ACUTE HAEMATOGENOUS OSTEOMYELITIS

Diagnosis and Treatment

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There has been a remarkable change in the course and in the prognosis of acute haematogenous osteomyelitis during the last four years. Until recently this disease was one of the most dangerous and crippling infections of childhood and early youth. Now it need be no more dangerous or crippling than a cellulitis, though it may be of longer duration.

The change is due to penicillin, the internal antiseptic for which surgeons have longed when treating cases of acute osteomyelitis. It has made necessary a complete revision of the accepted principles and methods of treatment, a revision comparable with that in all branches of surgery which followed much earlier antibacterial advances. The introduction of antisepsis and later of asepsis at the end of the last century demanded a new attitude of mind towards surgical interference. After Lister surgeons could operate on sterile tissue knowing that it would remain sterile, and the idea of ' laudable pus ' had to be discarded. Similarly after the discoveries of Fleming and Florey the principle of wide incision to obtain ' drainage ' of pus in acute osteomyelitis has now to be discarded.

The old picture of acute osteomyelitis is worth recalling. The prospect for a patient with infection of the larger bones was a dreary one (Fig. 1) ; weeks of severe toxaemia and swinging temperature punctuated by operations on the original and the metastatic foci ; repeated anaesthetics for evacuation of abscesses, for daily dressings and for changes of plaster ; possibly a diaphysectomy or even an amputation ; and always the danger of a septic arthritis. Then after the acute stage might follow a long tale of chronic sepsis ; sinuses, dermatitis, recurrent abscess formation and sequestration treated by saucerization. And when healing was at last obtained reconstructive operations were often necessary for the deformities of the disease and its treatment : for irregular bone growth from damaged epiphyses (Fig. 2), for diaphysectomy with failure to regenerate (Fig. 3), and for damaged joints (Fig. 4). Finally, no patient could ever be regarded as secure from recurrence at the original focus or in another bone. More fortunate cases with early healing and full function were in the minority, and even they were not safe from recurrence, especially after trauma.

The significant difference between this disappearing picture and the present one was the relative impotence of the doctor against the infection. However early his diagnosis and however careful his treatment, he could do little to alter the course of the disease. He immobilized the part, maintained the patient's resistance by transfusion, vaccine and diet, and drained abscesses as they occurred. All the time he had to consider the needs of the bone as secondary to the preservation of life, for too often surgery designed to save the bone resulted in a generalized spread of the infection. On the other hand radical operations such as diaphysectomy, aiming at the preservation of life, often caused permanent disability. In any discussion on the surgical treatment, the mortality rate had to be the final criterion and the effects of any particular treatment on the bone itself had to take second place. The mortality rate varied from 5 to 25 per cent. and the disability rate might be as high as 50 per cent.

The introduction of the sulphonamides in 1936 had no spectacular effect, though some benefit followed their use ; the course of the fever was shorter, metastases were fewer, bone destruction was less and healing was earlier. But still some cases were quite unaffected, and though the surgeon could be just a little bolder and more optimistic, the treatment was not materially altered.

Results with Penicillin

Penicillin was first used in this disease at Oxford in 1941 by the Floreys and among others, by one of us. Its value was obvious even though the method of administration was not established. The Floreys wrote :

> ' The evidence is that with adequate dosage it is possible to eliminate all infection, and one may look forward to the time when osteomyelitis treated early will no longer be a surgical condition.'

All the published results since then have been most favourable. The mortality rate has been reduced to less than 1 per cent., and the disability rate varies from 1 to 10 per cent. Most of these results were obtained when penicillin was scarce, when dosage and duration of treatment were still being investigated, and when the part of surgery was uncertain.

In our own series of 60 cases, followed up since the first case in June 1944, the results are very satisfactory compared with 'the bad old days.' Fifty-two of the 60 cases have full function, sound healing and minimal bone scarring, so that they are unlikely to have any recurrence (Figs. 6 and 7). Four further cases have full function and sound healing, but with considerable bone scarring which may possibly lead to recurrence. The remaining four cases are less satisfactory. One has restriction of knee movement (0°-90°), one has a persistent minute sinus and two have had one mild recurrence of inflammation. It is significant that none of these last four cases was treated by the methods recommended here; they taught us what not to do. In fact, we believe that the treatment of acute osteomyelitis should eventually be 100 per cent. successful, i.e., there should be no mortality, no joint involvement, no permanent disability, and bone scarring should be absent or so slight that there is no risk of faulty growth or recurrence.

The essential requirement is early diagnosis. Penicillin alone can cure the disease if administered before bone damage has occurred, that is, in the first stage. Its action in the second and third stages is also dramatic, but permanent bone damage may already have occurred. It is possible that the diagnosis will in future be made earlier, for often in the past the practitioner has felt that diagnosis was not urgent and waited for it to become obvious before transferring the patient to hospital. Fifty per cent. of our patients had been seen one or more days previously by a doctor and either the diagnosis had not been made or sulphonamides had been tried at home until abscess formation demanded intervention. Unfortunately most textbooks describe the disease only in this advanced stage and we make no apology for dealing with early diagnosis in some detail.

Early Diagnosis

1. Pathology

There are three stages in the pathology, each with a corresponding clinical picture (Fig. 7).

Stage 1. A pyogenic organism carried to the bone in the blood settles there and multiplies. The organism is usually the staphylococcus aureus, but may be a streptococcus, a pneumococcus, or staphylococcus albus. The site is usually the metaphysis of a growing bone, though it may be any part of any bone at any age. The initial bacteraemia is usually symptomless, but there may be frank septicaemia.

As the organism multiplies in the bone a septic focus develops. This 'boil' may resolve, it may form a Brodie's abscess, symptomless for the time being, or it may advance to Stage 2.

Stage 2. The infection overcomes the local resistance and spreads through the neighbouring tissue:

(a) into the medullary space.

(b) through the cortex into the subperiostea space.

(c) across or round the epiphysis into the joint. Fortunately this is the least common route; the signs and symptoms are those of septic arthritis.

If the infection spreads into the medulla or beneath the periosteum, pus tends to collect there. Thus it tends to fill the medulla before invading the subperiosteal space, and it tends to fill the subperiosteal space before perforating into the soft tissues or the joint. The periosteum is as resistant to infection from within as from without and pus may strip it off the entire diaphysis before there is either sufficient tension for rupture or sufficient necrosis for perforation.

Stage 3. The pus reaches the soft tissues, spreads along the tissue planes and eventually reaches the skin.

It will be seen that until the third stage is reached the infection remains within the periosteum or even within the cortex, and the pus may thus be relatively inaccessible for clinical examination. Yet if perfect results are to be secured, the disease must be recognized while the pus is so concealed. Fortunately, even in the first stage, one sign and one symptom together strongly suggest the diagnosis.

2. Signs and Symptoms

Clinical Picture in Stage 1—A 'boil' in the bone

(a) *The symptom of acute osteomyelitis*

The patient complains of pain over or near the focus. The pain is not at first well localized, but it is severe, constant and often described as 'deep' or even 'in the bone.' Quite young children are good witnesses if not frightened by too hasty handling, and vagueness may be corrected if they are told to point with one finger to the painful part. A child with acute infection of the upper tibia may *say* that his foot hurts, but he will *point* to the upper end of the tibia, and there will be found the sign.

(b) *The sign of acute osteomyelitis*

The bone over the focus is exquisitely tender; this tenderness is constant both in position and intensity. It can usually be distinguished from tenderness of the overlying tissues, and with care

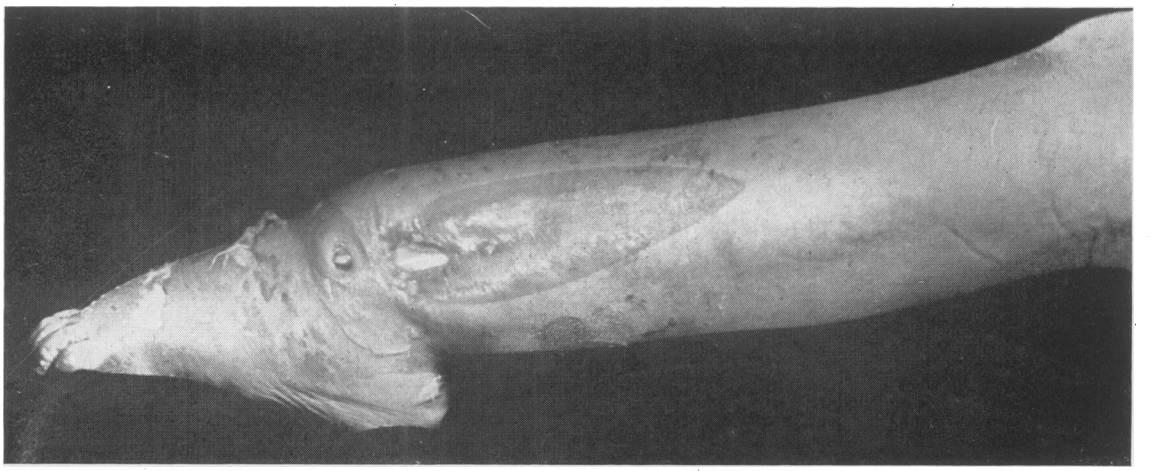

FIG. 1.—Unsuccessful Treatment of Acute Osteomyelitis before Penicillin. The leg of a boy with acute osteomyelitis 10 weeks after admission to hospital in 1942. A month later acute osteomyelitis of the humerus developed. Note the gross oedema, the unhealthy skin and the exposed bone. The foot was eventually amputated.

HISTORY OF J.W., AGED 11, AFTER ADMISSION TO HOSPITAL IN 1938.

March, 1938.	Admitted with acute osteomyelitis of R. and L. Ulna, lower L. Tibia, and R. Os calcis.
June, 1938.	Sequestrectomy both ulnae.
Sept., 1938.	Abscess L. Radius—curettage.
Nov., 1938.	Abscess L. femur—sequestra discharged.
Jan., 1939.	Abscess R. foot (small bones of tarsus).
June, 1939.	Abscess R. upper humerus. L. humerus discharged sequestra.
July, 1939.	Abscess L. femur, discharged sequestra.
Sept., 1939.	Abscess R. ankle—incision and curettage. L. clavicle—incision and curettage.
Jan., 1940.	Abscess L. femur.
April, 1940.	Curettage R. ankle (bony ankylosis of ankle and subastragaloid joint).
June, 1940.	Abscess R. mandible.
Sept., 1940.	Abscess R. instep.
Dec., 1940.	Five abscesses over humerus and tibia.
Aug., 1941.	Abscess R. ankle.
Mar., 1942.	Abscess L. femur—saucerization.
Feb., 1943.	Abscess R. ankle.
Oct., 1943.	Abscess L. femur.
April, 1944.	ALL HEALED.
Sept., 1945.	Osteotomy of tibia for deformity at ankle—wound broke down.
July, 1946.	ALL HEALED.

FIG. 2.—Deformity due to a damaged epiphysis after acute osteomyelitis of the tibia and femur. Note the marked valgus deformity of the knee and the irregular bone structure of the tibia.

FIG. 3.—Deformities from loss of the diaphysis of a long bone.

(*a*) Gross radial deviation of the hand following loss of the radial diaphysis 8 years previously at age of 2.

(*b*) Dislocation of the radius following loss of the ulnar diaphysis 14 years previously when 2 years old.

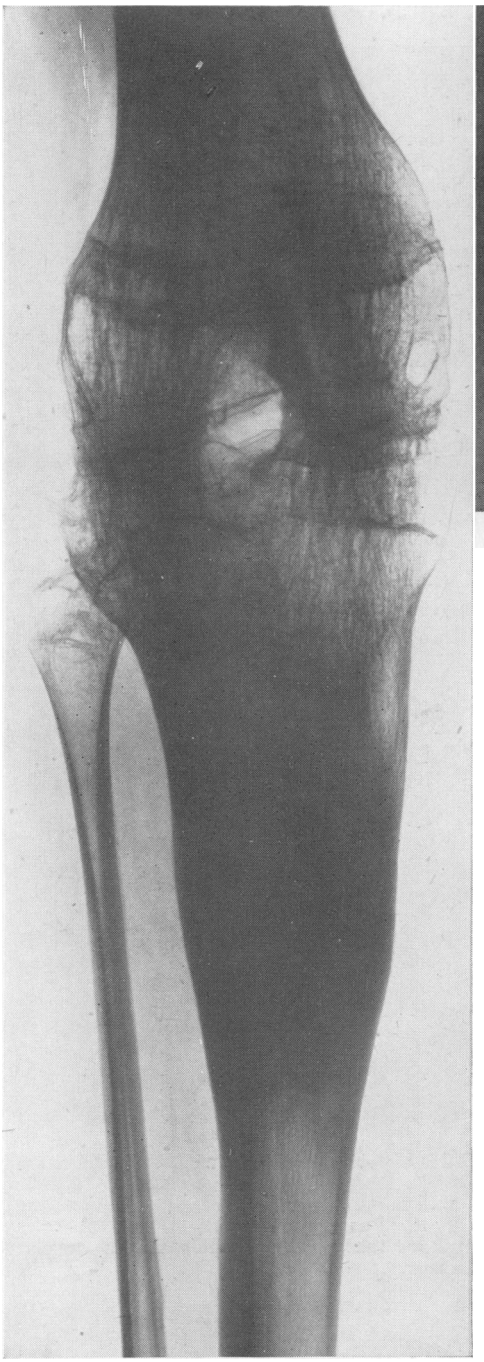

FIG. 4.—Ankylosis of the knee from septic arthritis secondary to acute osteomyelitis of the tibia.

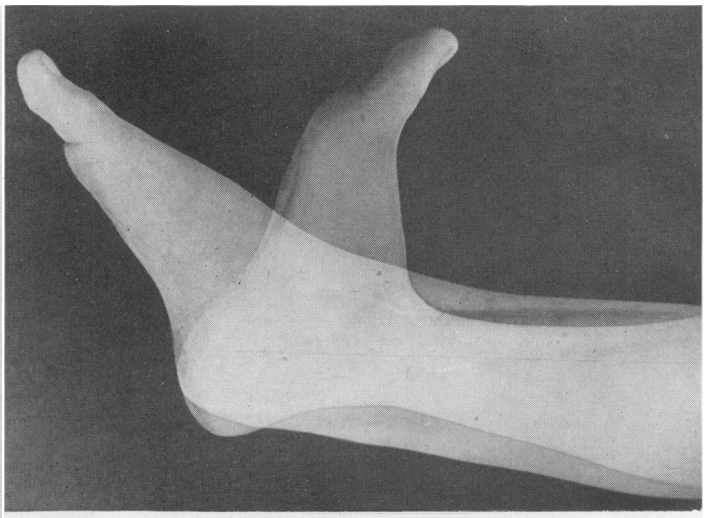

FIG. 5.

FIG. 5.—Results after the introduction of penicillin. Leg of a boy admitted for acute osteomyelitis of the tibia. There was sound healing after 2 months. This picture was taken 8 months after admission, when there was sound healing, no tenderness and full movement at the ankle. Contrast with Fig. 1. Two years later he was symptom free, with full joint movement.

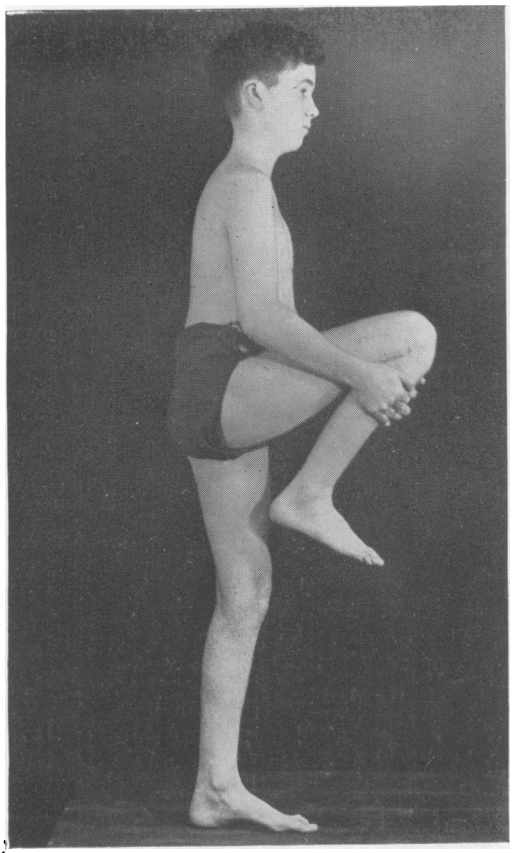

FIG. 6.—R.S., aged 12, ten weeks after admission to hospital with acute osteomyelitis of the lower R. femur. At operation pus was found without and within the bone ; the wound healed by first intention following primary suture. Apart from the linear scar there is now no detectable abnormality and a full range of movement at the knee.

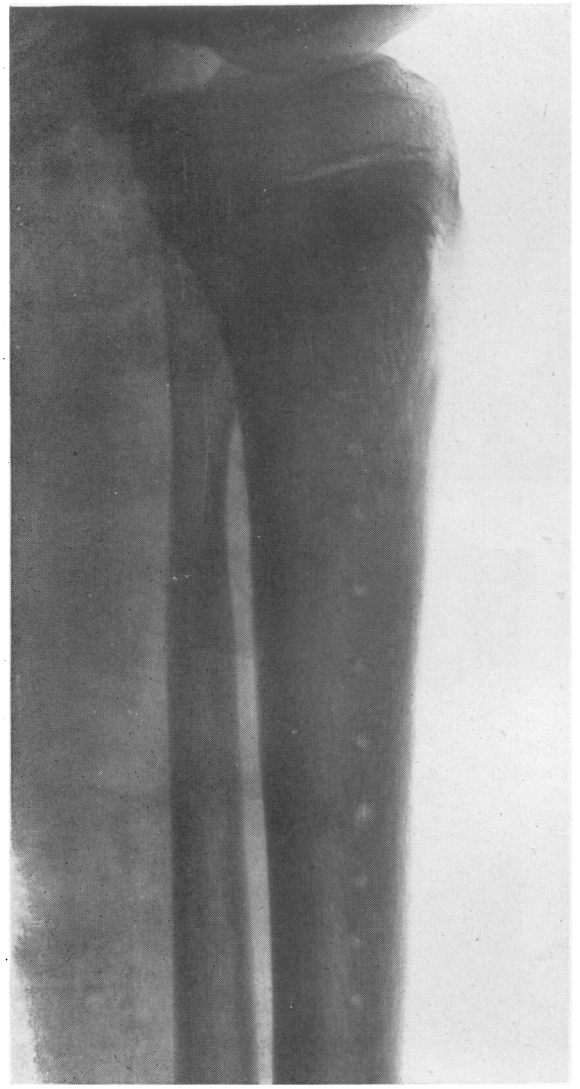

FIG. 8.—Radiograph of the tibia of a boy aged 12 with acute osteomyelitis of 6 days history. Before operation the bone appeared normal. The drill-holes show the extent of the intra-osseous abscess found at operation the same day. Pus under pressure was found at all but the lowest drill-hole.

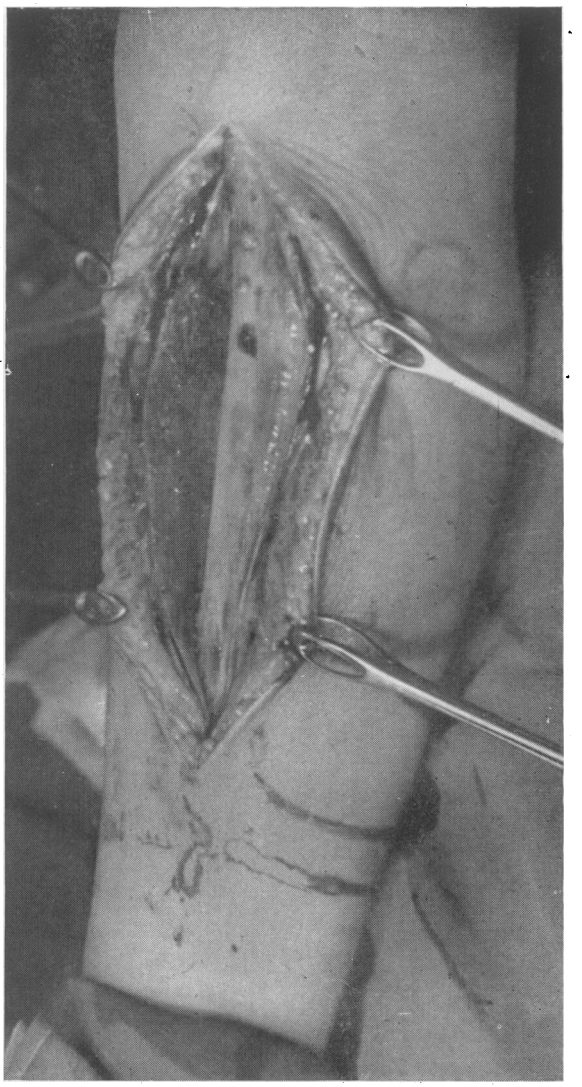

FIG. 9.—Tibia exposed at operation. A large collection of pus was found under the periosteum. A hole was found in the cortex but no pus was discharging through it. Pus is seen oozing out of drill-holes made above the spontaneous hole. 'One hole is not enough.'

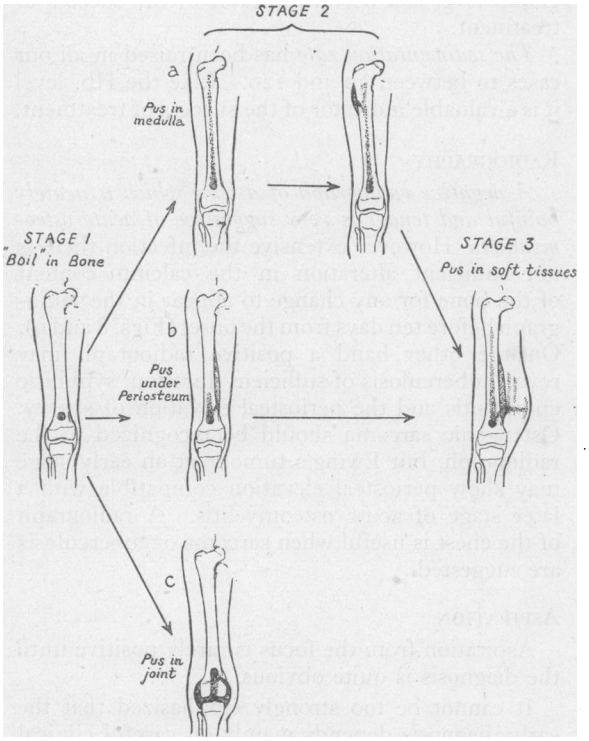

FIG. 7.—Diagrams of the progress of untreated acute osteomyelitis in a long bone.

can be mapped out with little disturbance of the patient. There is no need to handle the whole limb. Only the tip of one finger is used to palpate the bone gently, beginning some distance away and gradually approaching the focus. This 'one-finger' test is invaluable for accurate localization. If the whole hand is used it is easy to mistake the site of the focus, and if the forearm or leg is affected, to mistake the bone involved. For the same reason a limb should always be supported so that the examiner does not have to use both hands at once.

Pain and tenderness are the only local signs of acute inflammation in the first stage; there is normally no swelling, redness or heat, there is certainly no fluctuation, there may be no loss of function. These patients have been known to walk into a clinic, apparently fit, with pain as their only complaint. Too often the clinical examination is perfunctory, the tenderness is not noticed, radiography is of course negative, and the patient is sent home to develop the signs and symptoms of a florid acute osteomyelitis.

Clinical Picture in Stage 2. Pus in the medulla and the subperiosteal space.

The symptom and sign persist, but both are more marked; pain is more intense, tenderness is more extensive. With retained pus, systemic symptoms if not already present appear and vary from mild malaise to severe toxaemia and delirium. At this stage the patient often complains of aches and pains in other parts, which may lead the physician to diagnose rheumatic fever.

Clinical Picture in Stage 3. Pus in the soft tissues.

When the pus reaches the soft tissues all the signs of inflammation are at last present; pain, tenderness, heat, redness, loss of function and in the more superficial bones, even fluctuation. With the deeper bones involved, notably the femur and the humerus, fluctuation may still be undetected, for the pus tends to track along the deeper tissue planes before coming to the surface. This stage should never be allowed to occur.

3. Fever in Acute Osteomyelitis

In the first stage the patient's temperature may be normal, but more often it is slightly raised and occasionally there is high fever. In fact the presenting symptom may be fever, and the story of pain in a bone and the presence of tenderness may only be elicited on question and examination. In the second and third stages the temperature is nearly always raised, but the administration of antipyretics is so common that little attention should be paid to an isolated normal reading. Salicylates are sometimes given to eliminate rheumatic fever, but the fever of acute osteomyelitis may also respond, only to rise again with abscess formation.

4. Differential Diagnosis

In most cases the diagnosis is not difficult once the possibility of acute osteomyelitis has been considered. Rheumatic fever and septic arthritis are the most confusing, but occasionally tuberculosis of bone and joint, syphilitic epiphysitis, sarcoma and the subperiosteal haematoma of scurvy may have to be differentiated.

(a) *Acute Rheumatism.* The hot dry skin of the septic case is very different from the clammy skin of the rheumatic. Careful examination will show that the tenderness is of bone rather than of joint. This is confirmed by the lesser degree of spasm in acute osteomyelitis. Whereas virtually no joint movement is permitted by the rheumatic case, usually 10° or 20° are allowed in the early stage of acute osteomyelitis. In the later stages the oedema and swelling of the periarticular tissues contrasts with the wasting round a rheumatic joint. Rheumatic fever has rarely a single focus, but more than one focus can also occur in acute osteomyelitis. In acute rheumatism the anaemia is usually rapid and more severe.

(b) *Septic arthritis.* The diagnosis from acute osteomyelitis does not begin and end with aspiration. The two conditions may, of course, be present together, especially in infants, in whom it may be impossible to determine which was primary.

The following points are useful. In acute osteomyelitis the tenderness is not equally severe over the whole joint but is greatest over one particular part of it, either the focus or the related glands. Again, unless there is a large 'sympathetic effusion,' the joint is not held in the position of maximum synovial distension, but is held so as to relax the muscles attached to the affected bone. Thus in acute osteomyelitis of the pubis without joint infection, the hip may be held flexed but it will not be abducted. Abduction will be the movement most resented, while adduction and flexion, which do not stretch the adductors and consequently do not pull on the pubis, are allowed.

Aspiration of the joint may be useful, provided its limitations are remembered and its dangers avoided. Thus:

(i) Both bone and joint infection may be present together and pus in the joint does not necessarily mean primary septic arthritis.

(ii) *Macroscopic* examination of the fluid can be very misleading. An apparently innocent fluid may teem with organisms and a flocculent one may be sterile.

(iii) It is unforgivable to introduce infection into a joint by exploratory puncture. Aspiration must be performed through the part furthest from the inflamed area. If there is pus in the joint it can be withdrawn from any part of it.

Aids to Diagnosis and Special Investigations

These are of relatively little value compared with clinical examination. Some help may be gained from a history of minor infections such as a boil, septic spots, styes or a discharging ear.

Blood Examination

Culture is too slow for diagnosis, but a specimen should be taken before penicillin treatment begins, to obtain the organism for a sensitivity test.

The white blood count may show a leucocytosis, but a normal or even a low count is not unusual and is not against a diagnosis of acute osteomyelitis.

The red blood count and Hb % are not reduced in the early stages of rheumatic fever. The haemoglobin level is a useful indicator of the success of treatment.

The sedimentation rate has been raised in all our cases to between 30 and 120. Like the Hb. level it is a valuable indicator of the success of treatment.

Radiography

A negative radiograph of a bone which is acutely painful and tender is very suggestive of acute osteomyelitis. However extensive the infection there is not sufficient alteration in the calcium content of the bone for any change to appear in the radiograph before ten days from the onset (Figs. 8 and 9). On the other hand a positive radiograph may reveal tuberculosis of sufficient duration, syphilitic epiphysitis and the periosteal elevation of scurvy. Osteogenic sarcoma should be recognized in the radiograph, but Ewing's tumour at an early stage may show periosteal elevation compatible with a later stage of acute osteomyelitis. A radiograph of the chest is useful when sarcoma or tuberculosis are suggested.

Aspiration

Aspiration from the focus is rarely positive until the diagnosis is quite obvious.

It cannot be too strongly emphasized that the early diagnosis depends mainly on careful clinical examination and that in the first two stages the patient may present only one symptom (pain in bone) and one sign (exquisite tenderness of bone).

Treatment

Treatment has been so altered by penicillin that we describe here an effective method based on six principles arrived at after studying our own 60 cases and the series of other workers. In our experience complications may follow even a minor divergence from any one principle.

1. Systemic penicillin can by itself resolve the infection if the organism is sensitive and treatment is begun before pus has formed.

2. Systemic penicillin cannot sterilize avascular tissues or pus. Therefore pus and dead tissue already present must be effectively removed.

3. Systemic penicillin can prevent further formation of pus if removal of pus and dead soft tissue has been effective. Therefore primary suture is safe.

4. Bone, especially when diseased, is particularly susceptible to secondary infection. Therefore any local operation must be carried out under full aseptic conditions and must end with primary suture without any form of drainage.

5. The bone is damaged directly by the infection and indirectly by interference with its blood supply. Therefore every effort must be made to

improve the blood supply (a) by relieving pressure within and bone, and (b) *by restoring contact between cortex and periosteum when these have been separated by pus.*

6. Inflammation is so well concealed in bone that residual infection cannot be detected. Therefore penicillin and immobilization should not be discontinued immediately the clinical evidence of inflammation has disappeared.

Treatment along these lines is best described under four headings : Penicillin treatment, surgery, immobilization and after-care.

Penicillin Treatment

The penicillin must be given systemically, for the infection is in part a systemic one (50 per cent. of our cases had a positive blood culture) and only by the blood stream can the penicillin be brought to the infection. Further it seems, though the evidence is not complete, that for pyogenic infections of bone the systemic administration should aim at the constant presence of penicillin in the blood. It is probable that the temporary high levels often so effective in soft tissue infections act by the formation of a local pool of penicillin in the tissue fluids of the inflamed part, so that it acts for longer than appears from the blood levels. Bone with its rigid structure lacks this fluid reservoir and must rely on circulating penicillin.

The intramuscular drip has in our experience been most satisfactory for maintaining a constant blood level. It disturbs the patient much less than intermittent administration and is considerably more economical. Our dosage has been as follows :

First three days	..	400,000 units in 24 hours
Fourth day	..	300,000 ,, ,, ,, ,,
Fifth day onwards		200,000 ,, ,, ,, ,,

A more reasonable system of dosage would be one based on weight. Buchanan working with intermittent dosage has shown that 4,000 units per lb. of expected body weight per day maintains a bacteriostatic level when given :

(a) in infants under six months, orally in the first ½ oz. of each three- or four-hourly feed, e.g., 60,000 units daily in a six months child ;

(b) in children from six months to five years, intramuscularly every three hours, e.g., 170,000 units daily in a child of five years.

She found the intramuscular drip more economical. Thus 100,000 units per 24 hours maintained a constant bacteriostatic level in children up to ten years. This dose was increased up to 500,000 units in exceptional cases. We also favour such an increase for the first few days in acute osteomyelitis.

It is of course important to isolate the organism early, to test its sensitivity and if necessary to modify the dosage without delay.

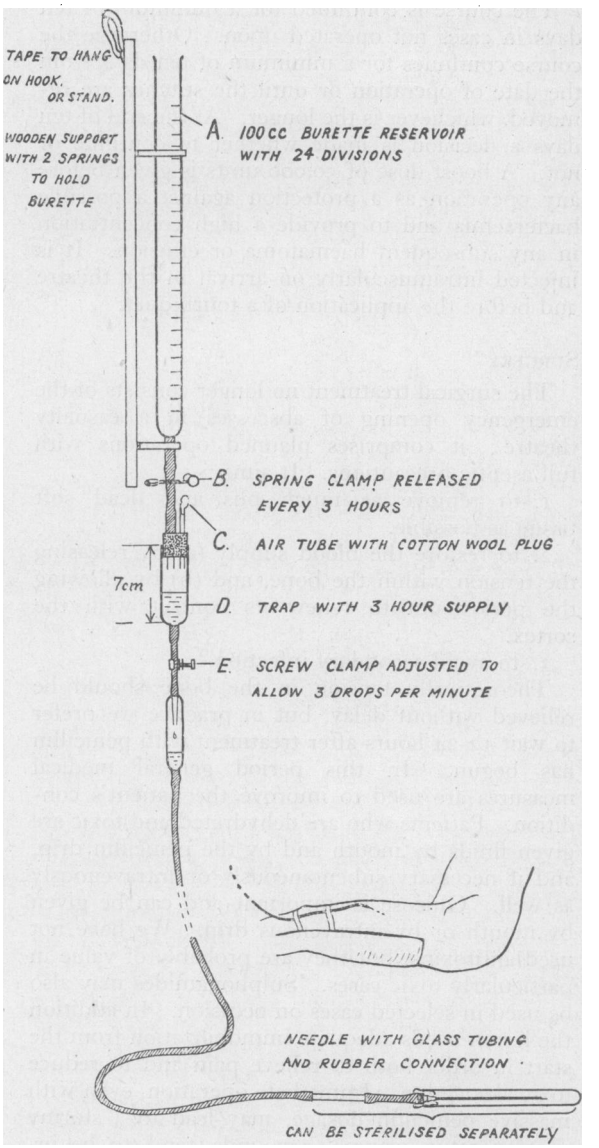

FIG. 10.—Diagram of penicillin drip system (Eudrip No. 1 described by MacAdam *et al.* in 1944).

The drip illustrated in Fig. 10 is the Eudrip No. 1 described by MacAdam in 1944. Non-pyrogenic saline as prepared for intravenous infusion is used ; less pure fluids often cause a cellulitis which interferes with absorption. The rubber tubing must be tested for penicillin destruction by incubating the two together for 24 hours. Harmless tubing can then be reserved for use in the drip apparatus.

The course is continued for a minimum of ten days in cases not operated upon. Otherwise the course continues for a minimum of ten days from the date of operation or until the stitches are removed, whichever is the longer. At the end of ten days a decision is made whether to continue or not. A boost dose of 50,000 units is given before any operation as a protection against a possible bacteraemia and to provide a high concentration in any subsequent haematoma or effusion. It is injected intramuscularly on arrival in the theatre and before the application of a tourniquet.

Surgery

The surgical treatment no longer consists of the emergency opening of abscesses in a casualty theatre; it comprises planned operations with full aseptic precautions. It aims:

1. to remove as much pus and dead soft tissue as possible.
2. to restore the blood supply (a) by releasing the tension within the bone, and (b) by allowing the periosteum to renew its contact with the cortex.
3. to avoid secondary infection.

Theoretically tension in the bone should be relieved without delay, but in practice we prefer to wait 12-24 hours after treatment with penicillin has begun. In this period general medical measures are used to improve the patient's condition. Patients who are dehydrated and toxic are given fluids by mouth and by the penicillin drip, and if necessary subcutaneously or intravenously as well. Glucose is important and can be given by mouth or by intravenous drip. We have not used antitoxins, but they are probably of value in particularly toxic cases. Sulphonamides may also be used in selected cases on occasion. In addition the lesion needs adequate immobilization from the start in order both to relieve pain and to reduce toxic absorption. Immediate operation, even with massive penicillin dosage, may lead to a stormy post-operative course; wounds tend to be inflamed and even to break down, in contrast with the rapid recovery and healthy healing of cases adequately restored before being taken to the theatre.

Operation is whenever possible done under a tourniquet to ensure a bloodless field. If there is fluid in the related joint it is aspirated before the osteomyelitic focus is incised. The centre of the incision is over the point of maximum tenderness and is long enough for adequate exposure. All pus is removed from the soft tissues and from under the periosteum, and any necrotic soft tissue is excised. The bone is then drilled in two places and if pus is found further drill holes are made till normal marrow is reached or until the epiphysis or joint capsule is approached. When the surgeon is satisfied with the clearance of pus and sloughs, the wound is closed with interrupted sutures *but without any form of drainage*. The tourniquet is then removed. The area is immobilized so that the wound can be easily inspected and if a limb is affected it is elevated.

Once it was considered unnecessary to drill the bone if subperiosteal pus were present, as this was thought to indicate spontaneous decompression. Decompression, however, is not adequate through one small hole; pus will come out of neighbouring bone under pressure when fresh holes are drilled (Fig. 9). On the other hand extensive guttering is not recommended, as drill holes decompress just as extensive an area with much less bone destruction. Drilled bone may later appear normal in the radiograph, whereas sclerosis is common at the site of guttering. In the acute stage it is impossible (we use the word advisedly) to distinguish dead from living bone at operation, and *excision of bone is now never indicated.*

Immobilization

Effective immobilization is important and should be applied early. It may be considered for two stages: the acute stage and the stage of repair.

In the acute stage the part should be immobilized, elevated and accessible for inspection. When operation is unlikely, the region must be inspected daily to see that there is no increase in local signs and that the joint is still unaffected. We inspect wounds on the fourth day for haematoma formation and on the seventh and tenth days for minor stitch infection. Full sterile precautions are observed, though the dressing is done in the ward.

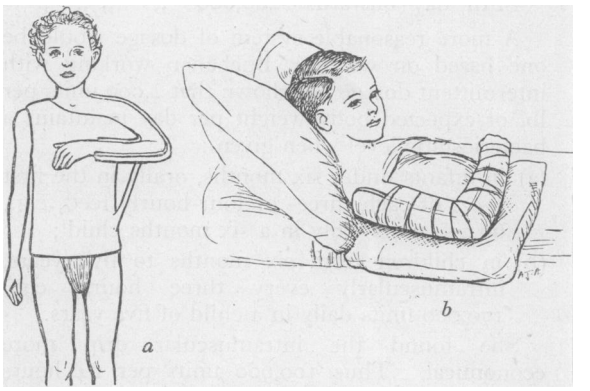

FIG. 11a.—For lesions of the shoulder and upper humerus: a thoraco-brachial plaster spica, the brachial part bivalved. A strut between elbow and ilium prevents collapse.

FIG. 11b.—For lesions of the lower humerus, forearm and hand: a plaster back slab.

A haematoma can easily be evacuated by inserting forceps between two stitches. There is never any indication for the insertion of a drain.

In the early stage the following methods of immobilization are satisfactory :

(a) *For the shoulder girdle and upper humerus* (Fig. 11a), a thoraco-brachial plaster with the upper half of the arm part removed. This need not be applied before the second or third day, till when a sling with the arm bandaged to the side is adequate.

FIG. 11c.—Jones' hip frame.

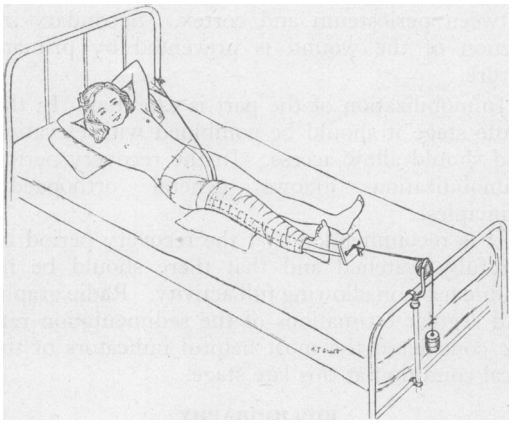

FIG. 11d.—Weight and pulley with groin strap for counter-traction. (The foot of the bed can be raised if necessary.)

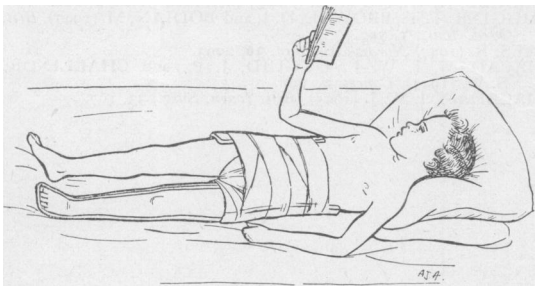

FIG. 11e.—For lesions of the pelvis and upper femur : the posterior part of a bivalved hip spica.

(b) *For the lower humerus, forearm and hand*, a long plaster back slab.

(c) *For the pelvis and upper femur*, a hip frame (Fig. 11c). When one is not available, skin traction to the leg by a weight over a pulley, with counter-traction by a groin strap on the opposite side, is a satisfactory method (Fig. 11d), but in serious cases we recommend the posterior half of a high hip spica (Fig. 11e). A Thomas splint is unsuitable, as it tends to keep the hip in flexion, lies across the area to be examined, does not immobilize the hip, and may confuse the diagnosis by causing tenderness over the pubis, ilium or ischium.

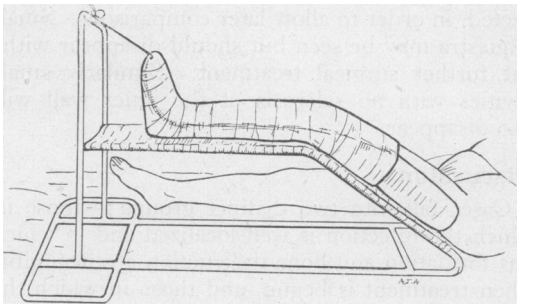

FIG. 11f.—For lesions of the lower femur, tibia and foot : a plaster back slab elevated on a Braun's frame.

(d) *For the lower femur, leg and foot*, a plaster back slab supported on a Braun's frame (Fig. 11f).

In the repair stage immobilization should follow standard orthopaedic principles.

AFTER-CARE

The most difficult decisions are how soon can treatment be stopped, the penicillin discontinued and mobilization begun. Chronic inflammation from incomplete treatment can be serious and it is best to err on the side of caution. Bone healing is slow and even though infection is overcome more rapidly than in the past, the speed of repair has not changed. It has been said that pathological fractures are more common since penicillin, but the surgeon who allows too early mobilization and weight-bearing is to blame for any such increase, not the penicillin.

INDICATIONS OF THE LOCAL CONDITION

Four indicators are useful to decide when mobilization is safe.

1. *The temperature chart* is the least sensitive indicator. The chart is usually normal by the second week, and only gross reactivation is reflected by a rise.

2. *The sedimentation rate* is the most valuable and we rely on it more and more. It may take several months for the rate to fall to normal in a severe infection and it need not reach normal before mobilization is allowed. But if mobilization is followed by a rise or by a decrease in the rate of fall of the weekly sedimentation rate, this should be understood as a warning and immobilization should be resumed.

3. *The white cell count* is sometimes useful and should also be recorded.

4. *Radiography* is essential before taking any decision on mobilization and especially on weight-bearing. A radiograph is taken not only on admission but also as soon as changes can be expected, in order to allow later comparisons. Small sequestra may be seen but should disappear without further surgical treatment. Similarly small cavities with no sclerosis of the inner wall will also disappear.

Discussion

Cases fall into two distinct groups :—those in which the infection is well localized and in which pus formation and bone destruction are negligible when treatment is begun, and those in which the infection is more advanced, pus has formed and the bone has been already damaged. In the first group adequate penicillin treatment and immobilization cause rapid resolution and usually no bone damage can be detected radiographically. In the second group the penicillin must be supplemented by surgery, since it can neither sterilize the pus nor relieve the mechanical interference with the blood supply of the bone. After operation these cases also show rapid resolution, and healing of the sutured wound usually occurs by first intention. Neither group should show systemic disturbance for longer than a week.

We recommend open surgery for the second group of cases. Some workers have been satisfied with aspiration of pus and prefer to repeat aspiration a number of times rather than to risk secondary infection by operation. But this risk is of course negligible when primary suture is done in a part which can be kept clean and immobilized. In infants the immobilization and cleanliness of some regions may be difficult and aspiration may then be preferable to open operation. Fortunately these cases are the most suitable for such treatment, as the structure of bone in infancy allows early escape of the pus into the soft tissues.

Summary

The improvement in results of acute haematogenous osteomyelitis during the last four years are described and are attributed to the use of penicillin.

The need for early diagnosis is stressed, and the underlying pathology is shown to be related to the clinical signs and symptoms.

Treatment is described under four headings : penicillin, surgery, immobilization and after-care.

The importance of maintaining without interruption a bacteriostatic level of penicillin in the blood is urged on theoretical grounds, and the need for continuing penicillin beyond the period of obvious inflammation is emphasized. The value of the intramuscular drip is noted.

Surgery is considered necessary when pus has already formed. It aims to remove pus, to relieve pressure within the bone and to restore contact between periosteum and cortex. Secondary infection of the wound is prevented by primary suture.

Immobilization of the part is essential. In the acute stage it should be combined with elevation and should allow access. In the recovery period immobilization follows general orthopaedic principles.

It is recommended that the recovery period be carefully watched and that there should be no undue haste in allowing full activity. Radio graphs and regular estimations of the sedimentation rate are considered the most helpful indicators of the local condition at this late stage.

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