Surgical treatment of spondylodiscitis. An update

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Abstract

Concept Spondylodiscitis refers to an infection affecting the intervertebral disk, the vertebral body or the posterior arch of the vertebra being aetiologically, pyogenic, granulomatous (tuberculosis, brucellosis, or fungal infection) or parasitic.

Diagnosis Spondylodiscitis diagnosis is based on clinical symptoms, a combination of erythrocyte sedimentation rate with C-reactive protein (CRP) tests and, less useful, leukocytosis. Blood culture is also a very cost-effective method of identifying organisms. Plain radiographs are useful, however changes may take several months to appear. Radionuclide tests are currently less used; nevertheless, fluorine-18 fluorodeoxyglucose positron emission tomography (FDG-PET) shows encouraging results particularly when magnetic resonance images (MRI) are unconvincing in the distinction between degenerative changes and infection. MRI with gadolinium enhancement is the choice for image diagnosis.

Management Medical management is usually the basis for treatment, alone or in combination with surgery. Surgical approach, either by endoscopy or open, is indicated for biopsy when clinical evolution is unsatisfactory and no micro-organism has been isolated, and also whenever a root, spinal cord or dural compression is seen on MRI; spinal instability or severe deformity are also clear indications for surgical treatment. Less invasive surgery either CT-scan guided or, particularly, by endoscopy has

good results. However open surgery is still the standard. The anterior approach allows for anterior disc and bone debridement. The posterior approach is indicated when posterior elements are involved or in the presence of an epidural abscess. Although good results have been claimed, the use of instrumentation in the presence of an infected focus is controversial, as the use of cages or BMPs are.

Introduction

Spondylodiscitis refers to an infection affecting the intervertebral disk, the vertebral body or the posterior arch of the vertebra. Aetiologically, spinal infection can be classified as pyogenic, granulomatous (tuberculosis, brucellosis, or fungal infection) or parasitic. Although improvements in surgical and radiological techniques together with modern antimicrobial therapy have dramatically diminished the morbidity and mortality of the disease, no well-designed randomised trial for its treatment has been published, although spinal surgical infections have been covered [23]. Furthermore, its incidence, although rare, is increasing up to four to 24 cases per million per year due to better diagnosis [33], intravenous drug use, a rise in health care-associated infection, e.g. via haemodialysis [8], and acute and elective spinal surgery [14].

Haematogenous spread, external inoculation or involvement from adjacent tissue are the three main contamination routes. Haematogenous pyogenic spondylodiscitis affects preferentially the lumbar spine, followed by the thoracic, the cervical spine, and, very rarely, a multifocal infection. Tuberculosis affects mostly the thoracic spine [41] involving more than two vertebral segments. *Staphylococcus aureus* is the

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predominant pathogen in pyogenic spondylodiscitis, followed, in older people, by enterobacteria, mainly *Escherichia coli*, *Proteus*, *Klebsiella*, and *Enterobacter* spp [45, 67]. *Pseudomonas aureaginosa* is more common in intravenous drug users. Some other bacteria such as Coagulase negative staphylococci, *Streptococci*, and *Enterococci* have also been described. Polymicrobial infections are uncommon and usually result from contiguous spread [54]. Tuberculosis is the most common cause of spondylodiscitis worldwide, even in developed countries where it represents up to 46% of all spondylodiscitis cases [9]. Fungal or parasitic infections are extremely uncommon [19].

Suspected diagnosis of spondylodiscitis is based on clinical symptoms (pain, fever and deformity), although, in some cases, they may be lacking. Laboratory diagnosis is mainly made on the combination of high erythrocyte sedimentation rate (ESR) together with high levels of C-reactive protein (CRP) and, less useful, leukocytosis. Spinal spondylitic tuberculosis diagnosis can be confirmed by the polymerase chain reaction (PCR) [29], and molecular diagnostic methods using broad-range 16S rDNA PCR are also especially useful in the context of prior antibiotic use or the presence of fastidious micro-organisms. Species-specific PCR, particularly targeting *Staphylococcus aureus*, can increase the sensitivity further with the additional benefit of providing methicillin susceptibility results by amplification of the *mecA* gene [23]. However, 16S rDNA PCR is inferior to culture at detecting mixed organisms due to preferential primer binding, and care should be taken in interpreting all results when deciding on antibiotic treatment. Therefore, at present, the role of these methods should be mainly considered as a valuable adjunct to standard cultures [23].

Blood culture is a very cost-effective investigation and image-based surgical diagnosis is the most important tool. Plain radiographs may be useful; however, large destructive spondylodiscitis may not be seen on X-rays as changes may take several months to appear. Furthermore, degenerative changes may be difficult to distinguish between infection destruction and degenerative changes. Radionuclide tests are currently less used; however, fluorine-18 fluorodeoxyglucose positron emission tomography (FDG-PET) shows encouraging results, particularly when magnetic resonance images (MRI) are unconvincing in the distinction between degenerative changes and infection [64]. MRI with gadolinium enhancement is considered the best choice for image diagnosis of spondylodiscitis because of its high sensitivity and specificity, and particularly because of its anatomical information [51]. CT-scan also gives important information on bone destruction, which is particularly useful for surgical planning.

Medical management is the first choice for eradicating the infection, restoring and preserving the structure and

function of the spine, and alleviating pain. Also when surgery is indicated, concomitant medical treatment is essential. Medical treatment usually starts with empirical antibiotics. In pyogenic spondylodiscitis, treatment combines three to eight weeks of parenteral antibiotics followed by oral administration for six to 12 weeks. Nonetheless, before switching to oral medication, endocarditis must be ruled out. Effectiveness of treatment is monitored by normalisation of ESR and CRP. The role of antibiotic combination in pyogenic spondylodiscitis is not clear, although publications on the treatment of surgical infection after instrumentation with the combination of quinolones and rifampicin have shown better results. In tuberculosis prolonged antibiotic therapy cures most of the cases; the current recommended regimen for the treatment of tuberculosis is a six-month combination of isoniazid and rifampicin with pyrazinamide and ethambutol for the first two months [55].

Surgical management

Surgical treatment of spinal infection requires a multidisciplinary approach, and guidelines for that have been developed [21, 62].

Biopsy

Biopsy has its main indication in patients with negative blood cultures. Culture from biopsy allows micro-organism identification in more than half of patients. Less invasive percutaneous biopsy is a safe procedure and can be taken either by guided CT-scan or by endoscopy [15]. Endoscopy also allows discectomy and drainage, and its performance for bacterial recovery is better than CT-guided spinal biopsy [68]. Whenever possible, endoscopy is nowadays the standard for taking samples as further surgical treatment may be performed. Should the biopsy be negative a second biopsy must be tried, and in any case more than six samples from different parts of the surgical field must be taken [62].

Surgically-taken biopsy is still used more than less invasive techniques [34, 45]; but with the development of endoscopy, open surgery will no longer be the choice for biopsy taking. Since biopsy after antibiotic treatment may end in a negative culture [13, 15], antibiotic suppression prior to the biopsy should be the rule. However this is a controverted issue as nearly 40% of spondylodiscitis without prior antibiotic treatment may present a negative culture [20].

Material taken from biopsy should undergo aerobic, anaerobic, fungal and mycobacterial cultures. Biopsy from bone marrow may be helpful in brucellosis [22], and special

stains (such as Ziehl–Nielsen for mycobacteria, or periodic acid-Schiff for fungi) must be performed if tuberculosis or fungal infection is suspected.

Whenever a biopsy is taken for bacteriology, sending samples for histology is also mandatory as it is not only necessary to distinguish between pyogenic and granulomatous disease, but malignancy must also be ruled out. Unsuspected malignancy is not uncommon as many of these patients are elderly people with higher malignancy risk.

Surgical treatment

Indications

Surgical treatment is indicated whenever a root, spinal cord or dura mater compression is seen on MRI (epidural abscess with an anterior longitudinal ligament bulge). Spinal instability due to bone destruction or severe deformity such as kyphosis are also clear indications for surgical treatment. Surgical evacuation of an anterior abscess is indicated whenever it is larger than 2.5 cm, and should concomitant vertebral body destruction exist bone debridement with subsequent reconstruction must be carried out. Unsuccessful medical treatment including negative biopsy or stubborn pain may also be an indication for surgery [11], provided some potential objective cause exists.

In many cases of tuberculous spondylodiscitis, the abscess and sequestered bone and disk are so extensive that the surgeon feels more confident treating the patient with a surgical approach and chemotherapy. Oddly enough, many respond to surgery better when the disease is active than in cases where the tuberculosis is already healed.

Timing

It is generally accepted nearly that the presence of an epidural abscess is an indication for emergency treatment [12] before the onset of neural compression. Of course the presence of nerve or cord compression is an indication for immediate surgical decompression. Prognosis in cases of established paralysis may be ineffective after 48 hours, although some authors claim good results even in long-term paralysis [42]. Whenever a microbial diagnosis exists, non-surgical treatment for epidural abscess is now recommended by some authors [16]; however if there is any doubt most surgeons opt for surgical debridement. Non-urgent surgical indications include those cases with anterior abscesses not compromising the dura mater, and in both pyogenic cases and tuberculosis, small abscesses can be treated by chemotherapy alone.

Techniques

The primary aim of surgical technique is debridement with biopsy for culture and histology, but since, in most cases, after decompression, drainage and a sequestrectomy the spine is unstable, a mechanical stabilisation is needed at the same or in a secondary operation. Nowadays, two different surgical philosophies can be applied: less invasive techniques or classic open surgery.

Until recently, less invasive techniques (LIS) have had their primary indication in less severe cases with small abscess and little bone destruction. However, currently more severe lesions are treated by LIS. Endoscopy facilitates debridement and reconstruction [68], and although CT-scan percutaneous guided surgery can be used for paravertebral or intradiscal abscess drainage [50, 63], bone lesions are more difficult to be treated. LIS are technically demanding but offer good results when applied early [28]. Percutaneous transpedicular discectomy and drainage also result in immediate pain relief [27].

The second approach, open surgery, is nowadays still the standard, particularly in cases of large bone destruction. Different approaches exist depending on the situation of the abscess and the bony lesion. The surgeon must be familiar with all surgical approaches and be prepared to use the most appropriate for the situation. Mainly, open surgical approaches can be divided into anterior, posterior, and combined types, performed either in one or two stages. In general, open surgical treatment consists of an anterior approach with full disc removal and careful excision of affected vertebral bodies followed by tricortical bone graft harvested from the iliac crest to fill the cavities. Whenever a secondary posterior approach is discarded, an anterior bridging osteosynthesis between one level above and one below the affected vertebral bodies can be performed in the same anterior procedure. The posterior approach is the first choice in cases of epidural abscess at the lumbar level, and, in all cases of important instability, pedicular instrumentation is advisable to complement anterior debridement and fusion. Likewise, in cases requiring a posterior approach, when also an anterior surgical access is performed in order to debride the affected disc and vertebral body, anterior instrumentation can be accomplished.

– Anterior approach.

The anterior approach is the standard for anterior vertebral body debridement and stabilisation. Much experience has been gained with tuberculosis treatment by the use of the radical Hong Kong technique. Most authors agree with the conclusion of the Medical Research Council that the Hong Kong procedure of anterior radical debridement with strut graft fusion is superior to any other procedure [5, 18, 30, 47]. Radical

and large Hong Kong technique must be combined with posterior stabilisation since the instability created is very high. Furthermore, it is more convenient starting by a posterior approach for mechanical stabilization followed by radical anterior debridement (Fig. 1a–e); in this way when performing the anterior approach, the surgeon will find the column very stable and anterior debridement can be more easily achieved [53, 66]. Some authors do not add bone graft at the time of the posterior approach [29]; however, better stability is achieved with circumferential fusion (Fig. 1d–e). Care must be taken whenever the posterior approach is made first, as screws should not reach the anterior affected vertebral bodies at the involved levels.

In the Hong Kong technique the decompression should reach back to the posterior longitudinal ligament until the dura is reached [46], and this large anterior gap must be reconstructed by a strut autograft. Autograft must be tricortical as the aim of it is twofold: as a biological instrument and as a structural support [25]. This is the choice for both adults and children. The

incidence of fusion with bone graft is 97% at ten years, compared to 90% with debridement alone [26]. Chemotherapy alone without surgery may achieve a solid fusion in 65–79% of cases [37]. In severe cases large bone and disk sequestrae can provoke profound kyphosis and secondary paraplegia, making surgery essential. Therefore, in order to prevent further mechanical problems, evolutioned cases must always be treated by means of surgery. This is true for any spondylodiscitis.

In smaller defects the autograft most frequently used is iliac crest and ribs, whereas fibular graft is the choice for larger defects [29] (Fig. 1a–e). The strength of fibular grafts is an advantage, although unclear in cases of secondary infection. Some authors have claimed that long segments of fibula are likely to fracture, particularly after several months when the bone is invaded by a “creeping substitution” process. Indeed all that is known about spinal arthrodesis and strut grafts comes from animal experimentation. In canine models it has been shown that long fibular grafts are markedly weakened between six weeks and six months after implantation, taking

Fig. 1 **a** A 24-year-old sub-Saharan man complained of low back pain for many months. He underwent anteroposterior and lateral lumbar X-rays and then a magnetic resonance study (MRI). He was admitted with the diagnosis of lumbar tuberculosis. MRI showed a large anterior pus collection between L3-L5 with affection of L4-L5 disc and vertebral bodies. A large epidural abscess compromising the dural cavity from L4-S1 can be seen. L5-S1 disc appears normal. **b**. Axial cut of MRI. The abscess was entering the spinal canal and compressed the dural sac in continuation with an anterior large collection in relation with psoas

muscle and iliac vessels. **c** Since infection of L4-L5 disc with large bone destruction and infection of L4-L5 vertebra (particularly L5 was destroyed), together with L3-L4 disc infection was found, large interbody debridement, and fibular graft insertion at both levels were carried out. **d**. After one-year follow-up the patient was symptom-free. AP X-ray control shows the laminectomy, the strut bone autograft and the posterior instrumentation. **e**. Lateral X-ray projection. Fibular strut autografts and instrumentation appear well located

several years for full incorporation; at 48 weeks, approximately 60% of the necrotic matrix is remodelled. The actual strength of the graft is nearly normal only after more than one year of implantation. Even so, in severe cases only fibular grafts can allow a buttressing support, with a tension band principle if a pedicular instrumentation is also performed [25].

The use of vascularised rib grafts for stabilisation of kyphosis appears to be a good solution to avoid secondary resorption of a very cortical fibular autograft. High fusion rates have been reported with this technique in the treatment of tuberculous kyphosis [44]. Nonetheless, very large gaps can hardly be managed with vascularised ribs, particularly in the lumbar spine, and a combination with a posterior instrumentation for full stabilisation is crucial. Some authors find rib grafting inadequate in adult patients, reporting up to 32% incidence of graft fracture and a mean increase in kyphosis of 20 degrees. Partial collapse can also occur because the ribs penetrate the endplate of the vertebrae above or below, already weakened after debridement of bone and disk sequestrectomy. The overall fusion rate of full-thickness iliac crest grafts [40], especially in patients with large defects [30, 35], is better than that of rib; but in very large defects, such as those of tuberculosis, extensive iliac crest graft harvesting may provoke further problems, and fibular graft with posterior instrumentation should be considered [44].

– Posterior approach.

The posterior approach is indicated in case of an epidural abscess in the lumbar spine. Drainage followed by pedicular instrumentation is the standard when a posterior approach is carried out. Large epidural abscess drainage should be an emergency operation since posterior migration of the abscess may result in paraplegia (Fig. 1a–e). Debridement without fusion is advocated by some surgeons [48], but some instability is inevitable. However if a paravertebral abscess exists in the thoracic spine and the anterior approach must be avoided, a posterior costotransversectomy can address the problem [7]; moreover, if only one level is approached, instrumentation can also be avoided.

Large multilevel laminectomies without instrumentation are contraindicated [26, 30, 35, 59], as more severe instability will result since in these cases concomitant destruction of the anterior structures may provoke paraplegia. The only indication for one-off laminectomy is the isolated involvement of a neural arch causing posterior spinal cord compression [20, 35]. In tuberculosis cases the posterior approach without instrumentation may be indicated in posterior epidural tuberculoma without large bony involvement [4].

– “Ad hoc” approaches.

The thoracic spine can be approached either through an anterior transthoracic approach, through a posterior costotransversectomy, or through an extrapleural anterolateral approach. In tuberculosis it has been claimed that the extrapleural anterolateral approach avoids tuberculous empyema [26]. Nevertheless this has not been demonstrated. Transthoracic approaches appear to achieve better results than lateral costotransversectomy or its modification (rachiotomy), not only for surgical exposure and debridement but also for fusion rate, and even mortality [38]. Thoracotomy is recommended in cases of early tuberculosis, whereas lateral rachiotomy may be indicated for late-onset paraplegia associated with a complex kyphosis requiring lateral exposure of the dura mater [35, 38]. The extrapleural anterolateral approach is suitable in cases of dense periosteal adhesions to the pleura, allowing for a subperiosteal dissection; should an abscess be found, debridement by scooping out the necrotic material may be performed and the cavity insufflated with streptomycin with closure of the visceral pleura. An air leak in this situation is very rare. The thoracic spine must be treated in the same way as the lumbar spine, with autograft and instrumentation [5, 58]. In this segment, we also use posterior pedicular instrumentation in addition to anterior strut graft. This is also advisable in immature patients as progressive deformity can appear during follow-up [18, 35]. An external support for these patients after surgical stabilisation may be advisable in cases of very large anterior defects [58]. Surgical indications and techniques for thoracic spine has been proposed elsewhere according to four groups based on the location of the infection [49]; however, the main philosophy of treatment has already been described above. Thoracoscopy has very much changed the philosophy of surgical techniques for the spondylodiscitic thoracic spine.

Retroperitoneal approach is very useful for anterior lumbar infections. Psoas abscesses are better drained by a retroperitoneal approach. The surgical technique must avoid opening the peritoneum as intraperitoneal complications can occur, and at the very least an unpleasant surgical technique will result. Radical debridement is necessary and, in cases of extensive involvement of bone and disks, concomitant sequestrectomy and grafting must be performed. Anterior instrumentation in these cases is very easy to undertake.

With regard to the cervical approach, tuberculosis of the cervical spine has also taught surgeons about how to manage severe pyogenic spondylodiscitis with a high risk of spinal cord compression. Surgical aggressive debridement by the Hong Kong technique is also an indication for the cervical spine [32]. Upper C1–C2

spine can be approached by a transoral access; a posterior approach for occiput-C2 fusion may be necessary whenever a major instability is observed. Very proximal involvement, such as infection of the arch of the atlas has been treated successfully by chemotherapy, needle aspiration of the abscess, and halo-brace immobilisation [10]. Craniocervical junction involvement requiring medical chemotherapy is extremely rare, but the anterior approach for decompression and posterior surgical fusion in more severe cases can be the choice [6]. The C3-C7 segment can be approached either anteriorly, posteriorly or both depending on abscess localisation, instability created, and fusion technique [69]. The posterior approach may be useful for both debridement and osteosynthesis; however, isolated laminectomy is contraindicated because it creates instability [32].

Controversies in surgical treatment

Instrumentation within infection must also be considered

Although in cases of *Staphylococcus epidermidis* the instrumentation rods can be colonised and covered with a thick biofilm, in both pyogenic and tuberculosis spondylodiscitis, the risk of using anterior spinal instrumentation after debridement is, apparently, very low since a few colonies adhere to the stainless steel rods. These findings encourage the use of anterior instrumentation at the time of anterior debridement [56], particularly titanium made devices where bacterial biofilm develops worse. In tuberculosis, a combination of instrumentation with strut autograft [24] or allograft also appears safe [70]. The fusion rate using allograft is slower than that enhanced by autogenous rib grafts.

Surgery for tuberculosis nowadays offers better solutions for debridement, for kyphosis treatment and for fusion; however, intraoperative and postoperative complications are still very frequent, particularly in elderly patients with more severe disease. Mortality may reach up to 4% of surgically treated patients [2, 43]. Late local complications such as graft resorption, graft fracture, nonunion, or progressive kyphosis are still very common [35, 57, 58]. General complications include convulsion from local Streptomycin affecting the exposed dura mater [31], adrenal insufficiency [17] and others.

Interbody cages

Titanium mesh cages have been introduced for single-stage anterior surgical debridement and reconstruction. Pedicle screw instrumentation is usually combined in all cases in order to secure fixation [40]. In many series radical debridement and anterior insertion of a titanium cage, filled with

autogenous bone graft, is also used together with posterior minimally invasive pedicle screw fixation in order to eliminate posterior soft tissue injury, to preserve blood supply, to reduce surgical time, blood loss and surgical complications [39]. In the cervical spine it also appears to be a reliable technique [52]. The advantage of this technique is to use one single operation for both debridement and bone fixation. Cages have strong mechanical support, and are friendly to osteoprogenitor cells proliferation. The idea of using cages is to avoid the morbidity of tricortical harvesting, and also its resorption phase which results in loss of strength for vertical support. Interbody cages provide a wonderful early support to compression forces exerted by the vertebrae above and below. However, secondary mobilisation rates in long term, stress shielding, and ensuing failure are its most common complications. According to recent reports, cages appear to have solved neither mechanically nor biologically interbody spinal osteosynthesis either in spinal fracture treatment, in degenerative spine stabilisation, or after correction of deformity [3, 36, 60, 61, 65].

BMPs

Anterior fusion with rhBMP-2 inserted in structural allograft or titanium cylindrical cages, followed by posterior instrumented fusion with autogenous iliac crest graft has been claimed to have good results after a range of 11–30 months follow-up [1]. However, since infection relapse and structural allograft failure may appear after very long follow-up, more studies with longer follow-up are needed.

Conflict of interest The authors declare that they have no conflict of interest.

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