The anterior stand-alone approach (ASAA) during the acute phase of spondylodiscitis: results in 40 consecutively treated patients

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Abstract

Purpose Spondylodiscitis mainly affects the anterior part of the spine. In this paper, we retrospectively analyze our experience with the anterior stand-alone approach (ASAA) in the treatment of spinal infections.

Methods Forty consecutive patients with severe spondylodiscitis underwent the ASAA during the acute infective phase. Treatment consisted of disease debridement, vertebral body reconstruction using titanium expandable prostheses and anterior fixation.

Results There was neither mortality nor major morbidity. Successful arthrodesis was achieved in 39 out of 40 patients who remained disease free throughout the follow-up period. Six months after treatment, one patient experienced pseudarthrosis and required supplemented posterior spinal fixation for vertebral instability. However, adequate arthrodesis was eventually obtained even in this patient.

Conclusions ASAA with spine reconstruction using synthetic materials during the acute infection phase was safe and effective. The infections were rapidly defeated, the patients were allowed to stand up early after the procedure and the length of hospital stay was significantly reduced.

Keywords Spinal anterior approach · Spinal infection · Titanium mesh cage · Vertebral debridement · Vertebral osteomyelitis

Introduction

Hodgson and Stock [1] were the first to report the surgical debridement of vertebral osteomyelitis in patients with spinal tuberculosis. Nowadays, vertebral osteomyelitis and discitis account for about 2–4% of all bone infections [2]. Spinal infections can be divided into two groups based on their pyogenic or non-pyogenic origin. The former includes bacteria or mycobacteria, and the latter fungi, yeasts or parasites. Tubercular infection remains a frequent cause of spondylitis, with typical tubercular kyphosis, called Pott's disease.

The majority of patients with pyogenic vertebral osteomyelitis cannot be operatively treated by just antibiotics and immobilization. This initially conservative treatment has been reported as effective in 60–95% of cases [3]. On the other hand, operative treatment must be considered in patients with significant bone destructions, impending fractures, progressive spinal deformities, neurological impairments, antibiotic-resistant sepsis, recurrent infections and/or epidural abscesses.

Surgical treatment should aim at the complete debridement of the infection site and the contextual reconstruction of the unstable spinal segments, thus promoting the infection control and healing. Since vertebral infections predominantly involve the anterior elements of the spinal column [4], the anterior operative approach is to be considered the golden standard for surgical treatment [5]. For several years, the placement of metallic instrumentations into infected operative fields has been considered problematic and potentially dangerous. Foreign materials may reduce the action of pharmacologic agents, thus interfering with the therapy and compromising full bacterial eradication. However, the modern titanium mesh cage and the expandable vertebral prostheses have been proved to be

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more resistant to bacterial adherence than any other previous metals [6]. Accordingly, new powerful tools are now available in spinal surgery to face spondylodiscitis since the initial acute phase.

In this paper, we report our results in the treatment of severe spinal infection during the acute phase using the anterior stand-alone approach (ASAA) and titanium mesh cages or expandable prostheses to reconstruct the anterior column defects.

Materials and methods

Clinical population

Between 2002 and 2009, we performed 41 operations in 40 patients with severe bone destructions due to vertebral osteomyelitis. The mean age was 56 years (range 29–81). There were 29 males and 11 females. Vertebral osteomyelitis affected the cervical level in 13 cases (32.5%), the thoracic level in 18 cases (45%) and the lumbar level in 9 cases (22.5%).

Preoperative diagnosis was based on anamnesis, neuro-radiological examinations (radiography, computer tomography and magnetic resonance imaging), laboratory blood examinations and blood cultures. In most cases, the pathogenic organisms were known since the preoperative period based on the clinical history, blood cultures, serology and/or the cutireaction tests. In all cases, the preoperative diagnosis was confirmed by subsequent cultures of the operative material.

Indications for surgical treatment were intractable pain, poor response to antibiotic therapy, progressive neurological impairment, epidural abscess, impending fractures and progressive spine deformity. Surgery was also performed when abscess drainage was needed. Neurological conditions were graded according to the ASIA classification [7]: 16 patients presented neurological deficits (4 = ASIA A, 2 = ASIA B, 3 = ASIA C, 7 = ASIA D), while 24 were neurologically intact (ASIA E). The pain level was classified according to the grading system of Denis et al. [8]: 19 patients had severe pain (Grade P5), 9 patients complained of moderate to severe pain (Grade P4), 7 patients of moderate pain (Grade P3), 4 patients had occasional pain (Grade P2) and 1 patient was pain free (Grade P1).

No patient underwent surgical biopsy to define the infective agent prior to the major surgical operation. Five patients in this series had undergone previous emergency laminectomy owing to rapid deterioration for epidural abscesses. In four out of five cases, this first emergency operation had been performed at other hospitals.

Surgical technique

All patients were managed by the ASAA with anterior instrumentation for vertebral body reconstruction and fixation. The anterior aspect of the spine was exposed through different anterior or antero-lateral surgical approaches that were chosen based on the level of the spine to be accessed. In all cases, the surgical access was planned to achieve adequate exposure of at least three vertebral bodies, and the two normal vertebrae adjacent to the lesion were always

Fig. 1 Cervical spondylodiscitis: **a** sagittal T2-weighted MR image demonstrating involvement of C6–C7 and T1 vertebral bodies with moderate C6–C7 deformity; **b** sagittal reconstructed postoperative CT scan showing C6 and C7 corpectomy, reconstruction with expandable titanium mesh cage and fixation by anterior C5–T1 screwing

Fig. 2 Thoracic spondylodiscitis: **a** sagittal T1-weighted MR images demonstrating involvement of T5 and T6 vertebral bodies with severe destruction and deformity of T5 and spinal cord compression by an epidural abscess; **b** sagittal reconstructed postoperative CT scan showing anterior T5 and T6 corpectomy, reconstruction with titanium expandable mesh cage and fixation by anterior screwing

exposed. This strategy allowed a corpectomy of at least one level, as well as vertebral body reconstruction and anterior instrumentation.

In 13 cases (Fig. 1), the cervical spine was accessed through the antero-lateral pre-sternocleidomastoid muscle approach. This approach also allowed adequate exposure of T1 for screw placement. Two patients requiring T2–T3 corpectomy were managed through trans-sternal transmediastinal approaches. Ten patients with T4–T11 lesions underwent transthoracic–transpleural approaches (Fig. 2). Eight patients with T12–L1 lesions required transthoracic–transpleural–transabdominal approaches. Five patients with L2–L4 lesions were managed through the transabdominal–retroperitoneal approach. Finally, two patients requiring L5 corpectomy underwent a transperitoneal access.

To sum up, 22 patients underwent intracavitary approaches (transmediastinal, transpleural or transperitoneal) and 18 were managed through extracavitary routes (transcervical or retroperitoneal).

Postoperatively, all patients maintained the intravenous antibiotic therapy for several weeks, and then the antibiotics were continued through oral administration. During the follow-up, ranging from 6 months to 7 years (mean 3.6 ± 2.1 years), all patients underwent clinical and radiological re-evaluation.

Results

There was neither mortality nor surgically related severe morbidity. Five patients (12.5%) experienced perioperative complications including four wound infections, which were successfully managed by re-operation, and one pleural collection, which could be managed conservatively.

The pathogenic organism was identified as *Staphylococcus aureus* (20 cases), *Staphylococcus epidermidis* (7 cases), *Mycobacterium tuberculosis* (10 cases), *Brucella* (1 case), *Pseudomonas* (1 case) and *Edwardsiella* (1 case).

Neurologic status was re-evaluated according to ASIA classification [7]. It remained unchanged in 32 patients, whereas 4 patients improved to the next ASIA grade. At the last follow-up, 27 patients were classified as ASIA type E, 4 as ASIA type D, 4 as ASIA Type C, 1 as ASIA type B and 4 as ASIA type A. The pain level was re-evaluated too: 17 patients were pain free (P1), 13 patients were P2, 4 patients were P3, 4 patients were P4 and 2 patients were P5 [8]. All patients remained disease free without any sign of recurrent or residual infection throughout the whole follow-up period.

Successful arthrodesis was radiographically confirmed in all patients but one (2.5%). In this patient, 6 months after surgery, the radiological assessments showed asymptomatic minimal dislocation of the anterior inter-body cage. Definitive

Fig. 3 Thoracic spondylodiscitis: **a** sagittal T2-weighted MR images demonstrating involvement of T2 and T3 vertebral bodies with severe destruction and deformity of T3; **b** intraoperative image showing vertebral body reconstruction and fixation; note the pericardium sac and the heart great vessels; **c** sagittal reconstructed postoperative CT scan showing anterior T2 and T3 corpectomy, reconstruction with titanium expandable mesh cage and fixation by anterior screwing

stabilization was obtained by supplemental transpedicular fixation through a posterior approach.

To sum up, the ASAA warranted the cure of the infections and final effective arthrodesis in all patients.

Discussion

Epidemiology and surgical indications

The incidence of spinal infections is progressively increasing in Western countries. This is probably related to several

factors such as the progressively aging population, diffusion of diabetes and migration from developing countries [9]. The majority of spondylodiscitis are pyogenic and sustained by Gram-positive organisms such as *Staphylococcus* and *Streptococcus* and affect more commonly the thoracic spine. *Mycobacteria* and *Brucella* are other possible causes of spondylitis. In our clinical practice, tubercular spondylitis had become quite rare during the past decades, but it is presently met with relatively increasing frequency. The incidence of *Brucella* infections is also increasing, although it remains relatively more uncommon than tuberculosis.

Fig. 4 Thoracic spondylodiscitis: **a** sagittal T2-weighted MR images demonstrating involvement of T4 vertebral body with destruction and deformity; **b** sagittal reconstructed postoperative CT scan showing anterior T4 corpectomy, reconstruction with titanium expandable mesh cage and fixation by anterior T3–T5 screwing

Fig. 5 Lumbar spondylodiscitis: **a** sagittal reconstructed CT scan demonstrating involvement of L1 and L2 vertebral bodies with severe destruction and deformity of the L2 vertebra; **b** sagittal reconstructed postoperative CT scan showing anterior L1 and L2 corpectomy, reconstruction with expandable titanium mesh cage and fixation by anterior screwing

Spinal infections almost invariably affect the disc space (discitis), which often represents the primary site of spinal infection. Since the disc is not vascularized, it is probably more prone to infections because it lacks adequate immunological reaction. In these conditions, the spinal canal and vertebral bodies (spondylodiscitis) can be easily involved.

In our and others' experience [10], surgical intervention was necessary in 40–60% of the patients with spinal infections. The incidence of neurological deficits in non-specific pyogenic spinal infections ranges from 6 to 17% [11] and from 5 to 69% in cases of tuberculosis [12].

Controversies exist about the role of pretreatment biopsy [13, 14]. We do not routinely perform this invasive maneuver. In most cases in this series, the pathogen

organism was known since the preoperative period: either it was isolated in blood cultures, or it was identified based on the history, serology or skin tests. In all these cases, the preoperative diagnosis was confirmed by the cultural assay of the intraoperative material. In the few cases without preoperative microbiological diagnosis, the operation was performed anyway. This affected neither the surgical procedures nor the outcomes. Therefore, to our knowledge, preoperative biopsy is either thoroughly unnecessary or useless and invasive.

Surgical treatment of vertebral osteomyelitis is indicated in cases of sepsis, neurological impairment, vertebral instability, significant spinal deformity, medically intractable pain, selected cases of infections sustained by unresponsive

Fig. 6 Lumbar spondylodiscitis: **a** sagittal T2-weighted MR images demonstrating involvement of L5 vertebral body; **b** intraoperative image showing vertebral body reconstruction; note the abdominal aorta and the iliac vessels; **c** antero-posterior postoperative X-ray showing anterior L5 corpectomy and reconstruction with expandable titanium mesh cage and posterior fixation by L4–S1 peduncular screws

agents, or when surgery may represent the only chance to drain abscess, obtain a cultural assay and perform local intracavitary antibiotic therapy.

Some criticisms and doubts have been reported about the safety of vertebral instrumentation during the acute

infection phase, particularly in cases of tubercular abscess or staphylococcal infections [5]. Metal implants were considered to hinder healing of the infections with increased rates of septic loosening [15, 16]. Indeed, extensive clinical and surgical studies uphold the choice of

synthetic material implantation during the acute infective phase of vertebral osteomyelitis [13]. In particular, the safety and effectiveness of anterior column reconstruction using titanium mesh cages and expandable vertebral prostheses have been recently proved [13]. The low rate of bacterial colonization of titanium implants with respect to other synthetic materials is now widely demonstrated [17, 18].

Surgical approaches

Since the first report of surgical treatment for spinal vertebral infections [10], the surgical technique has deeply changed. However, there is still no consensus about the surgical timing [9] and the proper operative approach: posterior, anterior or combined “back and front” [19, 20]. Although this series included patients who underwent emergency laminectomy, we do not think this treatment should be recommended. In fact, vertebral osteomyelitis predominantly involves the anterior structure of the spine (body), whereas the posterior elements (lamina, pedicles) are rarely affected [4]. Moreover, several authors [5, 21] have recently demonstrated the importance of the anterior surgical approach to obtain adequate debridement of the infection site with the complete resection of the whole infected and necrotic tissue. This is obviously the strongest basis to facilitate the control of infection and promote healing. However, one could object that extensive debridement might result in a further loss of support that requires more extended reconstruction. This objection was quite founded, especially in the past, when, for many years, the golden standard for anterior vertebral reconstruction was represented by the structural autograft [21, 22], which remained difficult or impractical for use in many patients with vertebral osteomyelitis due to a number of adverse factors. Fortunately, nowadays, strong alternatives to bone autograft exist. The reconstruction of the anterior vertebral column is now well accomplished by the titanium cages, which are recently available in the expandable version too. Meanwhile, handy and strong anterior fixation systems have been developed. Therefore, now there are tools, which permit optimal correction of spinal deformity without any additional posterior fixation. Indeed, while on the one hand, the anterior approach to the spine is now considered the treatment of choice in patients with vertebral osteomyelitis [6, 21], on the other hand, the role of posterior supplemented fixation remains debated [23]. In fact, there are authors [24] who consider the ASAA to vertebral osteomyelitis inadequate to restore and to warrant permanent stability of the infected spine. Accordingly, they believe that the posterior stage for supplemented fixation is mandatory. This back and front approach would be unique and able to generate a biomechanical sound construct that

meets the requirements of load sharing and tension-band principles. We do not agree with this statement. Based on our experience [5], we think the ASAA with the modern instrumentation tools can warrant adequate and strong spinal reconstruction in most cases.

The present series includes very complex cases with severe bone derangements that could be safely and effectively managed by ASAA. The anterior approach is the only way to obtain immediate and adequate neural decompression as well as optimal spine reconstruction and fixation through a single surgical procedure. In our experience, this technique could be safely performed even in the presence of both active infection and tubercular abscesses. Furthermore, it provided the same enduring stability of the circumferential approach. During the follow-up, supplemented posterior approach with vertebral fixation was required just in one (2.5%) elderly patient with serious osteopenia.

The anterior and anterolateral approaches

There is virtually no segment of the spinal cord, which cannot be accessed through the anterior route using modern surgical techniques [5]. The well-known antero-lateral cervical approach gave us easy access to the C3–C7 segments. However, with few approach modifications [25], even the C1–C2 prevertebral spaces could be reached. We found that the antero-lateral cervical approach was also adequate to expose the T1 segment for screw placement, but, when T1 corpectomy was required, the consequent T2 screwing demanded more caudalad extension through the sternal manubrium. Lesions at T2 and T3 levels were approached through a sternotomy. To access this anatomical region of the spine, we used an original technique consisting of collapsing the right lung and maintaining a dissection plane between the mediastinal pleura and the pericardial sac. This approach was performed with beating heart with no need of extracorporeal circulation. It permitted wide exposures of the anterior part of the thoracic spine between T1 and T6 (Fig. 3). However, the lateral transpleural approach has been usually used for the T4–T11 lesions. This approach was undoubtedly more easy and rapid. Despite the narrowness of the higher portion of the chest and the presence of the great vessels, it permitted the management of T4 lesions and T3 screwing (not T3 corpectomy) (Fig. 4). Lesions of the thoracolumbar junction required the contemporaneous transthoracic and transabdominal access through a thoraco-phreno-retroperitoneal laparotomy (Fig. 5). The simple retroperitoneal laparotomy allowed easy access to the L2–L4 segment. L5 exposure may be adequate for screwing, but not for corpectomy. For the L5 lesion, the corpectomy was fashioned through the transperitoneal route. However, in our hands,

this straight anterior approach did not allow adequate L4 and sacral screw placement owing to the local anatomy of the pelvic promontory. Accordingly, these patients underwent L5 corpectomy and body reconstruction through the anterior route and L4–S1 fixation through the posterior access (Fig. 6). In our practice, L5 lesions represent one of the few cases where the circumferential approach is mandatory [5].

Conclusion

The ASAA during the acute phase of spondylodiscitis was safe and effective and had enduring results. This approach may be now considered as the operative procedure of choice for treating patients with spinal infections.

Radical debridement of the infected tissue followed by anterior column reconstruction, using titanium mesh cage, appears as the best way to control the infection and to promote definitive healing. No adverse effects could be attributed to synthetic material implantation during the acute phase of infection.

Our series demonstrates that no case of spinal infection is too complex, too extended or too inaccessible to be satisfactorily and successfully treated through the anterior stand-alone surgical approach.

Conflict of interest None.

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