ORIGINAL ARTICLE

Comparison of four surgical techniques in the management of tuberculous spondylitis of the thoracic spine in adults

Comparación de cuatro técnicas quirúrgicas para el manejo de la espondilitis tuberculosa de la columna torácica en adultos

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Abstract

Objective: *To compare the efficiency of the 4 most used surgical techniques for the management of tuberculous spondylitis.* **Method:** *Retrospective study in which adult patients with a confirmed diagnosis of tuberculous spondylitis, involvement of two vertebral levels or less, and without severe vertebral deformity were included. The medical records, imaging studies, and demographic data of the operated patients were collected and reviewed to retrospectively analyze the clinical results of each group. The primary variables were cure of infection, spinal fusion, and complications. The secondary variables included intraoperative bleeding, hospital stay, and surgical time.* **Results:** *There were no significant differences ($p \geq 0.05$) in most of the variables analyzed; however, there were ($p \leq 0.001$) regarding bleeding, surgical time, hospital stay and complications between the groups analyzed, with a lower result in all cases for the single posterior approach.* **Conclusions:** *The single posterior approach obtained a clinical efficacy similar to the rest of the approaches in terms of eradication of the infection and vertebral fusion, however, it was associated with less surgical invasion (surgical time and bleeding), a shorter hospital stay and complications.*

Keywords: *Anterior approach. Combined approach. Posterior approach. Thoracic spine. Tuberculous spondylitis. Spinal tuberculosis.*

Resumen

Objetivo: *Comparar la eficiencia de las cuatro técnicas quirúrgicas más utilizadas para el manejo de la espondilitis tuberculosa.* **Método:** *Estudio retrospectivo en el que se incluyeron pacientes adultos con diagnóstico confirmado de espondilitis tuberculosa, afectación de dos niveles vertebrales o menos y sin deformidad vertebral grave. Se recopilaron y revisaron los expedientes médicos, los estudios de imagen y los datos demográficos de los pacientes intervenidos para analizar retrospectivamente los resultados clínicos y funcionales de cada grupo. Las variables primarias fueron la erradicación de la infección, la fusión vertebral y las complicaciones. Entre las variables secundarias se estudiaron el sangrado intraoperatorio, la estancia hospitalaria y el tiempo quirúrgico.* **Resultados:** *Entre los grupos analizados no hubo diferencias significativas ($p \geq 0.05$) en la mayoría de las variables analizadas, pero sí ($p \leq 0.001$) respecto al sangrado, el*

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Date of reception: 15-08-2020
Date of acceptance: 07-10-2020
DOI: 10.24875/CIRUE.M20000320

Cir Cir (Eng). 2021;89(3):289-295
Contents available at PubMed
www.cirugiaycirujanos.com

tiempo quirúrgico, la estancia intrahospitalaria y las complicaciones, a favor del abordaje posterior único. **Conclusiones:** *El abordaje posterior único logró una eficacia clínica similar a la del resto de los abordajes en términos de erradicación de la infección y fusión vertebral; sin embargo, se asoció a menores tiempo quirúrgico, sangrado, estancia hospitalaria y complicaciones.*

Palabras clave: *Abordaje anterior. Abordaje combinado. Abordaje posterior. Columna torácica. Espondilitis tuberculosa. Tuberculosis espinal.*

Introduction

In recent years, the prevalence of tuberculosis (TB) has rapidly increased all over the world, especially in undeveloped and developing countries[1], such as Mexico, particularly in the northeast of the country, where its prevalence is substantially high[2]. Spinal TB is one of the most common presentations of extrapulmonary TB, and the most common and severe form of musculoskeletal presentation, comprising up to 50% of all affected patients[3]. It causes destruction of anterior and middle columns, leading to kyphotic deformity and neurological deficit, among other serious clinical complications[4].

Most patients with spinal TB can be successfully treated with conservative methods, such as oral medication regimens[5]; however, some cases require surgical interventions. Indications for the surgical treatment of tuberculous spondylitis are: 1) patients with neurological deficit as a result of spinal cord compression; 2) bone and intervertebral disc sequestration, as well as presence of severe destructive changes; 3) conventional therapy with unsuccessful oral medication and external orthoses, with multiple recurrences; 4) significant instability with spinal deformity; 5) formation of epidural abscesses[6]; and 6) intractable pain[7]. The goals of surgery are to eradicate infection and prevent or treat neurological deficit by removing compressive elements (necrotic and granulation tissue, devitalized bone, and disc material), as well to correct spinal deformity. Surgery also increases vascularization, thereby improving the effectiveness of drugs by increasing their concentration at the site of disease, and thus aiding bone healing and fusion[8].

The techniques described for surgical treatment include anterior debridement and interbody fusion with or without supplemental instrumentation[9], posterior debridement with instrumentation, and anterior debridement with interbody fusion combined with posterior instrumentation in one or two stages[10]. Favorable results have been reported with the use of all these techniques; however, some reports have noticed certain differences with regard to intraoperative variables, postoperative clinical outcomes, and complications[11]. In the reviewed literature, we have not found any study that compares all these techniques in a single report, but they have been independently reported in other studies. The hypothesis of this study is that debridement and instrumentation via posterior approach is as efficacious as debridement and instrumentation via anterior approach and combined one-stage or two-stage approach for the management of thoracic spine TB. The purpose of this study was to retrospectively compare the efficiency of the four aforementioned techniques for the management of thoracic spine tuberculous spondylitis in adults.

Method

Study design and ethical considerations

This was a retrospective, cross-sectional, descriptive study. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines were followed. The study was approved by the Research Ethics Committee of our hospital prior to being carried out, and is compliant with the Declaration of Helsinki of the World Medical Association of 1964 and its 2013 revision[12]. The authors declare that there are no financial or commercial earnings for conducting this study, that they have no conflicts of interest, and that they did not receive external funding of any kind.

Eligibility criteria

Patients older than 18 years diagnosed with active tuberculous spondylodiscitis of the thoracic spine who underwent surgery in our institution between January 2002 and December 2019 were included in the study. The diagnosis was confirmed by culture, biopsy or quantitative polymerase chain reaction (within previous 5 years), following in all cases the internal protocol of our hospital, which involves performing a transpedicular biopsy under fluoroscopic guidance and intraoperative

sampling. Other inclusion criteria were involvement of two or less adjacent vertebrae and presence of type A spinal deformity according to the Rajasekaran classification[13]. The exclusion criteria were patients with any of the following conditions: multilevel involvement (more than two adjacent vertebrae), cervical or lumbar spine TB, TB with involvement of posterior elements, TB at multiple non-contiguous vertebral levels, and those patients who had previously undergone surgery for the management of TB of the thoracic or lumbar spine. All cases were operated on by the lead author.

Initial approach to the patient with suspected spinal TB was clinical-radiological. Laboratory tests were carried out (complete blood count, erythrocyte sedimentation rate [ESR], C-reactive protein [CRP], liver and kidney function tests, and tuberculin skin test [Mantoux]), chest X-ray, X-rays on anteroposterior and lateral views of the dorsal and lumbar spine, computed tomography and magnetic resonance imaging of the thoracolumbar spine. In all cases, the above studies were carried out prior to starting a quadruple regimen of anti-tuberculous chemotherapy with isoniazid (300 mg/day), rifampicin (450 mg/day), ethambutol (750 mg/day), and pyrazinamide (750 mg/day) orally for 2-4 weeks before surgery.

Patient medical records, imaging studies, and demographic data were collected and reviewed to retrospectively analyze the clinical outcomes of each group. The analyzed variables were classified into six types: 1) clinical, demographic and disease presentation characteristics; 2) intraoperative and postoperative variables (blood loss, blood transfusion, surgical time, hospital stay length, etc.); 3) correction of spinal deformity, fusion (Cobb angle, radiological fusion according to Lee et al. criteria[14]) and infection suppression (CRP < 0.6 mg/dL and ESR < 20 mm/h in the absence of systemic inflammatory pathology or malignant tumors (according to Masuda et al. criteria[15]); 4) laboratory values; 5) neurological status (using the American Spinal Injury Association [ASIA] scale), preoperatively and at follow-up conclusion; and 6) postoperative complications and mortality. The primary outcome variables were infection eradication, vertebral fusion, and complications. Secondary outcome variables were intraoperative bleeding, hospital length of stay, surgical time, deformity correction, pain, and laboratory values.

Surgical indications

Surgery was indicated if patients had one or more of the following conditions: 1) progressive presence of neurological deficit (Frankel A/B grade paraplegia or Frankel C/D grade paraplegia not responding to medical management in 3-4 weeks)[16]; 2) epidural abscess or cold abscesses formation; 3) more than 50% of vertebral bodies destruction; 4) severe kyphotic deformity; 5) intractable pain; and 6) persistent infection not responding to conservative treatment. The decision about the moment to carry out the surgical procedure was when ESR and body temperature returned to normal parameters, or when they had significantly decreased, as well as complete correction of anemia and hypoproteinemia or an increase in neurological deficit.

Surgical techniques

The surgical techniques that have been used in our center and that are compared in this study are: 1) anterior radical debridement, interbody fusion with autologous bone graft and anterior instrumentation (group A); 2) posterior debridement, transforaminal fusion and posterior instrumentation (group B); 3) combined approach in a single stage (posterior instrumentation plus anterior debridement and autologous bone graft placement) (group C); and 4) combined two-stage approach (group D). All procedures were carried out under general anesthesia and endotracheal intubation.

Group A (single anterior approach)

Single-stage anterior radical debridement, interbody fusion with autogenous/autologous bone graft and instrumentation with lateral blocked plate were carried out. Patients were placed in the right lateral decubitus position and the injured area was exposed via intrapleural approach performed by a thoracic surgeon. Decompression was carried out by corpectomy alone or corpectomy/discectomy. Subsequently, radical debridement of compromised tissue was performed, and necrotic tissue and the remaining granulation tissue were removed until healthy bleeding bone was visualized. Instrumentation was performed by means of a lateral titanium Z-lock plate to correct the kyphotic deformity, which extended one level above and one level below the compromised area. The bone obtained from upper ribs resection in combination with structural allografts (tibia or fibula diaphysis) was used for the defect resulting from radical debridement.

Group B (single posterior approach)

One-stage posterior debridement, transforaminal fusion, and instrumentation with transpedicular screws were carried out. Initially, the patient was placed in the prone position using two cushions for chest and pelvis support. An incision was made at the midline to expose the posterior vertebral and paravertebral elements. A dissection was carried out to isolate the compromised vertebrae and two vertebral levels above and below. The transpedicular screws were inserted into the previously exposed vertebrae under fluoroscopic guidance. Laminectomies were performed at the compromised level or levels in order to decompress and visualize the spinal cord. The spinous processes, laminae, facet joints and transverse processes at the compromised area were resected. The ribs at the upper level were dissected at 4 cm from the costotransverse joint. Careful ligation of the segmental blood vessels was performed and the nerve roots of the exposed area were meticulously moved away. After the injured area was fully exposed, radical debridement was carefully performed with the purpose to remove necrotic and granulation tissue until healthy bleeding bone was visualized. In addition, any existing abscess was drained. After radical debridement was carried out, the resulting kyphosis was corrected by instrumentation performance. Spine reconstruction was carried out by placing titanium mesh cages filled with autologous spongy bone obtained from previous resection.

Group C (one-stage combined approach)

A single-stage combined approach with transpedicular posterior instrumentation followed by anterior radical debridement was carried out. Initially, posterior instrumentation was applied to obtain sufficient fixation; pedicle screws were placed at the two upper vertebrae and the two lower vertebrae in relation to the compromised one. The levels to be fused were anteriorly grafted using a combination of autologous and allogeneic bone after spinous and transverse lamina and processes decortication. After posterior instrumentation, patients were repositioned in lateral decubitus with the purpose to perform an anterior approach and remove infected tissue. The compromised area was isolated (this included local abscesses, collapsed vertebrae or intervertebral discs) and debridement of necrotic and granulation tissue was carried out, as well as pus extraction until healthy bleeding bone was reached. After sufficient decompression was achieved, autologous structural grafts were used to fill the defect created in the debridement process and stabilize the anterior spine.

Group D (two-stage posterior approach)

A two-stage combined approach with posterior instrumentation followed by anterior debridement was performed. The same surgical techniques were used as in group C, but each intervention was carried out on separate occasions. On the first occasion (first stage), anterior instrumentation was performed and the surgery was completed. Two to six weeks after the procedure, depending on patient state of recovery, a new intervention was carried out to perform an anterior radical debridement, as well as autologous bone grafts implantation to fill the defect.

Postoperative care and follow-up

In all cases, a suction drain was placed and removed when 24-hour volume was lower than 50 mL in. Assisted ambulation was allowed 2 to 4 weeks after surgery with the use of a dorsolumbar girdle. Follow-up was carried out during the first year at 6 weeks, at 3, 6 and 9 months, and at 1 year. Subsequently, control follow-up visits were carried out with annual intervals. At each follow-up appointment, patients were clinically evaluated for neurological function and pain, as well as radiologically for spine alignment and fusion degree. At each visit, anteroposterior and lateral radiographs of the thoracic spine were obtained, which were compared with those obtained before and immediately after surgery. Sagittal alignment was assessed using the Cobb method. A CT scan of the thoracic spine was carried out to determine the state of fusion 6 months and 1 year after surgery. Monitoring of laboratory parameters (white blood cell count, ESR and CRP) was done regularly until the parameters returned to normal values. After surgery, the TB chemotherapy oral regimen was continued for 3 months, followed by isoniazid and rifampicin for up to 12 months.

Statistical analysis

The statistical program SPSS, version 20.0 (IBM, Armonk, NY, USA), was used. For quantitative data, the mean and standard deviation were calculated, and for categorical variables, frequencies and

percentages were expressed. For inferential analysis, Student's t-test and ANOVA were used for group comparisons with parametric numerical variables. The chi-square test was used to analyze qualitative variables between groups. A p-value < 0.05 was considered to indicate a statistically significant difference.

Results

Forty-eight patients were included, out of whom 31 were males (64.58%), and 17, females (35.42%). Patient mean age was 45 ± 7.12 years. Mean duration of the disease was 8 ± 2.3 months.

All patients suffered varying degrees of pain, stiffness and limitation on the vertebral column, and experienced immediate relief of their back pain on the first postoperative day, with fever decreasing after several days. The symptoms preoperatively experienced by patients included weight loss, fever, night sweats, and fatigue; laboratory data were nonspecific, such as anemia, hypoproteinemia and ESR and CRP elevation. On imaging studies, data consistent with bone sequestration, subligamentous infection dissemination, vertebral body destruction and collapse, and paraspinal abscesses formation were found in all cases.

No neurological impairment was observed after surgery in any of the cases. All cases of spinal TB included in the study were considered to be healed according to laboratory values (CRP and ESR) and radiological evidence of bone fusion and bridge formation on CT scan and plain radiographs.

Table 1 shows the results of each one of the groups included in the study and a statistical comparison between them. Of note, there were no statistically significant differences ($p \geq 0.05$) in most analyzed variables, but there were ($p \leq 0.001$) with regard to bleeding, surgical time, hospital stay and complications, with an inferior result in all cases for group B (single posterior approach). Postoperative evolution was favorable in all patients, but with a significantly lower rate of complications in the group with single posterior approach.

Discussion

In this retrospective analysis, we compared the clinical outcomes of four different surgical techniques in the management of tuberculous spondylitis of the thoracic spine in adults. The main finding was that the single posterior approach is as efficacious as the other approaches, with a significantly lower rate of complications and a significant decrease in bleeding and hospital stay.

Reports in the literature on this topic are rather scarce, and some retrospective studies have been published that analyze the experience of centers with any of the aforementioned techniques; however, to the best of our knowledge, there is so far no study aiming to compare the efficacy of all these approaches between each other, and we consider this comparison to be crucial for determining the best procedure, taking into account the efficacy and complications of each one.

Historically, patients had been intervened by anterior debridement with bone graft implantation, especially because the infectious focus is at the anterior portion of the spine; therefore, an anterior approach provides direct access to the infected area. However, this approach has important limitations, with the most important being the instability of the spine resulting from this intervention, with patients having to remain on prostration for long periods of time and being at risk of non-fusion, residual kyphosis or development of pressure ulcers. In addition, this procedure is only suitable for a certain number of vertebral levels, which is why its indications are notoriously limited. Although the combined use of anterior instrumentation has increased the efficacy of this route and decreased its complications, it is well known that performing anterior instrumentation at the thoracic spine is complicated by the topographic proximity of vital anatomical structures and a limited working area[17,18].

An anterior and posterior combined approach is highly helpful for reducing the stability loss related to single anterior approach, which is why it has become a popular surgical option for the management of tuberculous spondylitis. Some authors refer that this type of approach is preferred in cases where there is severe stiffness in the thoracic spine and the one-way approach would be insufficient[19]. Single posterior approach has been criticized because it is argued that, using a posterior route, it would be difficult to achieve proper debridement of the vertebral body anterior portion; however, studies have found that, with an extended approach plus added costotransversectomy, it can be effectively performed and the graft be correctly implanted for long-term fusion to be achieved[20,21].

Zeng et al.[22] carried out a study with 39 patients diagnosed with thoracolumbar spinal TB, out of whom one group was operated by single posterior approach

Table 1. Comparison of demographic, clinical and postoperative data of patients with the four approaches analyzed in the present study

Variable	Group A (n = 12)	Group B (n = 12)	Group C (n = 14)	Group D (n = 10)	p
Gender (M: F)	8:4	8:4	9:5	6:4	-
Age (years)	47.92 ± 8.16	42.54 ± 7.16	50.15 ± 5.78	48.56 ± 4.79	0.067
Vertebral body loss (%)	0.44 ± 0.04	0.41 ± 0.06	0.48 ± 0.05	0.40 ± 0.06	0.129
Follow-up (months)	32.33 ± 16.24	28.62 ± 11.13	24.46 ± 6.79	32.39 ± 4.45	0.212
Most compromised vertebral level (mode)	T10-T11 (9/12)	T9-T10 (9/12)	T9-T10 (11/14)	T10-T11 (8/10)	-
Preoperative ASIA scale (neurological impairment)	4E, 5D, 2C, 1D	5E, 4D, 3C	10E, 3D, 1C	7E, 3D	-
1-year ASIA scale (neurological impairment)	9E, 2D, 1C	9E, 3D	12E, 2D	9E, 1D	-
Surgical bleeding (mL)	680 ± 314	512 ± 245	985 ± 477	900 ± 412	< 0.001
Surgical time (min)	176 ± 37.44	160 ± 23.12	410 ± 60.45	386 ± 78.45	< 0.001
Hospital stay (days)	14.9 ± 4.23	10.5 ± 2.25	22.3 ± 5.8	18.9 ± 4.77	< 0.001
Mortality (n, %)	0%	0%	0%	1 (10%)	-
Time to fusion (months)	6.2 ± 1.22	6.5 ± 1.41	6.7 ± 1.02	6.0 ± 1.51	0.657
Achieved fusion (%)	91.67% (11/12)	100%	100%	100%	-
Preoperative CRP (mg/L)	14.69 ± 7.35	15.86 ± 6.45	19.45 ± 8.45	18.89 ± 3.11	0.257
Postoperative CRP, 3 months (mg/L)	5.77 ± 2.89	6.45 ± 3.12	5.54 ± 2.22	5.51 ± 2.37	0.811
Postoperative CRP, 1 year (mg/L)	0.45 ± 0.19	0.58 ± 0.29	0.63 ± 0.14	0.65 ± 0.25	0.102
Preoperative ESR (mm/h)	78.54 ± 15.89	50.23 ± 12.7	55.15 ± 18.45	61.3 ± 11.44	0.124
Postoperative ESR, 3 months (mm/h)	18.5 ± 5.89	22.78 ± 6.78	15.0 ± 5.7	17.8 ± 5.89	0.061
Postoperative ESR, 1 year (mm/h)	13.44 ± 3.89	15.98 ± 3.57	8.44 ± 2.34	11.67 ± 3.99	0.875
Healing of infection (%)	100%	100%	100%	100%	-
Preoperative Cobb (degrees)	19.56 ± 4.56	23.29 ± 4.19	30.45 ± 8.47	27.1 ± 5.78	0.067
Postoperative Cobb, 3 months (degrees)	4.6 ± 0.87	5.17 ± 0.68	8.79 ± 1.43	6.24 ± 1.17	0.061
Postoperative Cobb, 1 year (degrees)	6.98 ± 0.89	6.14 ± 0.75	6.14 ± 1.98	6.99 ± 2.02	0.315
Preoperative VAS	8.5 ± 2.15	7.12 ± 1.11	8.33 ± 1.55	7.88 ± 1.10	0.140
Postoperative VAS, 3 months	2.78 ± 1.54	2.23 ± 1.31	3.01 ± 1.14	2.69 ± 1.00	0.478
Postoperative VAS, 1 year	1.5 ± 0.86	1.02 ± 0.52	1.55 ± 0.69	1.33 ± 0.78	0.263
Epidural abscess (n, %)	2 (16.67%)	3 (25%)	1 (7.14%)	1 (10%)	0.598
Paravertebral abscess (n, %)	8 (66.67%)	9 (75%)	10 (71.42%)	6 (60%)	0.885
Correction loss (degrees)	1.89 ± 1.06	1.12 ± 0.89	1.10 ± 0.22	1.00 ± 0.56	0.121
Angle correction (degrees)	14.2 ± 3.86	16.99 ± 4.56	17.19 ± 5.85	18.12 ± 5.33	0.278
Complications (n, %)	2 (16.67%) (1 hemothorax and 1 pleural effusion)	0 (0%)	2 (14.28%) (1 intercostal neuralgia and 1 pneumonia)	3 (30%) (1 CSF fistula, 1 pneumothorax and 1 deep infection)	

ASIA: American Spinal Injury Association; CRP: C-reactive protein; CSF: cerebrospinal fluid; ESR: erythrocyte sedimentation rate; F: females; M: males; VAS: visual analogue scale.

and another by combined approach. They found that the single posterior approach significantly decreased surgical time, bleeding, and complications, without increasing the rates of fusion and infection eradication. Zhang et al.[23], in a retrospective study in which they compared the single posterior approach vs. the

combined approach in the management of elderly patients with tuberculous spondylitis of the thoracic spine, found that the posterior approach obtained better clinical results than the combined approach.

Limitations

This study has some limitations, because although it is a large sample for a rare pathology, the number of patients is still low and is distributed in four groups. In addition, the retrospective nature of the study represents a limitation by itself, and longer-term follow-up would be ideal for establishing definitive conclusions. We recognize that, since this is a retrospective study, the choice of treatment, the type of implants and the fixation/stabilization technique are not homogeneous, and a randomization process was not followed.

Conclusions

The single posterior approach obtained a clinical efficacy similar to that of the other approaches in terms of infection eradication and vertebral fusion, but was associated with lower surgical invasion (surgical time and bleeding), shorter hospital stay and a lower rate of complications, which is why we consider it to be a safe and efficacious approach for the management of tuberculous spondylitis in adults. Even so, further studies with a larger number of patients and longer follow-up are needed in order for definitive conclusions to be established.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained informed consent from the patients and/or subjects referred to in the article. This document is in the possession of the corresponding author.

Funding

Own resources of the authors' department.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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