FROM THE UNIVERSITY SURGICAL CLINIC, LUND, SWEDEN.
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ON THE TREATMENT OF ACUTE AND CHRONIC OSTEOMYELITIS OF THE LONG BONES

BY

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The type and time of operation in acute osteomyelitis of the long bones probably depends, in the individual case, mainly on the malignancy of the infection and on the patient's general condition. The surgeon must choose between extensive radical operation (even subperiosteal resection of the whole metaphysis has been used and recommended in severe cases[1]), smaller chiselling operations, drilling, incision of a subperiosteal abscess, and no operation.

On the whole, one gets the impression that in many countries, during the last two or three decades, acute osteomyelitis has become less frequent and has changed its character, becoming more benign. (*Wakeley, Lehmann, Jönsson,* etc.). The causes of these changes are not wholly clear. Probably a general improvement in the standard of living and improvements in hygiene are the main factors, helped by more effective and intensive treatment of nasopharyngeal infection, which is an important source of osteomyelitis (*Wakeley*). A reduction in the virulence of the bacteria is less likely. (*Jönsson,* etc.).

The use of modern chemotherapeutic substances has further markedly—one dares even to say, to a revolutionary

[1] See amongst others *Sven Johansson* and *Hj. Schilling*'s introduction at the meeting of the Nordisk Kirurgisk Forening in 1925.

extent—reduced the mortality rate and shortened the duration of the disease, and improved the prospects of final recovery. It is important that chemotherapy be begun early in the course of the disease, that it be administered in sufficiently large doses for a sufficiently long time, and that surgical intervention, if needed, should not be done too early, in any case not before the patient (for at least 24 hours) has been charged with the chemotherapeutic substance.

A study of, e.g. the Year Book of Industrial and Orthopaedic Surgery, 1945-7, in which a large number of big series are referred to, illustrates this view.

We consider that we have had a good and lasting result from chemotherapy alone in the following case treated in Lund:

Case 1. Boy, aged 7 years, born 26.12.37. (Jnr. 2744/45). Ill with fever for 2½ days. Will not stand on R. leg. Increasing swelling round the ankle for one day. Temp. about 38°. No shivering. On admission on 30.6, slight redness and marked swelling just above the lateral malleolus. Acute tenderness over the lower end of the fibular metaphysis. Reduced movement at the ankle. Pain on movement. Temp. 38.5° C. Course of penicillin, 8,000 units 3-hourly, and sulfathiazole begun immediately. *Sedimentation rates:* 2.7, 28; 9.7, 9; and 16.7 8 mm. per hr. *Radiography:* 30.6, negative; 11.7, circular layers of periosteal bone for about 3 cm. at the lower end of the fibular metaphysis. On 18.7. the patient was discharged "subjectively and objectively symptom-free". *Follow-up examination* on 27.5.48: no objective findings. *Sed. Rate:* 9 mm. per hour. *Radiography:* Lower half of R. fibula normal.

Thus, this case had a complete clinical and radiographic recovery, due partly to the fact that the process was mild from the beginning, but certainly also to the early chemotherapy with both penicillin and sulfonamide. A pre-requisite for such a recovery is that theoretically there is neither *macroscopic nor microscopic bone necrosis,* that is to say that there is no chance of the formation of a latent focus of bacteria. Certainly it is not incidental that this patient with so short and satisfactory a course was only 7 years old. The risk of bone necrosis is definitely less the younger the patient.

The Haversian canals are wider, the periosteum is less rigid and less intimately bound to the cortex, and the substance of the bone is softer, the younger the child. These anatomical variations mean that the infectious process in the marrow is less rigidly enclosed, and conditions are more favourable to spontaneous drainage outwards—taken in its widest meaning —so that the risks of damage to the vessels, with thrombosis and consequent bone necrosis, are less. It is possible that this better natural drainage of the marrow cavity in younger patients is the main reason for the better prognosis of osteomyelitis during the first and second years of life, as has been shown to be the case both before (e.g. *Green* and *Shannon*), and after (*Higgins, Browne* and *Bodian, Trueta* and *Agerholm, White* and *Dennison*) the introduction of chemotherapy.

We have also seen a similar prompt satisfactory recovery in the following case.

Case 2. Boy, aged 5½ years, born 8.1.43. (Jnr. 2939/48). Ill for 2 days with fever and local pain. Will not stand on r. leg. Maximum temperature 39.8° C. No shivering. *On admission* on 23.7.: Marked signs of osteomyelitis of the R. upper fibula; head of the fibula and knee-joint not involved. Penicillin 400,000 units daily intramuscularly for 20 days and sulfadital 1 g. 3 times a day for 14 days. Temperature normal after 24 hours and remained slightly raised until discharged. *Sedimentation Rate:* 24.7, 37; 27.7, 30; 2.8, 7; 10.8, 1 mm. per hr. Repeated *radiography* was negative until 26 days after onset, when periosteal ossification was seen on the anterior surface of the upper fibular metaphysis. Discharged as well on 18.8. *Follow-up examination,* 8.9.48. Well, no objective signs. Sed. Rate: 2 mm. per hr. *Radiography:* The periosteal ossification on the anterior surface of the tibia has now disappeared.

The diagnosis of these two cases was confirmed by the periosteal ossification; in case 2 this became visible only 4 weeks after the onset, which illustrates the importance of repeated radiography continued for a considerable time after the onset of the disease for confirmation of the diagnosis in these abortive forms of acute osteomyelitis. It is possible that in some cases which are treated early chemotherapy altogether

prevents the appearance of these radiographic changes in the bone.

These satisfactory results are not seen in all patients treated with chemotherapy. The following is an instructive example:

Case 3. A man, aged 22 years, born 12.6.22. (Jnr. 5089/44). Admitted to the Surgical Clinic 1.12.44 for urinary sepsis with mainly prostatic local signs. His serious sepsis improved definitely after 18.12. when sulfonamide therapy was replaced by penicillin, given by intravenous drip (the first penicillin case treated in Lund's Surgical Dept.). But in spite of the penicillin therapy he developed a pyaemic metastasis, an inflammation in front of the thyroid gland, which was understood to be a metastatic thyroiditis. This subsided without incision. At the same time he developed severe pain and swelling of the R. leg, which was at first thought to be a thrombophlebitis, following the intravenous drip at this site. The *sedimentation rate* fell gradually from 84 to normal values (2 and 7 mm. per hr.). The patient was discharged on 2.2.45. After discharge he often had pain in both ankles, mostly in the evening. The sedimentation rate was 12 and 9 mm. per hour on 2 occasions respectively. He began work on 5.4.45. On 5.5.45 he returned with inflammation on the anterior surface of the R. leg. It was thought to be a recurrence of the thrombophlebitis, though the author already suspected an underlying osteomyelitis. *Radiography* on 5.5., however, *was thought to be negative* (fig. 1). He was discharged recovered 10.5. The *sedimentation rate was 20,* and on 17.5., in Out-Patients, 6 mm. per hr. The patient did full work all the summer, and was readmitted on 4.10. Since discharge he had had intermittent pain in the R. leg, but had been doing full work all the time. The pain became worse 2 days before admission. Several incisions made for multiple abscesses. *Radiography* on 14.11. showed marked osteomyelitis changes in the lower part of the R. tibia (fig. 2 a and b). On 17.12.: incision and curettage of a cavity the size of a hen's egg in the tibia. Discharged 5.2.46. with slightly discharging sinus. 19.2.: Re-admitted with exacerbation. Rapid healing after sequestrectomy, but still a persisting sinus. Discharged, 26.3.46. Under observation as Out-Patient since then. 7.5.: Began to walk with a stick. Sinus discharged for a long time, but was healed by 7.12.46. Able to work without symptoms. *Radiography:* see Fig. 3. *Follow-up* 1.9.48: Is quite well, doing heavy farm work.

The main conclusion to be drawn from Case 3 is that the patient survived his sepsis thanks to the chemotherapy, especially the penicillin. But in spite of, and during, the treatment he developed pyaemic metastases in the form of a

thyreoiditis and an osteomyelitis of the R. lower tibia. The osteomyelitis regressed relatively rapidly, but persisted as a latent or subclinical focus for a long time, nearly 8 months, until the exacerbation in October '45. Re-examination of the radiograph taken on 5.5.45 (fig. 1) shows that there is an

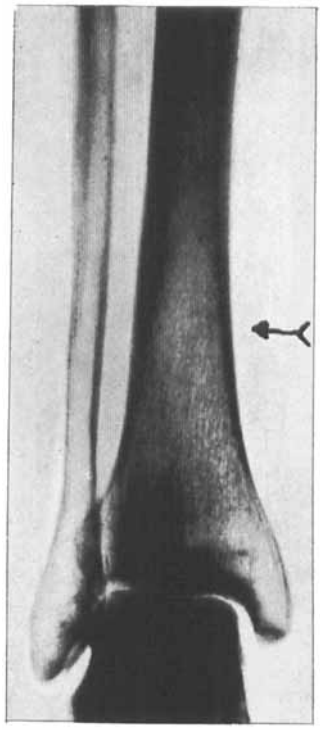

Fig. 1.
Case 3. Radiograph: 5.5.45. Egg-sized oval rarefaction in the spongiosa of the tibia without reactive changes.

oval area of decalcification, the size of an egg, without visible reaction from the surrounding spongiosa, corticalis, or periosteum, which corresponds exactly to the site of the osteomyelitis changes seen in November. In view of this development the thrombo-phlebitis was a subsidiary finding, though it may be objected that the osteomyelitis might have been

caused by the direct spread of the thrombophlebitis to the bone, but this is unlikely in view of the absence of periosteal changes in the radiograph of 5.5.45.

If the course of the disease outlined here is correct, it is possible for a pyaemic metastasis to develop in a typical

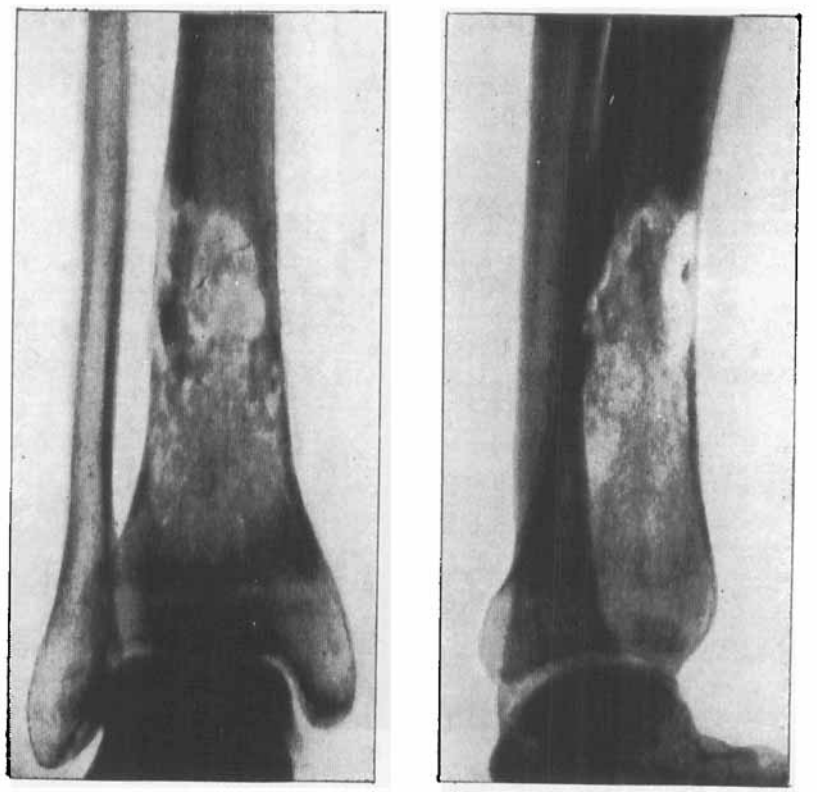

Fig. 2 a and b.
Case 3. Radiograph 14.11.45. Typical osteomyelitic changes at the site of the oval rarefaction of the spongiosa observed earlier.

osteomyelitis site, in this case the lower tibial metaphysis, during penicillin treatment, to give brief clinical symptoms (Jan. 45), to subside completely clinically, and then to be demonstrable 3 months later as a decalcified focus without

apparent reactive changes, very difficult to diagnose radiographically until 5 months later there is an exacerbation and a typical picture of osteomyelitis. When this patient was treated there was very little penicillin available in Sweden and he only received 100,000 Units daily for 8 consecutive days. If he could have been given bigger doses over a longer period there is reason to believe that the osteomyelitis would have regressed without the possibility of a second inflammation occurring later.

Fig. 3 a and b.
Case 3. Radiograph 12.10.46. The osteomyelitis is clinically healed.

Jönsson reports in his work on osteomyelitis that 2 of the 135 cases of his material were treated conservatively. No chemotherapy was used.

In one of these two cases the diagnosis of osteomyelitis must be regarded as rather uncertain. The other case, a 9-year-old girl (Jnr. 2110/41), had from the beginning an atypical course, without an acute onset. The radiography and the clinical picture led to biopsy about 4 weeks after the onset because of a suspected diagnosis of tumour. The operation wound healed without complication. The highest sedimentation rate was 96 mm. per hr., 6 weeks after the onset. Pathological-anatomical examination and the progress of the case pointed clearly to the diagnosis of osteomyelitis. She was discharged after 2 months in Hospital. Follow-

up examination 3½ months, 12 months and 4 years after onset, including radiography, further supported the diagnosis of osteomyelitis.

It is possible that the first case described here would have recovered without operation, with only plaster immobilisation, and *without chemotherapy*, but hardly so quickly or with such slight radiographic signs. In the second case it is difficult to believe that the course would have been so satisfactory without chemotherapy. In the third case the history would have been quite different, and more severe, without chemotherapy, and one must believe that chemotherapy greatly modified the septic process, but was unable to kill all the bacteria in the slightly necrotic area of the affected bone (cf. the indefinite radiographic picture of 5.5.45).

The author believes that intensive and prolonged chemotherapy should be the basic treatment in cases of acute osteomyelitis. It must be clear that sulfonamide and penicillin preparations must be used together from the very beginning and in maximal doses—400,000 Units of penicillin per 24 hours by intramuscular injection, even in small children. Further, the chemotherapy must be continued for a long time —the penicillin for at least 3 weeks—even if the sedimentation rate is nearly normal after a short time (cf. case 2). The 2 other cases reported support this view.[1] As soon as the sensitivity of the organism is known (by testing positive cultures obtained from the blood or from pus from the local focus) the need for continuing both the sulfonamide and the penicillin and any indication for streptomycin treatment can be decided.

Operation—in many cases operation is not necessary—should, as already mentioned, not be done before the patient is "filled" with the chemotherapeutic agent. The time for operation must be determined *for each case* by continuous careful observation in hospital of the patient's general and

[1] *White and Dennison* found positive cultures of penicillin-sensitive staphylococci from routine bone-marrow punctures as late as the 35th day of penicillin treatment of acute osteomyelitis.

local condition, and its nature will depend on the patient's age and on the findings during the operation. In young children the operation should be as slight as possible. Chemotherapy must be continued for a long time with sufficiently big doses *after* the operation, perhaps with an increase in the penicillin dose at the time of the operation itself.

McAdam treated 32 cases of acute osteomyelitis of the long bones of children with penicillin. Administration was not intermittent but continuous, given in 21 cases intramuscularly and in 11 cases intraosseously into the affected metaphysis. 5 cases "required" operation, in 3 cases subperiosteal incision with drilling, and in 2 cases only incision of a subperiosteal abscess, was done. Of the 27 conservatively treated cases 12 had intraosseous aspiration, 3 intraosseous + subperiosteal aspiration, and 2 only subperiosteal aspiration. 7 patients developed septic arthritis—a high incidence. (*Jönsson*, for example, saw septic arthritis in 21 % of 135 cases treated without chemotherapy). However, in 3 cases this complication was in the hip-joint which is readily involved in osteomyelitis of the femoral neck. In the more severe half of the cases the temperature remained raised for 7 to 14 days, and then fell by lysis.

The frequency of septic arthritis as a complication and the temperature records in McAdam's material, seem to the writer to suggest that in serious cases the treatment should be early combined with surgery, which should more often be an extensive chiselling than a minor operation such as drilling, incision of abscesses, and intra-osseous or abscess aspiration.

The question remains whether one should not, after 24 hours' treatment with penicillin and sulfonamide, do the guttering and make a big opening even before any macroscopic medullary or subperiosteal abscess has developed. Intramuscular penicillin cannot sterilise the pus of an abscess. (*Trueta* et al.). Pus under pressure in the medullary cavity interferes with the blood supply (compression of the vessels, damage to the vessels, thrombosis); and similarly a subperiosteal abscess interrupts the nutrition of the bone as it spreads, by stripping

off the periosteum from the surface of the bone. *Primary suture of the skin (Trueta) combined with a temporary (4-7 days) small drainage tube at one or both ends of the wound should be done.* Secondary infection is prevented by primary suture, and penicillin can, if necessary, be given locally

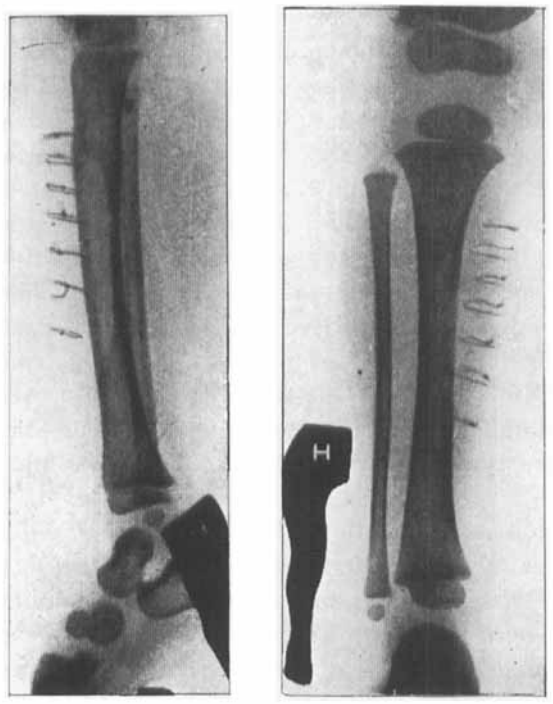

Fig. 4 a and b.
Case 4. Radiograph 10 days after onset and 5 days after operation.

through the small drainage tubes. Primary suture must also favour vascularisation of the marrow cavity. The immediate satisfactory course which one can obtain with this regime is shown in the following case from Lund; in which, however, the hole made by chiselling was not so big, because of the patient's age: (fig. 4).

Case 4. 20 months old; born 11.12.46. (Jnr. 3145/48). Ill for 3 days. Temp.: 39.5. 40.5°. Sulfonamide since 7.8. Swelling of R. leg for one day. Admitted 9.8.48. Generally ill. Examination showed marked swelling of the right leg; redness anteriorly. Probably deep fluctuation. Operation 11.8.48. (Stille). *Chiselling plus primary suture with small drainage tube for local penicillin irrigation.* Large subperiosteal abscess so that the

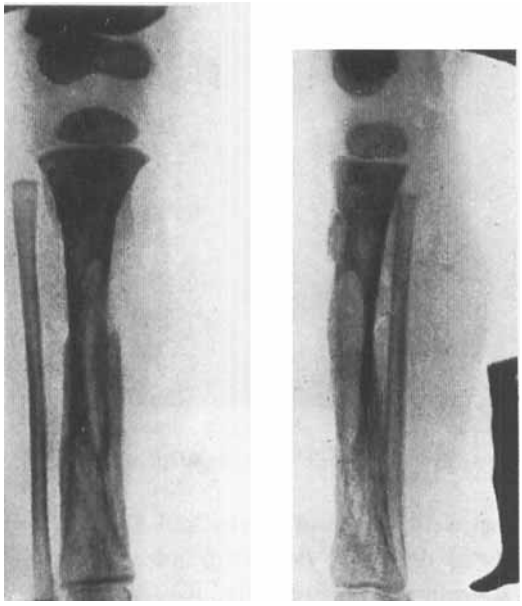

Fig. 5 a and b.
Case 4. Radiograph 31 days after onset and 26 days after operation.

tibia is bathed in pus for nearly its whole length. Pus under pressure in the medullary cavity. Saucerisation for nearly 1 dm. Suture of the skin. Because of the severe changes streptomycin treatment also begun. Culture from the subperiosteal abscess: coagulase positive staphylococcus aureus, sensitive in vitro to streptomycin, penicillin and sulfonamides. 14.8: Never any discharge from the drainage tube, which came out to-day. No inflammation of the wound. 16.8: Radiography: Operation defect 6 cm. long and 1 cm. wide in the middle and upper part of the diaphysis of the tibia. No evidence of an inflammatory process in its walls (fig. 4). 17.8: Nothing abnormal detected on examining the wound. Plaster applied from the toes to the upper thigh. 4.9: Plaster split in 2 halves. No inflammation of the wound. Sutures removed. Diffuse swelling of the leg. No

restriction of knee movement. Old plaster re-applied. 6.9: *Radiography:* Since the radiograph of 16.8. plentiful periosteal new bone formation round the whole diaphysis. Within this there is a flaky decalcification. There is beginning sclerosis of the cortex laterally. (Fig. 5 a and b). 14.9.: Photographed. (See fig. 5 c).

Fig. 5 c.
Case 4. Photograph 5 weeks after operation.

In this case with a big subperiosteal abscess the operation should have been done the day after admission. However, the satisfactory course is striking (fig. 6). The micro sedimentation rate, however, remained high (31 mm. per hr on 6.9); the temperature peak on 5.9. may have been due to the removal of the plaster on 4.9; on 6.9. the radiograph changes were very advanced; these facts all indicated a further course of penicillin. The later course was also satisfactory: no recurrence, no sinus, no sequestrum formation. Radiography on 16.2.49: see fig. 6 a.

Trueta and *Agerholm* have published the results of penicillin treatment of 30 cases. 9 cases were treated with penicillin alone, and 21 cases by surgery also (drilling in all cases). Of these 21, 14 had primary suture after drilling, 5 secondary suture and 2 no suture. After penicillin treatment was begun no patient developed metastases, joint symptoms, fractures,

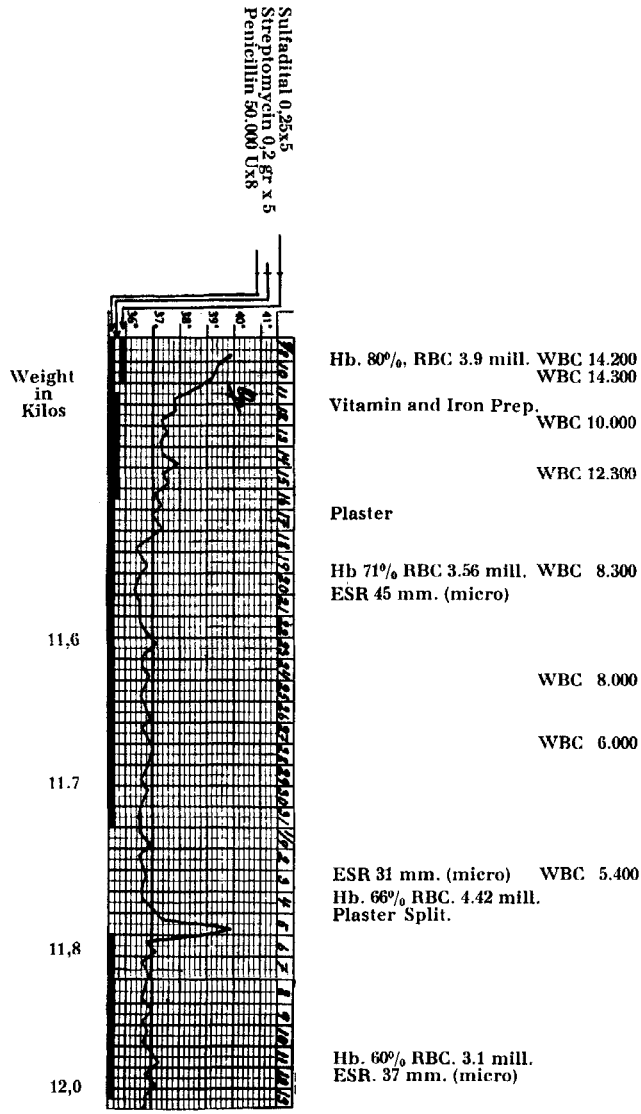

Fig. 6.

Case 4. Temperature chart and scheme of treatment.

or any relapse. Of the 21 operation wounds, 13 healed without complication, and 5 with delayed healing. One case became secondarily infected, and 2 developed sinuses. Of the 9 unoperated cases 4 developed sinuses. In 3 cases sequestration occurred later, without any reaction, through the already

Fig. 6 a.
Case 4. Radiograph 6 months after operation.

healed scar. In a number of cases sequestra were seen later on the radiographs, but disappeared spontaneously. 4 patients still had sinuses 18 months after onset. Penicillin treatment was continued for at least 6 and at most 14 days, and the highest daily dose was 400,000 units.

Altemeier and *Wadsworth* have published 71 cases of acute osteomyelitis (of the long bones in 67 cases), treated with penicillin. Incision of abscesses was done in 24 cases, aspiration in 5. *In no case was a bone operation performed in the*

acute stage. The mortality was 1.4 %. The joint was involved in 13 cases—19 % (the hip-joint in 6 cases). "Excellent" results were recorded in 31 cases who also had final normal radiographs. Good results were recorded in 34 cases, and bad in 6, of whom one died. Relapse occurred in 9 cases followed-up for a maximum of 39 months. Severe cases received at the beginning 50,000-100,000 Units 8 to 12 times daily and later smaller doses, for 3 or more weeks. In the severe cases decalcification continued in the bone for several months accompanied by new bone formation; but in spite of this nearly normal bone structure was gradually restored.

If the results of *Altemeier* and *Wadsworth*'s penicillin treatment without operation on the bone in the acute stage are compared with *Trueta* and *Agerholm*'s results obtained with drilling and primary suture in the severe cases, there is no doubt that better results were obtained with *Trueta* and *Agerholm*'s treatment. In view of this comparison and in spite of the good results obtained by these workers, the present author justifiably believes that it should be possible to get better results if in the severe cases, instead of drilling, chiselling is done early, with primary suture and temporary small drainage tubes, that is to say the method which the author describes on p. 395-396.

The possibility of primary healing should be just as good as in *Trueta* and *Agerholm*'s material and it is possible that the later radiographic changes would not have so destructive a character as those which both *Altemeier and Wadsworth* and *Trueta and Agerholm* describe. In 1948 *Dennison* published 30 cases of acute osteomyelitis (27 patients between 2 and 11 years old, and 3 under 2 years) treated, as far as the surgery was concerned, by a method midway between those of *Altemeier and Wadsworth* and *Trueta and Agerholm*. The results which he obtained are, in the view of the present writer, in favour of more radical surgery in severe cases.

Later in the course of the disease, in the chronic stage, one ought not to be reluctant to do a bigger operation when it is indicated by the clinical condition and by repeated radio-

graphs, using, of course, primary suture, with small drainage tubes at the ends of the wound, combined with prolonged pre- and postoperative chemotherapy. This view, is supported by the 5 cases reported on page 403-412.

Effective immobilisation of the affected limb, so that the patient has no pain with movement, which is both necessary and desirable, is an important part of the treatment of acute osteomyelitis. It is best obtained by means of a well-moulded plaster cast, which is split in half throughout its length, so that it is possible to inspect and palpate the affected area and its surroundings, if necessary.

Supervision of fluid administration, blood transfusions and vitamin therapy are important in the first stages of the disease. Later, a plentiful and nutritious diet is very important.

For *chronic osteomyelitis* and its exacerbations there is now clear evidence that in most cases chemotherapy alone will not lead to a final cure, clearly because the chemotherapeutic agent cannot reach the bacterial foci in necrotic bone. However, these agents are of inestimable value in combination with various forms of surgery. Surgically, one has to choose from a whole series of operations, ranging from radical saucerisations via multiple or single sequestrectomies to incisions of small abscesses, which are commonly used when an exacerbation ends in abscess formation in the scar. While I was junior surgeon in the Surgical Department of Uddevalla I was directed by the chief, Dr. Louis Andersson to operate on a large number of cases of chronic osteomyelitis, using radical saucerisation and partial suture. This was never done in the acute stage of the exacerbation, but even so, the patients often had a severe reaction after the operation with rapid pulse and raised temperature, and healing usually occurred after marked local signs of acute inflammation followed by a proportionately long suppuration, even when the muscle could be used to fill the defect made by the saucerisation effectively. With

these at that time satisfactory cases in mind the author later operated 5 cases of chronic osteomyelitis in the long bones with extensive chiselling and minimal drainage combined with intensive and prolonged chemotherapy both pre- and post-operatively. The satisfactory results seem to justify an account of the cases and the treatment.

Case 5. Woman, born 20.6.16. (Jnr. 4869/44). In 1928 acute osteomyelitis of the lower end of the left femur, for which she had been admitted to hospital 6 times for a total of 10 months; the first stay in hospital lasted 6½ months; she had 2 chisellings, one medial and one lateral; 5 incisions, 3 sequestrectomies. Re-admitted on 16.11.44: course of sulfathiazole begun. 21.11: incision of abscess through the lateral scar. Culture staphylococci; *Sed. Rate:* 120 mm/hr. *Radiography:* see fig. 7. 29.11: *Operation by the author:* Lateral incision, with excision of scar and sinus. Wide saucerisation 25 cm. long: one cavity the size of an egg and minor cavities containing pus. Nearly the whole condylar region of the femur scraped out, and the walls of the cavity partly removed. Generous powdering with sulfathiazole. Muscle fell in to the upper part

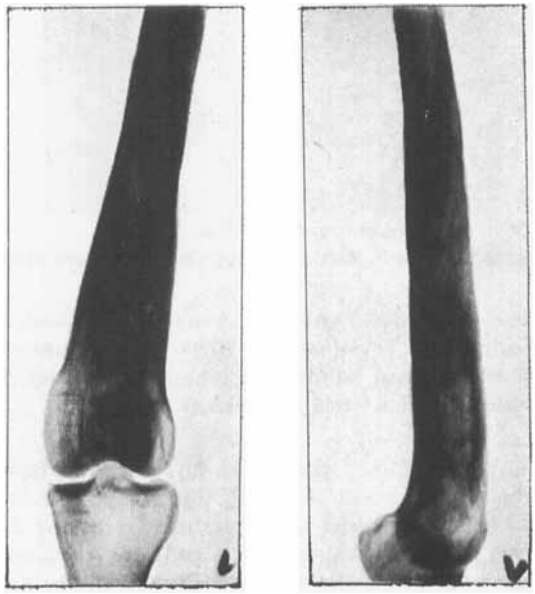

Fig. 7 a and b.
Case 5. Radiograph before chiselling 29.11.44.

of the cavity satisfactorily. *One tube* was used to drain the cavity in the condyles. Blood-transfusion. After operation: highest temperature 38.3° C., normal from the 6th day. Drain removed on the 10th day. Never any pus. 18.12: Primary healing. *Sed. Rate:* 35. *Discharged* 21.12: drainage holes scabbed. 20.2.45. *Seen as Out-Patient.* Complete healing 2 months after operation. Good movement. Beginning to walk. *Sed. Rate:* 13 mm.

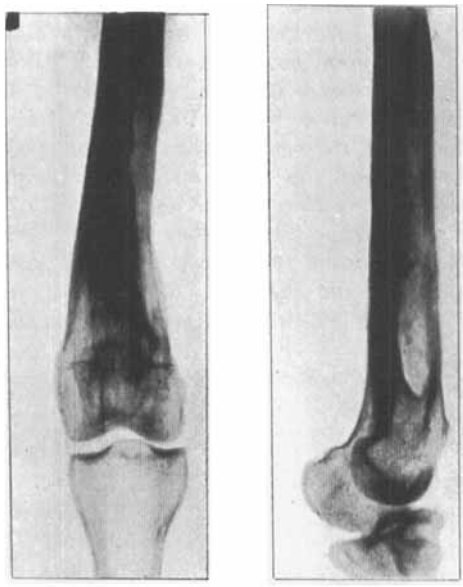

Fig. 8 a and b.
Case 5. Radiograph with obvious operation defect 2 years after operation.

2.10.45. Still healed. Normal movement. 6 months pregnant. 26.11.46. All well. See *radiograph* fig. 8. *Follow-up* 19.7.48. 3½ years after operation: Well, and able to work. Can walk any distance, uses no stick. Two normal pregnancies with deliveries 6.1.46. and 31.1.48.

Case 6. Man, born 21.10.31. (Jnr. 1527/46). Varberg's Hospital. Acute osteomyelitis of the upper end of the L. tibia in July, '45. Sulfathiazole on admission. Chiselling 4 days later. (Hejll). Discharged 21.12.45 with sinus which persisted. Admitted 2.7.46: 2 small sequestra removed from sinus. 3.7.: *Radiography,* see fig. 9. Course of sulfamidine and penicillin begun. *Sed. Rate:* 50. 12.7. *Operation by the author.* Excision of scar and sinus. Extensive chiselling of the upper end of the tibia up to, but

not across, the epiphysis. Pus and granulation tissue in several places. Part of the lateral and medial surfaces of the tibia removed. Sulfathiazole and penicillin powder. Small Mikulicz's drain; suture of the skin. 17.8. The highest temperature after operation, 37.7°; normal after the 9th day. Never any pus. 17.9.: Small cavity filled with granulations persists. The rest healed by first intention. Scraped out, penicillin-sulfa-

Fig. 9.
Case 6. Radiograph 3.7.46 before chiselling.

thiazole powder. *Exact skin suture.* 2.10.: Healing by first intention. The surgeon's opinion on this case was: "The post-operative course shows definitely that drainage with a small tube and primary suture—instead of the small Mikulicz's drain—should certainly have given primary healing and considerably shortened the post-operative period". *Sed. Rate:* 12. Discharged. *Seen as Out-Patient.* 9.11.: Walks well, leg does not tire. Dismissed. *Follow-up* by Dr. Ygberg, Varberg Hospital. 31.1.48: Well. Does heavy farm labouring. Can walk any distance. *Radiography:* see fig. 10. *Sed. Rate:* 7. *Follow-up* by letter 5.9.48. Continues well.

Case 7. Woman, born 18.3.26. (Jnr. 3794/47): Acute staphylococcal osteomyelitis of the lower end of the left femur 1938 with effusion in the knee; in hospital 8 times for a total of 14 months, the first time for 10 months. Has had 3 saucerisations, 4 incisions, 5 sequestrectomies,

2 aspirations of the knee. Re-admitted 18.9.47: course of penicillin and sulphathiazole begun. *Sed. Rate:* 20. 19.9.: *Radiography,* see fig. 11. 26.9. *Operation by the author:* Same lateral operation as in case 5. Saucerisation 25 cm. long. Pus and pussy granulation tissue, some down in the condyles, which were completely scraped out, and some up in the sclerotic area, which was chiselled away up to healthy medullary cavity.

Fig. 10 a and b.
Case 6. Radiograph 18 months after chiselling with obvious operation defect.

Culture sterile. Penicillin-sulfathiazole powder. Drainage of the cavity by one tube at the upper end and one at the lower. Rest of the wound closed in layers. Blood transfusion. Tubes removed, 4 days later. Maximum post-operative temperature 37.8°, normal from the 18th day. 15.10.: Primary healing. Never any discharge. *Sed. Rate:* 17.10., 10. *Radiography:* see fig. 12. 25.10.: Walks well. Normal movement. Discharged. *Follow-up* 25.5.48. *Sed. Rate:* 4. Scar healed freely mobile over the fascia without any palpable subcutaneous infiltration (fig. 13). Underlying muscle soft and movable without palpable infiltration. Has been doing full work in a factory since 1 month after discharge. *Follow-up* by letter 8.9.48: Still well.

Case 8. Woman, born 15.12.01. (Jnr. 1059/48). Several operations in 1912 for osteomyelitis of the R. leg at another hospital. First healed after

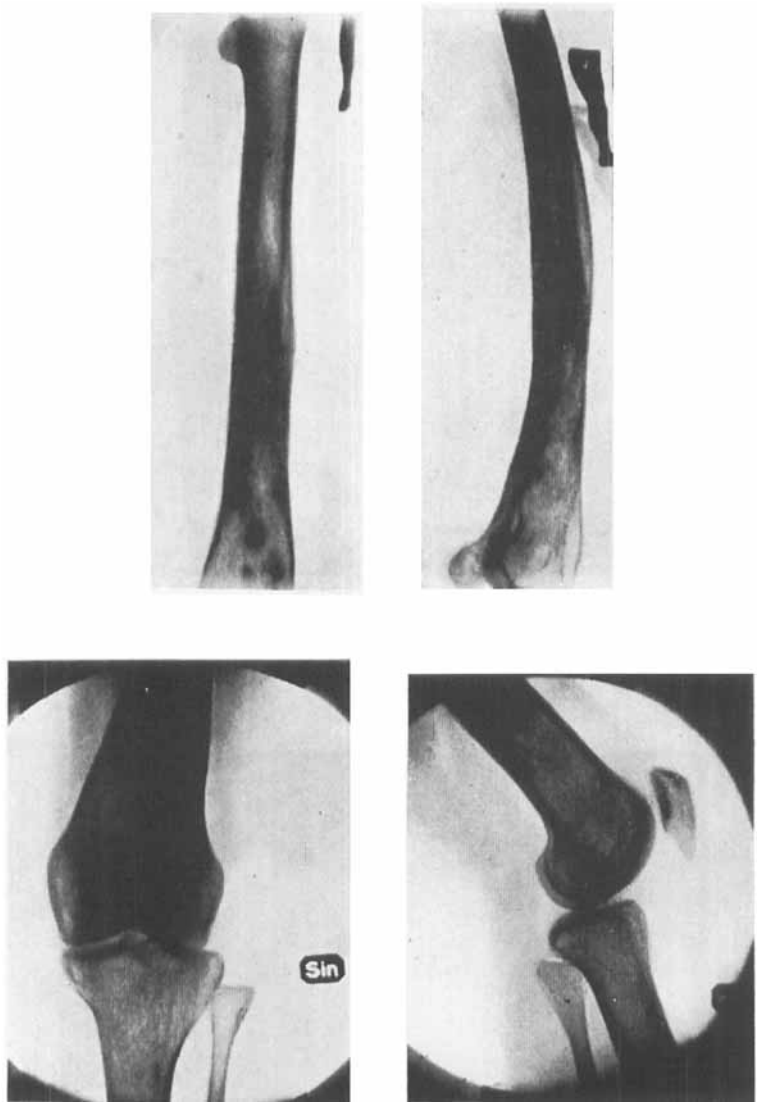

Fig. 11 a, b, c and d.
Case 7. Radiograph before chiselling 26.9.47.

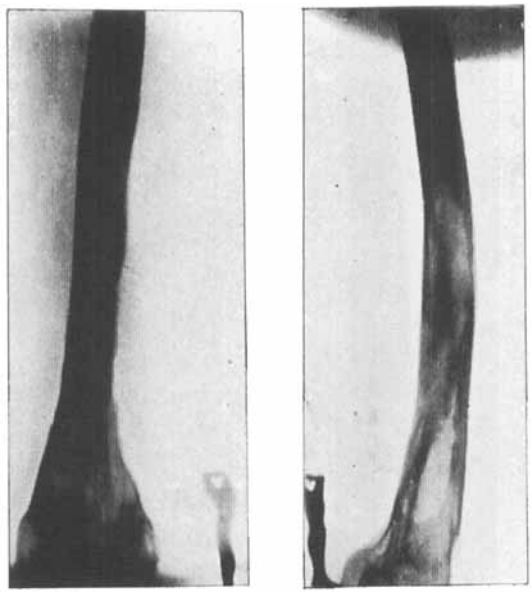

Fig. 12 a and b.
Case 7. Radiograph 3 weeks after chiselling, with obvious operation defect.

Fig. 13.
Case 7. Appearance of scar 8 months after operation.

several years, with ankylosis of the ankle-joint in good position. Exacerbation 1 week before admission, 6.3.48. Course of sulfathiazole and penicillin begun. *Sed. Rate:* 52. *Radiography:* see fig. 14. 22.3. *Operation by the author,* as in Case 6. Wide saucerisation of the tibia. Small collections of pus and much pussy granulation tissue, especially in the lower part of the tibia. *Culture:* Staphylococci. Cavity drained with one tube

Fig. 14.
Case 8. Radiograph before chiselling 22.3.48.

above and one below, brought out at the centre of the wound, which was otherwise closed by primary suture. Tubes removed 5 days later. Maximum post-operative temperature: 37.7° C. Normal from the 6th day. 3.4.: *Sed. Rate:* 29. 6.4.: *Radiography:* see fig. 15. 10.4.: Primary healing without discharge. Walks with a stick. Discharged. *Follow-up:* 1.6. *Sed. Rate,* 5. Linear scar. Walks normally. Dismissed.

Case 9. Woman, born 21.9.27. (Jnr. 1204/48). Operation at another hospital 4 years previously for acute osteomyelitis in the left humerus. Since then repeated exacerbations with incisions and sequestrectomies. Admitted 29.9.47 with exacerbation. Course of penicillin begun. *Sed. Rate:* 63. *Radiography:* see fig. 16. 7.10. *Operation* (Stille). Lateral incision in the old scar. Chiselling for 10 cm.; a number of cavities found, filled with greyish-red granulations. *Culture:* Sterile. The cavity was filled with penicillin dextran. Drainage tubes, one above and one below. 14.10.: *Radiography:* see fig. 17. Maximum post-operative temperature:

37.7° C. Primary healing. Discharged 17.10.47. Had all the time a tender lump proximal to the old sinus opening. Pain in the last few days. Readmitted 16.3.48. Course of sulfadital and penicillin begun. *Sed. Rate:* 32. 21.3.: Incision of Abscess. 24.3.: *Operation by the author.* Old scar excised. Subperiosteal exposure of the lateral side of the humerus through the anterior part of the deltoid and below, between the triceps and

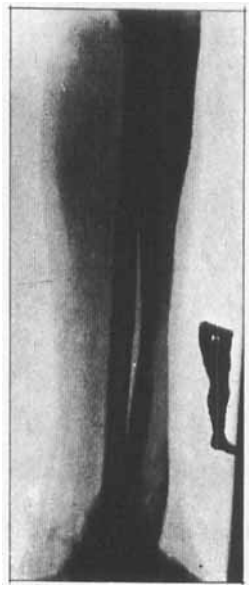

Fig. 15.
Case 8. Radiograph 2 weeks after operation, with obvious operation defect.

biceps muscles. Extensive saucerisation by the same method as in the previous cases fom the region of the head above down to below the middle of the bone. Granulations bathed in pus proximally. *Culture:* Sterile. More sclerotic bone reached lower down. Healthy bone-marrow found far distally. Sulfathiazole-penicillin powder. Drainage with one tube upwards, and one downwards, and led out through the middle of the wound, which was sutured. Blood-transfusion. 13.4.: Tube removed after 8 days. Never any discharge. Primary healing. Maximum post-operative temperature: 37.8°; normal from 4 days after operation. *Radiography:* see fig. 18. *Sed. Rate:* 12. Discharged. *Seen as Out-Patient,* 20.4.: Still healed. No discomfort. Has had sulfonamide every other week. *Sed. Rate:*

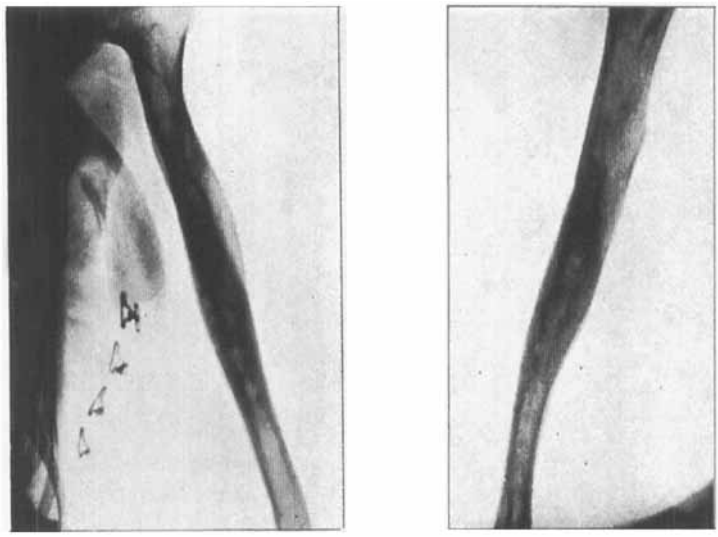

Fig. 16 a and b.
Case 9. Radiograph before operation 7.10.47.

Fig. 17.
Case 9. Radiograph 1 week after a small chiselling 7.10.47.

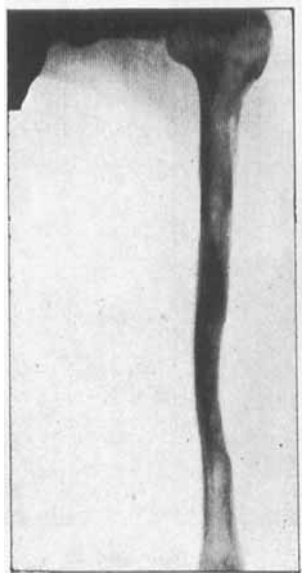

Fig. 18.
Case 9. Radiograph 2 weeks after operation 24.3.47, with obvious operation defect.

16. 9.8.: Still healed. Scar linear. *Sed. Rate:* 7. (Had not had so low a sedimentation rate since onset of the disease, it had never been below 20).

Scheme of Treatment for Combined Chemotherapy and Operation in Chronic Osteomyelitis:

1) Pre-operative sulfonamide and penicillin therapy (at least 400,000 Units Penicillin per day) for 1 or more weeks possibly with incision of abscess. It is advisable to test the resistance of bacteria obtained from the sinus, abscess and radical operation, and so avoid unnecessary continuation of combined penicillin and sulfonamide therapy. Obviously, before the resistance is known, or if it cannot be determined, combined sulfonamide and penicillin therapy is indicated. In some cases a resistance test may indicate a need for strepto-

mycin. 4 of the cases described here received both penicillin and sulfonamides. One of the cases, the first, had only sulfonamide. At that time it was not possible to obtain penicillin for this purpose in Sweden.

2) Extensive removal of bone resembling saucerisation, in which all softened or sclerotic bone is chiselled away until the opposite cortex is reached, and along the bone until healthy medullary cavity is found. Parts of the walls are chiselled or nibbled away so that the cavity is as shallow as possible, though without impairing the bone's strength. The periosteum must not be stripped off the bone more than is absolutely necessary. The cortex which forms part of a joint cannot be removed so that there always remains a large cavity open only towards the medullary cavity, after all diseased spongiosa has been removed with chisel and spoon. It is important that the walls of the cavity are left smooth and that all bony fragments, even the smallest, are removed; the smallest fragments are best removed by washing out the cavity and addition of hydrogen peroxide.

3) The wound cavity is plentifully filled with sulfathiazole in micro-crystalline form and penicillin (in the proportion of 10,000-20,000 units of penicillin to 1 g. of sulfathiazole). The muscle and attached periosteal fragments are allowed to fall as much as possible into the cavity made by the excision and are held in place by superficial catgut sutures. Narrow drainage tubes are placed in the opened marrow cavity, one at either end, and the wound is closed with sutures.

4) The subperiosteal excision of the femoral cortex has been done consistently from the lateral side between the extensor and flexor muscles of the knee, whether the original incision was on the lateral or the medial side; of the tibia, anteriorly, with excision of its free antero-medial surface; and of the humerus from the lateral side between the biceps and triceps muscles in the middle of the shaft, and through the anterior part of the deltoid more proximally.

5) If possible, the operation is done on bloodless tissue with an Esmarch bandage applied at the beginning; with this

it is important to double ligate all visible vessels as they are found.

6) A firm bandage is applied over a sulfa-vaseline dressing. Only after the bandage has been applied and the patient returned to bed with the limb really elevated, is the Esmarch bandage loosened. In this way one avoids a haematoma in the operation field from possibly unligated small vessels.

7) Treatment with penicillin and sulfonamide is continued for all the time spent in hospital, with perhaps increased doses during the first postoperative days. Sulfonamide therapy may perhaps be prolonged by intermittent treatment at home after discharge.

8) Usually the dressing is not changed before 4 to 7 days. In our cases there was found to be at this time no signs of local inflammation or suppuration, and after the small tubes were removed primary healing continued without sinus formation either at the drainage tracks or elsewhere. Irrigation with penicillin solution was not used.

Palmer reported in 1946 14 cases of chronic osteomyelitis treated by chiselling and packing the cavity with sulfathiazole-penicillin powder and primary suture. 4 of his cases were of the same type as the 5 discussed here, that is to say, acute exacerbations of chronic discharging haematogenous osteomyelitis; 3 were cases of haematogenous osteomyelitis without sinuses, that is, with Brodie's type of abscesses, and 7 were cases of osteomyelitis following compound fractures or operation infections (2 cases). All healed primarily, except for 1 case with an exacerbation in an undemarcated discharging osteomyelitis of the femur, which healed, however, after discharging for 2 weeks. *Palmer* does not mention pre- or post-operative chemotherapy in connection with the operations and the chiselling was less radical than in the present author's 5 cases.

Graham, Coventry and *Ghormley* recommended, in 1947, pre- and post-operative chemotherapy, radical excision, and irrigation with penicillin solution, and primary suture with or without temporary drainage. They operated after 3-7 days

preliminary pre-operative treatment, and healing was recorded after an average stay in hospital of 20 days in 66 % of cases, and at follow-up examination in 88 % of cases (the operations were done from 1944 to the first part of 1946). To judge from the radiographs the excisions were not so radical as in this author's five cases.

Hogeman has published 7 cases with foci of osteitis or osteomyelitis treated by minor chiselling and primary suture. The bone cavities were not saucerised, instead they were filled with spongiosa bone chips taken from the iliac crest and soaked in penicillin. Usually pre- and post-operative penicillin was not given. The post-operative course was good in spite of partial necrosis of the skin in 2 cases, and the chips fused. The observation period was short. One case with discharging osteitis after a compound fracture of the leg (one of the cases with skin necrosis) has been healed for 11, and 2 other cases for 6 months. The rest of the cases have been observed for a shorter period.

Apart from my case 6, which had a hospital stay of 90 days, of which 80 days were post-operative, and in which the post-operative course was prolonged due to the use of a Mikulicz's drain instead of small tubes, the average period in hospital for the remaining 4 patients was 35 days, and the average post-operative period in hospital, 23 days. Primary healing occurred in all cases while still in hospital apart from the case with a Mikulicz's drain which required secondary suture. The highest post-operative temperature recorded was 38.3° in one case and 37.8° in the others. The temperatures were normal after an average of 7 days.

The primary results of the operation have been good in all the cases. The patient who has been observed longest is perfectly well after 3½ years, during which time she has had 2 normal pregnancies without trouble. 2 patients are still well after 2 years and 9 months respectively. The observation periods of the 4th and 5th cases are very short. These 5 cases give so far no definite information about the final result. Relapses and exacerbations can indeed occur after a very long

latent period, up to 60 years as is illustrated by one case from Lund's Surgical Clinic. *Graham, Coventry and Ghromley* state that 40 years may elapse before a relapse.

Woman, aged 84 years. (Jnr. 2761/39). Osteomyelitis of the lower femur when 8 years old. First healed when 20 years old, after 9 pieces of bone had "worked out". Never in Hospital but looked after at home by general practitioner. Well for 60 years. For recent months pain in the thigh, worse in the last 2 weeks. In bed for a week. Thinks she has the same feeling as when the sequestra came out. Admitted 22.7.: Typical scars laterally and medially. Tenderness medially. Radiography: Typical chronic osteomyelitis. 27.7. Medial incision. Bare bone at the bottom. No sequestra. 26.8.: Discharged healed.

Table I summarises the sites of the osteomyelitis foci, and the primary and late results.

TABLE 1.

Primary and Late Results of Operation in Chronic Osteomyelitis Cases.

Site of Osteomyelitis: Lower ⅔ of femur: 2 cases (nos. 5 and 7).
Upper ⅔ of humerus: 1 case (no. 9).
Upper ⅓ of tibia: 1 case (no. 6).
Lower ⅔ of tibia: 1 case (no. 8).

Case No.	Age of Patient at Operation	Period in Hospital				Period of Observation	Healed and well all the Time
		Total no. of Days	Days after Operation	Highest Post-op Temperature	Primay healing without Suppuration		
5	28 years	35	22	38.3°	Yes	3½ years	Yes, and 2 pregnancies with normal deliveries
6	15 years	90	80	37.7°	Yes, but secondary suture at Mikulicz's drainage site	2 years	Yes
7	21 years	37	29	37.8°	Yes	9 months	Yes
8	47 years	35	19	37.7°	Yes	1 months	Yes
9	21 years	28	20	37.8°	Yes	4 months	Yes
		Average 45 Days	Average 34 Days				

The long post-operative stay in hospital of case 6 (80 days) was due to the unnecessary use of a Mikulicz drain, which necessitated a secondary suture 2 months after primary healing of the wound.

SUMMARY

The author sets out the principles of the modern treatment of acute and chronic haematogenous osteomyelitis by chemotherapy (sulfonamides, penicillin and possibly streptomycin) and operation. He points out that the treatment of *acute* osteomyelitis cannot be routine but must be adapted to the individual case by careful continuous clinical observation of the general and local condition in hospital, and repeated radiography. In many cases, especially in young children, complete clinical and radiographic healing takes place with intensive and prolonged chemotherapy alone. In severe cases early operation is indicated, preferably extensive chiselling with primary suture, and for a short time drainage with a tube at one or both ends of the wound. Primary suture prevents secondary infection and the narrow tubes make it possible to give local chemotherapy.

The most suitable chemotherapeutic agent can be chosen as soon as the infecting organism has been cultured (from the blood or from the local focus) and its resistance determined.

Four instructive cases are reported.

In *chronic* osteomyelitis with acute exacerbations, either with or without sinus formation, extensive removal of softened and sclerotic bone—saucerisation—should be done with primary suture, and the wound drained for a short time by narrow tubes.

Prolonged pre- and post-operative treatment with large doses of both sulfonamides and penicillin is recommended until the organism has been cultured and tested for resistance, when the most suitable chemotherapeutic agent (sulfonamide, penicillin or streptomycin) can be selected.

5 cases are described to illustrate the method used by the author.

RESUME

L'auteur part des principes du traitement moderne des ostéomyélitis hématogènes aiguës et chroniques par la ché-

mothérapie (sulfonamides, péniciline et peut-être aussi streptomycine) et l'opération. Il signale que le traitement des ostéomyélities *aiguës* ne peut pas se faire routinièrement, mais qu'il doit être adapté individuellement et être accompagné d'une observation clinique continue et consciencieuse de l'état général et local à l'hôpital et de radiographies répétées. Dans beaucoup de cas, notamment chez les petits enfants, une guérison clinique et radiographique complète est obtenue uniquement au moyen d'une chémothérapie intensive et prolongée. Dans les cas graves, il est indiqué d'opérer le plus tôt possible, de préférence par trépanation extensive avec suture primaire, et pour une courte durée, drainage par tube à l'une ou aux deux extrémités de la plaie. Les sutures primaires préviennent les infections secondaires et les petits tubes permettent d'appliquer une chémothérapie locale.

Le meilleur agent thérapeutique peut être choisi aussitôt que le microorganisme infectant a été cultivé (par prélevement de sang ou du focus local) et sa résistance déterminée.

Quatre cas instructifs sont rapportés.

Dans l'ostémyélite *chronique* avec exacerbations aiguës avec ou sans formation de séquestre, une résection extensive de l'os ramolli et sclérotique — saucerisation — doit être pratiquée avec suture primaire et la plaie drainée pour une courte durée par petits tubes.

Il est recommandé d'administrer un traitement pré- et postopératoire prolongé, avec de fortes doses à la fois de sulfonamides et de péniciline, jusqu'à ce que le microorganisme ait été cultivé et éprouvé pour déterminer sa résistance et que l'on puisse choisir le meilleur agent chémothérapeutique (sulfonamide, péniciline ou streptomycine).

Il est donné la description de 5 cas illustrant la méthode appliquée par l'auteur.

ZUSAMMENFASSUNG

Verfasser geht aus von den Grundsätzen der modernen Behandlung der akuten und chronischen hämatogenen Osteo-

myelitis mit Chemotherapie (Sulfonamide, Penicillin und eventuell Streptomycin) und Operation. Er weist darauf hin, dass die Behandlung der *akuten* Osteomyelitis nicht routinemässig erfolgen kann, sondern dem individuellen Falle angepasst werden muss durch sorgfältige, fortgesetzte klinische Beobachtung des allgemeinen und lokalen Zustandes in einem Krankenhause und durch wiederholte Röntgenaufnahmen. In vielen Fällen, insbesondere bei jungen Kindern, tritt bei blosser intensiver und prolongierter Chemotherapie eine vollständige klinische und röntgenologische Heilung ein. In ernsten Fällen ist eine frühe Operation angezeigt, vorzugsweise eine umfassende Meisselung mit primärer Sutur und kurzdauernder Drainage mit einem Drain an einem oder beiden Enden der Wunde. Eine Primärsutur beugt einer sekundären Infektion vor, und die engen Röhrchen gestatten eine lokale Chemotherapie.

Man kann das bestgeeignete therapeutische Agens wählen, sobald der infizierende Organismus (vom Blut oder vom lokalen Focus) gezüchtet und seine Widerstandsfähigkeit bestimmt worden ist.

Vier instruktive Fälle werden referiert.

Bei *chronischer* Osteomyelitis mit akuten Exazerbationen, mit oder ohne Sinusbildung, sollte eine umfassende Entfernung des erweichten und sklerotischen Knochens mit primärer Sutur vorgenommen und die Wunde kurze Zeit mit engen Röhrchen drainiert werden.

Eine prolongierte prä- und postoperative Behandlung mit grossen Dosen von Sulfonamiden und Penicillin wird empfohlen, bis der Organismus gezüchtet und auf seine Widerstandsfähigkeit hin getestet worden ist und sich das bestgeeignete chemotherapeutische Agens (Sulfonamid, Penicillin, Streptomycin) auswählen lässt.

5 Fälle werden beschrieben, um die vom Verfasser angewandte Methode zu illustrieren.

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