

SURGICAL TREATMENT OF THE COMPLICATIONS OF TUBERCULOSIS SPONDYLITIS

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Tuberculosis of the spinal column constitutes up to 50% of the cases with skeletal involvement. Most frequent location is the thoracic spine (50%), followed by the lumbar (40%) and the cervical spine (10%)(40). Sacral disease is usually associated with involvement of the lower lumbar spine (33). Three forms of vertebral involvement have been described; peridiscal, central, and anterior (6). Two-thirds of the classifiable cases present with peridiscal involvement, while in more than 50% of the cases the primary focus can not be determined because of the extension of the disease. Progression of the vertebral disease is usually by direct subperiosteal or subligamentous spread. Prior to the era of antibiotics and improvements in general health, multisegmental involvement was thought to be the norm, usually diagnosed at the autopsies, but today involvement of more than one noncontiguous region of the spine is very rare. The true incidence of primary posterior involvement is virtually unknown, however, the introduction of computerized tomography (CT) and magnetic resonance imaging (MRI) have probably increased the rate of identifiable cases to up to 10% of the cases with extensive disease (3,37).

Surgery in tuberculosis spondylitis is generally considered to be an adjuvant of effective chemotherapy. Indications for surgical treatment include

- 1) neurological involvement,
- 2) deformity and/or impending increase in deformity, and
- 3) the presence of large tuberculosis abscess and/or abundant necrotic tissue.

Neurological involvement:

The prognosis associated with and the treatment of neurologic involvement in tuberculosis spondylitis is influenced by many factors such as the age and general medical condition of the patient, the location of the involved vertebrae, drug resistance, the severity of neurological deficit, the cause and mechanism of the neurological deficit, and the time of onset and duration of symptoms (5,12,27). Paralysis occurring in children generally have a better prognosis compared to adults (5). Deficits arising from cervical or high thoracic involvement are associated with a dismal prognosis (17). Overall good response to chemotherapy carries a higher likelihood of improvement. Severe involvement (Frankel grades A or B) has bad prognosis and probably constitutes an indication for urgent decompression (17). Several mechanisms for the occurrence of neurological involvement have been described. During the early phases of the disease with active infection, possible reasons include direct compression of the neural structures by the abscess and/or sequestered bone fragments, direct dural invasion, vascular compromise due to compression or thrombosis, acute instability, or severe deformity. Direct compression by abscess or necrotic tissue is the most frequent cause of early onset paralysis and generally has a good prognosis and a relatively high probability to resolve with effective treatment (27). Deficits due to cord compression by sequestered bone fragments or at the apex of the kyphotic deformity require surgical decompression and the prognosis depends on the duration and severity of the paralysis. Acute instability of the involved segments

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may rarely cause subluxation or dislocation and subsequent paralysis which is best addressed by immediate surgical stabilization (5,19,37). Direct dural invasion and vascular thrombosis are very rare and probably carry the worst prognosis (37). The mechanisms involved in the late onset paralysis are the development of anterior bony ridges, disease reactivation, chronic instability, increase in kyphotic deformity and rarely degenerative changes adjacent to the segments healed with significant deformity (18). Patients with active disease have been reported to respond well to surgical decompression, however in cases with healed disease decompressive surgery appears to be more prone to complications and is less reliable (13).

Several approaches have been used for the treatment of paralysis due to tuberculosis spondylitis. These include:

- Chemotherapy alone
- Chemotherapy with immobilization (ambulatory or non-ambulatory)
- Chemotherapy with surgery
- Laminectomy
- Costotransversectomy
- Anterior decompression

Early MRC studies focused on the treatment of tuberculosis spondylitis with nonsurgical measures regardless of the neurological status. In the first MRC report, 10 patients with neurological involvement were included in the study (20). During the course of treatment, five (50%) of these deteriorated to complete paraplegia, but returned to their original status within 5 months. Finally, eight of the original ten patients had complete resolution of their paralysis. In the fifth report, which also includes the group of patients studied in the first report, a total of thirty-two patients had paraparesis at some stage of the treatment, twenty of whom had complete resolution at the end of the 18 months treatment protocol, eight required additional chemotherapy and/or surgery but at the end had complete resolution, three died, and one still had

neurological involvement on final evaluation at five years (23). On the other hand, Tuli reported significant improvement in only 38.5% of patients treated by chemotherapy alone, compared to 69% full and 11% partial recovery in patients who had surgical treatment (38).

Laminectomy probably has a very limited role in the decompression of the spinal canal. Patients with posterior element involvement should undergo laminectomy provided that surgical intervention is indicated, but apart from these, it should only be condemned in the majority of patients with anterior column involvement and collapse because of the additional instability caused by the procedure. Costotransversectomy was advocated as the treatment of choice for the evacuation of large paravertebral abscesses and decompression of the spinal canal before the anterior procedures were proven to be safe and effective (45). The only advantage over anterior debridement is that the dissection plane is usually extrapleural obviating the need for the placement of a chest tube and underwater drainage in the postoperative period. Disadvantages on the other hand include often inadequate visualization of the pathology and less than ideal decompression, further destabilization of a kyphotic segment, inadequate (if any) correction of deformity and the technical difficulties associated with the procedure. Based on a series of patients decompressed by costotransversectomies or anterolateral or posterolateral decompressions, Martin reported 60% recovery, while only a minority of the patients in this series had also received chemotherapy (19).

The gold standard of decompressive surgery for Pott's paralysis appears to be the anterior procedures. Anterior procedures were first demonstrated to be safe and effective by Hodgson and coworkers and had been commonly used for the treatment of a wide array of spinal disorders since then. Hodgson and coworkers treated 100 cases of Pott's paraplegia by either conservative inpatient immobilization or anterior

decompression (12). They reported a 74% complete recovery and an additional 10% incomplete recovery, but did not compare the two methods based on the rate of recovery. Lifeso and coworkers reported the results of 65 patients with neurological deficits, 94% of whom had improvement with surgical decompression compared to a 79% recovery rate by chemotherapy alone, and 55% after laminectomy (17). Conversely, in a population of 63 adults and children with neurological involvement, Moula and coworkers divided the patients arbitrarily into conservative and surgery groups and demonstrated that the conservatively treated group had 68% complete and 19% partial recovery, compared to 38% complete and grafting (31). Mortality in the group that only had medical treatment was 5% in contrast with the 23% after surgery. Our clinics experience consists of 33 patients who Frankel A in 1, Frankel B in 2, and Frankel C or D in 30, seen over a period of fifteen years (2,36). These patients were treated by either chemotherapy alone, or posterior fusion, or, anterior debridement and fusion, all mobilized with external support. All patients received chemotherapy for at least two weeks prior to surgery, and all were immobilized with the use of Halter traction during this period. Seventy-five percent of the patients were found to have had complete resolution, an 19% had partial improvement in their neurological status at final follow-up, regardless of the type of treatment used. The two patients who had no improvement were both treated surgically (1 in the PF group and the other in the AF group). The patient with Frankel grade A involvement was found to have significant improvement (to grade D) with anterior surgery. Of the two grade B patients, one had a minor improvement to grade C, while the other deteriorated to grade A.

Results of anterior decompressive surgery in unselected groups of patients with paralysis have been analyzed on several reports. Bailey and coworkers reported the results of 43 children with neurological involvement who were treated with the procedure described by Hodgson (5). Nineteen of the

23 (82.6%) patients with incomplete paralysis had total recovery within 12 months of the operation, and three other were independent walkers. For paraplegics, the total recovery rate was 85% (17 of 20) achieved at periods ranging from 2 to 36 months. On another study conducted on 200 patients with neurological lesions, Vidyasagar and Murty reported 70% complete and 15% incomplete recovery using various decompressive procedures (43). These authors strongly recommended surgical treatment for all patients with paralysis based on the relative uncertainty they have experienced in arriving a definite diagnosis of tuberculosis spondylitis as the cause of neurological involvement. Seventh report of MRC, based on a study conducted in two centers in South Africa, includes the neurological recovery rates of patients treated with anterior debridement or anterior debridement and fusion (25). Mortality in patients with paralysis was 14%. Paraplegics were found to have responded less favorably in terms of recovery compared to paraparetics on analyses performed at 6 and 18 months, but results of both groups were similar at 21 months, 72% and 69% respectively.

The definition of late onset neurological involvement is not quite clear. In most of the reports dealing with paralysis associated with tuberculosis spondylitis, the duration of neurological symptoms have been extremely variable, ranging from a few months to years. What we understand by late onset neurological involvement is the paralysis that had developed after the active infection has subsided and bone and soft tissue pathology have healed. Possible causes can be listed as the development of anterior bony ridges, disease reactivation, chronic instability, increase in kyphotic deformity and rarely degenerative changes adjacent to the segments that healed with significant deformity (18). Hsu and coworkers reported their experience with 22 patients with late onset paraplegia presenting an average of 18 years after initial symptoms (13). The cause of paralysis was disease reactivation in 14 and healed hard bony ridges in 8 patients. They have concluded that the

results after anterior decompressive surgery was favorable in the disease reactivation group (nine complete and three partial recoveries), however, the operation was less effective (three complete recoveries and one partial recovery) and more complicated if the paralysis was caused by hard bony ridges. Our experience with late onset Pottis paraplegia is similar, and we can say that decompression of the spinal cord in the presence of rigid bony deformity may be prone to severe complications, and deterioration of neurological status of the patients (2,36).

As a conclusion for the treatment of neurological involvement due to tuberculosis spondylitis, it can only be said that all patients with this disorder would not fit into one ideal treatment scheme, and the decision should be based upon the consideration of several factors, most important of which are probably the severity and duration of the paralysis and the exact cause of the neural compression.

Abscess:

The necessity of surgical treatment for the evacuation of paravertebral cold abscesses and/or debridement of necrotic tissue is as controversial as any other subject in the treatment of tuberculosis spondylitis. The first report of MRC gives a detailed analysis of the course of mediastinal or psoas abscesses in a group of patients who did not receive any surgical treatment (20). Seventy six percent of inpatients and 72% of outpatients had clinically or radiologically evident abscesses or draining sinuses, or developed one during the course of medical treatment. On final evaluation at three years, 11% and 5% respectively still had residual abscesses or sinuses. On a further study, disappearance of the clinically or radiologically evident abscesses were reported in 100% of patients treated by chemotherapy alone, or debridement, or anterior spinal fusion (23). Moon and coworkers have reported favorable results with conservative treatment in children and concluded that surgical drainage of a cold abscess is not required and should not be recommended (28). In our

experience however, 89 out of 100 patients retrospectively evaluated had cold abscesses at presentation, and nine of these developed actively draining sinuses, five of which persisted longer than one year. Of interest, only one of these nine patients had been treated by anterior debridement and fusion (one in thirty-three), the rest by posterior fusion without evacuation of the abscess (eight in fifty-six), but the difference was not statistically significant. The no-drainage patients were observed to require a longer period of chemotherapy (36). Thus, we still think that the presence of a large paravertebral abscess constitutes a relative indication for surgery. Several other methods of abscess drainage including costotransversectomy, anterior extrapleural approach, and transpedicular drainage have been recommended in several reports, without any demonstrated advantages over anterior drainage or debridement (8,15,45).

Deformity:

The term "Deformity" generally depicts kyphosis in tuberculous spondylitis. The anterior spinal column is most frequently involved, and the natural history of the disease is that of progressive bone loss, resulting in the collapse of the involved segments. The resulting deformity carries an intrinsic instability, and tends to progress in a manner directly related to the amount of bony destruction, independent of the activity of the infection (34). This concept of instability is different from the classical definitions based on spinal functional units, and more like the instability involved in the development of late deformity following thoracolumbar fractures (7,44). The natural end result in the surviving patient is expected to be the healing of the infection with bony and/or fibrous union of the involved segments regardless of the type of treatment used.

Kyphosis is generally classified into two types based on the flexibility (30). The mobile type is usually that seen with active disease, or before the complete healing of the lesion, and becomes rigid after bony or fibrous union. Therefore, we prefer to classify

deformity due to spinal tuberculosis into two types, early deformity and late deformity, based on the activity of the disease. Early deformity is associated with active disease and tends to be relatively flexible, and late deformity occurs after the active infection has healed by fibrous or bony union. Several procedures have been proposed for the management of either type of deformity. A list of the procedures and an overview of the advantages and disadvantages of each procedure will be cited below.

A) Early deformity

- * Posterior fusion
- * Anterior debridement
- * Anterior debridement and fusion
- * Posterior fusion and instrumentation
- * Posterior fusion and instrumentation along with anterior fusion
- * Anterior debridement and fusion with instrumentation

B) Late deformity

- * Anterior osteotomy and fusion with strut grafting
- * Egg shell procedure
- * Posterior fusion and instrumentation along with anterior fusion
- * Anterior osteotomy, halo traction, posterior osteotomy and fusion followed by anterior fusion (Three stage procedure)
- * Simultaneous anterior and posterior osteotomies and fusion

Posterior fusion:

Posterior fusion had been the standard surgical procedure for the limited correction and prevention of progression of deformity in many centers, before the safe and liberal use of anterior spinal surgery became feasible. The rationale behind this procedure are; a) stabilization of the spinal column once the fusion is achieved, preventing the progression of the deformity, b) enhancing the rate of healing of the infection by obtaining a stable spinal segment, and c) obtaining a

posterior epiphysiodesis so as to counter the deforming effect of the loss of anterior growth potential. Our experience with this procedure has so far been disappointing. On a review of 56 patients who had undergone posterior fusion, fourteen patients were found to have completed the treatment with severe deformity (local kyphosis exceeding 50 degrees) despite prolonged periods of immobilization with plaster of Paris jackets (2,36). We saw that pseudoarthrosis was very common especially in the group of patients who were already severely kyphotic, and even if fusion could be achieved, bending of the fusion mass resulted in progression of the deformity in several patients (2). Furthermore, the overall healing of the infection was not more rapid compared to those who did not have any surgical treatment. Other reports in the literature support these findings (42). Moreover, evidence confirming the role of unopposed posterior spinal growth in the progression of kyphosis appears not to be conclusive.

Anterior debridement:

Anterior debridement without fusion in the treatment of spinal tuberculosis has been evaluated in MRC studies performed in Hong Kong and Bulawayo (21,22). The results of these studies demonstrated that the magnitude and the rate of progression of the kyphotic deformity was similar in patients who had no surgery and those who had anterior debridement without fusion, and were significantly inferior compared to anterior debridement and fusion. Longitudinal follow-up of the same group of patients revealed that body fusion occurred later in those who had anterior grafting compared to only debridement, but the rates of fusion were similar at five years (24). Over ten years, debridement patients exhibited mean increases in kyphosis of 9.8 degrees for thoracic and thoracolumbar lesions and 7.6 degrees for lumbar lesions, compared to minor changes in the fusion group (26). Upadhyay and coworkers reported the later follow-up of the same group of patients, concluding that the debridement patients demonstrated increases in kyphotic deformity for up to

six months. Adult patients then demonstrated an arrest in progression, while some spontaneous correction of the deformity occurred in the pediatric patients (40,41,42).

Anterior debridement and Fusion (Hong Kong operation):

Anterior debridement and fusion for the treatment of tuberculosis spondylitis was popularized by Hodgson and coworkers in 1960 (11). Since then it has been tested against other treatment modalities by several studies. The MRC trials demonstrated that an increase in kyphotic deformity occurred in only 17% of patients treated with this procedure compared to 39% of patients treated with chemotherapy, and compared to patients treated with anterior debridement alone, the progression the kyphotic deformity was considerably less with the Hong Kong procedure, especially during the first six months of the treatment (21,22,24,26). As mentioned above, kyphotic deformity did not significantly increase in these patients regardless of the treatment method after six months. Rajasekaran and Soundarapandian retrospectively analyzed 81 patients treated by anterior arthrodesis (35). Fifty-nine percent of their patients had favorable results (excellent or good), 19% were rated as fair, and 22% as poor. Favorable results were obtained in patients 1) who had minimum destruction of vertebral bodies, 2) required limited surgical excision of bone resulting in a small postdebridement defect that needed only a short graft, 3) with marked intraoperative correction of the deformity, and 4) in those with lumbar spine disease. The amount of intraoperative correction of the deformity is usually not included in the analysis of other studies, and generally appears to be negligible.

Graft material has been pointed out as being one of the most important factors governing a favorable outcome in several other studies as well. Hodgson and Stock reported problems associated with graft failure in 12% of their cases (11). Bailey and coworkers reported the same incidence for graft fracture in a series of 100 children, and slippage of the graft in further five patients (5). Seventy four patients

exhibited some increase in their kyphotic deformity in this series (Average 22.2 degrees). Progression was associated with graft slippage in five, protrusion of the grafts into adjacent vertebral bodies in nine, graft fracture in ten, resorption and shortening of the forty, and posterior overgrowth of the fusion mass in only five cases. Rajasekaran and Soundarapandian reported graft slippage in 24%, resorption in 20% and fracture in 12% of their cases (34,35). Rib grafts were used in the majority of these patients, and were demonstrated to be unable to prevent vertebral collapse in patients in whom the length of the graft exceeds two disc spaces. The use of tricortical iliac crest grafts appears to yield better results compared to rib grafts. Kemp and coworkers reported 32% graft fractures using rib grafts resulting in a significant increase in the deformity (14). The overall fusion rates were 62% for rib grafts and 94.5% for iliac crest grafts in their series. On the other hand, Yazıcı and coworkers demonstrated a limited rate of graft incorporation and secondary remodeling using MR imaging in a series of patients who had undergone anterior fusion with tricortical iliac crest grafts at two years follow-up, although the preservation of the correction of deformities in this series was very good (48).

The use of anterior instrumentation supplementing the strut graft has been performed on a limited number of series. Oga and coworkers evaluated the adherence properties of mycobacterium tuberculosis to stainless steel and demonstrated that adherence was negligible, and the use of implants in regions with active tuberculosis infection may be safe (32). Kostuik reported his experience on cases with healed or inactive disease (16). Anterior plate fixation along with debridement and fusion of the active disease have been used for a very limited number of patients with active disease (4). Addition of the implant does not seem to increase the overall correction, and whether it is going to be effective in decreasing the graft related complications is yet to be seen. Nevertheless, a very limited number of cases in whom posterior

instrumentation may not be advisable because of complications of previous posterior surgery appear to be suitable for anterior instrumentation along with a complete debridement and strut grafting.

Posterior fusion and instrumentation:

The necessity of prolonged immobilization following anterior procedures, and the relatively high rates of progression of kyphosis frequently related to the problems with strut grafts prompted the idea that tuberculosis spondylitis may be stabilized by posterior instrumentation. Oga and coworkers reported their experience with this method in a series consisting of 11 patients, 4 of whom had only posterior surgery. Their indication for the use of posterior instrumentation alone was basically posterior element involvement. Good clinical results were reported but the instrumentation was extended to an alarming average of 8.5 levels, in spite of the fact that 3.5 levels on average were involved by the disease (32). Güven and coworkers reported their experience on the treatment of anterior column tuberculosis with posterior instrumentation and fusion on a series of 10 patients (8). Pedicular screws were used in the majority of cases, and the paravertebral abscesses were drained transpedicularly in two cases. Some kyphosis correction could be obtained in only five cases, however the instrumentation appeared to be effective in preventing the progression of the deformity. Short segment fixation was pointed out as a risk factor for losses of correction. The long term results of this approach have not been reported to date. It appears that posterior instrumentation prevents the increases in kyphosis which were usually encountered during the first six months of this treatment, but the problems frequently reported in series of posterior instrumentation and fusion in fractures devoid of any anterior column support may raise some concern.

Anterior and posterior fusion with posterior instrumentation:

Both Oga and coworkers and Moon and coworkers have reported satisfactory results using this technique

(29,32). Both authors advised performing the posterior surgery first, followed by the anterior debridement and fusion either sequentially, or after a period of a couple of weeks. Moon et al reported very good rates of correction and good maintenance of correction for both children and adults, fusion occurred in four months in single level spondylodesis cases and in six months in two-levels (29). We have performed a similar procedure executing the anterior stage first, followed by posterior fusion and instrumentation, never sequentially, for patients in whom anterior column destruction exceeded two disc spaces. For this sequence, the amount of correction is limited to that obtained in the anterior fusion. We believe this method to be superior in safety especially in patients with incomplete paralysis due to active disease as spinal cord decompression is carried out directly as the primary stage.

Anterior debridement and fusion with instrumentation:

There is only limited and recent on this type of treatment. As discussed above, surgeons have been reluctant in placing metallic implants in cases of infection.

The use of posterior instrumentation have gained some popularity in recent years, and upon seeing the reported results suggesting low complication rates prompted the idea of anterior instrumentation. The only clinical series so far is from Yılmaz and coworkers reporting 64% deformity correction for single or double level involvement, and 81% correction for multi level involvement, with minimal loss of correction and very few complications at follow-up (49).

Late Deformity:

Indications for surgical approaches aiming the correction of deformity after the active disease have completely healed are less clear and somewhat controversial. In our belief, this clinical entity is profoundly different compared to the deformity with active disease, and much more complex. In many

instances it may be considered as being a similar problem with a kyphotic deformity following a fracture malunion, but the ligaments and soft tissues are far more contracted, the anatomic planes may be nonexistent because of fibrosis, and furthermore, several vertebral levels may be involved. Staged operations are usually required and the functional cosmetic end results have so far not been uniformly good.

Kostuik reported favorable results with anterior osteotomy, decompression and fusion with instrumentation in a large series of patients with various diagnoses (16). In only two cases the deformity was related to healed tuberculous spondylitis, but, nevertheless he concluded that supplementary posterior fixation was not necessary except for those cases with more than single level involvement.

The eggshell procedure as devised by Heinig, consists of the decancellation of the body of the deformed vertebra via a transpedicular route (10). The posterior wall is then fractured and pushed anteriorly while the kyphotic deformity is corrected, under direct vision obtained by complete laminectomy of that level. Güven and coworkers reported their experience with this method in the treatment of kyphosis due to tuberculosis (9). The average correction obtained in three patients was 53 degrees, and no major complications were encountered. Three stage operations have been advocated for the treatment of rigid severe kyphosis. Yau and coworkers reported the results of a combination of spinal osteotomy, halopelvic traction, and anterior and posterior fusion performed on 23 patients with severe kyphosis (46). Deformity correction in this series averaged 28.3% in spite of the fact that all patients had undergone at least three major operations. Eleven of the 23 patients were reported to have severe restrictions in their vital capacities, leading to a mortality rate of 10%. While several other studies that include some patients treated with three stage operations reported more favorable results, the correction rates appear to be

similar to those obtained with two stage operations.

An alternative for the three stage operation is the simultaneous anterior posterior approach as defined by Farcy and coworkers (7,44). This operation consists of the simultaneous exposure of both the anterior and the posterior elements of the involved segments by two separate surgical teams. By this way the anterior and posterior osteotomies can be performed at the same time, not only totally limberizing the segment, but also allowing the surgeons to effectively shorten the posterior column prior to the application of any distractive force to the anterior column, thereby decreasing the risk of overall lengthening of the deformed segment. Very favorable results have been reported in the treatment of late kyphotic deformity following thoracolumbar fractures by the original authors (1). Our experience with this technique has been as favorable when performed for the same indication, while being slightly disappointing in cases of kyphosis due to tuberculosis spondylitis (47). The average preoperative sagittal index was 45 degrees in this series, the cases of tuberculosis kyphosis being significantly more severe compared to those of fracture complications, average sagittal indexes being 79.5 and 27.75 degrees respectively. The trauma group could be corrected to an average sagittal index of 2.5 degrees (91% correction), while in the tuberculosis group the average final sagittal index was 35 degrees (56% correction), due to the severe fibrosis and contracture of ligaments encountered. Average blood loss and the duration of surgery were similar for both groups.

It thus appears that an ideal treatment for late deformity following tuberculosis spondylitis does not exist. The approach to this difficult problem should be tailored according to the expectations of the patients as well as the experience and the ability of the involved medical center.

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