ACUTE HAEMATOGENOUS OSTEITIS IN CHILDHOOD

A Review of 212 Cases

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This paper is concerned with the observations made on 212 cases of acute haematogenous osteitis admitted to one of the surgical units of the Royal Hospital for Sick Children, Glasgow, during the years 1936 to 1950.

The term osteitis is preferred to osteomyelitis because the bone marrow plays only a small part in bone suppuration (Nowicki 1931, Romanis and Mitchiner 1932, White 1937, and Dennison 1948, 1951). In many centres the older terms periostitis, osteitis and osteomyelitis as denoting separate diseases have been abandoned and the inflammations of bone tissue are alluded to as osteitis, a term which covers all the essential structures of a bone. By "acute" osteitis we mean a sudden illness with severe toxaemia and definite evidence of inflammation of bone, the duration of the illness being days rather than weeks (Williams 1932). Streptococcal osteitis of infancy, by its nature and age incidence, differs from the disease that we are considering (Dennison 1948) and has therefore been excluded from this review.

The treatment of osteitis falls naturally into three periods: 1) The period before the introduction of chemotherapy. 2) The period of effective chemotherapy. 3) The penicillin "era." The present survey offers an opportunity of assessing the various therapeutic agents in three comparable groups of patients. Group I covers the five-year period (1936-1940) immediately before the introduction of effective chemotherapy. The mortality was 36 per cent. Group II covers the next five years (1941-1945) when sulphathiazole was used. The mortality fell to 12.7 per cent. Group III covers five years (1946-1950) in which penicillin has been used. In this group there has been only one death—a mortality of 1.2 per cent. The mortality in the three groups is shown in Figure 1.

GROUP I: PATIENTS TREATED BEFORE THE INTRODUCTION OF EFFECTIVE CHEMOTHERAPY

Seventy-five patients were treated. Forty-three were boys and thirty-two girls. Their ages varied from nine months to twelve years, but most were over two years (Fig. 2).

Onset—The duration of the disease before admission to hospital is taken from the time of onset of local pain in the limb. This varied from one to ten days, and forty-one patients were admitted within four days of onset (Fig. 5). Injury and septic focus—There was a history of injury in forty-one cases (53 per cent) and evidence of a septic focus in twenty-seven (36 per cent). Bones affected—The commonest sites were the femur and tibia. The frequency and relative death rate at each site is shown in Table 1.

Bacteriology—Blood culture was positive in thirty-eight patients (50 per cent) before treatment began and was seldom positive after the ninth day in those that survived. The
infecting organism (grown from the blood or pus) was staphylococcus aureus in seventy-one cases (95 per cent), streptococcus in three, and pneumococcus in one. Staphylococcal infection was responsible for twenty-six of the twenty-seven deaths, the other being due to the pneumococcus.

Clinical course—All patients were obviously ill on admission, with a flushed face, bright eyes and dry furred tongue. Examination was usually resented. In many cases the child was comatose on admission and localisation of the lesion was difficult. Even in less severe infections generalised pain and tenderness made accurate diagnosis difficult. The temperature was usually high (103–105 degrees Fahrenheit) but in severe cases a subnormal temperature was sometimes recorded. Even in the more favourable cases the temperature usually remained elevated for several weeks. In the more superficial bones, local swelling usually appeared early and was followed by erythema of the skin and effusion into an adjacent joint. These
classical local signs appeared late in lesions of the pelvis, ribs and upper femur. Leucocytosis was present in all except the most fulminating cases. Rigors usually indicated pyaemic abscess formation, but the presence of such lesions could usually be confirmed only at necropsy. Apart from soft-tissue oedema, radiographic changes were seldom seen before the tenth or twelfth day of the illness.

Duration of stay in hospital of non-fatal cases—Many factors affected the duration of stay in hospital, which is shown in Figure 8. Home conditions often influenced the decision to detain the patient in hospital for a prolonged period.

Radiographic changes—After ten or twelve days a layer of new subperiosteal bone could be seen. Within a few days, areas of rarefaction appeared in the metaphysis, but the changes were soon obscured by dense involucrum formation. The changes almost always extended throughout the shaft, and after four weeks the dense dying shaft could be seen through the more porous involucrum. Over a period of months sequestra of varying size were seen to separate, while the involucrum became even more dense, obscuring the details of bony change.

Mortality—Thirteen of the twenty-seven patients who died succumbed within five days of admission. When death occurred within the first week, there were seldom gross changes in the metaphysis either at operation or at autopsy.

Necropsy findings—Post-mortem examination was carried out in nineteen cases. In all, there were widespread pyaemic lesions. Suppurative pericarditis, abscesses in the lungs and kidneys were common (Table II). In all cases there was a large septic spleen from which abundant staphylococcus aureus was grown.
Complications. Arthritis—Of the forty-eight patients who recovered, two presented definite evidence of pyogenic arthritis, without evidence of osteitis in the adjacent metaphysis. Ten patients developed arthritis from direct extension. Two joints were treated by repeated aspiration with return of a full range of movement. Of eight cases treated by open drainage the joint subsequently became ankylosed in four; about half the normal function was regained in three, and only one recovered a full range of movement. Limb lengthening—Lengthening of the leg was noted in the case records in seven instances, but no accurate measurements were made in this group and there was no radiographic comparison of the sound and diseased bones. Five of the seven patients were seen again in 1950 and in none was there any measurable difference in length of the two legs. Pathological fractures—Pathological fracture was common but union occurred with certainty. The support of a dense involucrum usually prevented gross displacement.

Methods of treatment—Treatment during this period was essentially surgical. The use of maggots (Baer 1931) and maggot extract had been abandoned by 1936. The results of administration of intramuscular anti-scarlatinal serum and intravenous mercurochrome were disappointing. Sulphanilamide raised hopes, but even in massive doses it had no effect in staphylococcal infection. Uleron (a dimethyl sulphanilamide) proved useful in the hands of Mitchell (1938) but there was no evidence of any beneficial effect in the cases in this series. Fluid was given freely and intravenous glucose-saline was administered to all acutely ill patients. Exsanguination and replacement transfusion (Robertson 1927) were not used.
The methods of surgical intervention were based on the teaching of Starr (1922) as modified by Winnet Orr (1927). A long incision was made over the affected metaphysis, down to and through periosteum. If much pus was evacuated nothing further was done to the bone, and the wound was lightly packed with vaseline gauze and immobilised in a bivalved plaster-of-Paris case. If no gross pus formation was found under the periosteum, holes were drilled obliquely from the cortex towards the epiphysis, the line of drill-holes extending at least into the centre of the shaft. Although pus was not always obtained, culture of the oedematous marrow or blood oozing from the drill-holes always revealed the infecting organism. Within forty-eight hours pus was usually draining freely. Obvious indications for change of dressing were rise of temperature and increase of local pain.

More radical surgery was sometimes undertaken, and gutters were made in the affected bone in fourteen cases. But it is doubtful whether the more radical intervention gave more satisfactory drainage. Primary diaphysectomy (Mitchell 1928) was not performed in any case in this group. White (1935) pointed out that no surgeon who has had to treat a limb in which the shaft has failed to regenerate will lightly embark on primary diaphysectomy (except for the fibula).

**Results**—In assessing the results of treatment four factors must be considered (Williams 1932): 1) the immediate mortality; 2) the saving of the limb; 3) the extent of necrosis of the bone; and 4) the persistence of suppuration in later years.

The mortality has already been discussed. In no case was amputation necessary. It is almost impossible to assess accurately the morbidity which followed osteitis before the introduction of effective chemotherapy and antibiotics. Sequelae were undoubtedly common, and adherent scars which break down and ulcerate, and discharging sinuses due to underlying cavities and sequestra following osteitis which first occurred during the period under discussion are still seen (Gallie 1951). Only sixteen of the forty-eight survivors were traced. Of these, two still had discharging sinuses with ankylosis of the hip joint. In the others, the wounds were soundly healed, but all the scars were depressed and many were adherent. Four had had further operations since discharge from hospital but radiography revealed no evidence of active bone disease.

### TABLE II

**Group I: Findings at Necropsy in Nineteen Cases**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pericarditis</td>
<td>10</td>
</tr>
<tr>
<td>Empyema</td>
<td>4</td>
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<tr>
<td>Abscesses in lungs</td>
<td>16</td>
</tr>
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<td>Abscesses in kidneys</td>
<td>15</td>
</tr>
<tr>
<td>Arthritis</td>
<td>5</td>
</tr>
<tr>
<td>Subcutaneous and intramuscular abscesses</td>
<td>2</td>
</tr>
<tr>
<td>Abscesses in heart wall</td>
<td>2</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>3</td>
</tr>
<tr>
<td>Abscesses in liver</td>
<td>1</td>
</tr>
<tr>
<td>Meningitis</td>
<td>1</td>
</tr>
<tr>
<td>Suppurative otitis media</td>
<td>1</td>
</tr>
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</table>

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GROUP II: PATIENTS TREATED BY SULPHATHIAZOLE

Fifty-five patients were treated. Thirty-one were boys and twenty-four girls. Their ages varied from one to twelve years (Fig. 3).

Onset—The duration of local pain before admission to hospital varied from one to nine days and, as in Group I, most patients were admitted within four days of onset of pain (Fig. 6).

Injury and septic focus—There was a history of injury in twenty-one cases (38 per cent) and a septic focus was found in twenty-two (40 per cent). Bones affected—The most common sites were the tibia and femur and the sites and deaths from each are shown in Table I.

Bacteriology—The infecting organisms were staphylococcus aureus (fifty-two cases), streptococcus (two cases), and pneumococcus (one case).

Clinical course—There was no spectacular changes in the course of the disease when treated with sulphathiazole. The duration of fever was shorter and metastases were fewer, but healing was no more rapid. From a study of the radiographs the degree of bone destruction appeared to be less, but on the whole the changes were very similar to those seen in the previous group.

McKeown (1943) reported minimal bone changes in a large proportion of his cases but we could not confirm this. The duration of stay in hospital varied from twenty days to just over two years (Fig. 9).

Radiographic changes—The radiographic findings were similar to those in the earlier group.

Mortality—Seven out of the fifty-five patients died (12·7 per cent). Four of the deaths (57 per cent) occurred within fourteen days of admission.

Necropsy findings—Six subjects were submitted to necropsy (Table III). All showed pyaemic lesions similar to those of Group I.

Complications—From the information in the case records it appeared that the complications in this group differ in no respect from those discussed in Group I.

Methods of treatment—In this group surgical intervention was carried out on similar lines to those described for Group I cases. Drilling of the metaphysis and immobilisation in plaster was combined with administration of fluids and sulphathiazole. The dosage of sulphathiazole was based on the minimal effective blood concentration of 2·5 milligrams per cent (McKeown 1943) and was approximately 1 gramme per 20 lb. body weight a day. Sulphathiazole was given for a week; if considered necessary a second course was given three weeks later. In fifteen cases the affected bone was guttered.

<p>| TABLE III |</p>
<table>
<thead>
<tr>
<th>Group II: Findings at Necropsy in Six Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purulent pericarditis</td>
</tr>
<tr>
<td>Empyema</td>
</tr>
<tr>
<td>Abscesses in lungs</td>
</tr>
<tr>
<td>Abscesses in kidneys</td>
</tr>
<tr>
<td>Arthritis</td>
</tr>
<tr>
<td>Abscesses in heart</td>
</tr>
<tr>
<td>Endocarditis</td>
</tr>
<tr>
<td>Subcutaneous and intramuscular abscesses</td>
</tr>
</tbody>
</table>

* In one case the heart ruptured, causing sudden death on the fourteenth day.
Results—The follow-up was disappointing. Only nineteen of the forty-eight survivors were traced. Nine were well with no disability and no radiographic evidence of active bone disease. Of the remaining ten patients, five had been readmitted for removal of sequestra. Four of the ten had marked overgrowth and three moderate overgrowth of the affected limb, and lengthening was measurable in the remaining three patients. Adherent scars were present in four of the ten cases. Two joints (hip and ankle) were ankylosed and one hip joint was subluxated. There was one sinus associated with an intrapelvic abscess. One patient had a flexion deformity of the knee following damage to the posterior aspect of the lower femoral epiphysis.

GROUP III: PATIENTS TREATED WITH PENICILLIN

Eighty-two patients were treated. Forty-eight were boys and thirty-four girls. Their ages varied from one month to twelve years (Fig. 4).

Onset—The duration of local pain before admission to hospital varied from one day to twelve days. In five cases the history of onset was vague; the duration in the other seventy-seven cases is shown in Figure 7. Injury and septic focus—There was a history of injury in thirty-seven cases (45 per cent) and evidence of a septic focus was found in twenty-seven (32 per cent). Bones affected—The common sites were again the tibia and femur (Table I).

Bacteriology—Blood culture was positive in forty-two cases (51 per cent). The infecting organism was staphylococcus in eighty cases, streptococcus in one, and pneumococcus in one. In two infections (one neonatal) the staphylococcus was resistant to penicillin.

Clinical course—The response of the septicæmia to penicillin, although not immediate, was dramatic. General improvement was usually slowly progressive from the start of treatment but the patient remained ill for several days. Pyrexia continued for a few days, resolving slowly by lysis. The blood culture, if initially positive, was sterile by the third day in all except the two cases in which the organism was insensitive to penicillin. In over 80 per cent of cases pus was present under the periosteum or in the soft tissues on admission, but neither the temperature chart nor the leucocyte count was a reliable criterion for assessing the local condition of the bone. Careful examination of the limb, repeated marrow aspiration and accurate radiographic observation were all necessary when assessing the progress of the bone lesion. With careful immobilisation and relief of tension by surgical intervention when indicated, severe pain was usually abolished in penicillin-treated cases after the second day of treatment. Swelling due to soft tissue oedema usually subsided within seven days. If it remained longer it raised the suspicion of persistent deep pus. The duration of stay in hospital varied from twelve days to six months (Fig. 10). Over two-thirds of the patients were home within six weeks.

Radiographic changes—The usual sequence of radiographic changes in penicillin-treated osteitis have been described previously (Dennison 1948). Altemeier and Helmsworth (1945), Higgins et al. (1947) and Beerman (1948) reported cases in which the course of disease was typical of acute osteitis but radiographic changes never occurred to confirm the diagnosis. Such cases occur, and we must admit that early treatment may so limit bony changes that they are never sufficiently extensive to be seen by radiography (White and Dennison 1947).

Mortality—Of the eighty-two patients, one died. The organism in this case was a penicillin-resistant staphylococcus. Neither streptomycin nor aureomycin was available at that time and, despite massive doses of penicillin and intravenous sulphonamide, the child died on the fourth day. Results reported from other centres are shown in Table IV.

Necropsy findings—There was no pus in the hip joint. A subperiosteal abscess extended for seven centimetres below the greater trochanter. There was no naked eye evidence of a bone focus in the upper femur. There was a large septic spleen and there were pyaemic abscesses in both lungs.
TABLE IV
RESULTS IN ACUTE OSTEITIS TREATED WITH PENICILLIN*

<table>
<thead>
<tr>
<th>Author</th>
<th>Cases</th>
<th>Deaths</th>
<th>Mortality (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altemeier and Helmsworth (1945)</td>
<td>34</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td>McAdam (1945)</td>
<td>40</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>Trueta (1946)</td>
<td>30</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Butler (1946)</td>
<td>14</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Hudson (1946)</td>
<td>37</td>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td>Higgins et al. (1947)</td>
<td>31</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dennison (1948)</td>
<td>30</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tucker and Hollenberg (1948)</td>
<td>39</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Wilkinson (1948)</td>
<td>50</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Present series (Group III)</td>
<td>82</td>
<td>1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

* The reports of Higgins, Dennison and Wilkinson deal with infants and children; the others are mixed groups of children and adults.

Fig. 11
Lengthening of limb after acute osteitis treated by penicillin. In the photograph (Fig. 11) note increased length of left leg and pelvic tilt (correctable by blocks 2 centimetres high). The radiograph (Fig. 12) shows increase in length and girth of left femur.
Complications—Some complications are avoidable, but so long as patients continue to arrive in hospital at a relatively late stage of the disease, complications are inevitable. 

Arthritis—Pyogenic arthritis occurred in twelve of the eight-one surviving patients. The joints were involved by direct extension from an adjacent metaphysis. One patient developed scarlet fever on the twenty-fourth day of his illness and was transferred to a fever hospital. There he developed multiple lesions, and he now has a bony ankylosis of the right ankle. In two patients there is gross irregularity of the lower femoral epiphysis. In the other nine cases in which arthritis developed there was recovery of joint movement. One joint was treated by open drainage, with recovery; the other joint infections were treated by aspiration and instillation of penicillin. The infecting organism was a coagulase-positive staphylococcus in all cases of arthritis. The frequent recovery of full joint function was gratifying. Before the introduction of antibiotics, staphylococcal arthritis in children led to ankylosis of the joint in 50 per cent of the cases; the prognosis was much better in streptococcal joint infections (White 1935).

Limb lengthening (Dennison 1952a)—In twenty-four infections of long bones treated during 1945 and 1946 measurable increase in length (1–3 centimetres) occurred in thirteen patients (50 per cent) followed up for at least four years. In some, lengthening was not apparent for almost a year after the onset of the acute bone infection (Figs. 11 and 12) and in one patient lengthening of 2 centimetres eighteen months after onset increased to 2:5 centimetres after four years, though there was no clinical or radiographic evidence of active bone disease during this time. Since January 1947 no case of increased length of more than 1 centimetre has been observed. Gross increase in girth and length is uncommon in penicillin-treated cases, but in the earlier cases of this group failure to perform primary suture led to cavitation and sequestrum formation in a number of limbs with resulting overgrowth. When only one of two paired bones is diseased the increase in length affects both bones equally.

Pathological fracture—Despite our awareness of the risks of pathological fracture in the osteoporotic bone in penicillin-treated osteitis (Agerholm and Trueta 1946, Aird 1946, Dennison 1948 et al.), this complication occurred on seven occasions. The displacement was usually negligible and there was no pain to indicate the moment of fracture. The fractures have all united, but rather slowly and with little callus formation.

Sequestrum formation—Sequestrum formation necessitating surgical intervention occurred in fourteen cases. The patient who developed scarlet fever on the twenty-fourth day of treatment had metastatic spread of infection from femur to the tibia and fibula of the same limb, and the ankle joint was destroyed by arthritis. Multiple sequestrectomies were required. All the cases in this group were reviewed in 1951 and there was no clinical or radiographic evidence of active bone disease or sequestrum formation in any patient.

Other complications—There was one case of pericarditis, successfully treated by aspiration and instillation of streptokinase. Hyperaemic subluxation followed osteitis of the axis. The patient was treated by immobilisation in plaster until the second and third cervical vertebrae fused in the subluxated position. Adherent scars developed in only two cases; both scars have been excised with satisfactory results. Genus valgum developed in two cases. One patient reported with osteochondritis of the opposite hip fourteen months after recovery from osteitis of the femur. One patient developed a stress fracture of the third metatarsal thirteen months after the onset of osteitis of the femur on the opposite side (Macpherson 1951).

Treatment—The aim of treatment is to control septicaemia and to reduce tension in the local bone focus. If the infecting organism is penicillin-sensitive and penicillin therapy is instituted early, these objects should be achieved without surgical intervention (Florey and Florey 1943). In this group, the average duration of local pain was four and a half days before admission to hospital, and in sixty-eight of the eighty-two cases pus was present under the periosteum or in the soft tissues on admission and surgical intervention was necessary. It is disappointing that cases come to hospital no earlier to-day than they did fifteen years ago.
The details of treatment have been described previously* (Dennison 1948). The frequent intramuscular injections of penicillin cause pain and unhappiness to many of the children and the many methods of prolonging therapeutic action of a single injection (by delayed absorption or by delayed excretion) have been fully investigated. We have found that the blood levels obtained by such methods are too variable to justify our relying on once-daily injections in such a serious infection as acute osteitis. The dose of penicillin suggested in the footnote is often exceeded. Penicillin administration is continued for twenty-one days or until the marrow culture is reported sterile, whichever is the longer period. Should the infecting organism be grown from the metaphysis after twenty-one days, the metaphysis is drilled and penicillin is instilled. Five penicillin-resistant staphylococcal bone infections have been encountered since aureomycin became available (Dennison and Macpherson 1952); the systemic response was dramatic in each case.

Operative procedures—Once an abscess has formed it cannot be sterilised by the systemic administration of penicillin, and in such cases surgery is still necessary. Surgical procedure has been discussed fully in a previous communication (Dennison 1948) and only a brief outline is given here. Despite reports to the contrary (Higgins et al. 1947) we have found that aspiration is seldom successful in evacuating the pus. The pus may be too thick to pass through the needle or through the nozzle of the syringe. After aspirating pus as thoroughly as possible, it is instructive to leave the needle in position and to cut down upon the abscess; the quantity of residual pus is usually considerable. In osteitis of the tibia, pus frequently collects between the tibia and fibula rather than on the subcutaneous surface as one might expect; it is difficult to aspirate pus adequately from this intersosseous position.

Bone drilling should seldom be necessary, but less harm will be done by bone drilling followed by primary suture of the skin, than by incomplete relief of tension. If pus is present in the soft tissues or under the periosteum, the tension in the bone has probably been relieved. If acute pain persists after simple incision, or if at a later stage one suspects that the blood supply to the bone is inadequate, drill holes without elevating the periosteum will at least give an alternative blood supply and will also allow local instillation of penicillin. Metaphysial decompression (Tucker and Hollenberg 1948) should certainly be carried out if there is any suggestion of tension within the bone.

Guttering and "sauercisation" have no place in the modern treatment of acute osteitis.

* The following is the routine method of investigation and treatment of cases of acute osteitis used at this hospital. 1) Routine history and examination. 2) Blood taken for culture, sedimentation rate. 3) Leucocyte count. 4) Penicillin therapy begun as below (based on dose of 5,000 units/lb. body weight/24 hours).

<table>
<thead>
<tr>
<th>Age</th>
<th>Dose each 24 hours</th>
<th>Frequency and route</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–3 months</td>
<td>80,000 units</td>
<td>3-hourly by mouth (aureomycin preferable)</td>
</tr>
<tr>
<td>3–6 months</td>
<td>80,000 units</td>
<td>3-hourly by intramuscular injection</td>
</tr>
<tr>
<td>6–12 months</td>
<td>120,000 units</td>
<td></td>
</tr>
<tr>
<td>1–5 years</td>
<td>200,000 units</td>
<td>3-hourly by intramuscular injection</td>
</tr>
<tr>
<td>5–10 years</td>
<td>300,000 units</td>
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</tr>
<tr>
<td>10–12 years</td>
<td>450,000 units</td>
<td>4-hourly by intramuscular injection</td>
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</tbody>
</table>

5) Limb immobilised (but not enclosed) in plaster. 6) Blood culture on first, second and third days or until culture is sterile. 7) Marrow culture on fourteenth, twenty-first and twenty-eighth days or until sterile. Penicillin level in marrow assayed at same time. Blood calcium, phosphate and phosphatase estimated. 8) Case reviewed daily with special reference to pain, temperature and local condition. 9) Operation only with penicillin control. 10) Penicillin continued for twenty-one days or until marrow sterile. 11) Radiography—If lesion in doubt, immediate (after giving penicillin); then seventh, tenth, fourteenth, twenty-first and twenty-eighth days; two, three, four and six months and thereafter as required.
Diaphysectomy should never be necessary, but in two cases of extensive osteitis of a rib the necrotic bone was removed and the wound sutured.

Treatment of arthritis—Pyogenic arthritis has been treated by aspiration followed by instillation of penicillin. Aspiration is repeated as required. One joint infection was treated by open drainage. Should the organism prove to be resistant to penicillin, streptomycin should be instilled into the joint after aspiration (Dennison and Macpherson 1952).

Results—Three of the eighty-one survivors have not been traced. Of the remaining seventy-eight, sixty are well and have no disability and no radiographic evidence of active bone disease. Fifteen have measurable increase (from 1 centimetre to 2·5 centimetres) in length of the affected limb, and in two of these there is a postural genu valgum. Of the eleven patients with pyogenic arthritis, one has ankylosis of the ankle and another (in a case of neonatal osteitis) has one and a half inches shortening of the leg four years after gross damage to the lower end of the femur. In the remaining nine patients joint movements are full, free and painless. There are no adherent scars and no sinuses.

DISCUSSION

Etiology—The etiology of acute haematogenous osteitis is not fully understood. The disease varies not only from district to district but also with the resistance of the individual patient, with the virulence of the invading organism and with the massiveness of the dose. Social incidence—According to Truea (1948) the incidence of osteitis is low where the standard of cleanliness is high. In the industrial areas of Scotland there is still appalling overcrowding and in some of the rural districts that this hospital serves, living conditions are poor. It was established that unsatisfactory home conditions existed in fifty-seven (70 per cent) of the eighty-two penicillin-treated cases. Mitchell (1928) stated that there is a definite class distinction in children affected by osteitis, and Stevenson (1946) found that acute osteitis was seldom encountered in private consulting practice. Bailey and Love (1946) state that osteitis is almost unknown in naval schools, although minor injuries and infected abrasions are common. From Salzburg, Domanig (1947) reported that the rural population is more susceptible to osteitis than are the city inhabitants. This is ascribed to poorer living conditions in rural districts.

Age and sex—This hospital admits children up to the age of twelve years, and cases of acute osteitis have occurred in all age groups (Fig. 13). The proportion of boys to girls was approximately four to three (122 boys; 90 girls). These figures are similar to those published by White (1937) from the same hospital and in Table V they are compared with figures from other centres.

Significance of septic foci and injury—The accepted etiology is that a child suffering from a symptomless bacteraemia arising from such septic foci as boils, septic abrasions, infected teeth and tonsils, is subjected to some minor injury to the delicate vascular metabolism.
There was a definite history of injury to the affected limb within fourteen days of onset of osteitis in ninety-nine of the 212 patients (46 per cent) and evidence of a septic focus in seventy-six (35 per cent) (Table VI). Similar figures are given by Self (1948). Since osteitis never follows a simple fracture, one must postulate that solution in the continuity of a bone allows release of tension in the region of the fracture haematoma.

It is well known that infection can lie latent for long periods in childhood. In the common inguinal adenitis of infancy and childhood the primary focus is frequently healed before the glandular infection becomes apparent. It is hardly surprising that an obvious primary septic focus is found in only about a third of all cases of osteitis; the initial lesion is often healed and forgotten for two or three weeks before the onset of the disease. The daily bumps and twists to which the normal child subjects himself may be similarly forgotten. It is unusual to find any local evidence of injury and it is possible that the upset in metabolism which may follow a fright or injury lowers the child’s resistance to infection.

**Bones affected**—The preponderant incidence of infection in the bones of the lower limb (Fraser 1926) is possibly explained by its greater liability to injury.

**Treatment**—The methods adopted in Groups I and II of the present series are now only of historical interest. With the introduction of penicillin the change in reaction of the patient was so remarkable that the local changes in the bone were neglected or considered inevitable. But it was soon recognised that failure to obtain a satisfactory result was the fault, not of the drug, but of the surgeon. The suitability of a case for penicillin treatment, the details of treatment, and the prognosis depend on exact clinical and bacteriological diagnosis. Four conditions must be fulfilled to ensure a satisfactory result—that is, to control septicaemia,

**Acute Haematogenous Osteitis in Childhood**

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### TABLE V

**Age and Sex Incidence in Acute Osteitis**

<table>
<thead>
<tr>
<th>Centre</th>
<th>Author</th>
<th>Number of cases</th>
<th>Age incidence</th>
<th>Ratio of boys to girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edinburgh</td>
<td>Fraser (1924)</td>
<td>400</td>
<td>8–12 years</td>
<td>6 to 1</td>
</tr>
<tr>
<td></td>
<td>(1926)</td>
<td>200</td>
<td>3–10 years</td>
<td>4 to 1</td>
</tr>
<tr>
<td>London</td>
<td>Ogilvie (1928)</td>
<td>51</td>
<td>12–9 years</td>
<td>4 to 1</td>
</tr>
<tr>
<td></td>
<td>Pyrah and Pain</td>
<td>262</td>
<td>5–14 years</td>
<td>2 to 1</td>
</tr>
<tr>
<td>Paris</td>
<td>Fèvre (1933)</td>
<td>115</td>
<td>4–16 years</td>
<td>2 to 1</td>
</tr>
<tr>
<td>Glasgow</td>
<td>White (1937)</td>
<td>200</td>
<td>5–10 years</td>
<td>7 to 5</td>
</tr>
<tr>
<td></td>
<td>Present series</td>
<td>212</td>
<td>2–12 years</td>
<td>4 to 3</td>
</tr>
</tbody>
</table>

### TABLE VI

**Incidence of Injury and Sepsis in Groups I, II, III**

<table>
<thead>
<tr>
<th>Injury</th>
<th>Septic focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Per cent</td>
</tr>
<tr>
<td>Group I</td>
<td>(1936–1940)</td>
</tr>
<tr>
<td>Group II</td>
<td>(1941–1945)</td>
</tr>
<tr>
<td>Group III</td>
<td>(1946–1950)</td>
</tr>
</tbody>
</table>

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to prevent the development of metastatic foci, and to induce resolution of the initial bone focus without cavitation or sequestrum formation. 1) Penicillin administration must be begun early (before serious damage to the blood supply with irreversible bone damage has occurred) and the dosage must be adequate. 2) The organism must be sensitive to penicillin. 3) The treatment must be continued until metaphysial culture is sterile. 4) Subperiosteal or soft tissue abscesses must be evacuated and the wound sutured.

After withdrawing blood for culture, forty-eight hours elapse before a report is received on the penicillin-sensitivity of the infecting organism. If a child is acutely ill one must consider the possibility of a penicillin-resistant infection. If the clinical condition of the patient has not improved after twenty-four hours of penicillin therapy (combined if necessary with metaphysial decompression), aureomycin is given and penicillin is stopped (Lankford and Lacy 1949). Nichols and Needham (1949) and Beigelman and Rantz (1950), reporting the increasing frequency of penicillin-resistant staphylococci, state that all their strains have been sensitive to aureomycin.

When assessing the probable effect of penicillin in a particular case the surgeon must not rely too much on the bacteriologist’s report. The bacteriologist’s medium is very different from the human body and there are at least three problems which the bacteriologist cannot answer: 1) How many organisms is penicillin likely to encounter in the body in any given infection? 2) Do staphylococci produce penicillinase at the same rate in vivo as in vitro? 3) What is the most effective level of penicillin in the blood stream? The aid of the laboratory is essential in assessing the action of antibiotics, but the results of the laboratory tests must not be applied too rigidly in the treatment of disease.

By aspiration of the infected marrow, McAdam (1945) showed that neither the temperature chart nor the leucocyte count was a reliable criterion of the time of sterilization of infected bone. After considerable hesitation we decided that repeated marrow puncture was the only method by which we could obtain some idea of the state of the metaphysis. In two of the early cases, penicillin-sensitive staphylococci were grown from the marrow after thirty-eight and twenty-eight days of what was considered adequate penicillin therapy (Dennison 1952b).

Absence of a therapeutic level of penicillin in the marrow on one occasion may be due to an error in technique. A repeatedly negative level combined with the growth of penicillin-sensitive staphylococci indicates interference with the blood supply. The detailed blood supply to the long bone of a child is difficult to demonstrate (Fig. 14) but it is probable that the distribution of vessels as described by Lexer (1903) and Johnson (1927) is reasonably accurate. Interference with this blood supply (Fig. 15) prevents the distribution of penicillin to the metaphysial focus. In such cases it is our custom to drill several holes in the metaphysial region. This allows local instillation of penicillin and, by the later
downgrowth of granulation tissue, probably provides an alternative blood supply to the metaphysis.

So long as patients continue to arrive in hospital with pus already formed, surgical intervention will continue to be necessary. But the methods of surgery described in Groups I and II of the present series have no place in the modern treatment of acute osteitis, and surgery has now become the handmaiden of penicillin. Bone drilling should rarely be adopted as a primary operation, but less harm will be caused by drilling followed by primary suture than by incomplete relief of tension.

**Results**—To those of us who were called upon to treat acute haematogenous osteitis before the introduction of penicillin, it is obvious that we are now working in a new era (Wilkinson 1931). During the period under review more and more attention has been given to maintenance of fluid and electrolyte balance. By 1936 intravenous therapy had replaced the subcutaneous and rectal routes in maintaining normal fluid balance and during the war years plasma became available and gradually replaced or supplemented glucose-saline. These factors must be taken into consideration when assessing the results of chemotherapy and antibiotics. The decline in mortality figures in the successive groups of cases has already been mentioned. On the other hand improvement in the morbidity rate is more difficult to demonstrate. Some indication of the reduced morbidity is given in Figures 5 to 7, which show the duration of hospital treatment in the three groups. Although metastatic lesions have become rare, the single case of pericarditis in Group III is a reminder that penicillin has not lessened our responsibility for thorough examination and precise diagnosis. An increasing incidence of penicillin-resistant staphylococci has been reported from many centres but apart from neonatal cases these organisms are still rare in the surgical division of this hospital. One acute bone infection caused by a penicillin-resistant staphylococcus ended fatally. The newer antibiotics should prevent the repetition of such a tragedy. Delay in evacuation of pus, inadequate penicillin dosage or insufficient duration of treatment may all lead to cavitation or sequestrum formation and, if these conditions are not treated early, to limb lengthening. Sequestra, if sterilised, will be absorbed. Coagulase-positive staphylococci have been cultured from all sequestra that required surgical removal. In spite of the increased attention that is being paid to the teaching of paediatrics, it is regrettable that patients in Group III were brought for treatment even later than those in the two earlier groups.

It should be remembered that there has been an improvement in the general management of paediatric cases in the period under review. When assessing the beneficial results of chemotherapy and antibiotics in osteitis we must consider the contribution made by this factor, which is attributable partly to an increase in the number of those who devote the main part of their time to the problems of surgery and anaesthesia in childhood. The paediatric surgeons and anaesthetists work in close collaboration with their medical colleagues and meet them in a much wider common field than exists for those who work only with adults. Consequently there has been more detailed pre-operative and post-operative care, particularly in the maintenance of normal fluid and electrolytic balance.
SUMMARY

1. Two hundred and twelve cases of acute haematogenous osteitis treated between 1936 and 1950 have been reviewed.
2. The cases are described in three groups: Group I—Seventy-five cases treated before the introduction of effective chemotherapy; Group II—Fifty-five cases treated with sulphathiazole and Group III—Eighty-two cases treated with penicillin.
3. The problems of penicillin therapy are discussed.

We wish to thank Dr Alistair M. MacDonald and his colleagues for their inestimable help with pathological problems and we are grateful to Dr D. Campbell Suttie for his help in the interpretation of radiographs. The photographs are the work of Mr J. L. A. Evatt.

REFERENCES

ACUTE HAEMATOGENOUS OSTEITIS IN CHILDHOOD


