Medical and surgical treatment of pyogenic spondylodiscitis

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Abstract. – Background: Pyogenic vertebral osteomyelitis (PVO) represents approximately 2-7% of all cases of osteomyelitis. The approach to the treatment of PVO may be conservative, which includes antibiotic therapy and orthopaedic treatment, or surgical.

Aim: To overview conservative and surgical approaches to PVO.

Methods: A literature review was performed using the Pubmed database to identify studies published in the last 20 years, addressing the treatment of PVO.

Results: Empirical antibiotic treatment of PVO, while waiting for the results of cultures or in culture-negative cases, should include broad spectrum agents in association with agents active on Staphylococcus (S.) aureus. Based on local epidemiological data, antibiotics active on methicillin resistant S. aureus (MRSA) should be included. Once an organism has been identified, antibiotics should be initially administered intravenously but the optimal duration of antimicrobial therapy is unclear. Studies have reported that the incidence of treatment failure was higher when i.v. therapy was administered for less than 4 weeks. Rifampin is widely used in the combination therapy of PVO, but no controlled trials are available to define whether this approach is beneficial. Many PVO need a surgical treatment and many can represent a real challenge for the orthopaedic surgeon. Anterior and posterior cervical, thoracic, lumbar approaches and the relatives surgical strategies are reported in this review. Moreover, recently the minimvasive posterior stabilization have been proposed as an efficient alternative to open surgery in elderly with severe comorbidities. Possible advantages and limitations of this technique are also reported.

Conclusions: Further research is needed in order to define the optimal duration of antibiotic therapy, and the benefits and limitations of open or mini-invasive surgical techniques.

Key words: Pyogenic vertebral osteomyelitis, Conservative treatment, Surgical treatment.

Introduction

Pyogenic vertebral osteomyelitis (PVO), or pyogenic spondylodiscitis, represents approximately 2-7% of all cases of osteomyelitis; it involves the vertebral body and the disc space and is caused by many types of microorganisms with the prevalence of *Staphylococcus (S.) aureus*, responsible for the majority of PVO.

Although PVO remains rare, its incidence is rising, due to an increasing population with predisposing factors such as advanced age, diabetes mellitus, chronic renal or liver disease, intravenous drug use, HIV infection, long-term steroid use, malignancy, chemotherapy, severe trauma, previous surgery. An other reason of the increased incidence is the availability of more effective diagnostic tools. A high index of suspicion for vertebral osteomyelitis is needed in patients presenting with unremitting back or neck pain and inconstant fever, to ensure prompt diagnosis and improved long-term outcomes.

Because of the non-specific nature of the symptoms at presentation, PVO is usually not recognized at an early stage, when treatment is most effective.

Early diagnosis is based on a high level of suspicion with emphasis on the following:

- Symptoms: fever, localized spinal pain with paravertebral muscle spasm, limitation of movement and evidence of neurological deficit;
- Risk factors: increased age, diabetes mellitus, rheumatoid arthritis, steroid use, ethanol abuse, immunosuppression, intravenous drug abuse (IVDA), infectious endocarditis, and history of recent surgical or invasive diagnostic spinal procedure;
- Imaging studies, with magnetic resonance imaging (MRI) to be considered the gold standard.
• Research of distant infectious foci;
• Laboratory studies: blood cultures, C-reactive protein (CPR), erithrocyte sedimentation rate (ESR), WBC count.

The treatment of spontaneous PVO is either conservative or surgical.

The goals of treatment are to eradicate infection, establish spinal stability, relieve pain, prevent or reverse neurologic deficits and prevent recurrence.

Conservative management consists of antimicrobial therapy and non-pharmacological treatments such as immobilization.

The spinal column should be immobilized13 to prevent vertebral damage.

In order to establish an effective antibiotic treatment an accurate microbiological diagnosis is necessary. The choice of appropriate antibiotics should also take into account the pharmacological features of each drug.

Since PVO is mostly a hematogenous infection, blood cultures should be obtained as soon as the disease is suspected. Blood should be collected in three separate samples for cultures, if possible during fever spikes or chills. A percutaneous biopsy of the affected disc can be performed, also obtaining blood cultures routinely after the procedure14. This procedure is particularly useful when the previous tests are negative. The diagnostic yield of blood cultures ranges from 40% to 60%6. If the percutaneous biopsy is not diagnostic, an open surgical biopsy may be indicated6.

Once an organism has been identified, antibiotics should be initially administered intravenously but the optimal total duration of antimicrobial therapy is unclear. Most Authors recommend an initial treatment with intravenous antibiotics to reach adequate concentrations in necrotic bone6. Studies have reported that the percentage of treatment failure was higher when parenteral therapy was administered for less than 4 weeks10,17. After induction with parenteral antibiotics, oral therapy should be continued to complete treatment. Early oral switch is not recommended until endocarditis has been excluded18. A convenient cost-effective19 option for the treatment of PVO is outpatient parenteral therapy, that can be proposed when the patient is stable, compliant with the therapy and when it is possible to reduce the number of daily administrations. However, specific data for PVO are limited20.

The discontinuation of antibiotic therapy is decided taking into account clinical resolution and a gradual decrease of aspecific inflammation indexes such as ESR and CRP21,22. According to some Authors, a CRP weekly reduction of 50% represents a good marker of improvement23. Follow-up MRI may be unnecessary16 and even misleading, since in some cases there may be an initial worsening of the images in spite of clinical and laboratory improvement24. An MRI during treatment and follow-up is useful only if there is no clinical or laboratory improvement or if an epidural abscess formation is suspected25.

The choice of antibiotic depends on the causal pathogen and its sensitivity pattern. Also the ability of bone and disc penetration should be considered. Bone penetration of many antibiotics has been tested in vivo and in vitro26,27, but because of the lack of standardized methodology, results are not always comparable28.

With the available data we know that clindamycin, fluoroquinolones, macrolides, rifampicin, fusidic acid, metronidazole and linezolid reach good levels in bone tissue. Beta-lactam antibiotics and glycopeptides achieve moderate levels and aminoglycosides diffuse poorly into the bone16.

Due to the relatively low vascularity in necrotic bone, areas of poor penetration and low oxygen tension result at the site of infection; this can compromise the activity of certain antimicrobials such as gentamicin and vancomycin29,30.

Rifampin has a good tissue penetration index and is probably active on biofilm phenotypes. However, it should never be given as monothera-
py, due to the rapid development of resistance. Regimens including rifampin in combination with other antimicrobials are widely used in bone and joint infections; however, there are very few compelling data to support this strategy. In fact, the available data indicate that rifampin combination therapy is clinically effective in biofilm infections and in the presence of prosthetic implants. No controlled trials are available to define whether combination therapy with rifampin is beneficial for the treatment of PVO.

Table I summarizes the suggested antibiotic regimens for the i.v. treatment of PVO. Suggestions are based on guidelines and review of observational studies.

The main characteristics of antimicrobials used for the treatment of bone infections are listed below.

**Beta-lactams** have a moderate bone penetration. Nonetheless, the good tolerance and the high dosages achievable parenterally make them the first choice for the induction treatment of PVO caused by sensitive pathogens.

**Clindamycin** is a bacteriostatic antibiotic that has the major advantage of a higher bone penetration than beta-lactams, also in the presence of relatively low serum concentrations. Because of its good bioavailability and high levels in bone, clindamycin is a convenient choice for oral switch therapy in patients who can be discharged.

**Quinolones** are widely used for the treatment of bone infections because they are active against a broad spectrum of bacteria (including adherent bacteria), they penetrate macrophages and PMNCs and reach effective bone concentration also with oral administration. Quinolones can be also used for long periods since they have a favourable safety profile. However, it should be considered that long antibiotic treatments are a well-established risk factor for the development of resistant bacterial strains.

**Rifampicin** is peculiarly effective against bacterial biofilm and can kill phagocytosed bacteria penetrating white blood cells; it has also a good bone penetration. Rifampicin should never be used in monotherapy because of the rapid development of resistance, but it can be used in combination therapy with beta-lactams, with quinolones and with vancomycin, teicoplanin or minocycline for MRSA. The commonest side effect is hepatic damage, so monitoring of liver function is recommended.

**Fusidic acid** has a good bone penetration and a bactericidal activity against S. aureus but, like rifampicin, it causes the rapid development of resistance, so it should be used in combination therapy.

**Glycopeptides** are the first choice in infections caused by MRSA. The use of vancomycin allows a more rapid killing of staphylococci than teicoplanin, but if it has a decreased activity in anaerobic conditions. Vancomycin is more nephrotoxic but more easily measurable in serum than teicoplanin. Teicoplanin is more frequently associated with thrombocytopenia and neutropenia. Vancomycin cannot be administered once daily, whereas teicoplanin can be used for outpatient parental therapy.

**Daptomycin** is a new lipopeptide antibiotic, active on Gram-positive bacteria, useful in the treatment of MRSA osteomyelitis, even if it is FDA-approved only for adults with S. aureus bacteremia, right-sided infective endocarditis, and skin and soft tissue infections. It has a

| **Table I. Suggested antibiotic regimens for the i.v. treatment of PVO.** |
|-----------------------------|-----------------------------|
| **MSSA**                   | Equivalents: 2 g q6h iv or equivalent anti-staphylococcal penicillin OR | 2 g daily iv |
| **MRSA**                   | Vancomycin 15-20 mg/kg q12h-q8h iv aiming for pre-dose levels of 15-20 mg/L OR | 2 g daily iv |
|                            | Teicoplanin 8-12 mg/kg daily iv after loading OR | 15 mg/kg q12h iv |
|                            | Daptomycin 6 mg/kg/day IV QD 6-10 mg/kg/day IV QD |
| **Enterobacteriaceae**     | Ciprofloxacin 300 mg q12h or 750 mg q12h orally OR | 2 g daily iv |
|                            | Ceftriaxone 2 g daily iv OR | 1 g q8h iv |
| **Pseudomonas aeruginosa** | Ceftazidime 2 g q8h iv + aminoglycosides OR | 1 g q8h iv |
|                            | Meropenem 1 g q8h iv + aminoglycosides OR | 1 g q8h iv |
|                            | Combination of two different antibiotic classes |
| **Streptococci**           | Benzylpenicillin 2.4 g q6h iv OR | 2 g once daily iv |
|                            | Ceftriaxone 2 g q6h iv |
| **Enterococcus faecalis**  | Amoxicillin 2 g q6h iv + gentamicin 1 mg/kg q12h-q8h iv |
| **Enterococcus faecium**   | Vancomycin 15 mg/kg q12h iv + gentamicin 1 mg/kg q12h-q8h iv |
| **Anaerobes**              | Metronidazole 500 mg q8h iv OR | 600 mg q6h i.v. |

MRSA = methicillin-resistant Staphylococcus aureus
rapid bactericidal activity and there might be a possible cross resistance with vancomycin. An interesting feature of daptomycin is its possible activity on biofilm infections. Main adverse effects are elevation in creatinine phosphokinase (appeared in patient treated with the maximal doses), weakness, myalgia, renal failure; eosinophilic pneumonia is rare. Further studies on its bone penetration, safety in long-term treatments and effectiveness compared with glycopeptides are needed.

Trimethoprim/sulfamethoxazole administrated orally in high doses can be an alternative for the treatment of MRSA infections. However, it is associated with adverse effects (hematologic and renal toxicity) that may limit its use in prolonged treatments.

Oral minocycline (with or without rifampicin) is effective in the treatment of MRSA bone infection. It has a good bioavailability and it is frequently used when shifting from parenteral to oral therapy.

Quinupristin/dalfopristin is a parenteral antibiotic with bactericidal activity against Enterococcus (E.) faecium, including VRE and S. aureus, including MRSA, it has no activity against E. faecalis. Quinupristin/dalfopristin administered three times daily by central infusion can cause myalgia, which may necessitate cessation of treatment.

Linezolid is an oxazolidinone antibiotic which inhibits bacterial protein synthesis and is active against Gram-positive organisms including VRE (E. faecium and E. faecalis) and MRSA. There is no evidence of cross-resistance with other antibiotics. Although its good bone penetration and its complete oral bioavailability, linezolid is not approved for the treatment of osteomyelitis. The use of linezolid is limited by its potential hematologic toxicity (anemia, thrombocytopenia), especially during long-term treatments, and by its high cost.

Orthopedic conservative and surgical treatment

The treatment of pyogenic vertebral osteomyelitis (PVO) can represent a challenge for the spine surgeon. The role of surgery in the management of PVO is firstly diagnostic: needle aspiration biopsy from the intervertebral disc space or vertebral bone usually confirms the clinical and/or radiographic suspicion of PVO, aids in differential diagnosis between infectious and non-infectious vertebral lesions, and identifies the specific etiologic agent of PVO. Percutaneous biopsy can be performed with either a thin needle or cutting needle under fluoroscopy or CT guidance. The surgical approach performing a biopsy is most often transpedicular, occasionally parapedicular or passing directly into the soft tissue masses. Sensitivity has been reported in different case series from a low of 30-50% to a high of 70-90%. However, these reports are based on small numbers of patients. As both culture and histology of biopsy specimens may be negative despite the presence of infection, open biopsy sampling should be performed when two times-repeated CT-guided biopsy samples or blood cultures do not identify the causative agent.

In the last two decades the treatment with more effective antimicrobial agents have promoted nonsurgical medical management of PVO, but have even allowed for more aggressive surgical procedures when needed.

When there are no neurological deficits and no significant kyphotic deformity or instability, spinal infections can be managed without surgical intervention. Discitis without structurally significant osteomyelitis that does not threaten nervous tissue may be treated with antibiotic medications alone. Lumbar epidural abscess may be approached with a conservative treatment only if there is no evidence for cauda equina or conus dysfunction. Spondylitis is commonly managed non-operatively, with intravenous culture-specific antibiotics for a minimum of 4 to 6 weeks and bracing. Bed rest with low-molecular weight heparin treatment is needed for 3 to 4 weeks. Subsequently, a thoraco-lumbo-sacral orthosis or hard cervical collar should be worn for 1 to 3 months. Immobilization with bracing is necessary for patient comfort and walking, to maintain spinal stability and to prevent deformity until bony ankylosis occurs on neuroimaging.

Spontaneous bony ankylosis, however, requires 6 to 24 months and may not take place at all. This fusion, moreover, may be accompanied by narrowing of the foramina and kyphosis or listhesis. Chronic mechanical back pain in nonsurgically treated patients is attributable to both postinfection kyphosis and pseudarthrosis. Even if the majority of PVOs responds to medical treatment, about 40% of patients suffering from PVO need surgical intervention. In case of failure of prolonged medical manage-
ment, delayed treatment or complications as sepsis, neurologic impairment, or residual vertebral destruction leading to early or late spinal instability or segmental kyphosis with intractable pain, surgery is indicated\(^7^1-7^5,7^9-8^4\). The surgical indications should always be conditioned by the medical comorbidities of each patient\(^7^2\). The main goals of surgical treatment are maximal preservation of neurological function and healing of the infection with prevention of sepsis. These goals are obtained mainly by means of aggressive radical debridement and spinal stabilization\(^1^3,7^8,7^9,8^3\). Emergency decompression is indicated if complete paraplegia develops\(^1^6,8^1\). Cervical and thoracic epidural abscess should be treated by surgical decompression. Motor loss or cauda equina syndrome due to lumbar epidural abscess may require nerve root or spinal cord decompression surgery\(^1^6\). Surgical removal of a bone sequester or fixation material in case of postoperative PVO may be required.

If neurological deficit exists, decompression and instrumented spinal stabilization may be performed in the same procedure, even in the setting of acute pyogenic infection; on the contrary, if deformity and pain are present in a patient without neurological compromise, correction of deformity with placement of instrumentation may be delayed until the infection has been cleared with antimicrobial drugs\(^7^1,8^5\). After the complete resolution of the vertebral infection, surgery may be needed to correct residual instability, kyphosis, and/or scoliosis\(^1^9\) (Case illustration, Figure 1).

Nonetheless, the choice of surgical techniques and appropriate approaches, instrumentation and staging to treat PVO are still a matter of controversy\(^7^3,7^5,7^7,7^8,8^0,8^1,8^3\). Options include anterior or posterior approach, single-stage or two-stage surgery, with or without instrumentation\(^7^3\), but the decision about the surgical approach and technique should be always guided by the determination of the state of neurological threat or mechanical instability\(^1^6\). A neurological injury requires prompt neural decompression with or without spinal arthrodesis, whereas mechanical instability requires arthrodesis. The decision whether to obtain spinal arthrodesis with spinal fixation or bed rest or rigid external bracing is determined by the degree of segmental instability\(^7^8\).

Radical excision of all infected and necrotic disc and bony tissues and evacuation or drainage of paravertebral abscesses are mandatory for the permanent healing of PVO\(^1^3,7^3,7^9,8^6,9^1\).

**Figure 1.** *Case illustration 1.* A 64-year-old male patient with diabetes and a 3-week history of back pain and low-grade fever was admitted with fever, mental confusion in a state of septicemia and progressive acute right monoplegia. Sagittal CT reconstruction (A) and T2-weighted MR image (B) of thoraco-lumbar spine at the time of presentation showed wedge-shaped collapse of T6 with spinal cord compression and bone destruction of the superior end plate of T7 and the extent of inflammatory changes of the disc space and a prevertebral abscess extended from T5 to T7 and an epidural abscesses from T6 to T12. Because of the wide extension of VO and the high risk for his general health condition, the patient underwent emergent posterior decompression with no internal fixation. Cultures were obtained during the operation. The patient was treated with postoperative intravenous antimicrobial drugs for *Staphylococcus aureus* and reported a significant improvement of neurological deficits. Postoperative MR image at 3-months follow-up (C) showed residual severe deformity in segmental kyphosis.
PVO predominantly involves the vascularized vertebral body and adjacent disc spaces (anterior and/or middle spinal column), with involvement of the posterior elements in only 5% of the cases\textsuperscript{72,75,81}; thus, anterior surgical approach is most often used to allow direct access to the focus of infection for aggressive debridement\textsuperscript{13,73,75,78,84}. Nevertheless, the involved area is exposed either from an anterior or posterior approach, depending on its localization and pathological features, and in all cases surgical debridement should be planned preoperatively by using appropriate imaging\textsuperscript{13}.

In the cervical spine, an abscess can be found in the anterior or posterior triangle of the neck or in the supraclavicular area, but sometimes it extends into the prevertebral fascia and into the mediastinum. Drainage of the abscess should be performed immediately via an extra-oral approach in case of airway compromise, but generally the approach is antero-lateral (Case illustration, Figure 2). The costotransversectomy approach is commonly used for drainage of abscesses in the high-thoracic spine; the approach to midthoracic spine is transthoracic from the right side, the thoracolumbar and upper lumbar spine is approached by a left-sided transdiaphragmatic-retroperitoneal exposure, and the lower lumbar spine via a standard retroperitoneal or transperitoneal approach. However, when an abscess extends posteriorly in the thoracolumbar region in a clinically unstable patient, a posterior approach should be preferred since an anterior approach would carry a high risk of morbidity and/or mortality. Paravertebral lumbar abscesses can be evacuated through a longitudinal incision laterally to the vertebral spinal processes. Psoas muscle abscesses are extraperitoneal and can be drained through the Petit triangle. Wound swabs and biotic tissue samples should be obtained from infected areas; debridement can be considered complete when bleeding from vital well-vascularized cancellous bone, muscle, or fat tissues has been achieved and it should be followed by an extensive irrigation of the cavity with antibiotic solution\textsuperscript{13}.

Debridement and spondylodesis seem to be sufficient in cases without instability and severe deformity\textsuperscript{16,75,82}, combined with bed rest and bracing. When the defect created by the debridement leads to the loss of anterior column integrity with potential instability, especially in multi-segmental involvement, surgical reconstruction is necessary to maintain sagittal profile, prevent deformity or segmental collapses, and to achieve interbody fusion\textsuperscript{77}. Laminectomy alone is contraindicated in PVO because it may increase spinal instability\textsuperscript{13,77}. Laminectomy is indicated only for primary epidural abscess or granulation tissue causing neurocompression\textsuperscript{77,87}, but it should be followed by posterior stabilization, with or without staged anterior reconstruction\textsuperscript{77,83}. Anterior decompression and fusion with strut grafting or titanium cages and single- or two-stage additional posterior instrumentation is the procedure of choice for PVO with a significant amount of bone destruction, complicated by neurologic deficit and severe instability\textsuperscript{13,72,74,75,80,82}. The addition of posterior instrumentation provides better deformity correction, a faster rate of bony fusion and it does not appear to increase the risk of infection\textsuperscript{14}. The posterior stabilization is obtained with internal fixation by means of monoaxial pedicle screw-rod system, which restore spinal alignment avoiding the communication with the anterior infection site.

After extensive anterior debridement, residual large defects can adversely affect spinal stability leading to long-term segmental kyphosis\textsuperscript{79}. The gold standard for anterior column reconstruction is the use of structural bone grafting\textsuperscript{82,85}. Among interbody grafts, iliac crest bone autograft is often the first choice\textsuperscript{13,73,88}, vascularized rib graft has also been used with good success and fibula allograft is used in the cervical spine\textsuperscript{71,78}. Allograft as an alternative of autogenous bone grafting can avoid the donor site morbidity\textsuperscript{21} and shorten the operation time, even if the risk of disease transmission and immunological reaction for allografting should be considered\textsuperscript{83,79,82}. Other methods for interbody fusion included bone cement and methylmethacrylate\textsuperscript{73,78}.

Even if tricortical iliac crest autograft with or without addition of anterior compression titanium plates commonly achieve a complete interbody fusion, long-term results have shown that this technique is associated with pseudarthrosis, graft collapse, and extrusion even in the presence of rigid posterior instrumentation\textsuperscript{81}. An effective alternative to structural bone autograft for anterior support is the titanium mesh or PEEK cage\textsuperscript{73,79,82,84}. Available in various diameters and heights, the cage can provide custom reconstruction of the anterior column defect. The fenestrations and its circular shape allow for containment of the morsellised autologous bone graft so that the cage can act as a bony conduit\textsuperscript{81}. 

Figure 2. Case illustration 2. T2-weighted gadolinium-enhanced sagittal MR image (A) demonstrating C4-7 spondylodiscitis with a marked kyphotic deformity with apex in C5 compressing the cervical myelon. Two prevertebral abscesses formation, respectively median and right paramedian extended contiguous to carotid artery are concomitant at coronal MR image (B). CT-guided needle biopsy samples and cultures from ultrasonography-guided thin needle aspiration of the abscesses identified *Candida albicans* as causative agents. The 58-year-old female patient underwent anterior debridement via left-sided antero-lateral approach (C) with microsurgical evacuation of cervical spondylodiscitis, drainage of prevertebral abscesses and careful irrigation in one setting. Postoperative sagittal MR image 15 days after surgery and intravenous antibiotic treatment (D) showing minimally decompressed myelon, evacuated disc spaces, but residual kyphosis and stenosis. Lateral cervical plain X-ray image 10 months after surgery (E) showing bony fusion of the involved vertebral bodies.
When cage is combined with rigid anterior and/or posterior instrumentation in a single-stage procedure, this technique ensures immediate stability with marked neurological amelioration, maintenance or correction of sagittal alignment avoiding graft collapse and, moreover, it decreases morbidity from donor site.

The metal selection for the implant should also be considered. In infected areas, titanium and titanium alloys are superior to stainless steel implants; firstly titanium reduces the formation of a
Medical and surgical treatment of pyogenic spondylodiscitis

Pseudocapsule and biofilm that could facilitate bacterial adhesion and proliferation; moreover, the porous nature of titanium facilitates soft-tissue attachment and the delivery of adequate concentrations of antimicrobial drugs. Third, titanium produces less artifact on the MR imaging needed during the follow-up.

Some controversy exist whether anterior and posterior approaches should be performed as single or multiple stage procedures. Two-stage surgery allows a shorter operation time, less blood loss, and it is safer for patients with poor general health conditions as compared to one stage operation. However, the trend is, nowadays, to treat sick patients affected by persistent or complicated septic PVO with one-stage combined surgical approach including anterior debridement, instrumented reconstruction with autogenous bone graft and cage with or without anterior plates, plus posterior traditional open or minimally invasive pedicle screw fixation. Simultaneous anterior and posterior approaches does not predispose patients to recurrent infection if compared to staged procedures and it results in shorter hospital stay, lower rate of complications, earlier mobilization and a less troubled compliance of the patient since he undergoes only one anesthesia. Surgical intervention with instrumentation can relieve pain, improve sagittal balance and neurologic function and it finally results in an early mobilization and faster rehabilitation, which is of considerable importance in an usually old patient population. However, among different options the final decision should be made on the basis of the experience of the surgeons and the general health condition of the patients.

The reported recurrence rate of infection after non-surgical treatment ranged from 0% to 25%, while recurrence rates of 2% to 18% were noted after the surgical treatment of PVO in the antibiotic era. These data suggest that the surgical implants did not interfere with the reactivity against the infection. However, occasional recurrence of infection at the site of surgical stabilization is one of the most feared complications because of the potential dislocation of spinal instrumentation (Case illustration).

Other complications in surgical treatment of PVO are graft dislodgements or extrusion or hardware failures with or without nerve root compression, dislocation or settling of the cage, vertebral osteoporotic fractures, persistence of infection at the site of debridement, nerve root lesions, infection developed at an adjacent level to the interbody fusion, pseudarthrosis, wound infections, hematomas. The most common complications after not instrumented surgical treatment include loss of kyphosis correction ranging from 3° to 12°, olisthesis, pseudarthrosis, and spinal stenosis. Surgical combined procedures are associated with considerable morbidity in up to 11% of all patients, correlated to potential risk of lesion of major vessels such as the aorta, vena cava and the azygos system. Therefore, in the last years minimal invasive surgery has been reported as an useful and efficient option especially in elderly patients, also because of severe comorbidities and a high risk of thromboembolism correlated to immobilization. Video-assisted thoracoscopic surgery debridement and instrumentation over multiple levels can be achieved with minimal invasiveness, but this procedure is still technically demanding and special instruments are needed. Also percutaneous transpedicular discectomy and drainage has been described especially in the management of early stages of uncomplicated PVO, obtaining infection local control and an immediate relief of pain when the kyphotic deformity is not structured yet; it is contraindicated in advanced infections wherein excessive neurocompression or extensive bony destruction have developed. A percutaneous dorsal pedicle screw-rod fixation is increasingly performed in case of thoraco-lumbar PVO with no neurological deficit in order to avoid prolonged immobilization and to overcome the potential complications of a dorsoventral open surgery. Minimally invasive instrumentation seems to be theoretically in contrast with the current management of PVO, in according to which a complete debris resection is mandatory for the healing of infection. However, in case of PVO with no instability nor neurological deficits needing decompression, a minimally invasive pedicle screw-rod system fixed to non-infected bone of the adjacent vertebral levels acts as an effective internal fixation that can ensure posterior bridging “bypassing” the site of infection, with a significant reduction of intraoperative complications and good short and mid-term outcomes in terms of spontaneous bony fusion and spinal stability, comparable with combined anterior and posterior open surgery. Further reports including larger series and continuing long-term follow-up examinations are necessary in order to define benefits and limitations of mini-invasive surgical technique (Case illustration).
Figure 4. Case illustration 4. A 63-year-old man presented with low-back pain and pain in his lower extremities. Plain X-ray film (A) was performed in suspicion of osteoporotic fracture, but it showed narrowing of the intervertebral disc space L4-L5 with sclerosis of contiguous end plates of the two adjacent vertebrae. Gadolinium-enhanced MR image (B) demonstrated spondylodiscitis at L4-5 with epidural abscess formation and wide bilateral psoas muscle and paravertebral abscesses. Because of his critical general health conditions, the patient underwent posterior aggressive debridement, wide decompression and stabilization with pedicle screw-rod system fixed at L2 and L5, as documented at the 6-months postoperative X-ray (C). Cultures were obtained during the operation, and the causative organism was identified as *Staphylococcus epidermidis*, for which the patient was treated with specific antibiotics for 3 months. The patient was re-admitted 2-year after surgery referring acute low back pain and plain X-ray (D).

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Figure 4 cont’d. CT reconstruction and MR image (E) showed absence of bony fusion, partial dislocation of instrumentation and recurrence of the spinal infection. This was treated by posterior debridement and complete removal of the implanted material. Because of the lack of severe deformity and neurological symptoms, only antibiotic therapy, bed rest and lumbar orthosis were indicated for 3-months after surgery; the 3-months postoperative X-ray image (F) showed initial bony fusion and maintenance of the correct alignment of lumbar spine.

Figure 5. Case illustration 5. Preoperative sagittal and axial T1-weighted gadolinium-enhanced MR image (A) demonstrating typical features of VO with irregular end plates bony erosion and contrast enhancement in L2 and L3, in the epidural space leading to marked spinal cord compression and in the paravertebral soft tissue. The 79-year-old patient underwent spondylodesis with minimally invasive percutaneous posterior instrumentation fixed in L1 and L4. Posterior decompression and debridement were performed and Staphylococcus epidermidis was isolated as the causative agent. Postoperative X-ray (B) demonstrates correct alignment of pedicle screws and rods.
References


