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Surgical Management for Spinal Tuberculosis: A Review

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Abstract
Spinal tuberculosis (TB) incidence in both developing and developed countries has dramatically increased, owing to the increase of HIV infection and drug resistance [1,2]. Antituberculous chemotherapy is proven to be ineffective in the prevention of paraplegia, kyphosis and instability of vertebrae [3]. Surgical procedures are a supplementary of chemotherapy playing an important role in the treatment of patients with neurological deficit, caseous abscesses or sequestrum formation, unstable spine and kyphotic deformity[4, 5]. Current surgical approaches mainly advocated by the surgeons are anterior approach alone, posterior approach alone and combined approach. To date, consensus as to whether anterior or posterior approach or combined approach should be applied in the treatment of spinal TB is not available in the literature. Based on analysis of many literatures, an anterior radical debridement and strut grafting with instrumentation allow reaching the focal point of the disease directly, effective debridement of the focal point. But, it also has many disadvantages which includes great surgical invasion, crinose complications and comparatively ineffective correction of instability and lordosis. Though a posterior debridement and strut grafting with instrumentation may not fit for the patients with prevertebral or paravertebral huge abscess or large vertebral destruction, it is safer, technically easier, effective kyphosis correction and less potential intra- and post- operative complication which can be associated with the anterior and combined posterior procedures. The combined approach owns both advantages of anterior and posterior surgery suitable for patients with extreme prevertebral or paravertebral huge abscess or large vertebral destruction. But, it is not advisable for every patient, as it has a longer operation time, longer healing duration, and higher incidence of surgical complications. Consequently, the operating management choices for spinal TB should follow to the needs of the individual patient. With the continuous development of posterior techniques, the posterior debridement achieves the role of anterior debridement to a certain extent. Based on analysis of the literatures, posterior debridement and bone grafting fusion with posterior instrumentation mentioned by more and more surgeons and acquired favorable outcomes can be the superior surgical approach to spinal TB at early metaphase.

Introduction

Spinal TB is one of the most common severe spinal diseases that frequently cause spinal instability, kyphotic deformity, neurologic deficit and even paralysation. The treatment goals of spinal TB is to eradicate the disease, prevent the development of neurological deficit, correct kyphosis deformities, allow early ambulation and return the patient back to daily life [6-8]. Antituberculous chemotherapy is proven to be effective in some early cases and has become the mainstay of the treatment [9,10]. While, the early and definite diagnosis to spinal TB is not easy, because disease progression is insidious in nature [11]. And that chemotherapy alone or long periods of bed rest may not yet be effective in the prevention of paraplegia, kyphosis and instability of vertebrae [2,3]. Kyphotic deformity is a common complication in people with spinal TB [12]. 15 degrees increase in deformity on average, if patients with spinal TB treated by chemotherapy alone [13]. The progressive deformity may result in increased potential for pain, respiratory distress and spinal cord compression. A progressive neurological deficit or paraplegia will be the worst complication of a progressive kyphotic deformity. For the reason of maintaining normal sagittal alignment and avoiding a worsening of symptoms surgical intervention is very necessary. Besides，Stability of spine is necessary for normal spinal biomechanical function. Instability leads to low back pain, aggravate the neurologic deficit and hinder patients' movement in daily life. Surgical strut grafting and instrumentation can provide excellent stability of the spine. Therefore， surgical procedures still play an important role in the treatment of patients with neurological deficit, caseous abscesses or sequestered bone formation, instability and kyphotic deformity [4, 5].

However, the best surgical approach and instrumentation modality of spinal TB remains controversy. Current surgical approaches mainly advocated by the surgeons are anterior approach alone, posterior approach alone and combined approach. This review focuses on discussing the choices of surgical approach to spinal TB.

Anterior-Only Approach

An anterior approach for decompression and autologous bone grafting (Hong-Kong operation) was first introduced by Hodgson et al [14] in Hong Kong, 1960. They reported that 94% of patients who underwent this approach made a complete recovery. Subsequently, several surgeons have used it for spinal tuberculous lesions owing to its advantages as direct access to the focus of disease, effective resection of pathologically changed tissue (damaged vertebrae, sequestra, tuberculous granuloma, abscessus), rapid bony union with the grafts and prevent progressive collapse and kyphosis [15-20]. Because of these advantages, Anterior approach was traditionally considered as the benchmark for the surgical procedure of spinal TB [19, 21]. It must be emphasized that radical debridement is the key of surgical management for patient with spinal TB [9]. Abscess accumulation can lead to supercharge of the spinal cord or the nerve roots, and the neurologic deficit is aggravated gradually. In cases of halfway focal excision, sinuses may emerge, and there is the likelihood of failure of both bone grafting. As the spinal TB causes abscess mainly to accumulate in the pre and para-vertebral spaces， anterior debridement can debride the absces， sequestra， tuberculous granuloma directly and thoroughly. But the problem that several surgeons noted is that there was an increase in the deformity of patients who had broad involvement of the vertebral bodies after this simple debridement and autologous bone

grafting [3]. The reason could be that the excessive forces transmitted across the graft and the weakening of the graft once the patients were mobile and leading to fracture of the graft, slippage of the graft out of its bed, resorption of the graft. In order to increase postoperative stability of vertebrae and improve the fusion rate, anterior instrumentation was used in classical anterior radical surgery. The anterior instrumentation provided significant stability and promoted the fusion of bone grafting [22-25]. The titanium mesh cages usually placed in the bone defect by anterior approach by the surgeons also played an important role of preventing bone graft sinking or dislodgement. Under the function of the cages and anterior instrumentation, anterior approach obtained favorable stability of vertebrae and fusion rate of the graft. Nowadays, the modern anterior approach for anterior focal debridement and bone grafting fusion with anterior instrumentation was considered that it can not only debride the focal point thoroughly, but as well is effective in the correction and maintenance of kyphotic deformities [26-28].

Also, it has been criticized by some surgeons. With authors giving their opinions and thoughts mainly these following reasons：

First， the anterior approach is too drastic， because the anterior of body has more major visceral organs and structures than the posterior and the anterior extension of surgery may carry the risk of them being damaged, leading to higher surgical complications including respiratory insufficiency, hemopneumothorax, pneumonia, postoperative ileac， retrograde ejaculation and angiorrhexis [29-33]. Especially, the surgical risk will increase in upper thoracic TB, as anterior exposure of the focus being blocked by the thoracic bones, clavicle, costal bone, scapula, and mediastinal organs [34]. An anterior paramedian transthoracic approach requires massive transection of muscle, thoracic bones, costal bone and going through the pleural cavity, causing great damage and probable perioperative or postoperative complications [29-31], and the risk of surgery will increase when destruction by infection leads to kyphosis [29]. Some surgeons[35] used an extrapleural approach that open the sternum to treat upper thoracic tuberculosis avoiding the pleural cavity， but involved complex and vital structures like the recurrent laryngeal nerve, tenth nerve, phrenic nerve, alimentary duct, and other important structures. The anterior instrumentation lacks enough space to insert the implants and may risk the great vessels, particularly in the thoracic spine. While, the thoracic posterolateral approach is inconvenient to install vertebral body screws for its 60 degree roll position and yet provides a limited operative space. It is also hazardous for anterior debridement used in lumbosacral TB, because of the presence of major vessels crossing the lateral aspects of the vertebral bodies [33, 36]. Thus the anterior approach may require more accomplished technique and is not suitable for infirm or elderly.

Second, surgeons considered the classical anterior approach in combination with anterior instrumentation only to provide partial spinal stability [37, 38]. It is suggested that anterior fixation performed a weaker holding power in reconstructing vertebral instability versus posterior rigid stabilization system， for the adjacent segments are usually too osteoporotic. Fixation of anterior vertebral screws only punches the anterior, middle columns supplying weak anti-torsion and anti-buckling capabilities (Figs.1b). This weakness is very obvious When tuberculous lesions involving multi levels of the vertebras. Most importantly, if multiple segments

of the spine are affected, long anterior instrumentation will be technically difficult if not impossible.

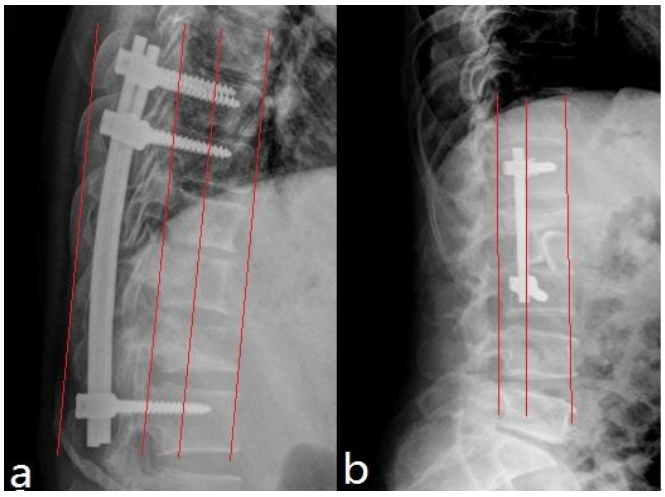

Fig.1 Posterior rigid stabilization system can obtains better kyphosis correction and provides the three column stability-the tensile force. Anterior vertebral screws only punch the anterior, middle columns supplying weak anti-torsion and anti-buckling capabilities -the supporting force (Courtesy: second affiliated hospital of Soochow university).

Third, the effect of preventing the progression of kyphosis through anterior debridement and bone grafting fusion with instrumentation approach remains controversy. Benli et al. [26] considered that anterior approach was effective in the correction and maintenance of kyphotic deformities. But Kim et al. [38] who operated on 21 patients with spinal TB by anterior instrumentation mentioned that although a 11.3° correction (67.7 %) was achieved initially, a correction of 9.4°(83 %) was lost at latest follow-up. The weaker holding power we mentioned above may be the reason that many surgeons have found that a progression of kyphosis as a consequence of failure of the bone graft during the follow-up period.

Finally, as the anterior approach is difficult to decompress the cauda equina nerve roots via anterior approaches, for some special cases, surgeons considered that the anterior approach can be indicated when pathologic process mainly affects the anterior and middle columns and the posterior column is healthy [27, 39]. Besides, we all know that spinal TB often involves anterior column, so the placement foreign material of anterior in an infected area remains controversial as they have been linked with increased risk of deep wound infections [40]. Whatever, one thing is sure that it offers a possibility that tubercle bacillus is more or less adherent to the anterior metal cage and thus forms a colony, which leads to failure of anterior instrumentation.

Posterior-Only Approach

In recent years, one-stage posterior focal debridement and bone grafting fusion with instrumentation approach only for the spinal TB has been reported frequently by some researchers [7,36,41-44]. The advantages of posterior approach include minor surgical invasion, satisfactory effect of debridement, provide rigid fixation and stability, with the ability to decompress the cord and nerve roots and effective kyphosis correction. Surgeons preferring anterior approach thought the posterior approach was infeasible, owing to its disadvantages as it couldn't expose the focal point of the disease directly which probably led to incomplete focal debridement. However , Surgeons using posterior approach focus on treating spinal TB obtaining effective debridement [4, 7, 36, 39, 41, 42, 45, 46]. Zhang et al. [43] considered that the approach of posterior debridement can successfully remove the focus of tuberculosis. They exposed posterior elements of thoracic vertebra (unilateral facet joint resection, excision of the upper or lower costotransverse joint with a small fragment of ribs) and achieved 270°

decompression under direct vision without injuring the spinal cord (Figs.2). Coupled with the use of various angle curette， pressure washing and negative pressure suction, the abscess, granulation and bony sequestrum was ridded neatly, and the cord and spinal nerve also was decompressed thoroughly [34, 41, 43]. This posterior debridement approaches have several advantages which includes creating enough operating room, allowing posterior decompression, debridement under direct visualization of the endorhachis and had comparable effects of anterior debridement. These advantages will be magnified, if the lesions are behind vertebrae. For upper thoracic tuberculosis (anterior and posterolateral approach are not convenient we mentioned above), the posterior approach may be especially suitable in terms of safety and convenience. Because most of the surgeons are much familiarized with the posterior surgical approach and the posterior spine have fewer blockages of visceral organs and structures. However, there are some problems we need to pay attention to. The posterior decompression, compared with anterior approach, may not be complete and might not be convenient for the spinal TB that largely involves the prevertebral and/or paravertebral tissues [45]. As Zhang's posterior decompression decreasing stability caused by resection of the zygapophyseal and costotransverse joints，the stability of long segment posterior instrumentation may be faced with a challenge when the spinal abscess involving multi segment.

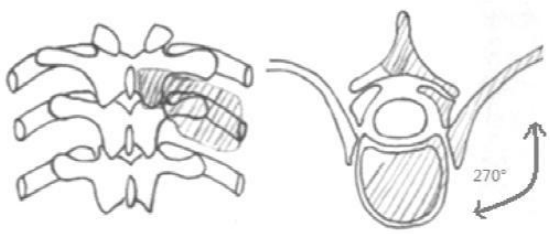

Fig.2 Zhang et al. resected zygapophyseal joint, costotransverse joint and small portion of ribs and achieved 270° decompression under direct vision. Resection range (shaded portion).

Posterior instrumentation has become popular as a technique for correction of kyphotic deformity. It corrects the deformity by severing (or do not) the spinal rear structure and installing the rods from side to side with compression maneuvers under vision resulting modest distraction of the intervertebral space at the involved level. Satisfactory correction rate was always obtained by surgeons who performed posterior instrumentation and fusion, debridement in spinal TB with kyphotic deformity [2, 44, 47-49]. Bezer et al. [49] reported that by posterior instrumentation and fusion, debridement was obtained around 69.1% correction rate postoperatively from the preoperative value of 17.5°， there was no significant loss during follow-up period. In Sun's study, kyphosis improved from preoperative 21.68° to postoperative -24.16° ， average kyphosis angle improvement was 45.8°(range, 34.9°-53.1°) and there was no significant loss during follow-up period [7]. The posterior osteotomies have played a positive role in correcting the kyphotic angle of great degrees. Wang et al. [48] treated nine patients with severe kyphotic angle of greater than 90 degrees with posterior-only multilevel modified vertebral column resection. Mean preoperative kyphosis of 100 degrees was corrected to 16 degrees. Similarly, other surgeons obtained effective

correction of severe kyphotic deformity via posterior approach in recent years [7, 36, 39, 41]. Several reports have shown there were no differences between the posterior and anterior instrumentation systems in terms of kyphosis correction and fusion rate for moderate post-tuberculosis kyphosis [23, 28]. Nevertheless, posterior pedicle subtraction osteotomies or vertebral column resection may be more effect in correcting the larger degrees of kyphotic deformity (greater than 80 degrees of kyphosis) [47].

Surgeons considered that the posterior spinal instrumentation can provide rigid fixation and stability [50, 51]. The posterior internal fixation has experienced from the Harrington rods, Harrington-Luque segmental wire fixation, and multiple hook devices to the pedicle screw fixation systems of today. The transpedicular screws provide greater biomechanical purchase than anterior fixation due to its three column fixation at adjacent level of decompression [41] and posterior rigid stabilization system can provides better kyphosis correction and is beneficial to the stress dispersion which effectively prevents implants failure (Figs.1a). An additional posterior short-segment fusion was also applied to restrain the overgrowth of posterior elements, which can balance the growth ratio between anterior height of fusion mass and posterior height of fusion mass and to prevent a progress in kyphosis during the growth period [52]. The fusion rate of surgical strut grafting also plays an important role in maintaining the stability of spine after operation. The authors reported no significant differences between anterior approach and posterior approach in terms of fusion rate [26-28, 31, 39]. However we agree with several surgeons that the posterior interbody fusion is not suitable for patients with severe vertebral body destruction. The posterior approach unlike the anterior grafting with a cage that can hold the graft in the location so the graft slippage and resorption may be the main reason of failure of posterior approach.

Combined Approach

The third surgical management for patients with spinal TB is that anterior radical debridement and strut grafting with posterior instrumentation. The combined approach of posterior instrumentation and anterior debridement were always performed by one-stage procedures or two separate approaches. Several researches considered that this approach was feasible and effective in patients with severe destruction by the lesion, resulting in the impossibility of anterior instrumentation, or in patients with severe lower lumbar kyphosis that requires lordosis correction and restoration, or those in whom initial anterior instrumentation failed [37,39,53,54]. But the one-stage anterior debridement and posterior instrumentation often has a longer operation time, longer healing duration, and higher surgical complications [4]. It was likely to have additional damage or aggravate the illness, when the patients required turning from the lateral to the prone position after anterior debridement for posterior instrumentation surgery, because the vertebrae were often instability after anterior radical debridement for abscess, granulation and bony sequestrum. Indeed, it also isn't fit for infirm or elderly. Although a two-stage approach, with posterior instrumentation performed after 2-3 weeks following anterior debridement [10, 18, 55] seems to can avoid the above problems, It increases the risk of postoperative for spinal instability after anterior debridement. However, if the posterior instrumentation is performed first, then the degree of kyphosis correction will be less than desired [2]. The patients in better condition with spinal TB who have huge prevertebral or

paravertebral abscess and severe vertebral destruction which the anterior approach alone or posterior surgery alone can't achieve satisfactory outcomes are suitable for the combined approach, as this surgery owns double advantages of anterior or posterior surgery mentioned above.

Conclusion and Outlook

However, there is no the best surgery approach to spinal TB for every patient. It needs to emphasise the importance of operating management choices to the needs of the individual patient. Anterior approach can be indicated when non-existent severe kyphotic angle and pathologic process mainly affects the anterior and middle columns and the posterior column is healthy. If the patients with spinal TB have huge prevertebral or paravertebral abscess and severe vertebral destruction, the combined approach of anterior radical debridement and strut grafting with posterior instrumentation is indicated. Based on analysis of many literatures, the outcome of treating patients of early-diagnosed and lesser-involved spinal TB with posterior instrumentation was not as bad as some surgeons expected originally. On the contrary,the posterior procedure has the advantages of less complications more effective kyphosis correction, better stabilisation, earlier movement than anterior procedures [15,41,45]. It may be the superior surgical approach to spinal tuberculosis at early metaphase. With the advent of diagnostic tools, spinal TB will be diagnosed early and big abscesses appear rarely Posterior surgery is gaining acceptance and it may be popular in hospitals as its safety, simplicity and availability. By now, operation treatment of spinal tuberculosis had underwent four milepost type progresses: anterior debridement alone, anterior debridement and autologous bone grafting, one or two-stage anterior radical debridement and strut grafting with posterior instrumentation, one-stage anterior debridement, interbody fusion and instrumentation Will the one-stage posterior debridement, inter body fusion and instrumentation become the fifth step? It may need further study with a large number of patients and longer follow-up to verify. Recent decade years, CT-guided percutaneous puncture and persistent local drainage and chemotherapy was applied in forepart and metaphase patients who suffered from abscess, light nerve deficit but no evident deformity achieved wonderful results of focus debridement [56-58]. Thoracoscopic approach [59] which is another minimal invasive surgery for eliminating the tuberculous abscess has many advantages include mild trauma， less postoperative pain, access to multiple levels and can obtained good exposure. These minimal invasive surgeries give more choices for debridement of tuberculose focus. With the development of these minimal invasive surgeries,the combination of opened surgery and minimal invasive surgery may become the trend in future.

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