra have separated and an involucrum formed before contemplating any radicle surgery. According to statistics waiting is not only rewarded by a diminished incidence of complications, but many cases heal completely following the primary operation, and rarely the disease resolves without surgery of any kind being necessary. (64, 75, 78, 86, 117, 189)
**Systemic Treatment**

For acute osteomyelitis, the systemic infection is treated with usual supportive measures. Fluids are forced, intravenous dextrose (5-10%) in normal saline being frequently used to combat acidosis and dehydration and to keep up nutrition. The patient should receive a high caloric, high vitamin diet, repeated small transfusions, and enough sedation to allay the pain and keep him resting. (1, 11, 42, 58, 64, 75, 78, 113, 117, 147, 148, 153, 156, 185)

**Specific Medication**

The use of specific medication varies. Gentian violet has been used locally, intravenously, and intramuscularly, but its value is questionable. (174) Sulfonilamide or some of its derivatives may be of some value. (117, 128) It should be particularly useful in osteomyelitis of infants because more than half of those cases are caused by hemolytic streptococci. (129) Klein (94) reports several cases in which he used stannoxyl with good results. Neosalvarsan was used by Le Cocq (104) and although his series of cases was small the results he reports are very good.
Blood Transfusions

Frequently, blood transfusions are used. Some men use plain blood, while others prefer immuno-transfusions. Their value seems to be questionable, some men believing they are definitely beneficial, especially the immuno-transfusions, while others believe that they are of no use at all. At least, they should assist in combatting the anemia resulting from the infection. (1, 11, 15, 51, 58, 64, 91, 117, 127, 148, 153, 156, 185)

Vaccines and Serum

Autogenous vaccines, stock vaccines, and antitoxins both with, and without surgery have been employed in treating acute and chronic osteomyelitis in all their stages. On reading the various reports one gets the impression that the status of vaccine and antitoxin therapy is unsettled. Vaccine therapy has a few supporters but no good proof of its value has yet been obtained. Dolman (50) whose series of cases is the largest in the literature, reports very favorably on the use of antitoxin in 32 cases of acute osteomyelitis in children. He states that in cases in which there is a positive blood culture the mortality rate, usually 50 per cent, has been reduced to 31 per cent.
In his series the clinical condition of individual patients, and not only statistical considerations, was the chief method of assessing the value of serum therapy. He believes that antitoxic serum therapy has undoubtedly proved a life-saving measure in many instances of osteomyelitis in childhood. He emphasizes the value of early diagnosis and the use of large doses of serum intramuscularly. However, this method of treatment has the danger of serum sensitivity and shock to contend with and since its efficacy is far from established, it is not generally used.

(30, 66, 67, 88, 111, 128, 133, 159, 160)

It is always desirable to run routine cultures on the blood and lesions of a case of acute osteomyelitis. The information they give is valuable in indicating the prognosis and directing the treatment. Septicemia has a high mortality rate. However, when it is caused by a hemolytic streptococcus, specific medication gives frequent cures. Straphylococcic septicemia is highly fatal, yet antitoxins may render enough assistance so that a seemingly hopeless case eventually recovers. Autogenous vaccines or immuno-transfusions with the cultures may occasionally aid materially in causing a favorable resolution of the disease, while organ
isms which produce a low grade infection are very apt to give rise to indolent, but very persistent bone lesions. (64, 91, 117, 133)

Local Therapy

Local therapy used before surgery is instituted consists of immobilization of the limb, local heat, and local applications. Immobilization is usually obtained by the use of plaster of Thomas splints. (58, 61, 65, 148)

Physiotherapy is an important adjuvant in both the acute and chronic states and should be used freely. There is probably not much difference in the value of the various methods of applying heat to the involved area. (27, 58) However, Kobak (97) reports that through and through diathermy gives the most prompt and brilliant results.

For local applications, Vignard (183) recommended the use of turpentine packs. He used them exclusively saying that surgery was unnecessary and reported that of 7 patients so treated one failed.

Pennington (149) applied potassium nitrate in rolled oats as a paste over areas of chronic infection. He says it makes surgery unnecessary and treated over 200 successfully. Carruthers (34) used
it on 10 cases with good results. Thorek (179, 180) also recommends its use in the various stages of osteomyelitis, but does not advocate its use where radical surgery is indicated. He believes that preoperatively it often facilitates surgery in badly infected cases, and postoperatively often stamps out persisting infection. This may all be true, but we believe that essentially the same could be said for practically any of the various local applications.

**Foci of Infection**

Gannett (61) reminds us that in treating this disease we should not forget that teeth, tonsils, boils, sinuses, ears, and similar foci are possible sources of the infecting bacterial. Whenever, such foci are found their removal may arrest or cure the disease. All conditions which are possibly an underlying cause should be appropriately treated. (140)

**Methods of Operation**

In all operative procedures the patient should be prepared and sterile technic used with the work done in a bloodless field obtained by the use of a tourniquet, as in any orthopedic surgery. The anesthetic used varies with the surgeon, the patient, and
the operation. Incisions should be located along anatomical planes so as to gain adequate exposure with a minimum of functional impairment. Scar tissue formation in osteomyelitis is often very extensive, so in many cases the proper path of approaching a bone lesion may be a real problem. (40)

The operation should always be done as quickly and gently as possible with the least possible tissue damage. The periosteum should not be stripped from the bone any farther than can possibly be avoided. (171) Tools should be used that produce the least amount of trauma. The possibility of fracture is often present, and bone trauma is conducive of shock. (34, 39, 55, 113, 140, 148, 189)

If an operation is done before there is any radiological evidence of bone distraction to locate the lesion, the bone is usually attacked at its point of greatest tenderness. If an abscess is present it frequently indicates the place where surgery is required. (140, 171)

The methods of treating acute osteomyelitis vary from immediate radical drainage to conservative treatment without any surgery. Most men recommend surgery of one type or another, some operate early, others late; some stress preoperative preparation,
while others consider it of minor importance.

For years the complaint has been that the diagnosis of acute osteomyelitis is usually not made soon enough, surgical interference is delayed, and disastrous results follow. The general belief was, as Doran and Brown (51) put it, "If time of onset to surgical treatment is hours, convalescence is weeks; if measured in days, convalescence in months or years." The key-note of their treatment was that acute osteomyelitis should be treated with early drainage. (7, 34, 36, 39, 43, 47, 58, 91, 95, 98, 105, 113, 139, 140, 145, 147, 148, 151, 156, 167, 184, 185)

However, recently some very good evidence has been presented, which indicates that such is not the case. According to Wilensky (187), the treatment of acute hemotogenous osteomyelitis in its early stages has the general infection as its most important item. The mortality statistics of acute hemotogenous osteomyelitis in its early stages reflects accurately the mortality of general bacterial infection and in the absence of any fatal complications or associated lesions, the mortality of the local osseous lesion is nil (46).

It may be that acute osteomyelitis is an incident in a general bacterial infection so that one
may not expect or hope that the mortality of the local osseous lesion will be any less than that of the corresponding and accompanying general infection. Yet, it is believed by some that the generalized infection results from the bone infection and that if it is drained immediately the systemic invasion will not develop. (153, 187)

Rarely, but more commonly that is generally known and understood, foci of hematogenous osteomyelitis subside completely and spontaneously without going on to the stage of sequestration and necrosis. (101, 187)

The extent of operation is a problem the answer to which varies greatly among different surgeons. Many believe that adequate drainage of a subperiosteal or soft tissue abscess is sufficient. (20, 46, 78, 85, 99, 101, 117, 136, 177, 187)

Among those who believe that the bone as well as the soft tissue and subperiosteal abscesses should be drained there is great difference of opinion as to how it should be done, and to what extent. Simple drilling is a commonly used procedure. However, if there is pus present, drilling alone is usually not considered adequate enough so many men then use a chisel, saw, or burr and remove the cortex between
the drill holes, or an even larger portion of it.
The amount of cortex removed varies from a narrow
groove to two-thirds the width of the bone and ex-
tending as far as there is infected and necrosed
metaphysis and necrosed medullary tissue beneath
it. Sometimes a trough the width and length of the
medullary canal is removed. Some men remove all the
necrotic tissue, so that nothing but healthy tissue
remains. This is not the usual procedure, however,
and curetting is generally condemned. Necrotic tis-
sue should be left alone or gently sponged away.
(1, 2, 7, 8, 11, 15, 33, 34, 37, 38, 39, 43, 47, 51,
53, 55, 58, 61, 75, 84, 91, 95, 105, 113, 118, 133,
135, 136, 140, 147, 148, 151, 153, 156, 167, 169,
185, 189)

In either drilling or guttering, great care
must be taken not to damage the epiphysis and it is
often stated that the medullary cavity should not be
disturbed unless it is already invaded by infection.
(33, 34, 53, 95, 171, 194)

In the absence of a subperiosteal abscess,
the men who do either of these operations generally
believe that there is no harm in opening the meta-
physis on the suspicion that it is infected. If there
is no infection found the lesion soon heals, while if
it is present, drainage is instituted. If suppuration has not yet occurred, a good avenue has been established for the escape of pus when it does appear. (33, 42, 91, 95, 99, 155, 156, 171, 184.)

These men want to drain the bone because infection in it is surrounded by rigid walls. That causes pressure to develop which enhances the absorption of toxins, and bacteria. Thus they believe the patient's chances of remaining very sick and developing a phemia or septicemia are great if a decompression is not done; there is danger of the pressure obliterating the blood vessels so that bone is destroyed, and it may force infection into the neighboring epiphysis and joint. However, many other men believe that the incidence of these complications is not decreased but, on the contrary, increased by surgically invading the bone; instead of the disease subsiding as is desired, it flares up. (46, 47, 153, 155, 184)

Some men only open the metaphysis when there is no subperiosteal abscess believing that when it is present, drainage from the bone is adequate and that nothing further should be done at the primary operation. (15, 64, 171, 189)

Occasionally, at primary operation, the bone is found to be extensively involved, the periosteum
sometimes being literally a bag of pus. Here again, the procedure varies. Those who are conservative merely incise the periosteum and establish adequate drainage. Other resect the necrotic shaft. One man, (155), thought it advisable in some cases to resect part of the shaft and replace it with a glass rod. It would prevent deformity, and it would be easier for a good involucrum to form around it than around a shaft which was loaded with infection. (11, 46, 58, 84, 98, 99, 140)

Osteomyelitis in Infancy.

It has been pointed out that acute osteomyelitis in children under two years of age should be treated in a different manner than in patients past that age. In the first place, over half of these cases are apparently caused by streptococci, and the incidence of very acutely ill and toxic cases is much higher than in the older age group. Conservatism, with great stress laid upon general supportive measures, is the treatment most frequently advocated. Because the incidence of streptococccic infection is so high, sulfonilamide or one of its derivatives, may be a life saving procedure. Surgery is usually limited to simple incision and drainage after localization has occurred. Invasion of the
bone also has its advocates here, but that is not the treatment of choice because it has been found that in infants very extensive bone involvement may occur and yet will take place without sequestration if only simple incision of the abscess is done. This abscess is usually in the soft tissues, because the infection quickly extends through the porous bone, and thin periosteum. (65, 92, 129, 138, 175)

It is interesting to note that some men who recommend immediate surgery in older age groups, treat osteomyelitis in infants conservatively. They do so because they say the older patients have greater resistance and can withstand the strain of immediate surgery better. (92) If such is the case, why not let the older patients use that resistance to combat the infection instead of to withstand the onslaught of surgery?

It is not uncommon for osteomyelitis in infants to resolve under general supportive measures and medication, without the use of surgery of any type. If such is to be the case, diagnosis must be early so that both general and specific systemic treatment may be instituted as soon as possible.

While the mortality rate, multiplicity of foci, and incidence of epiphyseal separation is high in infants, the incidence of cases which heal completely
with a complete absence of any residual local or metastatic infection or deformity, is greater than in older patients. (65, 175)

Mortality

The mortality rate of acute hematogenous osteomyelitis is high. (145) Just exactly how high is hard to determine, because each man is prone to report a low mortality rate for the particular method of treatment which he recommends.

Weil, Mettaur and Rohm (185) reported, in 1931, that the average mortality rate in the United States during the preceding 15 years, obtained from a large series of reported cases from the various clinics, was 14.8 per cent. In the British Isles from 1915 to 1927, it was 15 per cent. Yet, Mr. E. Lloyd (189) stated, in 1932, that the mortality of acute osteomyelitis varied from 20 to 60 per cent, and was commonly 30 to 35 per cent. It is generally accepted that the mortality in cases with septicemia also present is about 50 per cent.

According to Key (91) about 20 per cent of the acute cases die, about 30 per cent are cured by early operation and about 50 per cent become chronic.

At least, it can be safely said that the mortal-
ity and morbidity rate is much higher than we think it should be so that every surgeon ought to keep his mind open and give very careful consideration to any suggestions which might aid him in increasing the efficiency of his own method of treatment.

**Sequestra**

Sequestra form a major problem in the treatment of this disease. They are formed not so much by direct destruction and invasion of osseous tissue by infection, but more by embolic or thrombotic occlusion of the artery supplying a given portion of bone. Early adequate surgical drainage of the infected and necrotic focus in the bone is believed by its advocates to be the best method of preventing such occlusion. They advise against curetting of infected and necrotic tissue, because they fear that such a procedure would release emboli and cause an extension of thrombosis, and caution that all blood vessels encountered must be treated very gently for the same reasons. Also they wish to prevent extensive subperiosteal stripping by their early invasion of the bone. That would prevent medullary infection and thus thrombosis of all or all of the nutrient artery could be avoided. They seem to forget they can just as readi-
ly prevent its becoming infected by simple incision of the subperiosteal abscess since infection usually invades it by way of the Haversian system from such an abscess. The same can be said for preventing joint complication because infection usually enters it from a subperiosteal abscess and only rarely extends directly through the epiphysis. (7, 39, 46, 85, 117, 153, 189)

It is generally agreed, even by those who invade the bone at primary operation, that sequestra should not be removed until they have separated completely, the disease has quieted down, and an involucrum formed. It can best be determined when this has occurred by the use of the x-ray. Rarely a sequestrum which is very accessible and free may be removed at primary operation, although routine primary sequestrectomy is recommended by a few surgeons. Very rarely, but oftener than is suspected, sequestra disappear; they may be absorbed and assist in repairing the bone defect in much the same manner as a bone graft. (1, 64, 75, 91, 117, 136, 167, 187)

**Metastases.**

With metastases, we are confronted with the question as to whether they are foci from a persis-
tent primary focus or an early metastasis which remains quiet for a varying length of time. We cannot answer that question, but perhaps they are both. We do know that most of them appear during the acute phase of osteomyelitis, and thus constitute a definite problem in treating that stage. They sometimes appear after the disease has become chronic, but their treatment should then be essentially the same as during the acute stage. (152)

The consensus of opinion seems to be that they should be treated very conservatively with local physiotheraph, and drained only after suppuration occurs. With conservative management they often disappear spontaneously without the use of any surgery what-so-ever. A few men disagree with this contention and maintain that they should be treated in the same manner as the primary site of bone involvement — by radical surgery. This may be true in some cases, but probably not in the majority of instances. (175)

Pyogenic metastasis into other tissues of the body should, like any abscess or septic process, be treated according to its size, location, the virulence of the infection, organism involved, and the resistance and condition of the patient.
It would be a real triumph if metastases could be prevented. That was part of the goal of the men who advocated early and varyingly extensive surgery. However, we shall present some statistics which indicate that their incidence is the primary focus is drained lowest when during the second week of the acute stage of the disease. (64, 113, 115)

**Joint Involvement**

Extension of the infection into the neighboring joint is one of the commonest complications of acute hematogenous osteomyelitis. They are also frequently the site of metastatic involvement. The treatment of such joint infection is intimately linked with that of the osteomyelitic process which is often present in the adjoining epiphysis. The treatment of choice seems to be adequate drainage of the joint capsule, when suppuration has occurred. This followed by the generally accepted Willems method of early mobilization of joints has apparently proved of the greatest value in the treatment of infection which has extended into major joints, and is most liable to give a good functional result. (64, 90, 98)

When a neighboring epiphysis is also involved,
it should be treated in essentially the same manner as the primary focus. If it is deemed necessary to attack it surgically, great care should be taken to avoid injury the epiphyseal line. (2) Osteomyelitis of the epiphysis usually results in ankylosis of the joint. When that becomes inevitable, it is the duty of the surgeon to make sure that it occurs in the best functional position. This is done by means of splints, or a case, and with or without the use of traction.

Statistics

So far, what we have said concerning the treatment of the acute stage of hematogenous osteomyelitis has been based chiefly on the therapy which various men have recommended and their opinion concerning its treatment. Now we shall approach it from a statistical point of view. Many articles in the literature contain statistics of various kinds and scope, but the majority of them are too inadequate and presented in such a varied fashion that they do not lend themselves well to correlation. (20, 51, 65, 78, 99, 105, 107, 126, 138, 145, 153, 169, 189)

The following statistics which we quote were chosen because they seemed to be the most comprehensive, unbiased, and complete. All phases of the
therapeutic problem of the acute stage are not considered, but we believe that the majority of the most important ones are.

It is of interest to note the dates at which these statistics were published.

Tables I, II, III, and IV, are concerned with the results of time of operation and mortality.

TABLE I

MORTALITY PERCENTAGE OF ENTIRE GROUP IN REFERENCE TO CONDITION OF PATIENT AND TIME OF OPERATION.

(Brown (28) 1939

<table>
<thead>
<tr>
<th></th>
<th>Deaths</th>
<th>Lived</th>
<th>Mortality Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOXIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate Operation</td>
<td>22</td>
<td>37</td>
<td>37.3</td>
</tr>
<tr>
<td>Delayed operation</td>
<td>5</td>
<td>13</td>
<td>27.7</td>
</tr>
<tr>
<td><strong>NONTOXIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate Operation</td>
<td>1</td>
<td>24</td>
<td>4.0</td>
</tr>
<tr>
<td>Delayed Operation</td>
<td>1</td>
<td>39</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Operation within 48 hours after the diagnosis is made is considered immediate.
TABLE II

TIME OF OPERATION AND MORTALITY

Crossan (45) 1936

<table>
<thead>
<tr>
<th>Operation from onset, days inclusive</th>
<th>Number</th>
<th>Deaths</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within 4 days</td>
<td>18</td>
<td>7</td>
<td>39</td>
</tr>
<tr>
<td>5-7</td>
<td>35</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td>8-10</td>
<td>12</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>11-14</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15-21</td>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>22-30</td>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Over 30 days</td>
<td>18</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>121</td>
<td>26</td>
<td>21.49</td>
</tr>
</tbody>
</table>

TABLE III

MORTALITY ACCORDING TO TIME OF OPERATION AFTER ONSET

Mahorner (117) 1937

<table>
<thead>
<tr>
<th>Time, days</th>
<th>Cases</th>
<th>Deaths</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-7</td>
<td>57</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>8-10</td>
<td>15</td>
<td>12</td>
<td>33.3</td>
</tr>
<tr>
<td>11 plus</td>
<td>30</td>
<td>4</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td>107</td>
<td>26</td>
<td>24.3</td>
</tr>
</tbody>
</table>
TABLE IV

MORTALITY ACCORDING TO TIME OF OPERATION AFTER ADMISSION

Mahorner (117) 1937

<table>
<thead>
<tr>
<th>Time, days</th>
<th>Cases</th>
<th>Deaths</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>35</td>
<td>31.7</td>
</tr>
<tr>
<td>3 plus</td>
<td>28</td>
<td>1</td>
<td>3.45</td>
</tr>
</tbody>
</table>

No deaths when operated on the fourth day or after. Disease has been present up to 3 weeks.

A consideration of Table I does not leave much room for doubt that, at least in this series, immediate operation in the very toxic and even non-toxic patient was accompanied by a higher mortality, in contrast to those instances in which operation was delayed.

These statistics were compiled from the same series of cases as Table V so that they were operated upon with either the gouge or drill. They thus indicate that immediate operation with opening of the bone whether by gouge or drill, upon diagnosis of acute osteomyelitis in an acutely toxic patient, is accompanied by unjustified mortality and, should the patient survive, it is probably in spite of, rather than because of surgery.
Tables II, III, and IV list the time element more accurately than Table I. Table II is definitely in agreement with Table I in indicating that mortality is distinctly higher when operation is early than when it is delayed. However, it indicates in addition that there is an optimum time for operation, which is during the second week after onset of the disease. After that time the mortality goes up, but is still not as high as during the first week. This points out that early diagnosis and treatment which has been stressed for so many years is probably not the optimum treatment.

Table III is not in agreement, however. Only 5 cases were operated upon within the first two days after onset, so we don't know how significant this finding is, but it does tend to support the recommendation that surgical treatment be given early, although the table also shows a low mortality rate for the second week.

Table IV is very interesting and is the only one of its kind we were able to find in the literature. It emphasizes the contention that in order to lower the mortality of acute osteomyelitis the care of the patient's systemic reaction is of far more importance than that of his local lesion.
Tables V, VI, and VII deal chiefly with type of operation, and mortality.

### TABLE V

**RESULTS OF IMMEDIATE AND DELAYED OPERATIONS IN REFERENCE TO DEGREE OF TOXICITY, AND OPERATIVE PROCEDURE**

Brown (28) 1939

<table>
<thead>
<tr>
<th></th>
<th>Number of Cases</th>
<th>Deaths</th>
<th>Percentage Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IMMEDIATE OPERATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very toxic, drill</td>
<td>24</td>
<td>11</td>
<td>45.8</td>
</tr>
<tr>
<td>Very toxic, Gouge</td>
<td>35</td>
<td>11</td>
<td>31.4</td>
</tr>
<tr>
<td>Slightly toxic, drill</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slightly toxic, gouge</td>
<td>16</td>
<td>1</td>
<td>6.2</td>
</tr>
<tr>
<td><strong>DELAYED OPERATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very toxic, drill</td>
<td>10</td>
<td>2</td>
<td>20.2</td>
</tr>
<tr>
<td>Very toxic, gouge</td>
<td>8</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>Slightly toxic, drill</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slightly toxic, gouge</td>
<td>34</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>NO OPERATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic</td>
<td>18</td>
<td>3</td>
<td>16.6</td>
</tr>
<tr>
<td>Totals</td>
<td>160</td>
<td>32</td>
<td>20.0</td>
</tr>
</tbody>
</table>

Gouge-guttering. Operation within 48 hours after the diagnosis is made is considered immediate.
### TABLE VI

**TYPE OF OPERATION AND MORTALITY IN SEVERELY ILL PATIENTS, TEMP. 103°F.**

Mahorner (117) 1937

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>Cases</th>
<th>Deaths</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple incision</td>
<td>7</td>
<td>1</td>
<td>14.3</td>
</tr>
<tr>
<td>Drill</td>
<td>43</td>
<td>16</td>
<td>37.2</td>
</tr>
<tr>
<td>Saucerization or curettage</td>
<td>8</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>Subperiosteal reaction</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>59</td>
<td>31</td>
<td>41</td>
</tr>
</tbody>
</table>

### TABLE VII

**TYPE OF OPERATION AND MORTALITY**

Crossan (45) 1936

<table>
<thead>
<tr>
<th>IMMEDIATE</th>
<th>Cases</th>
<th>Deaths</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidement</td>
<td>23</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Drilling</td>
<td>18</td>
<td>6</td>
<td>33 - 26%</td>
</tr>
<tr>
<td>Incision</td>
<td>18</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DELAYED</th>
<th>Cases</th>
<th>Deaths</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidement</td>
<td>15</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>Drilling</td>
<td>14</td>
<td>4</td>
<td>28 - 15%</td>
</tr>
<tr>
<td>Incision</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

This is the work of eight surgeons, Immediate--within 24 hours of admission. Delayed--after 24 hours of admission.
Table V gives the results of immediate and delayed operation with gouge or drill in reference to degree of toxicity. In studying it, we find that in every instance but one (immediate operation of very toxic patients), the mortality was consistently higher when the bone was guttered than when only the drill was used. This indicates that, at lease in the majority of instances, the drill is to be preferred.

The mortality in 59 severely ill patients with a temperature of 103 F. or over with regard to type of operation is listed in Table VI. Simple incision with its mortality of 14.3 per cent is apparently by far the safest of the types of operations here recorded.

Table VII is also concerned with the type, as well as time of surgical attack. Again we find it definitely indicated that, in this stage, operation should be delayed, and that simple incision is the safest of the surgical procedures, no matter when the operation is done.
TABLE VIII

OUTCOME IN REFERENCE TO DEVELOPMENT
OF SECONDARY FOCI, MORTALITY,
AND TIME OF OPERATION.

Brown (28) 1939.

<table>
<thead>
<tr>
<th>SECONDARY FOCI DEVELOPED</th>
<th>Number of Cases</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early operation</td>
<td>36 (33.9%)</td>
<td>10 (27.7%)</td>
</tr>
<tr>
<td>Delayed operation</td>
<td>9 (21.9%)</td>
<td>1 (11.1%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECONDARY FOCI DID NOT DEVELOP</th>
<th>Number of Cases</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early operation</td>
<td>70 (66.1%)</td>
<td>12 (17.9%)</td>
</tr>
<tr>
<td>Delayed operation</td>
<td>32 (78.1%)</td>
<td>4 (12.5%)</td>
</tr>
</tbody>
</table>

In Table VIII the incidence of secondary foci, as well as mortality are considered with regard to time of operation. It was compiled in a clinical review of 160 cases of acute hematogenous osteomyelitis. In studying it, we see that secondary foci are more apt to appear in cases that are operated upon early rather than late, and when such foci appear, the mortality is higher.

Brown (28) from whose report we obtained Tables I, V, and VIII, also found that the time of operation had but little effect on the formation of sequestra—22.4 per cent in the early cases and 28.3 per cent in the late.
TABLE IX

MORTALITY, AND INCIDENCE OF METASTASES WITH REGARD TO TIME AND TYPE OF OPERATION.

Wilson and McKeever (192) 1936.

<table>
<thead>
<tr>
<th>Cases</th>
<th>Mortality</th>
<th>Cases with Metastases</th>
<th>Maximum Number Metastases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEDULLARY CANAL DRAINED</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 7 days of onset</td>
<td>24</td>
<td>6 (25%)</td>
<td>9 (37.5%)</td>
</tr>
<tr>
<td>7-28 days after onset</td>
<td>31</td>
<td>3 (9.7%)</td>
<td>7 (22.5%)</td>
</tr>
<tr>
<td><strong>SOFT TISSUE DRAINED</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time not given</td>
<td>16</td>
<td>2 (12.5%)</td>
<td>5 (31%)</td>
</tr>
<tr>
<td><strong>SPONTANEOUS PERFORATION OF ABSCESS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time not given</td>
<td>23</td>
<td>1 (4.3%)</td>
<td>8 (35%)</td>
</tr>
</tbody>
</table>

We compiled Table IX from material given in an article written by Wilson and McKeever (192). They believed these finding suggest that perhaps the answer to the problem is not the earliest possible surgical invasion of the bone, but a well-timed adequate drainage of the medullary canal when the individual's resistance is at the highest possible point.
It should be noted that the mortality rate is lowest in that series of cases in which the abscess perforated the skin spontaneously. However, the incidence of metastases was highest with the greatest number of metastases in a single patient.

We found only one article in which statistics were given concerning joint involvement. McCarroll and Key (121) reviewed 200 consecutive patients admitted to the St. Louis unit of the Shriners' hospital for Crippled Children between the years 1924 and 1938. In all of these cases their condition had apparently resulted from an acute hemogenous osteomyelitis.

In 100 (50%) of the patients there was involvement of the joint adjacent to the focus in the bone, and in 50 (25%) of the patients secondary foci developed in other bones. Thirty-eight of the 50 patients with secondary foci were among the 100 patients in whom the adjacent joint was involved. This indicates a high incidence of joint complications, with metastitic foci being more numerous when the adjacent joint is involved.

Of the 9 patients who had had the bone opened within the first week after onset, the adjacent joint was involved in only 1 (11%) instance and there was
only 1 (11%) secondary focus in another bone. Forty-two patients had had soft tissue drainage in the first week. There were 9 (21%) secondary foci and 17 (40%) with adjacent joint involvement.

This finding concerning the incidence of secondary foci is consistent with Wilson and McKeever's data as given in Table IX, with regard to type of operation, but disagrees with that data and that of Brown in Table VIII, with regard to optimum time of operation, because it indicates operation should be done within seven days after onset.

They attempted to correlate the extent of the bone pathology present on admission with the type of treatment which these patients had received during their acute illness. However, they were unable to draw any definite conclusions although it appeared to them that the degree of bone destruction was not definitely influenced by the early treatment that was given in this series.

Apparently the disease tends to be self limited, the bone is invaded very rapidly, and the amount of bone destroyed varies directly with the virulence of the organism and inversely with the resistance of the individual.

It will be noted that in this statistical study no mention has been made of the incidence of healing.
or cures. Instead, the mortality rate is the chief criterion for measuring the success of treatment. Statistical reports of healing are very sparse in the literature written on the treatment of the acute stage of osteomyelitis.

Thus in accord with the material which we have presented here, judicial conservatism is the proper therapy to be practiced in treating the acute stage hematogenous osteomyelitis. Rest and supportive measures alone should be adopted till the defense mechanism of the body has had time to develop. When surgery is indicated, it should be performed with as little disturbance to the part involved as is consistent with obtaining its objectives.

**SUBACUTE and CHRONIC Stages**

We shall discuss the treatment of these stages together, because the extent of the pathological lesions can be as great in one as in the other. Surgery is essentially the same in both of them. Their difference lies mostly in the degree to which bone regeneration, especially in the form of involucra, has taken place, and the time the disease has been present.

As in any debilitating disease, the patient
should be kept in the best possible physical condition both pre and post operatively. He should receive an adequate nutritious diet. If he is anemic, it should be properly treated. Every effort should be made to increase his resistance and reparative response, and to re-establish his general health which this disease so often undermines. Physical therapy is an important adjuvant and should be used freely. (15, 27)

Again, as in the acute stage or in any orthopedic surgery, all due consideration must be given to the anesthetic, asepsis, hemostasis, optimum amount and path of surgical exposure, and injury to periosteum, bone and surrounding tissues. (2)

In this regard, Kurtz (102) recommends the use of a large drill attached to a high-speed surgical motor which offers a rapid and ideal method of attack in chronic osteomyelitis. Time of operation and anesthesia is shortened; hemorrhage is reduced to a minimum, with absence of bone concussion which is productive shock.

Operation should be done when something definite is to be gained by it and when infective process is quiescent (85).

All surgery should be directed by proper and carefully conducted roentgenological studies. They
not only locate the pathological lesion, but enable the surgeon to follow its progress or recession, and the extent and stage of repair. (2, 86)

The best technique to follow in the treatment of chronic osteomyelitis depends upon the exact amount and character of bone destruction, the stage of such destruction and bone repair, the bone involved, the joint involvement, the age of the patient, and to some extent upon the convictions of the surgeon (63). One fundamental should be stressed; remove all diseased bone, all new bone possible should be saved (9).

The surgical procedures recommended vary from complete diaphyseal resection to leaving the sequestrum in place. Amputation is more extreme, but it is an admission of defeat and when it is at all possible, is strictly avoided.

Resection

Nichols (135) was the prime advocate of resection. His was the most complete article on that subject found in the literature. He based his work on the studies made on bone regeneration by Ollier, in the last half of the nineteenth century. It would seem that resection as he performed it would be a very difficult procedure, but when it worked the results
would be very gratifying. It should be mentioned that although there were several reports in which regeneration failed, healing was usually very kind and the results good when the defect was repaired with a bone graft (18).

Nichols preferred to remove the necrotic shaft from the involucrum when it was young and flexible, but in several cases in which it was old and hard, he obtained good results by removing both the shaft and its involucrum subperiosteally. Most men report failures when they attempt Nichol's method of removing the necrotic shaft. (18, 169) It is very difficult to determine when the involucrum is in the proper stage of development for such an operation.

There are several precautions which should be taken in performing a subperiosteal resection. Great care must be taken with the periosteum. It should be traumatized as little as possible and all of it should be preserved. Best results are obtained when it is sharply dissected (48). Bones such as the femur and humerus, which have no adjacent bone support, should not be resected until an involucrum has formed which is sufficiently strong enough to assist artificial support in preventing deformity due to weight of the limb and muscle spasm. (15, 7)
Resection should not be done unless it is definitely indicated (9). When it is necessary, d'Abreu (46) believes that it should only be done on patients between the ages of 6 and 16 years. He gives as his reasons the facts that in infants wide periosteal stripping may not cause shaft necrosis, and in adults regeneration is too uncertain.

However, although few if any man care to do a subperiosteal resection if then can avoid it, it is frequently the operation of choice, and one of the best means of curing the infection permanently. The latter is especially true when by performing this operation, all the infected and necrotic tissue is removed. Sometimes it is the only method of avoiding amputation. (10, 167)

Subperiosteal resection in some cases of total necrosis of the shaft can be avoided by waiting until a strong involucrum has formed and then removing the sequestrum and most of the involucrum leaving a shallow cavity (12).

Drill Sequestra

The other extreme in the treatment of the subacute and chronic stages of osteomyelitis was advocated by Boysan (24). He removes no necrotic tis-
sue and simply bores holes through necrotic bone into living bone. His theory is that granulation tissue will grow into the sequestra from the living bone, they will become revascularized, and healing will follow. Perhaps this will work in some cases, but we have our doubts.

**Debridement and Saucerization**

The technique which is most commonly accepted and used in the treatment of subacute and chronic osteomyelitis was recommended, in 1911, by Beck (12). His surgery was based on three principals: Open broadly leaving the periosteum intact as much as possible; remove all the diseased tissue; and leave no cavity behind.

If necessary, he removed all the bone. He believed that most men fail to remove all the necrotic tissue and leave a cavity which is mechanically difficult or impossible to fill. He left only a shallow through or flat bone in order to avoid the formation of irregular cavities which do not allow a mechanical closure of the wound. X-rays should be taken during after treatment so as to be sure that no dead bone has been left behind and that such forms of bone have been obtained as allow mechanical closure.
However, there are a few men who operate to secure free drainage and to remove sequestra, but they do not believe that all the necrotic tissue should be curetted away. (37, 63, 167)

Bone which is chronically infected has eburnation which extends for a considerable distance up the shaft and this contains minute temporarily walled off islets of granulation tissue which may give rise to an active infection in the future (121). Abscesses continually recur.

This is the type of bone in which resection sometimes gives a very good result (9, 167). It is also the kind which frequently causes the patient to demand amputation. With conservative treatment, or while waiting for the optimum time for radical surgery to be performed, the abscesses are simply treated with local physiotherapy and drained with fluctuation occurs. When abscesses continually recur in the same location, Mr. W. H. Ogilvie (153) institutes permanent drainage with a silver wire extending down to the bone. It should be removed daily and boiled. This type of treatment does not appear to be very desirable.
Sequestra

As we have already mentioned in our discussion of sequestra (pg. 28) they should only be removed after they have completely separated, and after sufficient involucrum has formed (15, 23, 87, 139). That is usually 3 to 6 months after primary operation and drainage of the acute stage. There is no definite time element for their appearance and separation in the chronic stage. The opinion, with few exceptions, is that cure can not and will not take place in the presence of sequestra. (24, 74)

The primary causes for reoperation, in the subacute and chronic stages of osteomyelitis, are usually sequestrum formation, persistent dead space, failure to remove all the diseased tissue, and irregular soft tissue sinus formation (101).

Old persistent sinuses must be eradicated. Many sinuses continue to drain simply because they are lined by a dense layer of chronic granulation tissue. They should either be excised or laid open depending upon their location, type, and extent (101).

Freund (59) calls attention to a method that is harmless and may often render good service in chronic sinuses. He carefully inserts a silver nitrate stick.
into the tract and covers the surrounding skin with a thick layer of zinc oxide ointment to decrease the effects of the resulting irritating discharge. Removal of the stick in 2 to 3 days brings the entire tract with it and a sinus tract is left covered by nice, healthy, red granulations.

**Sterile Abscess**

Brickner (21) called attention to chronic abscesses in the medulla of long bones as a condition but little recognized. They are usually sterile, or the organisms much attenuated, and seem to most often be found some time after a siege of osteomyelitis (22). The bone is usually thickened around them, but they are best located by the use of the x-ray.

Since they are sterile or very nearly so, simple drainage is all that is required. The only other requirements are that infection should not be introduced and the lesion should be made to heal from the bottom. Brickner (22) believed that drainage through a small drill hole was sufficient, and prompt healing followed. Simmons (167) stated that it makes little difference what is done, because they all heal anyway.
Cavities

Sequestrectomy and removal of necrotic bone in chronic osteomyelitis always leaves a variously sized bony cavity. Nature will begin the closure of a large cavernous defect in the interior of a bone by granulations and succeed to a certain point, but there will remain an infected cavity or sinus; persistent sinuses may last indefinitely. Recuretting fails, because the cavity may have become too large to be healed, unaided, by nature's processes. (112)

Treatment of this condition has always been a difficult problem, particularly, before saucerization was used and when the surgeon preferred to close the wound by primary suture. Some of the materials used to fill these defects during that time were Hamilton's (135) sponge grafts (1881), Schede's (135) aseptic blood clot (1886), Senn's (163) decalcified bone chips (1889), and Moorhof's (37, 52, 131) wax (1903). Most of these worked fairly well, and primary closure was successful, if all of the infection were removed during the operation. Moorhof's wax and most of the other techniques required perfect hemostasis and a cavity as smooth and clean as one made in a tooth by a dentist. However, it was too often impossible to fill these requirements so failures were frequent.
Saucerization, which leaves a shallow cavity in the bone, not only leaves a defect which it is mechanical possible for the osseous tissue to repair, but it also allows the soft parts to fall in and fill it. (139, 172) When such soft parts are not available, a muscle or skin flap may be used. (106, 112) The former is preferable. (123, 172) Free fat grafts are preferred by some men, (54, 68, 119) but others have no success with them. (114)

Skin grafts are frequently sued to line these cavities as sliding or pedicle flaps, or pinch grafts.

In many cases it is necessary to use Carrel-Dakin or other irrigations in preparation for the tissue transplant and during the time they are healing. (106, 123)

Many times grafting has lessened the convalescent period in a case of chronic osteomyelitis. However, in the majority of instances the infection is too active to allow the use of grafts or primary suture. It is because of these cases that numerous methods of after treatment have been devised and popularized.

**Scars**

Osteomyelitis scars are usually adherent to
underlying bone. They are often extensive, troublesome and break down easily when bruised. Those on the tibia are especially liable to be injured. In order to give such areas better protection, the thin epithelium which grows in from the surrounding skin can be replaced by large skin grafts. (8, 16, 112, 157)

AFTER TREATMENT

There are innumerable methods and variations of after treatment. The majority of them, whether their authors accept or condemn the Orr method, are patterned after it. This is most noticeable with regard to the use of vaseline in place of plain or iodoform gauze; wounds are packed open and granulations thus encouraged to fill the wound from the bottom; immobilization is emphasized; and dressings are infrequent, although used far more often than Orr recommends. In many cases, the Orr method is used in combination with one of the others.

We shall discuss a few of the methods which are best known and standardized. No distinction is made with regard to stage of the disease because their requirements are all essentially the same. Unless otherwise stated, it is to be kept in mind that each
of these methods is to be preceded by careful removal of all the infected and necrotic tissue and saucerization of the bone.

**Carrel-Dakin Technique**

At the suggestion of the Rockefeller Institute, and in co-operation with the United States Steel Corporation, Sherman (166) spent 5 months in England, Scotland, Belgium and France studying the various methods of wound sterilization.

He found the Carrel-Dakin technique to be almost ideal. The solution he recommended was sodium hypochlorite free of caustic alkali, containing only 0.45 to 0.50 per cent of hypochlorite. However, some men use other, but similar solutions such as chloramine, chlorazene, and eusol.

The hypochlorites were supposed to act by the liberation of chlorine in the wound. Sherman found sodium hypochlorite to be 150 to 200 times as bactericidal as carbolic acid.

The success of the treatment is dependent upon the thoroughness with which it is applied and the care given to the most minute details of the technique. Sherman believed Dakin's solution (sodium hypochlorite)
represented 20 per cent, and the Carrel technique 80 per cent of the cure.

Properly perforated Carrel tubes should be used and inserted into the wound so that all its parts are constantly bathed with the solution. Strips of gauze are placed loosely between the tubes to keep them from bunching. The edges of the wound are protected with vaseline gauze.

The wound should be "laked" or "puddled" with the solution, by means of the tubes, every 2 hours, day and night. It should be redressed daily, and every aseptic precaution must be scrupulously exercised to prevent reinfection. The skin should be cleaned and the wound gently sponged free of secretions, necrotic tissue, and other debris, and the tubes reinserted.

It was Sherman's belief that this treatment can clean either an acute or chronic osteomyelitis area within 15 to 25 days if it is opened freely and all parts constantly bathed with Dakin's solution.

The solution should be used until smears from the wound show less than 3 bacteria per high power field of the microscope. Then, after waiting a few days longer, secondary closure can be done. (58, 58)
As a method of active wound antisepsis, the Carrel-Dakin technique is undoubtedly the best that has ever been devised. The methods by which various surgeons have used it are many. We would like to mention one reported by Bauman (10) in 1926. He would resect a diseased diaphysis and sew the periosteum over perforated rubber drainage tubes letting them protrude at either end. The tubes were then used for Carrel-Dakin irrigation and allowed to remain 2 to 5 weeks depending upon the nature of the discharge from the wound.

This method does not harm tissues, it dissolves the wound exudates, and permits nascent chlorine, which it contains, to penetrate to the bacteria in the recesses of the wound. (2) However, Buchman (29) does not agree; he believes that with it there is no particular chemical sterilization, but it acts by physical removal and possibly chemical solution of the wound discharges. He finds that an inert solution with the same technique gives the same results, and that failures and recurrences are frequent.

Albee (2) was one of its most enthusiastic advocates. He found that it was far superior to any other antiseptic used in the World War No. 1, and states
that of 6,000 serious bone cases which came under his care, half owe useful extremities to conquest of wound infection by this method, before reconstruction surgery was attempted.

Yet, there were obvious objections in spite of excellent results. Frequency of dressings and irrigations were distressing to the patient, arduous for the surgeon, and associated with risk of reinfection. They were painful, tedious, and time consuming. Prolonged hospitalization was necessary. The technique rendered necessary immobilization imperfect. Disinfection was working at cross purposes with immobilization and the ultimate goal of bone repair. Within the area of the window in a cast, it induced edema of the granulation and surrounding tissue. Uniform pressure was desirable, but lacking. (1, 29, 145)

The technique of the Carrel-Dakin method is rigid, and requires a well trained and vigilant personnel. It is for those reasons that it so often fails. (60, 180)

Pomeranz (154) found by radiological studies, that regeneration of bone following irrigation (Carrel-Dakin treatment, etc.) is extremely slow and somewhat irregular. Alternating patches of osteosclerosis and osteoporosis are common and recurrences of the infection are not infrequent.
Immobilization is not generally used routinely, but mainly when fracture is feared or with other special indications.

The Orr Method

1. Dry wound and wipe out with 10 per cent iodine followed by 95 per cent alcohol, or use another suitable antiseptic.

2. Pack entire wound open firmly, but not tightly with sterile vaseline gauze. Cover with dry sterile pad and bandage on.

3. Then do any reasonable required manipulation to place the part in the correct anatomical position for splinting.

4. Apply a plaster cast or a suitable splint.

5. Leave cast and dressing intact. The wound is not to be dressed except for rise in temperature or other signs of acute sepsis. Dressing usually not necessary for several weeks, and then only because of odor.

6. If a cavity is still present on redressing, repack the wound and apply another cast. Do not hesitate to use an anesthetic for it.

It will be found when the wound is dressed that it heals from the bottom and healthy granulation tissue gradually pushes the pack to the surface.
The principles upon which this treatment is based are drainage, rest, and prevention of reinfection.

The value of drainage in treating infection is not to be denied. With this method it is adequate (19).

Rest has always been considered to be an important factor in the treatment of injuries and inflammation, particularly those of bones and joints. Immobilization does not cause ankylosis of joints if they are not infected. The cast should not have a window in it. That not only decreases the tendency to dress the wound, but causes pressure to be equally distributed over the entire area.

Orr criticizes frequent dressings. He feels that they make proper immobilization impossible. Frequent dressings are liable to destroy a great deal of what has been gained between times, and there is the grave danger that secondary infection will be introduced. He bases this principle on the teachings of Lister.

He admits, that by his method, healing takes longer than first intention, but it involves him in no more anxiety than the primary healing of a clean surgical wound. He feels that there is little distinction between the healing time between the present and long standing cases of osteomyelitis. The really
important point is that those operated on before secondary mixed infection occurs recover much more promptly and with fewer complications than those who must be treated by his method later.

Some of the advantages of this treatment are that it is painless and economical Hospitalization time is decreased. In many instances the patient need be in the hospital only for his operation, and when his wound is dressed. Functional results are good. It is a simple procedure which can easily be carried out by the average physician or surgeon. It gives good results in most men's hands, but they dress more frequently than he recommends. The screams of daily dressings are eliminated. The patients are more comfortable than with any other method. Time of healing is shortened and bony defects are less. Scars are almost incredibly good. The patients are more comfortable than with any other treatment. It permits individual attention. (19, 32, 49, 60, 93, 101, 126, 137, 156)

Meehan (126) believes that adherent gauze tears away many of the granulations. So that nature's handiwork is torn down, so often the temperature soon rises soon after dressing. Vaseline gauze and infrequent dressings prevents those incidents.
Wentworth (186) states that the greatest contribution of the Orr treatment is the elimination of meddlesomeness with nature's process of killing bacteria.

By making careful radiological studies, Pom-eranz (154) found that the Orr method bone regeneration usually begins in the excavated area. It is slow in forming and gradually fills the defect made surgically. The new bone is extremely dense and somewhat irregular in character. Reconstruction of a new cortex is not so characteristic as that following maggot treatment, and periosteal thickening is often extensive.

The odor which follows the prolonged immobilization in a cast without redressing is the most frequently cited objection. It undoubtedly also serves as an excuse to redress the wound for those are unable to refrain from the desire to find out how it looks. They don't do it any good by looking at it, but they want to anyway.

Hawk (71) states that the bone itself is rigid, and nature gives immobilization to the n'th degree. All a cast does is render circulation more sluggish.

He advises getting the patient on his feet as
soon as he has recovered from the effects of the operation and the bone is strong enough to support weight. He believes use promotes healing of the tissues and increases resistance to infection.

According to Stewart (173), the Orr method has a high incidence of recurrence, there is much scar tissue, and the poorly nourished fibroid tissue breaks down easily.

Mr. W. H. Ogilvie (189) found that the scars interfered with healing in future operations and there was unnecessary ankylosis of joints.

In other words, some men praise the Orr method, while others criticize the same points. This indicates to us that the results it gives depends a great deal upon the work of the surgeon who uses it.

On the whole, the Orr method has given to surgeons over the country a degree of success that has not been approached by any other form of treatment. (26)

**Bacteriophage**

Orr's explanation that rest, immobilization, non-interference, and avoidance of reinfection accounted for the marked success of his treatment did not satisfy Albee (2) so he looked elsewhere for the unusual
phenomenon which was befriending both patient and surgeon.

He found that in about 94 per cent of cases of acute and chronic osteomyelitis, a specific bacteriophage appears spontaneously when treated by the Orr method.

The laborator was able to furnish a phange in 3 of the 6 per cent of cases in which it failed to appear that was specific for the organism in question. In the 3 per cent in which the laboratory was unable to cultivate a specific bacteriophage, he frequently found that one later appeared spontaneously, so watchful waiting was in order.

The Orr method should be used and no dressing done for 6 to 10 weeks in order to secure the best effects from the spontaneous appearance of a specific bacteriophage or one that may be introduced. Antiseptics should not be used to swab the bone cavity because they might prevent phage development.

He tries to cultivate a specific phage preoperatively. If one is found, he pours two-thirds of a test tube of it over the wound at operation. He then packs it with a paraffin and vaseline mixture (usually 3/1) to keep the wound open. Being fluid when applied
it can enter every recess of the wound, doesn't adhere to bone or granulations, and is gradually extruded as granulation tissue forms beneath it.

He then inserts one end of a rubber catheter through the tampon into the bone cavity, the other end projecting through the dressing and cast which is applied.

If the laboratory can develop a specific bacteriophage, he injects 10 cubic centimeters into the wound two or three times a week, care being taken not to contaminate the wound.

The cast is removed in 8 weeks, and the wound dressed in a manner similar to the post operative dressing, a cast reapplied, and periodic injections continued. He found that usually three, eight weeks dressings were enough. He states that in 100 cases, the average healing time was six months.

He believes that the method is simple in its application and requires a short period of hospitalization.

Stewart (173) feels that Albee's paraffin vaseline plug inhibits drainage; tissue colbids absorb and inactive for the bacteriophage, and they may be present and inactive for months. He also believes that an antiphage often develops and abolishes its action.
Wentworth (186) also found bacteriophage is present in about 94 per cent of cases treated by the Orr method, but its clinical effect is questionable. It is probably inactive in the presence of mucus, fibrin, pus, blood serum, erythrocytes, and fixed tissue cells.

Mac Neal (116) tried to use bacteriophages intravenously, but found that in the circulating blood it merely seems to exert an opsonic effect.

**Hydrotherapy**

Brockway (25, 26) believes that Orr treatment is very good, but that it has definite shortcomings in cases where the infective process is in close proximity to the major joints, particularly if there is an accompanying suppurative arthritis. Restoration of motion in a pus ridden joint is not best accomplished by a long period of immobilization in a plaster cast. The regeneration of pus-ridden joints and the restoration of function are best accomplished by early evacuation and motion. He prefers to use a 7 per cent warm salt water pool treatment in such cases, and also on some cases where prolonged immobilization and drainage tend to restrict joint motion by
muscle plastering, atrophy, and capsule thickening.

Hudson (80) uses plain tap water in a tub heated to a temperature of about 110 F. He believes Brockway's hypertonic solution should give better results, but has never had such a pool available. Owen (147) also reports on the use of plain water.

These men recommend hydrotherapy because it gives painless motion and no discomfort in the joint on returning to bed, movement is so effortless and painless that the patients soon lose the fear of pain, and active motion returns unconsciously. The warm water is soothing and helps to improve the circulation and hasten healing of the wound. The psychic appeal is more than imaginary.

Hudson finds that the discharge and odor disappear and healthy granulations appear more rapidly than by the use of maggots. The limb does not become water logged, and he has never had any difficulty with spread of infection or superinduced infection.

Brockway found that cultures of the pool remained sterile.

Hudson further claims that cases usually heal in 2 months that would take six months by the Orr method, and that the patients can treat themselves at home.
The technique of these men is to use the Orr method for two to six weeks after operation. The cast is then bivalved, the two halves being used as splints. All packing and dressings are removed and the treatment begun. The patient's entire body is immersed. Brockway uses an electric hoist carrying a stretcher to get the patient in and out of the pool. Light splints may be used the first few times.

The treatment is given for two hours twice every day. After the treatment, the wound is again packed and dressed, and immobilization secured by means of traction, splints, or the bivalved cast.

Maggots

The presence and valuable effects of maggots in infected wounds has been noted and commented upon for centuries. Frequently their presence was encouraged, but, it was not until 1929, that Baer (5) reported a definite attempt to scientifically use them as a method of treating osteomyelitis.

In his first case he worked without any sterilization, without gloves, without washing the skin. That case healed successfully.

Following the usual operative procedure, no an-
tiseptic of any kind should be used. It would inhibit or kill the maggots. The wound is packed for 24 hours to stop the bleeding (often not necessary). It should then be filled with sterile blow fly maggots, and covered by a properly constructed, snugly fitting mesh wire cage. It should not be covered with a bandage, but exposed to the sunlight. Light is essential because maggots abhor it and will penetrate deeper into the wound. Every 4 or 5 days the wound should be washed out with normal saline and filled again with maggots. Dressings have to be that frequent because the larvae only live about 7 days and are not active until they are 2 days old.

Itching can be aided by painting the surrounding skin with collodion. Where a nerve is exposed there is some pain for a time. The wound frequently itches, but most of the patients get used to it although many times sedatives are necessary, especially at night. There is usually a watery discharge from the wound and a slight odor for a time, but both gradually disappear. (5, 6)

The maggots are supposed to produce their effect in the infected wound in several ways. After two or three applications the wound becomes saline
which inhibits bacterial growth. They ingest and destroy bacteria, remove the necrotic tissue, and thus make conditions less favorable for bacterial growth, stimulate drainage, and cause sequestra to separate sooner. (5, 6, 29, 158)

Baer (5) believed maggots prefer dead bone and go directly to it, but stop working on it when it starts to bleed.

The maggots apparently stimulate the growth of granulation tissue, so the period of convalescence is shortened. Healing is frequently complete at the end of 6 or 7 weeks. By the end of that time, the granulation tissues have come directly up to the top of the wound and the epithelium grown over it. There is little or no pitting down into the wound itself. The scars are less extensive, irritable and disfiguring than those obtained with any other method. (5, 29, 53, 61)

It was the belief of Baer and many other workers that there is something formed between the maggots and human body. This belief is enhanced by the fact after 3 or 4 applications the maggots begin to die soon after they are placed in the wound. As the number of applications increases, the life of the maggots decreases. (5, 31) It is hard to explain the benefits
caused by their presence to their physical action alone. For these reasons, many attempts have been made to isolate an active principle.

Livingston (109, 110), alone, and in conjunction with Prince (11), has done a great deal of work along that line. In 1932, he and Prince reported (111) on the use of an extract filtered from the bodies of dead maggots. They stated that the results obtained were better than when only maggots were used. However, they not only used it in conjunction with maggots, but also with polyvalent or autogenous vaccine.

In a later report Livingston (109) stated that his active principle (maggot extract) contained the radicles sulphydryl, natural allantoin, calcium, cysteine, glutathione, and in addition, embryonic growth stimulating substances.

He believes that maggot stimulation of tissue regeneration is due to the substances found in his extract, that is without the psychic trauma, is a more powerful growth stimulant than any of its ingredients, and has wider application than maggots.

In 1932, Buchman and Blair (31) noted that older cases are sometimes complicated by a temperature of 104°F to 105°F, 24 to 48 hours after maggots are introduced. In several cases the limbs presented an
erysipeloid appearance with bullae formation. However, the general condition remained good.

Wentworth (186) observed a similar rise in temperature in about one-third of cases. He believes it is the result of increased absorption of bacterial toxin through a growing surface of granulation tissue exposed to wound secretions.

Pomeranz (154) studied the repair of bone by means of the x-ray in cases treated according to the Orr, Carrel-Dakin, and Baer methods. He found that after the maggot treatment the bony defect becomes filled with osteoplastic tissue. In about 4 weeks the shape of the bone is re-established and the defect filled with osteoid tissue about as dense as the bone. After about 6 months the excavated area is well rounded and the medulla replaced by dense eburnated bone. He believes that in time the medullary cavity will reform and a new cortex be reconstructed. He is also of the opinion that with this method healing is more rapid and the new bone more nearly normal. Suchman and Blair (29, 31) also found that when maggots are used the new bone is smoothly and evenly calcified, not blotchy as in other methods.

There are several disadvantages to the use
of maggots. The hardest problem is the growth and maintenance of the proper stock of flies. This requires a great deal of equipment and someone who knows how to raise them. If obtained from a supply house, they are very expensive. (53, 173)

There is always the danger that they are not sterile. This greatly increases the difficulty of raising and handling them. Baer (5) lost a case from tetanus because of contaminated maggots. Livingston, gives injections of tetanus routinely when he uses them. They should always be cultured to detect contamination before being introduced into a wound.

The patient has to be hospitalized as long as maggots are being used. The period of convalescence may be shortened somewhat by them, but this is the most expensive of all the methods of after treatment. (31)

Patients are very often opposed to their use. The psychic effect and the tickling sensation which they produce frequently makes it necessary to administer a sedative so the patient can sleep. (173, 186)

Wentworth also lists a few technical disadvantages. Maggots require oxygen at all times. Lack of food or oxygen in deep wounds, or those fill with secretions drives them out. They are repelled by light, but
will not work down in small dark sinuses. The muscles must be retracted to the depths of the wound and fluid kept at a minimum by aspiration or dependent drainage or they will drown.

Brockway (26) feels that both they and the bacteriophage may be ideal theoretically, but the fact remains they do not greatly alter the stubborn course of the disease. Good results have been attained, but the same is true of most regimens.

**Miscellaneous**

We shall mention several antiseptics which have been reported in the more recent literature as being very good in the after treatment of osteomyelitis.

Bismuth iodoform paraffin paste, or "Bipp" as it is usually called, was widely used in the treatment of infected wounds before the first World War. It was though to be a very active wound antiseptic, but Dakin’s solution was found to be far superior.

Myers (133) treats osteomyelitis with a modified Orr technique and recommend using "Bipp" impregnated gauze in place of vaseline gauze. "Bipp" may have some antiseptic value, but most of its benefits have probably always been to the fact that it assists in obliterating tissue spaces.
In 1933, Hawk (71) reported that he obtained very good results in treating osteomyelitis by using a mixture of glycerine and magnesium sulfate after proper removal of all necrotic tissue and bone. It was criticized, in 1934, by Stewart (173) who stated that better results were obtained by his more rational treatment which was by the use of picric acid and calcium carbonate.

Wright (195) recommends a mixture of zinc peroxide and cod liver oil.

We do not know just what the value of such materials is, but we are inclined to believe the findings of McCarroll and Key (121) reported in June of 1939. They stated that they have used Carrel-Dakin treatment, various other antiseptics, and hog lard without getting results differing much from those obtained with vaseline. Maggots were not used because they are too expensive. They say, "The infected tissue which is left (after saucerization) is beyond the reach of maggots or of any chemical or other agent which can be applied to the surface of the wound."

It was thought that it might be of value to try and compare some of the statistics which various men have given as evidence of the superior results obtained by the particular method of after treatment which
they advocate. However, we found that it got us nowhere. Each claims good results, so in order to choose which is the best, one is forced to reevaluate the statistics to the background, and judge each method chiefly on its rational applicability, and technical details.

John (39), McCarroll and Key (121), and many other surgeons believe that with proper surgery, one type of after treatment is as good as another. After studying many of the methods used, with good results claimed for all of them, we are inclined to agree.

We shall merely say that in reading the literature, the impression is gained that the Orr method is the standard basis of treatment throughout the country; before its advent, the Carrel-Dakin technique was the universal standard, and before it "3ipp" received great acclaim; though maggot therapy caused quite a flurry when Baer introduced it, it is not widely used. Many other methods, some of which we have mentioned, have been advocated and used to some extent, but have not been generally accepted.

Summary

In summarizing, we find that in the acute stage of hematogenous osteomyelitis, the patient is usually
very sick and his life is primarily at stake. It is by the use of judicious surgery that the mortality and incidence of complications are reduced.

The surgery used in the sugacute and chronic stages is rather uniform. When it fails it is sometimes the fault of the surgeon, but the location and nature of the disease frequently make cure possible. Tissue which at operation appears entirely healthy may be permeated with a low grade infection so that there is eventually a recurrence of the disease. In the presence of such infection, no method of after treatment has yet been devised which can prevent a recurrence.

It would seem that the best method of both surgery and after treatment is the one which is most suited to a particular case, the surgeon, and the equipment which he has at his disposal.

In no case should the local lesion be treated and the general condition of the patient disregarded or entirely forgotten.

Conclusions

1. Treat the acute stage of osteomyelitis conservatively. Treat the patient first, then do no more surgery than is absolutely necessary at pri-
mary operation. Vaccines and antitoxins may, or may not be of value in either the acute or chronic stages. Sulfonilamide should be of value in cases infected by hemolytic streptococci.

2. Do not remove sequestra until they have separated completely and an involucrum has been formed.

3. In the subacute and chronic stages, use surgery according to the merits of the individual case. When resection is necessary do it, but do not use it as a routine procedure. Most lesions require debridement and saucerization. Sterile abscesses need only be drained. Muscle and skin grafts are often very effective in obtaining a rapid closure of old cavities and sinuses. Skin grafts may be used to replace large, easily injured osteomyelitis scars.

4. No method of after treatment is without its drawbacks and no one is best in all cases. The Orr method is applicable to the largest number of cases, is simple and most widely used.
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