

TUBERCULOUS SPONDYLITIS
A CLINICAL STUDY WITH SPECIAL REFERENCE
TO THE SIGNIFICANCE OF SPINAL FUSION
AND CHEMOTHERAPY

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PREFACE

The theme of the present investigation was suggested to me 1955 by my former teacher, Professor K. E. KALLIO, present Chief of the Clinic for Orthopaedics and Traumatology, University of Helsinki. He has followed the progress of my work with untiring interest. I wish to say that I feel deeply grateful for the help and encouragement that Professor KALLIO has given me.

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I INTRODUCTION

In Finland, tuberculosis has always had great social and medical significance. The resources available for combatting bone and joint tuberculosis have always been limited. The small provincial, urban and university hospitals have not been able to allow these patients, whose care normally takes two to three years, take up their few beds. The new scheme for central hospitals has not yet been completely realized.

According to the Finnish Association for the Prevention of Tuberculosis (1953), at the beginning of this century seven to eight thousand persons died annually of pulmonary tuberculosis. By 1952, the mortality had dropped to 2,042. The annual reports of the Central Medical Board state that during the period 1929—1938 a total of 7,434 cases of bone and joint tuberculosis were treated. Since then, the statistics have been upset by the war, and the annual reports of the Central Medical Board have not been compiled.

The treatment of tuberculous spondylitis is usually taken to imply treatment in sanatoria. In Finland there are no sanatoria for adults with bone and joint tuberculosis. It is thus of interest to see what results have been obtained here without sanatoria.

The method developed about 1911 by Albee with fusion of the spine was introduced into Finland by F. LANGENSKIÖLD in about 1923. Streptomycin became available in this country in 1947. Isoniazid arrived in 1951 and PAS in 1952. There is a feeling that cases make a better recovery than before. Nevertheless it seems obvious that the new drugs do not give complete protection against recurrences and complications. And now that radical operations on the tuberculous lesions have come into wider use, an evaluation of the results obtained by the earlier methods of treatment seems indicated.

II REVIEW OF THE LITERATURE

The Clinical Picture

Age and Sex Distribution.

HENDERSON (1917) stated that the greatest frequency of tuberculous spondylitis occurred at the age of 25 years. ZUR NEDDEN (1919) held that between 50 and 60 % of all cases arose in patients aged from one to ten, and LESKINEN (1923, 1924) considered that 81.6 % of those affected fell ill during the first fifteen years of life. DUBOIS (1927) thought that 75 % fell ill during childhood, and KYRKLUND (1928) affirmed that the greatest frequency occurred before the age of six. It was the opinion of RUMMELHARDT (1930) that those most commonly affected were young persons between the ages of twenty and thirty. PALMÉN (1931) stated that almost one half of the cases were of children less than ten years of age, and KUSS (1931) found that in 52.3 % the disease developed after school age. HARRIS and COULTHARD (1940) and CLEVELAND (1940) found the highest incidence from 21 to 30 years of age. In a series of operatively treated cases, KLOSSNER (1949) gave the greatest incidence as occurring between the ages of fifteen and thirty. ALVIK (1949) stated that the largest group, in excess of 23 %, was that of persons between the ages of twenty and twenty-five.

WULLSTEIN (1904), LESKINEN (1913, 1923, 1924), STALMANN (1935), LAMPADIUS (1937), WALHEIM (1939) and HEMPRICH (1940) stated that the frequency of tuberculosis of the spine was greater among women than among men. In THOMSEN's (1939) series the number of men exceeded that of women (344/255), and MEYERDING (1940) stated that the proportions were 37.7 % women, 62.3 % men.

Thus publications have indicated a gradual shift towards older age groups.

Site of the Lesion.

The different parts of the spine are not equally liable to be affected by tuberculosis. In Table I can be seen the percentages according to published reports.

TABLE I
The Regions of the Spine Involved, Given as Percentages.

Author	Year	Cervical	Cervico-thoracic	Thoracic	Thoraco-lumbar	Lumbar	Lumbo-sacral	Sacral
HENDERSON	1917			44.4	13.6	42.0		
HIBBS	1918		3.9	45.8	32.3	18.1		
Zur NEDDEN	1919	14.2		54.0		32.0		
LESKINEN	1923	16.2		56.4		27.4		
HIBBS & RISSER	1928	3.8		52.1		40.6	3.5	
BUSINGER	1928	5.5		48.2		46.3		
RUMMELHARDT	1930	12.9		34.3		39.3		
KUSS	1931	5.6		45.2		37.6		
KOFMANN	1937	5.4		44.0	10.0	39.6		
STEINMANN	1938			33.3	20.8	45.8		
THOMSEN	1939	4.8		45.6		48.7	0.9	
WALHEIM (children)	1939	2.7		51.4	9.4	35.6	1.3	
» (adults) ..	1939			48.2	8.3	42.4	1.1	
HEMPRICH	1940			19.1	33.3	47.6		
MEYERDING	1940	0.2	0.4	41.7	16.3	41.5		
ALVIK	1949	1.2	0.6	26.6	11.4	40.6	6.0	9.7

There are six publications from the period 1916—1928 which show a higher frequency in the thoracic region, and five publications from the period 1930—1949 which give a higher figure for the lumbar region. Three publications from the last-mentioned period show a higher figure in the thoracic region. Children are more often affected in the thoracic region, and adults in the lumbar region (SCHUBERTH 1928, KYRKLUND 1928, WALHEIM 1939).

Authorities vary in their statements as to the chances of different vertebrae being affected. According to Zur Nedden (1919), the percentages are L I 29, L II 27, L III and Th XII 15. RUMMELHARDT (1930) found Th IX to be the commonest site of tuberculosis, BIERRING (1934) L II, LAMPADIUS (1937) Th XII, THOMSEN (1939) L I, KLOSSNER (1949) L II, and ALVIK (1949) L IV.

Zur NEDDEN (1919) found one affected vertebra in 44 cases, and two in 51 cases. KUSS (1931) had one vertebra in 89 cases, and two in 167 cases. ALVIK (1949) had one vertebra in 4.5 %, and two in 58.4 %. COLOMBANI (1956) stated that of 1,500 cases, only one case was discovered with mono-vertebral localization, although this case was uncertain. HALLOCK and JONES (1954) instanced only 1 % in a single vertebra.

ANDERSON (1940) described cases of solitary tuberculosis in the spinous processes.

PEABODY (1922), in a series of 312 cases, found that 4 % had a second lesion in the spine. He pointed out that the discovery of the other focus could in almost every case be attributed to chance. In a considerable number of the cases, the area of the spine that was roentgenographed was too small. SCHUBERTH (1928) expressed the opinion that the second lesion seldom caused pain. KUSS (1931) estimated the frequency of multiple foci in the spine at 7.2 %, BIERRING (1934) at 7 %, HELLSTADIUS (1937) at 9.4 %, WALHEIM (1939) at 5 %, KEY (1940) at 10 %, ALVIK (1949) at 9.9 %, HALLOCK and JONES (1954) at 7.8 % with two separate lesions, and at 1.6 % with three.

Thus, with the shift from childhood to older age-groups, tuberculosis moved downward from the thoracic to the lumbar section.

The existence of monovertebral lesions may be questioned.

Multiple foci occur in the spine and, according to the literature, two separate lesions are present in 5—10 % of cases.

Abscess, Kyphosis and Paraplegia.

KUSS (1931) emphasized that 32.7 % of the cases had an abscess as the first symptom. SEVER (1929) stated that he took greater interest in cases without an abscess than in those with one. WIDENHORN (1935) found abscesses in 100 % of cases on postmortem examinations. Table 2, below, presents the percentual figures for the frequency of abscesses, extracted from published reports.

TABLE 2
The Frequency of Abscesses in the Literature

Author	Year	Percentage	Remarks
BUSINGER	1928	62.9	
DOUB & BADGLEY	1932	84.0	
BIERRING	1934	78.0	
THOMSEN	1939	64.0	incl. X-ray visible 80 %
MEYERDING	1940	52.3	
Harris & Coulthard	1942	90.0	
LAUGE HANSEN	1946	25.0	
ALVIK	1949	39.8	incl. X-ray visible 91.7 %

The frequency of abscesses varies between 23 and 100 %. Those which are visible radiologically, but which exhibit no clinical symptoms, increase the frequency to 80—91.7 %. Post-mortem findings give a figure which attains 100 %. Authors do not always state the basis on which their estimate has been made.

The frequency of fistulae, according to the literature, varies between 10 and 38.9 %.

Table 3, below, gives the fistula frequency according to published reports.

TABLE 3
The Frequency of Fistulae according to the Literature

Author	Year	Percentage	Remarks
KUSS	1931	21.2	
KOFMANN	1933	10.0	
STALMANN	1935	18.8	
THOMSEN	1939	23.0	
WALHEIM	1939	25.0	
BOSWORTH & LEVINE	1949	38.9	
ALVIK	1949	13.4	with children 11.9 %

BETTMAN (1928) was of the opinion that the delayed puncturing of abscesses, or puncturing carried out in a technically unsatisfactory way, caused fistula, mixed infection, amyloidosis, miliary tuberculosis and meningitis. HARRIS and COULTHARD (1942) stressed that infection of the sinus is not dangerous in itself but that secondary infection of the bony tissue created a very serious situation.

LANGE (1924) challenged the assumption that kyphosis is unavoidable, and stated that the first task was that of preventing gibbus formation. BUSINGER (1928) found kyphosis in 50.9 % of cases, STALMANN (1935) in 10 %, and STEINMANN (1938) in 62.5 %. OTTERLOO (1938) emphasized that children had a greater tendency towards kyphosis than adults.

In the year 1779 Percival Pott published his famous monograph entitled »Remarks on that kind of Palsy of the Lower Limbs which is frequently found to accompany a Curvature of the Spine, and is supposed to be caused by it». Questions relating to the symptomathology of paraplegia in tuberculous spondylitis were given consideration by DENK (1924),

BUSINGER (1928), RUMMELHARDT (1930), KUSS (1931), ARNESEN (1932), SEDDON (1935), GRIFFITH, SEDDON and ROAF (1956).

Table 4 gives the frequency of paraplegia in the literature.

TABLE 4
The Frequency of Paraplegia in the Literature

Author	Year	Percentage
Zur NEDDEN	1919	11.2
SCHMIEDEN	1930	12.0
ALBEE	1930	7.7
THOMSEN	1939	12.4
CLEVELAND	1940	23.7
MEYERDING	1940	17.5
CHANDLER & PAGE	1940	7.7
HARRIS & COULTHARD	1940	16.3
BOSWORTH & LEVINE	1949	15.8
ALVIK	1949	5.6
DOBSON	1951	24.8
HALLOCK & JONES	1954	12.0

The frequency of paraplegia is reported to vary between 5,6 % and 24,8 %.

Other Tuberculous Manifestations.

BUSINGER (1928) gave a figure of 56.5 % for patients with other tuberculous lesions. From their material, CLEVELAND and PYLE (1929) inferred that cases with many other manifestations react unfavourably. In children with tuberculous spondylitis, WIDENHORN (1935) found that 81 % had primary infection in the lungs, and 2 % in the abdomen. DUNCAN (1937) stated that pulmonary tuberculosis associated with bone and joint tuberculosis is likely to be extremely benign. RIVOIR (1938), on making follow-up examinations of patients affected by spondylitis, found 5—12.8 % of urogenital lesions. F. LANGENSKIÖLD (1923) emphasized the significance of pleuritis in the antecedent history. In an insurance series, THOMSEN (1939) found 35 % of multiple lesions. HARRIS and COULTHARD (1942) were of the opinion that pulmonary tuberculosis is the worst complication. BUSINGER (1928), KUSS (1931), ALVIK (1949) and SNELLMAN (1950) reported concomitant of urogenital tuberculosis. HARRIS and COULTHARD (1940)

stressed that in tuberculous spondylitis the urine test is as important as a picture of the lung. In Table 5, below, are given the various sites and the frequency of such manifestations.

TABLE 5

The Frequency of Other Tuberculous Manifestations in Connection with Tuberculous Spondylitis according to the Literature, Given as Percentages

Author	Year	Bones and joints	Meninges	Lungs	Tonsils	Urogenital system	Glands
BUSINGER	1928	17.0		33.0		10.0	12.0
ALBEE	1930	2.8		2.4			
KUSS	1931	24.2		54.5		7.0	6.0
DUNCAN	1937			35.9	24.2		
STEINMANN	1938			12.5			
WALHEIM	1939	13.0		25.0			
CHANDLER & PAGE	1940			61.5			
HARRIS & COULTHARD	1940			30.0		26.3	
HARRIS & COULTHARD	1942	21.4		21.4		15.6	
BOSWORTH & LEVINE	1949			24.3			
ALVIK	1949	17.4	3.9	59.7		3.6	1.2
HALLOCK & JONES	1954			51.0			

It thus seems that there are widely differing reports as regards other manifestations. The most important sites are the bones and joints, the lungs and the urogenital system, with a surprisingly small number of reports of meningitis.

Diganosis and differential diagnosis.

CLEVELAND and PYLE (1929) were astonished at the length of time that a patient had to stay at a hospital, waiting for effective treatment to begin. KUSS (1931) recommended more frequent suspicion of tuberculosis of the spine if radiating pains, i.e. »distant» symptoms were present. GYLLING (1951) gave a description of three cases of tuberculosis of the spine in which positive myelography resulted in exploration of the disc, a disc prolapse being suspected. DOUB and BADGLEY (1931), HELLSTADIUS (1946), GIRDLESTONE (1950) and BROCHER (1953) laid emphasis on the significance of the narrowed intervertebral space as being the first radiological symptom in tuberculosis of the spine. SCHUBERTH (1928) urged the necessity of taking X-ray pictures of the whole of the spine, and HELLNER (1937) attached importance to taking roentgenograms in two projections. HELLSTADIUS

(1946) described a case in which tuberculous necrosis of the whole of the 5th lumbar vertebra was not apparent on the roentgenogram. BROCHER (1953) assumed that modern tomography would disclose similar cases. STENSTRÖM (1951) pointed out that tomography reveals small areas of bone destruction that are not visible in normal roentgenograms in tuberculosis. CLEVELAND and BOSWORTH (1942) drew attention to the fact that the roentgenogram fails to show the full extent of the whole process in the vertebra. BÜSSEM (1933) gave it as his opinion that to be visible on the normal roentgenogram the focus would have to be $1\frac{1}{2}$ cm in diameter. HAGELSTAM (1948) drew attention to certain conditions in tuberculosis of the spine which are similar to spondylolisthesis. A. LANGENSKIÖLD (1953) gave a description of «ivory vertebra» in tuberculous spondylitis, a radiological phenomenon which is also present under other conditions. EDGREN and VAINIO (1957) have discussed the differential diagnosis in cases of tuberculosis of the spine. Questions relating to differential diagnosis were also given consideration by MEYER and CUNY (1926), PETTER and MEDELMAN (1934), GOLD and STERNBERG (1935), WIDENHORN (1935), HILDEBRAND (1936), WASSERFALLEN (1946), SICARD and TERQUEM (1954), and others. The relationship between low back pain and lumbo-sacral tuberculosis is treated in a different paper. Among 3,203 cases of back trouble treated at the Orthopaedic Clinic, there were 20 cases of lumbosacral and 11 cases of sacroiliac tuberculosis which were being given treatment elsewhere, without diagnosis, as ordinary cases of pain (BAKALIM, 1959).

Tuberculosis of the spine must accordingly always be taken into consideration when back troubles are being treated. The first of the radiological symptoms may be a narrowed intervertebral disc. Tomography is very important in such cases.

Treatment

General Principles.

Emphasis was laid upon the importance of general treatment by ROLLIER (1913), MAU (1924), KÖNIG (1928), ALLISON (1928), SEDDON (1935), COMPÈRE and JÉRÔME (1935), KEY (1940), CLEVELAND (1940), MEYERDING (1940), MAYER (1940), etc. Rest, nutritious food, vitamins, and certain special forms of diet were earlier the rule in the treatment of tuberculosis. Heliotherapy, introduced by ROLLIER (1913) and VULPIUS (1913), is still advocated today, as is lying in the open air, especially where pulmonary tuberculosis is concerned. Sun and light

treatment were also recommended by MÉNARD (1913), KROGIUS (1921), PALMÉN (1922), JOHNSTONE (1927), ALLISON (1927), KÖNIG (1928), JOISTEN (1928, 1929), DUCREY (1936), and MEYERDING (1940). ALLISON (1927) laid stress upon the combination of this treatment with surgical intervention.

During the »historical» period of spondylitis treatment, the application of force to bring about reduction by means of manual pressure, traction or extension was proposed, those advocating such treatment being CALOT and PIERRE (1895), HEUSNER (1899), and RÉDARD (1899). The experience gained with this method was not satisfactory however, and gentler means of gradual reduction were introduced by v. FINCK (1904), WULLSTEIN (1904), GAUGELE (1909), BIESALSKI (1923) and WALDENSTRÖM (1924), the last-mentioned combining this form of treatment with spinal fusion in accordance with ALBÉÉ's method. NITSCHÉ (1934) and ORELL (1942) rejected reduction completely because of the gaps arising between the vertebrae.

The LORENZ plaster bed still constitutes part of the routine treatment of tuberculosis. The importance of this means of securing immobilization was pointed out by F. LANGENSKIÖLD (1923), LANGE (1924), BETTMANN (1927), JOISTEN (1928), v. GAZA (1932) FREUND (1933), HERLYN and KOCHS (1935), COMPÈRE and JÉROME (1935), WAHREN (1936), CALVE and GALLAND (1936). WALDENSTRÖM (1924) and HILSE (1927) employed sheets of felt under the gibbus for gradual reduction and WALHEIM (1939) used filling, which had to be applied through a hole cut in the plaster.

Chemotherapy.

GÉRARD, MARCHANT and SALMON (1950) compiled a detailed synopsis of the chemotherapy employed in bone and joint tuberculosis. According to BOSWORTH, PIETRA and FARRELL (1950), healing depended upon the duration of medication with streptomycin rather than upon the total quantity. DAUBENSPECK (1951) recommended the evacuation of abscesses and instillation of tuberculostatic drugs. KASTERT (1950, 1956) used instillations of streptomysin after radical operations. BOSWORTH and WRIGHT (1952), EVANS (1952), HARRIS, COULTHARD and DEWAR (1952) achieved the most satisfactory results in cases where chemotherapy had been combined with surgical treatment. EVANS (1952) stated that sanatorium treatment without surgery brought the worst results. As regards the treatment of old lesions by streptomycin, the results were not very good. VOLKERT (1951) did not realize the advantages to be gained by the combination of streptomycin with PAS. LANGE and GLOGOWSKI (1956) em-

phasized that a combination of isoniazid and streptomycin is more effective than PAS and streptomycin. GÉRARD and MARCHANT (1954) pointed out that chemotherapy has no effect until the reactions of the body itself, or the powers of defence, have established themselves. ORELL (1951), according to a number of papers, administered PAS for 2 weeks before intervention (evacuation of focus), then streptomycin and PAS a few days before and for two weeks after, and finally PAS. Conteben was given with PAS. Iproniazid was recommended by BOSWORTH, WRIGHT, FIELDING and Wilson (1953), and by BOSWORTH (1959). VOLKERT (1951) recommended 1 gram of streptomycin (0.5×2) in 24 hours, in all 30—70 grams. For children, the dosage would be 0.25—0.5 grams in 24 hours. BOSWORTH, PIETRA and FARRELL (1950) prescribed 2.0 grams every sixth hour during the first week, then 1 gram a day, and subsequently 0.5 grams a day. EVANS (1952) used small doses of streptomycin over a longer period: 1.2 grams $\times$ 2 each week, and 4 grams of PAS daily. HARRIS, COULTHARD and DEWAR (1952) also recommended 0.5 grams $\times$ 2 daily. Local applications of streptomycin were made seldom, and without exception only in cases where intramuscular injections proved fruitless. As regards PAS, the dosage should be 10 grams daily. For adults, ERLACHER (1955) used streptomycin 0.5 grams $\times$ 2, for children under the age of 15, 0.25 grams $\times$ 2, and for those under 5, 0.125 grams $\times$ 2. As for isoniazid, 50 milligrams should be given per 10 kilograms of body-weight every 24 hours. From 10—14 grams of PAS should be given every 24 hours.

FINLAND, MURRAY, HARRIS, KIHLMAN and MEADS (1946) were of the opinion that the emergence of drug resistance is a greater danger with streptomycin than it is with penicillin. DAUBENSPECK (1951) was unable to detect any resistance during the second cure. HARRIS, COULTHARD and DEWAR (1952) pointed out that resistance did not develop if the patient were simultaneously getting 10 grams of PAS daily. During the period 1948—49, resistance occurred in every case but one, streptomycin alone being used.

Accordingly, a combined treatment with streptomycin, isoniazid and PAS is to be preferred. The problem of drug resistance is of great importance. Streptomycin is given mostly in doses of 1.0 gram, isoniazid 0.3 gram, and PAS 10—14 grams every twenty-four hours.

Spinal Fusion.

Indications. The object of ALBEE (1911), HENLE (1911), and HIBBS (1912) was to achieve spinal stability and to eliminate the functional insufficiency brought about by the lesion.

Having operated upon three cases (1911), ALBEE recommended spinal fusion in every case of tuberculosis of the spine, provided that neither fistula nor abscess was present in the operative region. In 1935, he gave detailed indications: paraplegia, paravertebral abscess, multiple lesions. The fistula was insignificant. Every age-group was to be operated on. The sole contra-indication was high temperature. F. LANGENSKIÖLD (1923) introduced ALBEE's spinal fusion into Finland, adopting it as the normal method for the treatment of tuberculous spondylitis; the contra-indications were very large kyphosis and cervical tuberculosis. Preliminary treatment was advised for abscesses and paraplegia. Furthermore, he pointed out that the reduction of the period of treatment would have social and economic consequences. At that time, German surgeons were in general opposed to ALBEE's operation because of the complications and the poor results obtained: SCHMIEDEN (1930), BAUER and JENNER (1933), BÉRARD and KNORR (1939). ALBEE (1911, 1930), HIBBS (1912), and HOESSLY (1916) wished to carry out the operation at as early a stage as possible, v. GAZA (1932) and BIERRING (1934) recommended it to be done somewhat later, and WALDENSTRÖM (1924), DENK (1924), DUBOIS (1927), JOISTEN (1928), FREUND (1933), WALHEIM (1939), and MEYERDING (1940) felt that it should be performed in the final stage after conservative treatment. Contrary to the opinion expressed by ALBEE (1911), many surgeons disapproved of spinal fusion as far as children were concerned, as for instance HIBBS (1912), HENDERSON (1917, 1929), MAU (1924), SORREL and ROCHER (1929), MARIANTCHIK (1935), WIDENHORN (1935) and FINKELSTEIN (1938). According to FROMME (1920), DARDEL (1928), SCHMIEDEN (1930), F. LANGENSKIÖLD (1932) and STEINMANN (1938), tuberculous manifestations in other organs are contra-indications.

Technique. In ALBEE's original method of 1911, the spinous processes had to be split medially. A graft from the tibia, 10—19 cms in length, 6 to 12 mms in breadth, and 6—9 mms thick was inserted in the furrow so formed. Fixation was achieved by means of careful suturing of the supraspinal and interspinal ligaments; ALBEE made use of kangaroo tendons for suture material. If the kyphosis were too acute-angled for a straight graft, an arched splint had to be sawn from the tibia, this splint being less curved than the kyphosis in order to maintain the correction produced by manual pressure and recumbency. Should the kyphosis be large, the sawing of notches was recommended, and the splint had to be bent. In such a case, a spinal brace was necessary during postoperative treatment, but it was to be used in

no other instance, the primary stability afforded by the graft being sufficient.

In 1930, ALBEE published an account which laid stress upon the necessity of immobilization of only 1 healthy spinous process above and below in the lumbar region, but 2 healthy spinous processes above and below in the thoracic region. So as to avoid any interference with the blood supply, a point which ALBEE especially emphasized, only one half of the spinous process was to be bent outwards. In cases with larger kyphosis, the graft had to be rendered flexible by means of longitudinal cuts with the saw. If there were extensive kyphosis, only longitudinal bone slips were employed.

HENLE (1911) made the skin incision 1—1 ½ cm laterally from the medial line. The spinous processes were exposed, and the fascia and muscles detached from the spinous processes on either side. A slight manual pressure was then put on the kyphosis. He split the tibial graft longitudinally into two parts of equal size, and fixed it on either side of the spinous processes. Fixation was achieved by means of silk threads drawn around both grafts through the interspinous ligaments. If the shape of the kyphosis was unsuitable for straight grafts, HENLE sawed arched grafts from the tibia. If the kyphosis was very large, he advised breaking of the graft, preferably by infraction.

HIBBS (1912) made an incision in the medial line. The periosteum was split over the spinous processes, and turned aside to the transverse processes. Each spinous process had to be exposed, and following this, they were removed from their bases, and turned over, thus forming bridges over the spaces between the vertebral arches. The bases were then lying on the raw surfaces of the arches, with the tips on the surface of the following arch. Later, these three methods had innumerable modifications:

HALSTEAD (1915) and POLYA (1921) cut the spinous processes off at the base, placing the graft as near to the focus as possible. KIPNIS (1926) and SPRINGER (1928) totally removed the spinous processes for the same reason. ROOS (1923) set the graft laterally between the spinous processes and the arches. HASS (1921) cut and turned to one side the tips of the spinous processes. ALLISON (1928) split the spinous processes in three parts, and placed a graft on either side. CALVÉ and GALLAND (1936) and NICOD (1942) fused the arches. COMPÈRE and JÉROME (1935) and PETTER (1937) ankylosed the small intervertebral joints, excising the facets. ELSNER (1922) bored holes through the bases of the spinous processes and drew silver threads through them. MAGNUSON (1924) advocated screw fixation of the graft. MYRON and GEIST (1933) employed a modification of HIBB's

operation, making finger-nail-sized tibial grafts. GIBSON (1931) and BOSWORTH (1942, 1945) introduced the »H-graft». GJESSING (1951) recommended anterior spinal fusion. BOSWORTH (1956) suggested his »circumduction method». CALVÉ (1928) and ORELL (1942), in contrast to ALBEE, recommended a short and broad connection between a few vertebrae. ORELL (1942) introduced a method making use of »os novum». BOSWORTH, WRIGHT, FIELDING and GOODRICH (1953) abandoned the employment of bank bone for spinal fusion in tuberculosis.

A faulty location of the graft is an aggravating complication. WALDENSTRÖM (1924) drew a catgut suture through the skin as a marker. DUCREY (1936) used two needles. CALVE (1928) made use of a special screw with a handle, which was inserted into the spinous process. LECLERCE (1936) recommended methylene blue solution, and ORELL (1942) drove in a Rissler's nail, about 15—20 cm long, which had to be palpable through the skin, the X-ray picture being then taken.

Post-operative Treatment.

ALBEE (1911, 1935) prescribed rest in bed for six weeks after the performance of spinal fusion with no subsequent support, in accordance with the principle of substitution of external by internal fixation, that is to say the graft. The implementation of this rule gave rise to many failures in spondylitis therapy.

F. LANGENSKIÖLD applied a rule (1923) of rest in bed for six to eight weeks in hospital following the operation; furthermore, patients were instructed not to engage in employment for a period of one year. During the first eight months, they were allowed to get up at meal-times only, and for visits to the toilet. Otherwise, they had to lie supine on a rather hard mattress. Certain authors recommended that despite the operation, the usual conservative treatment should be given (BUSINGER 1928, SCHMIEDEN 1930, and FREUND 1933). ODELBURG-JOHNSON (1934), ORELL (1942) and ALVIK (1949) recommended individual treatment, with regular X-ray examination and checks of blood sedimentation rate. BETTMAN (1928) stressed the necessity for supervision extending over a period of years, and of great care in the use of the back. CHANDLER and PAGE (1940) wished to extend supervision to the whole lifetime of the patient.

A plaster bed was made use of by LANGE (1924) for six weeks subsequent to the performance of spinal fusion, by WALDENSTRÖM (1924) and WAHREN (1936) for two to three months, and by BIERRING (1934), and GRIGORESCU and VASILIU (1936) for two months.

GUILDAL (1923), DENK (1924) and ELY (1926) prescribed the wearing

of a leather corset for one year after the plaster bed. WAHREN (1936) used either a plaster jacket or a leather corset. F. LANGESKIÖLD (1923) prescribed a spinal brace for children only. Mere rest in bed after spinal fusion, without a plaster bed, was employed by F. LANGESKIÖLD (1923), by MAU (1924) for twelve weeks, by ELY (1926) for six weeks, by ODELBERG-JOHNSON (1934) for six to eight weeks, by ACKERMANN (1937) for eight to ten weeks, and by SWIFT (1940) for from three weeks to four months. HOFFMAN (1925) stressed the necessity for using a spinal brace and a plaster bed because of the healing in of the graft.

There is considerable divergence of opinion among authors as to post-operative treatment. Some prescribe rest in bed, plaster bed, plaster jacket or leather corset; the period of immobilization varies.

Complications in connection with Bone Grafting.

ALBEE makes no mention of graft complications in his first publication of 1911. In 1930, he had one fracture among 865 spinal fusions. LEXER (1925) stated that fracture and resorption of the graft were of frequent occurrence. BIESALSKI (1923) had three pseudarthroses among eight patients undergoing spinal fusion. ELY (1926) wrote that spinal fusion often proved a failure because of breakage of the bone bridge. The frequency of pseudarthrosis in the graft according to the literature is shown in Table 6.

TABLE 6

Frequency of Pseudarthrosis in the Graft, According to the Literature

Author	Year	Percentage
WALDENSTRÖM	1924	17.5 %
ODELBERG-JOHNSON	1934	12.9 %
WAHREN	1936	25.0 %
STEINMANN	1938	6.3 %
MEYERDING	1940	3.3 %
HARRIS & COULTHARD	1942	8.0 %
ALVIK	1949	12.9 %
KLOSSNER	1949	17.1 %
HALLOCK & JONES	1954	26.0 %

The frequency accordingly varies between 3.3 % and 26.0 %.

LEXER (1925) considered the graft to be exposed to a bending force («Knickung»). BIESALSKI (1923), BAUER and JENNER (1933) were of the opinion that the spondylitic process determines the future of the graft, bringing about pseudarthrosis if necessary, softening the transplanted bone

and transforming it. LANGE (1924) laid stress upon the extreme fragility of tibial grafts; a sudden movement might cause a fracture. WALDENSTRÖM (1924) stated that fractures always occur after a trauma. BIESALSKI (1923), MAU (1924) and JOISTEN (1928) expressed agreement with LOOSER's old doctrine of rebuilding areas («Umbauzonen»), and their transformation into pseudarthrosis, that is a substitution process lasting from nine to twelve months. During this period, the graft would be sensitive to any trauma. LEXER (1925) described fibre formation within the longitudinal lamellae not identical with Looser's areas of rebuilding. ODELBURG-JOHNSON (1934, 1939), partly on the basis of experimental work, discussed this question in detail. He was of the opinion that the graft gradually undergoes physiological necrosis and resorption, being replaced by new bone. Fractures in the graft would occur when the graft, more or less resorbed, is exposed to a trauma which might be acute, or have a slight or gradual effect. Even physiological movements, such as bending, may bring about fracture. ORELL (1942) mentioned that from six to seven weeks have to elapse before the union with the bed is sufficiently strong, and that fracture may occur. Normally, the interval is from four to seven months, reckoned from the date of the operation. In their material, HARRIS and COULTHARD (1942) found that fractures occurred most often between L V and S I. JUHL (1942) found that a fracture occurred in every instance in which the bone bridge extended downwards to the sacrum. ALVIK (1949) had fractures only in the application of long grafts; none occurred with short ones. HALLOCK and JONES (1954) gave the following factors as an explanation of the phenomenon: (1) the local effect of the tuberculous infection, (2) posterior site of the focus in the vertebra, (3) the tendency of the graft to bend forwards, with the consequent effect of extension of the graft as well as the fusing spinous processes. In this respect, grafts in the lower thoracic and thoraco-lumbar regions are the most liable to fracture.

ROOS (1923) emphasized that the healing of graft fractures is not proved. ODELBURG-JOHNSON (1934) considered that if fracture make their appearance during the stage of regression, they exhibit good capacity for healing with conservative treatment. If the vertebrae are already well fused, the graft fracture will prove to be insignificant. If inflexion is gradually increasing, together with angulation of the graft, the tendency to heal is slight. In two cases, a fracture occurred even with renewed transplantation of bone. STEINMANN (1938) stressed that the results were wholly dependent upon the tuberculous process in the vertebra. If the lesion is limited, the graft is strongly inclined to heal. As soon as the lesion has healed, the graft heals too. In some instances, the vertebrae are destroyed and collapse, in spite of the graft.

LEXER (1925), HOFFMAN (1925) and STEINMANN (1938) considered that too early getting up and placing of stress upon the graft leads to fracture and pseudarthrosis. To the contrary ODELBURG-JOHNSON (1934) and ORELL (1942) emphasized the importance of a short immobilisation if graft fractures are to be avoided. If the patient is confined to bed for a lengthy period, there is a risk that the graft will be resorbed. The patient should stay in a plaster bed for seven to eight weeks, and wear a corset for twelve to eighteen months. According to ORELL, the patient should be allowed to get up from two to three months after the spinal fusion.

Thus according to the literature, the frequency of fractures or pseudarthroses of the graft varies between 3.3 % and 26 %. Many authors enter into discussion of the cause of graft fractures, and present various theories concerning rebuilding areas («Umbauzonen»), trauma, physiological trauma, long grafts, and the location between L V and S I. The graft fracture may heal spontaneously, but this depends upon the course of the disease in the vertebra. Some authors are of the opinion that too early stress is an important factor in causing fracture whereas others believe the exact opposite.

Results of Treatment

ROLLIER (1913) described the process of healing as seen on the X-ray picture as follows: 1) clear limitation and demarcation. Sclerosis occurring at the edges of the focus. 2) resorption of pathological products, 3) functional readaptation of structures and bone. Block formation, 4) reparative processes with bridge formation and reorganization of small abscesses. Filling of defects with tissue. HERLYN and KOCHS (1935) pointed out the significance of recalcification and increased density of structures. SCHEEL (1939) also analyzed the osteosclerosis in tuberculosis of the spine. ADAMS and DECKER (1937), WESTERMARK and FORSMAN (1938) and HELLSTADIUS (1946) made endeavours to classify the different types and stages of tuberculous spondylitis seen in X-ray pictures.

The signs of healing in the X-ray picture may accordingly be as follows: clear limitation, sclerosis and increased density, the filling of defects, fusion and block formation.

Vertebral recurrences.

BUSINGER (1928) stated that as far as a recurrence is concerned, one never knows for certain whether a tuberculous lesion has healed completely; it is necessary to take into consideration the risk of a relapse,

even though the disease is completely quiescent. The second and the third year after healing are the most dangerous, relapse sometimes taking place five, seven and nine years subsequently. He recommended re-examination at intervals of from six months to one year. NITSCHÉ (1934) was of the opinion that the period of healing lasted up to thirty years, and that tuberculous spondylitis might recur after twenty years or more. WALHEIM reported (1939) 6 % of relapses among operatively treated cases, and 18 % among those given conservative treatment. CLEVELAND (1940) mentioned two relapses after six years among 50 operatively treated cases, generally with a good subsequent result on re-examination after a period of seven years. MEYERDING (1940) found 3.8 % of relapses. SERRÉE, DETTLOFF, HUBERT and VERNET (1950) had 10 % of relapses after early spinal fusion, and only 2 % with classical conservative treatment. ORELL (1956) considered that in some cases there was no possibility of preventing relapse.

Publications thus indicate that relapses may occur many years after spinal fusion or after conservative treatment. The frequency varies between 2.0 % and 10.0 %.

New manifestations.

DARDEL (1928) stated that new manifestations may occur in the pleura, kidneys and coxa during after-treatment, and ascribed this to too early rising from bed and too short a stay in hospital. ADAMS (1940) wrote that the healing of the spondylitis does not prevent the development of new foci in joints, or in the lungs or kidneys. HARRIS and COULTHARD (1940) estimated the new manifestations in the hip, knee, adrenals, the genitourinary tract and the meninges at 12 %. SWIFT (1940) pointed out that even after the disease has been quiescent for years the patient might present evidence of virulent infection.

The end results after spinal fusion.

ALBEE (1911, 1930, 1935) reported good results in each publication. For example, in the year 1930, he reported 90 % of results as successful, 10 % not being so. There was severe criticism of ALBEE's good results when subsequent experience showed that the cases concerned did not always follow a favourable course (SCHMIEDEN 1930, BIERRING 1934 and BECKER 1937). F. LANGENSKIÖLD gave an introductory lecture at the Fifth Meeting of the Scandinavian Orthopaedic Society in Stockholm, 1923; twenty patients out of a total of thirty-four who had undergone spinal fusion had recovered, and were fully fit for work within periods of six months to two and a half

years. Guildal, who also spoke at this meeting in 1923, reported good results for most of the cases, and arrest of the kyphotic process, and WALDENSTRÖM reported (the was published in 1924) that of eighty patients undergoing operation fiftysix had recovered. In 58 cases, the spine was quite straight without kyphosis. KÖNIG (1928) was of the opinion that spinal fusion prevented kyphosis from developing, and kept it within reasonable bounds. Nevertheless, the effect upon a large gibbus was uncertain. DARDEL (1928) and RESCHKE (1939) emphasized that spinal fusion contributes to quicker and more sound healing. In 1930, ALBEE's spinal fusion was placed upon the agenda for discussion at the German Surgical Congress. The discussion was opened by SCHMIEDEN, who condemned this method of intervention on account of bad results.

The percentages of those recovering, those experiencing improvement, and those patients for whom failure was recorded as regards improvement and fitness for work, are given in Table 7 according to the authors of the published reports.

TABLE 7

Results after Spinal Fusion, According to Publications Issued between 1917 and 1954.

Author	Year	Healed	Improved	Not healed	Remarks
HENDERSSON	1917	42.4 %	45.2 %	2.7 %	
DEBRUNNER	1921	81.2 %	2.7 %	5.4 %	
F. LANGENSKIÖLD	1923	64.5 %		6.5 %	
WALDENSTRÖM	1924	72.5 %			
ELY	1926	82.3 %	2.7 %	13.5 %	
KÖNIG	1928	50.0 %		13.0 %	
DARDEL	1928	74.0 %		6.4 %	
SCHMIEDEN	1930	25.0 %	56.0 %	10.0 %	
RUMMELHARDT	1930	98.9 %			
ALBEE	1930	73.0 %	17.0 %	8.0 %	
BAUER & JENNER	1932	50.0 %		10.0 %	
F. LANGENSKIÖLD	1932	68.0 %		10.0 %	
HERLYN & KOCHS	1935	55.0 %		5.0 %	
GRIGORESCU & VASILIU ..	1936	29.0 %	60.9 %		
STEINMANN	1938	63.6 %	31.9 %	4.5 %	Mortality not included
BERARD & KNORR	1939	76.1 %	19.1 %	4.8 %	
WALHEIM	1939	82.7 %	16.4 %	0.9 %	
CLEVELAND	1940	54.2 %	19.2 %		
SWIFT	1940	50.0 %	14.0 %	8.0 %	
MEYERDING	1940	63.6 %	11.6 %	6.3 %	
CHANDLER & PAGE	1940	74.3 %		10.3 %	
HARRIS & COULTHARD ..	1942	81.0 %		12.0 %	
KLOSSNER	1949	66.9 %	7.8 %	9.5 %	
HALLOCK & JONES	1954	74.5 %		7.7 %	

The percentage of patients reported as being healthy and fit for work varies between 25.0 % and 98.9 %, in most series falling between 40.0 % and 80.0 %, between 2.7 % and 60.9 % for »improved», and finally, for »not healed» between 0.9 % and 14.0 %, year after year. Statistics regarding the results of spinal fusion since the introduction of chemotherapy are not available.

The end results after conservative treatment.

Bad results on conservative treatment before the introduction of tuberculostatic drugs were reported by LESKINEN (1913), F. LANGENSKIÖLD (1922), KYRKLUND (1928), BUSINGER (1928) and LAGERBORG (1931). HERLYN and KOCHS (1935) reported 26 % of good results. The series of DOBSON (1951) showed 55 % of healed cases. JOISTEN (1929), SWETT, BENNET and STREET (1940), SERÉ, DETTLOFF, HUBERT and VERNET (1950) found no difference between the results of conservative treatment and spinal fusion.

The end results after conservative treatment with tuberculostatic drugs.

VOLKERT (1951) stated that there was improvement in hopeless cases. DAUBENSPECK (1951) reported complete recovery of children in fresh cases of skeletal tuberculosis (including spondylitis). Fistulae closed quickly (DAUBENSPECK 1951, VOLKERT 1951, DEROY and FISHER 1952). KATTHAGEN (1954) held the view that chemotherapy had no great significance in the treatment of tuberculous spondylitis in closed cases. DEROY and FISHER (1952) warned of the danger of new lesions despite treatment with tuberculostatic drugs. A public health service cooperative investigation (1952) made a comparison of cases of streptomycin-treated skeletal tuberculosis (including spondylitis) with untreated patients and reported good effects on the general condition and the secondary focus. Fistulae healed more rapidly. WILKINSON (1954) discovered no marked difference between a group of forty-six patients treated by chemotherapy and another group of sixty patients given conservative treatment alone.

Mortality.

The immediate operative mortality brought about by post-operative shock, embolus, deaths due to narcosis, pneumonia and secondary infection is reported in the respective publications. As may be expected in

an intervention of this type, the figures are generally small. For example, DARDEL (1928) had one immediate post-operative death. In seven spinal fusions, SCHMIEDEN (1930) had two deaths on the operation table. SWIFT (1940) had 1.4 % due to post-operative shock, and 5 % as a result of infections. MEYERDING (1940) had 1 %. KLOSSNER (1949) reported three deaths in a series he had followed up, one being due to fat embolus, one to pneumonia and one to icterus. ALBEE (1911), HIBBS (1918), LANGENSKIÖLD (1923), WALDENSTRÖM (1924), LANGE (1924) and WALHEIM (1939) cited no complications of this type.

According to the literature, the cause of death after discharge from hospital were as follows: miliary tuberculosis, tuberculous meningitis, pulmonary tuberculosis, tuberculosis of the kidneys, and, as a secondary complication, amyloidosis (HIBBS 1918, DENK 1924, ELY 1926, KÖNIG 1928, KUSS 1931). The figures given by different authors for this late mortality after spinal fusion and following conservative treatment are detailed in Tables 8 and 9.

TABLE 8

Late Mortality after Spinal Fusion, According to the Literature

Author	Year	Percentage
CHANDLER & PAGE	1940	15.4 %
CLEVELAND	1940	26.6 %
HARRIS & COULTHARD	1940	12.0 %
SWIFT	1940	28.0 %
BOSWORTH & LEVINE	1949	37.3 %

TABLE 9

Late Mortality after Conservative Treatment, According to the Literature

Author	Year	Percentage
ZUR NEDDEN	1919	59.0 %
BETTMAN	1928	33.0 %
BUSINGER	1928	24.1 %
STALMANN	1935	22.9 %
KOFMANN	1937	28.0 %
HARRIS & COULTHARD	1940	56.7 %

In the spinal fusion group, the mortality varies between 12.0 and 37.3%. Only tuberculous complications are taken into account, and intercurrent

diseases are excluded. In the conservatively treated group, the mortality varies between 22.9 and 59.0 %, and thus the figures are considerable higher than those in the operatively treated group. FREUND (1933) considered the mortality from this operation to be not much less than that found with conservative treatment.

Finally, mention may be made of the effect of possible complications on mortality. BUSINGER (1928) stated that 35.3 % died of an abscess, and only 5 % had no abscess. Of 23 patients with fistulae, 14 died. According to STALMANN (1935) neither abscess nor fistula had any influence on mortality. CLEVELAND (1940) stressed that 50 % of patients with fistula had died. ADAMS (1934) found that young patients in the age group 12—20 had the highest mortality. HALLOCK and JONES (1954) stated that of patients with paraplegia 50 % died. BOSWORTH, PIETRA, RAHILLY (1953) and GRIFFITH, SEDDON and ROAF (1956) gave similar figures for flaccid paraplegia; for partial and spastic paraplegia, the mortality was 6.7—14 %.

Published information regarding the influence of chemotherapy upon the mortality in bone and joint tuberculosis, especially in tuberculous spondylitis, is scanty. An attempt was made by BOSWORTH and WRIGHT (1952) to divide their material into two periods, one before the advent of tuberculostatic drugs from 1941 to 1946, and the other after their introduction from 1946 to 1951. In the first-mentioned period, they reported 21.1 % of deaths, and in the latter 5.8 %. The mortality was reduced by 72.5 %. GÉRARD-MARCHANT (1954) pointed out that chemotherapy has changed the prognosis in bone and joint tuberculosis. HORVAT (1956) reported that mortality had decreased.

The immediate operative mortality is thus inconsiderable, as far as published details are concerned.

The subsequent mortality, after discharge from hospital, is surprisingly high, varying between 12 % and 37.3 % in the spinal fusion group, and being still higher in the material given conservative treatment, varying between 22.9 and 59.0 %. Complications such as abscess, fistula and permanent paraplegia raised the figures to 50 %.

III PROBLEMS

The aim of this study was to investigate the results of treatment in a series of patients with tuberculosis of the spine not treated in sanatoria. The author has attempted to provide an answer to the following questions regarding the treatment of tuberculous spondylitis.

A. The significance of spinal fusion.

1. Can spinal fusion prevent the recurrence of tuberculosis of the spine?
2. Can spinal fusion prevent the spread of the disease to other organs?
3. What is the frequency and significance of graft fractures?
4. Can early spinal fusion prevent kyphosis?
5. Does spinal fusion hasten healing and block-building?

B. The significance of chemotherapy.

6. Can chemotherapeutic agents prevent the recurrence of tuberculosis of the spine?

7. Can these drugs prevent the spread of the disease to other organs?
8. What is the effect of chemotherapy on the regression of the lesion and on block-building?

9. Has mortality diminished since the advent of the new antibiotic or tuberculostatic drugs?

10. What are the results of treatment by spinal fusion, with and without chemotherapy?

IV MATERIAL

The material consists of a total of 1,018 cases of tuberculous spondylitis, not treated in sanatoria, from the Surgical Clinics I, II and III, University of Helsinki, and from the Kuopio General Hospital. Since 1950, all cases of bone and joint tuberculosis seen at the University Surgical Clinics have been remitted to the III Clinic. Spinal fusion was carried out in 208 cases, and were given conservative treatment. Subsequently, 53 cases which had been operated on in other hospitals were included in the material. They could hardly be recorded among those getting conservative treatment, nor among those undergoing spinal fusion, since the operation had been performed elsewhere. The period covered is from 1930 to 1953 (Table 10).

TABLE 10
Series of 1018 Cases.

	Spinal fusion	Fusion performed earlier in other hospitals	Conserva- tive treatment only	Lamin- ectomy	Resection of lesions in the spinous and transverse processes	Whole series
Surgical Clinics						
I, II and III	131	41	438	8	4	622
Kuopio General Hospital	77	12	306	1		396
	208	53	744	9	4	1,018

In the University Clinics, there had been 622 cases of tuberculous spondylitis, of which 131 had undergone spinal fusion, whilst 438 had had conservative treatment only. Eight cases of paraplegia had been treated by laminectomy. In four cases, resection of lesions in the spinous and transverse processes had been performed. In 41 cases ultimately treated at the University Clinics, spinal fusion had been performed elsewhere at an earlier date. 396 were treated at the Kuopio General Hospital.

In 77 of these cases spinal fusion had been performed, and 306 had had conservative treatment alone. In 12 cases spinal fusion had been carried out elsewhere at an earlier date.

As mentioned above, these patients had not been treated in sanatoria. After being treated at the clinics, they were sent home or to provincial hospitals to lie in plaster beds, and came back regularly for examination.

Method of Investigation

Each of the 1,018 patients was sent a questionnaire. If no reply came, a further questionnaire was sent. In all, 1,103 questionnaires were distributed, 517 inquiries made to parish offices, 32 to registry offices, and afterwards 100 summons were sent to patients upon whom spinal fusion had been performed, asking them to attend in person for follow-up examination. The idea of the questionnaire was that it should not contain questions too difficult to understand, but yet that it should be sufficiently detailed to provide information as to the state of the patient. In addition, anamnestic information might be completed. The case records, with notes concerning recent visits, were available.

The questionnaire was worded as follows:

What was your former profession?

Date of birth?

Has there been any tuberculosis in your family?

Have you been living with a person having tuberculosis of the lungs, or of any other organs?

Have you had enlarged lymphatic glands?

Have you had pleurisy?

When did you feel back trouble for the first time?

In which place did you feel pain for the first time?

Did you feel pain only when working?

Did you feel any pain when stooping?

Did you feel any pain after being in a sitting posture for any length of time?

Have you had any pain in the back at night?

Did you have any rise in temperature?

Did the pain radiate into the thigh or the leg?

Have you had pain or paralysis in the lower extremities?

Have you had any trouble with urination or evacuation?

Have you undergone medical treatment at hospital earlier? If so, when?

What was your illness called at that time?

Was it believed to be tuberculosis?

What kind of treatment did you get?

Did you lie in a plaster bed? For how long?

Was rest in bed alone prescribed? For how long?

Did you get a corset?

Have you been using it regularly for a long time?

What directions were given you for using it? Did you not obtain any directions?

Have you been operated on for tuberculosis of the spine?

At which hospital?

For how long were you confined to bed after the operation?

Did you have a relapse in the spine?

Did you have a relapse in any other organ?

How are you now?

When did you return to work?

Did you change your work because of tuberculosis?

On what work are you engaged now?

Of the patients who had undergone spinal fusion, 173 answered the questionnaire, and 27 had died. Replies were not received from 8. The conservatively treated group consisted of 744 cases, and answers were obtained to 300 questionnaires; 319 patients had died. In 125 cases, either the place of residence was unknown, or the inquiries remained unanswered despite repeated requests.

Every patient who had undergone spinal fusion and had answered the questionnaire was requested to submit personally to a follow-up examination. An appearance was made by 85 % (69/81). Patients who were in good condition were the only ones to attend; it is readily understandable that those still ill, confined to bed or lying in a plaster bed, and those with paraplegia or a relapse were not prepared to go to the inconvenience of a long trip. Despite great efforts, the author found it impossible to achieve his aim of getting at least 100 patients to submit personally to the follow-up examination.

Under these circumstances, it must be remembered that those who did attend have to be considered as a selected group to some extent. Consideration of this group should therefore in itself yield results which are too favourable.

The following routine examination was carried out: an X-ray photograph of the whole of the spine and the lungs, determination of the sedimentation rate, a urine test with culture of tubercle bacilli (LÖWENSTEIN) and guinea-pig inoculation. The flexibility of the spine was examined forwards, backwards and laterally. See section VI.

The angle of kyphosis was measured on the X-ray pictures. See section VI, Fig. 20.

Age and Sex Distribution

Interest attaches to the age distribution in this series insofar as it gives information as to the age at the onset of the disease, the age at diagnosis and admission to hospital, and finally the age at performance of spinal

fusion. The age of the patient at the onset of tuberculous spondylitis and the age when diagnosis is made are not always identical. The course of the disease is chronic. Some of the patients had undergone treatment earlier at other hospitals, and not infrequently others consulted a doctor only after the lapse of some years. In some instances the disease was exceedingly slow in developing at the beginning; many cases were diagnosed astonishingly late.

Thus it is often impossible to obtain exact information as to the onset of the disease, and only the information contained in the case record is available. If the classification is made at five year intervals, the differences between the ages at onset and on admission to hospital do, nevertheless, diminish considerably.

The age distribution of the whole series of patients can be seen from Table 11. The greatest frequency occurs within the age group 16—30 years, the maximum being attained in the group 21—25 years (17.2 %).

TABLE 11
Age and Sex Distribution of the 1,018 Cases

Age group	Male	Female	Total	Percentage
0— 5	38	36	74	7.3 %
6—10	28	21	49	4.8 %
11—15	38	26	64	6.3 %
16—20	80	61	141	13.9 %
21—25	101	74	175	17.2 %
26—30	72	72	144	14.2 %
31—35	49	48	97	9.5 %
36—40	40	38	78	7.7 %
41—45	29	25	54	5.3 %
46—50	17	23	40	3.9 %
51—55	19	14	33	3.2 %
56—60	9	27	36	3.5 %
61—65	5	14	19	1.9 %
66—70	4	5	9	0.9 %
71—75	1	2	3	0.3 %
76—80	—	2	2	0.1 %
Totals	530	488	1,018	100.0 %

Spinal fusion was most frequently performed within the age groups from 16 to 40 years, the maximum appearing in the age group 21—25 years. The youngest patient to undergo spinal fusion was 4 years old, and the next youngest 5. The oldest patient undergoing this operation was 64. Of the operations, 27.9 % were performed on patients from 21 to 25 years of age, 14.9 % from 16 to 20 years, and 12.5 % from 26 to 30 years.

As far as conservative treatment is concerned, the age groups were more uniformly represented, with the exception of the maximum figures between 16 and 30. The figures for children were rather high, although children's treatment has in recent years been transferred to other hospitals; generally speaking, children did not undergo operation, but were given conservative treatment. Nevertheless, our clinics are not as a matter of principle opposed to spinal fusion in children.

In all, the series comprises 530 males and 488 females. 97 men and 111 women had undergone spinal fusion, and 403 men and 341 women had conservative treatment. The difference in distribution between the sexes is not remarkable, with the exception of the age group 16—25, with a majority of males.

Site of the Lesion

In this material, the cases of tuberculous spondylitis were grouped according to the site of the lesion as follows: the cervical, cervico-thoracic, thoracic, thoraco-lumbar, lumbar, lumbo-sacral and sacral. In Table 12 are to be seen the different localizations, together with the various methods of treatment. Children are placed in a separate group.

TABLE 12

The Location of Tuberculosis in Different Parts of the Spine and Treatment in Adults and Children

Location	Spinal fusion	Fusion performed elsewhere	Laminectomy	Extirpation of spinous and transverse processes	Conservative treatment	Totals		
						Adults	Children	Whole material
Cervical	—	—	—	—	38	38	20	58
Cervico-thoracic ..	—	—	—	—	1	1	3	4
Thoracic	72	20	8	2	213	315	81	396
Thoraco-lumbar ..	21	5	1	—	56	83	14	97
Lumbar	97	26	—	2	241	366	38	404
Lumbo-sacral	17	1	—	—	30	48	2	50
Sacral	1	1	—	—	7	9	—	9
Totals	208	53	9	4	586	860	158	1018

With adults, the lumbar region is affected more often than the thoracic region both in the spinal fusion group, 46.6 % (97/208), and in the patients given conservative treatment, 41.1 % (241/586). With children, thoracic

lesions are the most frequent, 51.3 % (81/158), this area being affected twice as often as the lumbar region. The figures are somewhat confused by the existence of the transitional regions, but the predominance in the lower part of the spine is obvious as far as adults are concerned.

The observations made are in conformity with those reported in the literature, according to which a shifting of the most usual site of spinal tuberculosis from the thoracic to the lumbar region has taken place. One circumstance which might be conducive to this is the decreased incidence of tuberculosis in children and the increase in more advanced age-groups.

As is stated in earlier reports, the occurrence of tuberculous spondylitis outside the corpus is rare. In this material, the small intervertebral articulations were affected in one case, the transverse processes in two, and the spinous processes in three cases.

Table 13 gives information as to the vertebrae affected.

TABLE 13
Vertebrae Involved and Treatment

Vertebra	Spinal fusion group	Conservatively treated group	Whole series
C I	—	6	6
C II	—	10	10
C III	—	12	12
C IV	—	10	10
C V	—	12	12
C VI	—	17	17
C VII	—	14	14
Th I	1	11	12
Th II	2	12	14
Th III	5	21	26
Th IV	11	36	47
Th V	10	43	53
Th VI	13	48	61
Th VII	22	58	80
Th VIII	32	69	101
Th IX	32	78	110
Th X	38	80	118
Th XI	50	73	123
Th XII	49	95	144
L I	46	100	146
L II	41	114	155
L III	47	118	165
L IV	54	127	181
L V	38	114	152
L VI	1	1	2
S I	18	34	52
S II	—	1	1
S III	—	3	3

In this series, both among the patients undergoing spinal fusion, and among those given conservative treatment, L IV was attacked most frequently. The subsequent sequence was: L III—165, L II—155, L V—152, L I—146, Th XII—144, and so on. In one case, coccygeal vertebra IV was affected.

The number of affected vertebrae per patient is shown in Table 14.

TABLE 14

Distribution of the Number of Affected Vertebrae and Treatment

Number of vertebrae	1	2	3	4	5	6	7	8	9	10	11	12
Spinal fusion, per cent	8.7%	72.2%	13.0%	2.5%	1.2%	0.6%	1.2%	0.6%	—	—	—	—
Conservatively treated group												1
per cent	22.9%	50.0%	16.1%	5.3%	3.1%	1.6%	0.6%	0.2%	—	—	—	0.2%
Whole series, per cent	17.9%	54.1%	16.8%	6.1%	2.5%	1.7%	0.7%	0.1%	—	—	—	0.1%

In most instances, there were two vertebrae involved. In the conservatively treated group, there were a larger number of monovertebral affections than in the spinal fusion group. It is probable that the diagnosis was more accurate in cases undergoing operation. From the literature, one gathers that monovertebral affections may be called in question, and frequently the second tuberculous vertebra may fail to be diagnosed on the basis of the X-ray picture. Tomography has only been practiced in recent years in the examination of these patients.

Cases with 4, 5, 6 or more affected vertebrae had been subjected to operation rather seldom, possibly by reason of the technical difficulty of performing spinal fusion by means of bone grafts according to Albee's method in cases with a large kyphosis.

Multiple foci in the spine have been allocated to a class by themselves. Only cases in which there is a healthy vertebra and a healthy intervertebral disc separating one focus from the other have been included. The definition is important in this connection, as multiple lesions in the spine may be confused with surface spondylitis with many vertebrae affected, but unchanged intervertebral discs.

In 21 cases, there were two different foci, and in 3 cases, three foci. Each part of the spine was represented; the 24 cases constituted 2.4 % of the whole material (24/1018).

Accordingly, the possibility of multiple lesions in the spine always necessitates roentgenography of the whole of the spine. The second lesion may be latent or occasion very little pain or discomfort.

By way of summary, the main observations may be given as follows: with adults, the lumbar region is affected more often than the thoracic region. Thoracic lesions are the most frequent in children. A shift in the commonest site of spinal tuberculosis from the thoracic region to the lumbar region has occurred, in accordance with the age-shift from childhood to more advanced age-groups; this is in agreement with the reports of others.

In this series, the incidence seems to have been highest in the lumbar vertebra IV.

In the majority of cases, two vertebrae were affected.

Abscess, Kyphosis and Paraplegia

The triad abscess, kyphosis and paraplegia at one time played an important role in the diagnosis of tuberculous spondylitis. Nowadays, these are to be regarded as late symptoms, and signs of neglected cases. Notwithstanding this, cases are still sometimes seen in which the diagnosis has not been made before this phase has developed.

Abscesses. Abscesses were established in the material as is shown in Table 15.

TABLE 15
The Site of Abscesses

Site	Spinal fusion group	Conservatively treated group	Whole series
Neck	—	10	10
Retropharyngeal	—	4	4
Paravertebral (incl.roentgenological) *)	39	132	171
Retroperitoneal	1	—	1
Iliac fossa, psoas	24	37	61
Gluteal	6	16	22
Inguinal	8	39	47
Femoral	8	24	32
Totals	86	262	348
*) Paravertebral clinical only.....	10	73	83

Thus, in the whole series there were abscesses in 34.2 % (348/1018), among patients undergoing spinal fusion in 41.3 % (86/208) and among patients given conservative treatment in 35.2 % (262/744). By comparison with earlier reports, these figures are low. Comparisons with reported figures present difficulties, however, as there is uncertainty whether they include cases which were roentgenologically visible but impossible to diagnose clinically. On the other hand, if information were given clearly that every abscess visible on X-ray pictures was included, the percentages would rise considerably. In an autopsy series, it might amount to 100 %.

Among those patients undergoing spinal fusion, fistulae were found in 7.2 % (15/208) prior to the operation, and among those patients given conservative treatment in 10.1 % (75/744). The corresponding figures for the whole series were 8.8 % (90/1018).

Kyphosis. In Tables 16—18 a classification of this material has been made according to the degree of kyphosis.

TABLE 16

Degree of Kyphosis in Different Parts of the Spine in the Whole Series

Kyphosis	Cervical	Cervico-thoracic	Thoracic	Thoraco-lumbar	Lumbar	Lumbo-sacral	Total	Per-centage
Severe	4	—	57	12	9	—	82	21.4%
Moderate	2	—	59	17	14	—	92	23.9%
Slight	11	—	98	13	86	2	210	54.7%
Totals	17	—	214	42	109	2	384	100.0%
Percentages	4.4%	—	55.7%	11.0%	28.4%	0.5%	100.0%	

TABLE 17

Degree of Kyphosis in Different Parts of the Spine in the Operatively treated cases

Kyphosis	Cervical	Cervico-thoracic	Thoracic	Thoraco-lumbar	Lumbar	Lumbo-sacral	Total	Per-centage
Severe	4	—	6	—	1	—	11	10.0%
Moderate	1	—	18	6	3	—	28	25.5%
Slight	2	—	26	8	35	—	71	64.5%
Totals	7	—	50	14	39	—	110	100.0%
Percentages	6.4%	—	45.4%	12.7%	35.5%	—	100.0%	

TABLE 18

Degree of Kyphosis in Different Parts of the Spine in the Conservatively treated Cases

Kyphosis	Cervical	Cervico-thoracic	Thoracic	Thoraco-lumbar	Lumbar	Lumbo-sacral	Total	Percentage
Severe	—	—	51	12	8	—	71	25.9%
Moderate	1	—	41	11	11	—	64	23.4%
Slight	9	—	72	5	51	2	139	50.7%
Totals	10	—	164	28	70	2	274	100.0%
Percentages	3.7%	—	59.8%	10.2%	25.5%	0.7%	100.0%	

Kyphoses are divided into slight, moderate and severe ones. A slight kyphosis is palpable as a node or prominence only, with no importance for the patient from either the physiological aspect or from the point of view of physical appearance. The angle of kyphosis is less than 10°. A severe kyphosis involves numerous vertebrae with irregular deformities. Large areas of the spine are affected, the internal organs become dislocated, and the physical appearance is altered. Subsequently, the respiratory function and the heart function are affected. The vital capacity diminishes. The angle of kyphosis is over 40°. In section VI, an explanation is given of the principles applied in measurement of the angle. In Table 16 is given the frequency of kyphosis in the whole series, in Table 17 that in the spinal fusion group, and in Table 18 that in the group receiving conservative treatment. As could be expected from the natural tendency towards kyphosis in the thoracic region, it is here that the frequency is greatest in all groups. There are few cases with severe kyphosis in the spinal fusion group because of the tendency towards selection to some extent of the cases for operation. In the whole series, kyphoses are given as 37.7 % (384/1018), in the spinal fusion group as 52.9 % (110/208), and in the conservatively treated group as 36.8 % (274/744). The number in the operatively treated group is surprisingly high; the explanation here may be that some early cases without severe changes are conservatively treated.

Paraplegia. In this series 11.2 % (114/1018) of cases had paraplegia with clear neurological symptoms in complete correspondence to the information given in earlier investigations.

Table 19 shows the percentages of cases with paraplegia grouped according to the site of the lesion.

TABLE 19

The number of cases with paraplegia grouped according to the site of the lesions

Location	Spinal fusion group	Conservatively treated group	Whole series	Per-centage
Cervical	—	5	5	4,4
Cervico-toracic ..	—	—	—	—
Thoracic	7	70	77	67,5
Thoraco-lumbar ..	—	6	6	5,3
Lumbar	2	24	26	22,8
Totals	9	105	114	100,0

Paraplegia is most apt to occur when the lesion is in the thoracic region. In the case records relating to the spinal fusion group, paraplegia is mentioned in 4,3 % (9/208), and in those for the conservatively treated group in 17,7 % (105/586). Exact figures for spastic and flaccid paralysis could not be obtained.

In addition to these cases of paraplegia, in which the neurological symptoms are clear, others have occurred in which the patients have complained of weakness and paraesthesia in the lower limbs. These symptoms could not always be distinguished from the other vague ailments of which patients frequently complain. They may nevertheless be the prodromes of incipient paraplegia.

Thus abscesses occurred in 34.2 % of cases, kyphosis in 37.7 %, and paraplegia in 11.2 %.

Other Tuberculous Manifestations

The earliest manifestations of tuberculosis, such as erythema nodosum and conjunctivitis phlyctenulosa, were taken into consideration when examining the material. They are allergic conditions not specific to tuberculosis, and may arise from other causes. Frequently, patients do not associate them with subsequent manifest tuberculosis. Erythema nodosum was recorded in only 4 cases in the material, and conjunctivitis phlyctenulosa in 3. It is most probable that these conditions were not taken into account when recording the case history.

Pleurisy. The classic sequence pleurisy, pulmonary infiltrate, bone and joint tuberculosis as well as parenchymatous tuberculosis, may be difficult to follow in every individual case, as each state does not always

become manifest. Pleurisy may be of nontuberculous origin, e.g. from rheumatic fever, pneumonia, tumour, etc. It was impossible to exclude such cases, but the probability that pleurisy in these patients was in fact of tuberculous origin was very great. Patients undergoing spinal fusion gave a history of pleurisy in 36.8 % (98/208) of cases, and the group undergoing conservative treatment in 15.7 % (117/744) of cases. The predominance of this condition in the spinal fusion group may be only apparent, and explained by the fact there were 158 children in the conservatively treated group, from whom no history of pleurisy could be elicited. The first-mentioned figure is thus more useful. A certain elapse of time takes place between pleurisy and the first symptoms of tuberculous spondylitis. In Table 20, the interval is shown in 156 cases.

TABLE 20
The Interval from Pleurisy to the First Symptoms in the Spine

Interval	Spinal fusion group	Conservatively treated group	Whoel series
Synchronous	7	4	11
3 months	2	—	2
6 »	1	3	4
1 year	16	10	26
2 years	20	23	43
3 »	13	7	20
4 »	3	3	6
5 »	5	2	7
6—10 years	10	14	24
11—15 »	2	2	4
16—20 »	3	2	5
21—23 »	—	3	3
33 »	—	1	1
Totals	82	74	156
Uncertain date	14	43	57
Totals	96	117	213

As regards a further 57 cases, no statement could be made as to the date of pleurisy or the date of the appearance of the first symptoms in the spine. In 11 cases, spondylitis and pleurisy coincided. The most usual interval was 2 years, then 1 year and 3 years. For at least three years after pleurisy, attention must be given to possible symptoms in the spine and other organs.

Hilar adenitis. There is little information regarding the prevalence of this condition in the present series, and hence it is not possible to enter into discussion on it.

Pulmonary tuberculosis. In the majority of cases, pulmonary tuberculosis had already been diagnosed earlier. As regards the fusion group, 15.4 % (32/208) had earlier had active pulmonary changes. In 13 cases, inactive pulmonary lesions were established radiologically at the routine X-ray examination. The patients receiving conservative treatment showed 18.1 % (137/744). These figures appear in Table 21.

TABLE 21

Sites of Nonskeletal Tuberculous Manifestations

Site	Spinal fusion group	Conservatively treated group	Whole series	Percentage
Acute miliary spread ..	1	5	6	0.6%
Meninges	—	7	7	0.7%
Lymphatic glands	18	76	94	9.9%
Mamma	—	1	1	0.1%
Larynx	1	2	3	0.3%
Lungs	32	137	169	17.8%
Abdomen	6	16	22	2.3%
Urogenital system*) ..	17	56	73	7.7%
Eye	—	4	4	0.4%
Skin	2	8	10	1.1%
Totals	77	312	389	
*)Kidneys	4	37	41	4.3%

No attempt has been made here at classification of the pulmonary changes into fresh, old, active, inactive, demonstrable tubercle bacilli, etc.

Other extrapulmonary soft tissue foci. Table 21 shows the sites of non-skeletal extrapulmonary foci. Next to the lungs, the most frequent changes are those in the lymphatic glands, the urogenital system, and abdomen (peritoneum, intestine).

Accordingly, in the whole series the frequency of soft tissue tuberculosis (pleuritis and hilar adenitis excluded) was 38.2 % (389/1018), in the spinal fusion group 37.0 % (77/208), and in the conservatively treated group 41.9 % (312/744). When pleurisy is included, the figures for the

whole series are 59.1 % (602/1018), for the spinal fusion group 83.2 % (173/208), and for the conservatively treated group 57.7 % (429/744).

As regards other foci in bones and joints, Table 22 shows their location and frequency.

TABLE 22

Site of other Tuberculous Manifestations in Bones and Joints

Site	Spinal fusion group	Conservatively treated group	Whole series	Percentage
Mandible	1	—	1	0.1 %
Sternum	—	1	1	0.1 %
Ribs	3	16	19	1.9 %
Acromion	—	1	1	0.1 %
Elbow	1	3	4	0.4 %
Radius	1	—	1	0.1 %
Wrist	—	3	3	0.3 %
Phalanx digiti	—	4	4	0.4 %
Ilium	—	4	4	0.4 %
Sacroiliac joint	1	1	2	0.2 %
Hip	7	21	28	2.7 %
Knee	2	13	15	1.5 %
Ankle	2	8	10	1.0 %
Metatarsus	3	1	4	0.4 %
Totals	21	76	97	9.6 %

Changes in the hip, ribs, knee and ankle predominate. In the whole material, the frequency amounts to 9.6 % (97/1018), in the spinal fusion group 10.1 % (21/208), and in the conservatively treated group 10.2 % (76/744). The frequency for each site is given in the table.

Multiple lesions may thus occur, and must be taken into consideration in every case. Nevertheless, it does appear that soft tissue lesions far outnumbered changes in the bones and joints.

Diagnostic and Differential Diagnostic Aspects

It is not the author's intention to deal with the well established and well known symptomatology of tuberculosis of the spine. Erythema nodosum, hilar adenitis and pleurisy have been mentioned earlier, as have the triad consisting of abscess, kyphosis and paraplegia. In the diagnosis of tuberculous, spondylitis, what were formerly the classic symptoms, such as abscess, kyphosis and paraplegia, are nowadays to a certain extent deprived

of their significance. Earlier diagnosis is expected. The early symptoms of incipient spondylitis, the pain (sometimes radiating), the narrowed disc and the tomographic findings are very important. But in some cases pain may be absent.

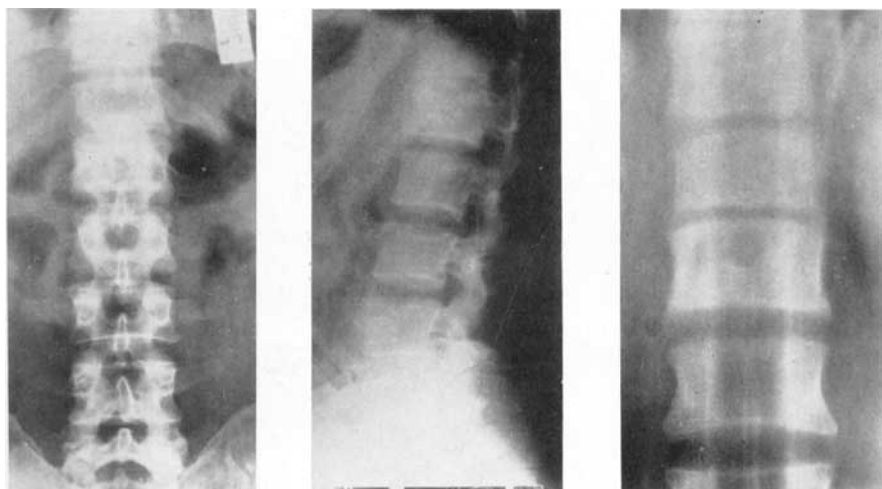


Fig. 1. Diagnosis by tomography of tuberculous spondylitis in the initial stage. The patient was sent to another hospital for spinal fusion: there, they had no faith in the tomographic finding. After admission to three further hospitals, without result, the patient returned after three years with abscess, incipient kyphosis and slight spasticity in the feet.

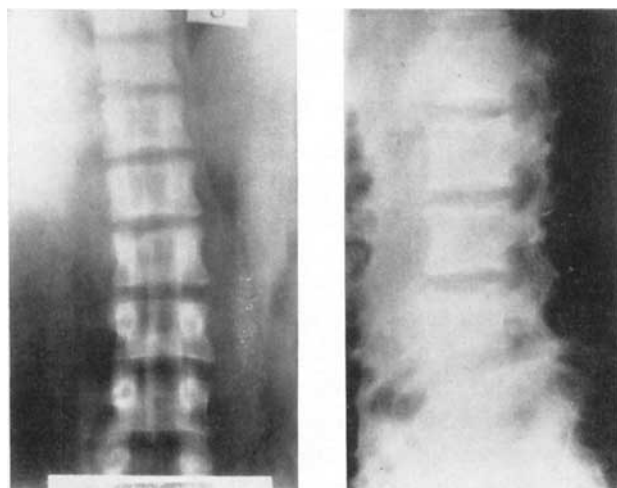


Fig. 2. Incipient tuberculous spondylitis. The lateral roentgenogram shows indistinct erosion of the discal surfaces. Tomography indicates the site of the lesion and its extent.

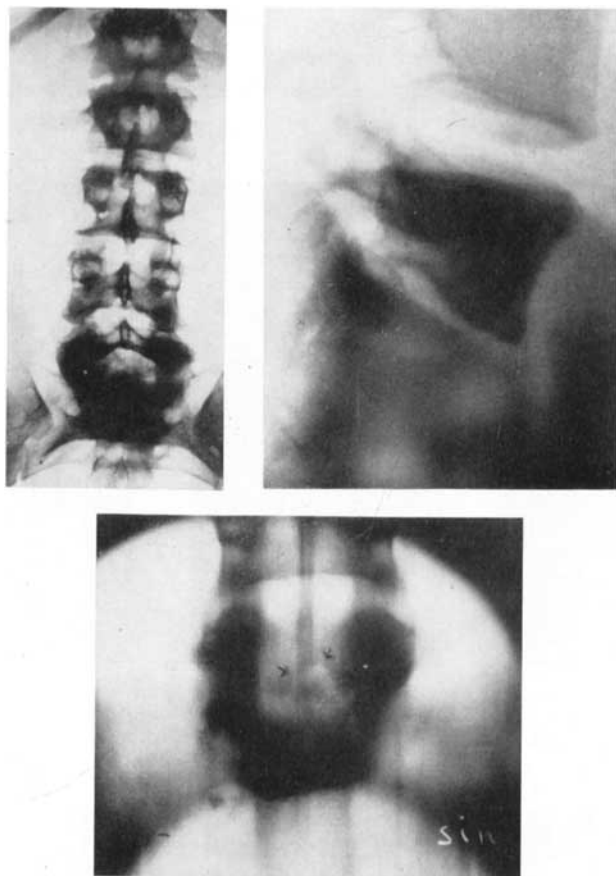


Fig 3. Tuberculosis in the initial stage. Normal pictures show only a narrowing of the intervertebral space L V—S I. There may be an indication of pathological changes in the lateral view in the posterior lower part of the Vth lumbar vertebra. Tomography reveals that there is destruction of the lower edge of L V by sequestration.

Tomography is very important in the diagnosis of tuberculous spondylitis, especially in incipient, early cases, and also subsequently in order to arrive at an understanding of the real extent of the lesion. In Figures 1—3 are illustrated three such cases, in which tomography was decisive in diagnosis. Figure 1 shows a patient whose diagnosis was made at the Out-patients' Department of the Surgical Clinic. The patient was sent to another hospital, where the tomographic finding was not regarded with any faith. After admission to three further hospitals, without result, the patient returned after two years, with abscess, incipient kyphosis and slight

spasticity in the feet. Figure 2 illustrates how tomography aids the diagnosis. The lateral view shows indistinct erosion of the discal surfaces. Tomography shows distinctly the site of the lesion and its extent. As regards Figure 3, the routine X-ray pictures show merely a narrowing of the intervertebral space. There may be an indication of pathological changes in the lateral view in the posterior lower part of the Vth lumbar vertebra. Tomography illustrates the fact that there is destruction of the lower edge of L V by sequestration.

In some cases, it was possible to state the interval between the commencement of back pain and the making of a diagnosis. As is shown in Table 23 10.7 % (41/384) were diagnosed from 2—3 months after the occurrence of pain, 11.9 % (46/384) after 6 months, 25 % (96/384) after twelve months, and 24.5 % (94/384) after 2 years. Thus, in 49.5 % of the cases 3 years and upwards. Remarkably lengthy periods were found in rare cases in which the interval was 15, 16, 19, 20, 30 and 31 years. Only 46.7 % were diagnosed before the end of the first year. Frequently, these patients had consulted a large number of doctors without getting a correct diagnosis. The figures given above relate to the phase prior to admission to hospital.

TABLE 23

The Interval between the Occurrence of Back Pain and the Diagnosis

Interval	No. of cases	Percentage
2—3 months	41	10.7 %
6 months	46	11.9 %
12 months	96	25.0 %
2 years	94	24.5 %
3 years	32	8.3 %
4 years	21	5.5 %
5 years	14	3.7 %
6—10 years	23	6.0 %
11—15 years	9	2.3 %
16—20 years	6	1.5 %
30 years	1	0.3 %
31 years	1	0.3 %
Totals	384	100.0 %

The following faulty diagnoses were recorded: Rheumatism was reported most commonly, in 49.6 % of cases, sciatica next in 9.8 %,

lumbago in 6.2%, deforming spondylosis in 3.5%, weak back in 3.5%, spondylolisthesis, old fracture of the spine, congenital vertebral affection, muscular rheumatism, muscular inflammation, muscular sprain, »rheumatism of the nerves«, neuralgia, osteomyelitis, tumour, pleuritis, fracture of the ribs, affection of the kidneys, appendicitis, lues, gynaecological affections, too frequent partus, dyspeptic trouble, anaemia, hypersensitiveness, tiredness, hypochondriasis, simulation.

All of these faulty diagnoses were made during the period before admission to hospital. An examination has also been made as regards correct diagnosis in hospital.

Spinal fusion was performed on the basis of faulty diagnosis in 6 cases. The diagnosis was: 2 spondylolisthesis L V—S I, ankylosing spondylarthritis, myeloma, metastasis in Th XII of a malignant melanoma, and congenital synostosis of Th IV—V.

V. TREATMENT

General Principles

The treatment included measures to improve the patient's general condition, chemotherapy, immobilization, plaster of paris bed and surgery. Constitutional treatment consisted of improved nutrition, general care of the patient, and rest.

The patients of the present series were not treated in sanatoria. Since 1950, spinal fusion has been performed in every case. During the period 1930—1948, there were some cases including both children and adults, in which spinal fusion was not undertaken. This is the »conservatively treated» group.

Chemotherapy

In this series, 49 cases were treated with streptomycin, isoniazid (ISN), and PAS (para-amino salicylic acid).

As a rule, streptomycin was given in doses of 1 gram daily, isoniazid 0.1 gram $\times$ 3 daily, and PAS 10—16 gram daily. Streptomycin was given in 44 cases, isoniazid in 18, and PAS in 37. The combination streptomycin/PAS was used in 32 cases, streptomycin/isoniazid being used in 10 cases. If there was hypersensitiveness to a certain drug, it had to be discontinued. Dermatitis with streptomycin, and gastric troubles with PAS were the most frequent side-effects. Antihistaminic preparations were employed for the treatment of allergic reactions. Complications such as vertigo, hearing disturbances and permanent deafness were not noted. To avoid resistance, streptomycin was reserved for the pre- and post-operative periods when spinal fusion was performed; combinations of two or three drugs were employed for the same purpose. With fistulae and abscesses, streptomycin was used. On occasion, it was locally injected in connection with the aspiration of pus, or was applied in connection with the evacuation of abscesses.

Spinal Fusion

Indications

From various points of view, prolonged conservative treatment is not desirable. One of the main arguments in favour of spinal fusion is the reduction of the treatment time. In the absence of sanatoria for adults with bone and joint tuberculosis, a long period of conservative treatment is very undesirable. Lengthy periods of bed rest have substantial disadvantages from the economic and social points of view. The psyche may be altered in the direction of depression and apathy. Separation from home and family may have unfavourable consequences. It is even possible to speak of the social and economic advantages of spinal fusion — but the shortening of the treatment is only relative in nature. To regard the process in the vertebrae as being healed after the consolidation of the graft is a mistake.

The object of operative intervention is, by constructing a bone bridge to provide compensation for the weakness of the vertebrae and the poor contact between the diseased vertebrae. In Section VI, some consideration is given to the question of whether spinal fusion is capable of preventing deformity or increase of a deformity which already exists. It may be presumed that it is easier to prevent a deformity in an early stage of the disease. Thoughy must be given to the risk of paraplegia. As a rule, our indications have not been as wide in scope as those of ALBEE, whose only contra-indication was that of a high temperature brought about by a mixed infection.

In the performance of spinal fusion, the patient's general condition should be as good as interventions of this magnitude demand, taking into consideration the possibility of carrying out the operation under local anaesthesia. The sedimentation rate should be on the way to becoming normal, but does not need to be normal. Preoperative treatment must have been begun (immobilization, plaster of paris bed, chemotherapy, etc.). In recent years spinal fusion has, in consequence of chemotherapy, been performed earlier than was at one time considered indicated. The tuberculous vertebral lesion should show regression on the X-ray picture. The diffused fuzzy zones of resorption should disappear, giving place to clearer structures and sclerosis.

The indications become clearer when one takes into consideration the contra-indications as well. Some of these are only relative, and may dis-

appear during the course of treatment. Large abscesses may vanish as a result of aspiration or surgical evacuation. Fistulae must close; they may be excised. Very old patients should not be subjected to operation. Active tuberculous changes in the lungs, intestines, or kidneys or in other bones and joints may be treated first. Bilateral affections of the kidney may be regarded as a permanent contra-indication to the performance of spinal fusion.

T e c h n i q u e

ALBEE's original method was employed in 128 cases (61.5 %, Fig. 4). The graft was placed somewhat laterally in 17 cases (8.2 %, Fig. 7). It was placed bilaterally and subperiosteally (HENLE) in 10 cases (4.8 %, Fig. 8), unilaterally and subperiosteally in 28 cases (13.5 %, Fig. 10). In 8 cases, (3.8 %) the techniques of ALBEE and HENLE were combined, three splints being used, namely one medially according to ALBEE, and two bilaterally according to HENLE. The »H-graft» of GIBSON and BOSWORTH was employed in 12 cases (1.9 %). HIBB's technique was adopted in 12 cases (5.8 %). It is not possible to draw a sharp line between the two first mentioned modifications. In numerous cases, the chisel must certainly have split the spinous processes laterally instead of medially as intended.

In most cases, tibial grafts were used — in 202 instances. In 6 cases, a graft from the crista iliaca was applied. Use was not made of »bone bank» material.

SINCE 1950, the only method employed at the Orthopaedic Clinic has been the unilateral subperiosteal one, this being a modification of the methods of ALBEE, HENLE and ROOS. The incision is made laterally of the medial line. The tips of the spinous processes are exposed, and the periosteum detached on one side as far as the base. Both the surface of the spinous process and the arch are freshened. The graft is taken from the tibia. Frequently, chips are also used. Normally, the operation is performed under local anaesthesia. The following advantages are gained by this method. The operative trauma is less if the periosteum is detached, the surfaces freshened and no bone chiselled with force in proximity to the lesion. Mechanically, the function of the support becomes more efficient the nearer it is to the lesion. In contrast to HENLE's method, only one splint has to be used (Fig. 10). Sawing the graft in two longitudinally weakens it: sawing it into three parts is still worse. The arch also has to be fused.



Fig. 4. Albee's original method, the spinous processes being split exactly in the middle (the uppermost spinous process is to some extent laterally split).



Fig. 5. The drawbacks of Albee's original method. The graft is far from the lesion. Mechanically unsound.



Fig. 6. The comments on Fig. 5 apply equally well here.

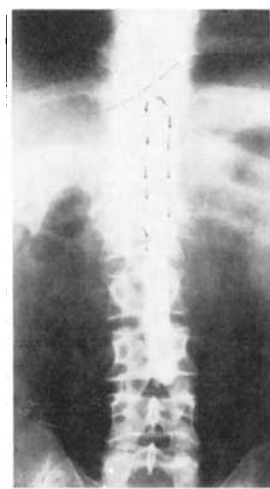


Fig. 7. Typical long graft, fixed laterally. Consolidated well and thickened: two healthy vertebrae above and below the lesion immobilized.



Fig. 8. Two grafts according to Henle's method. Both consolidated well.



Fig. 9. Similar in method to Fig. 8, but with one of the grafts placed on the arch.



Fig. 10. Short graft fixed unilaterally and subperiosteally.

The principle followed at present is that vertebrae should be fused only where this is absolutely necessary. If the process is assumed to be limited, healed or inveterate, only the affected vertebrae should be fused. In view of the possibility that the disease process might later spread to adjacent vertebrae, one vertebra above and one below the lesion have to be fused in order to ensure that support is provided by the bone graft.

From Figs. 5—7, one can see the inconveniences of the original method introduced by ALBEE. In the thoracic region, two healthy vertebrae above and below the lesion should be fused. This requires extremely long grafts; for instance, that in Fig. 7 is 19 cm. long. Fig. 4—6 show the difficulties of splitting the spinous processes exactly in the middle, and the impossibility of pushing the graft deep enough towards the base. The graft will remain at a considerable distance from the lesion, and the ankylosing effect will be dubious. Fig. 7 shows a case with lateral splitting of the spinous processes. The graft was uniting well, and had thickened. Fig. 9 shows a bilateral method according to HENLE; one of the grafts is placed on the arch, and makes no contact with the spinous processes.

As far as the end results are concerned, there do not appear to be any substantial differences between the various groups. The occurrence of graft fractures seems to have been caused by certain circumstances connected with the transplanted bone.

Faulty location of the graft during the operation was confirmed in 2.6 % (2/76) of the patients re-examined. If all the other cases known on the basis of information found in case records and old X-ray photographs are included, the figures are 3.8 % (8/208). Reoperation was performed in 3 cases.

Faulty location of the graft may be avoided by the use of lead marker films taken before the operation. The skin above the spinous processes should be marked by means of an intracutaneous injection of methylene blue solution. See Fig. 11.



Fig. 11. The lead marker film before the operation, and marking the skin with methylene blue solution facilitate identification of the correct vertebrae.

Complications Connected with Bone Grafting.

In the review of the literature, some of the mechanisms and changes in the graft connected with transplantation are considered. It is not possible in this paper to discuss the theories of the biological processes involved on the basis of the clinical material: nevertheless, some clinical and roentgenological observations may be noted.

The complications in the material connected with bone grafting were fracture, and pseudarthrosis of the graft. Among those cases examined subsequently, 6.6 % had fractures (5/76), of which pseudarthrosis per-

sisted in 2.6 % (2/76). From case records and old X-ray pictures, 3 further fractures were established, 1 pseudarthrosis remaining. None of the patients with fractures which had healed experienced any trouble at the follow-up examination.

Complete aseptic necrosis and resorption, as mentioned in the literature were not found. In many cases, after a time the graft becomes rather faint and indistinct on the X-ray picture as a result of physiological resorption and rebuilding. Routine X-ray photographs taken at definite intervals often did not cover the period during which this process occurred, so that it cannot be fixed with precision; presumably the change takes place up to one year after the transplanation. This period should accordingly be critical as far as the graft is concerned, and some form of immobilization (corset) is required. Later X-ray photographs frequently show the graft getting stronger and thickening, with plentiful new bone formation taking place (cf. Fig. 7). The stronger the graft is from the beginning, the more clearly discernible it will be. A tibial graft with a strong cortex will be more clearly visible than a graft taken from the crista iliaca. If the side of the graft covered with spongiosa is turned towards the spinous processes, there seems at times to be an unsatisfactory contact.

The longer the interval after spinal fusion, the better is the consolidation of the graft as shown on the X-ray picture. Frequently, block formation occurs simultaneously between the vertebrae.

It is probable that in all cases of spinal fusion (spondylolisthesis, low back pain, etc.), the factors which conduce to graft pseudarthrosis are in part the same but in tuberculous spondylitis there is the additional influence of the disease process, which may lead to compression, fusion, changing of kyphosis, scoliosis and torsion. The importance of the following factors will therefore now be considered: postoperative trauma, the location of the graft, the number of vertebrae affected, the length of the graft, the extent of the graft, the progression of the tuberculous process, the degree of kyphosis and increase of the angle of kyphosis, and the after-treatment.

The problem presented by graft fractures may be considered in the light of the 8 cases known to have occurred in the present series, although this figure is comparatively small (Figures 12—19). Trauma had occurred in only one case, that of a patient who fell on his back. Thus trauma was of little significance. It is difficult to pass judgment on small physiological traumas, particularly if they occurred repeatedly, which might give rise to partial aseptic necrosis of the same type as in Looser's »Umbauzonen» areas of rebuilding, or what is termed a »march» fracture in other connections.



Fig. 12. Case 1. Lesion L II—IV. Graft: length 19 cms. Extent Th XII—S I. Fracture on level with L II—III.



Fig. 13. Case 2. Lesion L V—S I. 2 grafts: longer one 18 cms. Extent L II—S I. Fracture on level with L V—S I.



Fig. 14. Case 3. Lesion L II—IV. Graft length 17 cms. Extent L I—S II. Fracture on level with the upper surface of L III.



Fig. 15. Case 4. Lesion Th XII—L I. Graft length 15 cms. Extent Th X—L III. Fracture on level with Th XII—L I.



Fig. 16. Case 5. Lesion L II—III. Graft length 15 cms. Extent Th XII—L IV. Fracture on level with L I—II



Fig. 17. Case 6. Lesion L III—IV. 2 grafts. Length of arch 15 cms, extent L II—V. Fracture on level with L III—IV'

The site of the tuberculous lesion in cases of fracture of the graft can be seen from Table 35. As appears from the Table, the lesion was on one occasion located in Th XII and L I: in 5 cases the lumbar spine was affect-



Fig. 18. Case 7. Lesion L IV—V. Graft length 13 cms. Extent L III—S II. Fracture on level with L V—S I.



Fig. 19. Case 8. Lesion L V—S I. Graft length 12 cms. Extent L IV—S III. Fracture on level with S I—II.

ed, and in 2 cases the lumbo-sacral. Thus in 7 cases the site was lumbar or lumbo-sacral, this region being noteworthy for the great mobility and flexibility of the spine. The graft is more exposed to injury at this level than in the thoracic region.

As regards the significance of the number of affected vertebrae in graft fractures, it can be stated that 3 vertebrae were involved in two cases, and 2 vertebrae in the remaining 6 cases. The number of vertebrae involved was thus not large. According to Table 14 the number of affected vertebrae in the spinal fusion cases was usually 2, with 3 ranking next.

TABLE 35

The Length and Extent of the Graft in Cases of Fracture

Case No.	Site of the lesion	Extent of graft	Length of graft in cm.	Level of fracture
1	L II — IV	Th XII — S I	19	L II — III
2	L V — S I	L II — S I	18	L V — S I
3	L II — IV	L I — S II	17	L III
4	Th XII — L I	Th X — L III	15	Th XII — L I
5	L II — III	Th XII — L IV	15	L I — II
6	L III — IV	L II — L V	15	L III — IV
7	L IV — V	L III — S II	13	L V — S I
8	L V — S I	L IV — S III	12	S I — II

Fracture of the graft never occurred on a level with the centre of the focus in these cases, but at a distance of about one vertebra above or below (Table 35). See Figures 12—19.

The length and extent of the graft in the various cases can be seen from Table 35 (cf. Figs. 12—19). In these cases, long grafts had generally been employed — 19, 18, 17, 15, 13 and 12 centimetres. The lengths were measured at operation and noted in the case records. The longest graft of the series extended from Th XII to S I (19 cm). Such long grafts may be necessary when adhering to the principle of fusion of a number of healthy vertebrae above and below those affected. ALBEE fused 2 healthy vertebrae above and below the focus in the thoracic region, and 1 healthy vertebra above and below in the lumbar region. In long grafts here were 37.5 % (6/16) of fractures and in short ones 3.3 % (2/60). The length of the graft appears to have significant influence on the occurrence of fractures.

A further important factor may be that in 6 cases out of 8 the lower end of the graft rested on the sacrum.

The spread of the disease into new vertebrae did not play an important role in this connection, and only one case occurred, the new lesion being situated in a completely different region of the spine. The primary lesion was in L IV—V, and the secondary one in Th VIII—IX. The spread of the disease into new vertebrae thus had no significance.

Kyphosis occurred in 50 % of graft defects. The angle of kyphosis was 5°, 10°, 15° and 25°. Large kyphosis was thus absent. 44.1 % (26/59) had kyphosis at the time of the operation; among them, fracture of the graft was confirmed in one instance. It seems that the size of the kyphosis had accordingly no significance in this respect.

In only one case of graft fractures did the kyphosis increase by 3°: the figure is such a small one that it might well have been occasioned by an error of measurement on the X-ray photograph. The fusion of the vertebrae and the change taking place in their mutual position extended over so long a period that the graft had ample time for transformation.

As far as graft fractures are concerned, it is rather difficult to determine the interval between spinal fusion and the occurrence of fractures. In four cases it could not be done. In those cases where the interval could be determined, it was 2 months, 1 year and 4 years respectively.

After-treatment given before the occurrence of graft fractures included bed rest, a plaster bed in one case, a plaster jacket for eight months in another. Five patients were given spinal braces. In only one case was the duration of bed rest less than the six weeks recommended by ALBEE. Presumably, in prescribing this short period of immobilization he took

into consideration the consolidation of the graft only, and not the healing of the tuberculous process. Thus for cases with graft pseudarthrosis, the plaster bed was used in only one case.

The eight cases in this series are rather too few in number to provide information one way or the other.

The above-mentioned complications did not notably prolong the period of treatment. There is only one case in which the patient did not recommence work until five years after the performance of spinal fusion. The treatment rendered necessary by the complication, that is to say immobilization in a plaster bed or spinal fusion for the second time, might, of course, extend the period of treatment, although this is not apparent from this series of cases.

In most instances, a plaster bed was employed when fracture of the graft occurred. Two patients underwent further operations. In two cases, pseudarthrosis persisted during conservative treatment. It is possible that graft fractures heal more easily in a tuberculous spine which is already stiffening as a result of the disease and immobilization subsequent to spinal fusion, than at transplantation in other connections, eg. in spondylolisthesis, low back pain, etc.

As regards end results, there is no difference between the cases with graft fractures and those with grafts that have healed without fracturing. Quite possibly, fractures of the graft are of little significance as far as the final outcome is concerned. It is true that the operation fails in its aim, but this state of affairs is compensated by the tendency of the graft to heal satisfactorily and the somewhat prolonged period of immobilization which promotes the healing of the tuberculous lesion.

Since 1950, a noteworthy feature has been the absence of complications involving the graft. Fractures and pseudarthrosis have been avoided, probably because the following principles and precautions were observed: short grafts are used if possible, and (bearing in mind the danger of spread to adjacent vertebrae) only one vertebra above and below the focus are fused: the patient is laid in his previously made plaster bed before he leaves the operating theatre: the period of immobilization has to be sufficiently long after the bone grafting: a spinal brace is prescribed for wear for twelve months after the patient is allowed to leave his bed.

If a comparison is made with the results reported in the literature, it is seen that the frequency of 6.6 % is rather low.

To summarize, it may be said that fractures of the graft amounted to 6.6 %, and that pseudarthrosis persisted in 2.6 %. There was no occurrence of complete aseptic necrosis and resorption.

The following factors appeared to be of importance in fractures and pseudarthrosis: the length of the graft, its location and its extent. The lumbar and lumbo-sacral parts of the spine are predisposed to such mishaps.

Most graft fractures should heal as a result of conservative treatment. The plaster bed must be tried first; if this should be of no avail then a new fusion has to be carried out.

The observations made on this series of patients showed that the final results of tuberculous spondylitis were not substantially impaired by graft fractures. They may well be less significant than has been presumed, and possibly heal more easily in a tuberculous spine which is already stiffening as a result of the disease and the immobilization than in other connections.

Post-operative Treatment.

In part, post-operative treatment was the same as that given pre-operatively. Subsequent treatment was partly carried out in other hospitals, or at home, the patients returning at regular intervals for examination as during the period of pre-operative treatment.

Earlier, the patient was immobilized in hospital for six to eight weeks after spinal fusion, and further advised, to refrain from earning a livelihood by physical work for a period of one year. During the first eight months, he was allowed up at mealtimes only, and for making visits to the toilet. Otherwise, he would be lying flat on his back on a comparatively hard mattress. In some cases, ALBEE's after-treatment of only six weeks in hospital was given, this being a short period indeed. In a few of the earlier cases, patients recommenced work immediately on discharge from hospital; they might even fail to follow the prescribed after-treatment and neglect to attend follow-up examinations. The aim at the Orthopaedic Clinic has been to give individual treatment to each case. The course of the disease process as seen by X-rays, the sedimentation rate and the general condition have been the decisive factors in determining the form of after-treatment given to the patient. He would, in his plaster bed, be subjected to examination at intervals of three months (sedimentation rate, X-ray pictures of the spinal column and lungs).

As mentioned earlier in the section on indications, at the Orthopaedic Clinic endeavours have been made in recent years to perform spinal fusion somewhat earlier than before with the aid of chemotherapy. To some extent, this principle has had some influence upon after-treatment. The plaster bed has been made before the performance of spinal fusion. While the patient is still on the operating table, it is placed beneath his back,

and he is lying in it when lifted on to his ordinary bed. The possibility of trauma is thus reduced to a minimum. The immobilization of the patient in the plaster bed is carried on for six to nine months, depending upon the individual case.

After operation, chemotherapy is continued with streptomycin, isoniazid and PAS. Streptomycin is given during the pre- and post-operative periods. Isoniazid and PAS may be given for 1—2 years.

During the period of immobilization, the patient must exercise his extremities. Occupational therapy is continued during after-treatment, and does in part prepare for the resumption of work.

Mobilization of the patient from the plaster bed is carried out gradually. Once the patient manages to stand for a sufficient length of time, he is measured for a spinal brace, which is used for one year. In cases of lumbar tuberculosis, a spinal brace of »Taylor» type is employed.

When the spinal brace become superfluous, the patient begins back exercises so that he may strengthen the muscles and ligaments. Despite the healing of the lesion, pain in the back may occur later. It is at this stage that the question of a change of employment may arise. Any kind of work which obliges the patient to stoop for a number of hours each day, or which makes it necessary for him to lift heavy weights is unsuitable, even if the lesion in the spine has healed.

VI RESULTS OF TREATMENT

Recurrences

After the discharge of the patient from hospital, recurrences may occur, and they manifest themselves by a renewed outbreak of the disease after a symptom-free interval which varies in duration. Pain, an increased sedimentation rate, abscess, fistula or paraplegia occur again. It is not always an easy matter to determine whether this is a continuance, or recurrence. In this paper, the following criteria are applied to a relapse. A period of at least two years should have passed since the occurrence of the last previous symptoms, and this period should have been completely pain-free. Thus, in this section, relapses will be considered in a clinical sense. Naturally, there can be argument as to whether they are so in a patho-anatomical sense. The information regarding relapses comes from records, questionnaires and follow-up examinations.

Table 25 shows recurrences among patients who had undergone spinal fusion, and those given conservative treatment alone. After spinal fusion, there were 17.5 % (25/200) of relapses, and on conservative treatment 7.4 % (46/619).

TABLE 25
Recurrences

Spinal fusion group	Conservatively treated group	Totals
35	49	84

Of the patients who had undergone spinal fusion, 1.5 % (3/200) relapsed into paraplegia, and of those given conservative treatment, 1.9 % (12/619).

In the series as a whole, there were thus altogether 10.3 % (84/819) of recurrences in the spine.

As recurrences appear to occur at varying intervals, the period elapsing between of the discontinuance of post-operative treatment, or of the conservative treatment, is of interest. See Table 26.

TABLE 26
Symptom-free Interval between Previous Treatment and Relapse

Interval	Spinal fusion group	Conservatively treated group	Totals
Years			
2	12	12	24
3	6	8	14
4	4	5	9
5	1	2	3
6—10	7	18	25
11—15	3	1	4
16—20	2	2	4
21	—	1	1
Totals	35	49	84

In patients who had undergone spinal fusion, approximately 50 % of relapses occurred during a period of two to four years after the end of the post-operative treatment, or after the last symptoms of activity had subsided. As regards the conservatively treated group, the corresponding figure during the same period after the end of the treatment was 40.8 %.

Table 27 shows the distribution of vertebral relapses according to site. Among patients who had undergone spinal fusion, relapses occurred most frequently in the thoracic region. As far as conservatively treated cases were concerned, the distribution was comparatively even. Nevertheless, there were no relapses in the cervical group, very likely owing to the fact that the follow-up interval was lengthy, and that 57.5 % had died. There were no relapses among the patients with lumbosacral lesions in the operatively treated group, and only two in the group treated conservatively.

TABLE 27
The Distribution of Relapses According to Site and Method of Treatment

Site	Spinal fusion group			Conservatively treated group			Total of relapses
	No. of patients	Relapses	Percentage relapses	No. of patients	Relapses	Percentage relapses	
Cervical	—	—	—	40	—	—	—
Cervico-thoracic	—	—	—	2	—	—	—
Thoracic	70	17	24.3 %	227	21	9.3 %	38
Thoraco-lumbar	21	1	4.8 %	57	3	5.3 %	4
Lumbar	92	8	8.7 %	254	23	9.1 %	31
Lumbo-sacral ..	17	—	—	32	2	6.3 %	2
Sacral	—	—	—	7	—	—	—
Totals	200	26	—	619	49	—	75

It is extremely difficult to provide an explanation of the striking difference in favour of those patients who had been given conservative treatment. The opposite might have been expected to be the case, with less favourable results from the conservatively treated group. Possibly the conservatively treated cases ran a more chronic course, without improvement. Or again, the explanation might be that formerly, especially at the beginning of the spinal fusion epoch, the intervention was sometimes performed too early, and the stage of the disease not being taken into consideration and without satisfactory pre-operative treatment disease. Furthermore, the post-operative treatment was comparatively short; some patients recommenced work too early. The significance of surgical intervention has perhaps been overestimated.

Subsequent to the introduction of tuberculostatic drugs, only 2.0 % (1/49) of relapses occurred among patients who had undergone spinal fusion. There are no patients in the present series who received purely conservative treatment and chemotherapeutic drugs. In a corresponding control group, without chemotherapy, recurrences amounted to 11.1 % (5/45).

Thus in a great number of cases the performance of fusion offered no protection against recurrences.

Following the introduction of chemotherapy only 2.0 % relapses occurred in the spinal fusion group.

New Manifestations

New tuberculous foci may appear in other bones or joints or extra-skeletal structures. Of the patients who had undergone spinal fusion 24.0 % (48/200) had new manifestations, compared with 17.9 % (111/619) in patients who had been given conservative treatment. See the Table 28. Here, the figure 19.4 % (159/819) appears. In this series, patients who had undergone spinal fusion were subject to rather more new manifestations than those who had been given conservative treatment.

If the distribution of these new manifestations is analysed, it can be seen that the operatively treated group had new manifestations as follows: hip — 1, knee — 1, tarsus — 1, and thus the skeletal cases amounted to 6.3 % (3/48); meninges 20.8 % (10/48), lungs 27.1 % (13/48), pleura 10.4 % (5/48), urogenital system 22.9 % (11/48). As regards the patients given conservative treatment, the corresponding figures show that the elbow was affected in one case, the hip in 4.5 % (5/111), the knee in 1, tarsus in 1,

TABLE 28
New Manifestations

Site	Spinal fusion group	Conservatively treated group	Totals
Skeletal:			
Elbow	—	1	1
Hip	1	5	6
Knee	1	1	2
Tarsus	1	1	2
Extra-skeletal:			
Acute miliary spread	—	11	11
Meninges	10	18	28
Lymphatic glands	4	4	8
Mamma	1	—	1
Lungs	13	43	56
Pleura	5	6	11
Abdomen	1	4	5
Urogenital *)	11	17	28
Totals	48	111	159
*) Kidneys	8	14	22

the skeletal cases thus being 7.2 % (8/111). Acute miliary spread occurred 9.9 % (11/111), and new extraskkeletal lesions arose in the following organs: meninges 16.2 % (18/111), lungs 38.7 % (43/111), urogenital system 15.3% (17/111), etc. (cf. Table 28).

The most important new sites in both groups are the meninges, lungs, pleura and urogenital system (kidneys). It was only in the conservatively treated material that miliary tuberculosis occurred. All of the meningitis cases, with the exception of one treated with tuberculostatic drugs, and all miliary cases, ran a lethal course.

When percentages are calculated for the whole of the operatively and conservatively treated groups, the figures are as follows:

In the whole spinal fusion group —
 meninges 5.0 % (10/200), lungs 6.5 % (13/200),
 urogenital system 5.5 % (11/200), and
 in the whole conservatively treated group —
 acute miliary spread 1.8 % (11/619)
 meninges 2.9 % (18/619), lungs 6.9 % (43/619),
 urogenital system 2.7 % (17/619).

In the series as a whole, the corresponding figures are —
 acute miliary spread 1.3 % (11/819), meninges 3.4 % (28/819).
 lungs 6.8 % (56/819), urogenital system 3.4 % (28/819).
 kidneys 2.7 % (22/819).

In Table 29 are shown the length of the intervals from the performance of spinal fusion, or from the beginning of the conservative treatment until the occurrence of the new manifestation.

TABLE 29

The Interval from the Beginning of Treatment to the Occurrence of New Manifestations

Time elapsed	Spinal fusion group	Conservatively treated group	Totals
3 months	4	9	13
6 months	2	6	8
1 year	8	13	21
2 years	15	11	26
3 »	4	9	13
4 »	2	12	14
5 »	3	3	6
6—10 »	9	32	41
11—15 »	—	7	7
16—20 »	1	3	4
21—24 »	—	2	2
Totals	48	107	155

As regards the patients who had undergone spinal fusion, 60.4 % of new manifestation occurred within the first two years after the intervention. In the conservatively treated group, the corresponding figure was 44.9 %.

Thus the spinal fusion cases in the series were subject to more new manifestations. This may be explained by the fact that in the operatively treated group there were more recent cases, and in the conservatively treated group more old cases in which a different phase of the disease had already been reached. When the operation was performed possibly at too early an active stage, or the duration of pre- and post-operative treatment was too short, the danger of the tuberculous infection spreading was considerable.

After the introduction of chemotherapy, new manifestations occurred in only 8.2 % (4/49) in the knee, kidney, mamma and lymphatic glands. The lengths of the intervals from the operation until the occurrence of the new focus were in three cases two years and in one case five years.

In a corresponding group of spinal fusion cases, without chemotherapy, new manifestations occurred in 13.3 % (6/45) or rather fewer than in the whole group; three were cases of meningitis and the kidneys were affected in a further three cases.

The old question of the relationship between the operative trauma and the military spread of tubercle bacilli infecting other organs via the lymphatic glands and blood vessels may be mentioned in this connection. Of course, the chiselling of the spinous processes for the graft bed is a trauma, the extent of which is greatly dependent upon the technique employed and the force applied. The intervention may bring about hyperaemia of the surrounding parts, and perhaps also of the focus. Nevertheless, perhaps the most important factor was the deterioration in the general condition which at one time took place after an operation performed under general anaesthesia without sufficient shock treatment in the absence of chemotherapy.

The above observations may be summarized as follows:

New extravertebral manifestations occurred among patients undergoing spinal fusion.

Following the introduction of chemotherapy the frequency of new manifestations decreased.

End Results of Spinal Fusion.

This section is concerned with the end results obtained with the 208 patients who had undergone spinal fusion. The 49 cases given chemotherapy are given consideration separately, and a comparison is made with a group not given chemotherapy. The end results are also discussed from the roentgenological aspect, and also the possibility of preventing kyphosis by means of spinal fusion.

As has been stated, relapses may occur in the spine even 15 or 20 years after the end of treatment. It is always a difficult matter to judge the definitive healing of spondylitis, and for this reason an interval of two years was taken as the shortest period of observation. A follow-up period of five years would be ideal, but then those patients treated with chemotherapy would be largely omitted, in view of the recent introduction of this form of treatment.

In approximately 50 % of the cases, the period of observation was from 6 to 24 years, and in the remainder from 2 to 5 years. The shortest follow-up time was accordingly 2 years, and the longest 24.

Generally speaking, the same advice was given to all the patients i.e. that for one year following spinal fusion the patient should not return to work. In practice, only some of the patients were able to set about earning a livelihood at the end of a year. See Table 30.

TABLE 30
The Interval between Spinal Fusion and Return to Work.

Interval	Number of cases
6 weeks	9
3 months	8
6 months	19
1 year	65
2 years	23
3 »	12
4 »	4
5 »	3
6 »	3
7 »	1
8 »	1
9 »	
10 »	1
11 »	2
Total	151
Unfit for work	22
Questionnaire unanswered	8
Dead	27
Total	208

Nine patients started work immediately on discharge, their period of treatment thus being limited to 6 weeks only, the length of the time spent in hospital. Such an early resumption of activity may have been due to an incorrect conception of the rate of return to health of the spine after operation. To place implicit reliance on the capacity of the graft to protect the affected vertebrae, is to forget that tuberculosis is a systemic disease which runs its own course, depending upon the virulence of the bacteria and the immunobiological resistance. In some instances, the patients ignored the instructions given to them on discharge. 5.9 % (9/151) returned to work immediately after leaving hospital, 8 after three months, and 19 after six months. In all, 23.8 % of the patients returned to work too early. 43.0 % (65/151) were reported as starting work after the elapse of a year.

Thus a total of 66.9 % (101/151) returned to work within one year or less of the operation. It is our opinion at the Clinic that it is impossible to present any definite scheme as to when a patient can be considered fit to resume employment, but that too early a return to work is to be condemned.

It is a difficult matter to make an objective appraisal of working capacity during the course of a follow-up examination. The capacity varies according to such circumstances as the profession of the patient before the operation. One who had been engaged on forest work before falling ill would regain his working capacity by slower degrees than one whose work consisted of light sedentary duties in an office, or running a household.

The classification given below was formulated according to the work engaged in by the patients — heavy, average or light. Factory work, forest work and farm work were considered to be »heavy». »Average work» includes clerical duties, the work carried out by shop assistants, chauffeurs, domestic servants in town, servants in general, school-teachers, those engaged in handicrafts or attending school, milliners, dressmakers, etc. »Light work» comprises such activities as needlework, housework at home, half-day employment and incidental work, and work done by pensioners. As can be seen from Table 31, of 208 persons who had undergone the operation, 8 failed to answer the questionnaire, and 27 had died. Of the 173 patients who provided information, 12.7 % (22/173) were unfit for work, 13.3 % (23/173) were engaged on heavy work, 47.4 %

TABLE 31

The Working Capacity at Follow-up Examination of Patients who had Undergone Spinal Fusion

Working capacity	No. of cases	Percentage
Heavy work	23	13.3 %
Average work	82	47.4 %
Light work	46	26.6 %
Unfit for work	22	12.7 %
Total	173	100.0 %
Questionnaire unanswered	8	
Dead	27	
Total	208	

(82/173) on average work, and 26.6 % (46/173) on light work only. An examination of those patients who were unfit for work (Table 32) showed

that in 5 patients the focus in the spine continued active following the performance of spinal fusion. Relapse was confirmed in 6 patients (3 of whom had paraplegia), and new extravertebral lesions in 3: pulmonary tuberculosis in 1, tuberculosis of the kidneys in 1, and tuberculosis of the knee joint in the third. Two were unfit for work as a result of nontuberculous affections; heart and asthma. In 6 cases, back pain was given as the reason for unfitness.

TABLE 32

The Causes of Complete Unfitness for Work at Follow-up Examination

Cause of unfitness for work	Number of cases
Active lesion	5
Relapse (including 3 with paraplegia)	6
Extravertebral tuberculosis	
Knee	1
Lungs	1
Kidneys	1
Nontuberculous causes	
Heart	1
Asthma	1
Causes presumably in connection with tuberculosis of the spine	
Back pain	6
Total	22

Of the 76 patients submitting to this follow-up examination, one still had an active lesion in the spine and was lying in a plaster bed; the sedimentation rate was high. The remaining 75 were healthy and fit for work.

The X-ray pictures of the lungs showed no active lesions for any of the patients, only evidencing healed and calcified changes.

At follow-up examination, the sedimentation rate was found to be raised in 26.3 % (20/76). Despite careful examination, it was not possible to provide an explanation of the raised sedimentation rate; continued observation might have resulted in determination of the cause. The sedimentation rate, although it is not a specific reaction in cases of tuberculosis, is of significance in providing a means for following up the course, improvement or impairment, of the patient's condition.

One urine test showed a positive culture, and the patient was sent for further urological examination. Other urine findings were comparatively insignificant (B.coli was found in 2, and streptococci in 3 cases).

In one case, active untreated tuberculosis of the knee was found; the sedimentation rate was normal.

No great significance can be attached to the bending capacity of the spine as the tuberculous lesion in itself results in stiffening of the affected part and spinal fusion has the same intended and desirable effect. A long graft had a greater stiffening effect than a short one; in one instance, a 19 centimetre graft (measured at operation) made bending impossible. The bending capacity of the spine, was tested forwards, laterally and backwards. Note was made of the capacity to reach the floor with the fingertips without flexing the knees. This is by no means a satisfactory test. On carrying it out, it is important to observe the extent to which the spine itself can be bent, as in some instances the hip joint provides compensation for the stiffness of the spine; a patient can touch the floor with the finger tips despite a spine which is absolutely inflexible. Nevertheless, this method was employed so that some indication of the bending capacity could be obtained, together with the condition of the back muscles. Weakness of the latter may subsequently result in weakness, tiredness and possibly pain even after successful fusion and healing of the tuberculous lesion.

52.6 % (40/76) of the cases showed excellent ability to bend the spine forwards and touch the floor with the finger-tips. It was established that those engaged in heavy work showed greater capacity to bend than those carrying out light sedentary work. At the follow-up examination, the results were least satisfactory as regards those still wearing a spinal brace, or those who had used one for a long time. In the region of the spine where the graft had been fixed, flexibility was of course non-existent, and hardly desirable either. Generally speaking, the sections above and below the lesion must provide compensation for the stiffness through increased flexibility and enlargement of the intervertebral space. This last-mentioned change is also brought about by another cause, and is often visible on the X-ray pictures. The sections of the spine above and below the kyphos undergo a compensatory lordosis. The enlargement of the intervertebral spaces and the increased flexibility may damage the disc, with attendant degeneration. This affords an explanation of the pain which may subsequently occur even though the tuberculous process has, healed.

In 77.6 % (59/76) of the cases, lateral flexibility was good (15—20°), and the capacity to bend backwards was good in 65.8 % (50/76) of the cases (20—30°). The angles were measured at the clinical examination.

At follow-up examination 73.4 % (55/76) of the patients complained of trouble in the back, although the X-ray photograph showed the process to be inactive; 28.9 % (22/76) complained of pain, 30.3 % (23/76) of

tiredness, and 13.2 % (10/76) of stiffness. Eleven patients stated that there was pain, especially after performing heavy work, and 1 intimated that there was pain at the top of the graft, although nothing of special note was found. Three complained of pain brought about by changes in the weather, and 1 of pain which existed irrespective of the nature of the work done. One stated that he suffered from pain in the evening after work, and 1 said that he was troubled at night. One patient was admitted to hospital with sciatica; no special cause could be found. Two spoke of heart trouble. Next to pain, tiredness of the back was given as the most important symptom.

Mention may still be made of five female patients who married subsequent to spinal fusion; each of them gave birth successfully to at least one child. At follow-up examination, the condition was good. Two had backache, but no special cause was established.

Roentgenological Findings at Follow-up Examination

So that the course and the healing of the disease as shown by X-ray pictures might be investigated, the roentgenological findings were classified in six stages as follows: I. Cases with roentgenological changes visible by tomography alone, II Cases with a narrowed disc, III Cuneiform vertebrae, IV Pseudoblock formation, V Complete block formation, and VI Irregular deformities (cf. Table 33).

TABLE 33

Roentgenological Findings at Follow-up Examination

Stage *)	No. of cases before fusion	No. of cases at follow-up examination	Increase or decrease
I	3	—	— 3
II	14	8	— 6
III	40	18	—22
IV	—	8	+ 8
V	1	23	+22
VI	1	2	+ 1
Totals	59	59	

*) The stages are explained in the text.

Stage I includes cases which were diagnosed by tomography alone. This group includes those having spinal tuberculosis in the initial stage. There were surprisingly few such cases in the series II. Narrowed disc, small bone defects on X-ray pictures. Stage III. A cuneiform vertebra and a narrowed disc, possibly completely destroyed. Unfortunately, this is a rather usual type of healing resulting in kyphosis. Stage IV. Pseudoblock formation, being an incomplete fusion of two vertebrae. In one or other of the projections, large or small remnants of the intervertebral disc will appear. If partial osseous fusion occurs, the result may be as good as the following one. Stage V. Complete block formation. Complete fusion occurs, and no intervertebral disc is seen in any projection. This is the most satisfactory type of healing. Group VI. Cases which showed a number of vertebrae with irregular deformities and remnants of intervertebral discs. The vertebral corpus may disappear completely, or leave only small remnants. Generally, the kyphosis is large and disturbing from the viewpoints of anatomy, function and physical appearance.

The pre-operative occurrence of the various X-ray stages can be compared with the changes observed at follow-up examination, with a view to determining the possible increase or decrease (Table 33). In 59 of the 76 cases, complete series of X-ray photographs were available for those who had undergone spinal fusion, and who had attended follow-up examination. Unfortunately, some of the X-ray records of the other cases had been lost.

It can be seen that Stages II—III decreased and Stages IV—V increased; thus complete block formation and pseudoblock formation rose in number, whereas there was a decrease in cases with a narrow disc alone or cuneiform cases without block formation. With the passing of the years, accordingly, it seems that there have been more and more cases with pseudoblock formation and complete block formation, or in other words the most satisfactory type of healing is on the upgrade.

In Table 34 is shown the effect of time-factors on vertebral affections after spinal fusion.

TABLE 34

The Relationship between the Period of Observation and Roentgenological Findings after Spinal Fusion

Period of observation Years	Groups					
	I	II	III	IV	V	VI
2	—	2	1	1	5	—
3	—	2	2	1	5	—
4	—	—	6	—	—	—
5	—	1	9	—	—	1
6	—	1	—	—	—	—
7	—	—	2	2	3	—
8	—	—	1	—	2	—
9	—	1	1	2	4	—
10	—	—	1	—	2	1
12	—	—	—	—	1	—
13	—	—	1	—	—	—
14	—	—	—	1	2	1
15	—	—	—	1	—	1
18	—	—	—	—	1	1
19	—	—	—	1	—	—
20	—	—	—	—	2	—
21	—	—	—	—	1	—
		7	24	9	31	5

Where the follow-up period was lengthy, it is obvious that partial and complete block formations were predominant.

Prevention of Kyphosis by Spinal Fusion

In order to determine whether fusion prevents the occurrence of kyphosis, or brings about an increase in one already in existence, the cases have been divided into four groups.

Figure 20 illustrates the means used to measure the angle of kyphosis on the X-ray pictures. As the ends of the curves, those vertebrae were selected which were nearest to being on one curve or the other, a—b and c—d. Lines A—B and C—D were drawn, and the angle AOC measured.

1. Cases with no kyphosis either before or after the fusion,
2. Cases with no kyphosis before, but with kyphosis after spinal fusion,
3. Cases with kyphosis before the fusion, which did not increase after the operation,

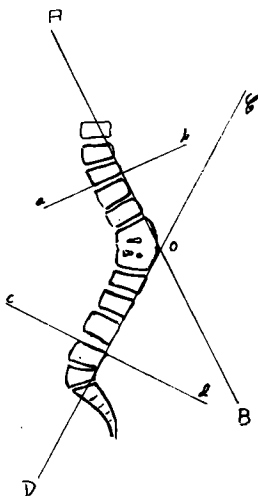


Fig. 20. The method used to measure the angle of kyphosis on the X-rays. See the text.

4. Cases with kyphosis before the fusion, which increased despite the operation.

Group 1. For the 31 cases with no kyphosis either before or after the fusion the observation period varied from 2—19 years. The affected vertebrae were mostly 2 in number. There were wide variations in the grafting technique employed. Most frequently, or in 19 cases, grafts were fixed laterally or subperiosteally. In four cases ALBEE's primary technique was employed, with the spinous processes split medially, in five cases bilaterally; in two cases the H-graft was used, and in one instance HIBB's technique. In two cases, fractures of the graft occurred with no increase in the kyphosis.

Group 2. In two cases kyphosis was absent before the performance of fusion, but came into being later. The angles of kyphosis were 16° and 30° .

Group 3. In six cases the kyphosis present before the operation did not increase after fusion. The angles of kyphosis were: 4° , 17° , 21° , 25° , 30° and 48° . The period of observation was between two and eight years, 3 cases having been followed-up for only two years. In one case, the graft was fixed in the medially split spinous processes, and five times laterally and subperiosteally. There were no graft fractures in this group. The conclusion drawn is that only in 23.1 % (6/26) of the cases was it possible that spinal fusion may have prevented the deformity from increasing.

TABLE 35

Patients in whom Kyphosis Increased in Spite of Spinal Fusion

Follow-up Interval (Years)	Site	X-ray stage	Angle of kyphosis before spinal fusion	Follow-up examination		
				Angle of kyphosis	Increase of the angle	X-ray stage
5	L I—II	III	2	4	+ 2	III
2	Th XII—L I	III	31	33	+ 2	V
4	L II—III	III	29	32	+ 3	III
9	L I—II	III	7	10	+ 3	IV
5	Th X—XI	III	35	38	+ 3	III
4	Th IX—XII	III	19	23	+ 4	III
8	Th VIII—X	III	16	21	+ 5	V
6	Th X—XI	II	8	13	+ 5	II
4	L II—IV	III	16	21	+ 5	V
7	Th XI—XII	III	21	26	+ 5	V
3	Th XII—L I	III	24	30	+ 6	V
9	Th IX—X	III	16	26	+10	V
5	L I—II	III	40	50	+10	III
10	Th VIII—IX	VI	84	95	+11	VI
15	Th IX—X	III	25	37	+12	VI
13	Th VII—X	III	37	49	+12	III
2	Th XI—XII	III	36	49	+13	V
4	Th VIII—IX	III	23	57	+34	V
15	Th X—XII	III	63	101	+38	VI
14	Th VIII—XII	III	32	81	+ 49	V

Group 4. Table 35 includes the 20 cases where the kyphosis increased despite fusion. In these cases, there was an inconsiderable or small increase in the angle of kyphosis, (2° — 6°), in 11 of the patients, i.e. in 55.0 % (11/20). On the other hand, in 45.0 % (9/20) a considerable increase had occurred. Thus, in the majority of these cases severe kyphosis was already present before the fusion operation. Roentgenologically, most of them were in Group III (one case II, and one case VI). ALBEE's primary technique, with medial splitting of the spinous processes, was employed in 3 cases, in 11 cases with lateral splitting or lateral subperiosteal location of the graft, and 1 bilaterally. There was 1 case with an H-graft, and Hibbs' operation was performed four times.

A further analysis of the groups shows that 48.4 % of the cases in Group 1 belonged to stages I—II, and 51.6 % to III; 5 % of the cases in Group 4 were in stages I—II, and 90 % in stage III before spinal fusion. In this respect, it thus appears that the early stage of the tuberculous process responds best to operative treatment. After spinal fusion, stages I—II, III, IV and V are almost equally distributed in Group 1, and, in comparison with stages I—II, stages IV and V dominate in Table 37. In all groups, the number of vertebrae in the different cases are nearly identical. As

regards the end results, the technique employed seems to have had little effect, with the exception of the four HIBBS' operations with considerably increased gibbus. The three fractures of the graft do not appear to have influenced the course of healing; the union of the graft was equally satisfactory in all groups. It does not seem that the length of the graft was of any significance.

The preceding account may be re-stated as follows:

1. Cases without kyphosis before the fusion operation did not, with the exception of two cases 6.1 % (2/33), have kyphosis subsequently.
2. Kyphosis which was in existence before the operation increased in 76.9 % (20/26) of the cases. The relationship between the thoracic, lumbar and lumbosacral locations in the groups might, nevertheless, necessitate reconsideration of this conclusion, as the lumbar and lumbosacral regions were less prone to develop kyphosis owing to their natural forward curve. Table 36 has been prepared in order to throw, some light on this point; the table shows the percentage distribution of these locations in the four groups mentioned above (p.72, classified according to the state and the course of development of the kyphosis).

TABLE 36

Percentage Distribution of the Various Locations of the Disease Focus in the Groups based on the State and Course of Development of the Kyphosis

Group	Th	L	L—S	Totals
1	16.1 %	58.1 %	25.8 %	100.0
2	50.0 %	50.0 %		100.0
3	83.3 %	16.7 %		100.0
4	75.0 %	25.0 %		100.0

In Group 1, the proportion of thoracic lesions is low. Group 4 has three times as many thoracic as lumbar lesions. This casts some doubt upon the assertion that spinal fusion is certain to prevent kyphosis from developing in cases where it is lacking.

The main observations may be stated as follows:

The follow-up interval varied between two and twenty-four years. In about 50 % of the cases, the follow-up interval was from six to twenty-four years.

12.7 % were unfit for work, 13.3 % were engaged in heavy work, 47.4 % were engaged in average work, and 26.6 % in light work.

The cases in which the patient proved to be completely unfit for work were as follows: 5 with continued active disease, 6 relapses, 3 new extra-vertebral lesions, and 6 cases of severe back pain.

The results obtained are in general in conformity with those reported in the literature.

In the personally re-examined group, 73.4 % of the patients had some subjective trouble in the back; 28.9 % had pain, 30.3 % tiredness, and 13.2 % stiffness. The flexibility of the spine was investigated. 52.6 % of the patients could touch the floor with their finger-tips. Long grafts made the spine stiffer. Work generally increased the flexibility.

X-ray pictures of the spine revealed a tendency to fusion in a block formation where the follow-up interval was lengthy. The groups with narrowed discs only, or cuneiform vertebrae with material defects, decreased, and block formation increased. This process may take ten years or more, with the lesion quiescent and giving rise to no symptoms.

Where kyphosis was absent before the performance of spinal fusion, it developed subsequently in only two cases in this series. It is possible that the operation hindered its occurrence. In only 23.1 % of the cases was it possible that spinal fusion might have prevented an increase in the existing kyphosis.

End Results after the Use of Chemotherapy in connection with Spinal Fusion.

At present, but little data is available in Finland concerning patients treated with spinal fusion and chemotherapy. Only a short time has elapsed since the introduction of chemotherapy for tuberculosis, and a long period of observation is necessary before definitive conclusions can be drawn. The reports published so far are somewhat conflicting, and at times confusing. In this section, I intend to make a comparison between the results of cases treated with chemotherapy and those of a corresponding group of patients treated without these drugs. The number of patients receiving chemotherapy is small, there being only 49 cases from the years 1950—1953 section V, the dosage is given of streptomycin, isoniazid and PAS. In the present series there are no cases treated with chemotherapy without the performance of spinal fusion.

During exactly the same period, from 1950 to 1953, 45 patients were treated with spinal fusion without chemotherapy and these cases were for

purposes of comparison taken as a control group. On the whole, the material corresponded with the group treated with chemotherapy as regards follow-up interval age (Table 37) site of lesion (Table 38) and number of affected vertebrae. In both groups there was one case, with two lesions, one of them thoraco-lumbar, and the other lumbar, the number of locations in each group thus increasing by one.

TABLE 37

Age Distribution in the Group treated with Chemotherapy and the Control Group

Age in years	Group given chemotherapy	Control group
6—10	—	1
11—20	7	6
21—30	18	17
31—40	10	14
41—50	9	7
51—60	4	—
61—65	1	—
Totals	49	45

TABLE 38

Site of the Lesion in the Group treated with Chemotherapy Compared with the Control Group

Site	Group given chemotherapy	Control group
Th	18	19
Th—L	3	5
L	20	18
L—S	8	4
S	1	—
Totals	50	46

In the group given chemotherapy, the interval between spinal fusion and return to work, compared with the control group, shows no substantial divergence. Chemotherapeutic drugs thus made no real difference in this respect. It is here most likely that, despite the possible advantages gained, aftertreatment has to be given in the same manner and for the same length of time as if no chemotherapy were employed. (Table 39).

TABLE 39

The Interval between Spinal Fusion and Return to Work; a Comparison of the Group treated with Chemotherapy and the Control Group

Interval	Group given chemotherapy	Control group
3 months	2	4
6 months	6	7
1 year	18	13
2 years	9	7
3 »	4	4
4 »	2	—
5 »	—	1
Totals	41	36
Unfit for work	5	7
Dead	3	2
Totals	49	45

In Table 40, a comparison is made between the working capacity of the two groups.

TABLE 40

Working Capacity on Re-examination of the Group treated with Chemotherapy as compared with the Control Group

Working capacity	Group given chemotherapy		Control group	
	No. of cases	Percentage	No. of cases	Percentage
Heavy work	5	10.9 %	4	9.3 %
Average work	24	52.2 %	19	44.2 %
Light work	12	26.0 %	13	30.2 %
Unfit for work	5	10.9 %	7	16.3 %
Totals	46	100.0 %	43	100.0 %
Dead	3		2	
Totals	49		45	

In the group treated with chemotherapy, 10.9 % of the patients were unfit for work (5/46), 10.9 % (5/46) were engaged in heavy work, 52.2 % (24/46) in average work, and 26.1 % (12/46) in light work. In the control group, 16.3 % (7/43) were unfit for work, 9.3 % (4/43) were engaged in heavy work, 44.2 % (19/43) in average work, and 30.2 % (13/43) in light work. Thus, rather more of the patients in the group given chemotherapy

did average work, and rather more of the patients in the control group did light work only or were unfit for work. A further analysis of the cases unfit for work in both groups (Table 41) shows that in the group treated with chemotherapy 1 patient had a lesion which had continued active after the performance of spinal fusion. Further, there was 1 relapse, 1 case

TABLE 41

The Causes of Complete Unfitness for Work; a Comparison of the Group treated with Chemotherapy and the Control Group

Cause of unfitness for work	Group given chemotherapy	Control group
1. Tuberculosis of the spine		
Continuing disease	1	1
Recurrence	1	3
2. Extravertebral tuberculosis		
Knee	1	—
Kidneys	1	—
3. Non-tuberculous causes		
Organic heart disease	1	—
4. Causes possibly connected with tuberculosis of the spine		
Back pain	—	3
Totals	5	7

of tuberculosis of the kidney, and 1 of tuberculosis of the knee joint. One patient was rendered unfit for work by reason of a diseased heart. The corresponding figures for the control group were: 1 case of continued active disease, and 3 relapses. There were no new manifestations.

As mortality will be discussed later, it will only be stated here that there was no death occasioned by tuberculous causes in the group treated with chemotherapy. Three patients died of such complications as pulmonary embolus, perforated stomach ulcer and suicide with phenol. Following discharge. 2 patients of the control group died of tuberculous meningitis.

The sedimentation rate did not drop to a normal value in all cases as a result of chemotherapy. On follow-up examination, the following raised values were noted: 15, 18, 18, 21, 23 and 33. These rises could not be explained by the clinical and roentgenological examinations.

The effect of chemotherapy on the course of the disease is of great interest. The roentgenologic findings seen at follow-up examination, in comparison with the initial stage before the fusion operation, are apparent from Table 42.

TABLE 42

The Roentgenological Findings at Follow-up examination: a Comparison with the Initial Stage of Patients treated by Spinal Fusion and Chemotherapy

Stage	No. of cases before fusion	No. of cases at follow-up examination
I	1	0
II	8	8
III	32	24
IV	—	3
V	—	6
VI	—	—
Total	41	41
X-ray pictures before operation not available	5	5
Dead	3	3
Totals	49	49

The ideal end stage, with block formation IV and V, appears in 21.9 % of cases (9/41), III, the cuneiform one in 58.5 % (24/41), II, with a narrowed intervertebral space without vertebral changes in 19.5 % (8/41). As regards the shift in distribution between the different groups before and after fusion, it may be stated that the proportion of cases showing block formation within this group (21.9 %) is rather low in comparison with the 50.0 % among all patients who underwent spinal fusion. However, two different explanations may be advanced to account for this:

1. Chemotherapy arrest the disease at an earlier stage.
2. The follow-up period was shorter (from 2 to 5 years) than for the whole fusion group (from 2 to 24 years). The frequency of block formation appears to increase with time.

In earlier sections the recurrences and new manifestations during the course of the disease were discussed. In the group given chemotherapy 2.0 % (1/49) of relapses and 8.2 % (4/49) of new manifestations occurred. In the control group 11.6 % (5/45) of recurrences and 13.3 % (6/45) of new manifestations occurred. At the time of the follow-up examination only still active foci or fresh complications were diagnosed.

The recurrences decreased from 17.5 % in the series as a whole to 2.0 % in the group treated with chemotherapy. The control group had more recurrences (11.1 %).

The new manifestations decreased from 24.0 % in the series as a whole to 8.2 % in the group given chemotherapy. The control group had 13.3 % or rather fewer than in the series as a whole.

The favourable trend may also be ascribed to decreased virulence of the bacillus together with better treatment during recent years.

Nevertheless, as mentioned earlier, chemotherapy did not always provide protection against the spreading of the tuberculous infection to other organs.

Thus the answer to the important questions of whether chemotherapy reduced mortality and recurrences, shortened the time of treatment and made possible an earlier return to work, permitted better working capacity, and prevented deformity by arresting the process at an earlier stage, cannot be so favourable as might have been expected. There were no deaths, but one recurrence and some new manifestations considerably diminished the feelings of optimism. The sedimentation rate did not become normal in all cases, and there were no striking differences to be noted in the working capacity. Perhaps the process was halted at an earlier stage and thus deformity was avoided, but the observation time, two to five years, was shorter in this group.

The observations may be summarised as follows:

The follow-up interval was 2—5 years.

In both groups, the patients returned to work at almost exactly corresponding intervals.

The working capacity of the group treated with chemotherapy was rather more favourable, but the difference was not great.

In the chemotherapy group, there were fewer recurrences, i.e. 2.0 % compared with 11.1 % in the control group. New manifestations in other organs occurred in 8.2 %, against 13.3 %. Here, there is no obvious difference. At the time of the follow-up examination of the cases, the chemotherapy group had only one recurrence, to 3 in the control group. There were 2 new manifestations, against none in the control group.

There were no deaths caused by tuberculous complications. In the control group, 2 died of tuberculous meningitis.

The results are thus not so encouraging as might have been expected.

End Results of Conservative Treatment before the Use of Chemotherapy

Conservative treatment only was given to 744 patients from 1930 to 1955. All groups were treated initially in the same way: bed rest immobilization in a plaster of paris bed, etc. If spinal fusion was contraindicated, conservative treatment continued to be given. In recent years, all patients

have been subjected to spinal fusion. No material has been treated by means of chemotherapy only. In earlier days, patients sometimes refused operation; in the period before 1940, fusion was performed in some few cases only.

It is thus impossible to make direct comparisons between patients undergoing spinal fusion and those being given conservative treatment. The former constitute a selected group in good general condition without open fistulae, without very large lesions and with comparatively small deformities.

Despite this reservation, one cannot ignore this group, as at any rate it does throw some light upon the treatment given from 1930 to 1953. The material includes 73.1 % (744/1018) of patients who had been given conservative treatment. Mortality, recurrences and new manifestations within the group have been dealt with in other sections. Thus, 41.0 % (24/619) died of tuberculous causes, and 10.5 % (65/619) of other causes. Recurrences amounted to 7.4 % (46/619) and new manifestations to 17.9 % (111/619).

The follow-up interval is given in Table 43 below.

TABLE 43
The Follow-up Interval for Patients Given Conservative Treatment

Follow-up interval in years	No. of cases
2	44
3	18
4	15
5	13
6—10	68
11—15	48
16—20	48
21—24	56
Total	300
Dead	319
Inquiries unanswered	125
Total	744

The shortest follow-up interval was two years, and the longest twenty four. In about 50 % of the cases, the follow-up interval was from eleven to twenty four years, in the remainder from two to ten years.

In Table 44, there can be seen the elapse of time before return to work after conservative treatment.

TABLE 44
The Return to Work after Conservative Treatment.

Interval	No. of Patients
Immediately	9
6 months	7
1 year	18
2 years	18
3 »	8
4 »	7
5 »	2
6 »	2
7 »	1
9 »	2
10 »	1
12 »	1
13 »	2
17 »	1
10 »	1
20 »	1
Total	81
Unfit for work	60
Children without employment	77
Questionnaires unanswered ..	125
No information available	82
Dead	319
Total	744

Nine patients employment immediately after the end of immobilization. More than 50 % of the patients returned to work from 6 months to 2 years afterwards.

The results of treatment were classified on the basis of the answered questionnaires. See Table 45.

TABLE 45
The Working Capacity, at Follow-up examination of Patients who had been given Conservative Treatment.

Working capacity	No. of patients	Percentage
Heavy work	59	19.7 %
Average work	142	47.3 %
Light work	39	13.0 %
Unfit for work	60	20.0 %
Total	300	100.0 %
Questionnaires unanswered	125	
Dead	319	
Total	744	

Those not answering the questionnaires amounted to 16.8 % (125/744), and 40.2 % (319/744) had died in the interim. As regards 16.8 %, these either failed to answer, or could not be traced. 20.0 % (60/300) were unfit for work, 19.7 % (59/300) were engaged in heavy work, 47.3 % (142/300) in average work, and 13.3 % (39/300) in light work only. The principles employed in classification corresponded to those used for spinal fusion patients. An examination of those unfit for work (Table 46) showed that 23 had an active process, and of these 8 had paraplegia. Twelve had a continued active process, and 11 had recurrences. Extravertebral tuberculosis was established at re-examination in 12 cases, and nontuberculous causes in 8. Eight patients complained of poor general condition, and 8 of back pain, these troubles presumably being connected with tuberculosis directly, or being the result of static disturbances in the spine.

TABLE 46
*The Causes of Complete Unfitness for Work among the Patients
given Conservative Treatment.*

Causes of unfitness for work	No.
1. Tuberculosis of the spine	
Continuing disease	12
Recurrences *)	11
2. Extravertebral tuberculosis	
Coxa	5
Knee	1
Phalanx digiti	1
Lungs	3
Abdomen	1
Kidneys	1
3. Non-tuberculous causes	
Chronic rheumatoid arthritis	1
Hepatitis	1
Cerebral apoplexy	2
Arteriosclerosis and senile marasmus	2
Pensioned below retirement age	2
4. Causes possibly connected with tuberculosis	
Poor general condition	8
Back pain	8
Total	60
*) 8 with paraplegia	

It is a matter for surprise that 19.7 % were able to carry out heavy work in this group, against 13.3 % of the spinal fusion group, and 9.3 %

of those treated with chemotherapy. Average work showed approximate correspondence as regards percentages in all groups. As might have been expected, more patients were unfit for work (20 %) in the conservatively treated group than in the spinal fusion group (12.7 %).

Thus the follow-up interval varied between two and twenty four years. In 50 % of the cases, the follow-up interval was seven to twenty four years and as regards the remainder from two to six years.

20 % were unfit for work, 19.7 % were engaged in heavy work, 47.3 % in average work and 13.0 % in light work only.

On re-examination, an active lesion was detected in 23 patients, comprising 11 recurrences and 8 with paraplegia. There was extravertebral tuberculosis in 12 cases.

Profession

Tuberculosis has always been regarded as a disease which is more prevalent among those in straitened social circumstances. There are exceptions, however. Persons engaged on heavy work, factory workers, forest labourers, farm labourers, farmers and smallholders represented 39.6 % of the whole material (403/1018); intellectual workers constituted 3.7 % (38/1018) only. Close examination of the main forms of employment gives us the following figures: workman 10.6 % (108/1018) female workers 1.7 % (17/1018), wives of workmen 4.6 % (47/1018). Farmers were 8.1 % (82/1018), and farmers' wives 5.7 % (58/1018).

On closer examination of the material, it appears that a change of occupation was rarely undertaken.

Mortality

The mortality in the material is considered in the three main groups of treatment: cases of spinal fusion, cases of spinal fusion given tuberculostatic drugs, and cases treated conservatively.

Deaths among patients undergoing spinal fusion are divided into three groups:

1. Deaths occurring immediately in connection with the operation
2. Deaths later during stay in hospital
3. Deaths after discharge

1. None of the patients died as an immediate result of spinal fusion, either on the operating table or during the subsequent postoperative treat-

ment. One case of pulmonary embolus resulted in death three weeks after the operation. The patient was a young man, twenty-three years of age, who was suddenly overtaken by dyspnoea and became cyanotic with a weak pulse: he died within a few minutes. As three weeks had elapsed since the operation, the case might be transferred to the following group.

2. Later, during stay in hospital, three patients died of tuberculous meningitis before the introduction of chemotherapy, representing 1.4 % (3/208). These patients were respectively 22, 28 and 36 years of age. Each one of them was affected by stiffness of the neck one month subsequent to spinal fusion, and died within two weeks, six weeks and three months respectively. It is to be presumed that the meningitis was brought about by the operation, and was partly explained by the poor general condition, and partly operative trauma (cf. Table 49).

3. After discharge, a further sixteen died, of whom nine had tuberculous spondylitis with attendant complications, six meningitis, and one pulmonary tuberculosis. The patients affected by meningitis were also adults. Refer to Table 47.

TABLE 47
Deaths from Tuberculosis in the Spinal Fusion Group

Cause of death	During stay in hospital	After discharge	Totals
Tuberculosis of the spine with sinus and secondary infections	—	9	9
Tuberculous meningitis	3	6	9
Pulmonary tuberculosis	—	1	1
Totals	3	16	19

As regards the causes of death during stay in hospital, the necessary information was obtained from the case records. Mortality after discharge was obtained from parish registers, and was based upon the death certificates made out by the doctors concerned. No post-mortem examinations were made. In accordance with the nomenclature employed earlier to indicate the cause of death, non-specified diagnoses, such as spondylitis tuberculosa, paraplegia and tuberculosis ossium et articulorum were sometimes given, without statement of particulars. Eight patients about whom no information could be obtained were not taken into account.

In all, 9.5 % (19/200) of the patients who had undergone spinal fusion died of tuberculous complications (cf. Table 48). A further seven died of

nontuberculous causes after discharge: cerebral haemorrhage, tumour of the brain, diabetes, perforation of the gall bladder, perforation of gastric ulcer, intoxication and accident.

Deaths among patients who were given conservative treatment are divided into two groups:

1. Death during stay in hospital. 2. Death after discharge.

During stay in hospital, 3.2 % (24/744) of the patients being given conservative treatment died of tuberculous complications (cf. Table 48). Two died of nontuberculous causes, diphtheria and chronic nephritis.

After discharge, 37.2 % (230/619) died of tuberculous complications, as can be seen from Table 50. The most common tuberculous causes of death according to the incomplete deaths certificates were: spondylitis with attendant complications (21 cases of paraplegia) and other bone and joint tuberculosis with attendant complications. tuberculous meningitis and tuberculosis of the kidneys.

TABLE 48

Deaths from Tuberculosis in the Conservatively Treated Group

Cause of death	During stay in hospital	After discharge	Totals
Tuberculosis of the spine with attendant complications*)	12	69	81
Other bone and joint tuberculosis with attendant complications	1	25	26
Miliary tuberculosis	1	13	14
Tuberculous meningitis	7	23	30
Pulmonary tuberculosis	2	65	67
Abdominal tuberculosis	1	9	10
Urogenital tuberculosis **)	—	26	26
Totals	24	230	254
*) with paraplegia	3	21	24
**) renal	—	21	21

Of patients who had been given conservative treatment, 41.0 % (254/619) died of tuberculous complications.

Those dying of nontuberculous causes amounted to 7.4 % (46/619): 1 sepsis, 3 diphtheria, 1 influenza, 1 poliomyelitis, 2 pneumonia, 1 embolus, 6 cerebral haemorrhage, 2 cardiac infarctions, 10 myocardial diseases, 1 ductus choledochus stone, 1 chronic nephritis, 2 senile marasmus, 1 septic abortion, 2 sarcoma, 1 parotid carcinoma, 1 oesophageal carcinoma, 1

ventricular carcinoma, 1 mammary carcinoma, 2 fractures of the cranium, 5 by accident and 1 killed in war. In seventeen cases the causes of death were unknown. The case records were consulted for details of those who had died in hospital. Information on mortality subsequent to discharge was obtained from the parish registers. Those who could not be traced and were not taken into account numbered 125.

None of the patients who had undergone spinal fusion died with paraplegia, whereas 3.9 % (24/619) of those who were given conservative treatment did so.

Of 9 patients with paraplegia who underwent laminectomy, 1 died in hospital of decubitis and sepsis; 6 died later after discharge, 3 of decubitis and sepsis, 2 of pulmonary tuberculosis, and 1 of miliary tuberculosis. In some cases of paraplegia, the prognosis may be very bad.

As regards four cases with radical operation on lesions in the spinous and transverse processes, one patient died after discharge, the cause of death being given inexactly in the certificate as tuberculous spondylitis.

Close examination of the causes of death after fusion and conservative treatment shows, as mentioned earlier, that the following were most frequently given; tuberculous spondylitis with complications, lesions in other bones and joints with complications, miliary tuberculosis, tuberculous meningitis, pulmonary tuberculosis and urogenital tuberculosis.

Tuberculous spondylitis: this inexact diagnosis was all that was given on the death certificates. Complications such as abscess, fistula, paraplegia, decubitus, sepsis, amyloidosis, urinary infections, etc., pertain to this group. This diagnosis was given as occurring among patients who had undergone spinal fusion to the extent of 4.5 % (9/200), and among cases who had received conservative treatment in 13.1 % (81/619). In the series as a whole, the corresponding figures were 10.9 % (90/819). As mentioned above, of patients who had been given conservative treatment 3.9 % (24/619) died with paraplegia.

Other skeletal manifestations: this group included various diagnoses of lesions and complications. The operatively treated cases had no causes of death pertaining to other bones and joints. The conservatively treated cases had 4.2 % (26/619).

Miliary tuberculosis: in the operatively treated cases there were no deaths due to this cause; conservatively treated cases showed 2.3 % (14/619).

Tuberculous meningitis: 4.5 % (9/200) of the patients who had undergone spinal fusion died of this complication. As stated above, 1.4 % (3/208) of those operated on were affected with stiffness in the neck one month after the intervention, and died within a period of from two weeks

to three months during the stay in hospital. Later, following discharge, a further 6 died of meningitis. At that time, streptomycin, PAS and isoniazid were not yet available. As for the patients who had been given conservative treatment, the corresponding figures were 4.8 % (30/619), and for the series as a whole, 4.7 % (39/832).

Pulmonary tuberculosis: this diagnosis is one of those most commonly given as a cause of death. Of spinal fusion patients, 0.5 % (1/200) died of this, and among conservatively treated patients 10.8 % (67/619). The corresponding figures for the series as a whole were 8.3 % (68/819).

Urogenital tuberculosis: Usually, tuberculosis of the kidney, ureter, bladder and genitals constitutes a whole, and several parts are affected simultaneously. This cause of death did not appear among those patients who had had spinal fusion, whereas those conservatively treated showed 4.2 % (26/619). The kidneys were affected in 3.4 % of the cases (21/619).

Table 49 has been compiled in order to present the mortality distribution according to the region of the spine affected.

TABLE 49

Mortality Distribution according to the Region of the Spine affected

Site of lesion	Spinal fusion group			Conservatively treated group		
	Total	Died	Percentage	Total	Died	Percentage
Cervical	—	—	—	40	23	57.5 %
Cervico-thoracic	—	—	—	2	2	100.0 %
Thoracic	70	5	7.1 %	227	113	49.8 %
Thoraco-lumbar	21	3	14.2 %	57	27	47.4 %
Lumbar	92	9	9.8 %	254	81	31.9 %
Lumbo-sacral	17	2	11.1 %	32	8	2.5 %
Sacral	—	—	—	7	—	—
	200	19		619	254	

Mortality among patients who had been given conservative treatment increased the higher up the spine the disease focus was located. Mortality was inconsiderable or nil as regards the lumbo-sacral and sacral sites; the highest mortality occurred in the cervical group. As deaths following spinal fusion were so few in number, it is impossible to draw any conclusions.

The number of children (under 15 years of age) in the series amounted to 126. The mortality among children was 38.9 %. The treatment given was generally conservative. The following causes of death were given: 14 cases

of tuberculous spondylitis and complications (abscess, fistula, secondary infection, paraplegia, etc.), 11 tuberculous meningitis, 6 miliary tuberculosis, 1 abdominal tuberculosis, 3 renal tuberculosis, 1 sepsis following secondary infection, 2 tuberculous coxitis, 2 died of amyloidosis, 4 of diphtheria, 1 of pneumonia, 2 of heart disease, 1 (as an adult) of septic abortion, and 3 of causes unknown. The 4 cases of diphtheria are a reminder of the onetime diptheroid infections in children's departments. The mortality among children, 38.9 %, was not higher than the mortality following conservative treatment for the whole group.

As regards the effect of tuberculostatic drugs on mortality, it was stated that none of the 49 patients given chemotherapy had died of tuberculous causes (see section on tuberculostatic drugs and the control group). As for one case of meningitis, the patient, who had not been initially treated with tuberculostatic drugs and had undergone spinal fusion, was found to be beyond recovery despite the subsequent use of streptomycin. In the corresponding group to whom chemotherapy had not been applied two died of tuberculous meningitis.

Accordingly, it can be said that the mortality in the present series was extremely low, amounting to 9.0 % of patients who had had spinal fusion, and considerably higher 41.0 %, among those given conservative treatment. The mortality among children was 38.9 %. Nevertheless, the groups cannot be directly compared as those operated on were a selected group of favourable cases.

The inexact causes of death given, possibly under difficult circumstances, presented many obstacles to determination of the actual causes of death in my material. But the large number of cases available provides some data concerning mortality in connection with tuberculosis of the spine. There is no importance attached to the comparison of the mortality of the material with that of the general population of Finland; it is difficult to do this because of the variations during the years, especially in the Second World War.

In conclusion, there may be discussed the deaths caused by meningitis in the hospital and after discharge following spinal fusion, taking into consideration the question of possible dissemination of tubercle bacilli occurring in connection with the operation, by the lymphatic system and blood vessels as a result of trauma or any deterioration of the general condition after the intervention. This point is discussed in part in the section on operation technique. The difference between the percentage of deaths from tuberculous meningitis during the stay in hospital, 1.4 % (3/208), and the percentage among the conservatively treated cases, 0.9 % (7/744),

is not striking. Following discharge, there is also correspondence between the figures: 3.0 % (6/200) after spinal fusion, and 3.7 % (23/619) after conservative treatment. It is probable that no real significance can be attached to the intervention as a cause of spread of the infection. On the other hand, it should be borne in mind that generally speaking the conservatively treated group was a selected unfavourable one.

The main observations may be summarised as follows:

Immediate operative mortality did not exist among those patients in the material undergoing spinal fusion.

In all, 9.5 % of the patients who had undergone spinal fusion died of tuberculous complications.

Of those patients given conservative treatment, 41.0 % died of tuberculous complications.

The mortality of children was not higher than that of the whole material.

The figures provided for the material are extremely favourable as regards patients who had undergone spinal fusion; nevertheless, no direct comparison can be made between the groups as those operated on constituted a selected favourable group.

None of the cases given chemotherapy died of tuberculous complications. A group from the same period not given these drugs had two deaths from tuberculous meningitis. Thus chemotherapy appears to prevent mortality for such complications.

VII DISCUSSION

The aim of this study was to investigate the results of treatment of tuberculous spondylitis with spinal fusion and chemotherapeutic drugs. The patients concerned were not treated in sanatoria.

Early treatment is of paramount importance because the spinal deformity which may occur is irreversible. Early diagnosis is therefore essential. Abscess, sinus and paraplegia may occur. In spite of new methods of diagnosis, such as tomography, many patients have for years gone from one doctor to another without getting a diagnosis. A large proportion of cases have been treated as rheumatism or other common painful conditions in the spine. This applies not only in the case of lumbo-sacral tuberculosis, but also when the focus is situated in other regions of the spine.

Tomography is of great importance in revealing the true extent of the disease in the vertebrae. The existence of monovertebral lesions is nowadays doubted by most authorities. Among the present series of patients, there appeared to be numerous cases of monovertebral involvement. It is possible that in the earlier years covered by the study the second focus escaped detection in the absence of the present-day improved and more accurate methods of examination such as tomography. It is nowadays a much easier matter than before to spot each affected vertebra.

Every case exhibits peculiarities both qualitative and quantitative. In some the course is acute and fulminant, while others progress slowly and insidiously. Treatment must be individual, and the same plan of action cannot be applied to every case.

Treatment must be directed towards improving the general condition (malnutrition, fatigue, worry, anaemia or some associated condition) and locally towards the lesion.

Bad results of conservative treatment before the introduction of chemotherapy are mentioned in a number of reports.

In some reports no differences appeared between the results of conservative treatment and spinal fusion. After World War I, German surgeons were opposed to fusion on grounds of the bad results obtained.

The mortality in my conservatively treated group before the introduc-

tion of chemotherapy is considerable. A higher proportion of the patients were incapable of work than in the operatively treated group. However, the conservatively treated group cannot be directly compared with the operatively treated group, which is a selected, favourable group. If spinal fusion was contra-indicated, conservative treatment was given.

It is extremely difficult to find reports of comparable series comprising cases which on the one hand had undergone spinal fusion, and on the other had been subjected to conservative treatment. The results are affected by so many different factors, such as the time of observation, the variations in the cases, and the stage at which treatment was given. The majority of conservatively treated cases are of earlier date, and those of spinal fusion more recent. The virulence of the tuberculous infection also varies.

Good results have been obtained from operations based on the highly plausible assumption that a bone bridge between the spinous processes and arches will immobilize and protect diseased vertebrae. Albee himself claimed that this operation had a directly curative effect, through hyperaemia and inward growth of the blood vessels. There is scarcely any real foundation for this assumption.

Spinal fusion has found a permanent and widely recognized place in the treatment of tubercular spondylitis. This surgical measure has for a long time been the treatment of choice for these patients. On occasion, the objection has been raised that spinal fusion interferes with the tendency of the vertebrae to break down and form a block. Follow-up examinations have shown, however, that the latter process frequently takes a very considerable time, during which there are often no symptoms. Early in the era of spinal fusion, possibly under the influence of Albee's enthusiasm, there was a dangerous tendency to assume that the disease had healed as soon as the graft had united. The large number of recurrences and complications, together with the mortality brought about by other tuberculous manifestations, often after a long period of time, reveal the need for caution. The old saying, based upon clinical experience, »once a phthisis patient always a phthisis patient«, also applies here.

The methods of ALBEE and HIBBS for spinal fusion have been subject to innumerable modifications.

The multiplicity of the methods employed is a consequence of the desire to achieve as stable a fusion as possible. Accordingly, the original immobilization of the spinous processes was extended to include fusion of the arches and the small intervertebral joints. Furthermore, it was intended that the graft should be set as near to the disease focus as possible which is of advantage mechanically.

By the administration of chemotherapeutic drugs, it is hoped that better prospects will be created for the battle against the tubercle bacillus. The number of bacilli may decrease, and hence the toxic effect as well, with consequent improvement in the general condition. The body can more easily overcome the injury to the tissue, the exsudate may be resorbed, and the tuberculous tissue heal more quickly.

Even before the introduction of chemotherapy, good results could be obtained with spinal fusion; this is evident from the control group treated during the period 1949—1953, for whom tuberculostatic drugs were not available. The new medicines have not fulfilled all the hopes raised by their discovery. In addition, there is the threat of the problem of resistance which arises from length treatment. It appears that mortality is reduced or nil, but there may be recurrences together with new manifestations. Meningitis, which at one time played so great a role, has not occurred. Isoniazid and PAS may be given for a prolonged period, usually of 1—2 years. The recurrences and new manifestations showed that the value of the new drugs had been overestimated. Fusion and immobilisations must be resorted to just as before the introduction of tuberculostatic drugs.

The sedimentation rate provides a good means of following the course of a case. If it remains high, despite repeated examinations which reveal no clinical symptoms, and with the necessary roentgen control, it does not always indicate active tuberculosis.

In the past, in consequence of experience gained, a very cautious view was taken of abscesses. Fistulae, secondary infections, amyloidosis, miliary tuberculosis and meningitis threatened if abscesses were evacuated. BOSWORTH, PIETRA and FARELL 1950, ORELL (in several papers) 1951, BOSWORTH and WRIGHT 1952, HARRIS, COULTHARD and DEWAR (1952) emphasized that conservative treatment alone with tuberculostatic drugs does not lead to good results in bone and joint tuberculosis. Surgical intervention, such as ankylosing operations, evacuation of abscesses and curettage of foci, is also necessary.

Radical operations in cases of tubercular spondylitis have been performed by WILKINSON (1953), ORELL (1951), KASTERT (1950, 1956, 1957) and FELLÄNDER (1955). The difficulty, which is also acknowledged by the majority of authors with experience in this field, is that the extirpation of the diseased tissue is never wholly complete.

FELLÄNDER reported 36 % of relapses, an operative mortality of 3 %, and a subsequent mortality of 10 %. Nowadays, the operative mortality in cases of spinal fusion is almost negligible. FELLÄNDER had deaths as a consequence of meningitis, miliary tuberculosis and pulmonary tuberculosis.

A comparison of patients rendered fully capable of return to work after radical surgery in my series and in those of others does not reveal any great differences: WILKINSON 62.0 %, KASTERT 68.5 % and FELLÄNDER 85 %. In a series of patients from the period 1949—58 BAKALIM and A. LANGENSKIÖLD (1960) found that even among those subjected to radical surgery, block building was relatively slow, and that in these cases spinal fusion some time after the first operation would have accelerated the process.

Paraplegia constitutes a problem on its own, and has not been discussed on the basis of this series. In most cases, the treatment given was conservative.

The pathological anatomy of paraplegia has for a long time been undefined, and opinions have varied as to the cause of the pressure; such opinions have been based upon experience in postmortem examinations and laminectomies. BUSINGER (1928) stated that tuberculous granulation tissue reached the spinal cord and its membranes. FREUND (1930) believed that paraplegia was the result of pressure from the bony narrowing of the spinal canal and from sequestra, seldom being due to pachymeningitis. ARNESEN (1932) described a case of cervical spondylitis with luxation bringing about compression of the medulla. KEY (1940) emphasized that it is only in rare cases that a sequestrum occurs in the spinal canal. HALLOCK and JONES (1954) reported some instances of paraplegia after spinal fusion as operative trauma. At what is termed »anterolateral decompression», GRIFFITH, SEDDON and ROAF (1956) found the following causes of spinal cord compression: contrary to earlier opinions, they discovered in each case a cause of compression anterior to the dura mater, a partly dried up abscess, parts of a sequestrated intervertebral disc, and one or several bone sequestra. In older cases, there was an interior kyphosis or a bone ridge.

The numerous cases of recurrences and new manifestations, which seem perpetually to menace these patients, constitute a reminder of the multifocal tendency of tuberculosis. This is systemic disease, in which the vertebral lesion may be merely one of many foci. In planning therapy, it is important to remember that in the final issue the contest is between the immuno-biological powers of the organism and the virulence and size of the population of the tubercle bacilli. At its disposition, the organism, has the immuno-biological powers dependent upon inherent or acquired resistance, the passing through primary infection, Calmette vaccination, treatment, raising of the general condition and chemotherapeutic drugs. Immobilization also plays its part in this connection.

In many instances, a change in the patient's occupation is desirable. Even if spinal fusion is performed successfully, and the process of healing is good, it must be considered that heavy work is unsuitable for the most part, as for instance in farm-labouring, forestry work, factory employment, and so on. In such cases, training for entry into another profession is indicated. During recent years, the development of social welfare schemes intended to assist invalids in our country has greatly increased the opportunities available for change of occupation. Courses are arranged for those suffering from tuberculosis, but in each individual instance the advisability of the new profession or form of employment must be given careful consideration.

VIII CONCLUSIONS

On the basis of the findings made in the present investigation, the following conclusions may be drawn in answer to the questions posed at the beginning of this paper:

1. Relapses and new manifestations occur despite spinal fusion.
2. The series included no instances of immediate operative death.
3. In the spinal fusion group, 9.5 % of the patients died later of tuberculous complications and 41.0 % in the conservatively treated group.
4. Fractures of the graft occurred in 6.6 % of cases and pseudarthrosis persisted in 2.6 %. The length of the graft, its location and extent appeared affect the occurrence of fractures and pseudarthrosis. The lumbar and lumbo-sacral parts of the spine are predisposed to such accidents. The final results of treatment of tuberculous spondylitis were not substantially impaired by graft fractures. They may well be less significant than has been presumed.
5. In the present series, if kyphosis was absent before the fusion, it appeared subsequently in only 6.1 %. Where kyphosis was already established it was prevented by fusion from increasing in only 11.4 % of cases.
6. X-rays of the spine revealed a tendency to fusion and block formation during a lengthy period of observation.
7. The end results of spinal fusion showed that 12.7 % of the followed up were unfit for work, 13.3 % carried out heavy work, 47.4 % average work, and 26.6 % light work.
8. The end results in the group treated with fusion and chemotherapy were somewhat better, especially as regards recurrences and new manifestations. There were no deaths caused by tuberculous complications.
9. After conservative treatment, before the introduction of chemotherapy, 20.0 % of the followed up were unfit for work, 19.7 % were engaged in heavy work, 47.3 % doing average work and 13.0 % light work only.
10. Tuberculostatic drugs have somewhat improved the results, but have not fulfilled all the hopes raised by their discovery.
11. The results are in conformity with those reported in the literature.
12. Fusion aids in giving stability to the diseased portion of the spine.
13. Spinal fusion and the old conservative methods of treatment still have a place in modern therapy.

IX SUMMARY

The object of this paper was to investigate the results of treatment in a series of patients with tuberculosis of the spine not admitted to sanatoria. During the period from 1930 to 1953, 1,018 cases were treated at the Surgical Clinics I, II and III, University of Helsinki and at the Kuopio General Hospital. There were 622 cases from the former, and 396 from the latter. Spinal fusion was performed in 208 cases, and 744 were given conservative treatment.

The paper is divided into three parts, the first of which gives an account of the composition of the series, the second the treatment given to the patients, and the third the end results.

The age distribution in the series shows that tuberculous spondylitis most frequently occurred in the age group 16 to 30 years, the peak being reached in the group 21 to 25 years. The greatest number of spinal fusions was carried out on patients between 16 and 40 years of age, the peak being reached between 21 and 25.

There were no considerable divergences as regards sex distribution, with the exception of the age group 16—25 years, where males were in the majority.

As far as adults were concerned, the lumbar region was affected more frequently than the thoracic, whereas with children the thoracic region was affected twice as often as the lumbar. Lumbar vertebra IV was affected most frequently. Most commonly, two vertebrae were affected, then three and then one.

Before treatment, abscesses were present in 34.2 % of all cases, fistulae in 8.8 %, kyphosis in 37.7 %, and paraplegia in 11.2 %.

Other manifestations in bones and joints occurred in 9.5 %, mostly in the ribs, hip, knee and ankle.

The frequency of soft tissue tuberculosis was 38.2 %. After the lungs, the most frequent changes were in the lymphatic glands, the urogenital system (kidneys), and abdomen. Pleurisy was present in 36.8 % of the spinal fusion group, generally two to three years before the vertebral manifestation.

The difficulties of diagnosis were emphasized: 27.9 % had to wait from three to thirty-one years to obtain a diagnosis before admission to hospital.

The commonest erroneous were rheumatism, sciatica, lumbago, deforming spondylosis, »weak back», and so on.

The importance of tomography in obscure and early cases is emphasized. The narrowed intervertebral space may be the only roentgenological symptom in the early stage.

Constitutional treatment and immobilization, bed rest, a plaster of paris bed, etc., are still important. During the period 1949—1953, 49 cases were given chemotherapeutic drugs: streptomycin, isoniazid and PAS, the most common combination being streptomycin and PAS; 44 patients were given streptomycin, 18 isoniazid, and 37 PAS. In the literature, resistance is most commonly reported with streptomycin. As it proved the most efficient medicament it was generally reserved for pre-operative and post-operative treatment in spinal fusion. Streptomycin was also used in treating fistulae and abscesses. Because of the low dosage, it is presumed, complications did not arise in connection with chemotherapy.

Spinal fusion is of advantage in almost all cases of tuberculous spondylitis, in order to counteract the weakness of the spine and functional insufficiency.

In recent years, spinal fusion has been performed at a rather earlier stage, thanks to the assistance given by tuberculostatic drugs.

Contra-indications are as follows: large abscesses, fistulae, extensive foci in the lungs and other active manifestations. Some of these are relative, and disappear during the course of treatment.

The spinal fusion technique employed has varied to some extent. ALBEE's original method was employed in 61.5 % of the cases. Since the year 1950, unilateral subperiosteal applications of grafts have been in use the graft being placed at the bases of the spinous processes. The arches also have to be fused. Vertebrae should only be fused where this is absolutely necessary, and thus as a general rule only short grafts are required.

During immobilization, the patient must exercise his extremities in order to avoid decalcification of the bones and atrophy the muscles.

Occupational therapy is also of the greatest importance. It helps during the long period of illness, and prepares the patient for greater activity.

The treatment should be individual, the sedimentation rate and X-ray photographs being valuable aids in following the course of the disease.

Relapses occurred in the vertebrae of patients who had undergone spinal fusion in 17.5 %, and in 7.4 % of cases given conservative treatment. The increased disposition towards relapses which is evident in the fusion group

might have been occasioned by inadequate pre-operative and post-operative treatment at the beginning of the fusion epoch. Following the introduction of tuberculostatic drugs, only one relapse occurred (2.0 %) in this group.

Extravertebral new manifestations occurred in 24.0 % of the operatively treated cases, and in 17.9 % of the conservatively treated cases. New manifestations, such as miliary tuberculosis, and tuberculosis in the meninges, lungs and urogenital system (kidneys), occurred. In the spinal fusion group 60.4 % of the new manifestations appeared within the first two years after operation.

After the introduction of chemotherapy, the frequency of new foci decreased from 24.0 % to 8.2 %. Nevertheless, the tuberculostatic drugs did not always provide protection against the spread of tuberculous infection to new organs. It is possible that the favourable trend might be due to a less virulent type of infection having arisen.

The immediate operative mortality in the series was nil. Subsequently, 9.5 % of the patients who had undergone spinal fusion died of tuberculous complications. Of the patients who had been given conservative treatment, 41.0 % died of tuberculous complications. The mortality among children was no higher than that for the whole series.

None of the patients given tuberculostatic drugs died of tuberculous complications; chemotherapy thus seemed to reduce mortality to nil. The most common causes of death were complications such as secondary infections of abscesses and fistulae, amyloidosis, paraplegia, decubitus, sepsis, urinary infections, etc., tuberculous meningitis, pulmonary tuberculosis, urogenital tuberculosis, tuberculosis of other joints and bones with complications, miliary tuberculosis and abdominal manifestations.

Fractures of the graft occurred in 6.6 % of cases, and pseudarthrosis persisted in 2.6 %. The following factors seemed to play an important role in the occurrence of fractures and pseudarthrosis: the length of the graft, its location and extent. Fracture seemed particularly liable to occur when the graft was in the lumbar and lumbosacral regions. Most graft fractures should heal on conservative treatment: if healing does not take place, rearthrodesis has to be performed. In the material, the fractures did not impair the final results to any great extent.

Before an evaluation of the end results, the elapse of at least two years was considered necessary. Approximately 50 % of the cases were followed up after an interval of from six to twenty-four years. Of the patients who had undergone spinal fusion, 12.7 % of the followed up were unfit for work, 13.3 % were engaged in heavy work, 47.7 % in average work,

and 26.6 % in light work. 5.9 % returned to work immediately on discharge, and on the whole 23.8 % took up employment too early.

The sedimentation rate was found to be raised in 26.3 % of the cases followed up; despite very careful examination, no explanation was forthcoming for this. Study of the sedimentation rate provides a good means following the course of a case, but it is possible that in some instances in which it remains high no significance need be attached to this fact.

52.6 % of those re-examined subsequent to fusion could touch the floor with their finger tips. The flexibility was in general increased by work. Long grafts made the spine less flexible.

73.4 % had some subjective trouble in the back: 28.9 % suffered from pain, 30.3 % from tiredness, and 13.2 % from stiffness.

X-ray photographs of the spine revealed a tendency of the affected vertebrae to fuse together into a block formation with the passage of time. This process might take ten years or more.

Where kyphosis was nonexistent prior to surgical intervention, it arose in only 6.1 % afterwards. It is thus possible that the operation prevented its occurrence. In only 23.1 % of the material did spinal fusion prevent the increase of already existing kyphosis.

The working capacity of the group treated with tuberculostatic drugs showed figures which were somewhat better, although the difference was not a striking one. 10.9 % were unfit for work. Heavy work was being done by 10.9 %, average work by 52.2 % and light work by 26.0 %.

No valid comparison can be made between those patients who had undergone spinal fusion and those given conservative treatment. The first-mentioned comprised a selected group in good general condition, without open fistulae, without extensive spread of the focus, and with comparatively minor deformities.

As regards those patients who were given conservative treatment before the introduction of chemotherapy, 20 % of the followed up were unfit for work, 19.7 % were engaged in heavy work, 47.3 % in average work, and 13.0 % in lightwork.

In the series as a whole, 39.6 % carried out heavy work. Intellectual workers constituted only 3.7 %. Changes of profession did not take place to the extent desired.

The results are in conformity with those shown in earlier reports. Tuberculostatic drugs partially improved the results, but have not fulfilled all the hopes raised by their discovery. Spinal fusion and the old conservative treatment still have a place in modern therapy.

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