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RADICAL OPERATION IN TUBERCULOSIS OF THE SPINE

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From the Swedish
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Introduction

The treatment of tuberculosis of the spine has usually been decidedly conservative, the most important factors being prolonged immobilization and heliotherapy, and possibly internal fixation. The latter can also be regarded as a conservative measure, since it is an extrafocal method avoiding the site of the disease. A direct attack upon the tuberculous spine lesion has been described in the earlier literature, but the draw-backs were evidently so great that the method has been abandoned.

The introduction of chemotherapeutic agents active against the tubercle bacillus has changed our view on the treatment. At the end of 1949 streptomycin became available in Sweden, and at that time ORELL introduced in his department combined surgery and chemotherapy as the standard method of treatment of bone and joint tuberculosis, including also tuberculosis of the spine. In the beginning one aimed at evacuating abscesses originating from spondylitis, but it was soon found that the bone lesions themselves could be attacked. Since the results of this active therapy seemed very encouraging with early healing, the treatment has been continued after the same lines.

This work is a study of the first 100 patients operated upon by this method. In the heading the surgical intervention is designated as "radical operation". This term is hardly adequate, yet it has been chosen because one aims at assuring a radical evacuation not only of the abscesses but also of the bone lesions themselves, which sometimes, however, cannot be done for technical reasons.

An account is given of the indications for operation and the operative technique. The chemotherapy is described together with the attempts to find out by the aid of determinations of the streptomycin concentration whether the dosage used was adequate. Some patho-anatomic studies done at the operations and the results of bacteriologic tests are also presented. These observations add to the knowledge of the disease and its course that has been gained during conservative treatment.

Finally, the therapeutic results of the method are reported and discussed in detail. The patients have been followed up personally after an observation

period of one to four years. In a disease like tuberculosis such a short observation is of course insufficient to enable us to judge the ultimate healing, but this preliminary study is necessary for an evaluation, at the present stage, of the active surgical treatment. Several questions have to be answered:

Are we justified in continuing these technically difficult interventions, in view of the risk of operation and of complications?

Which cases should be chosen for operation?

Is internal fixation between arches and spinous processes necessary, or can bony block in some cases be obtained by bone grafting in the lesion itself?

CHAPTER 1

Review of the literature on the treatment of tuberculous spondylitis

Up to the present the keystone of treatment in tuberculous spondylitis has been prolonged and strict rest in bed with immobilization in plaster or other appliances, combined with general hygienic and dietetic measures and heliotherapy, etc., for the purpose of strengthening the body's resistance to the disease. This conservative treatment will not be dealt with in the present communication. ROLLIER (1913, 1929) and VON FINCK (1940) may be mentioned as prominent followers of this rigid conservative therapy.

Ankylosing operations. At the end of the 19th century trials were made to use foreign material for fixation of the affected vertebrae, but the results were mostly ungratifying.

In 1911 several authors described different methods of obtaining internal fixation of the affected vertebrae by bone grafting. HIBBS carried out this osteosynthesis by using bone available in the operative field; the spinous process is chiselled through at the base and is then bent downwards so that the tip of it will rest on the arch of the vertebra next below, thus forming a bridge between the arches. Subsequently, he modified the technique by decortication of the arches and inserting the chiselled-off chips between the arches and producing an arthrodesis of the intervertebral joints.

ALBEE used a bone graft from the tibia, which was inserted into the divided spinous process. WHITMAN also used a bone graft, one on each side of the spinous process, in accordance with the technique described by HENLE in a case of dislocation in the cervical spine.

Internal fixation became a mile-stone in the history of the treatment of spondylitis. The method gained enthusiastic followers everywhere. Valuable contributions to this question have been presented by WALDENSTRÖM (1924) who reported excellent results of redressment of tuberculous gibbus, combined with osteosynthesis; by CALVÉ and GALLAND (1936) who stressed the important fact that osteosynthesis should not be performed until at the end of prolonged conservative treatment, and that only the affected vertebrae should be fixed, contrary to earlier authors who apply fixation of several vertebrae above and below the affected ones; and by ORELL (1942) who uses *os novum* as a grafting material, that is, newly formed soft bone

produced from *os purum* (bone freed from connective tissue, protein and fat) which for some time has been implanted subperiosteally on the tibia.

Direct operations into the tuberculous spine lesion were reported as early as in the 1880's. MÉNARD's monograph (1900) contained detailed accounts of these early radical operations at which large incisions were made into the abscesses, the abscess capsules were excised and tuberculous granulation tissue was scraped out. CHIPAULT compiled the results of these operations by various workers. MÉNARD, however, considered that the therapeutic results were so poor that he preferred a method of his own by which he punctured the abscesses and injected some caustic agent. He tried the operative treatment himself but found that it was justified only when the injection therapy failed or when the abscesses threatened to perforate. The operations mentioned here were performed in uncomplicated cases of spondylitis with closed lesions.

In cases complicated by paraplegia decompression laminectomy was performed by MAYER as early as 1846 (the patient died 21 days after operation), and by OLLIER, 1882 (the patient survived and the paraplegia subsided). The subsequent results of laminectomy were discouraging, and MÉNARD asserted that by laminectomy the posterior intact support, the arch, is removed while the anterior one, the vertebral body, is already destroyed. His studies of autopsy cases showed that the compression occurs in front of the spinal cord and that in many cases the posterior arch has no contact at all with the compressed spinal cord.

Laminectomy is done solely for the purpose of removing compression of the spinal cord and does not affect the process in the vertebral body. On one occasion while performing such a laminectomy MÉNARD was able to open a paravertebral abscess, and the patient recovered. This led MÉNARD to devise a new operative method for the treatment of spondylitis with paraplegia, viz. costotransversectomy. By excision of the posterior parts of the ribs and of the transverse process the tuberculous abscesses were drained. MÉNARD reported immediate remission of the paraplegia in thirteen of twenty-five operative cases. Prolonged drainage of the abscesses gave rise to sinus formation, but MÉNARD found that these sinuses were more benign than those developing spontaneously. He subsequently abandoned the method also in paraplegia.

During the next 30 years no notable reports concerning this kind of operations appeared in the literature. In 1930 SCHMIEDEN, in a record of surgery of the spine, presented some data. He questioned several surgeons about operative management of tuberculous spondylitis. The total number of patients operated upon was 65, and the mortality varied from 17 per cent to 63 per cent. The approach was by posterior incision in both thoracic and lumbar involvement, in the latter sometimes transperitoneal incision.

SCHMIEDEN advised against operation by summarizing: "Es darf heute als ein Wagnis bezeichnet werden, noch viel von operativer Therapie der Spondylitis zu sprechen, nachdem BERNARD und ROLLIER glänzende Erfolge mit der geduldligen konservativen klimatischen Behandlung der chirurgischen Tuberkulose erzielt haben." SCHMIEDEN also advised against laminectomy in paraplegia for the same reasons as MÉNARD. The record comprised 251 patients subjected to laminectomy, of whom 74 died.

In 1934 the Japanese worker Ito et al. reported 10 cases of radical operation, in thoracic spine involvement using costotransversectomy, in lumbar involvement extraperitoneal exposure. The lesions were evacuated, part of the surrounding bone was also excised, and in some cases a bone graft was then inserted directly into the resultant cavity. The method was recommended in cases of closed lesions. No complications occurred. No new reports have followed this preliminary communication.

Chemotherapy combined with radical surgery. The next mile-stone was in 1944 when streptomycin was introduced after having been discovered by WAKSMAN and his co-workers. Subsequently there followed the other tuberculostatic agents, PAS, conteben, isoniazid. In 1948 the Veterans' Administration published the first brief report on streptomycin therapy in skeletal tuberculosis (JANSEY et al.). Most surgeons who work with tuberculosis of bone and joints have since then used chemotherapy as an adjunct in the usual conservative treatment, which, if necessary, is completed by osteosynthesis.

However, the introduction of streptomycin led a few surgeons to revert to the use of more radical surgery. And so, in 1950 there appeared, independently of one another, preliminary reports by ORELL in Sweden, KASTERT in Germany, and WILKINSON in England.

HIRSCH (1951), from ORELL's department, published 14 operative cases of spondylitis with abscesses. FELLÄNDER (1953), from the same department, published continued observations in 42 operative cases of which the bone lesion was evacuated in 19; in some cases the bone lesion was filled with bone. According to ORELL's method streptomycin was administered partly intramuscularly, and partly locally as dry powder, and the wounds were closed by primary suture.

KASTERT (1950) in his first report described 35 operative cases. The wounds were left open for drainage and prolonged local treatment with tuberculostatic agents. KASTERT calls his method operative tuberculostatic treatment of the lesions. He does not aim at radical operation but the goal is to place a catheter in the lesion for local treatment. He has described the technique in several communications between 1950 and 1954, in the last one the number of patients operated on was 489.

WILKINSON (1950) described two cases in which the lesions were evacuated and intrafocal osteosynthesis with bone chips from ribs was performed. Subsequently he has reported 28 operative cases (1954). In contradistinction to ORELL and KASTERT, WILKINSON does not perform radical operation until after usual conservative treatment.

GJESSING (1951) reported two cases of tuberculous spondylitis in which he while performing anterior osteosynthesis also drained the bone lesions. FRÜND (1951) drains the bone lesions and fills them with a plaster plomb and closes the wound by primary suture. The plomb protects against collapse of the vertebrae and excites to new bone formation. R. KAUFMANN (1952) treats spondylitis of the thoracic spine by costotransversectomy and evacuation of the abscesses in order to prevent the development of a bone lesion. He considers that spondylitis develops by direct spread from the pleura via the lymphatic vessels and that the osteitis is a secondary phenomenon (see further the chapter on pathology and pathogenesis).

Judging from the literature, most surgeons in the USA are conservative in the treatment of tuberculous spondylitis, but a few reports on active surgical therapy have appeared. Thus, DEROY and FISCHER (1952) have published 24 cases treated surgically by radical evacuation of the lesions with the drainage tube left in the lesion, combined with general streptomycin therapy. JOHNSON et al. (1953) account for a material from the period 1948—1951, in which the chief object seemed to be to obtain an exact diagnosis by direct biopsy.

In 1954 a further few reports appeared (MACKENZIE, H. MAY and ERLACHER). ERLACHER who in the 1930's unsuccessfully tried radical operation, is now a devoted follower of the method of direct attack upon the lesion, which he considers should be done radically up to healthy bone. He fills the bone cavities with bone grafts and uses prolonged chemotherapy locally according to KASTERT's method.

Most orthopaedic surgeons, however, are still decidedly conservative, with the stress on prolonged immobilization and general treatment. Chemotherapeutics, especially streptomycin, are used to complete the treatment. The opinion is, however, that the lesions themselves are hardly affected by chemotherapeutics which do not penetrate into them in sufficient concentration. The effect is considered to be indirect by improving the general condition. In a few clinics, however, one has in consequence of the fact that chemotherapeutics do not affect the bone lesions, started to remove operatively inflammatory products, sequestra, etc., partly so that local chemotherapy can be applied and partly to obtain a better effect of the general treatment. Most orthopaedic surgeons who specialize in skeletal tuberculosis, however, seem to take an expectant attitude to radical surgery.

CHAPTER 2

A survey of the present material

The investigation comprises 100 patients operated upon during the period Nov. 1949—May 1953 in the Orthopaedic Department of St. Görans Sjukhus, Stockholm, and a few patients operated on elsewhere by the surgeons of this department and according to the same principles. Most of the patients are resident in Stockholm Town which is the reception area of the hospital, but the material also includes some patients from other parts of the country and three in whom the tuberculous disease developed while they were in a concentration camp during the war.

The *distribution according to age and sex* is seen in Table 1 and Fig. 1. It is remarkable that the children constitute a very small group. This is explained by the fact that there has been a marked reduction in the incidence of

Table 1. Age and sex distribution.

Age in years	Men	Women	Total
0—10	1	2	3
10—20	6	2	8
20—30	16	13	29
30—40	19	14	33
40—50	7	6	13
50—60	3	5	8
60—70	1	1	2
70—80	2	2	4
Total	55	45	100

bone and joint tuberculosis in children in Sweden, probably as a result of intense prophylactic and hygienic measures. Most cases belong to the age group 20—40 years. In previously published materials the number of children is considerably higher.

Site of lesion. The spondylitis was localized in the vertebral bodies and had in one case secondarily encroached on the arch. One case formed an exception in that the disease involved the first and second cervical vertebrae and the lesion seemed to originate from one of the intervertebral joints.

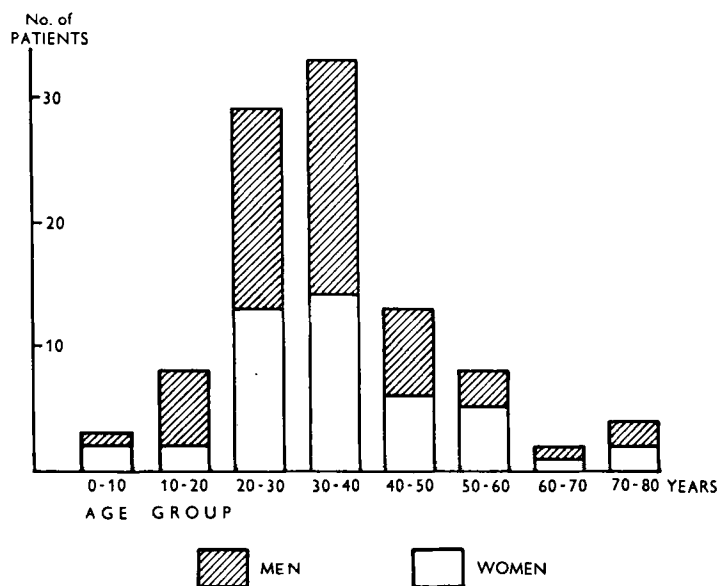


Fig. 1. Distribution according to age and sex.

Isolated tuberculosis of the arches and processes is very rare (WESTERMARK and FORSSMAN 1938, ORELL 1948) and was not present in this material.

The disease was localized in one region only in all cases except one in which at the time of the operative treatment the patient had double spondylitis with signs of activity, involving both the thoracic and the lumbar spine. Thus, 101 operations for spondylitis were performed, and the distribution over the different regions of the spine is the same as that reported by other workers (Table 2). Five patients had healed spondylitis with other localization.

The presence of a bone lesion was demonstrated by radiography in all cases except one, in which a tuberculous psoas abscess was found at operation. In three cases only one vertebra was involved and adjacent inter-

Table 2. Localization of the lesions.

Site of lesion	No. of cases
Cervical.....	1
Cervicothoracic.....	1
Thoracic.....	42
Thoracolumbar.....	10
Lumbar.....	42
Lumbosacral.....	5
Total	101

vertebral discs were normal, these were one case of thoracic and two cases of lumbar spondylitis. In most cases two adjoining vertebrae and the intervening intervertebral disc were involved. This occurred in a total of 71 cases of which the cervical spine was involved in 1 case, the thoracic in 27, the thoraco-lumbar in 4, the lumbar in 34, and the lumbo-sacral in 5 cases. Several adjoining vertebrae were involved in the remaining 26 cases, the cervico-thoracic spine in 1 case, the thoracic in 13 cases, the thoraco-lumbar in 6, the lumbar in 6. Three vertebrae were involved in 9 cases and four vertebrae also in 9 cases, five vertebrae were involved in 3 cases, six in 4 cases and seven in 1 case. The total number of lesions in different regions of the spine is seen in Fig. 2. This distribution is in accordance with that found by other authors in their materials (BIERRING 1934, ALVIK 1949).

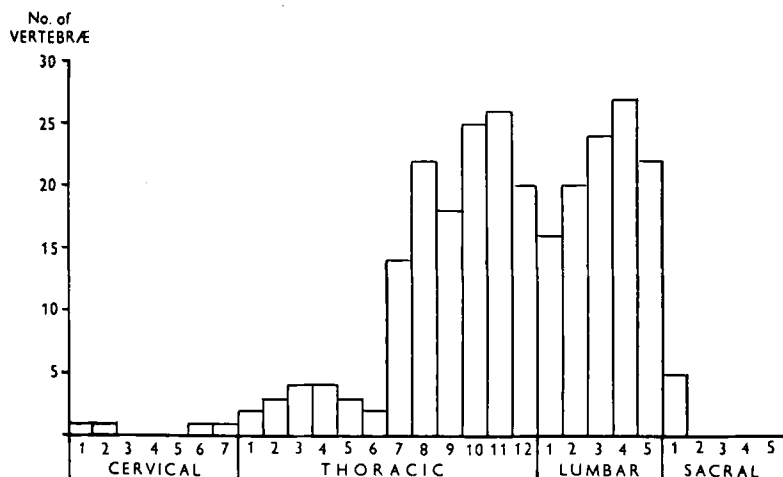


Fig. 2. Number of vertebrae involved.

The duration of the disease. It is impossible to assess with certainty how long the disease lasts, by radiography, clinical examination or the patient's history. It is generally considered that the disease has reached an advanced stage when it can be demonstrated by radiography. The duration quoted varies between $3\frac{1}{2}$ and 24 months (BROCHER 1953). An average of 12 months may be expected in adults. It is not unusual that the disease runs a clinical course without symptoms until collapse with gibbus occurs or an abscess appears.

In the present material I have not tried to establish the age of the lesion, but content myself with stating the period of time from the diagnosis of the disease to the operation. In 56 cases the spondylitis had not been recognized previously. In 26 cases the process was old but less than five years, in the remaining 19 cases it was older than five years.

Abscesses and sinuses. Subcutaneous abscesses at the level of the lesion occurred in 11 cases, of which six were cases of thoracic spine involvement and five were cases of lumbar involvement. Six patients had gravitation abscesses, three of them in the groin, and three in the thigh. A psoas abscess was present on palpation in 17 cases, but in a further 20 a psoas abscess was found at operation.

Nine patients had sinuses at the time of operation, which is a lower incidence than that quoted in the literature. In ALVIK's material sinuses occurred in 13.21 per cent. Other authors (cited by ALVIK) quote figures varying between 13 per cent and 25 per cent. DOBSON (1951) in a series of 914 patients reports sinuses in 55.6 per cent.

Paraplegia. Five patients gave evidence of spastic paralysis at operation. In the literature this incidence varies between 6 per cent and 23 per cent.

Other tuberculous lesions. Eighty patients had or had had tuberculous manifestations other than spondylitis. The remaining twenty patients had spondylitis as the only manifestation of tuberculosis at the time of operation. In one of these tuberculous meningitis developed seven months after operation.

The cases of pleurisy and pulmonary tuberculosis include also cases in which radiographic examination showed rests of clinically symptom-free disease that had healed. All the cases were examined by culture of the tubercle bacillus and guinea pig tests of the urine, and when anyone of these tests was positive, urography was carried out, by which some symptom-free cases of urogenital tuberculosis could be diagnosed.

The distribution of the tuberculous manifestations among the different organs is recorded in Table 3. A total of 24 patients had other *active* tuberculous foci. Five patients who besides spondylitis had active disease in two different organs had pulmonary tuberculosis. Two had in addition a urogenital focus, two had other skeletal foci, and one patient had tuberculous lymphadenitis.

There is a fairly high correspondence between this material and earlier reports on tuberculosis of the spine, in which this question has been discussed. MEYER (1935) found active pulmonary tuberculosis in 12.9 per cent of

Table 3. *Other tuberculous manifestations.*

Tuberculous lesion	Inactive or healed No. of cases	Active No. of cases	Total No. of cases
Erythema nodosum.....	5	—	5
Pleurisy.....	33	—	33
Pulmonary.....	39	16	55
Urogenital.....	5	6	11
Bone and joint.....	14	6	20
Other.....	16	1	17

178 cases. HARRIS et al. (1940) reported active pulmonary tuberculosis in 30 per cent of 85 cases and urogenital tuberculosis in 26.25 per cent, and emphasized that pulmonary tuberculosis is of the greatest importance to the course of the disease and the mortality rate in spondylitis, and that urogenital tuberculosis is one of the commonest complications which is often overlooked because it gives no symptoms. ALVIK (1949) in a material of 507 cases found spondylitis as the only manifestation of tuberculosis in 10.08 per cent, pleurisy in 36.76 per cent, active pulmonary tuberculosis in 25.89 per cent, other skeletal tuberculosis in 20.71 per cent, and renal tuberculosis in 5.71 per cent. DOBSON (1951) in a material of 914 cases had no less than 48.5 per cent of active multiple foci, viz. 19.1 per cent pulmonary, 7.8 per cent other skeletal, 3.5 per cent renal tuberculosis, and 18.1 per cent widespread generalized disease.

CHAPTER 3

The treatment

Indications for operation

Patients with *previously unrecognized* spondylitis which showed clinical or radiographic evidence of activity were subjected to operation. Evidence of activity includes abscess formation, clinically or radiographically confirmed, poor general condition, fever, or a rise of the sedimentation rate. Operation was considered to be indicated if a bone lesion was clearly demonstrated in the radiograph, even though there was no sign of an abscess. In cases of slight changes and without noteworthy clinical symptoms the progress was watched before interfering.

The *older* cases consist of patients who had either been in hospital for treatment at the time when active surgical therapy was first applied or had attended for continuous control after previous conservative treatment and had exhibited increased clinical symptoms, abscess or sinus. The latter group includes both patients who had been treated earlier in this hospital and in other hospitals for bone and joint tuberculosis. It is remarkable that no less than 29 patients had completed their conservative therapy and at the control showed symptoms of such a nature that radical operation was considered indicated. This suggests the inefficiency of conservative treatment.

For the rest, no selection was made. During the period of time which this investigation comprises, only nine patients were admitted to this department with tuberculous spondylitis without being subjected to radical operation. In seven of these cases the spondylitis was of a mild nature or completely inactive. In one patient with old spondylitis and large gibbus and sinus a life-threatening edema of the lungs developed and the operation had to be discontinued. The patient survived and was subsequently treated by chemotherapy only. One patient had a very poor general condition, severe anemia, calculi in both kidneys, manifestations of multiple tuberculosis, and a paravertebral abscess which communicated with the digestive tract, thus, a desperate case.

A poor general condition or fever are no contra-indications to operation. Removal at an early stage of toxic products from large abscesses and bone lesions should improve the possibilities to control the disease. Nor are

other tuberculous manifestations any contra-indications, except in extreme cases. We agree with our consulting lung specialists and urologists that the skeletal tuberculosis should be treated first. In this way the patient's power of resistance is increased and better conditions are ensured for continued chemotherapy of lungs and kidneys, respectively.

Operative technique

The operation was as a rule performed under anesthesia administered endotracheally. In a few cases of lumbar spondylitis spinal anesthesia was used.

The surgical approach to the diseased area varied with the localization of the lesion. In the upper *cervical* spine a posteromedial incision was used; in the lower cervical spine the incision was made in the supraclavicular region.

In spondylitis of the *thoracic* spine the vertebrae were exposed by costo-transversectomy. The transverse process was chiselled off and about 5 cm of the rib was excised. According to the extent of the process one, two or three ribs were excised.

When an abscess was present it was usually entered after the rib had been excised. The rib was often found to be destroyed by direct contact infection from the abscess. In some cases the abscess was not found until blunt dissection had been made along the side of the vertebral bodies. In the cases without abscess blunt dissection was also made, whereupon the lesion could be reached by chiselling with the aid of radiography and an indicator. It may be added that it was sometimes difficult to decide from which side the thoracic lesions should be most suitably approached. They are entered from the side on which the abscess shadow was largest and most bulging, or if this could not be ascertained, from the side where the destruction in the bone was most marked, and where it opened at the surface of the vertebral body. In uncertain cases planigraphy has been of great value (ORELL and BACKLUND 1953).

In cases of *lumbar* spondylitis the operation was done by extraperitoneal exposure, in the beginning by large muscle split incision, but because of the difficulty of access in many cases, a change was made to incision as for nephrectomy with cutting through the abdominal muscles and, if necessary, resection of the twelfth rib. By this large extraperitoneal exposure, which is now routinely used, a good view is obtained of the psoas region and of the anterolateral parts of the lumbar vertebrae. At operations on the right side the access is rendered difficult by the *vena cava*.

When a psoas abscess was present it was easily found and usually yielded a tract directly to the vertebral lesion. If it did not do so, or when no abscess was present, the lateral parts of the vertebrae were exposed, and, if necessary

by the aid of radiographic examination with indicator, the bone lesion could be attacked without having broken through the cortex.

In three of the lumbar cases the operation was performed from behind with excision of the transverse process, transversectomy, which is the method routinely used by KASTERT and most of his followers. In our opinion this method of exposure allows a much poorer view of the involved area than does extraperitoneal exposure. In none of the three cases could the lesion be explored by transversectomy, whereas it could be done in one of them at a subsequent extraperitoneal exposure. For the sake of comparison it may be mentioned that the bone lesion could be exposed by extraperitoneal incision in a total number of 31 of the cases of lumbar and lumbosacral spondylitis.

Lesions in the upper lumbar region may be difficult to explore by extraperitoneal incision. In one case of four, in which the lesion was localized in the first and second lumbar vertebrae, it could not be reached from the incision. In this case a posterior incision with transversectomy would perhaps have been more suitable. Of the cases of thoraco-lumbar spine involvement operation by extraperitoneal exposure was performed in two, and in both these cases the lesion could be drained. In the rest costotransversectomy was applied. In one case of low thoracic spine involvement with a psoas abscess operation by extraperitoneal exposure was first performed. The lesion could not be reached from the incision, and a second-stage operation by costotransversectomy was therefore carried out and the lesion was evacuated (case no. 5 in the Case Report).

Irrespective of the site of the lesion the subsequent operative procedure was as follows:

The abscesses were thoroughly drained, so that the tuberculous granulations were removed. The sinus tracks were followed, so that no gravitation abscesses were overlooked. No attempt was made, however, to remove the whole wall of the abscess. The outer abscess membrane was left intact. Histologically it may be regarded as the body's defence zone against the tuberculous process and as such it is of value (ORELL).

For the same reason the aim was not to perform a complete resection of the bone lesions in healthy bone tissue. Such a resection would also involve great technical difficulties. Sequestra of bone and of intervertebral disc tissue were removed. If it is difficult to survey the bone cavity, one has to use a spoon to make sure that most of the diseased tissue has been removed. The procedure is completed by washing under pressure with physiologic saline solution, by which some further sequestra and granulations may appear. Slight diffuse bleeding cannot be avoided, but this usually ceases after washing with hydrogen peroxide. In those cases in which a radical evacuation of the lesion was thought to have been ensured and in which

internal fixation was considered to be of value, the cavity was filled with bone chips. Streptomycin powder was applied both in the bone cavity and in the abscess, and the wound was closed by primary suture.

Pre- and post-operative orthopaedic treatment

Immediately after the diagnosis has been established and the decision to operate has been made, the patient is placed in a plaster bed, with the exception of those patients who have earlier undergone osteosynthesis which radiographically appears to have healed well and to stabilize the area concerned. When the patient has got accustomed to lying day and night in the plaster bed, the operation is carried out. We do not wait until the disease has reached a more favourable stage, but consider that the operation should be performed as soon as possible in order to eliminate the adverse effect of toxic products that are present in abscesses and bone lesions.

After operation the patient is immobilized in the plaster bed for two months. In uncomplicated cases the patient is then allowed to be ambulant wearing a plaster jacket, which usually after a further two months is exchanged for a corset. When the process is considered to have healed, light physiotherapy may strengthen the muscles of the back and eliminate the need of an external support.

In cases of recurrence of sinuses or abscesses the patients are kept in the plaster bed until healing of the sinus is achieved.

Chemotherapy

The surgical intervention is combined with general and local chemotherapy. Of the tuberculostatic agents that are available we consider streptomycin¹ the most important one, which will protect against secondary infection and against possible spread of the tuberculous process at the operation and during the immediate postoperative period. Other chemotherapeutic agents used in this material, para-aminosalicylic acid (PAS), isoniazid and cimetben, constitute the basic medication which with a long-range view will affect the tuberculous infection in the body.

Dosage and length of treatment have been changed in the course of time. We have been guided by the general principles and experiences of the treatment of pulmonary and urogenital tuberculosis, since in these conditions the effect of chemotherapy is much easier to assess, especially by bacteriologic control, than it is in skeletal tuberculosis.

In the beginning the following dosage scheme was established: PAS 8 to 14 g daily for a prolonged period, usually for the duration of hospitaliza-

¹ In the following streptomycin refers both to streptomycin and to dihydrostreptomycin. The latter drug has been used throughout, except for a short period in the beginning.

tion. Streptomycin $\frac{1}{2}$ g twice daily intramuscularly for 14 days beginning two days before operation (ORELL and ÖSTMAN 1949).

Since many of our patients could not tolerate PAS, we abandoned the use of this drug for a short period, but in view of the unanimous reports in the literature stating that PAS considerably reduces the risk of emergence of streptomycin-resistant strains of tubercle bacilli the drug was re-introduced as basic medication. It should be mentioned, however, that PAS remarkably often causes severe gastrointestinal disorders. In such cases we reduced the dosage or discontinued the drug for a period or permanently. In our opinion it is more important that the patient after operation recovers a good balance with regard to nutrition and fluid.

The streptomycin dosage was successively increased, and the twice daily doses of $\frac{1}{2}$ g each were changed to a single dose of 1 g. During one period 1 g daily for three weeks was given. Finally, we decided in favour of a three week period with daily injections of streptomycin followed by a further three week period with injections twice a week. In cases of secondary infection or in which the disease was complicated by other active tuberculous manifestations the course of treatment was further increased. By instituting such an intermittent streptomycin therapy, which has a satisfactory bacteriostatic effect and at the same time considerably reduces the risk of streptomycin resistance and toxic reactions (DYE 1950, TUCKER 1952, TEMPEL 1952) it can probably quite safely be continued for a prolonged period, for three to six months or longer. In a few cases the streptomycin therapy was discontinued earlier than after two weeks because of toxic reactions.

Streptomycin was applied locally in the wound and the bone lesions as dry powder which is presumed to be absorbed more slowly than a water solution. The dose varied between 1 g and 3 g, usually 2 g.

Conteben was given in only a few cases, especially where a basic medication was considered desirable in view of the general tuberculous condition, or to patients who could not tolerate PAS.

Since the middle of 1952 isoniazid has been given systemically and locally in ten cases. We have followed the general trend of applying combined therapy in tuberculosis.

Penicillin was initially administered together with streptomycin for 14 days and also locally, but subsequently we have not considered this drug necessary as a protection against secondary infection, since streptomycin acts on most pyogenic bacteria that may be thought to cause secondary infection in the operative field. Penicillin is now given merely in those cases of open lesions with sinuses in which especially highly penicillin-sensitive bacteria have been isolated.

CHAPTER 4

Studies on the concentration of streptomycin

In the *literature* one finds several detailed investigations on streptomycin absorption, excretion and diffusion in body fluids and cavities (HEILMAN et al. 1945, ZINTEL et al. 1945, LEVIN et al. 1948). These studies showed that the concentration of streptomycin in blood serum after intramuscular injection reaches a maximum about one hour after the injection and then slowly decreases. With a dose of 1 to 2 g the highest concentration was about 40 to 50 microgram per ml of serum and 24 hours after injection streptomycin was still present in a concentration of 1 to 2 microgram per ml. After parenteral administration streptomycin was found to be distributed in various body fluids in significant quantities.

With respect to the desired concentration *in vivo* there is no clear information. YOUNG et al. (1947) in experiments *in vitro* found that tubercle bacilli cultivated from sputum were in most instances primarily sensitive; 90 per cent were inhibited by streptomycin in a concentration below 1.56 microgram per ml. Thus, the desirable minimum concentration *in vivo* would appear to be 1—2 microgram per ml.

Only a few studies on the concentration of streptomycin in bone lesions and abscesses have been reported (PIETROGRANDE 1949, FROYEZ et al. 1949, INGELRANS et al. 1949, KONDO 1953). Since the number of examined cases is small and since the results do not agree, further and more systematic studies seem to be needed.

The present writer and his co-workers have earlier published a paper on the concentration of streptomycin in the treatment of bone and joint tuberculosis (FELLÄNDER, HIERTONN and WALLMARK 1952). This previous study includes some cases of tuberculous spondylitis. The present investigation comprises these cases and a number of additional ones. The purpose of the investigation is to try to find out whether systemic streptomycin would reach the bone lesions which usually are avascular, and to study the absorption of local streptomycin.

It may be mentioned here that the determinations of the concentration were carried out according to a microbiologic method. For further data concerning the technique, the material and the relevant literature, refer-

ences may be made to the above-mentioned communication. The results of the investigation will be reported in the following.

General treatment

In 14 patients the *content of streptomycin in the pus* was examined at operation, in one case on two different occasions. Great care was taken to obtain samples free from blood. The time interval between the intramuscular injection of streptomycin and the collection of the sample varied from two to six hours. In two cases no streptomycin was recovered in the sample, whereas the content of streptomycin in the blood on the same occasion was 9.5 and 16 microgram per ml of serum, respectively. In three cases traces of streptomycin were present in the pus. In one case the concentration was as high as 18 microgram per ml. In the remaining eight cases

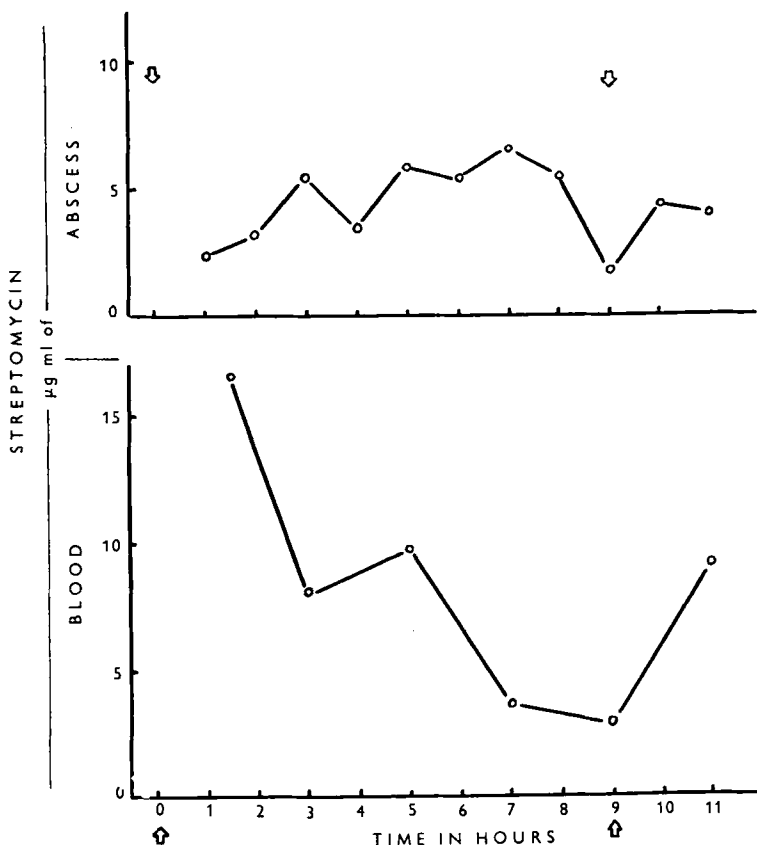


Fig. 3. Streptomycin in the blood and in a psoas abscess following intramuscular injection of $\frac{1}{2}$ g twice daily. Examination performed after a seven day course. In all the charts intramuscular injection is indicated by white arrows and local application by solid black arrows. The length of the arrow signifies the size of the dose.

the streptomycin concentration varied between 1.0 and 7.8 microgram per ml. The amount of injected streptomycin was $\frac{1}{2}$ g in eleven cases and 1 g in three cases.

These variations in the concentration of streptomycin in the lesions could not be explained either by clinical or anatomical factors or by different dosage. Nor is the variation in time intervals (two to six hours) between the injections and the collection of samples likely to be of any importance, judging from the following serially examined cases.

In one case the concentration of streptomycin was tested serially during one day by leaving the puncture needle in the abscess during *the course of general streptomycin treatment*, the dosage being $\frac{1}{2}$ g twice daily. It will be seen in Fig. 3 that the concentration increases slowly after the injection and then remains constant, being even higher than the blood streptomycin level seven to eight hours after administration. After the next injection there was a similar slow rise. Thus, this curve has a later maximum and a longer duration than the curve for the blood streptomycin content. In a further two cases the concentration of streptomycin was determined serially in the content of abscesses after a *single intramuscular injection* of 1 g. In one of these cases no streptomycin was found in the samples, in the other one the pus at the end of the examination ten hours after the injection contained 2 microgram per ml, which exceeded the blood streptomycin level (Table 4).

Table 4. Concentration of streptomycin in $\mu\text{g/ml}$ following a single intramuscular injection.

Case No.	Dose g		Time in hours after injection						
			1/4	1/2	3/4	1	4	7	10
1	1.0	Pus	1.4	0	1.0	2.3	1.0	1.3	2.0
		Blood	—	—	—	15.5	7.7	9.3	1.5
2	1.0	Pus	0	0	0	0	0	0	0
		Blood	—	—	—	9.3	7.8	3.8	2.5

Local application

In the two last-mentioned cases the *content of streptomycin in the blood* was determined on another occasion, after *local* injection only of 1 g of streptomycin into the abscess. The result is shown in Table 5. Fifteen minutes after injection streptomycin in a fairly high concentration was present in the blood, and it remained high still ten hours after injection, which suggested retarded absorption.

To try to find out at what rate streptomycin powder is absorbed from a wound the concentration in the blood was serially examined in three cases in which streptomycin was administered *locally* only and in a dose of 2 g, which is the usual dose at the operations. For the sake of comparison,

Table 5. Concentration of streptomycin in $\mu\text{g/ml}$ following a single local injection in an abscess.

Case No.	Dose g		Time in hours after injection						
			1/4	1/2	3/4	1	4	7	10
1	1.0	Blood	4.6	7.4	5.5	7.2	7.2	5.5	—
2	1.0	Blood	—	1.4	3.5	4.4	6.0	4.7	3.2

the blood streptomycin level in the same three cases about one week before operation was determined after a single *intramuscular* injection of the same dose, 2 g. The results are recorded in Table 6. Fig. 4 shows mean curves for the three examined cases. It will be seen that the blood streptomycin level after the local application still after 24 hours is as high as 3.7 microgram per ml and considerably higher than it is after intramuscular administration. Thus, one may expect an appreciably delayed absorption after

Table 6. Concentration of streptomycin in blood ($\mu\text{g/ml}$) following local application and intramuscular injection.

Case No.	Dose g		Time in hours after administration											
			1/4	1/2	3/4	1	3	6	9	12	15	18	21	24
3	2.0	local.....	2.6	1.7	5.8	6.2	12.3	13.2	13.5	13.5	8.3	10.7	7.4	7.4
	2.0	intramusc.	6.8	19.0	17.8	28.8	31.5	22.4	14.1	8.0	5.4	4.9	2.8	1.6
4	2.0	local.....	1.0	2.3	4.7	3.1	10.0	11.2	12.0	7.8	3.2	4.0	3.2	2.2
	2.0	intramusc.	14.5	31.5	—	24.6	24.6	12.0	10.0	6.0	2.2	1.8	2.2	1.9
5	2.0	local.....	2.8	—	14.1	15.9	21.4	15.1	15.5	7.8	8.7	4.6	3.1	1.5
	2.0	intramusc.	5.4	18.2	13.2	28.0	28.0	16.0	23.0	12.6	9.8	3.5	2.6	1.2

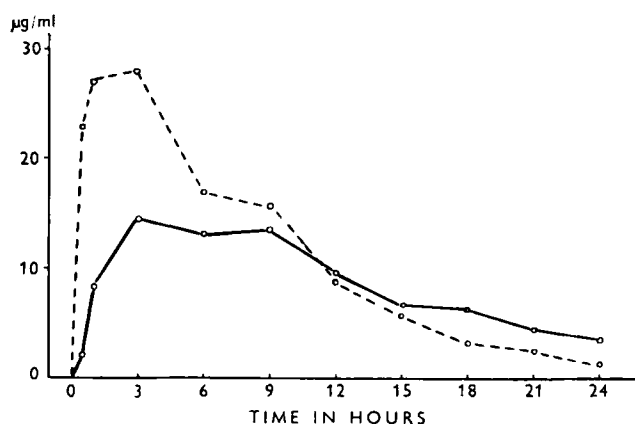
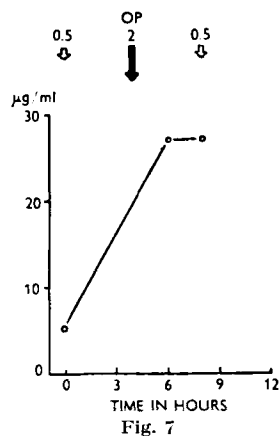
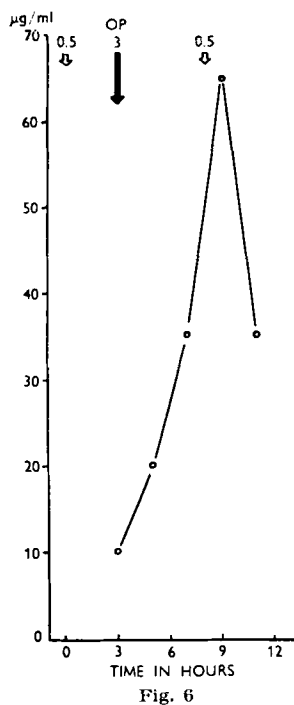
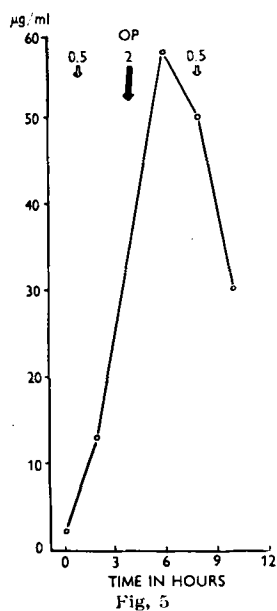


Fig. 4. Streptomycin in the blood after a single intramuscular injection of 2 g of streptomycin, broken line; after local application in the wound of 2 g of streptomycin, continuous line. The mean of three cases.

local application of streptomycin powder. Unfortunately, the investigation provides no information as to how long this depot effect may be expected to last.

Combined general and local treatment

Naturally, it is impossible to test the concentration of streptomycin in the actual lesion after surgical intervention coupled with general and local streptomycin therapy. To get some conception of the rate of absorption



Figs. 5, 6, 7. Streptomycin in the blood on the day of operation, following intramuscular and local administration.

the *blood streptomycin content* was serially determined at operation. The results are recorded in Figs. 4, 5, 6. It will be seen in the figures that in two of the cases the blood streptomycin level is very high, 58 and 65 microgram per ml, respectively. It falls fairly rapidly, however, and there is therefore hardly any risk of toxic effect.

Conclusions and discussion

It is surprising to find that in these often thick-walled abscesses and de-capsulated bone lesions streptomycin, in many cases, is present in such a concentration that a bacteriostatic effect can be anticipated. It might have been presumed that the conditions would be analogous with those prevailing in cases of lung cavities in which streptomycin is said not to penetrate in any noteworthy amount (JENSEN 1949). However, streptomycin does not in all cases enter abscesses and bone lesions, and therefore, systemic treatment only can hardly be adequate, even if only the streptomycin content in the actual lesion is considered.

However, the effect of streptomycin is not dependent only on the concentration in the diseased area but, as FROYEZ et al. (1952) have found, the action of streptomycin is inhibited by the tuberculous pus as a result of its acidity and consistence. Therefore, all inflammatory products should be removed by surgery before chemotherapy can have any effect.

These concentration tests have shown that this combination of general and local streptomycin therapy that is given together with operative evacuation of the lesions, and the doses of the drug that we have administered seem to be adequate to ensure a beneficial effect on the process. It would be desirable, however, to obtain a delayed effect of the local streptomycin.

CHAPTER 5

Pathology and pathogenesis

Most earlier patho-anatomical studies on tuberculous spondylitis have been carried out on autopsy material. They provide very detailed descriptions of the process on this particular occasion, but give an incomplete picture of those stages of the process that are clinically of greater importance. The post-mortem material consists mostly of acute cases in which the disease has reached an advanced stage, where the body's defence mechanisms have become exhausted, or cases in which the process has healed. This incompleteness has also been mentioned by some pathologists (HUEBSCHMANN 1928, KEY 1940). At radical operation for spondylitis the process can be studied at stages which earlier could not have been studied. However, the material obtained at operation and submitted for microscopic examination is not of such a nature that the patho-anatomical picture can be reconstructed and compared with clinical and radiographical findings. As has been mentioned earlier, the diseased tissue was not completely excised but the operation was done by curettage, destroyed bone tissue and tuberculous granulation tissue being removed in small pieces. The observations made at the operations and discussed in the following will therefore in the main concern the macroscopic picture, though only of those parts of the morbid anatomy on which this material could furnish information.

Literature

Skeletal tuberculosis like all other tuberculosis appears in two forms, granulating or productive, and caseous or exudative. Most authors agree that in spondylitis these two forms usually appear simultaneously. There is, however, some disagreement about the paths of dissemination. The most usual conception is that spondylitis as a rule develops by hematogenous spread (KREMER and WIESE 1930, RANDEATH 1932, and others). Dissemination through the lymphatics is by other authors considered to have been clearly demonstrated (FRASER 1929, VON FINCK 1940, BURKE 1940, R. KAUFMANN 1952).

Presuming that *hematogenous* dissemination occurs, spondylitis develops as follows: Tubercle bacilli may settle anywhere in the vertebral body, the area nearest the intervertebral disc being especially liable to becoming infected. At the point of localization there occurs a bone destruction the appearance of which varies according to which form of tuberculosis that predominates, the productive or the exudative. A characteristic feature of tuberculosis is that restorative processes occur parallel to destructive ones, and so the course of the disease will differ markedly according to which of them that predominates. The result may be a limited cavity without any change in the shape of the vertebrae, or extensive progressive destructions with collapse of the vertebrae. When the lesion is situated close to the cortex, usually in the anterior portion of the vertebral body, which according to KREMER and WIESE is especially susceptible to infection because of the rich vascular supply, the cortex will gradually be perforated and an abscess formed beneath the longitudinal ligament. The reaction of the surrounding tissue and progressive central disintegration of inflammatory tissue give rise to the gravitation abscesses that are so characteristic of tuberculous spondylitis. Because of the anatomical arrangements these abscesses extend quite typically in different regions of the spinal column. They follow the path of least resistance and enlarge in an area where the tissue is soft and yielding. In the lumbar region they develop in the psoas. In the thoracic spine where the surrounding tissue is taut the abscesses are less likely to penetrate from the paravertebral region. They will be subjected to heavy pressure, and the fusiform abscess shadows characteristic of the radiographic picture will develop. In the cervical region the abscesses find their way either retropharyngeally or subcutaneously on the lateral aspect of the neck. Bone lesions situated close to the intervertebral disc destroy the end plates of the vertebrae and the disease spreads to the disc, where the *nucleus pulposus* in particular is considered to favour the dissemination, while the *annulus fibrosus* is more resistant to tuberculosis (RANDERATH). Most authors consider that the spread to the adjacent vertebra occurs through the intervertebral disc, which would explain the frequent appearance of lesions in adjacent vertebrae in the region nearest the disc. HANSSON (1926) in studies on vessels has shown that two adjacent vertebrae are supplied by arteries from a common branch of intercostal and lumbar arteries, respectively, and that this renders possible simultaneous involvement of two adjacent vertebrae.

According to the *localization and extent* tuberculous spondylitis may be divided into different types. Lesions close to the intervertebral disc, which are the most common ones, are by HELLSTADIUS (1937) called paradiscal, which seems to be a better term than the earlier designations, epiphyseal, intervertebral. The most common classification is into paradiscal, central

and superficial spondylitis (DOUB and BADGLEY 1932, BIERRING 1934, KEY 1940, ALVIK 1949, and others). SORREL (1932) distinguished between a "forme superficielle" and a "forme caverneuse". In all classifications the superficial type occurs as a distinct type of tuberculous spondylitis, and is considered to begin beneath the cortex (KREMER and WIESE, SORREL). Radiographically it appears as a superficial erosion usually of the anterior surface of the vertebral body. It is characteristic of this type that it progresses with absorption only, without formation of sequestra (HELLSTADIUS). Remarkably often there is no radiographic evidence of a reactive barrier without the disease necessarily becoming progressive (MALLUCHE 1947). Intervertebral discs and end plates do not become involved except in advanced severe cases. All authors, pathologists, clinicians and radiologists, seem to agree that by spreading extensively upwards and downwards this superficial type of spondylitis may give rise to spondylitis at other levels than that of the original lesion by direct contact infection, in which granulation tissue from the surface enters the vertebral body through the nutrient foramina.

The role of the *intervertebral discs* in the development of spondylitis has been the subject of discussion. A common early symptom in spondylitis is narrowing of the intervertebral space without other changes. Some authors consider that primary tuberculous infection of the disc is possible (SCHMORL and JUNGHANS 1932, ASSHOFF 1952). VON FINCK holds the extreme view that the disc as a rule is primarily involved. MALLUCHE describes a few cases which he considered to be primary tuberculosis of the disc. In my opinion, however, none of these publications contain conclusive evidence of this view. A few autopsy cases are described, but no microscopic pictures are shown, and one cannot rule out the possibility that these were cases of healed bone lesions with remaining small abscesses in the discs. The demonstration of narrowing of the intervertebral space by radiography is no evidence that only the disc is affected, because small bone lesions cannot be revealed by ordinary radiographic examination. Planigraphy was not used in the described cases. KELLER (1951) has by planigraphy demonstrated central bone lesions beneath the end plate where ordinary radiography shows only narrowing of the intervertebral space.

The most usual opinion is that the changes in the disc are secondary, and that the narrowing of the intervertebral space is due to the fact that the *nucleus pulposus* prolapses into an adjacent vertebral lesion after the end plate has been destroyed (COMPERE and GARRISON 1936, SCHINZ et al. 1950, KELLER 1951, SCHMORL and JUNGHANS 1953), or that it is directly destroyed by tuberculous granulation tissue which from the bone encroaches on the disc.

On the presumption that the spread of the tuberculous infection to the spine occurs via the *lymphatics*, spondylitis would develop by infection from the periphery towards the centre of the bone. VON FINCK supports this theory of dissemination via the lymphatics and points to the frequency of calcified lymph glands in the neighbourhood of the tuberculous vertebral lesion. ASSHOFF demonstrated lymph spaces beneath the ligaments and in the intervertebral disc, and considers that the disease may spread both via the blood stream and via the lymphatics. KAUFMANN is decidedly of the opinion that tuberculous spondylitis develops by contact infection from the pleura via the lymphatics. At operations for thoracic spondylitis he has in many instances found thickening of the pleura and adhesions to the vertebrae. Primarily there appears tuberculosis of the soft parts in the lymphatics paravertebrally, which secondarily causes osteolysis in the vertebrae, initially of an unspecific nature. He published some planigraphic pictures to show that the arrosion does not begin in the centre of the vertebrae but is a surface process. However, the quality of the reproduced pictures is not such that central destructions can be ruled out. KAUFMANN does not discuss the development of lumbar spondylitis.

Healing of tuberculous spondylitis occurs by absorption of destroyed tissue and inflammatory products by in-growth of connective tissue which becomes increasingly fibrous and is transformed into bone. This absorption is often not complete but portions of diseased tissue, e.g. sequestra, become enclosed in cicatricial tissue or bone. Abscesses may also be absorbed or partly encapsulated and calcified. It is generally considered that children have a greater tendency to healing than adults in whom a fibrous fusion of the involved vertebrae usually occurs (KEY, SORREL). The fate of the sequestra during the healing process has not been clarified. Histologic examinations do not provide definite information. ERDHEIM (1932) considers that sequestra are not absorbed. SCHEEL (1944) has seen pictures that suggest that they can be destroyed in the same way as living bone. Workers engaged on clinical research are also of different opinions. HELLNER (1930) considers that bone sequestra can be absorbed, SORREL holds the opposite view. SORREL further considers that in adults complete healing never occurs. "Toutes les lésions perdent de leur activité, entrent en sommeil, mais elles n'arrivent pour ainsi dire jamais à guérir complètement, elles restent susceptibles de réveil." Much the same opinion is expressed by several other authors with experience in this field (KEY, KONSHEGG, and others). It should be emphasized, however, that patho-anatomical studies on the healing of bone tuberculosis are incomplete (KEY, BIERRING). Most studies on the healing are conducted by the aid of radiographic pictures of the progress of the disease, thus, radiographic pathology and not pathological

anatomy. The radiographic picture cannot furnish complete information concerning the pathologic processes.

Observations on the present material

Bone lesions were found at operation in 68 cases. Radiographically they were demonstrated also in all the rest of the cases except in one in which there was narrowing of the intervertebral space and a psoas abscess. In the remaining 33 operated cases abscesses were found at operation. The fact that no bone lesion was found in these cases may have many explanations. In the earliest cases we simply evacuated the abscesses. We soon found that it was possible to evacuate the bone lesions that communicated with abscesses. After having gained more experience we started to chisel through intact surfaces and were thus able to explore a bone lesion that was shut off from the surface of the vertebral body and the paravertebral abscess. In a few cases the exploration was rendered impossible by technical difficulties.

A circumscribed bone cavity was found at operation in 41 cases, in 25 of which there was a corresponding circumscribed radiographic change. The remaining 16 patients had more extensive radiographic changes, which was probably explained by reactive processes in the perifocal bone tissue. In some of the cases, however, the possibility that the exploration of the lesion was incomplete cannot be ruled out.

Extensive bone destructions were found at operation in 27 cases and these corresponded to the radiographic appearance. One exception was the case with involvement of the first and second cervical vertebrae, in which the destructions were considerably larger than could be demonstrated radiographically. The cervical region is of course more difficult to radiograph than other regions of the spine. Planigraphy was not performed before operation, since no planigraph was available at that time.

Bone lesions without paravertebral abscesses occurred in no less than 12 cases. In five of these there was a circumscribed cavity and in seven extensive destructions. In eight cases the disease was localized in the lumbar spine and in four in the thoracic spine. In five of the lumbar cases the surface of the vertebral body was macroscopically completely normal, in the rest the surface was slightly uneven and rough.

At operation it is difficult to decide which patho-anatomic type of tuberculosis that is present, the productive or the exudative, but it is evident that in most cases both types coexist. Thus, in most instances the bone lesions were found to contain sequestra, pus and granulation tissue. On the other hand, no purely caseous foci without disintegration were found, which is a usual finding at autopsy. This is of course attributable to the

body's power of reaction. In the latter case the defence mechanisms are exhausted and the process becomes markedly exudative or caseous, whereas at operation they produce a different picture, the predominating feature being granulating tuberculosis with absorption and disintegration of bone trabeculae. In one case the picture was atypical. There was a circumscribed lesion in the vertebral body of fairly firm consistence without formation of pus or bone destruction. The radiographic picture was also unusual, and a tumour was suspected before operation. However, microscopic examination showed signs of tuberculous inflammation with marked necrosis of the bone and tendency to sclerosis. Culture of the tubercle bacillus was also positive.

Abscesses. — *Psoas abscesses* were found at operation in 37 cases, in two of these bilaterally. The bone lesions were localized in the lumbar region in 29 cases, in the lumbosacral region in three, in the thoracolumbar region in three, and in the two lower thoracic vertebrae in two cases. In two cases the abscess was not demonstrated with certainty by radiography before operation. In 17 cases the abscess was palpable.

Paravertebral abscesses occur most commonly in the thoracic region, where the abscesses cannot enlarge towards the surface as readily as in other regions. Such limited paravertebral abscesses were present in three cases of lumbar spondylitis in the present material. One was situated beneath the ligament in front of the vertebra, the other two were small abscesses situated in the immediate neighbourhood of the bone lesions lateral to the vertebral body.

On the film the thoracic paravertebral abscesses are usually seen as bilateral shadows in the soft parts, but in some instances these shadows are paralleled by a true abscess formation on one side only. Thoracic paravertebral abscesses were found at operation in 46 cases. In 27 of these an abscess was demonstrated on one side only, and in 14 of these 27 cases bilateral soft-tissue shadows were seen on the film. In 19 cases abscesses were found on both sides and in front of the vertebrae, all were confirmed by radiography and all could be drained by exposure from one side, except in one case in which operation had to be performed on both sides.

In four cases in which a paravertebral soft-tissue shadow was seen on the film, no abscess was found at operation. In one of these cases an error was made in the interpretation because of scoliosis, the shadow of the aorta being interpreted as evidence of an abscess in the soft parts. That in some cases soft-tissue shadows are visible on the film without corresponding abscess formation may be explained by the fact that the tissue nearest the vertebrae is the seat of a reactive inflammation that cannot be macroscopically demonstrated at operation.

The superficial type of spondylitis (spondylitis anterior, forme superficielle) appears radiographically as a superficial destruction on the anterior surface of the vertebrae, at an early stage in the form of a crescent-shaped defect in the anterior surface with intact end plates and intervertebral space, at later stages as deeper defects often involving several vertebrae.

In this material such radiographic changes were present in 33 cases with the following localization: 24 in the thoracic region, 3 in the thoracolumbar, 5 in the lumbar and 1 in the lumbosacral region. There is a distinct parallelism between the radiographic appearance of this anterior spondylitis and the finding of paravertebral abscesses at operation. In three of the lumbar cases there were corresponding local prevertebral formations of pus beneath the ligaments.

In ten of the 33 cases the radiographic changes extended over several segments and in nine of these ten cases extensive elongated paravertebral abscesses were present. In the remaining case no explanation of the radiographic findings could be found.

Isolated anterior spondylitis did not occur in the present material, in all the 33 cases there were also central bone destructions visible in the radiograph. In 18 of these the central bone destruction was evacuated at operation. The fact that in the remaining 15 cases a paravertebral abscess only was found may be explained by incomplete exploration, since the central bone lesions do not directly communicate with the abscesses. This is the case especially at later stages and on recurrence in cases of previously evacuated lesions, where abscesses in the soft parts may develop as an independent tuberculous process after the bone lesion seems to have healed, as has also been observed by KASTERT (1951) at his operations.

Lymph nodes were found paravertebrally at operation in nine cases. In the lumbar region they were situated immediately by the sides of the vertebrae, in the thoracic region beneath the ribs. They were collected for microscopic examination. Unfortunately culture of the tubercle bacillus and guinea pig test were not carried out on lymphoid tissue. In Table 7 the results of the microscopic examinations are recorded together with the clinical and radiographic data and the result of the bacteriologic examination of the content in the abscesses or bone lesions.

No conclusions can be drawn from these examinations of the lymph nodes, but a few facts may be worth mentioning. The finding of a lymph node in the cervical region is of little interest, since these lymph nodes drain the upper respiratory tract, which is often the seat of infection. This lymph node showed acute lymphadenitis of unspecific nature, which may be explained both by the reason just mentioned and by the fact that the patient had long had a sinus.

Table. 7 Cases in which lymph nodes were found at operation.

Site of lesion	Clinical data	Gross picture	Microscopic picture	Sample of pus from bone lesion or abscess	
				Tb culture	Guinea pig test
C6—T4	5 year old lesion with sinus.	Old lesion, detritus, sequestra.	Acute unspecific lymphadenitis.	Negative	Positive
T10—12	Back trouble for 16 months. 2 years before diagnosis pulmonary tb, pleurisy, peritonitis.	Well-defined bone lesion. Abscess.	Lymph node with numerous tubercles, caseous necrosis, Langhans' giant-cells.	Positive	Positive
T10—L1	Back trouble for 5 months. Radiographically much older lesion. Lungs: fibrosis of apex. Rest of pleurisy.	Large bone destructions. Abscess.	Lymph node with small fresh epithelioid cell tubercles. Small areas of necrosis, not caseous.	Positive	Positive
T12—L1	Back trouble for 3 months. Radiographically early case. Lungs: rests of pleurisy and primary tb.	Fresh bone lesion and abscess.	Lymph node with numerous tubercles. No necrosis. Langhans' giant-cells. Slight sclerosis.	Positive	Positive
L2 —5	Tb of lungs and shoulder joint. Prolonged chemotherapy prior to operation. 3 year old spondylitis.	Psoas abscess with serous content.	Subacute unspecific lymphadenitis.	Negative	Positive
L4 —5	1 year old spondylitis. Disseminated chronic pulmonary tb.	Well-defined bone lesion and abscess.	Lymph node with tuberculous changes and caseous necrosis.	Positive	Positive
L4 —5	Back trouble for 3 years; tuberculous lymphoma 7 years before diagnosis. Radiography of lungs negative.	Extensive bone destruction, detritus, caseous pus.	Lymph node with caseous necrosis, enclosed in a connective tissue capsule. Old decapsulated tb.	Negative	Negative
L4—5	Back trouble for 1 year. Pleurisy and ascites 7 years before diagnosis. Radiography of lungs: rests of pleurisy.	Well-defined bone cavity centrally. No abscess.	Acute unspecific lymphadenitis. No tb changes.	Positive	Positive
L5	Back trouble for 1½ year. Unusual radiographic picture. Lungs: fibrosis of the apex, rests of pleurisy.	Unusual operative findings. No pus. No destruction. Firm consistence.	Lymph node: tb with sclerosis. Bone lesion: necrosis of the bone with Langhans' giant-cells, sclerosis.	Positive	Negative

A remarkable fact is that all the rest of the lymph nodes were found in the lumbar spine or in the junction between the thoracic and the lumbar spine. In six of the cases microscopic examination showed the picture of tuberculosis, in the rest lymphadenitis of unspecific appearance. KASTERT (1953) found paravertebral lymph nodes in exceptional cases in his material and only in old cases. I can find no further information concerning lymph nodes in the literature on the pathology of skeletal tuberculosis. In the present material the presumed age of the bone lesions corresponds largely to the histologic picture of the tuberculous adenitis. In contradistinction to KASTERT I have found tuberculous adenitis both in early and in old cases.

Histologic examination of material from bone lesions and abscess walls was carried out in 86 cases. The microscopic appearance suggested tuberculous inflammation in 81 of these cases. In the remaining five no pictures typical of tuberculosis were found, but guinea pig test was positive in all of them, which clinched the diagnosis (Table 8).

Table 8. Result of histologic examination compared with tb culture and guinea pig test.

Histologic examination	No. of tests	Tb culture			Guinea pig test			Tb culture and guinea pig test	
		pos.	neg.	no exam.	pos.	neg.	no exam.	pos.	neg.
tb pos.	81	60	12	9	68	11	2	57	7
tb neg.	5	3	2	—	5	—	—	3	—

Discussion

The operative findings support the opinion that primarily tuberculous spondylitis is always osteomyelitis which in all probability develops by hematogenous spread.

We have not found any evidence in support of KAUFMANN's theory of dissemination via the lymphatics from the pleura. The present material includes three cases of thoracic osteomyelitis in which, although the inflammation had reached the surface of the vertebral body, there was no paravertebral abscess. In these and in a few other cases with abscesses it was found that the adjacent pleura was thin and macroscopically normal. With regard to lumbar spondylitis the material includes eight cases with a vertebral lesion without abscess, and five in which the surface of the vertebral body was intact. Spreading via the lymphatics from one vertebra to another through the lymph spaces of the intervertebral disc may of course be possible in accordance with ASSHOFF's investigations.

The usual classification of the cases of spondylitis according to the localization seems to be of little practical value. The osteomyelitis develops

on the whole irrespective of the primary point of localization, centrally, paradiscally, or beneath the cortex. The course of the disease will depend on the body's power of reaction to the infection. It may, indeed, be difficult subsequently to reconstruct the origin of the bone lesion, since the disease is frequently not diagnosed until after large destructions and collapse have occurred. From an operative point of view, however, it may be useful to distinguish between osteomyelitis with and without formation of abscesses, although we are merely concerned with two stages of the same condition.

I would be inclined to abolish the term anterior spondylitis, since I believe that the radiographic changes, at least initially, are produced by pressure atrophy of the bone caused by an abscess under high pressure. Similar pictures may appear also in other expansive processes, for instance in aneurysm of the aorta. I think that Fig. 8 can be said to speak clearly in favour of this opinion. This was a case of a circumscribed abscess formation beneath the ligament on the anterior surface of the affected vertebra, corresponding to the concave surface. The ligament had by the abscess been



Fig. 8. Spondylitis with paradiscal lesion in L. 4—5. The anterior surface of L. 5 is concave as a result of atrophy due to pressure caused by a prevertebral abscess.

stripped from the bone but was still firmly fastened in the end plate and the intervertebral disc next above and below.

In later stages secondary superficial osteomyelitis produced by direct contact infection from the abscess is of course possible. The general opinion, however, is that the superficial spondylitis gives rise to new foci at other levels along the course of the abscess, which seems probable. But the question is whether there may not exist a different mechanism of the development of the often multiple thoracic spondylitis with large paravertebral abscesses. In the beginning there is usually only one vertebral lesion, but gradually narrowing of the disc is seen in several places and later there may also be multiple central foci. According to RANDERATH'S investigations multiple tubercles in the bone marrow occur in all cases of miliary tuberculosis and in most cases of chronic pulmonary tuberculosis. It is probable that these lesions are present also in isolated skeletal tuberculosis. In such cases it may be thought that primarily there are multiple tuberculous changes in the bone in different stages of development from microscopic small tubercles to macroscopically observable lesions of which maybe only one is visible on the film. These multiple bone lesions at different levels may then jointly give rise to a paravertebral abscess. The possibility of this development has not been discussed in the literature.

CHAPTER 6

Bacteriologic examinations

Besides the microscopic examination material was also collected at operation for culture of the tubercle bacillus, guinea pig inoculation and routine culture. These bacteriologic examinations were carried out at the bacteriologic laboratory of the Hospitals Board, Stockholm, and in a few cases at the National Bacteriological Laboratory. The material was cultured on solid Löwenstein medium after pretreatment with 6 % acid¹ and centrifuging. As a rule cultures were also made on Dubos solid medium. The inoculation of the guinea pigs was done by direct injection.

Culture of the tubercle bacillus and guinea pig inoculation

The results of the examination for the presence of tubercle bacilli are recorded in Tables 9 and 10, in which the results of the microscopic examination are also presented. The following data of importance are evident in the tables:

Culture was positive in 67 of 87 examinations (77.0 per cent). Guinea pig test was positive in 82 of 97 examinations (84.5 per cent).

In 57 cases all the three methods of examination for tuberculosis gave a positive result, which constitutes 74.0 per cent of the 77 cases in which all three examinations were carried out.

In 64 cases both culture and guinea pig inoculation was positive which is 73.6 per cent of the 87 cases in which both examinations were performed.

In three cases culture was positive and guinea pig test negative. Negative culture and positive guinea pig test was noted in ten cases.

In those five cases in which the microscopic examination gave no evidence of tuberculous infection guinea pig inoculation was positive in all the cases, while culture was positive in three.

In three cases in which microscopic examination was not performed both guinea pig test and culture was negative, yet the diagnosis of tuberculosis was considered to be certain. In one of these the patient had double spondylitis; the diagnosis was verified at the first operation (the chemotherapy may have been the reason why the bacteriologic tests were negative).

¹ Equal parts of sulphuric and phosphoric acid.

Table 9. Result of tb culture compared with guinea pig test and histologic examination.

Tb culture	No. of tests	Guinea pig test			Histologic examination			Guinea pig test and histologic examination	
		pos.	neg.	no exam.	tb pos.	tb neg.	no exam.	pos.	neg.
pos.	67	64	3	—	60	3	4	57	—
neg.	20	10	10	—	12	2	6	5	—

Table 10. Result of guinea pig test compared with tb culture and histologic examination.

Guinea pig test	No. of tests	Tb culture			Histologic examination			Tb culture and histologic examination	
		pos.	neg.	no exam.	tb pos.	tb neg.	no exam.	pos.	neg.
pos.	82	64	10	8	68	5	9	57	2
neg.	15	3	10	2	11	—	4	3	—

The second patient had previously had several other manifestations of tuberculosis, of which one was localized in the skeleton. In the third case the patient's history did not suggest tuberculosis but the clinical picture and radiographic evidence favoured this etiology. Finally it may be mentioned that two patients who died had not been subjected to either microscopic or bacteriologic examination. Both had earlier had multiple manifestations of tuberculosis, and post-mortem examination showed macroscopic changes in the spine typical of tuberculosis.

The *conclusion* of this account is that besides microscopic examination culture of the tubercle bacillus and guinea pig inoculation should be carried out in every case in order to establish the diagnosis.

In some accounts of laboratory tests, in which most examinations were done on sputum, gastric lavage or urine, the number of positive cultures for the tubercle bacillus is about half of that of positive guinea pig inoculations (SIEVERS 1952, PACKALÉN 1952). In the material described here a positive culture was obtained in a much greater number of cases, which is quite natural, since the examinations were carried out on pus or tuberculous granulation tissue.

Resistance to streptomycin

In the *literature* one finds only a few studies on chemoresistance of bacterial strains grown from tuberculous lesions of bone and joints. HARRIS et al. (1952) have presented a systematically performed investigation on 118 cases of bone and joint tuberculosis. In 33 per cent of these no tubercle bacilli were present during or after streptomycin therapy, in 34.7 per cent

no bacilli were present after streptomycin therapy, and in 30.5 per cent they were present both before and after the treatment, that is, in 36 cases. The tubercle bacilli remained sensitive during the course of treatment in 26 of these 36 cases. In five they were sensitive before treatment but acquired resistance. In the remaining five cases they were resistant both before and after streptomycin therapy. The tests were done on solid medium (modified Herrold's). The organisms were considered to be sensitive to streptomycin if they were inhibited in a concentration of 10.0 microgram per ml or lower. After the introduction of streptomycin therapy combined with PAS no case of streptomycin resistance *in vitro* occurred.

MAYR (1953) found primary streptomycin resistance in 13 cases but gives no information concerning technique and number of examined strains.

In the *present material* the resistance of the tubercle bacilli to streptomycin was examined in 48 cases by indirect methods in a Dubos liquid medium with tween 80. In 39 cases only one examination of the resistance was done, since primary healing occurred. The results are presented in Table 11. In one single case there was distinctly reduced sensitivity to strep-

Table 11. Sensitivity to streptomycin (SM).

SM prior to collection of samples g	No. of tests	Lowest inhibiting concentration $\mu\text{g/ml}$ No. of strains						
		0.04	0.08	0.16	0.31	0.63	1.25	> 5.0
0	36	5	14	9	3	3	2	—
9—30	13	—	5	4	3	—	—	1
30—60	5	1	3	1	—	—	—	—
60—90	3	—	2	—	1	—	—	—
> 90	2	—	2	—	—	—	—	—
Total	59	6	26	14	7	3	2	1

tomycin. This was a case of a patient whose bacterial strains primarily showed total inhibition of growth at 0.16 microgram per ml. At reoperation for an abscess in the soft parts one year later they showed partial inhibition at a streptomycin concentration of 5.0 microgram per ml. Since no further sample could be obtained, this value could not be checked. The patient had only received 17 g of streptomycin in connection with the first operation, combined with PAS. This resistance *in vitro* was *not* paralleled by clinical resistance. Rapid clinical and radiographic healing occurred (case no. 7 in the Case Report).

One patient, however, who received 183 g of streptomycin combined with PAS and whose tubercle bacilli still showed marked sensitivity to streptomycin exhibited a distinct clinical resistance. This was a case of a woman who at the first operation had active extensive pulmonary tuberculosis,

but despite repeated operations for the spondylitis, coupled with series of chemotherapy, it did not heal. The changes in the lungs, on the other hand, showed marked regression during the chemotherapy and have remained stationary up to the time of writing. Tubercle bacilli cultured from sputum at the onset of treatment also showed marked sensitivity to streptomycin.

Twenty-three patients were subjected to resistance tests after previous streptomycin therapy and six of these had not received PAS or any other tuberculostatic agent. All these six patients exhibited marked sensitivity to streptomycin; one had received 61 g and another 95 g of streptomycin, the others a smaller dose.

This small material would hardly justify any conclusions. It may be summarized, however, that in one case streptomycin resistance *in vitro* occurred despite a very good clinical result, and that another case, on the contrary, showed distinct clinical resistance while the *in vitro* test showed no resistance after prolonged treatment with streptomycin and PAS.

Routine culture

The operation material was also examined by routine culture which was carried out in 93 of the cases and gave a positive result in seven. Staphylococci were isolated in all the seven cases, *staphylococcus albus* in five and *staphylococcus aureus* in two.

Of these seven secondarily infected cases five had sinuses at operation. A further four had sinuses at operation although culture of pyogenic bacteria yielded no growth.

Of the two patients with closed spondylitis and secondary infection one was punctured several times before operation and the aspirated pus showed no growth of pyogenic bacteria. It was therefore considered probable that the punctures were responsible for the secondary infection. This case healed quickly without complications in spite of the secondary infection. The other patient, however, had recurrence, and bone grafts inserted in the bone cavity showed no signs of reconstruction and had to be removed at reoperation.

It is of great importance that routine culture of bacteria is done, especially with a view to being able to reveal a chronic pyogenic osteomyelitis of the spine which clinically and radiographically may be puzzlingly like tuberculous spondylitis. This problem will be further discussed in the next chapter.

Exploratory operations

Negative operative findings

In five cases exploratory exposure of the spine was performed because of the suspicion of spondylitis with abscess formation, no certain pathologic changes being found at the operation. In two of these cases with thoracic spine involvement the patients probably had tuberculous spondylitis at the healing stage. Both patients showed clinical symptoms of activity. Besides radiographic evidence of bone destruction there were soft-tissue shadows suggesting paravertebral abscesses, in one of these cases erroneous interpretation owing to scoliosis. The third patient, a 68 year old man with clinical symptoms indicating pyogenic osteomyelitis of the spine, had radiographic evidence of paradiscal destructions in the upper thoracic region without noteworthy collapse of the two affected vertebrae, and a paravertebral soft-tissue shadow, suggesting an abscess. At re-examination of these films it was found that they had been erroneously interpreted because of marked scoliosis. After the operation the symptoms gradually regressed and the diagnosis remained uncertain. The fourth patient was a 66 year old woman with fairly poor general condition and an extensive destructive tuberculous process in the lumbar spine. From the beginning it was decided to make the smallest possible intervention, and since the operation offered technical difficulties, the large exposure of the spine which would have been necessary for the radical operation, was not carried out. The fifth patient had thoracic tuberculous spondylitis. In this case the exposure was made in the wrong segment, which was not discovered until after operation at the first radiographic control.

These five cases are not included in the material described here. The exploratory operations were not followed by any complications and did not seem to affect the subsequent course of the disease.

It may be mentioned here that five patients included in the material were explored with a negative result, prior to the radical operation. These were three cases of lumbar and two of thoracic spondylitis. In the lumbar cases a psoas abscess was later found in two and a large bone lesion in one of the cases. The exploration in the two thoracic cases was made at the level of the point that according to the radiographic pictures was considered

to be the centre of the paravertebral abscess but nothing was found. At the reoperation the exposure was made at the level of the bone lesion, and the abscess and the lesion were found. All these explorations, at which tuberculous abscesses were overlooked, were carried out at a time when the experience of such operations was poor.

To avoid exploratory interventions of this kind the lesion can be localized by radiography during operation. In cases of thoracic spine involvement it may be suitable to mark with an indicator those ribs that are to be excised. The bone lesion itself can be marked with a puncture needle as indicator inserted into the affected intervertebral disc. In the thoracic spine exposure should be made at the level of the lesion itself, even if the maximum of the abscess shadow is not situated at that level. Finally, it should be borne in mind that mediastinal contours of soft parts, especially in cases of scoliosis, may be erroneously interpreted as abscess shadows.

Reversal of diagnosis

By these operations of the spine it has become possible to correct errors in the preoperative diagnosis of tuberculous spondylitis.

Pyogenic osteomyelitis of the spine was recorded in six cases. In three it was localized in the lower thoracic, in two in the lumbar, and in one case in the cervical spine. One patient with lumbar-spine involvement had a sinus. In all these cases nothing was found in the patient's history or at clinical and radiographic examination that suggested chronic unspecific inflammations.

In all the cases histologic examination of the operation material showed signs of unspecific inflammation. Guinea pig inoculation and culture of the tubercle bacillus were negative. Routine culture yielded growth of *staphylococcus pyogenes* in three cases and *streptococcus pyogenes* in one case with sinus. In the other two routine culture was not made, but the diagnosis of pyogenic osteomyelitis of the spine is probably certain, since the continued radiographic controls showed pictures that were more typical of unspecific than of tuberculous inflammation.

Tumours were found in two cases. In both there was clinically some suspicion that they may be bone tumours. No primary tumours were found after thorough examination, and the radiographic appearance was such that tuberculous spondylitis could not be ruled out.

In one case with thoracic-spine involvement microscopic examination revealed cancer metastasis; no primary tumour was found later. In the other case, in which the patient had a lesion in a lumbar vertebra, microscopic examination showed the picture of a chordoma.

Discussion

These operations afford a valuable opportunity to reveal other conditions than tuberculous spondylitis. With regard to pyogenic osteomyelitis of the spine, the prognosis and the course of the disease are quite different. In such cases double advantage is gained. Bone lesions and abscesses can be radically evacuated, and adequate chemotherapy can be instituted in accordance with the bacteriologic finding. Moreover, there is no need for the patient to undergo prolonged after-treatment and many years' follow-up examinations, which is necessary in tuberculous spondylitis, and which is a mental strain.

Chronic pyogenic osteomyelitis of the spine is generally said to be the vertebral disease that most resembles tuberculous spondylitis, and some authors stress that quite a number of cases are probably being treated on the wrong diagnosis (ALVIK, BROCHER, HELLNER, MALLUCHE). DEFOREST SMITH (1933) found that tuberculous spondylitis had been erroneously diagnosed in 11 of 17 cases of pyogenic osteomyelitis of the spine. ALVIK (1951) compared 32 cases of chronic pyogenic osteomyelitis of the spine with 507 cases of tuberculous spondylitis during the same period of time and found a very similar picture with the same incidence of abscesses, sinuses and paraplegia. KULOWSKI (1936) has made similar observations.

JOHNSON et al. (1953), as has been mentioned in the survey of the literature, aim at establishing a correct diagnosis by direct biopsy. These authors reported that the preliminary diagnosis of tuberculosis was earlier erroneous in 12 per cent of the cases, established by subsequent clinical course or postmortem. Since biopsy was introduced the diagnostic errors have increased to one-third of 87 operative cases. In eight cases preoperatively diagnosed as tuberculosis the operation revealed other conditions, while 21 cases with other preoperative diagnosis were found to be tuberculous spondylitis.

In this material the diagnosis was corrected in eight cases, which constitutes 7 per cent of the total number of patients operated upon, i.e. 100 certain cases of tuberculous spondylitis, six cases which were explored with negative finding and the above eight, making a total number of 114 cases.

A characteristic feature of pyogenic osteomyelitis of the spine is the marked tendency to bone regeneration, which on the film appears as early development of sclerosis and bone bridges. This phenomenon failed to appear in some of the cases reported here, which shows the difficulty of making the diagnosis solely on the basis of clinical and radiographic evidence and supports the presumption that among cases of tuberculosis treated conservatively there may be quite a number of cases of pyogenic osteomyelitis of the spine that will never be discovered.

CHAPTER 8

Therapeutic results

Survey of the literature

In studying the literature on tuberculosis of the spine one is struck by the difficulty of assessing the course of the disease, especially the healing stage. Several authors emphasize that, actually, healing in a patho-anatomical sense never occurs, and that when the term healing is used it implies merely arrest of the disease. It is frequently found that the disease is judged from the clinical result, that is, the ability to work, without considering the radiographic end-result. During a period of great enthusiasm for the spine-fusion operation the therapeutic result was evidently assessed merely on the basis of the incorporation of the bone graft, and the tuberculous process itself was not taken into consideration. It was apparently considered that the disease had been checked by producing a bony ankylosis between the affected vertebrae.

Some reports from different periods will be reviewed here with special reference to the assessment of healing, duration of the disease and mortality.

SVEN JOHANSSON (1926) compiled a series of children treated between 1909 and 1923. It included 91 cases of spondylitis of whom not quite one-third were treated by surgical fusion and the rest conservatively. In evaluating the result the clinical evidence seemed to have been conclusive. The mortality rate was 28 per cent.

BUSINGER (1928) presented an account of a series of soldiers treated conservatively. It included 108 patients from 1902 to 1927. He found that the condition entered the healing stage after an average of four and a half years, no case healed in less than two years' time. The mortality rate was 24.1 per cent. He emphasized that absolutely certain healing is never to be expected; the possibility of reactivation will always exist.

In a study of 865 operative cases ALBEE (1930) presented excellent results of early fusion operation after an observation period of up to 20 years. The results were assessed on the basis of information concerning the history of the cases, obtained by questionnaires. Radiographic evidence was not mentioned. A follow-up investigation of this kind seems to be of little value. The mortality rate was said to be 2 per cent, a figure that is so low that it can hardly refer to the whole material.

In KREMER and WIESE's (1930) monograph on skeletal tuberculosis the duration of the disease in spondylitis was reported to be four years.

RUMMELHARDT (1930) among 178 cases treated between 1907 and 1927 had a mortality rate of 50.6 per cent. This applied to both fused and non-fused cases. BOEREMA (1933) also quoted a high mortality, 53 per cent of 178 cases between 1923 and 1933.

KING (1933) reported a personal follow-up investigation of 84 patients from 1925 to 1931. The minimum observation time was one year and the treatment consisted in surgical fusion. The result was designated as good if the patients were without subjective complaints and solid fusion had taken place, which was recorded in 69 per cent. Total mortality was 16.1 per cent, and death from tuberculosis occurred in 9.5 per cent. As for the radiographic result KING mentioned only solid fusion but said nothing about the tuberculous process itself.

BIERRING (1934) compiled a material from several hospitals in Denmark. 76 patients, of whom nearly one-fourth were children, were treated surgically. In the majority of cases the observation period was more than five years. He examined the material with reference to the healing of the tuberculous process, and stated that the surest signs of healing are restoration of the normal structure details, diminishing of the abscess shadow, and block formation. He found block formation in 54 per cent of the children and in 44 per cent of the adults. In all the surviving children there seemed to be clinical and radiographic evidence of healing, and the mean length of the children's hospitalization was one and a half year. Of the adults 70 per cent were symptom-free, 20 per cent had persistent symptoms, and 10 per cent had died. In the whole of his material of both operated and non-operated cases with more than five years' observation the mortality was 33 per cent, death being due to spondylitis in about half of these cases. The total incidence of death from tuberculosis was estimated at about 24 per cent. In the operated cases the mean duration of treatment for the survivors was 13 months. Return to work shortly after the discharge from hospital was recorded for one-third of the cases, after half to one year for one-third, and of the remaining one-third some returned to work after a longer time and the rest gave no information on this point.

MEYER (1935) reported a mortality of 29.8 per cent among 178 patients from 1922 to 1930. The mortality rate was considerably higher in cases of multiple tuberculous lesions, where it was 40 per cent.

McKEE (1937) compared the results of spine-fusion operation and conservative treatment in adult patients. The study comprised 50 operated and 100 non-operated cases. The radiographic end-result was classified as follows: Bony ankylosis, firm fibrous ankylosis, insecure fibrous ankylosis, large gap or dislocation, remained active until death. The results were much

better in the conservatively treated group, judged both from clinical and from radiographic evidence. Bony ankylosis or firm fibrous ankylosis, together listed as good result, occurred in 62 per cent in the conservative therapy group, and in 38 per cent in the operated group. Remaining active process was recorded in 2 per cent and 12 per cent, respectively. McKEE considers that spontaneous anterior fusion occurs earlier after conservative treatment than after a fusion operation. 70 per cent and 32 per cent, respectively, were clinically symptom-free, and 10 per cent and 22 per cent, respectively, were dead. The duration of treatment in the conservative therapy group averaged 18 months.

SEDDON (1938) was not convinced of the value of fusion operation, and he had seen fusion occur spontaneously just as often as after operation. He further considered that an early operation prevents spontaneous fusion, and that, when it is to be employed, it should be performed at the end of conservative treatment. In a series of 92 patients, of whom one-third had been operated upon, the death rate for tuberculosis during the first five years was 19.3 per cent. In cases of coexisting visceral tuberculosis the prognosis became more uncertain, the mortality being 61 per cent. When four years had elapsed after the onset of the disease, the prognosis was good and the mortality risk small. The duration of treatment averaged 20 months.

In WALHEIM'S (1939) series of 221 patients treated between 1913 and 1930 the mortality, after an observation period of more than nine years, was 27.1 per cent. About one-third of the cases were treated conservatively. The duration of hospital care averaged 19 months in the group of operated cases and 17 months in the non-operated group. The average duration of treatment until the process was considered to have been arrested was 33 months and 57 months, respectively.

In an introduction at a symposium on the treatment of tuberculosis of the spine presented at a meeting of the American Academy of Orthopaedic Surgeons, 1940, GILL, speaking about the value of surgical fusion, made the following statement: "We do not particularly wish to know in what percentage of cases a skilful operation will produce a permanent fusion of the processes of the vertebrae, but rather in what percentage it will produce a fusion of the bodies or otherwise result in lasting cure."

Some of the more prominent contributions to the symposium will be reviewed here.

SWETT et al. stressed the important part played by the abscess in the healing of tuberculosis of the spine. Healing usually promptly followed the disappearance of the abscess. The bone lesion rarely healed in the presence of an abscess, even if the abscess was calcified. The authors gave the following definition of healing: "Healing consists of the disappearance of the destruc-

tive lesion, a firm bony ankylosis between the remaining portions of the involved vertebrae, and the restoration of a normal consistency of the surrounding bone." They made a study of the end-results in a series of 350 cases from different hospitals. The observation period was 5 to 25 years. Of 109 healed cases none healed in less than two years, and only three in less than five years. The results were the same for operative and conservative treatment. The treatment of spinal tuberculosis was considered to be unsatisfactory, because in the cases studied healing as defined by the authors occurred in only 35 per cent, while in 45 per cent healing failed to occur, and in 20 per cent the result was questionable. This study seems to me to be one of the most valuable contributions from that period. The definitions are distinct and the presentation of the material is clear and easily surveyable.

SWIFT published HIBB's large material of 1,020 cases from 1911 to 1940. Of these, 584 operated cases with a minimum observation period of five years were studied more closely. More than half were children under ten years of age. The following results were recorded: Excellent early 50 per cent, excellent delayed 14 per cent, failure 8 per cent, death 28 per cent. No definitions of healing were given.

HARRIS et al. classified the results into bony ankylosis, firm fibrous ankylosis, and healing without ankylosis, and presented definitions of these different types of healing. The third group was listed as fair. After studying 80 cases with a minimum observation period of five years the following results were recorded: Bony ankylosis 50 per cent, firm fibrous ankylosis 13.75 per cent, no ankylosis 8.75 per cent, progressive disease 27.5 per cent. The mortality rate was 28.75 per cent. The patients in this series were treated by conservative methods until they showed signs of mastering the infection, after which fusion operation was carried out.

CLEVELAND pointed out that in skeletal tuberculosis the problem is not the therapeutic methods but the extent of invasion by the tubercle bacillus and the patient's reaction to it. He found a much higher mortality when skeletal tuberculosis and active pulmonary tuberculosis coexisted. The total mortality in his material of 203 cases was 26.6 per cent. Excellent result (solidly fused spines, no active pulmonary tuberculosis, the patient leading a normal life) was recorded in 54.18 per cent.

MEYERDING was of the opinion that fusion is advisable as an aid in strengthening the healed tuberculous spine. With regard to the five-year results it may be mentioned that the mortality among 480 operated cases, mostly adult patients, was 18.43 per cent.

GIRDLESTONE (1940), in a monograph on bone and joint tuberculosis presented an account of 319 cases of spondylitis from 1923 to 1937. Slightly more than half of these cases were treated by fusion operation at the end

of conservative therapy, the rest had only conservative therapy. The observation period was more than five years. The therapeutic result was classified as good in 65 per cent of the operated group and in 53 per cent of the conservative therapy group. The mortality was 16 per cent and 28 per cent, respectively. The results were distinctly unsatisfactory in cases of active pulmonary tuberculosis and the mortality was high.

In ALVIK's (1949) exhaustive work on tuberculosis of the spine the following data concerning the treatment and its result may be worth mentioning. The material consisted of 507 cases from 1936 to 1946. In this material the basic plan was to employ conservative methods until the process clinically and radiographically appeared to be quiescent, and then to consider surgical fusion. Many patients were allowed to be ambulant before operation so as to ensure better collapse at the site of destruction. The decision to operate or not to operate was made on the basis of the radiographic judgment of stability. Children were not operated upon. Fusion operation was performed in a total of 35.89 per cent of the cases.

The average length of hospital care was one year. Follow-up investigation of 348 patients observed for from two to ten years showed that 69.54 per cent were fully fit for work. Calculated on the whole material 47.73 per cent were fully fit for work, and 12.08 per cent partially fit for work. The time at which the patients returned to full employment could be recorded in 184 cases, being six months after the discharge from hospital in 24.46 per cent. After one year the figure had increased to 58.16 per cent, and after two years to 89.68 per cent. The cause of the unfitness for work was in most cases progress of the spondylitis or the development of new spondylitis, which was recorded in 19.17 per cent, usually spreading to the adjacent segment. Surgical fusion did not prevent such a spread of the disease. The total mortality was 17.75 per cent, the rate of deaths due to tuberculosis 15.38 per cent.

ALVIK stressed that healing in the true sense of the word seldom occurs; he used the term "healing and recovery" when there was clinical and radiographic evidence of arrest of the disease. He made a very thorough division and classification into different types of radiographic healing. With regard to the incidence it may be mentioned that incomplete block was recorded for 17.66 per cent and complete block for 30.43 per cent. The figures refer to part of the series only, that is, to 291 patients who were followed up after an observation period of at least two years. Fusion operation did not seem to influence the results which were almost the same with and without operation.

DOBSON (1951) presented a study of a large material from 1932 to 1948, mostly patients given conservative therapy. The late results in 672 cases with a minimum observation period of three years were 55 per cent healed

and 23 per cent dead. No less than 22.3 per cent of the patients discharged as healed were readmitted with recurrence or complications. Reactivation of old spondylitis was the commonest cause and was recorded in nearly half of these cases.

A subsequent follow-up study from HIBB's clinic was presented by HALLOCK et al. (1954). It comprised patients treated between 1931 and 1947 and included 192 cases. HIBB's spine-fusion operation was performed both in children and in adults, and the operation was carried out early without previous conservative therapy. The total mortality was 20.3 per cent, the rate of deaths due to tuberculosis 18.8 per cent. The total incidence of healed cases was 71 per cent. The disease was considered to have been arrested in 95 of 100 cases with an observation period of 5 to 22 years, while it was still active in the remaining five.

In a study by HASCHE-KLÜNDER et al. (1954) including 131 cases of spondylitis between 1920 and 1950, only 36.5 per cent were able to work among the patients old enough to be in employment. The mortality was 13 per cent. In the majority of cases the treatment was conservative.

In summarizing this survey of the literature on the therapeutic results *before the era of chemotherapy* it may be stated that the first enthusiastic attitude to the method of surgical fusion has gradually changed. Many surgeons have become increasingly moderate in employing this operation, and there are those who consider that it interferes with the spontaneous tendency to block formation, especially if it is performed too early. Many reports are of no value in assessing the healing of the tuberculous process, since no definitions are given. More critical authors admit that real healing never occurs with the therapeutic methods applied.

It is impossible to compare the various reports concerning the radiographic results, but if one selects those in which clear definitions are given it will be found that the incidence of radiographic healing, or rather arrest of the disease, varies between 35 and 62 per cent.

Recurrence in the form of reactivation of the original lesion or spread to adjacent segments is usual and occurs in about 20 per cent.

The incidence of a clinically good result varies between 36.5 per cent and 71 per cent. The mortality varies between 13 per cent and 53 per cent.

The average length of hospital care is usually reported to be $1\frac{1}{2}$ year. It is considered that the actual disease cannot be regarded as healed until after three to five years.

To what extent *chemotherapy* affects the course of skeletal tuberculosis has as yet not been made clear. In A Public Health Service Cooperative Investigation (1952) from the USA 50 cases of streptomycin-treated skeletal tuberculosis were studied and compared with 40 untreated control subjects. In the streptomycin-treated group was noted a beneficial effect on the pa-

tient's general condition and on secondary manifestations of the tuberculous process. Sinuses healed more quickly, the sedimentation rate fell and the blood count became normal, while no difference was found in the radiographic appearance of the tuberculous lesion after 15 months of observation.

In most orthopaedic departments chemotherapy is used as a complement to usual conservative therapy in cases of spondylitis. Most authors (GERARD-MARCHAND et al. 1950, DONISCH 1951, HARRIS et al. 1952, KATTHAGEN 1954) are of the opinion that chemotherapy has a beneficial effect in spondylitis with sinus formation but no certain effect in closed cases.

ALLARIA et al. (1952) published a series of 306 patients with spondylitis, treated by streptomycin and PAS and recumbency for three months to three years, with an average of nine months. The result of the treatment was that 203 patients, or two-thirds of the cases, were classified as clinically and radiographically healed, or "zum Stillstand gebracht". In contrast to what has been found by other authors the results were good also in closed cases.

WILKINSON (1954) compared a group of 46 patients with tuberculous spondylitis who were treated by chemotherapy and another group of 60 patients who during the same period of time received conservative treatment only. No marked difference between the two groups was noted, either in the radiographic result after a minimum of one year or in the length of treatment. In the chemotherapy group bony ankylosis occurred in seven cases, "sound fibrous ankylosis" in eleven, and "unsound ankylosis" in three cases; about the rest no information was available.

STEVENSON (1954) failed to find that three months' chemotherapy had any effect on the rapidity of radiological improvement and recommended half a year as the minimum length of treatment.

Several workers have made the observation that streptomycin provides no protection against dissemination of the tuberculous process (GLOGOWSKI 1953, WILKINSON 1954, KATTHAGEN 1954). It has also been observed that skeletal foci may develop and progress during chemotherapy for other tuberculous disease (ORELL 1951, DERoy et al. 1952).

With regard to *operative evacuation of the lesion combined with chemotherapy* only a few studies of the therapeutic results have been published. JOHNSON et al. (1953) reported 78 cases of spondylitis treated by operation without any deaths. However, the operation was not a radical evacuation of the lesion, in many cases it consisted merely in biopsy. Earlier, 149 similar operations had been carried out without protection by streptomycin with nine deaths of which eight were due to dissemination of the tuberculous disease. Other therapeutic results were not included in the report.

At *Verhandlungen der Deutschen Ortopädischen Gesellschaft* in October 1953 the evacuation of lesions in tuberculous spondylitis was one of the

main subjects. KASTERT presented a large series of 489 patients operated upon by his method with local tuberculostatic treatment through a drainage tube. After an observation period of 45 months the mortality was 1.75 per cent. Patients with normal clinical data and radiographic evidence of block formation were listed as healed. Block formation was recorded in all cases except two in which bone grafting was subsequently done. The report contained no information concerning the degree of block or the structure of the bone on the whole. Among 250 patients with an observation period of 15 to 45 months 93.6 per cent were healed, which are extremely good results in comparison with earlier conservative treatment. 69.2 per cent were able to work, 16.4 per cent definitely invalids, and 14.4 per cent temporarily ("auf Zeit") invalided. ERLACHER gave an account of his observations of 43 patients treated by KASTERT's method. In some cases bone defects had been filled with bone. Two patients had died, one from a non-tuberculous disease. Autopsy showed that the spondylitis had healed in both these cases. No other results were mentioned, since the observation period was too short. FRÜND reported on his experiences of plaster filling of bone defects in 36 cases of which 28 had an uneventful postoperative course. Maximum observation period was two and a half years. One case was unsuccessful despite reoperation. In one case there was histological evidence of bone regeneration six months after operation.

WILKINSON (1954) reported on the results in a series of 21 operated cases of which 18 "by success", meaning firm ankylosis. The average length of treatment in early cases of spondylitis was for adults 11.6 months and for children 26 months.

Spondylitis complicated by paraplegia.

This presents a special therapeutic problem. MÉNARD introduced operative treatment in the form of costotransversectomy and evacuation of abscesses. Subsequently he abandoned the method himself because of persistent sinuses but he obtained good results with respect to the medullary symptoms. Later this therapeutic method gained several followers, but it has never been ascertained whether or not this operation is to be preferred to conservative treatment.

KREMER and WIESE (1930) considered that evacuation of the abscesses by costotransversectomy in many cases had a beneficial effect on the paralysis and that laminectomy seldom had any effect.

SORREL (1932) found that of 80 patients 80 per cent showed healing with conservative treatment only.

SEDDON (1935) presented a study of 100 patients of whom 70 recovered and 21 died. He recommended principally conservative therapy but considered that costotransversectomy was justified in paraplegia with a sudden

onset, and in those cases in which a fresh abscess becomes clearly demonstrable. He advised against laminectomy which was successful in only two of nine cases.

KIRE (1936) reported on a series of 20 patients of whom three were treated by laminectomy, the rest conservatively. The mortality was 20 per cent. Of the conservatively treated patients whose paralysis was of less than one year's standing, 15 cases, all recovered in three weeks to ten months with a mean of 3.8 months. In two cases where the paralysis was of more than one year's standing there was no improvement.

The neurosurgeon ALEXANDER (1946) described a method called antero-lateral decompression which is in large part an extensive costotransversectomy but goes further, in that the bone on the anterior aspect of the theca is removed. This operation seems to be suitable in cases of marked kyphosis. Thirteen patients were operated upon, three died. The neurological recovery was often rapid. With one exception all patients recovered motor and sensory function. Since the observation period was short, there could not be any evidence of reossification, but the disease had not advanced as judged radiographically.

DOBSON's (1951) material included 165 patients with paraplegia, who were treated by conservative methods. 48.5 per cent recovered completely, 20 per cent obtained improvement, 6.7 per cent had no improvement, and 24.8 per cent died.

JOHNSON et al. (1953) treated 79 patients conservatively, of whom 28 showed improvement. Thirteen patients were operated upon by laminectomy, with improvement in one case only. Operative evacuation of lesions was performed in seven cases with improvement in five.

BOSWORTH et al. (1953) studied 122 cases from 1937 to 1950. Fusion operation was considered to be the essential part of the treatment. Costotransversectomy plus sequestrectomy was performed in five cases with paralysis of very long standing. There was improvement in all cases excepting one. The total mortality was 56.55 per cent. Excluding those who on admission were hopelessly ill, the mortality was 29.3 per cent. Of the 75 patients who could be treated 33 (44 per cent) recovered completely. Thirteen (17 $\frac{1}{3}$ per cent) had restoration of function to about two-thirds, seven (9 $\frac{1}{3}$ per cent) showed no improvement, and 22 (29 $\frac{1}{3}$ per cent) died. Laminectomy was condemned.

Result in the present series

Follow-up investigation

The majority of patients were after operation controlled by continuous clinical and radiographic examinations, in the beginning every third month,

and after the process was regarded as healed every fourth to sixth month. Those who did not attend spontaneously were sent for, and all appeared. Thus, the follow-up investigation was personal and included all the patients.

The radiographs were examined by the writer, and when the interpretation was doubtful they were discussed with the radiologists of the hospital.

The length of observation was one to four years calculated from the date of operation. Data collected before July 1, 1954, are included in the record presented below.

Clinical results and definitions

For the whole material the results were as follows:	
Symptom-free and fully able to work	51
Slight complaints not affecting the ability to work and to undertake normal activities.....	11
Able to undertake part-time work.....	6
Unable to work because of spondylitis, sequelae or other tuberculous disease.....	18
Unable to work for other reasons.....	5
Died	9
Total 100	

It will be seen that 62 patients have no or mild complaints and are able to undertake full-time work. Six of these have changed their occupation. Most of those able to do part-time work are house-wives who in spite of some back trouble can carry out the greater part of the house-work. In the following they will be counted together with the other two groups of patients who are able to work.

Of the 18 patients who are unable to work because of spondylitis or sequelae six will probably remain definitely invalids. Nine are convalescents, most of whom will presumably be able to work within a reasonable length of time. The remaining three are radiographically healed; one is unable to work after having had tuberculosis with various manifestations for 30 years; two may be classified as unwilling to work.

All those five patients who are unable to work for other reasons are radiographically healed. Two of them are young men for whom no suitable employment can be found; after prolonged conservative therapy and many years' sanatorium regimen they find it difficult to adjust themselves to a normal life. One patient is unable to work because of heart disease, one is to undergo mammoplasty, and one is unable to work for psychic reasons. If these five patients, whose spondylitis is healed, are included, the total number of *clinically healed* will be 73.

Radiographic results and definitions

From the radiographic picture it is often very difficult to determine whether the vertebral lesions are healed, unless there is total block. The assessment is therefore bound to be subjective. It may be pointed out, however, that since radical operation was introduced our criteria for radiographic healing have become very strict. The reason for this is that we expect a cure that patho-anatomically is more reliable than the healing that was obtained by conservative treatment, when an arrest of the disease was often regarded as evidence of healing.

In interpreting the radiographs I have divided the radiographic results into the following types:

I. *Total block*. Complete fusion of the trabecular structure of the affected vertebral bodies. Possibly very small remnant of the intervertebral disc (Fig. 15 b, page 81).

II. *Partial block*. Wide bony bridging between the affected vertebrae and smooth outlines around a small remnant of the intervertebral disc or bone cavity (Fig. 10 c, page 73).

III. *Clear outlines*. Normal trabecular structure, absence of reactive changes in the surrounding tissue in the form of sclerosis, but no bony bridging (Fig. 16 c, page 83).

IV. *Doubtful*. This group includes some cases that were difficult to assess in which the contours are not quite clear and smooth. There remains a small reactive zone or suspected sequestrum but no soft-tissue shadow indicating an abscess.

V. *Not healed*. Distinct changes suggesting a destructive process, unclear contours, sequestra or abscess formation.

For the whole material, which consists of 101 cases, since one patient was operated upon in two different regions, the radiographic end-result was as follows:

Total block	13
Partial block	29
Clear outlines	10
Doubtful	16
Not healed	28
Died before X-ray control	5
Total	101

Patients included in the first three groups, *totalling 52, are assessed as radiographically healed.*

The radiographic result was controlled by planigraphy in 27 of the 52 cases listed as healed, and in 23 of the remaining 44 who were doubtful or not healed.

In the patients included in the "doubtful" group the lesions are regressing and most of them probably in the healing stage. Partial block is recorded in five of the cases. According to the old terminology these would be regarded as healed. The majority of patients in the group "not healed" have lesions that are regressing or stationary, and in these cases, according to the old terminology, the process would be designated as arrested.

I have tried to judge the prognosis in those 28 patients who showed no radiographic evidence of healing. In view of the fact that in the majority of these cases the observation period, as will be seen in Table 13, is less than two years, it may be expected that several of them will recover. I have calculated that on the basis of clinical and radiographic evidence 17 of these patients should, reasonably, obtain healing. In two cases, in which there have been several recurrences of abscesses and sinuses, the prognosis seems to be doubtful. Seven patients, four adults and three children, have such extensive destruction that healing may hardly be expected to occur. The three children have had their spondylitis for several years and before the operative treatment they had also undergone prolonged conservative therapy. The remaining two have died.

It is often difficult to judge the point of time at which a vertebral lesion should be considered to be radiographically healed. In 31 of the 52 cases classified as healed, however, we have series of radiographs which were made at regular intervals of about three months, so that the approximate time of healing could be stated. Six of the patients had radiographic evidence of healing in less than one year after operation. In one case with a lumbosacral, seemingly fresh, lesion and a small prevertebral abscess healing occurred four months after radical evacuation, and the patient returned to work three months after operation. Another fresh process in the thoracolumbar region healed in six months and a lumbar lesion with a large psoas abscess healed with total bony block in 11 months (Case 7 in the Case Reports). After one and a half year the number of radiographically healed cases had increased to 22, after two years to 28, and after two and half years postoperatively all the 31 cases were healed.

Influence of different factors on the results

Observation period. As has been mentioned earlier, the period of observation is too short for an assessment of the ultimate result of the operative treatment. It will be seen in Table 12, however, that 65.9 per cent of the

Table 12. Correlation between clinical results and observation time.

Observation time (yr)	No. of patients	Clinical results				
		Able to work (cases) (per cent)		Not able to work		Died
				Spondylitis or sequelae	Other reasons not tb	
0—1	4	—	—	—	—	4
1—2	47	31	65.9	11	2	3
2—3	30	22	73.3	5	2	1
3—4	20	16	80.0	2	1	1
Total	101	69		18	5	9

patients who were observed for only one to two years are able to work. The result is slightly less satisfactory than in the patients who were observed for a longer period.

With regard to the radiographic result the length of the observation period is of course the decisive factor and the number of not healed cases will be relatively larger for the patients with the shorter observation period (Table 13). Yet, no less than 42.6 per cent are healed of those who were observed for one to two years, and 38.3 per cent had both clinical and radiographic evidence of healing (Table 14).

Table 13. Correlation between radiographic results and observation time.

Observation time (yr)	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
0—1	4	—	—	—	—	—	—	4
1—2	47	8	9	3	42.6	8	18	1
2—3	30	3	11	4	60.0	4	8	—
3—4	20	2	9	3	70.0	4	2	—
Total	101	13	29	10		16	28	5

Table 14. Correlation between clinical and radiographic healing and observation time.

Observation time (yr)	No. of patients	Clinically and radiographically healed (cases) (per cent)	
0—1	4	—	—
1—2	47	18	38.3
2—3	30	15	50.0
3—4	20	11	55.0
Total	101	44	

Age. Of those eleven patients who at operation were under 20 years of age three had previously unrecognized spondylitis, and eight had had the disease for more than five years. At the follow-up six had clinical and five radiographic evidence of healing. A remarkable fact is that those three patients with previously unrecognized spondylitis showed radiographic healing, and that radiographic healing was recorded for only two of the cases of spondylitis recognized more than five years before operation. All these "late" cases had extensive destructions involving more than two vertebrae.

Of those six patients who were operated upon after the age of 60 years, none showed either clinical or radiographic evidence of healing. Two had died from the spondylitis.

Localization of lesion. It will be seen in Tables 15 and 16 that there is no marked difference with respect to clinical and radiographic healing between thoracic and lumbar spondylitis. A remarkable fact is that all the lumbosacral cases are healed both clinically and radiographically.

Table 15. Correlation between clinical results and localization of the lesion.

Localization	No. of patients	Clinical results			
		Able to work	Not able to work		Died
			Spondylitis or sequelae	Other reasons not tb	
Cervical.....	2	—	2	—	—
Thoracic.....	42	29	8	2	3
Thoracolumbar	10	8	—	1	1
Lumbar.....	42	27	8	2	5
Lumbosacral...	5	5	—	—	—
Total	101	69	18	5	9

Table 16. Correlation between radiographic results and localization of the lesion.

Localization	No. of patients	Radiographic results					
		Total block	Partial block	Clear outlines	Doubtful	Not healed	Died before x-ray control
Cervical.....	2	—	—	—	2	—	—
Thoracic.....	42	6	11	3	4	17	1
Thoracolumbar..	10	—	4	1	2	2	1
Lumbar.....	42	5	12	5	8	9	3
Lumbosacral....	5	2	2	1	—	—	—
Total	101	13	29	10	16	28	5

Table 17. Correlation between clinical results and duration of disease before radical operation.

Operation performed	No. of patients	Clinical results				
		Able to work (cases) (per cent)		Not able to work		Died
				Spondylitis or sequelae	Other reasons not th	
Early.....	56	40	71.4	9	1	6
Late:						
< 5 years.....	26	18	69.2	5	2	1
> 5 years.....	19	11	57.9	4	2	2
Total	101	69		18	5	9

Table 18. Correlation between radiographic results and duration of disease before radical operation.

Operation performed	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
Early.....	56	10	16	6	57.1	7	14	3
Late:								
< 5 years.....	26	3	10	4	65.4	5	4	—
> 5 years.....	19	—	3	—	15.8	4	10	2
Total	101	13	29	10		16	28	5

Duration of the disease. It will be seen in Tables 17 and 18 that with respect to clinical and radiographic results there is no distinct difference between the group of patients operated upon immediately after the establishment of the diagnosis (early) and those operated upon later but within five years after the diagnosis. On the other hand, the results, especially the radiographic results, are much more unsatisfactory in the group of patients who were operated upon later than five years after the recognition of the disease. The same difference is noted if both clinical and radiographic healing is considered (Table 19).

Sinuses were present at operation in ten cases. In all except one there was postoperative recurrence of sinuses or abscesses which healed spontaneously in three and after reoperation in three of the cases. Three patients died, two from the tuberculous process with sinus formation, the third from meningitis. Of the survivors all except one showed evidence of radiographic healing.

Paraplegia. Five patients had at operation marked spastic paralysis of the legs. The symptoms appeared for the first time a few months before operation. Two of these patients had earlier had paralysis which had abated after conservative therapy. Both had spondylitis of several years' standing

Table 19. Correlation between clinical and radiographic healing and duration of disease before radical operation.

Operation performed	No. of patients	Clinically and radiographically healed
Early	56	28
Late:		
< 5 years.....	26	13
> 5 years.....	19	3
Total	101	44

and exhibited acute angulation of the lower thoracic spine. In one of these latter cases radical operation had no effect on the neurologic symptoms which have become permanent. In the other four cases the paralysis subsided; motor function was restored completely within a period of time varying between two and six months.

In addition to paralysis of the legs, a disturbance in sensibility and urinary bladder paralysis developed in one patient during immobilization in a plaster bed shortly before operation. Judging from the operative finding the paralysis in the latter case appeared to be caused by mechanical pressure against the medulla by large sequestra. In the rest of the cases it was doubtful whether mechanical pressure was present.

Other tuberculous manifestations. A remarkable fact is that the clinical result is exactly the same in the group of patients who have an active extraspinal tuberculous process and the group without pre-existing manifest tuberculosis; in both groups 75 per cent of the patients are able to work (Table 20).

With respect to the radiographic result (Table 21), the number of healed cases is largest in the group with an active extraspinal tuberculous process, being 58.3 per cent, while it is 55.0 per cent in the group with no other previous manifestation of tuberculosis, and 46.4 per cent in the group

Table 20. Correlation between clinical results and other tb lesions.

Tb lesions	No. of patients	Clinical results					
		Able to work (cases) (per cent)		Not able to work		Died	Recur- rence
				Spondylitis or sequelae	Other reasons not tb		
Other active tb.	24	18	75.0	5	—	1	7
Other inactive or healed tb.....	56	35	62.5	12	3	6	21
No other active or healed tb...	20	15	75.0	1	2	2	8
Total	100	68		18	5	9	36

Table 21. Correlation between radiographic results and other *tb* lesions.

Tb lesions	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
Other active tb.	24	5	4	5	58.3	3	7	—
Other inactive or healed tb.....	56	6	17	3	46.4	10	16	4
No other active or healed tb..	20	2	7	2	55.0	3	5	1
Total	100	13	28	10		16	28	5

with pre-existing manifestation of tuberculosis. The number of patients who have both clinical and radiographic evidence of healing is relatively slightly larger in the group without other manifestation of tuberculosis (Table 22).

Table 22. Correlation between clinical and radiographic healing and other *tb* lesions.

Tb lesions	No. of patients	Clinically and radiographically healed
Other active tb....	24	11
Other inactive or healed tb.....	56	21
No other active or healed tb.....	20	11
Total	100	43

If we consider only the occurrence of *active* extraspinal tuberculosis, it will be seen in Table 23 that of those patients who have other bone and joint tuberculosis and those who have multiple lesions (pulmonary tuberculosis and coexisting tuberculosis of some other organ) all show clinical healing, while slightly more than half of those who have only pulmonary

Table 23. Correlation between clinical results and incidence of other active *tb* lesions.

Other active tb lesions	No. of patients	Clinical results				
		Able to work	Not able to work		Died	Reurrence
			Spondylitis or sequelae	Other reasons not tb		
Pulmonary.....	11	6	4	—	1	5
Urogenital.....	4	3	1	—	—	1
Bone and joint..	4	4	—	—	—	1
Multiple.....	5	5	—	—	—	—
Total	24	18	5	—	1	7

tuberculosis are healed. Two of the five patients with multiple tuberculosis, however, showed no radiographic evidence of healing. In the rest of the groups the radiographic result was relatively identical with the clinical result (Table 24). It will be seen in Table 25 that 11 of 24 patients (45.8 per cent) have obtained both clinical and radiographic healing. For the whole material the corresponding incidence is 43 per cent (Table 22).

Table 24. Correlation between radiographic results and incidence of other active tb lesions.

Other active tb lesions	No. of patients	Radiographic results					
		Total block	Partial block	Clear outlines	Doubtful	Not healed	Died before x-ray control
Pulmonary	11	2	1	2	2	4	—
Urogenital	4	2	1	—	—	1	—
Bone and joint	4	1	1	1	—	1	—
Multiple	5	—	1	2	1	1	—
Total	24	5	4	5	3	7	—

Table 25. Correlation between clinical and radiographic healing and incidence of other active tb lesions.

Other active tb lesions	No. of patients	Clinically and radiographically healed
Pulmonary	11	3
Urogenital	4	2
Bone and joint	4	3
Multiple	5	3
Total	24	11

An attempt was also made to find out how the operative treatment of spondylitis affects active changes in the lungs. Series of radiographs of lungs taken before and after operation were examined by the writer in co-operation with lung specialists. In most instances there was a slow regression of the changes in the lungs. One patient, however, who had tuberculosis of both lungs of eight years' standing with alternating periods of progression and regression, showed a distinct regression after the operation. In one single case there was no change in the radiographic appearance of the lungs. This was a case of a patient who had chronic disseminated tuberculosis of both lungs. The radiographic appearance remained unchanged during the first nine months following operation, but after this the condition progressed and terminated in death. It was found that in this case the operation had a primary beneficial effect on the patient's general condition and that the lethal outcome did not seem to depend on the operation.

Postoperatively, *new tuberculous lesions* were diagnosed in eight cases. In two cases a new lesion appeared in the adjacent vertebral segment, without involving the previously operated area. Both these patients fell ill three years after the first operation, after having been in good health and in full employment during the intervening time and having shown radiographic evidence of healing and normal sedimentation rate.

Two patients developed meningitis, one seven months, the other two and a half months after operation. Both had received three to four weeks' streptomycin therapy combined with PAS. One patient developed coxitis two and a half years postoperatively; he had been treated by streptomycin and PAS for eight weeks. In one patient osteitis of the ribs was diagnosed five months after operation. He had had six weeks' streptomycin therapy after operation, and three years previously streptomycin and PAS for pulmonary tuberculosis, altogether he had had over 100 g of streptomycin. One patient had miliary tuberculosis which had probably been present in a latent form before operation, when he had had a prolonged septic condition. In one patient renal tuberculosis was diagnosed two years after operation; because of giddiness streptomycin had been discontinued one week after operation. In this case, as in all the afore-mentioned ones, PAS was given for a prolonged period.

Operative findings. The clinical results are slightly better in those patients in whom only abscesses were found at operation than in those who had circumscribed or extensive bone destructions (Table 26). The incidence of clinical healing in the three groups is 75.8 per cent, 68.3 per cent, and 59.3 per cent, respectively. As was expected, the radiographic result is appreci-

Table 26. Correlation between clinical results and findings at operation.

Findings at operation	No. of patients	Clinical results					
		Able to work (cases) (per cent)		Not able to work		Died	Recur- rence
				Spondylitis or sequelae	Other reasons not tb		
No bone lesion	33	25	75.8	3	—	5	11
Well-defined cavity.....	41	28	68.3	4	5	4	16
Extensive destruction...	27	16	59.3	11	—	—	9
Total	101	69		18	5	9	36

ably better in the first two groups, viz. healing in 60.6 per cent and 58.5 per cent, respectively, while in the group with extensive destruction radiographic healing was recorded in only 29.6 per cent (Table 27). Both clinical

Table 27. Correlation between radiographic results and findings at operation.

Findings at operation	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
No bone lesion...	33	4	11	5	60.6	5	4	4
Well-defined cavity	41	3	16	5	58.5	7	9	1
Extensive destruction.....	27	6	2	—	29.6	4	15	—
Total	101	13	29	10		16	28	5

and radiographic healing was recorded for about half of the patients in the first two groups, and for less than one-third in the group with extensive destruction (Table 28).

Table 28. Correlation between clinical and radiographic healing and findings at operation.

Findings at operation	No. of patients	Clinically and radiographically healed
No bone lesion.....	33	17
Well-defined cavity	41	19
Extensive destruction.....	27	8
Total	101	44

In those 51 cases in which the operation was regarded as being radically performed, radiographic healing occurred in 52.9 per cent, whereas only 29.4 per cent of the cases of incomplete evacuation of the abscesses healed. After evacuation of only the soft-tissue abscesses 60.6 per cent showed evidence of radiographic healing (Table 29).

Table 29. Correlation between radiographic results and type of operation.

Type of operation	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
Evacuation of abscess.....	33	4	11	5	60.6	5	4	4
Radical evacuation of bone lesion..	51	7	15	5	52.9	8	16	—
Incomplete evacuation of bone lesion	17	2	3	—	29.4	3	8	1
Total	101	13	29	10		16	28	5

Bone filling. In 25 cases the bone cavities were filled with bone chips after radical operation, either homoplastic bone granulate (ORELL 1952, LINDAHL 1952) or autoplasic bone from ribs. In two of the cases the graft was subsequently removed because of abscess or sinus formation. Of the remaining 23 cases, 13 were assessed as being radiographically healed. In nine of these the grafts were completely transformed and incorporated with the surrounding trabeculae, but in the remaining four cases this did not occur to a full extent. Of the ten cases in which radiographic healing did not occur, the grafts were transformed in two cases although the process as a whole showed no signs of complete healing. Thus, the grafts were transformed in 11 of the 25 cases.

At operation the said bone cavities appeared to be well defined, but judging from the radiographic appearance the process was in some cases more extensive. This discrepancy between the operative findings and the radiographic appearance may be due to insufficient exploration of the diseased area or to a marked defence reaction. Cavities of this kind are less suitable for bone filling. Of 15 cases with radiographically extensive destruction only six healed, whereas circumscribed destruction was seen on the film in eight cases of which seven healed.

Before the radical operation *osteosynthesis between arches and spinous processes* had been carried out during conservative treatment in 39 cases. After radical operation such an osteosynthesis was done in 26 cases, in the beginning routinely in those cases in which the cavity had not been filled with bone, but subsequently only when the radiographic appearance suggested poor stability. Thus, 65 patients were treated by osteosynthesis, and it will be seen in Table 30 that 49.2 per cent healed and that, remarkably enough, of the remaining 36 a relatively larger number, 55.6 per cent, obtained healing.

Table 30. Radical operation with and without internal fixation between arches and spinal processes (*osteosynthesis*). All cases.

	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
Internal fixation . .	65	8	17	7	49.2	12	19	2
No internal fixation	36	5	12	3	55.6	4	9	3
Total	101	13	29	10		16	28	5

To get a better conception of the value of osteosynthesis the same evaluation was done for the early cases only (Table 31). It will then be found that 53.8 per cent are healed of the fused cases, and 60.0 per cent of the rest.

Table 31. Radical operation with and without internal fixation between arches and spinal processes (osteosynthesis). Early cases.

	No. of patients	Radiographic results						
		Total block	Partial block	Clear outlines	Healed (per cent)	Doubtful	Not healed	Died before x-ray control
Internal fixation...	26	5	6	3	53.8	4	8	—
No internal fixation	30	5	10	3	60.0	3	6	3
Total	56	10	16	6		7	14	3

So here, too, the result was slightly better in the group of patients who had not been subjected to osteosynthesis. It will be seen in the table that the incidence of total block is the same in the two groups.

Chemotherapy. This varied with regard to both the streptomycin dosage and the combination with other tuberculostatic agents. Fifty-five patients received 1 g of streptomycin daily for two to four weeks, eight patients for a shorter period than two weeks. For 35 patients the treatment lasted for six weeks or longer. Only streptomycin was given in 25 cases, combined with PAS in 67, with isoniazid in three and with conteben in two cases. The results seem to be independent of this varied chemotherapy. However, the material is too small to provide any clear information on this point. A severe toxic effect of chemotherapeutics was noted in one case, which will be described later.

Complications

Severe hemorrhage occurred in four cases, all with lumbar involvement. One patient died during operation from excessive loss of blood because of injury of the iliac vein. In the rest of the cases the hemorrhage did not influence the postoperative course. By the formation of thick scarry tissue about the psoas abscess the anatomical conditions had changed to such an extent that large veins were injured at the exposure of the vertebral lesions. With increased experience of operation such complications have not occurred.

Injury of the pleura at the exposure of lesions in the thoracic spine occurred in eight cases but gave clinical symptoms in only five. In one of the cases the symptoms were fairly alarming with hemothorax, which, however, subsided after repeated punctures of the pleura. All the cases healed without sequelae.

In two cases postoperative pleurisy developed without injury of the pleura. No tubercle bacilli were present in the exudate. The cause was probably a reactive unspecific inflammation. This may also appear without operation, for instance in one of the patients included in this material. He had earlier

had pleurisy of tuberculous origin and three years later renewed exudative pleurisy. On the latter occasion no tubercle bacilli were isolated from the exudate, and examination of the lungs provided no explanation of the development of pleurisy. It was then found that the patient had spondylitis with a paravertebral abscess, and the latter had in all probability caused the exudation in the adjacent pleura.

Postoperative paralysis of the intestine was not uncommon in operative cases of lumbar spondylitis, and in four of the patients it was fairly marked. One of them died of paralytic ileus. Autopsy showed extensive tuberculosis of the adrenal glands, which must be considered to have been the reason why the patient succumbed to the strain of the operation.

Postoperative shock of a severe nature occurred in three cases, in one it was due to insulin shock.

Thrombosis of the leg occurred in one case but gave no sequelae.

A *brain lesion* with hemiplegia of obscure origin was present in one case. Three days after operation the patient showed symptoms of hypersensitivity to streptomycin. 3 g of streptomycin had been applied locally in the wound in addition to the usual daily dose of 1 g intramuscularly. The drug was discontinued on the fifth postoperative day, when the symptoms became stormy. Nine days after operation streptomycin was re-instituted in a small dose, but had to be discontinued after two days because of similar allergic symptoms. Three weeks after operation spastic hemiplegia and aphasia were diagnosed. Concurrent symptoms of a general parenchymatous lesion, icterus and uremia appeared. The hemiplegia became permanent. Whether it was caused by purely allergic phenomena or embolism of the cerebral artery remains unclear.

Recurrence

Recurrence of sinuses or abscesses occurred in no less than 36 cases. Late recurrence was unusual, 29 patients had recurrence within nine months after operation.

The sinuses healed spontaneously in six cases. In the rest reoperation was performed, once in 23 cases, twice in four and three times in three cases. Such reoperations are usually less severe interventions than the primary operation. In 13 cases there was recurrence in the soft tissues only, the bone lesions appeared to be healed.

In nine cases the bone lesion could be attacked at reoperation, since at the primary operation only the abscess had been evacuated.

Two patients died with a persistent sinus, and three had a persistent sinus at the last follow-up. In one-third of the cases the sinus healed within six months after the primary operation, and in two-thirds within a year.

Such recurrence does not seem to influence the radiographic end-result; healing was recorded in 16 cases.

The incidence of recurrence was approximately the same whether only an abscess or circumscribed or extensive bone destruction was found at operation (Table 26). Nor does the presence of other tuberculous manifestations seem to affect the result (Tables 20 and 23).

Length of treatment

Four patients died in association with the operation. For the remaining 96 patients the length of hospitalization was as follows:

< 2 months.....	8 cases
2—4 months.....	33 cases
4—6 months.....	24 cases
6—12 months.....	20 cases
12—24 months.....	7 cases
> 24 months.....	4 cases

The mean length of hospitalization was 169 ± 12 days, excluding those who died during the first period of hospitalization and three patients who required permanent care. With the further exclusion of eight patients who had either been admitted long before radical operation was introduced as the standard method, or been operated on for some other tuberculous lesion at the same time, the mean length of hospitalization was 140 ± 7 days. The shortest hospitalization was 33 days in a case in which a psoas abscess was evacuated. Another patient was treated in hospital for 46 days after evacuation of a lumbar lesion. Forty-one patients were hospitalized for less than four months, and 65 for less than six months.

The short hospitalization does not seem to have had an unfavourable effect on the end-results. Of those patients who were hospitalized for less than four months 29 (70.7 per cent) were able to work, 10 were not able to work and two died. Radiographic healing was recorded in 23 cases (56.1 per cent). These figures differ only slightly from the corresponding figures for the whole material. Those who were hospitalized for more than two years were three children under 12 years of age, and one adult patient who had spondylitis and extensive pulmonary tuberculosis and whose spondylitis did not improve despite repeated operations and prolonged chemotherapy.

Interval between operation and resumption of work

Among the patients who were old enough to be in employment the interval between operation and return to work varied as follows:

2—6 months.....	13 cases
6—9 months.....	19 cases
9—12 months.....	11 cases
12—18 months.....	13 cases
18—24 months.....	6 cases
> 24 months.....	2 cases

It will be seen that no less than 43 patients returned to work within one year after operation, which is two-thirds of those who recovered their working ability.

No disadvantage of this early return to work was observed. Those recurrences that occurred in the form of sinuses or abscesses usually manifested themselves before the patients resumed work.

Deaths

Three patients died in connection with operation. One died during the operation from excessive loss of blood because of injury of the iliac vein at exposure of a lumbar lesion. Another patient died after operation from heart failure due to cardiosclerosis which had not been diagnosed before operation. Postoperative paralytic ileus occurred in the third case and terminated in death eight days after operation; autopsy showed extensive tuberculosis of the adrenal glands, which explained the lethal outcome.

A 70 year old man died of heart failure two and a half months after operation. The spondylitis had not responded favourably to the operative treatment, possibly because of previous very prolonged streptomycin therapy for generalized tuberculosis of the lymph glands.

Two patients died of tuberculous meningitis. In one case the symptoms of meningitis appeared seven months after operation and death occurred 20 months after operation. At autopsy the spondylitis had healed. The operative intervention consisted merely in evacuation of a lumbar abscess and was in all probability not the cause of the development of meningitis. In the other case the possibility cannot be ruled out that the operation may have affected the evolution, but it does not appear probable (Case 5 in the Case Reports, page 76).

One patient died three years after operation in amyloid disease due to prolonged sinus formation which started four years before operation. After operation, which consisted in evacuation of an abscess only, the patient refused all forms of treatment.

One patient died of miliary tuberculosis which was probably present in a latent form before operation, when he had a septic condition lasting one year (Case 6 in the Case Reports, page 79). The spondylitis itself was found to be healed at autopsy.

One patient who prior to operation had extensive tuberculosis of both lungs died of this disease 16 months after operation.

It may be summarized that the primary operative mortality was 3 per cent. In two of the cases, however, complications that are not attributable to the operative technique occurred.

In the remaining six cases the operation did not affect the course of the disease, except in one case in which it cannot be completely ruled out that meningitis developed as a sequel of the operation.

CHAPTER 9

Case Reports

To give a clearer background of the results reported here a brief account of some of the operative cases will be presented. They have been selected so as to provide examples of different types of disease course and surgical intervention.¹

Case 1. A 28 year old woman who had erythema nodosum and primary pulmonary tuberculosis in 1946. Spondylitis was diagnosed in Sept. 1947; she had then had back trouble for four months. She was treated by usual conservative therapy and osteosynthesis. In 1949 she had a subcutaneous abscess which was punctured several times.

Radiography in 1947 revealed a central cavity in the first and second lumbar vertebrae, normal margin of the psoas muscle. Despite the conservative treatment the size of the cavity increased, and in 1949 it involved the larger part of the vertebral bodies (Fig. 9 a). A bulging margin of the psoas was also seen, indicating an abscess.

Operation in Oct. 1949: Evacuation of the subcutaneous abscess and the psoas abscess. No communication was found between the abscess and the vertebrae which were not explored. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged from hospital six weeks after operation. She was in full employment two months after operation.

Radiographic controls showed successive decrease of the cavity which was defined by an increasingly marked sclerotic perifocal zone (Figs. 9 b and c). Since 1953 the process has remained stationary.

E.S.R. before operation was 30 mm. After operation it was still raised, varying between 25 and 40 mm, on a few occasions lower.

Comments: A case of psoas abscess originating from a large lumbar bone cavity. The abscess was evacuated. It had no demonstrable communication with the vertebrae. With our present knowledge we would also have explored the bone lesion. A cavity containing pus would probably have been found; after curettage this could have been filled with bone chips, and the prospects for healing of the bone lesion would have been good. Now the case has been included in the group of doubtful healing. Tubercle bacilli are probably still present in this bone cavity, and the process may be activated under unfavourable circumstances.

¹ Some of the reproduced radiographs were made at the last control. When the case had healed before that, the time of healing is stated in the report.

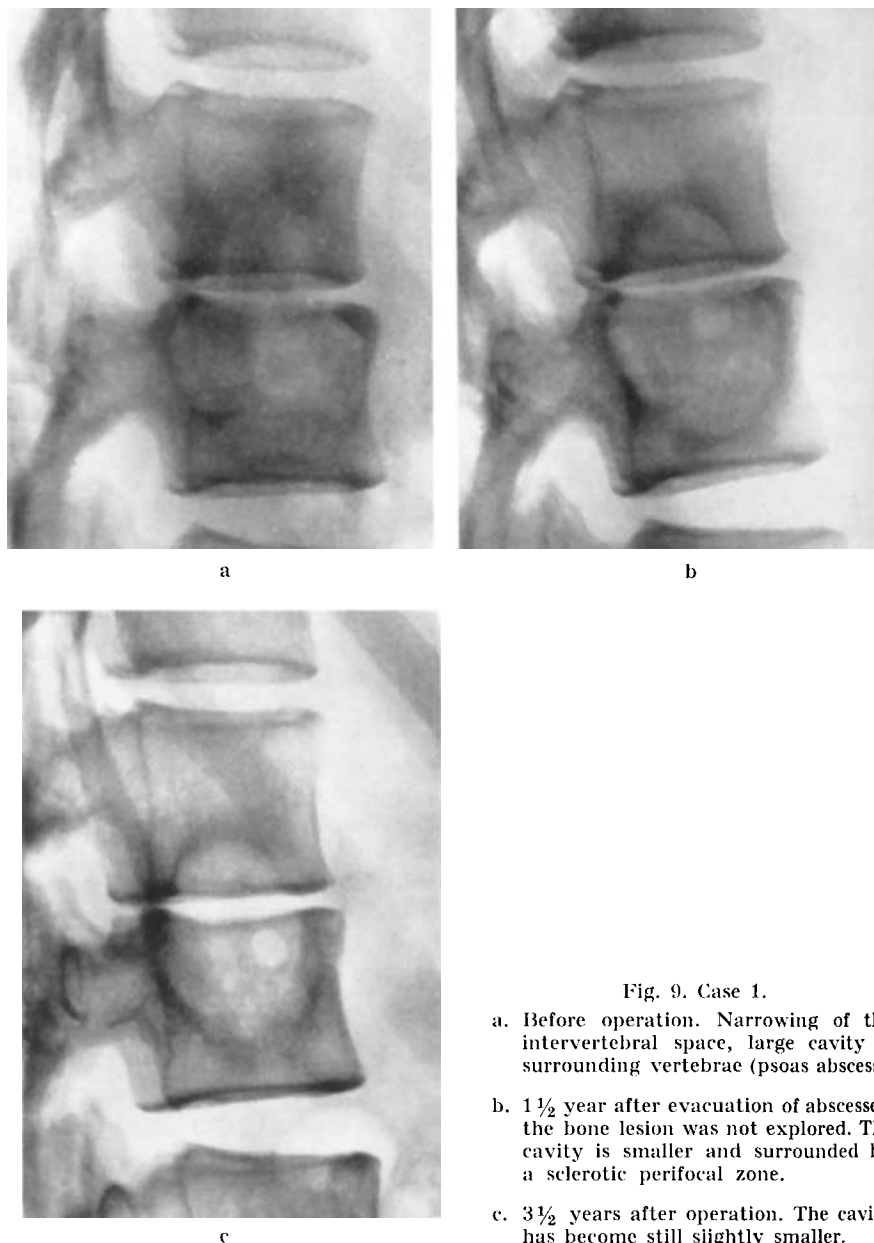


Fig. 9. Case 1.

- a. Before operation. Narrowing of the intervertebral space, large cavity in surrounding vertebrae (psoas abscess).
- b. 1½ year after evacuation of abscesses; the bone lesion was not explored. The cavity is smaller and surrounded by a sclerotic perifocal zone.
- c. 3½ years after operation. The cavity has become still slightly smaller.

Case 2. A 24 year old man who had pleurisy in 1946. Spondylitis was diagnosed in March 1949; he had then had back trouble for about 12 months. He received usual conservative treatment which was completed by osteosynthesis in Dec. 1949. A persistent large paravertebral abscess was punctured several times. The general condition deteriorated.

Radiography showed a bone cavity in the eleventh and twelfth thoracic vertebrae, containing sequestra, and a large paravertebral soft-tissue shadow (Fig. 10 a).

Operation in April 1950: Costotransversectomy and evacuation of abscess and bone lesion. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged eight weeks after operation. He was able to work six and a half months after operation and was then symptom-free.



a



b



c

Fig. 10. Case 2.

- a. Before operation. Bone cavity with sequestra, paravertebral abscess.
- b. 1 year after radical evacuation of bone lesion and abscess.
- c. 3 years after operation. (All the pictures were taken in the same oblique view.)

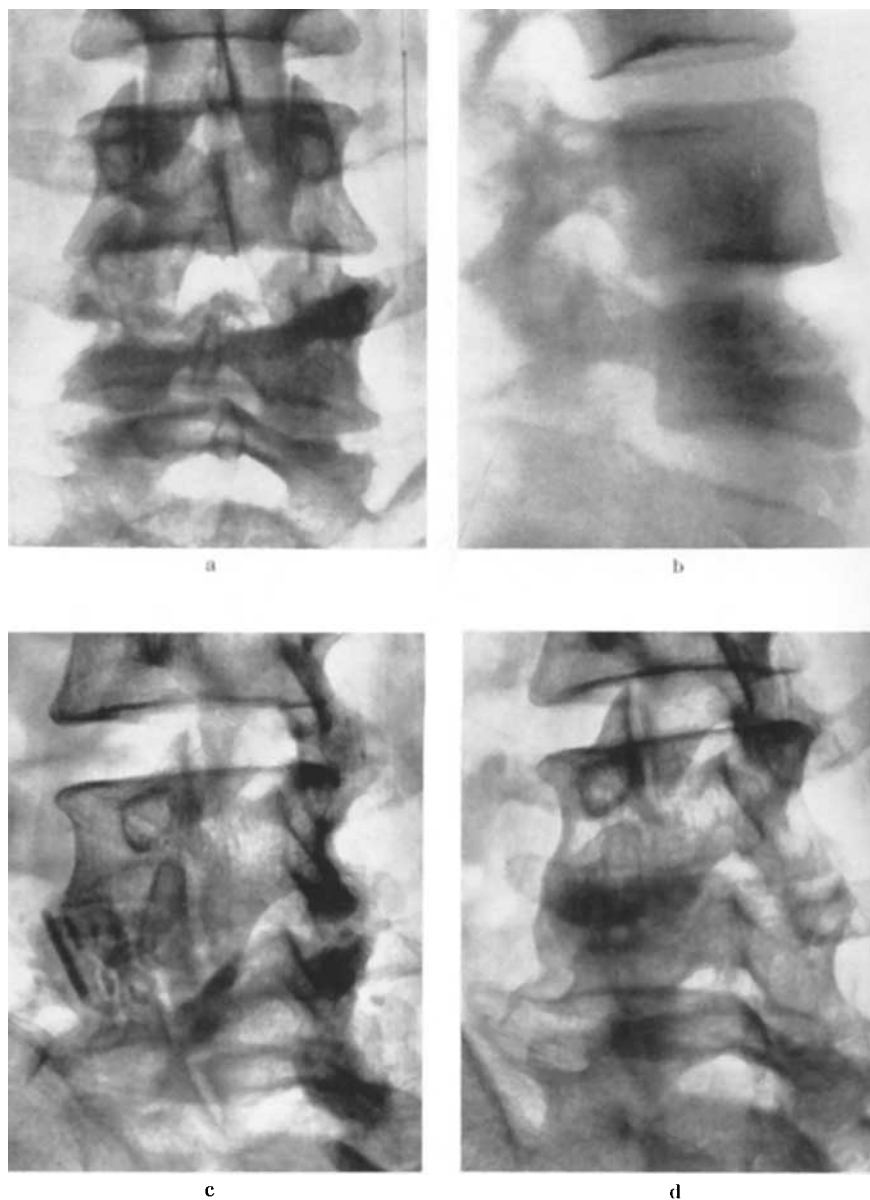


Fig. 11. Case 3.

- a. Before operation. Large bone destruction with sequestra (no abscess).
- b. Before operation.
- c. 2 months after radical evacuation of bone lesion and grafting; oblique view.
- d. 3 years after operation; oblique view.

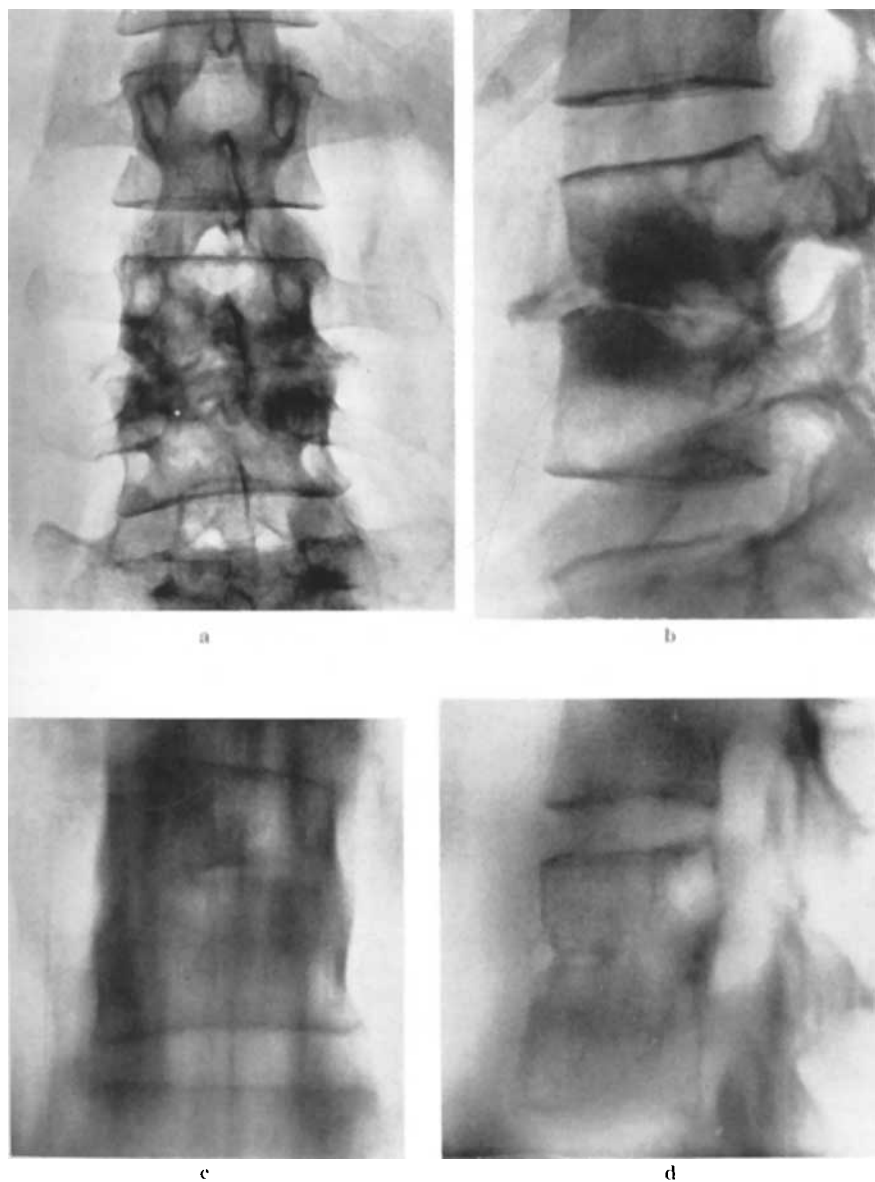


Fig. 12. Case 4.

- a. Before operation. Extensive paradiscal destruction, wide sclerotic perifocal zone, psoas abscess.
- b. Before operation. Wide sclerotic perifocal zone, sequestra.
- c. 2 years after radical evacuation of abscess and bone lesion, planigraphy in the anteroposterior view.
- d. 2 years after operation, planigraphy in the lateral view. All the sections show the same picture.

Radiographic controls showed diminishing of the bone cavity and increasing bony bridging (Figs. 10 b and c). This case was included in the group healing with partial block.

E.S.R. before operation varied but was mostly very high, maximum 83 mm. After operation it was rapidly normalized.

Comments: Thoracic spondylitis with persistent abscess; poor general condition after conservative treatment. After radical operation rapid healing and early return to work.

Case 3. A 49 year old woman who had diabetes mellitus. Spondylitis was diagnosed in Dec. 1949, she had then had back trouble for about nine months.

Radiography showed a large destruction involving the upper part of the fourth lumbar vertebra. There was no evidence of abscess (Figs. 11 a and b).

Operation in June 1950 after conservative treatment for six months: Evacuation of the lesion by retroperitoneal exposure. No psoas abscess was found, but there was a plum-sized bone cavity which was radically scraped out and filled with homoplastic bone. Insulin shock occurred after operation, the rest of the postoperative course was uncomplicated. The wound healed by first intention. The patient was discharged three months after operation, and was able to work eight months after operation. Slight back trouble on heavy exertion persisted.

First radiographic control (Fig. 11 c) showed bone grafts inserted in the cavity. Subsequently there was successive transformation of the grafts and increased bony bridging. The end-result is designated as healing with partial block (Fig. 11 d).

Comments: Large lumbar destruction without abscess. After radical operation and bone filling complete healing occurred in 1½ year.

Case 4. A 26 year old woman who was treated in a private hospital. Spondylitis was diagnosed in 1950; she had then had back trouble for about six months.

Radiography showed extensive paradiscal destructions in the third and fourth lumbar vertebrae, and a psoas abscess (Figs. 12 a and b).

Operation in Sept. 1950 without previous treatment: Evacuation of bone lesion and psoas abscess. The wound healed by first intention. The postoperative course was uncomplicated. The patient was discharged from hospital five and a half weeks after operation. She was able to work six months after operation, and has since then been symptom-free.

Radiographic controls showed successive block formation. The end-result was designated as healing with complete block, which was verified by planigraphy (Figs. 12 c and d).

Comments: Extensive lumbar destruction with psoas abscess. After radical operation and postoperative treatment for six weeks there was rapid clinical healing and early return to work. Complete block two years after operation.

Case 5. A 37 year old woman who had pulmonary tuberculosis, peritonitis and pleurisy in 1948. An artificial pneumothorax was made. Spondylitis was diagnosed in 1950; the patient had then had back trouble for nearly a year.

Radiography showed a paradiscal, well-defined destruction in the eleventh and twelfth thoracic vertebrae with an abscess paravertebrally and in the psoas (Figs. 13 a and b).

Operation in Nov. 1950 without previous treatment: Evacuation of the psoas abscess by extraperitoneal exposure. *The lesion could not be explored from the incision.* Five weeks later radical operation by costotransversectomy was performed, the lesion and the paravertebral abscess being evacuated. The defect in the bone was filled with bone chips from the excised rib.

The wound healed by first intention and the postoperative course was uncomplicated after both operations. The patient was discharged from hospital less than three months after the first operation. She was able to work 12 months after the first operation. The back trouble disappeared completely and the sedimentation rate became normal.

Radiographically the case was designated as healed with partial block $1\frac{1}{2}$ year after operation (Figs. 13 c and d). The contours were clear and even and the bone grafts appeared to be transformed.

After the patient had been completely symptom-free and in full employment with normal sedimentation rate for nearly three years, she fell acutely ill in Aug. 1953 with a temperature of about 40°C and pain in the back. Radiography showed no new changes. The condition was interpreted as acute septic infection, since the antistaphylococcal and anti-streptococcal titres showed appreciably raised values. Three months after the onset of the illness new spondylitis was diagnosed involving the vertebral segment immediately above the old operative field. The latter had not undergone any change.

Operation in Nov. 1953: Evacuation of abscess and lesion by costotransversectomy. The area of the previous operation was exposed and macroscopical healing seemed to have occurred. In the segment above there was a small paravertebral abscess and a minor destruction at the level of the intervertebral disc between the tenth and the eleventh thoracic vertebrae. The lesion contained pus but no sequestra. The bone walls were smooth and the cavity was no bigger than the tip of the little finger. Histologic examination showed tuberculous changes. Culture of the tubercle bacillus and guinea pig test were positive, routine culture was negative. The operation offered no technical difficulties. The postoperative course was initially uncomplicated. Later, tuberculous meningitis developed insidiously and terminated in death, despite intense chemotherapy. The diagnosis of meningitis was made ten weeks after operation and death occurred less than four months after operation.

Sagittal section in the midline of the autopsy preparation (Plate 1) revealed that at the site of the earlier evacuated lesion in the eleventh and twelfth thoracic vertebrae there was a small rest of the intervertebral disc anteriorly and a pea-sized rounded rest centrally. There was no macroscopic evidence of tuberculous destruction. Corresponding to the most recent lesion in the tenth and eleventh thoracic vertebrae, on the other hand, there was seen a purely caseous, fairly extensive, lesion. It extended closely to the dura which, however, appeared macroscopically normal. Considerable progress had taken place since the operation when only a small cavity containing fluid pus without caseation was seen.

Microscopic examination of the lesion in the eleventh and twelfth thoracic vertebrae evacuated three years later with filling of the defect with autoplasmic bone showed that the trabeculae of the bone graft had readily stainable nuclei and appeared to ramify into the spongy substance of the vertebral body. Thus, they were vital and incorporated (Plate 2 and 3). In a few places in the periphery of the operative field there were granulomas with giant cells containing anisotropic crystals, in all probability caused by talcum from the surgeon's gloves. The dura was normal at the level of the healed lesion but showed tuberculous changes further cranially by the caseous lesion.

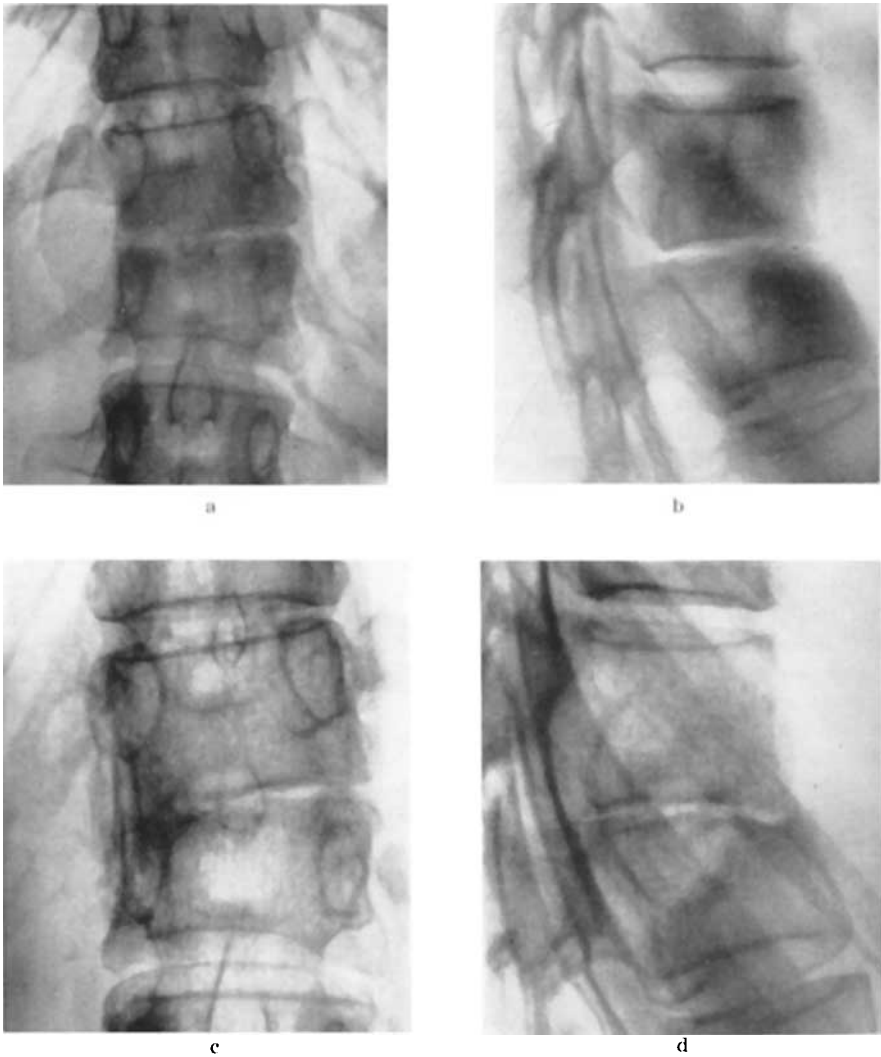
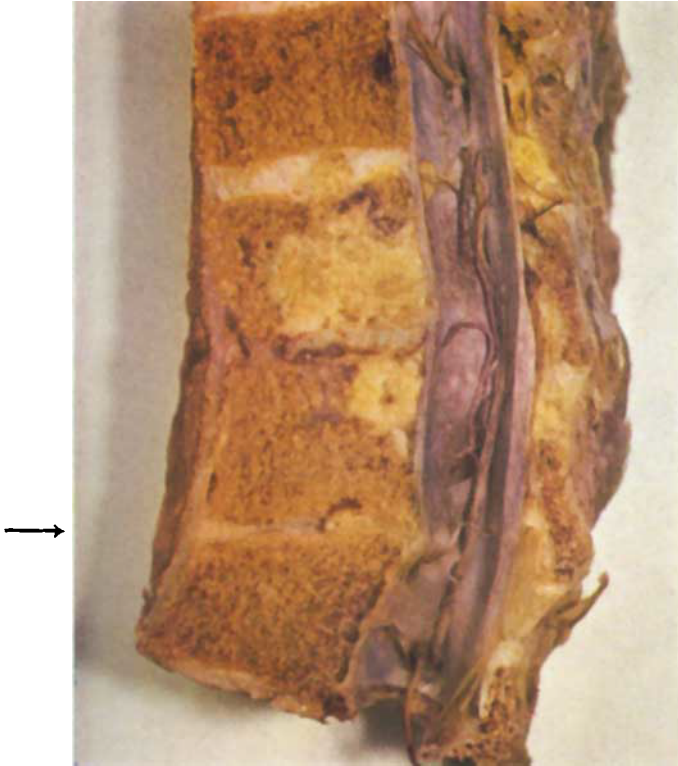


Fig. 13. Case 5.

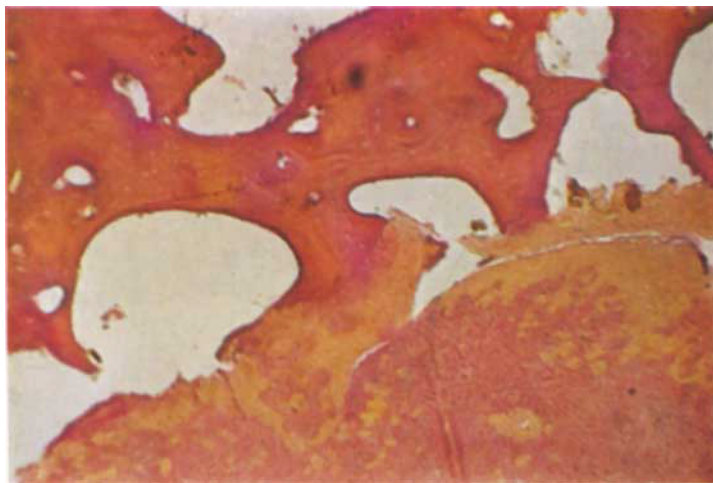
- a. Before operation. Narrowing of the intervertebral space, paradiscal destruction, paravertebral abscess.
- b. Before operation.
- c. 1½ year after radical evacuation of abscess and bone lesion, and grafting.
- d. 2 years after operation.

Comments: Spondylitis of the lower thoracic spine with psoas abscess treated by two-stage radical operation, with evacuation first of the psoas abscess and then of the bone lesion. Clinical and, seemingly, radiographic healing occurred. The patient was able to work and in good health for two years. Then she became acutely ill with evidence of acute septic infection;

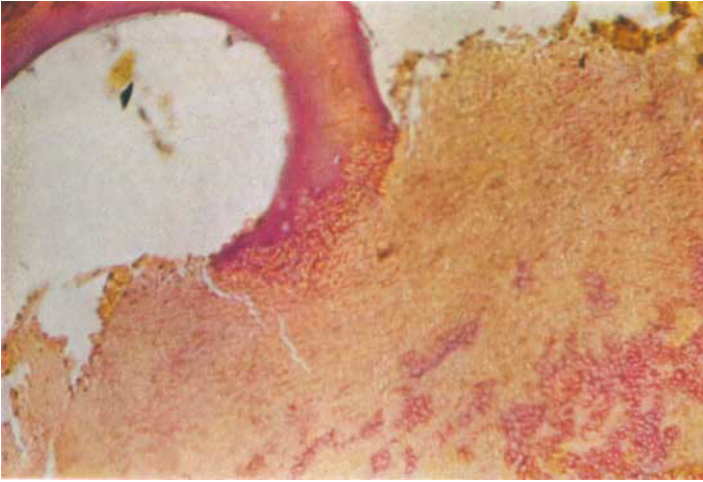


Post-mortem specimen. The arrow indicates the site of operation performed $3\frac{1}{2}$ years earlier, where small remnants in the intervertebral disc but no tuberculous changes may be seen. In the vertebrae above there are fresh caseous foci.

PLATE 2



Photomicrograph ($\times 60$) showing the site of the first operation, which in Figs 13 c and Plate 1 is indicated by the arrow. In the upper part are seen the trabeculae of the bone graft, with readily stainable nuclei. No tuberculous changes are seen.



Higher magnification ($\times 120$) from the same section. The transition from the graft to the spongy substance of the vertebra is clearly seen.

spondylitis developed, this time involving the segment above the site of the previous operation. After radical operation of the new lesion tuberculous meningitis developed and terminated in death. It is hardly probable that the dura was injured at operation. The meningitis is likely to have developed by direct spread from a progressive bone lesion. An interesting observation is that the new lesion did not appear at the site of the previous operation but in the segment next above without any visible signs of direct encroaching from the lesion that was first evacuated and had healed. Nor was there any observable soft-tissue abscess which may have persisted since the first operation. In this case the unspecific acute infection had probably weakened the body's defence mechanisms, with the result that microscopic latent tubercles (cf. RANDERATH's investigations quoted earlier) developed into a manifest tuberculous disease.

Case 6. A 66 year old man who became acutely ill in Aug. 1949 and was treated elsewhere on the diagnosis of septicaemia. He had frequent periods of fever. In Feb. 1950 an abscess was found in the gluteal region. In July 1950 a perianal abscess was incised and microscopic examination revealed tuberculous changes.

Radiography of the spine showed evidence of spondylitis of the fifth and sixth thoracic vertebrae. There was extensive paradiscal destruction with collapse of the affected vertebrae and a large paravertebral abscess (Figs. 14 a and b).

The patient was admitted to this department in the end of July 1950, that is, one year after the onset of the disease. After 2 ½ months of expectant treatment he was operated upon in Oct. 1950. Costotransversectomy was performed and the abscess and lesion were evacuated. The abscess extended in a distal direction as far as one could follow with the instrument down towards the diaphragm and had thus migrated into the gluteal region and the perineum, where sinuses were present at operation. The wound healed by first intention. The general condition improved markedly immediately after operation. The septic fever disappeared and the patient rapidly became afebrile. The sinuses healed. Three weeks after operation he had exudative pleurisy, which subsided spontaneously. Five months after operation multiple tuberculous lesions were found in the bone and soft tissues but the general condition was not affected. Twelve months after operation he had recurrence of the perianal abscess. Seventeen months after operation he died from miliary tuberculosis.

Post-mortem examination showed macroscopic healing of the spondylitis with complete block, as will be seen in the photograph of the macerated specimen (Fig. 14 c). Radiograph of this specimen (Fig. 14 d) showed complete transformation of the trabeculae and fusion of the two affected vertebrae. There were no inflammatory changes paravertebrally, but a gravitation abscess was found in the pelvic cavity.

Comments: Spondylitis of the upper thoracic spine with a large paravertebral abscess which had migrated into the perineum. The diagnosis was not made until one year after the onset of the disease which was interpreted as being an unspecific septicaemia. During that period miliary spread of the tuberculosis had probably occurred but had not yet become manifest. After radical operation the vertebral lesion healed completely, while a

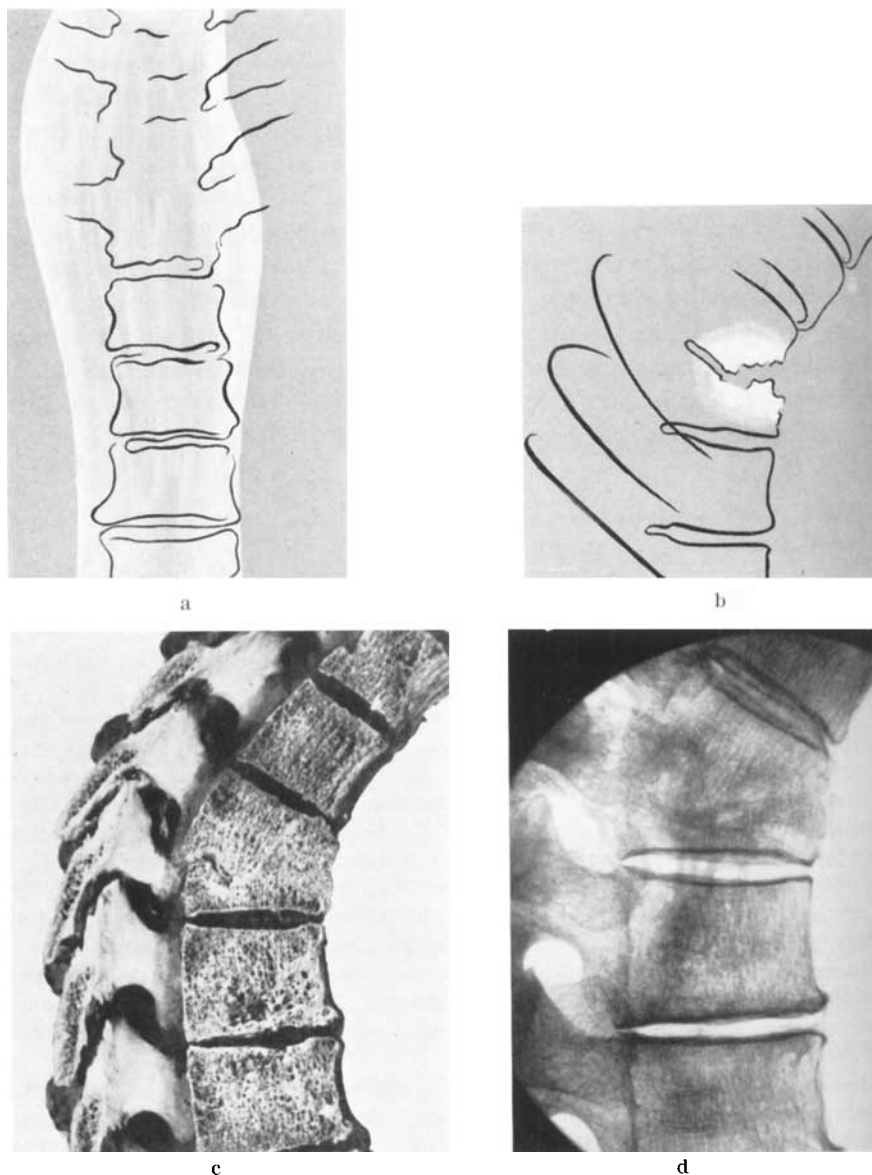


Fig. 14. Case 6.

- a. Drawing¹ after anteroposterior film before operation. Extensive paravertebral abscess.
- b. Drawing¹ after lateral film before operation. Paravertebral destructions with wedge-shaped collapse of the affected vertebrae. (The films are not suitable for reproduction. It is often difficult to render the upper thoracic spine plainly visible by ordinary radiographic technique; a planigraph was not available at the time.)
- c. Macerated post-mortem specimen. Total block. (The patient died 17 months after operation.)
- d. Radiograph of the same post-mortem specimen.

¹ The drawings are made by Dr BJÖRN LINDAHL.

gravitation abscess persisted as an isolated tuberculous process in the soft tissues. The patient died from miliary tuberculosis. The disease would probably have run a different course if the diagnosis had been established in time.

Case 7. A 26 year old woman who had pleurisy in 1946. In 1950 spondylitis was diagnosed by the finding of a large psoas abscess.

Radiography revealed a paradiscal destruction involving the fourth and fifth lumbar vertebrae and a large psoas abscess (Fig. 15 a).

Operation in Dec. 1950 without previous treatment: The psoas abscess was evacuated by extraperitoneal exposure, and in the vertebrae, corresponding to the radiographic appearance, was found a cavity filled with granulation tissue but no sequestra. One month later osteosynthesis between arches and spinal processes was performed. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged from hospital less than four months after the first operation. She was able to work eight months after operation, and was then symptom-free. One year post-operatively a sinus had developed in the scar. At reoperation a residual soft-tissue abscess was found. This last operation required only five weeks' hospitalization, and the patient was again able to work and symptom-free six weeks postoperatively.

Radiographic controls showed successive bony bridging and complete block formation eleven months after the first operation. The healing was verified by planigraphy (Fig. 15 b).

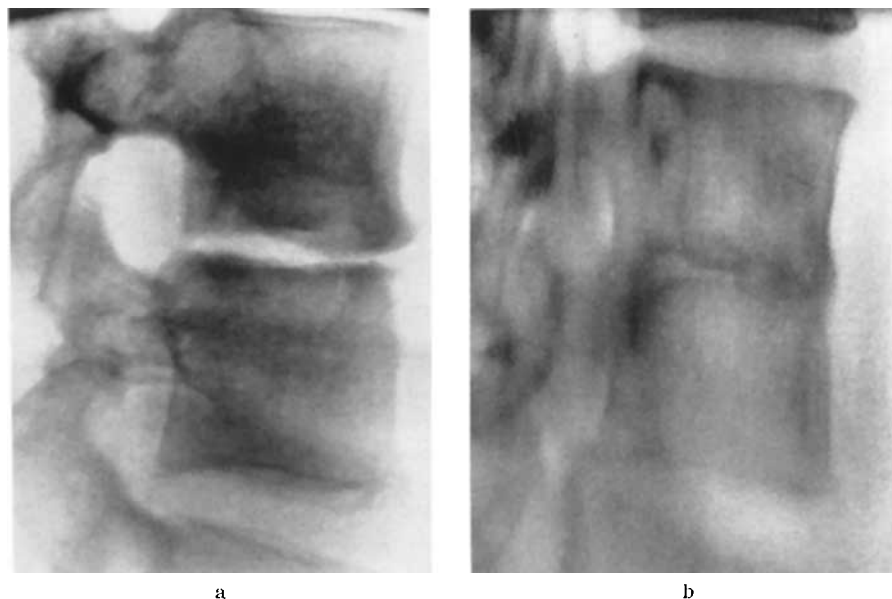


Fig. 15. Case 7.

- a. Lateral view before operation. Narrowing of the intervertebral space, paradiscal bone lesions (psoas abscess).
- b. Lateral planigram 2 years after radical evacuation of abscess and bone lesion. All the sections show the same picture.

Comments: Lumbar spondylitis with a large psoas abscess and a central cavity in the vertebral bodies. After radical operation the process was considered to be clinically and radiographically healed eleven months after operation, but within the next month a sinus developed at the site of operation. After evacuation of the soft-tissue abscess rapid and complete healing occurred.

Case 8. A 33 year old woman who had pulmonary tuberculosis and suspected tuberculosis of the intestine in July 1949. Spondylitis was diagnosed in Oct. 1949; she had then had back trouble for about a year. She was given usual conservative treatment, including osteosynthesis and punctures of a paravertebral abscess.

In Feb. 1951 radiography showed progress of the bone lesion and the abscess: paradiscal, fairly well-defined, destruction in the tenth and eleventh thoracic vertebrae with a large paravertebral abscess (Fig. 16 a).

Operation in May 1951: Costotransversectomy and evacuation of the abscess. On the surface of the vertebral bodies, at the level of the abscess, there was a shallow cavity with sclerotic walls, but there was no destruction centrally. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged from hospital six weeks after operation. At a follow-up two years later she had moderate backache, symptoms of insufficiency and slight limitation of motion. E.S.R. was normal.

Radiographically the process appeared to be healed with clear and even contours without bony bridging 15 months after operation. At the site of the abscess there was a very thin shadow (Fig. 16 b). The radiographic healing was verified by planigraphy (Fig. 16 c).

Comments: Spondylitis of the lower thoracic spine with a paravertebral abscess which progressed after conservative therapy including osteosynthesis and punctures. The process healed after operative evacuation of the abscess.

Case 9. A 26 year old man who had pulmonary tuberculosis in 1944. Spondylitis was diagnosed in May 1952; he had then had back trouble for about six months.

Radiography showed narrowing of the intervertebral space, and a paradiscal-central circumscribed lesion in the second and third lumbar vertebrae (Fig. 17 a). Planigraphy revealed distinctly the extension of the lesion (Fig. 17 b).

Operation in June 1952 without previous treatment: Evacuation of the vertebral lesion by extraperitoneal exposure. No psoas abscess was found and the surface of the vertebral body was macroscopically normal. After trepanation of the vertebra the lesion was entered and evacuated. The cavity was filled with homoplastic bone granulate. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged from hospital three months after operation. He was able to work nine months after operation, and was then symptom-free.

Radiography two years after operation showed still no certain transformation of the bone grafts. The bone cavity was clearly defined. The radiographic result was designated as doubtful healing.

Comments: Central bone destruction in the lumbar spine. Examination by planigraphy was of value in that it showed clearly the extension of the cavity. There was no abscess to indicate from which side the lesion was most easily accessible, but planigraphy provided information on this point.

- Fig. 16. Case 8.
- Before operation, oblique view. Narrowing of the intervertebral space, large paravertebral abscess.
 - 15 months after evacuation of abscess, oblique view.
 - 15 months after operation, lateral planigram. All the sections show the same picture.



a



b



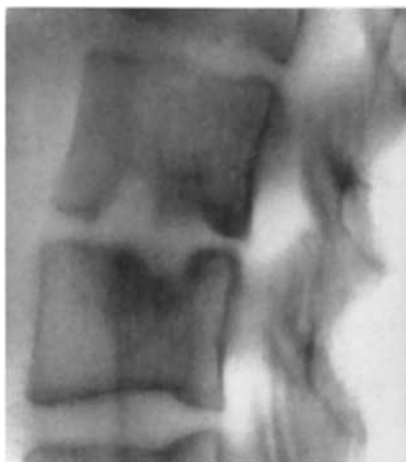
c

Case 10. A 44 year old woman who had pulmonary tuberculosis in 1930, spondylitis in 1935. Between 1935 and 1938 she was admitted to hospital on several occasion, receiving conservative treatment including osteosynthesis. In 1951 she had increasing back trouble.

Radiography at the first examination in 1935 showed well-defined destruction in the third lumbar vertebra without collapse (Fig. 18 a). Subsequently there was successive progress and some collapse of the vertebra despite conservative treatment (Fig. 18 b), and on admission in 1952 there were extensive destruction in the second, third and fourth lumbar vertebrae, extensive collapse and large, partly calcified, abscesses (Figs. 18 c and d).



a



b

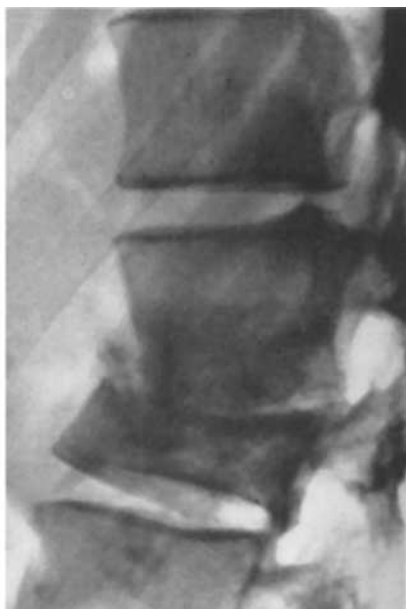
Fig. 17. Case 9.

- a. Before operation. Narrowing of the intervertebral space, paradiscal lesion.
 b. Before operation, lateral planigram. The extent of the lesion is clearly seen.

Operation in Oct. 1952: Evacuation of the abscess and the bone lesion by extraperitoneal exposure on the left side. A psoas abscess with fluid pus containing calcareous masses and sequestra was found, and it led directly into a large disintegrating cavity in the affected vertebral bodies, which contained sequestra and amorphous masses. The instrument was brought right through the vertebral bodies, and on the other side of them there was a



a



b

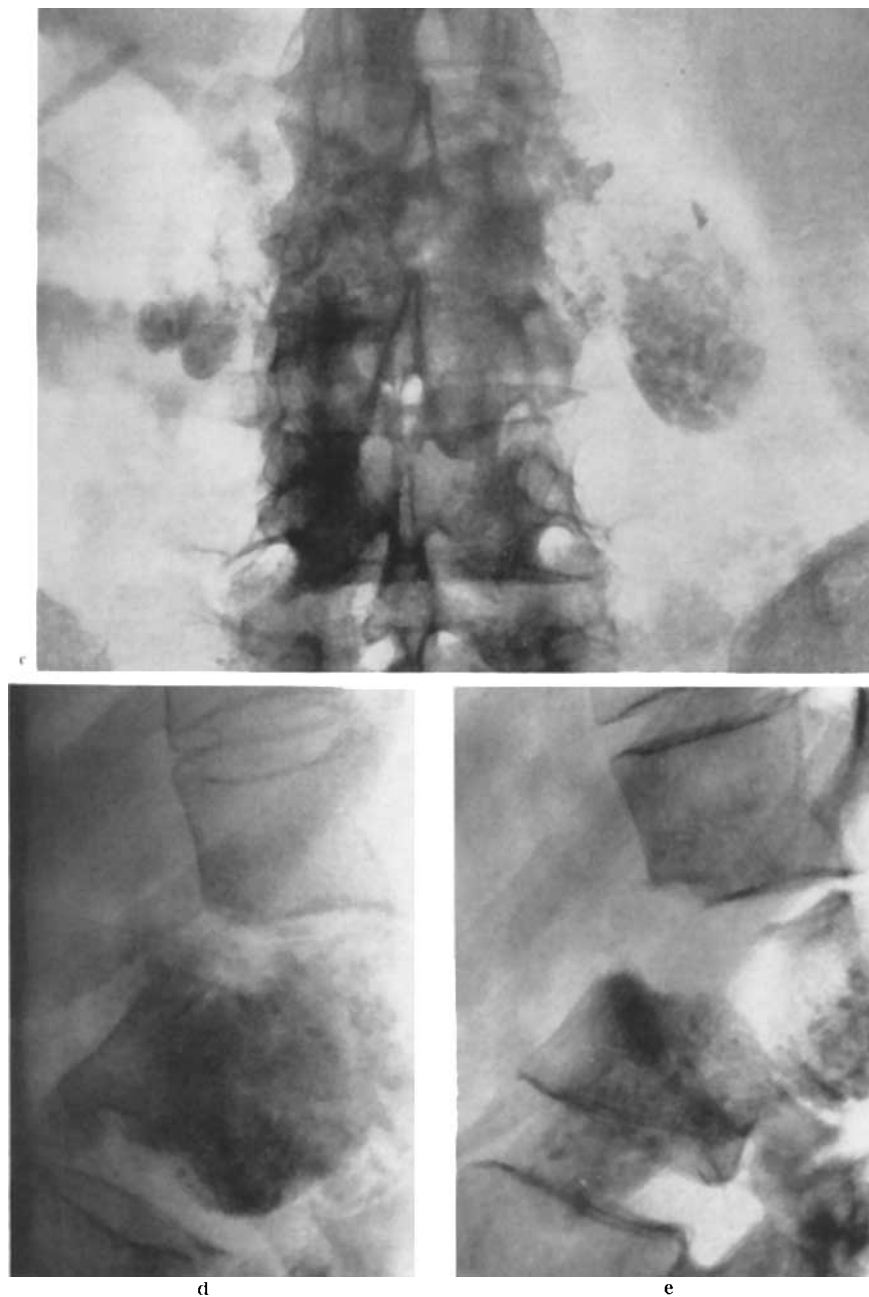


Fig. 18. Case 10.

- a. 17 years before operation. Extensive destruction without noteworthy collapse of the vertebral bodies, and sequestra.
- b. 14 years before operation. The destruction has increased and some collapse has occurred.
- c. Immediately before operation. Calcified psoas abscesses.
- d. Immediately before operation. Further increased collapse.
- e. 2 months after incomplete evacuation of abscess and bone lesion. No further collapse.

psoas abscess with similar content which was evacuated. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged from hospital less than two months after operation. For six months she had no back trouble, but subsequently pain resembling that in lumbago appeared and she had difficulties in walking erect. After a period some improvement occurred, and at the time of writing the back trouble is less marked than preoperatively, but she is not able to work.

Radiography after operation showed the large bone defect (Fig. 18 c). The small sequestrum-like bodies which were visible in the lateral view were probably caused by calcified material in the right psoas abscess which could not be radically evacuated from the left side where the exposure was made.

It may be mentioned that culture of the tubercle bacillus and guinea pig inoculation were positive for the pus.

Comments: Lumbar spondylitis which started with a circumscribed destruction without collapse of the vertebra, progressed continuously despite usual conservative therapy. Calcified abscesses, earlier regarded as evidence of healing, were in this case found to contain fluid pus with virulent tubercle bacilli. If this type of spondylitis had been treated by radical operation and the defect filled with bone at the recognition in 1935, when it was well defined, the prospects for healing would have been good (cf. Case 3).

Case 11. A 37 year old woman who had pleurisy in 1950. In June 1952 backache and gibbus developed, and in Sept. 1952 weakness of the legs. She sought medical advice in Sept., and spondylitis was diagnosed. On admission to hospital she had marked spastic paralysis of both legs.

Radiography revealed extensive destruction of the seventh and eighth thoracic vertebrae with collapse of the two affected vertebral bodies and large bilateral paravertebral abscesses (Figs. 19 a and b).

Operation in Oct. 1952 without previous treatment: Evacuation of abscess and lesion by costotransversectomy. The abscess led directly into the bone lesion which extended right through the vertebrae and appeared on the other side. Destroyed bone was radically removed and the defect was filled with bone chips from the excised ribs. Three and a half months later osteosynthesis between arches and spinous processes was performed. The wound healed by first intention and the postoperative course was uncomplicated. The paralysis subsided gradually within five months. The patient was discharged from hospital six months after operation when the neurological symptoms had disappeared except for heightened tendon-reflexes. The patient was able to do full work in her own home a little more than seven months after operation. At a follow-up 1½ year after operation she was completely symptom-free, able to work and also to undertake outdoor activities, such as skiing. Two years after operation normal delivery took place.

Radiography 10½ months after operation showed complete block verified by plain-radiography (Fig. 19 c).

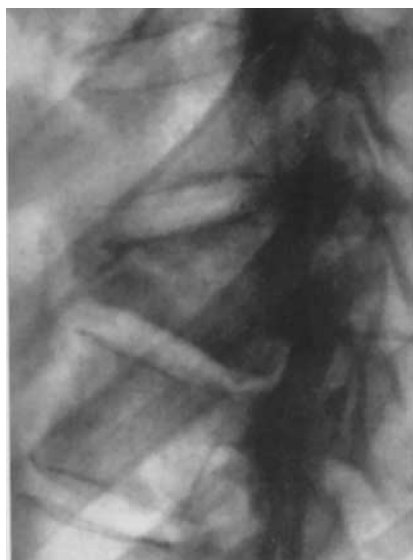
Comments: Thoracic spondylitis with collapse of the affected vertebrae, paravertebral abscess and paraplegia. Remarkably rapid healing occurred; clinical healing after seven months, radiographic block formation in less than a year. The paralysis cleared up completely.



Fig. 19. Case 11.

- a. Before operation. Large paravertebral abscess.
- b. Before operation. Wedge-shaped compression of the two affected vertebrae.
- c. 11 months after radical evacuation of abscess and bone lesion and grafting. Slightly increased collapse, total block.

a



b



c

Case 12. A 58 year old woman who had pulmonary tuberculosis in 1923, genital tuberculosis in 1933, and in 1946 renal tuberculosis treated by nephrectomy. Spondylitis was diagnosed in 1948. She received usual conservative therapy completed by osteosynthesis

in March 1949. In 1950 there was radiographic evidence of progress with pain in the back radiating into the left leg.

Radiography showed extensive paradiscal destruction in the third and fourth lumbar vertebrae with sequestra and a wide perifocal sclerotic zone (Fig. 20 a). Suspected psoas abscess.

In Jan. 1951 explorative extraperitoneal exposure was performed. No abscess was found, and since exploration of the lesion involved considerable difficulties, it was not attempted. The postoperative course was uncomplicated. Because of persistent complaints, especially the pain radiating into the leg, the patient was reoperated upon in Dec. 1952 and the lesion was evacuated by extraperitoneal incision from the other side. No psoas abscess was found but lateral to the affected vertebrae there was a small abscess which extended directly into a large cavity between the vertebrae. Sequestra, rests of degenerated disc tissue, and detritus were radically removed. The wound healed by first intention and the postoperative course was uncomplicated. The patient was discharged from hospital seven and a half weeks after operation. Postoperatively there was marked improvement with regard to the pain radiating into the left leg, but some back trouble persisted rendering the patient unable to work.

Radiographic examination four months after operation showed clear and even outlines, but there remained a defect without bony bridging (Fig. 20 b).

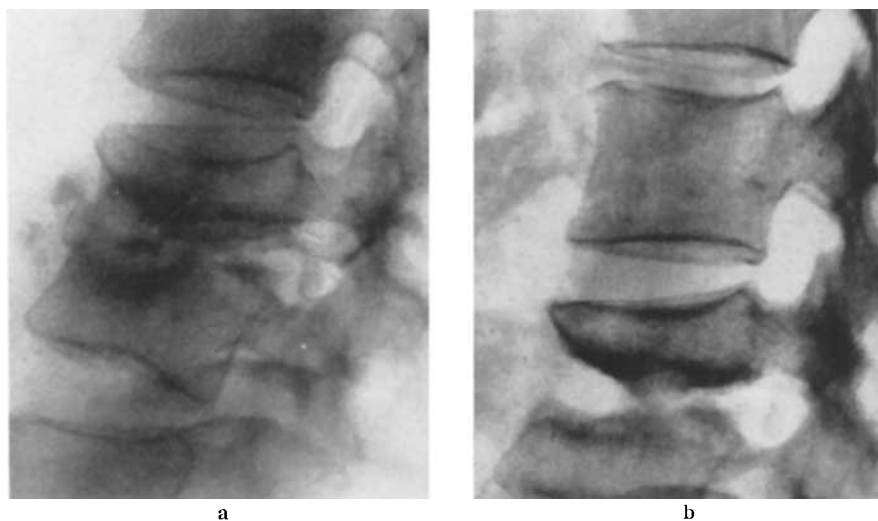


Fig. 20. Case 12.

- a. Before operation. Extensive paradiscal destruction, sequestra.
- b. 3 months after radical evacuation of bone lesion.

Comments: Old lumbar spondylitis which despite conservative treatment caused considerable back trouble with pain radiating into the left leg. After radical operation the pain subsided and there was radiographic evidence of healing with clear and even outlines but no bridging between the vertebral bodies, since the previously performed osteosynthesis prevented collapse.

CHAPTER 10

Discussion and conclusions

Since nearly all the patients who showed evidence of active spondylitis during the period covered by this study were treated by radical operation, I have no material for comparison at my disposal. The present series has therefore been compared with previously reported materials. It will be seen from Chapter 2 that the present material differs from other materials mainly in two respects: the number of children is small and the period of observation is short. A short period of observation may affect the results in such a direction that the number of recurrences and new tuberculous manifestations and the mortality will be lower than they may be in a follow-up investigation done later. On the other hand, the number of healed cases will probably increase with a prolonged period of observation. In a disease with such a slow course as spinal tuberculosis many cases will for a long time remain in a stage which has here been designated as doubtful healing. If the observation period were extended, the majority of these cases would probably enter into the stage of definite healing.

A comparison between our *clinical results* and those obtained before the era of chemotherapy shows that 62 per cent are fully fit for work and 73 per cent clinically healed, which is quite equal to the best results that have been reported.

By using radical operation, however, the length of treatment has been considerably reduced. The mean length of hospitalization is five months, as against one and a half year with conservative treatment.

The patients returned to work soon after operation, two-thirds of those who were able to work resumed their employment within the first post-operative year. Of BIERRING's patients two-thirds and of ALVIK's patients 58.16 per cent returned to work one year after the discharge from hospital. Since in my series the dates for resumption of employment are calculated from the operation, the difference is great.

It is obvious that a shorter length of treatment has great advantages from a social and economic view point. Vocational rehabilitation is seldom necessary. Furthermore, prolonged conservative sanatorium regimen has a psychic effect on the patient, which cannot be ignored. It is not seldom

found that the patients, especially children, have difficulties in adapting themselves to a normal life after the disease has healed, which was also observed in a few instances in the present series. Of those who underwent primary radical operation, on the other hand, all who showed radiographic evidence of healing are also able to work.

It may be claimed that in this series the criteria of *radiographic healing* have been considerably stricter than what is usually the case. Ankylosis between the affected vertebrae, either spontaneous or by osteosynthesis, has not by itself been regarded as evidence of healing, but restoration of structure details in the vertebrae has also been a criterium.

Healing occurred in 52 per cent, which is a slightly lower incidence than the best of the results reported earlier, which is 62 per cent. Considering that the criteria of radiographic healing were very strict and that the period of observation was short, our results may be regarded as better than earlier ones. Moreover, radiographic healing was obtained in a much shorter time than earlier, when healing usually required three to five years and never less than two years. In this series six patients obtained healing in less than one year. Of 31 patients, who were not selected in any other respect than that radiographic examinations were done continuously so that the time of radiographic healing could be judged, all were healed two and a half years after operation.

From the observations in this series it could not be established whether the *length and the combination of chemotherapy* had any influence on the results. We consider that streptomycin is the main drug. It is administered partly intramuscularly and partly locally as dry powder at operation. The length of the intramuscular course is successively increased to six or eight weeks and even more in complicated cases, the injections being given daily during the first three to four weeks and thereafter only twice a week. Except for a short period of time streptomycin has been given together with PAS or isoniazid or with both. The risk of the development of chemoresistance should be negligible with this regimen.

Whether *chemotherapy combined with usual conservative treatment* affects the healing and the length of treatment has not been made clear. No communications that throw light on this problem have as yet appeared. However, at a European symposium on the treatment of bone and joint tuberculosis in Sept. 1954 (not yet published) the contributions to the discussion made by the followers of conservative therapy gave the definite impression that streptomycin and other bacteriostatic agents do not affect the duration of the disease.

KASTERT in a paper read in Oct. 1953 reported the results of *operative evacuation of the lesions and prolonged local tuberculostatic treatment*. In his large series clinical healing was obtained in 69.2 per cent which is about the

same as the result obtained in the present series. Radiographic healing was recorded for 93.6 per cent. A more detailed report is anticipated; it will be especially interesting to learn how the radiographic result was judged.

When the *patient's age* is over 60 years the prognosis is found to be unfavourable with regard to both clinical and radiographic healing. In old persons the indications for operation should be very strict. However, the operation appears to be warranted when the clinical symptoms are marked, for instance when the patient has paraplegia, large abscesses or severe pain.

With respect to younger patients, under 20 years of age, the results have been found to be unsatisfactory when the patients have had their spondylitis for a long time. In a few instances, however, healing does occur, and the operation may therefore be justified.

The presence of preoperative *sinuses* is no contra-indication to operation. Admittedly, there was often recurrence of the sinus, but the late results were as good as those obtained in closed cases. The mortality was relatively higher in the sinus cases but this was not dependent on the operation.

The number of cases with *paraplegia* is so small that no definite conclusions can be drawn. In four cases of five motor function was completely restored in a short time. Equally good results with respect to motor function may be obtained by conservative treatment. With radical operation, however, there are the additional prospects of rapid healing of the process in the vertebrae. Therefore, in my opinion, radical operation should also be carried out early without previous conservative treatment.

Coexisting extraspinal tuberculosis, especially pulmonary tuberculosis, earlier used to have an adverse effect on the prognosis in patients with spondylitis. Mortality was very high and also in other respects the results were bad. In the present series the results in such cases were not influenced in this direction. Furthermore, the radical operation had a beneficial effect on active processes in the lungs. The development of new tuberculous manifestations occurred to a much smaller degree than earlier. This favourable effect on the whole tuberculous disease is partly to be attributed to the chemotherapy. It is probable, however, that the operative intervention is also of great importance in this respect; many patients received only a short course of chemotherapy. It seems to be advisable to evacuate the vertebral lesions first and remove toxic products, so that the patient will respond more favourably to the treatment of other tuberculous lesions.

In connection with the evacuation of the vertebral lesions *bone filling* was done in one-fourth of the cases without serious complications. Radiographic healing occurred in only 36 per cent of these cases. As has been mentioned earlier, we used homoplastic bone granulate or autoplasmic bone from ribs. Subsequently, however, spongy bone was used, which is greatly superior as bone-filling material. The spongy bone is plastic and can more easily be

packed snugly in the often irregular cavities. It is more quickly transformed, even if homoplastic bone is used.

The superiority of spongy bone as bone-filling material is beautifully demonstrated by radiographs of a patient who is not included in the present series, since she was operated upon at a later date. At operation a well-defined cavity was found which could be radically evacuated and closely inspected, after which it was packed with homoplastic spongy bone. Block formation had occurred ten months after operation (Fig. 21).

To sum up, bone filling is to be recommended in cases of well-defined cavities that can be radically evacuated. If preoperative radiographs show diffuse extension of the inflammatory process, and if at operation the bone walls are found to be sclerotic, then bone filling should not be done. The material most suitable for bone filling is spongy bone, autoplasmic or homoplastic.

Osteosynthesis between arches and spinous processes does not improve the results. In a few cases it may in fact be found that it will prevent or delay the spontaneous formation of a bony block between the vertebral bodies. Osteosynthesis should be carried out only in exceptional cases, when poor stability is suspected, and perhaps first and foremost in paraplegia. It should, however, not be performed until after the radical operation, so that some spontaneous collapse is not prevented.

Recurrence of a sinus or an abscess was recorded for 36 per cent of the cases, which is a very high frequency. In slightly more than half of this percentage, however, there was recurrence in the soft tissues only. Such cases offer no great therapeutic problems, they heal either spontaneously or by small re-operations. Further, the recurrences do not influence the radiographic end-results. The length of treatment is certainly prolonged but not remarkably so.

Recurrence may be explained either by incomplete operation or by tuberculous infection of hematomas in the operative field. One way of avoiding these is prolonged drainage of the lesions and local application of chemotherapeutic agents through the drainage tube. At the afore-mentioned European symposium on bone and joint tuberculosis in 1954 it was evident from the discussion concerning the evacuation of bone lesions in spondylitis that in some cases these drainage tubes, which were left for a long period, caused unspecific inflammation which was interpreted as an allergic reaction to the rubber tube; bronchial fistula was also reported to have occurred as a result of pressure. Toxic reaction in the hospital personnel after such prolonged local treatment is another risk that should not be neglected. Because of these considerations we prefer our method of primary closure of the wounds, especially since many cases heal by first intention, and since in the recurrence cases minor operations are followed by fairly prompt healing.

In reports from the time before the advent of chemotherapy the *mortality* varies between 13 per cent and 53 per cent. In the present series the total

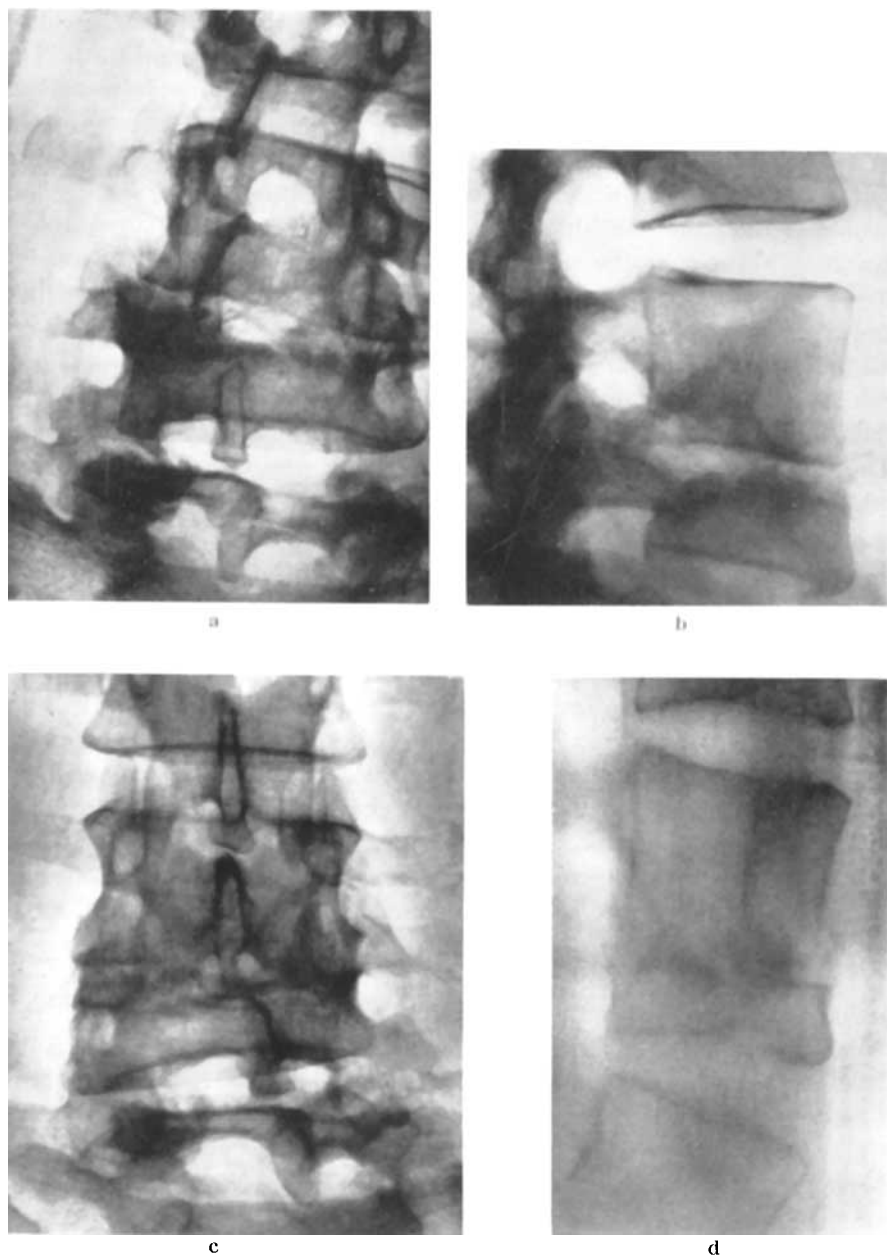


Fig. 21. Spondylitis with paradiscal lesion in L 4—L 5 (no abscess).

- a. Before operation.
- b. Before operation.
- c. 10 months after radical evacuation of bone lesion and filling with homoplastic spongy bone. The grafts were transformed; block formation.
- d. Lateral planigram 16 months after operation.

mortality was 9 per cent. In all the fatal cases death was due to a tuberculous disease, and 7 per cent had active spondylitis at the time of death. The primary operative mortality was 3 per cent.

There is as yet no information by which it can be established to what extent chemotherapy reduces the mortality after conservative treatment, but a considerable reduction in the incidence of deaths from tuberculosis should be expected. With surgery and local tuberculostatic treatment KASTERT has a mortality rate of only 1.75 per cent. From his reports published up to the present, however, it is not clear whether patients with a poor general condition are also subjected to operation. In our series almost all the patients with active spondylitis were operated upon, also those who could be regarded as poor surgical risks. We consider that removal of inflammatory products is the only possibility for these patients to recover. This circumstance may to some extent explain why the mortality rate is relatively high considering the short observation.

Serious *complications* attributable to the operative technique occurred in 3 per cent of the cases; one patient died from excessive loss of blood and one from meningitis; in one patient persistent hemiplegia developed. The remaining two postoperative deaths were due to complications of a kind that may occur after any major surgical intervention.

With a new operative technique some failures cannot be avoided. With increased experience fewer complications are to be expected. It may be mentioned that during the year following the period of time covered by this study a further 23 patients were operated upon by the same technique without any serious complications or deaths.

In the present series there are several examples showing that an abscess may remain as an isolated soft-tissue manifestation of tuberculosis after the bone lesion itself has healed or is in the process of healing. In such cases a *simple evacuation of the abscess* is of course sufficient to obtain prompt healing. This is probably the explanation why the results obtained in the cases in which only the abscess was evacuated were slightly better than in those where the bone lesion was also radically evacuated. But even if there is an active destructive bone lesion which cannot be attacked by surgery, it may be possible that after removal of the toxic products in the abscess the tissue reaction at the site of the disease will be more favourable, so that the spontaneous healing of the bone lesion will be hastened.

Even an *incomplete evacuation of lesions* gives results that do not differ too much from those obtained by complete evacuation. Some toxic products are removed, which should be beneficial. Further, the barrier that separates diseased and healthy tissue is broken down, so that the process of spontaneous healing is facilitated and the chemotherapeutic agents can reach the lesion in higher concentrations.

The *diagnosis* of tuberculous spondylitis has not been discussed in detail in this work, since no new aspects can be presented. One should, of course, aim at establishing an early diagnosis. The bone around old lesions often shows marked sclerosis which interferes with the re-ossification. However, if a lesion is attacked radically at an early stage, the re-ossification should occur more rapidly and the prospects for healing should be better. In the pre-chemotherapeutic era many surgeons hesitated to operate for skeletal tuberculosis in an early stage until after the appearance of a barrier against the surrounding healthy tissue, because of the risk of spread of the tuberculosis. With respect to spondylitis I scarcely think that the condition can be diagnosed until some limiting reaction has occurred, and therefore it would probably be safe to operate early, especially if it is done under a cover of chemotherapeutic agents.

Since spondylitis often gives very vague clinical symptoms, an early diagnosis can be made only by the aid of radiography. In such early cases the oblique view (WESTERMARK and FORSSMAN 1938) is very useful, in that it demonstrates periosteal reactions in the immediate neighbourhood of a lesion which is not visible in the usual anteroposterior and lateral views. In suspected cases, for instance when there is only narrowing of the intervertebral space, planigraphy is of great value in that it reveals small bone lesions. Planigraphy is particularly useful for regions that are technically difficult to examine by the routine technique, the upper and lower thoracic spine and the upper cervical spine. If there is a suspicion of spondylitis, one negative radiographic examination should never be considered sufficient, but the examination should be repeated after two to three months.

Because of the marked reduction in the incidence of tuberculosis in Sweden the number of severe cases of spondylitis has decreased, and spondylitis in children is now very rare. I am convinced, however, that radical operation is an excellent therapeutic method, also in the case of children and of patients with lower resistance than what is found in Sweden.

It may be mentioned here that one of the surgeons in this department (LJUNGQVIST 1954) in the Swedish Red Cross Field Hospital in Korea from January to May, 1954, carried out 25 operations for tuberculous spondylitis by the same technique as the one applied here. The patients were Korean civilians between 2 and 25 years of age. The majority were children and the mean age was 16 years. The primary results were very good. The postoperative course was uneventful in all patients excepting one who died from panmyelophthisis. The patients' general condition was much lower than in the series reported here, and many of them had large abscesses. But in these cases, too, the radical operation could be carried out without previous conservative treatment.

It is apparent that from a *patho-anatomical* point of view radical operation should be the most ideal treatment to ensure early and reliable healing of tuberculous spondylitis. In most cases bone sequestra are produced which with conservative treatment in exceptional cases are spontaneously expelled through sinuses but mostly will remain in the diseased area. It has been discussed whether spontaneous absorption can occur at all, at any rate it would be uncommon. At the radical operation both bone sequestra and also large sequestra of degenerated disc tissue can be removed, which is bound to facilitate the formation of block between the vertebral bodies. A spontaneous absorption of the disc would probably require long time.

A common symptom in spondylitis is irradiating pain corresponding to the affected segment. This pain may be explained not only by inflammation around the nerve-roots but also by purely mechanical pressure from sequestra of bone and of the intervertebral disc. The fact that after radical operation marked mitigation of the pain is noted immediately after the removal of large parts of the intervertebral discs seems to suggest that mechanical pressure plays an important role, analogous to that in rupture of an intervertebral disc. So, if the pain is severe radical operation is indicated also in those cases where there is no hope of a complete healing of the process.

With respect to peripheral bone and joint tuberculosis most authors consider that operative treatment is indicated if there are bone destructions. Thus, KREMER and WIESE stated: "Ist die radikale Operation möglich . . . so soll man radikal operieren und den Prozess wie eine Osteomyelitis behandeln."

Since chemotherapy was introduced we can treat spondylitis in the same way. We consider that radical evacuation of vertebral lesions can be carried out, and that in those cases in which complete evacuation cannot be done the operation helps to ensure more prompt and reliable healing.

When those who believe in conservative treatment definitely desist from evacuation of the bone lesions in spondylitis, although they consider that chemotherapy does not affect the bone process, their refusal must mean that they have surrendered to the technical difficulties. This study on radically operated cases has shown that the operations can be done without too great risks and that they lead to results that are much more satisfactory than those obtained by conservative treatment.

The questions made in the Introduction may be answered as follows:

The results reported here show clinical and radiographic healing which is sufficiently satisfactory to justify these radical operations, considering that the length of treatment is much shorter than with conservative therapy. The operative risks and the complications are not of such a magnitude that they outweigh the advantages.

In patients over 60 years of age the tendency to healing is poor also after radical operation and they should be subjected to operation only if the clinical symptoms are marked. All other patients who show evidence of active spondylitis with or without abscesses should be operated upon. Tuberculosis of other organs is no contra-indication.

Fusion between the affected vertebral bodies can be obtained by bone filling of a radically evacuated circumscribed bone cavity. The spontaneous healing is as good as or better than that obtained by osteosynthesis between arches and spinous processes.

Summary

This work is a study of 100 patients with tuberculous spondylitis, who were subjected to radical operation combined with chemotherapy. Apart from the fact that the number of children is smaller in this series it does not differ markedly from the materials in earlier reports on tuberculous spondylitis.

The bone lesions were exposed in the thoracic region by costotransversectomy, and in the lumbar region by extraperitoneal incision which in my opinion is much more suitable than a posterior incision with transversectomy which renders the access to the bone lesions more difficult.

In cases in which the disease had not been recognized earlier the operation was performed primarily without pretreatment. A poor general condition was not considered to be a contra-indication, nor was the presence of other tuberculous manifestations.

The postoperative orthopaedic treatment consisted in recumbency in a plaster bed for about two months, in complicated cases for a longer period of time.

At operation streptomycin powder was applied in the wound, usually in an amount of 2 g. The general chemotherapy was varied. In the beginning streptomycin was given for a short period as a protection during and immediately after operation. Subsequently the length of the streptomycin therapy was increased to six or eight weeks or more in complicated cases. Streptomycin was given together with one or two of the other tuberculo-static agents, PAS, conteben and isoniazid.

The concentration of streptomycin was determined in blood and pus from bone lesions and abscesses. It was found that in many cases the drug was surprisingly rapidly distributed from the general circulation to the tuberculous lesions, and that after intramuscular injections it reached the bone lesions in bacteriostatically effective concentrations. In some cases, however, no streptomycin was detected in the pus. Judging from these tests, the dosage used, 1 g of streptomycin intramuscularly daily and 2 g locally, appears to be adequate.

By the operative procedure employed patho-anatomical observations could be done in stages which earlier have not been subjected to study. In the majority of cases abscesses were found that communicated directly with the bone lesions, but in a few cases they were seemingly shut off from these lesions which were probably in the stage of healing. There were also cases in which an abscess was found as an independent soft-tissue process after the bone lesions had healed. In a few cases bone lesions occurred without an abscess and sometimes centrally in the vertebral bodies, the surface being intact. These closed bone lesions could also be attacked by surgery. The so-called anterior spondylitis which is generally considered to be a special form with superficial tuberculous destruction of the vertebral bodies is in my opinion caused by pure pressure from an abscess, at least in an early stage. The observations made during the operations support this view. The operative findings favoured the theory that spondylitis primarily is an osteomyelitis caused by hematogenous spread, which in fact since old is the commonest view.

Besides histological examination, culture for the tubercle bacillus, guinea pig inoculation and routine culture were carried out on material collected at operation. This comprehensive investigation was found to be of value in establishing a correct diagnosis, since there were cases in which one of the methods of examination for tuberculosis was negative, while one or the other two were positive.

The resistance of the tubercle bacilli was examined; reduced sensitivity to streptomycin was noted in only one case without any clinical resistance being present.

In eight cases other conditions than tuberculous spondylitis were revealed by histologic examination and routine culture of material collected at operation, chronic pyogenic osteomyelitis of the spine in six and tumours in two cases.

All the patients were after operation controlled by continuous clinical and radiographic examinations. The period of observation was one to four years. In view of the short period of observation it has been stressed that although the results may not be regarded as definite, the investigation is necessary to enable a further elaboration of the therapeutic method. Sixty-two patients were fully able to work and 73 could be regarded as clinically healed with respect to the spondylitis.

The mean length of hospitalization was 169 ± 12 days. Some patients were treated for a longer period in the hospital before radical operation was introduced as the standard method, and others were operated at the same time for other tuberculous manifestations. If these patients are not included, the mean length of hospitalization was 140 ± 7 days.

Two-thirds of those patients who were able to work returned to employment within the first postoperative year.

The criteria of radiographic healing were stricter than what is usually the case after conservative treatment. The radiographic results were divided into the following groups: I Total block; II Partial block; III Clear outlines; IV Doubtful; V Not healed. Patients belonging to the first three groups were judged as radiographically healed. Healing occurred in 52 per cent of the cases. 16 per cent were doubtful, but probably in the healing stage. Considering the short period of observation this radiographic result may be designated as very good.

Radiographic healing occurred in a much shorter time than after conservative treatment. Six patients obtained healing in less than one year, and of 31 patients who had been controlled by X-ray at regular intervals all had healed two and a half years after operation.

Among the patients who had been observed for only one to two years after operation no less than 65.9 per cent were clinically healed and 42.6 per cent radiographically healed.

None of the patients who were operated upon after the age of 60 years showed either clinical or radiographical healing and therefore radical operation in such cases is recommended only when the clinical symptoms are marked.

There was no appreciable difference in the therapeutic results between cases of thoracic and lumbar spondylitis.

Among the cases complicated by sinuses the mortality was higher than among the others, although this was not dependent on the operative intervention. For the rest, the results were proportionately the same as in uncomplicated cases. The sinuses certainly recurred in many cases but healed spontaneously or after re-operation.

Five patients in this series had paraplegia. With respect to both restoration of motor function and healing of the tuberculous process the results were so good that radical operation is recommended without previous expectant treatment.

The presence of coexisting extraspinal manifestations of tuberculosis did not influence the results. In the pré-chemotherapeutic era the prognosis was very unfavourable in such cases. Radical operation for the spondylitis seemed to have a beneficial effect on coexisting active pulmonary tuberculosis. Because of this observation we recommend that in multiple tuberculosis the vertebral lesions should first be attacked by surgery so as to ensure a more favourable response to the treatment of other lesions by chemotherapy.

New tuberculous manifestations occurred in eight cases, the spine being involved in two of these. In the latter the disease became manifest three

years after operation and was localized in the segment next to the previously operated one. One of these patients died and autopsy revealed that the lesion operated first had healed.

In 25 cases with well-defined bone cavities these were filled with bone after the radical evacuation. No serious disadvantages of this intervention were noticed. Thirteen of these cases could be regarded as radiographically healed. The method is recommended in cases of lesions that radiographically show a not very marked inflammatory perifocal reactive zone, and the most suitable bone filling material is spongy bone, autoplatic or homoplatic.

Osteosynthesis between arches and spinous processes did not improve the results; in fact, sometimes it prevented block formation between the vertebral bodies. This completing operation is probably not necessary except in those few cases in which poor stability can be suspected.

Serious complications occurred in two cases. One patient died from excessive loss of blood because of injury of the iliac vein. In another patient persistent hemiplegia of unclear origin developed, due either to a marked allergic reaction to streptomycin or to cerebral embolism. In a third patient meningitis developed and the possibility cannot be ruled out that it was a sequel of the operation.

Recurrence of a sinus or an abscess was recorded in 36 cases, being soft-tissue recurrence in more than half of the cases. The end-results were not adversely affected by these recurrences. Some cases healed spontaneously, but most of them were subjected to re-operation which usually was a smaller intervention than the primary operation. In spite of the high incidence of recurrence the writer considers that primary closure of the wounds is to be preferred to prolonged local chemotherapy by a drainage tube, which may cause trouble.

At the end of the period of observation nine patients had died, all from tuberculous disease. Three patients died in connection with the operation. In five of the cases the operation did not, from all indications, affect the unfavourable course.

Résumé

Cet ouvrage présente l'étude de 100 cas de spondylite tuberculeuse qui ont fait l'objet d'une opération radicale combinée à la chimiothérapie. Dans l'ensemble, la matière de ces travaux correspond par sa composition à celle que l'on trouve dans d'autres travaux publiés précédemment au sujet de cette maladie, à cela près que le nombre d'enfants y est moins élevé.

Pour exposer les foyers d'infection, on a procédé soit par costo-transversectomie dans la région thoracique, soit par incision extrapéritonéale dans la région lombaire, intervention qui me semble de beaucoup préférable à la section postérieure, la transversectomie, qui ne permet pas d'atteindre aussi facilement les foyers osseux.

Pour les cas récemment diagnostiqués, c'est l'opération qui constitua l'intervention primaire, sans traitement préalable. On n'a pas considéré qu'un mauvais état général fût une contre-indication, pas plus d'ailleurs que l'existence d'autres manifestations tuberculeuses.

Le traitement orthopédique consécutif à l'opération a consisté à maintenir le malade dans l'état de décubitus dorsal, dans un plâtre, pendant environ 2 mois, plus longtemps dans les cas compliqués.

Au cours de l'opération on a fait une application locale de streptomycine en poudre sèche, la quantité employée étant d'habitude de 2 g. Le traitement général par chimiothérapie a varié. Au début on a traité le malade à la streptomycine pendant une courte période, par mesure de protection, pendant l'opération et un certain temps après. Peu à peu on a prolongé le traitement, lui donnant une durée de 6 à 8 semaines, ou même plus dans les cas compliqués. On l'a combiné à l'application d'un ou de plusieurs des autres agents tuberculostatiques: PAS, conteben, isoniazid.

On a déterminé la concentration de streptomycine dans le sang et le pus issus des foyers osseux et des abcès, et on a pu constater que dans bien des cas la streptomycine était passée avec une rapidité étonnante de la circulation générale aux foyers tuberculeux, et que la streptomycine, à la suite d'injections intra-musculaires atteignait ces foyers de façon assez concentrée pour avoir une action bactériostatique efficace. Toutefois, dans

quelques cas, on ne trouva pas trace de streptomycine dans le pus. A en juger d'après ces examens, il a semblé que l'injection intra-musculaire d'1 g. par jour et l'application locale de 2 g. de streptomycine, telles qu'elles avaient été données au cours du traitement, était un dosage adéquat.

Grâce à l'intervention chirurgicale, on a pu faire des observations pathologico-anatomiques à des stades qui jusqu'alors n'avaient pas été étudiés. Dans la plupart des cas on a pu constater que les abcès communiquaient directement avec les foyers osseux, mais dans quelques cas il semble que les abcès aient été séparés de ces foyers qui, probablement, se trouvaient au stade de la guérison. On a même pu observer certains cas d'abcès de spondylite qui étaient une tuberculose des tissus mous indépendante, postérieure à la guérison des foyers osseux. Dans quelques cas, on a décelé l'existence de foyers osseux sans abcès, et parfois on les a découverts au centre même des vertèbres, sans que la surface ait été atteinte. Ces foyers osseux clos ont, eux aussi, pu faire l'objet d'une intervention chirurgicale. La spondylite dite spondylite antérieure que l'on considère d'habitude comme une forme spéciale du mal qui est une destruction superficielle des vertèbres par la tuberculose me semble, à la suite des observations faites au cours des opérations, la conséquence de la simple pression exercée par un abcès, au premier stade en tout cas. Ce que ces opérations ont révélé donne à penser que la spondylite est en premier lieu une ostéomyélite survenue par propagation hémato-génique, ce qui est, de longue date, l'opinion courante.

A l'examen histologique on en a joint d'autres: culture des tuberculo-bacilles, expérience sur les cobayes et cultures ordinaires sur la matière des opérations. Cet examen complet a été fort utile à la détermination du diagnostic exact. On a en effet rencontré certains cas où l'une des méthodes d'investigation donnait un résultat négatif alors que l'autre ou les deux autres donnaient une réponse positive.

On a examiné le degré de résistance des bacilles, et un cas seulement s'est révélé moins sensible à la streptomycine alors qu'on ne pouvait constater aucune résistance clinique.

Dans 8 cas, tant l'examen histologique que la culture ordinaire de la matière de l'opération ont révélé d'autres affections que la spondylite tuberculeuse; dans 6 cas il s'agissait de spondylite chronique non-spécifique et dans 2, de tumeurs.

Tous les malades ont été examinés après la fin du traitement, examen clinique et radiographique. La période d'observation allait de 1 à 4 ans. Etant donné que ce sont là des périodes assez courtes on a insisté sur le fait qu'il ne fallait pas encore considérer les résultats obtenus comme définitifs, mais on a fait valoir que l'étude poursuivie était nécessaire au perfectionnement de la méthode de traitement. 62 malades étaient entièrement

aptes au travail et 73 pouvaient être considérés comme guéris au point de vue clinique, en ce qui concernait la spondylite.

La durée d'hospitalisation moyenne du traitement a été de 169 ± 12 jours. Un certain nombre de malades avaient été soignés en clinique assez longtemps avant que la méthode de l'opération radicale n'eût été introduite comme méthode normale, et d'autres avaient été opérés en même temps pour une autre lésion tuberculeuse. Si l'on fait abstraction de ces cas, la durée moyenne du traitement a été de 140 ± 7 jours.

Les 2/3 des malades qui avaient recouvré leur aptitude au travail purent reprendre leur travail au cours de l'année qui suivit l'opération.

En jugeant les données de l'examen radiographique, on s'est montré plus stricte qu'on ne l'est d'habitude lorsqu'il s'agit des résultats du traitement classique. L'auteur a classé les résultats radiographiques dans les catégories suivantes : I Bloc total; II Bloc partiel; III Contours distincts; IV Douteux; V Non-guéris. On a considéré que les cas qui appartenaient aux trois premières catégories étaient guéris, radiographiquement. On a pu conclure à la guérison dans 52 % des cas. 16 % ont été considérés comme douteux, mais probablement en voie de guérison. Étant donné que la période d'observation est courte, on peut dire que c'est là un résultat radiographique très satisfaisant.

La guérison radiographique a été constatée dans un délai beaucoup plus court que lorsqu'il s'agissait de cas traités selon la méthode classique. Il y a eu 6 cas de guérison totale en moins d'un an, et sur les 31 sujets soumis au contrôle radiographique à intervals réguliers, on a pu constater la guérison dans un délai de 2 ans $\frac{1}{2}$ après l'opération.

Quant à ceux qui n'ont été observés que pendant 1—2 ans après l'opération, on a pu voir que la proportion des guérisons cliniques n'était pas inférieure à 65,9 % et que celle des guérisons radiographiques s'élevait à 42,6 %.

Aucun des malades opérés après l'âge de 60 ans n'arriva à la guérison clinique ou radiographique; c'est pourquoi on ne saurait recommander l'opération radicale dans ces cas que si les symptômes cliniques sont prononcés.

Les résultats du traitement n'accusent guère de différences selon qu'il s'agissait de spondylites thoraciques ou de spondylites lombaires.

Parmi les cas compliqués de fistules, la mortalité a été plus élevée qu'ailleurs, sans qu'il y ait de rapport entre ce fait et les interventions chirurgicales. Quant au reste, les résultats obtenus ont été assez semblables à ceux auxquels on est arrivé dans les cas simples. Il est vrai qu'il y a eu de fréquentes récurrences de fistules, mais suivies de guérison soit spontanée, soit à la suite d'une nouvelle opération.

Dans l'ensemble des cas étudiés, on relève 5 paraplégies. Les résultats, tant en ce qui concerne la reprise des fonctions nerveuses qu'en ce qui

touche à la guérison du processus tuberculeux ont été si bons qu'on recommande de procéder à l'opération radicale sans traitement préalable.

L'existence d'autres manifestations tuberculeuses extra-spinales n'a pas nui aux résultats. Avant l'avènement de la chimiothérapie, le pronostic qu'on établissait au sujet de ces cas donnait peu d'espoir. Il semble que l'opération radicale de la spondylite ait eu d'heureux effets sur la tuberculose pulmonaire active quand les deux affections ont coexisté chez un malade. D'où l'on peut conclure que dans les cas de tuberculose à manifestations multiples il convient de s'attaquer d'abord à la spondylite par une intervention chirurgicale, ce qui donne un meilleur point de départ pour soigner les autres lésions à l'aide d'agents chimiothérapeutiques.

Dans 8 cas, de nouvelles lésions tuberculeuses sont survenues, dont 2 dans la colonne vertébrale. Celles-ci se sont manifestées 3 ans après l'opération, localisées dans le segment contigu à celui qui avait été opéré. L'un de ces malades mourut et l'autopsie révéla que la première lésion était entièrement guérie.

Dans 25 cas, où les lésions osseuses étaient bien délimitées, on a plombé à l'os les cavités laissées par l'opération. On n'a pu observer aucun inconvénient résultant de ce procédé. A l'examen radiographique 13 de ces cas ont été considérés comme guéris. Cette méthode est à recommander pour les lésions où l'examen radiographique montre une zone de réaction péri-focale inflammatoire peu prononcée; ce qui convient le mieux au plombage, c'est l'os spongieux, autoplastique ou homoplastique.

L'ostéosynthèse des apophyses épineuses et des lames n'a amélioré en rien les résultats, parfois même elle a gêné la formation d'un bloc entre corps de vertèbres. Cette opération complémentaire semble bien n'être nécessaire que dans des cas exceptionnels, lorsqu'on a lieu de craindre un manque de stabilité.

Dans deux cas, des complications sérieuses survinrent. Un malade mourut d'une hémorragie, la vena iliaca ayant été endommagée. Un autre fut frappé d'hémiplégie durable dont on ne put expliquer l'origine, soit qu'elle vînt d'une réaction allergique violente à la streptomycine, soit d'une embolie cérébrale. Dans un troisième cas, on ne put exclure la possibilité d'une méningite occasionnée par l'opération.

Dans 36 cas, il y eut récurrence de fistules ou d'abcès, dont plus de la moitié ne concernaient que les tissus mous. Cela n'affecta pas les résultats. Certaines récurrences guérirent spontanément, mais dans la plupart des cas on fit de nouvelles interventions chirurgicales, en général moins graves que l'opération primaire. En dépit de la haute fréquence des récurrences, l'auteur estime que la suture primaire des plaies de l'opération est préférable à un traitement local chimiothérapeutique de longue durée au moyen de drains qui peut entraîner bien des inconvénients.

A la fin de la période d'observation, 9 malades étaient morts, tous à la suite d'une maladie tuberculeuse, 3 d'entre eux étaient morts à la suite de l'opération. Dans 5 cas, il n'y a pas lieu de croire que l'opération ait contribué à amener un tel dénouement.

Zusammenfassung

Die vorliegende Arbeit ist eine Studie über 100 Fälle von tuberkulöser Spondylitis, behandelt mit Radikaloperation in Kombination mit Chemotherapie. Die Zusammensetzung des Materials entspricht im grossen und ganzen derjenigen in bereits veröffentlichten einschlägigen Arbeiten, doch ist die Zahl der Kinder hier geringer.

Die Herde wurden in der Brustwirbelsäule durch Costotransversectomie und in der Lendenwirbelsäule durch Extraperitonealschnitt frei gelegt; letzterer erscheint mir wesentlich besser als ein hinterer Schnitt mit Transversectomie, welcher einen erheblich schlechteren Zutritt zu den Knochenherden gewährt.

Die Operation wurde in neu entdeckten Fällen primär, ohne vorangehende Behandlung ausgeführt. Schlechter Allgemeinzustand galt nicht als Kontraindikation, ebensowenig sonstige tuberkulöse Erscheinungen.

Die postoperative orthopädische Behandlung bestand in Bettruhe im Gipsbett, etwa 2 Monate, in komplizierten Fällen länger.

Bei der Operation wurde Streptomycin (Trockensubstanz) örtlich appliziert, gewöhnlich in einer Menge von 2 g. Die allgemeine Chemotherapie war wechselnd. Anfangs wurde Streptomycin kurze Zeit zum Schutz während und kurz nach der Operation gegeben. Schritt für Schritt wurde die Dauer der Streptomycinbehandlung ausgedehnt, auf 6—8 Wochen oder mehr in komplizierten Fällen. Streptomycin wurde mit einem oder mehreren der übrigen tuberkulostatischen Mittel, PAS, Conteben und Isoniazid, kombiniert.

Die Streptomycinkonzentration im Blut sowie in Eiter von Knochenherden und Abszessen wurde bestimmt, wobei man fand, dass das Mittel in vielen Fällen erstaunlich rasch aus dem Kreislauf in die tuberkulösen Herde gelangte, und dass es nach intramuskulärer Injektion die Herde in bakteriostatisch wirksamen Konzentrationen erreichte. In etlichen Fällen war indessen kein Streptomycin im Eiter zu finden. Die verwendete Dosierung, täglich 1 g Streptomycin intramuskulär sowie 2 g örtlich, erscheint auf Grund der vorliegenden Untersuchungen zweckentsprechend.

Das operative Eingreifen ermöglichte pathologisch-anatomische Beobachtungen in Stadien, welche bisher nicht den Gegenstand von Studien

gebildet hatten. In der Mehrzahl der Fälle wurden Abszesse gefunden, welche in unmittelbarer Verbindung mit den Knochenherden standen, aber in einigen Fällen waren sie anscheinend von diesen Herden getrennt, welche sich vermutlich im Stadium der Heilung befanden. Man konnte auch Fälle mit spondylitischen Abszessen als selbständige Weichteiltuberkulose, nach Ausheilung der knöchernen Herde, beobachten. In etlichen Fällen kamen Knochenherde ohne Abszess vor, manchmal zentral, im Innern des Wirbelkörpers, ohne dass dessen Oberfläche in Mitleidenschaft gezogen war. Auch diese geschlossenen Herde konnten chirurgisch angegangen werden. Die sog. vordere Spondylitis, die allgemein für eine Sonderform mit oberflächlicher tuberkulöser Zerstörung der Wirbelkörper gehalten wird, ist meines Erachtens — und ich stütze mich hierbei auf die Beobachtungen bei der Operation — durch eine reine Druckwirkung des Abszesses verursacht, wenigstens im Frühstadium. Die Operationsbefunde sprachen dafür, dass die Spondylitis primär eine durch hämatogene Aussaat entstehende Osteomyelitis ist, was auch von alters her die häufigste Ansicht ist.

Neben histologischen Untersuchungen wurden Tuberkelbazillenkulturen, Meerschweinchenimpfung und gewöhnliche bakteriologische Untersuchungen mit dem Operationsmaterial vorgenommen. Diese umfassende Untersuchung erwies sich als wertvoll für die Stellung einer exakten Diagnose. Es kamen nämlich Fälle vor, wo eine der Untersuchungsmethoden auf Tuberkelbazillen ein negatives, eine oder beide anderen aber ein positives Ergebnis lieferten.

Die Chemoresistenz der Tuberkelbazillen wurde ermittelt, wobei eine Herabsetzung der Streptomycinempfindlichkeit nur in einem Fall festgestellt werden konnte, ohne dass eine klinische Resistenz bestand.

In 8 Fällen ergaben histologische Untersuchung und gewöhnliche Bakterienzüchtung von Operationsmaterial, dass es sich um andere Erkrankungen als tuberkulöse Spondylitis handelte: in 6 Fällen um chronische unspezifische Spondylitis und in 2 um Tumoren.

Sämtliche Kranke wurden klinisch und röntgenologisch nachuntersucht. Die Beobachtungszeit war 1—4 Jahre. Im Hinblick auf die kurze Beobachtungszeit wird betont, dass die Ergebnisse zwar nicht als endgültig betrachtet werden können, dass aber die Ermittlung zwecks weiterer Ausarbeitung des Behandlungsverfahren notwendig ist. Von den Kranken waren 62 voll arbeitsfähig, und 73 durften hinsichtlich ihrer Spondylitis als klinisch geheilt gelten.

Die Behandlungsdauer betrug im Mittel 169 ± 12 Tage. Etliche Patienten wurden länger stationär behandelt, bevor die Radikaloperation als Normalverfahren eingeführt worden war, und andere wurden gleichzeitig wegen anderer tuberkulöser Affektionen operiert. Werden diese Fälle beiseite gelassen, dann ergibt sich eine Behandlungsdauer von im Mittel 140 ± 7 Tagen.

Zwei Drittel der Kranken, welche arbeitsfähig wurden, konnten binnen eines Jahres nach der Operation ihre Arbeit wiederaufnehmen.

Die röntgenologische Beurteilung war strenger, als es nach konservativer Behandlung der Fall zu sein pflegt. Verf. unterscheidet zwischen folgenden röntgenologischen Resultatgruppen: I Totalblock; II Partialblock; III Scharfe Umrisse; IV Zweifelhaft; V Nicht geheilt. Zu den drei ersten Gruppen gehörende Kranke wurden als röntgenologisch geheilt beurteilt. Heilung erfolgte in 52 % der Fälle; 16 % waren unsicher, wahrscheinlich aber im Stadium der Ausheilung. Im Hinblick auf die kurze Beobachtungszeit dürfte dieses röntgenologische Endergebnis als sehr gut bezeichnet werden können.

Röntgenologische Heilung erfolgte binnen wesentlich kürzerer Zeit als nach konservativer Behandlung. Rascher als binnen eines Jahres waren 6 Patienten geheilt, und bei 31 regelmässig röntgenologisch nachuntersuchten Kranken war in sämtlichen Fällen Ausheilung 2½ Jahre nach der Operation zu konstatieren.

Unter denjenigen Patienten, welche nur 1—2 Jahre nach der Operation beobachtet worden waren, waren nicht weniger als 65,9 % klinisch und 42,6 % röntgenologisch geheilt.

Keiner der Patienten, welche nach dem Alter von 60 Jahren operiert wurden, liess klinische oder röntgenologische Heilung erkennen; in derartigen Fällen wird daher die Radikaloperation nur dort empfohlen, wo die klinischen Erscheinungen ausgeprägt sind.

Zwischen Brust- und Lendenspondylitiden ergab sich kein wesentlicher Unterschied in bezug auf die Behandlungsergebnisse.

Bei durch Fisteln komplizierten Fällen war die Sterblichkeit höher als sonst, was jedoch nicht mit dem operativen Eingriff zusammenhängt. Abgesehen davon war das Ergebnis ziemlich das gleiche wie in unkomplizierten Fällen. Die Fisteln rezidierten freilich oft, heilten aber spontan oder nach wiederholter Operation.

Das Material enthält 5 Fälle mit Paraplegie. Die Resultate bezüglich sowohl Wiederherstellung der Nervenfunktion wie Heilung des tuberkulösen Prozesses waren so gut, dass primäre Radikaloperation ohne vorausgehende abwartende Behandlung empfohlen wird.

Das Vorliegen anderer, extraspinaler tuberkulöser Manifestationen beeinträchtigte die Ergebnisse nicht. Vor Einführung der Chemotherapie war die Prognose in diesen Fällen sehr schlecht. Die Radikaloperation der Spondylitis scheint eine gleichzeitig bestehende aktive Lungentuberkulose günstig zu beeinflussen. Infolgedessen wird empfohlen, bei multipler Tuberkulose zuerst die Spondylitis operativ anzugehen; hierdurch erhält man einen besseren Ausgangspunkt für die chemotherapeutische Inangriffnahme übriger Läsionen.

Neue tuberkulöse Veränderungen traten in 8 Fällen — in 2 von diesen in der Wirbelsäule — auf. Die letzteren offenbarten sich 3 Jahre nach der Operation und waren in dem Segment lokalisiert, welches dem zuvor operierten unmittelbar benachbart war. Einer der betreffenden Kranken kam ad exitum, und die Obduktion ergab, dass die zuerst operierte Läsion völlig geheilt war.

In 25 Fällen mit gut abgegrenzten Knochenhöhlen wurden letztere nach radikaler Ausräumung mit Knochen plombiert. Es wurden keine erheblichen Nachteile dieses Eingriffes beobachtet. Von diesen Fällen waren 13 als röntgenologisch geheilt zu betrachten. Das Verfahren wird für solche Läsionen empfohlen, welche im Röntgenbild eine wenig ausgeprägte entzündliche perifokale Reaktionszone aufweisen, und als Plombiermaterial eignet sich am besten spongiöser Knochen, auto- oder homoplastisch.

Osteosynthese zwischen Bögen und Dornfortsätzen verbesserte die Resultate nicht, sie bildete mitunter sogar ein Hindernis für die Blockbildung zwischen den Wirbelkörpern. Diese ergänzende Operation dürfte lediglich in Ausnahmefällen erforderlich sein, wo eine schlechte Stabilität zu befürchten ist.

Schwere Komplikationen traten in zwei Fällen ein. Ein Patient kam an Verblutung durch Verletzung der Vena iliaca ad exitum. Ein anderer Patient bekam eine dauernde Hemiplegie unklarer Genese; entweder handelte es sich um eine schwere allergische Streptomycinreaktion oder um eine zerebrale Embolie. In einem dritten Fall war nicht auszuschliessen, dass sich eine Meningitis infolge der Operation entwickelt hatte.

Rezidive von Fisteln oder Abszessen kamen in 36 Fällen vor, in über der Hälfte von diesen nur als Weichteilrezidive. Das Endergebnis wurde durch diese Rückfälle nicht verschlechtert. Zum Teil heilten sie von selbst aus, meistens aber wurden Reoperationen vorgenommen, welche im allgemeinen geringere Eingriffe waren als die Primäroperation. Trotz der hohen Rezidivfrequenz ist Verf. der Ansicht, Primärnaht der Operationswunden sei einer langwierigen örtlichen Chemotherapie durch Drainageröhre, welche einige Nachteilen mit sich bringen kann, vorzuziehen.

Am Ende der Beobachtungszeit waren 9 Patienten verstorben, alle an Tuberkulose. Im Anschluss an die Operation kamen 3 Kranke ad exitum. In 5 der Fälle übte die Operation allem Anschein nach keinen Einfluss auf den ungünstigen Verlauf aus.

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