SPINAL TUBERCULOSIS WITH NEUROLOGICAL DEFICIT

TREATMENT WITH ANTERIOR VASCULARISED RIB GRAFTS,
POSTERIOR OSTEOTOMIES AND FUSION

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Nineteen patients with thoracic or thoracolumbar spinal tuberculosis and neurological deficits were treated by anterior debridement, decompression and vascularised rib grafting, followed, either during the same procedure or 14 days later, by multilevel posterior osteotomies, instrumentation and fusion. Surgery was performed under cover of four-drug antituberculosis chemotherapy, given for 12 months.

The average pre-operative kyphotic angulation of 56° was reduced to 27° postoperatively and 30° at the latest follow-up (3° loss of correction). Radiological fusion between the vascularised rib graft and the vertebrae was seen after an average of 3.3 months. Eighteen patients (95%) had normal neurological function at 14 months, and the other could walk with the aid of crutches.

Spinal tuberculosis has deformed, paralysed and killed many of the human race for the past 7000 years. Antituberculous chemotherapy revolutionised its treatment in the 1950s, but could not improve nor satisfactorily arrest the associated kyphotic spinal deformity (Medical Research Council 1976). Many reported surgical techniques seem to be equally ineffective in preventing an increase in kyphosis.

The radical surgical treatment pioneered in Hong Kong (anterior debridement, decompression and autogenous bone grafting under antibiotic cover) was reported to give a 1° correction of kyphosis in their series, but allowed 21° deterioration in a South African series of patients with spinal tuberculosis and central nervous system involvement (Medical Research Council 1978b, 1982). Even in Hong Kong, Jenkins et al (1975) reported a 46.4% increase in kyphosis from admission to 10-year follow-up in children managed by anterior decompression and fusion.

Bony fusion of the tuberculous focus in the spine has long been regarded as the surest evidence of healing, though positive proof has never been presented. Sound healing is known to be slow: out-patient chemotherapy alone resulted in bony fusion in only 46% of patients after 60 months in Korea (Medical Research Council 1967). The radical operation gave better results in Hong Kong, where 90% of patients achieved bony fusion after 60 months (Medical Research Council 1982). However, there was only a small difference between the out-patient chemotherapy group in Rhodesia (71%, fusion after 36 months) and the radical surgery group in South Africa (81%, fusion after 36 months) (Medical Research Council 1978a, b).

Recovery from paraparesis in patients with spinal tuberculosis also seems to be similar whichever treatment is used. In South Africa, 69% of patients treated by radical surgery had complete neurological recovery at 36 months compared with 73% of patients in Korea and in Rhodesia on ambulatory chemotherapy only (Medical Research Council 1978b).

A new surgical approach, the Kalafong procedure,
is proposed to improve the results of surgical treatment of spinal tuberculosis. It consists of anterior debridement with decompression of the spinal cord (Hodgson and Stock 1956), osteotomy and/or soft tissue release and a vascular rib pedicle bone graft (Rose, Owen and Sanderson 1975; Bradford 1980). This is followed, either under the same anaesthetic (combined one-stage procedure) or 14 days later, by posterior multilevel osteotomies, spinal instrumentation and fusion. The author does not claim originality for the individual techniques, but rather proposes a new combination of methods.

PATIENTS AND METHODS

A prospective study was made of 19 patients with spinal tuberculosis presenting at the Kalafong Hospital from 1984 to 1988. The criteria for entry to the study were that there was histological confirmation of spinal tuberculosis and that neurological involvement was severe enough to prevent the patient from walking independently, even with the aid of crutches. There were five males and 14 females, with an average age of 25.2 years (range 2 to 56). Seven patients were 12 years of age or younger and three patients were over 50.

Neurological function on admission was classified according to Frankel et al (1969): three patients were grade A (complete motor and sensory deficit), seven grade B (sensory sparing but no motor function) and nine grade C (motor sparing, but functionally useless). Sixteen patients had been paralysed for an average of 6.2 months (range 2 weeks to 36 months); the other three had an inaccurate or incomplete history. Only one patient (case 2) had had a sudden deterioration of neurological function prior to admission, necessitating an emergency decompression.

Anteroposterior and lateral radiographs and technetium-99m bone scans of the entire vertebral column were obtained to exclude involvement at more than one level. There were no false negative scans and no second non-contiguous lesions were detected.

Kyphosis was measured from the upper end-plate of the first uninvolved proximal vertebra, to the lower end-plate of the first uninvolved distal vertebra. On admission this averaged 56° (range 12° to 85°), over a mean of three vertebral levels. Hyperextension views confirmed that the deformity was rigid in all the patients. Destruction of vertebral bodies, as shown on lateral tomograms, was recorded as the total number of vertebras, or parts of vertebras, that had been destroyed by tuberculosis. The average was 1.9 vertebras (range 1 to 4).

There were complications related to tuberculosis and paraplegia in four patients: three had associated pulmonary tuberculosis and one had two complications of paraplegia, a pressure sore over the greater trochanter and flexion contractures of both hips and knees, which were treated before spinal surgery was performed.

As soon as urine, sputum and stomach aspirate specimens had been collected for microscopy and culture, four-drug chemotherapy with rifampin,isoniazid, ethambutol, and pyrazinamide was started. All four drugs were given as single oral doses once every 24 hours for a period of 12 months.

Rib selection. The rib to be used as the pedicled bone graft is selected before surgery. Since anterior decompression and debridement is always performed for active spinal tuberculosis, the abscess wall must be incised longitudinally to reach the affected vertebrae. This necessitates division of the intercostal vessels where they are incorporated into, and densely adherent to, the abscess wall. The blood supply to the ribs lateral to such an incision is therefore also interrupted. The intercostal vessels that cross anteriorly over the first uninvolved upper and lower vertebras are not disturbed, so a rib which articulates with the transverse process of either of these can be used as the bone graft. As well as plain radiographs, which give some indication of the extent of bone and soft tissue involvement, tomography, computed tomography or magnetic resonance imaging are essential to establish without doubt the first normal proximal and distal vertebras beyond the tuberculous process.

Operative technique. Operation is performed under additional prophylactic antibiotic cover, using a first-generation cephalosporin. Hypotensive anaesthesia is used to give a 25% reduction of the mean arterial pressure.

For the anterior procedure, a thoracotomy is done using the technique of Bradford (1980) to mobilise a rib on its vascular pedicle for the bone graft (Fig. 1). The anterior debridement and decompression are performed by the technique described by Hodgson and Stock (1956). All pathological tissue, pus and debris in bone and soft tissue are removed until normal bleeding cancellous bone and soft tissues are exposed throughout the field. The dura is exposed and decompressed both anteriorly and laterally. Adhesions are frequently found at the apex of the deformity, anchoring the dura, pulling it posteriorly into the apex of the curve and preventing anterior displacement and expansion of the dura and spinal cord. A meticulous anterior and lateral release of all adhesions is therefore done before correction of the kyphosis is attempted. All bone and soft tissue which may prevent reduction of the kyphosis is also removed or divided.

The posterior procedure is performed 10 to 14 days after the anterior operation and reduction of the kyphosis is achieved by shortening the posterior column of the spine. This does not alter the length of the anterior column or the torso, because the anterior strut graft acts as a pivot. In the normal thoracic spine, shortening of the posterior column is limited by impaction of the inferior facets on a ridge below the superior facets. Using rongeurs, the spinous process, parts of the laminae and parts of the inferior facets are resected, and the posterior elements are shaped so that they can glide over each other and thus allow shortening to take place.

At all the levels where spontaneous fusion had
occurred, V-shaped osteotomies were made. The osteotomies were closed using either Harrington compression or Synthes internal fixator instrumentation in adults, and sublaminar Mersilene tape attached to a Luque rectangle in children.

**The one-stage procedure.** The patient is positioned with the right side down and secured to the operating table, great care being taken to align the spine correctly by placing sandbags cephalad to the iliac crest. An anteroposterior radiograph is taken to ensure that no lateral curvature has been created. Anterior debridement and decompression is then carried out, but before the rib graft is inserted, the posterior procedure is completed. The operating table is tilted from side to side to facilitate access to both wounds.

The aim of the one-stage combined anterior and posterior procedure is to obtain maximum correction of the kyphosis by elongation of the anterior column and simultaneous shortening of the posterior column in such a way that the spinal cord is at the imaginary axis of rotation. The spinal cord is kept under constant direct vision from both anterior and posterior aspects to ensure

### Table 1. Some details of patients and results

<table>
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<tr>
<th>Case</th>
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<th>Level of pathology</th>
<th>Hypertrophy of rib (% of original diameter)</th>
<th>Angulation in degrees Pre-op</th>
<th>Post-op</th>
<th>Latest</th>
<th>Neurological status (Frankel) Pre-op</th>
<th>Neurological status (Frankel) Latest</th>
<th>Post-op follow-up period (mth)</th>
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Fig. 2

Photographs and radiographs taken on admission and intra-operatively after wound closure to show the dramatic improvement in kyphotic deformity achieved by a one-stage anterior and posterior procedure.
that neither distraction nor compression occurs. The kyphosis is reduced by anteriorly directed pressure on the apex of the kyphos and posterior traction both proximally and distally. The Luque rectangle used with sublaminar Mersilene tape for children under five years of age and sublaminar wires for older children and adults, provides a good three-point pressure system. Reduction is enhanced by using a laminectomy spreader anteriorly. After the posterior procedure has been completed, the vascular rib graft is inserted anteriorly. Immediate dramatic improvement of the kyphotic deformity is usual (Figs 2 to 5).

The anterior and posterior procedures were performed in two stages in 13 patients, and as a combined procedure in the other six. Harrington compression instrumentation was used for posterior fixation in 10 cases, sublaminar Mersilene tape attached to a rectangle rod in four cases (Gaines and Abernathie 1986), sublaminar wires and a rectangle rod in one case and the Synthes internal fixator in one case (Dick 1987). Sublaminar Mersilene tape alone was used in three children for compression of the posterior column. The instrumentation and fusion extended from two normal vertebrae above the tuberculous focus to two below it in 14 cases and from one above to one below in the other five.

Postoperatively, the patients required intensive care until their general condition was stable. When the wounds had healed, the patients, wearing a spinal brace after a two-stage procedure or a hyperextension cast after a one-stage combined operation, started active rehabilitation. Patients were discharged when they could walk independently with the aid of crutches. Follow-up was monthly for 12 months, three-monthly during the second year and six-monthly thereafter. Radiographs of the spine were obtained monthly until bony fusion was evident, and then at each clinical review.

RESULTS

Details of the 19 patients are given in Table I. The average blood losses were 674 ml for the anterior operation, 556 ml for the posterior and 878 ml for the one-stage combined procedure. The average follow-up was 25.5 months.

Three stages of healing of the bone graft were recognised. In the early postoperative period no new bone is seen, and there is a lytic area around the rib graft. In the second stage there is callus formation between the graft and vertebrae but no bridging trabeculae. In the third stage there are trabeculae in continuity between graft and vertebrae, with no lytic lines.

Fig. 6a  
Fig. 6b  
Fig. 6c

Lateral radiographs of a 56-year-old man. Figure 6a – On admission there was a 30° kyphosis. Figure 6b – After the anterior procedure, with the rib graft in position. Figure 6c – Six months postoperatively the kyphosis has been reduced to 8°. There is bony fusion and 63% hypertrophy of the rib.
Lateral radiographs and photographs of a 5-year-old girl. Figure 7a – On admission there was an angulation of 85°. Figure 7b – Immediately after a one-stage combined procedure, the kyphosis is reduced to 35°. Figure 7c – At one year postoperatively there is 40° angulation, bony fusion and 90% hypertrophy of the rib graft. Figure 7d – The paralysed patient on admission. Figure 7e – Neurologically intact with a normal spinal curve at one year postoperatively.
The radiographs were separately reviewed by two independent senior radiologists who were asked to identify the earliest film which showed the third (complete) stage of bony healing. This was seen at an average of 3.3 months (range 1.5 to 10). Bony fusion was present in 14 (73%) at three months, 18 at six months, and in all 19 by 10 months. There was no radiographical evidence of erosion or destruction of the vascularised rib graft in any patient. The posterior fusion was complete in all patients by 10 months.

The average pre-operative angulation of 56° was reduced to 27.6° postoperatively (range 8° to 57°), a 50.7% correction. At the most recent follow-up, the average angulation was 30.9°, a loss of correction of 5.9° (3.3°) (see Fig. 6).

The six patients treated with a one-stage combined procedure had a mean angulation of 67.5° before operation and 22.6° postoperatively, a 66.5% reduction. At the latest follow-up, the average angulation was 26.3°, a 5.5° (3.7°) loss of correction (Fig. 7), still leaving a 61% correction.

Cosmetic improvement was rated by the patients (or parents) as excellent in 12 and good in five, the other two having only an insignificant kyphos on presentation. An important feature of the reduction of kyphosis was the restoration of normal spine balance (Fig. 8).

Hypertrophy of the rib pedicle graft was recorded as significant when its postoperative diameter on a lateral radiograph had increased by at least 25%. We used constant distances to eliminate any magnification error and used the width of the vertebra at the upper end of the graft as a control between the serial radiographs. Significant hypertrophy was seen in 14 of the 19 patients, the average being 57.5%.

Neurological recovery from admission to the latest follow-up averaged 2.6 grades on the Frankel scale: 18 patients had normal neurological function while the nineteenth walked with the aid of crutches (case 1). Full neurological recovery was achieved by 47% at three months postoperatively, 70% at six months, 88% at nine months and in 95% at 14 months. No patient was made worse by the surgical treatment.

Complications. There were minor complications in two cases: one developed bilateral bronchopneumonia post-operatively, but responded favourably to intravenous antibiotics and physiotherapy; the other, a grossly obese woman of 120 kg, had wound breakdown at the iliac crest donor site, but secondary wound suture was satisfactory.

DISCUSSION

The one-stage combined Kalafong procedure allows the reduction of a long-standing rigid kyphosis, even in the thoracic spine, and even in adults (Fig. 9). The most feared complication, spinal cord damage, is avoided by...
meticulous attention to the total release of all anterior and lateral adhesions, allowing the spinal cord to move forward unhindered during the reduction of the kyphosis.

Segmental rectangle instrumentation is preferred to the Harrington compression system, since it not only provides a very effective three-point system, but also allows for shortening of the posterior column. For small children with soft immature spines, a rectangle with sublaminar Mersilene tape is the only available effective instrumentation. In children, a late increase in kyphosis after anterior fusion alone is prevented by performing a posterior fusion, which also includes a posterior epi-

physeodesis. The posterior instrumentation helps to maintain the correction until the fusion is solid.

The variable clinical picture of spinal tuberculosis (Medical Research Council 1974, 1976; Lifeso, Weaver and Harder 1985) necessitates comparison of the results of the present study with those for the same race and in the same part of the world. Unfortunately, only one study in South Africa (Medical Research Council 1978b) included patients with CNS involvement. From this it was concluded that anterior debridement, decompression and bone grafting produced the best surgical results. Comparing 20 patients with CNS involvement in the MRC study with the 19 patients who had the Kalafong operation, bony fusion was seen in only 5% at six months postoperatively, as against 95% respectively. At 12 months all the Kalafong patients had bony fusion, as against 25% in the MRC study (Fig. 10). Both the Breslow and the Mantel-Cox tests confirmed that the differences were highly significant (p < 0.001). In the Kalafong group, there was a mean 44.8% reduction of the kyphosis, as against a mean deterioration of 52% from admission to the latest follow-up in the MRC study. Complete neurological recovery was seen in 47% of Kalafong and 13% of MRC patients after three months; 71% Kalafong and 33% MRC after six months; 95%, Kalafong and 50% MRC after 15 months. These differences are significant at p < 0.001 (Breslow and Mantel-Cox tests).

A similar technique of anterior decompression was used in both series, but the Kalafong method produced earlier and more complete neurological recovery, possibly because the rigid fixation of the involved portion of the spine allowed more uninterrupted recovery, since movement in and around the spinal cord was still possible in the MRC cases after anterior strut grafting alone. Sometimes this may even render the spine more unstable than before surgery.

Despite the excellent results of the Kalafong pro-
dure, there may be doubt whether all the additional effort and theatre time is justified in adult patients where the cosmetic result may be less important than the paralysis. However, in the earlier MRC study of anterior fusion alone, there was an increase in kyphosis to 61° over two levels, and this is important enough to necessitate correction.

Another issue which needs discussion is whether a vascularised bone graft has sufficient advantages over a non-vascularised graft to justify the more difficult and longer operation. Sound bony fusion is the best evidence of healing – and 95% of the vascularised grafts had healed by six months as against only 5% of the patients in the older MRC group with non-vascularised grafts. Furthermore, there was no increase in the kyphotic angulation in any adult patient with a vascularised graft after bony fusion at an average of 3.3 months postoperatively. This solid, early bony fusion seems to provide enough evidence to support the use of a vascularised bone graft in spinal tuberculosis patients. In our series these advantages were gained with no significant complications.

I am grateful to Dr P. J. Becker of the Institute for Biostatistics, South African Medical Research Council, for his assistance with the statistical analysis. I further wish to acknowledge Professor P. A. Fourie and Dr L. van de Werke for the evaluation of the radiographs.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


