

Minimally invasive surgery for the treatment of thoraco lumbar pyogenic spondylodiscitis: indications and outcomes

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Abstract. – OBJECTIVE: Pyogenic spondylodiscitis (PS) is a non-specific infection affecting intervertebral disks and adjacent vertebral bodies. Once considered a rare condition in developed countries, the incidence of PS has been increasing alarmingly and still represents a challenge for clinicians and orthopedic surgeons. New minimally invasive techniques have been proposed but the proper indications for these different approaches remain controversial. The aim of this study was to describe the available minimally invasive surgical techniques and to evaluate their proper indications through a review of recent literature.

MATERIALS AND METHODS: Over 30 articles of recent scientific literature have been reviewed and analyzed. Studies were searched through the PubMed database using the key words: spondylodiscitis, minimally invasive, and surgical treatment. The most interesting and valid techniques and results have been reported. Despite the exclusion of case reports, all the available studies have been conducted on small groups of patients. Indications for each technique have been reported according to a clinical-radiological classification of PS.

RESULTS: Six of the most widely used minimally invasive surgical techniques have been described. High success rates have been reported in terms of preventing the progression of spondylodiscitis into more destructive forms, reduction of time and operative hospitalization, faster pain relief, early mobilization, and achievement of microbiological diagnosis.

CONCLUSIONS: The role of minimally invasive surgery in the treatment of PS is rapidly expanding. Reducing surgery-related morbidity in these frail patients is possible and often necessary. However, while more and more new techniques are being proposed, still few clinical data are available. Clinical comparison studies with open traditional surgery should be encouraged, and more attention should be paid to long-term outcomes. For the present, the indications for minimally invasive procedures should, therefore, be evaluated on a case by case basis and on clinical and radiological findings.

Key Words

Minimally invasive surgery, Spondylodiscitis, Indications, Percutaneous discectomy, Endoscopic drainage, XLIF.

Introduction

Pyogenic spondylodiscitis (PS) is a non-specific infection affecting intervertebral discs and adjacent vertebral bodies. Once considered a rare condition in developed countries, the incidence of PS has been increasing alarmingly. The growing number of chronically debilitated patients, the diagnostic efficiency of MRI, and the spread of invasive spinal procedures may have played a significant role. Recent studies reported an increase of incidence of approximately 140% in the last two decades with peaks up to 5.8/100000 inhabitants in Europe¹⁻³. PS mostly occurs in male and elderly patients with peak prevalence between 50 and 70 years and a male to female ratio of 1.6-2.0:1⁴⁻⁶.

Despite the spread of invasive spinal procedures, PS is still mostly a hematogenous infection caused by septic emboli from distant infectious foci. Direct post-surgery inoculation accounts for about 18% of all cases⁷. The lumbar spine is the most frequently involved tract followed by the thoracic spine, respectively in 58% and 30% of all cases⁸.

As for the etiology, *Staphylococcus aureus* accounts for half of all cases followed by Coagulase-negative *Staphylococci* (CoNS), especially in post-surgery forms^{4,5,9}.

Clinical Challenges and Treatment Goals

Although known for a long time, PS is still a challenge for clinicians and orthopedic surgeons. Early diagnosis is often hindered by a non-specific clinical onset that is frequently confused with

more prevalent degenerative diseases. Acute spinal pain is the main symptom reported by more than 90% of patients^{5,10}. By contrast, only barely more than half of patients present with fever^{6,10}. Serum C-reactive protein (CRP) and full spine contrast-enhanced MRI are the most sensitive laboratory and radiological techniques but their specificity remains low^{11,12}. As a result, the diagnostic delay from symptoms onset still ranges from 30 to 90 days¹¹.

Mortality has significantly dropped since the first case series published by Kulowski in 1936, when more than 25% of patients died¹³. The first aim of the treatment should be to eradicate infection and prevent sepsis. The introduction of ever more effective antibiotics has led to nowadays mortality rates ranging from 1% to 11%^{5,14}. Nevertheless, PS is still burdened by high rates of orthopedic and neurological complications that may lead to major disabilities. The goals of orthopedic treatment should, therefore, be to relieve pain, preserve or restore spinal stability, and prevent or reverse neurological deficits.

Guidelines for the pharmacological management of PS were proposed by the Infectious Diseases Society of America (IDSA) in 2015. IDSA recommends four to six weeks of parental antibiotics followed by an oral course until resolution of infection¹⁵. On the other hand, there are only a few proposals of standard algorithms for orthopedic treatment¹⁶. When there are no neurological deficits nor significant instability, patients can be treated conservatively with thoraco-lumbar rigid orthosis and early mobilization^{8,17}. The role of surgery is firstly diagnostic with percutaneous or open biopsy. When segmental instability or neurological impairment occur, surgical treatment is indicated. Surgery includes debridement of osteonecrosis, decompression of neurological structures, and arthrodesis⁸.

New Minimally Invasive Perspectives

New minimally invasive techniques have been proposed but the proper indications for these different approaches remain controversial. Minimally invasive spine surgery allows for reduction in blood loss, surgical time, length of stay, recovery time, and complications rates. These are all highly desirable advantages when treating frail patients with multiple comorbidities. The aim of this study was to describe the available minimally invasive surgical techniques and to evaluate their proper indications through a review of recent literature.

Minimally invasive techniques for the treatment of pyogenic spondylodiscitis

The treatments for non-complicated PS generally include antibiotic therapy and immobilization. Antibiotics should be administered after microbiological diagnosis, at first intravenously and then by oral course. Rigid orthosis molded on plaster cast should be used for immobilization to avoid kyphosis. To be treated conservatively, there are some criteria that must be satisfied¹⁶:

1. good response to antibiotic therapy during the first 2-3 weeks;
2. no major bone destruction or instability;
3. no neurological deficits.

Otherwise, different minimally invasive surgical techniques have been proposed for non-complicated thoraco-lumbar PS.

Percutaneous Transpedicular Discectomy and Drainage (PTD)

This surgical procedure can be performed under local anesthesia with deep sedation if there are absolute contraindications to general anesthesia. With the patient lying in the prone position, and under fluoroscopic control, the operator introduces a percutaneous guide pin inside the pedicle caudal to the affected intervertebral disc. Through a particular angle of the instrument, the center of the disc is reached. Discectomy, washing and drainage with saline and antibiotic solution are performed.

PTD can be very effective in early spondylodiscitis. Draining and removing the infected disc can prevent the complications of progressive osteolysis, such as the development of epidural abscesses and deformities. Moreover, a faster healing process has been assumed. Approaching the infected disc space through the vertebral endplates, PTD may promote the resorption of the infection allowing the spread of vascular granulation tissue from the vertebral body through the subchondral bone. According to Hadjipavlou et al, this technique is not effective in post-laminectomy infections¹⁸. A reason may be the common occurrence of segmental instability in post-surgical PS. The technique also allows to collect samples for microbiological diagnosis with greater sensitivity compared to CT-guided biopsies. Moreover, it is demonstrated that the rate of secondary surgical intervention may be reduced if the infected disc is removed¹⁹.

This minimally invasive surgical technique is effective in providing immediate pain relief and faster mobilization if used in selected patients (i.e., early stage of PS). Patients may be discharged on the second postoperative day thus improving the cost-effectiveness of the procedure. Moreover, the surgical time is greatly reduced compared to the open approach, minimizing the number of peri-operative complications and allowing to treat debilitated patients. Hadjipavlou et al¹⁸ obtained good results in a retrospective study with 34 selected patients affected by pyogenic spondylodiscitis and treated with transpedicular discectomy. They reported that 75% of patients showed immediate improvement in pain. The residual pain was managed with decreasing doses of oral narcotics, and the patients were discharged on the second or third postoperative day. Three patients reported persistent severe back pain and radiculopathy (i.e., sciatica and drop foot). Subsequently, six patients underwent reconstructive surgery (i.e., anterior decompression, bone graft, and posterior instrumentation) with complete healing in five patients. In the long-term, the success rate dropped because two more patients required surgery for painful pseudarthrosis and persistent foraminal stenosis. The overall success rate was 76% (26/34 patients) in early results and 71% (24/34 patients) in the long-term follow-up.

Percutaneous Suction Aspiration and Drainage

This procedure can be added to the previous technique or it can be performed by direct percutaneous access to the disc. After irrigating the affected disc space with a large amount of saline solution, a suction drainage tube and an epidural catheter are placed into the infected disc. Suction aspiration is then applied for 3 weeks, and the antibiotic is given directly through the epidural catheter for 2 weeks. In thoracic levels, where direct access to the disc could be difficult because of the ribs, it is possible to perform a transpedicular approach. The treatment should be completed by systemic antibiotic therapy. If psoas muscular abscess occurs, it is possible to add a drainage tube into the iliopsoas abscess²⁰.

Ando et al²¹ obtained good outcomes in 29 patients (72.5%). They established that indications for this technique are: a) resistance to conservative treatment (2-3 weeks); b) localizations below the mid thoracic segments; c) two or less segments involved; d) no severe bone destruc-

tion; e) no neurological deficits. Nagata et al²² reported that the success rate of percutaneous discectomy and drainage was 87% in a group formed by 23 patients after 2 years of follow-up. This high success rate may be attributed to the inclusion of patients with only early and non-complicated PS.

Percutaneous Endoscopic Discectomy and Drainage (PEDD)

PEDD is a very recent minimally invasive technique. This surgical approach, is based on the use of an endoscope and the implant of a drainage tube connected to a negative-pressure suction system. Yang et al²³ reported excellent results in 15 patients. Concerning its role for microbiological diagnosis, a study compared PEDD and CT-guided biopsy and reported isolation rates of 90% and 47% respectively²⁴. Moreover, the rate of secondary surgical intervention was reduced after debridement of infected tissues using PEDD combined with antibiotic specific therapy^{23,24}. Choi et al²⁵ reported a success rate exceeding 82% for spinal infections. Including the possibility to repeat the PEDD procedure, the success rate increased to 94%. Ito et al²⁶ reported similar results for 15 patients treated with posterolateral PEDD and antibiotics without complications. Fu et al²⁷ also reported good results using PEDD in 6 immunocompromised patients with complicated PS. Moreover, a bilateral approach has been proposed for lumbar PEDD²⁸.

Percutaneous Endoscopic Debridement With Dilute Betadine Solution Irrigation (PEDI)

Recently, Yang et al²³ reported excellent results using percutaneous endoscopic debridement with dilute betadine solution irrigation (PEDI). After biopsy and debridement, 10,000 mL of dilute betadine solution is used for irrigation, and a pump system guarantees drainage through continuous flow. 84.4% of patients reported significant pain relief after PEDI²³.

Extreme Lateral Interbody Fusion (XLIF)

The extreme-lateral retroperitoneal transpsoas approach (XLIF) is useful in lumbar PS affecting anterior and middle column, especially for patients with multiple comorbidities who are unable to undergo complex surgery. The main advantages of the XLIF approach are that the great blood vessels do not have to be mobilized, and the

decrease of tissue trauma, blood loss, and operative time. Patel et al²⁹ conducted a retrospective review of six patients affected by lumbar PS and treated with the minimally invasive lateral transpsoas approach. All patients tolerated the procedure with no perioperative complications. Each patient experienced a significant improvement in back and leg pain and was able to ambulate within a few days after surgery.

Percutaneous Posterior Screw-Rod Instrumentation

Nasto et al³⁰ demonstrated that posterior percutaneous stabilization is a safe and effective procedure for the treatment of non-complicated lower thoracic and lumbar PS. They concluded that posterior percutaneous instrumentation did not offer any advantage in healing time over bracing. Nevertheless, surgical stabilization was associated with faster recovery, lower pain scores, and improved quality of life at 1, 3, and 6 months if compared with conservative treatment. Ha et al³¹ published the good results obtained in 16 patients treated with posterior percutaneous instrumentation followed by direct lateral interbody fusion with autologous bone graft. Deininger et al³² obtained excellent clinical results in 8 patients with thoracic PS treated with minimally invasive thoracic percutaneous instrumentation.

Thoracoscopic Debridement and Stabilization

An open surgical approach to thoracic or upper-lumbar PS requires an extended thoracotomy or a retroperitoneal exposure. The incidence of postoperative pain, as well as the morbidity rates for these approaches, are truly significant. Thoracoscopic minimally invasive surgery can reduce postoperative morbidity associated with traditional open surgery^{33,34}. The great advantage of this technique is that it is possible to combine radical debridement, decompression of vertebral canal, and anterior fusion with a minimally invasive approach. Muckley et al³³ reported a successful case series of patients affected by thoracolumbar spondylodiscitis undergoing thoracoscopic surgery. They showed the advantage of this technique to avoid large incisions used for standard thoracotomy. In their experience, a conversion to open technique was not necessary. Potential advantages of this technique include reduced postoperative pain, lower morbidity, and earlier patient mobilization. In this way, thoracic surgery becomes accessible for patients in non-optimal clinical conditions.

Discussion

Although the great improvement in terms of mortality rate, PS may still have a great impact on patients' quality of life. Reported rates of residual disabilities remain high involving about one-third of patients. Indeed, Gupta et al³⁵ estimated that the 10-year cumulative probability of treatment failure-free survival is around 69%. Chronic back pain is the leading cause of disability with observed rates ranging from 20% to 32%^{35,36}. Long-term neurological disabilities occur in about 12% of patients³⁶. Moreover, the public expenditure for the clinical management of PS exceeds 5000 euros per hospitalization, not including the costs for surgical treatments³⁷.

To prevent residual disabilities, the choice of adequate orthopedic treatments should be based on clinical conditions and radiological findings (i.e., spinal stability, abscesses, and neurological compressions). The need for a standard algorithm for the orthopedic treatment of PS is evident by now and is even more pressing with the introduction of new minimally invasive techniques. Therefore, we proposed a clinical-radiological classification of PS developed over the last ten years on one of the largest population of patients available in western literature¹⁶. We defined three main classes depending on the following primary classification criteria: bone destruction or segmental instability, epidural abscesses, and neurological impairment. Involvement of paravertebral soft tissues and intramuscular abscesses were adopted as secondary criteria to define each subclass. Patients without biomechanical instability neither acute neurological impairment or epidural abscesses were classified as type A¹⁶. Cases with significant bone destruction and/or biomechanical instability without neurological impairment or epidural abscess were classified as type B¹⁶. Finally, all cases with epidural abscess and/or acute neurological impairment were classified as type C¹⁶.

Minimally Invasive Surgery in Non-Complicated PS

The first minimally invasive techniques have been proposed as alternatives to conservative treatment in early and non-complicated forms of PS. These approaches allow to perform debridement or discectomy of infected disc space, and drainage of abscesses. Moreover, these procedures provide tissue samples for microbiological culture.

Non-complicated and non-destructive PS (type A in our classification) can be treated with percutaneous transpedicular or endoscopic discectomy

when the infection is limited to the disc space. When paraspinous or intramuscular abscesses occur (subclasses A.3 and A.4 in our classification), percutaneous suction aspiration and drainage can be performed. Main pros of these minimally invasive procedures are their diagnostic role and a faster relieve from pain. The results obtained in accelerating the eradication of the infection and preventing progression to bone destruction are controversial. However, the immobilization with rigid orthosis may still be necessary to prevent kyphosis. The conservative treatment can be sufficient when a microbiological diagnosis is already achieved with blood cultures.

The percutaneous stabilization deserves specific mention since this procedure can be indicated also when mild bone destruction or moderate instability occur (types B.1 and B.2 in our classification). Percutaneous posterior screw-rod instrumentation, bridging the infected level, is a safe and effective alternative to prolonged rigid bracing for single-level non-complicated PS. A retrospective cohort study demonstrated faster recovery and improved quality of life associated with this minimally invasive treatment³⁰.

Minimally Invasive Surgery in Complicated PS

The role of minimally invasive techniques is obviously limited when applied to more aggressive forms of PS with spinal instability or neurological compressions (types B and C in our classification).

When segmental instability and anterior bone destruction occur (types B.3, C.1, C.2), the lumbar spine can be approached with a combined minimally invasive procedure including percutaneous posterior stabilization and XLIF. This technique provides anterior support and may partially reverse kyphotic deformities. The lateral approach gives access to disc space allowing to perform debridement and discectomy. XLIF cannot be performed on L5-S1 due to the interposition of the iliac crest. However, instrumenting an infected vertebral level is still highly controversial due to the risk of persistent surgical-site infection³⁸.

As for the thoracic localizations, the thoracoscopic approach allows to perform debridement, discectomy, and stabilization through a single minimally invasive surgical access. Few clinical data are available so far, but the procedure seems effective in single-level PS with moderate instability and limited posterior extension³⁹.

The main limitations for minimally invasive approaches in complicated PS are the severity of biomechanical instability and the involvement of neurological structures. When extensive spinal reconstruction and posterior decompression are needed, open surgical approaches are still required. Moreover, the minimally invasive procedures are unsuitable in an emergency setting when acute and severe neurological deficits occur.

Conclusions

The role of minimally invasive surgery in the treatment of PS is rapidly expanding. Reducing surgery-related morbidity in these frail patients is possible and often necessary. However, while more and more new techniques are being proposed, still few clinical data are available. Clinical comparison studies with open traditional surgery should be encouraged and more attention should be paid to long-term outcomes. Anyway, the use of a standard algorithm based on reproducible clinical-radiological classification is highly recommended for future studies. For the present, the indications for minimally invasive procedures should, therefore, be evaluated on a case by case basis.

Conflict of Interests

The authors declare that they have no conflict of interest and that no grants or founding were received.

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