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Postoperative lumbar spondylodiscitis. A systematic review

Arsene Anamaria-Alexandra[1], Iacob Gabriel[2], Alexandru Vlad Ciurea[2,3]

[1] Department of Neurosurgery 2, Emergency University Hospital, Bucharest, ROMANIA
[2] Professor of Neurosurgery, "Carol Davila" University of Medicine and Pharmacy, Bucharest, ROMANIA
[3] Departament of Neurosurgery, Sanador Clinical Hospital, Neurosurgical Department, Bucharest, ROMANIA

Keywords
postoperative lumbar spondylodiscitis, septic and aseptic spondylodiscitis, conservative and surgical treatment, implants, biofilms

ABSTRACT

Background. Several causes that can trigger POD can be incriminated: the patient's immune status, surgical technical errors, intra-operative contamination, foreign materials microfilm. Extensive analysis is required to eradicate the limited or diffuse infection and manage the optimal therapeutic attitude conservative or by surgery to get: faster recovery time, to improve symptoms, to allow mobilization, to offer a good quality of life and to reduce the average length of hospital stay.

Objectives. To perform a systematic review of POD outcomes via retrospective analysis of current studies based on the mechanism, the pathogenesis, the management of patient's immunological status, aetiology (microorganism involved, foreign material applied for hemostasis, application of spinal instrumentation, cement, screws, spinal devices), laboratory (TLC, ESR, CRP), MRI/CT-scan, antibiotherapy guidelines and the type of surgery performed: classical or minim-invasive, length of procedure, intraoperative accidents, the experience of the neurosurgeon, post-operative stay in ICU, etc.

Methods. Several data were taken into account regarding lumbar infections using a comprehensive review of the literature published studies from 1998 to 2021. Demographic data, clinical variables, length of hospital stay, duration of antibiotic treatment, and post-treatment complications were assessed.

Results. We performed a systematic review concerning 31 studies regarding clinical status, diagnosis and treatment.

Conclusions. Based on our systematic analysis, training and continuous education in spine surgery are necessary to prevent POD. The diagnosis of lumbar POD is based on history and physical examination, biochemical markers, neuroradiologic studies, using appropriate MRI imaging. Most cases of lumbar POD can be managed by conservative treatment with antibiotics after causative germ isolation and antibiogram. Surgery is performed on patients with conservative treatment failure - resistant to antibiotic therapy, as those with neurological complications: acute paraplegia, pain resistance to analgetics, acute sepsis, abscesses, spinal instability, severe kyphosis. Early surgery with wound irrigation/debridement is more readily able to disrupt biofilm formation and facilitate penetration of systemic antimicrobials to allow for resolution of the infection, vacuum-assisted closure facilitates wound healing and eradicates spinal infections, decrease the rate of complications, permit

Corresponding author:
Alexandru Vlad Ciurea

Professor. "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

prof.avciurea@gmail.com

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rapid pain relief while preserving the instrumentation/stability, better clinical outcomes, infection control before extensive destruction of the vertebrae, spinal instability and kyphotic deformity appear. Instrumentation can usually be preserved in patients with early infections (e.g., <6 weeks), but instrumentation removal should be considered for infections presenting in a delayed fashion (e.g., >6 weeks to even years) PSII. Patients should be adequately followed for one postoperative year, to ensure that the infection has been fully eradicated. Implant sonication provides cultures for direct identification of active and/or persistent biofilm, while the introduction of enzymes that dissolve the biofilm matrix (e.g., DNase and alginate lyase) and quorum-sensing inhibitors that increase biofilm susceptibility to antibiotics may further help manage postoperative infection (2) (27-31).

Introduction

Postoperative lumbar infection, after adult spine surgery may interest the degenerated spinal disc: septic or aseptic - spinal disc infections generating post-operative discitis (POD), the adja- cent vertebral bodies infections known as osteomyelitis (OM), or both osteo-discitis (OD). In general these pathologic spinal entities rarely occur separately and are known under the term spondylodiscitis (SD); but also postoperative lumbar infection may extend epidural and/or to facet joint arthropathy, paravertebral spaces. Semantically POD - a rare complication, representing 3-5% of cases should be differentiated from primary vertebra endplate infection with secondary involvement of the disc; be- cause of this is more accurate to use the term spondylodiscitis (SD) or vertebral osteomyelitis (VO) (1), and surgical site infections (SSIs) after adult spine surgery, generated by preoperative, intraoper- ative, or postoperative factors that contribute to the risk of infection following spinal fusions - which varies from 0.7% to 20% (2). The diagnosis of POD must be based on a combination of clinical symptoms, laboratory tests, bacteriological cultures from disc puncture, and radiological findings (3- 6). It's a severe complication which can lead to severe impairment of quality of life, neurological deficits, deformities, segmental instabilities (4-6). A recent study in Denmark showed that the inci- dence of spondylodiscitis increased from 2.2 to 5.8 per 100.000 people per year between 1995 and 2008, and the incidence of age in Germany was estimated at 30 to 250.000 per year based on data provided by the Federal Statistical Office 2015 (7), in the West it is <1%, and in India from 4% to 10% (8).

Methods

15 studies, published from 2003-2021, are analysed, out of which two: Ahsan K. (3) and Jain M.(8) publications were referring to postoperative osteodiscitis were considered (Table 1).Patients were diagnosed clinically, by laboratory investigations such as: complete blood count (CBC) erhrytrocites sedimentation rate (ESR), C reactive protein (CRP) and coagulation levels, and radiological lumbar studies: X-rays, CT, MRI. Demographic data, clinical variables, length of hospital stay, duration of antibiotic treatment, and post-treatment complications were assessed. Inclusion and exclusion criterias are presented below (Table 1).

Authors and Year	Class of evidence	Summary	Criteria for inclusion in the study	Criteria for exclusion the study
Ahsan K. et. al. - 2020	I	Prospective study (n * = 38). Conservative Vs. operative management of postoperative lumbar discitis. Fusion status offered the best outcome after 1,3,6 to 12 months of follow-up, with no risk. The study was conducted from January 2017 till May 2020.	Patients with POD are diagnosed after lumbar discectomy at a single level. Back pain appeared 1-6 weeks after surgery. Bridge with radiculopathy.	Patients with spontaneous discitis. Patients with multilevel discectomy. Patients who lost follow-up during the 12 months after discharge. Patients who started medical management before switching to surgical treatment due to inadequate response. Patients with severe spinal instability.
Jain M. et. al. - 2019	II	Descriptive study (n = 12), 10 own and 2 referred. Postoperative lumbar Pyogenic spondylodiscitis. Fusion status offered a good outcome after 12 to 18 months of follow-up, with moderate risk. A study was conducted from January 2015 till January 2017.	Patients with lumbar discectomy at one level.	Patients with multiple discectomies. Patients with spontaneous discitis. Patients with implant-associated discitis.

n*= number of patients

Table 1. Study of fusion for conservative and interventional treatment of lumbar osteodiscitis, modified after (3)(8).

Results

The patients were followed for 12-24 months by Ahshan K. (3). Thus, they divided the patients into two groups A and B, respectively in the conservative and operative group and it was found that after primary discectomy, the pain-free interval was 1-6 weeks for the conservative group and 1-8 weeks for the operative group and the duration symptoms before admission were 5-21 days for group A and 7-21 days for group B. Patients experienced moderate to severe pain, radiculopathy, mild fever, paravertebral muscle spasm, positive SLR test, and pseudo Gower sign. Demographic characteristics in both groups showed no significant differences in age, sex, clinical presentation, pain-free interval for the development of disc symptoms, duration, disc level, and associated risk factors. ESR and CRP values, were elevated in all patients in both groups. After treatment, the values in some patients decreased in one to two weeks, and the values that remained

elevated returned to the initial preoperative value in 1-3 months. Values returned to normal in all patients within six months. Biopsy reports showed a mixture of inflammatory cells, including neutrophils, plasma cells and lymphocytes but no granulomatous lesions. Simple x-ray imaging investigations in antero-posterior and lateral incidence were recommended in all patients. Six to eight weeks later, patients in the first study had localized osteopenia, narrowing of the disc space, erosion of the final plaque, cavitation, and kyphotic deformity. Dynamic X-rays were used for patients who experienced pain in the first study, and in the second study no dynamic X-rays were performed due to severe pain on mobilization. CT showed that the final plate erosion had formed 3-6 weeks before the discitis. MRI showed hypointensity on T1- weighted images and hyperintensity on T2-weighted images with improved diffuse and continuous heterogeneous contrast of discs, end-plate, and adjacent bone marrow in all patients in both studies. Severe pain, after a painless interval, after lumbar discectomy increases the possibility of a recurrent disc herniation but the distinction is made after 6 months after surgery, between a recurrent disc with postoperative changes and scar tissue by MRI. Ahsan K (3) observed that after treatment with group A (conservative) the condition of patients improved after 4-6 weeks. Intravenous antibiotics were given for 4-6 weeks, followed by five weeks of oral administration until the pain improved, ESR and CRP returned to normal. The administration of antibiotics lasted 69 -92 days. In group B (operated patients) the good condition was found in two to three weeks of intravenous administration of antibiotics and followed by 3-4 weeks of oral administration. The duration of antibiotics was 34-50 days. Empirical antibiotics were initially prescribed for all patients (example: ceftriaxone, which was resistant to 40% of cases) and then culture-specific: Staphylococcus aureus, S. epidermidis (Meropenem, Flucoxacillin, Linezolid, fusidic acid). Ciprofloxacin and Tobramycin were administered for the culture in which E. coli, Enterobacter, Pseudomonas were present. Jain M. (7) treated group A (conservative) with antibiotics, analgesics, orthoses and physiotherapy and group B (operated patients) only with debridement surgery; debridement with postero-lateral fusion by autogenous bone graft and stabilization by screw and pedicle stem; inter-body lumbar transforaminal debridement with fusion through titanium cage and autogenous bone graft and stabilization by screw and pediculated stem. Serial ESR and CRP returned to baseline values in about three weeks. The condition of all patients improved in eight weeks. Patients were followed by a blood or x-ray test after 1,3,6 and 12 months after discharge and then once a year. The state of fusion was assessed at 6-12 months by X-ray and CT. No patients during the conservative and surgical treatments suffered neurological damage. The satisfaction rate was higher in the operating group than in the conservative group at the end of the one year. The operating group required significantly shorter hospitalization with bed rest and a shorter period of antibiotic administration and reduced discomfort symptoms. The costs of procedures and blood transfusions were higher for the operating group, but the complication rate was also higher.

Discussion

POD is a complication, extremely serious and rare today, after surgery on the intervertebral disc. Such entity was first described by Frank Turnbull in 1953 as a clinical entity (9-11). POD occur more commonly in the lumbar spine: a single level involvement 65%, multiple contiguous levels 20% and multiple non-contiguous levels (10%); appear after about 6-7 weeks mainly after discectomy, see an insufficient operation or a recurrent disc herniation (2-9); may present septic (more frequent as a postoperative complication involving skin flora such as Staphylococcus aureus) and aseptic forms (due to disc trauma and vascular compromise during surgery, involving spinal tuberculosis - spread along spinal ligament to involve the adjacent anterior vertebral bodies, causing angulation of the ver-tebrae with subsequent kyphosis (18). POD may also be caused by hematologic spread from a distant infection site has been identified in almost half of spondylodiscitis patients, as a remote infection (14). Common distant infection sites include the genito-urinary tract (17%), the heart (endocarditis, 12%), skin and soft tissue (11%), intravascular devices (5%), gastrointestinal tract (5%), respiratory tract (2%) and oral cavity (2%). POD has a male predominance, significant morbidity - especially in developing countries it has a high incidence (16) and mortality (17)

The most important risk factors (2-12)(15) in the development of POD are:

- preoperative: advanced age, male sex, obesity, long-term systemic administration of steroids, organ transplantation, diabetes mellitus, tobacco/alcohol use, malnutrition, coronary and severe vascular diseases, liver cirrhosis, chronic kidney disease, rheumatic disease, also concomitant infections (sep- sis, extra-spinal infections of the skin, teeth, lungs, ascending infection, e.g. from urogenital tract), immunocompromised patients especially to AIDS, intravenous drug abuse, organ transplantation, preoperative hospital stay, prior poly-trauma, tumor/malignancy, high ASA score, previous spinal surgery (16), multiple lumbar surgeries, suboptimal timing of prophylactic antibiotic therapy, ele- vated preoperative serum glucose levels.
- intraoperative: large blood loss, use of cell savers, operations that last very long > 5 hours, increased wound exposure to air (longer surgical duration), greater soft tissue dissection, and increased mus- cle/skin retraction devascularize the para-spinal muscles, increases the potential for blood loss, and results in larger dead spaces, which also contribute to the risk of infection, open interventions, number of levels operated, postoperative incontinence following laminectomy and/or fusion, but also mini- mally invasive spinal and endoscopic procedures, posterior vs. anterior spinal instrumentation, fu- sions, implant material (titanium vs stainless steel), use of allograft, use of microscope/O-arm/C-arm, fluoroscopy, intraoperative computed tomography, many people in the operating room (two or more residents on a case), open suction drainage, the failure to drain wounds correlates with a significantly higher risk of delayed spinal infections. The timing of administration of preoperative antibiotics is strongly correlated with an increased risk of POD. Ideally, preoperative prophylactic antibiotics should be administered within an hour of surgery (e.g., cephalosporin except in penicillin allergic patients); administration up to 15 minutes prior to the incision may be even more effective, spinal surgery for tumor resection is also independently associated with an increased risk of lumbar POD (2)
- postoperative urinary/faecal incontinence, poor wound care, postoperative ICU stay, elevated post- operative serum glucose levels

As an aetiology, POD mono-microbial or poly-microbial infection in 10-50% of cases (2) - contiguous infection spread (12)(14):

- pyogenic - bacterial: Staphylococcus aureus (60% of cases, methicillin-sensitive Staphylococcus aureus MSSA, still the predominant aetiologic agent in drug users), Streptococcus viridans (VDU, immunocompromised), Staphylococcus epidermidis is associated with implant- related infections, whereas coagulase-negative Staphylococci and Streptococcus viridans may be a cause of indolent infections, due to their low virulence, gram-negative organisms: Enterobacter spp. Escherichia coli (11% -25%) is the most common pathogen in this group, followed by Proteus, Klebsiella and Enterobacteriae spp. occur in the elderly, in states of immunosuppression and diabetes, Brucella spp.(6-12%) (common in the Mediterranean and Middle Eastern countries) (13), Salmonella, Pseudomonas aeruginosa in cases associated with intravenous drug abuse Enterobacter, and Acinetobacter, Burkholderia pseudomallei (i.e. melioidosis): diabetic patients from northern Australia and parts of Southeast Asia, Brucella spp.; in patients with sickle cell disease Salmonella spp... There are also common organisms implicated in POD with spinal instrumentation like S. aureus, coagulase negative Staphylococcus and Propionibacterium, have a predilection for biofilm formation (after seroma or hematoma who can alter the surface properties of an implant thereby impacting the overall susceptibility of bacterial adherence) with some protection for microbial organisms against antibiotics, phagocytes, and other cellular and humoral immune responses by an altered phenotype with regard to growth rate and gene transcription (both of which can impact diagnostic and management strategies (2).
- granulomatous: Mycobacterium tuberculosis (Pott disease) (7)(12)(13) is more frequent in developing countries, accounting for 46% of cases.
- fungal among immunodeficient people: Cryptococcus neoformans, Candida spp. Histoplasma capsulatum, Coccidioides immitis, Burkholderia pseudomallei (ie melioidosis) to

diabetics patients from northern Australia and parts of Southeast Asia
- parasitic - Echinococcosis (12)(14)
- 1/3 of patients the implicated organism may not be isolated (1)

In lumbar POD, infection extending to the adjacent disc and vertebra may generate extensive vertebral destruction, deformity, compromise stability, formation of paravertebral abscesses or may spread into the spinal canal causing epidural formation, neurological impairement with spinal cord or cauda equina compression, with high morbidity and mortality rates. There are three main ways of contamination (2) (12):

- iatrogenic by direct bacterial inoculation, direct open traumas of the spine responsible for 14% to 26% of spinal infections, by biofilm at the surface of the implants where certain bacteria can adhere with altered phenotype with regard to growth rate and gene transcription - both of which can impact diagnostic and management strategies (2);
- hematological dissemination are the most common cause of spondylodiscitis and is mainly arterial, allowing bacteria from distant sites to contaminate the spine in the setting of bacteremia;
- non-hematological, extension from a contiguous infectious site.

Clinical POD diagnosis is based on: continuous, deep-seated, throbbing low-back back pain the most common symptom (over 90% of patients), located at the site of infection, which worsened at night or gradually increased from mild pain to severe pain, associated with morning stiffness. POD pain appear early within 1-8 weeks of surgery, after an initial post-surgical relief of pain, aggravated by defecation, coughing, and sneezing, also at the slightest touch of the bed. Pain is accompanied by severe paravertebral muscle spasm that radiates to the buttocks, thighs, groin, perineum or abdomen; fever (less common - under 20% of patients, unreliable parameter, and often absent), fatigue, a general malaise may be seen in 11% - 68% of cases. Examination revealed severe restriction of movement, loss of lumbar lordosis, a positive pseudo-Gower sign, radiculopathy, less common neurologic defi- cits, wound drainage is common, may be present in up to 90% of patients (1-3)(9). Delayed lumbar POD relate to those infections occurring 3-9 months postoperatively (2), especially to those patients with spinal instrumentation typically present several months to years later with chronic pain - in- creased pain at the incision site and tenderness to palpation of the soft tissue under the incision, wound drainage, implant failure, or lack of adequate spinal fusion. Delayed infections are more often culture negative vs. early infections because as they are frequently caused by less virulent pathogens (e.g., Propionibacterium acnes, coagulase negative Staphylococcus epidermidis, bacillus, and micrococcus species), facultative anaerobe pathogens (2), favored by a postoperative sterile inflammatory pro- cesses who may create a favorable environment for the growth of low virulence organisms such as Propionibacterium.

Biochemical markers used to diagnose POD are:

- TLC - may be elevated, unsteady (9);
- ESR - normal at the time of admission (1)(7), is elevated during the first 2 weeks after lumbar discectomy (10) and slowly returns to baseline between 21-42 days;
- CRP the most important, normal at the time of admission(1)(7), reaches its maximum on the second day after discectomy and returns to normal between within 6 days, if no complication occurs (4), has also high sensitivity compared to cultures if there is only one germ. An elevated CRP after the first postoperative week thus indicates a bacterial infection, also higher postoperative CRP levels are can be find after instrumented spinal surgery vs. simple decompressions (2). A high CRP 2 weeks after surgery should make the neurosurgeon think (1)(3)(7)(16-18);
- blood culture positive in 17% of cases, in specimens from the intervertebral disc space at surgery and 12% showed a positive culture that came from the operation by microscope itself (6);
- blood investigations (blood glucose, serum albumin, liver, and renal function tests) (3)(8)
- aerobic, anaerobic, fungal and mycobacterial liquid and tissue samples, blood and urine cultures, as well as histology (14);
- biopsy, useful in the diagnosis of polymicrobial infections, if the blood cultures were negative; performed 48 hours after antibiotic treatment only if the patient is stable (6);

- CT- guided percutaneous biopsy for unidentified POD;
- technique of vortexing and sonification, followed by generally negative culturing scraped from the implant, in case of biofilm infection in POD with spinal instrumentation (2);

Neuroradiologic studies were done after hospitalization, before starting empirical treatment with antibiotics (3)(8) They relate to:

- x-rays performed in the anteroposterior and lateral incidence of the lumbosacral spine to observe in advanced cases, only after 2-4 weeks from the onset of the infection, to notice the extent of bone destruction, but also abnormalities of the infected spine: irregularity or ill definition of the vertebral endplates, cavitation, reduction of disc space, and instability in about 90% of cases, bony sclerosis may begin to appear in 10-12 weeks. In pyogenic POD, the first observation is narrowing of the disc space, followed by blurring and end-plate irregularity. In TB, the integrity of the disc is usually preserved, but after 8-12 weeks, significant bone destruction is evident.
- lumbar CT scan is more sensitive to plain film but are more sensitive to earlier changes: end-plate destruction, surrounding soft tissue swelling, intervertebral disc enhancement with contrast, collections (paraspinal, psoas muscle abscesses, even epidural abscesses), disc hypodensity. Bone necrosis and pathological calcification that occurs in TB are detected. CT is most commonly used for guided biopsy or if MRI is contraindicated. CT-guided aspiration, was performed using a needle or trocar for microscopy, culture, and biopsy were performed to identify pathogens. The culture from a fine-needle aspiration was positive in 1 patient and negative in 5 (19).
- serial lumbar MRI with gadolinium contrast enhancement, is the investigation of choice in lumbar POD, due to its very high sensitivity and specificity, also to evaluate the response to treatment (21). In the early stage of POD, MR imaging can not differentiate between the septic and aseptic forms (6), vertebral end-plate erosion is found in the majority of cases in both forms of discitis. POD that develops at a disc level with pre-operative degenerative type 2 or 3 changes may give some diagnostic problems owing to its variations from typical MR findings (6).

Signal's characteristics (1) include:

- on T1-weighted images irregular intensity with low signal in disc space, in adjacent endplates (bone marrow edema) and in (fluid) pyogenic infections;
- on T2 (fat saturated or STIR especially useful): high signal in disc space (fluid), in adjacent endplates (bone marrow edema), in paravertebral soft tissues, in the psoas muscle (imaging psoas sign): this finding is ~92% sensitive and ~92% specific for spondylodiscitis (Fig. 1) (Fig. 2)

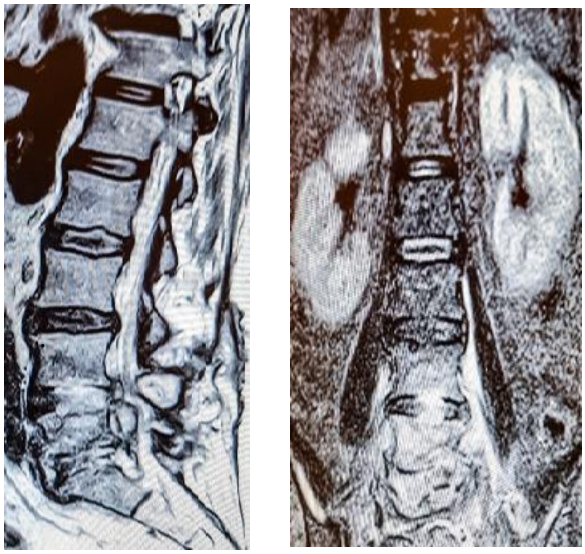

Figure 1. Imunocompromised patient with uncontrolled diabetes type 2. After 2 months post-fenestration at L4/L5 level presented with severe low back pain, elevated inflammatory markers. Sagittal (A) and coronal MRI T2-weighted (B) revealed massive height reduction of L5 vertebral body, edema and T2 hyperintensities at L4/L5 and L5/S1 along disc spaces and adjacent endplates suggestive for POD. Note the epidural abcess at the same level (A).

- after contrast administration (Gd) in T1: the enhancement of the disc, the narrowing of the disc space, the development of erosions in the vertebral endplates, peripheral enhancement around fluid collection(s), paravertebral soft tissues, around low-density center indicates abscess formation (hard to distinguish inflammatory phlegmon from abscess without contrast).
- on DWI sequences: hyperintense in the acute stage, hypointense in the chronic stage.

- positive MR imaging and elevated CRP should be followed by disc puncture and optimal antibiotic therapy.

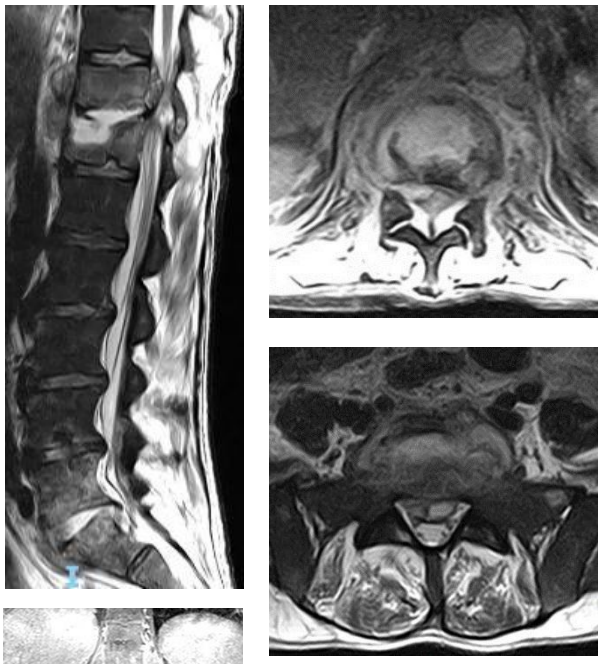

Figure 2. 55 years old, man, known with a lumbar polidiscopathy and decompensated diabetes presents spastic paraparesis installed one week after lumbar paravertebral infiltrations. Examination of lumbar spinal MRI (T2-weighted sequences A in the sagittal plane, B and C in the axial plane, D in the coronary plane) revealed a T11-T12 POD, spinal epidural abscess of the posterior vertebral body T11. Operated in an emergency, the dural sac and the T11-T12 disc space are decompressed, isolating Staphylococcus aureus MRSA +, 1 month postop. the motor deficit remits.

If the bacteriological culture is negative, it is appropriate to choose antibiotics against S. aureus, the most frequent cause of POD (21). In the absence of signal increase on T2-weighted images and undetectable or low improvement after the introduction of the contrast substance a fungal infection should be considered, also a diffuse vertebral infection with Brucella may be difficult to differentiate with TB (21). In the absence of specific MRI characteristics, insignificant values of ESR and CRP, it suggests a non-infectious aseptic etiology or a malignant tumour, in such case a biopsy is used. The intranuclear cleft sign described by Aguila (20), cited by (6) is not relevant indicator for POD (linear enhancement within the disc, seen as two thin bands parallelling the end-plates) appears in 20% of patients without post-operative complications at 3 months after lumbar discectomy, the annular enhancement in the most posterior aspect of the disc at the site of surgical curettage is a normal post-operative finding.

- if MRI is inconclusive or contraindicated, three-phase bone scintigraphy with technetium-99m, Gallium-67 (2), scintigraphy with single-photon emission CT (SPECT) and Fluorine-18 fluorodeoxyglucose positron (F-18-FDG PET) can be used, which has higher accuracy in POD, but is not widespread (14). If MRI is contraindicated or hampered by artifact, dual imaging with PET/CT could become the imaging modality of choice; also promising results in pilot studies/small series has shown Non-FDG PET/CT with Ga-68 citrate (24).
- labeled leukocyte imaging less sensitive for processes in which the predominant cellular response is not neutrophilic (e.g., tuberculosis) (2).

POD treatment means antibiotics after biopsy, depending on the pathogen involved, cultures, sensitivities; also strict bed rest, nutritional diet, analgetics, orthosis, physiotherapy, reducing the mobility of the affected region, either with a back brace or a plaster cast, recommended about two weeks until the acute pain subsides. Many studies have shown that long-term conservative treatment has a success rate of 70% -83% (3)(4)(9)(21-23). Anti-staphylococcal penicillin or a first-generation cephalosporin is the best choice in the treatment of methicillin-sensitive staphylococci infection. If the germs - Staphylococcus epidermidis are resistant to methicillin, Vancomycin is administered and alternatively Linezolid and Quinupristin-dalfopristin. Penicillin G is of choice in the treatment of infections with Streptococcus spp., Cephalosporin or a quinolone is administered for gram-negative bacteria and metronidazole or clindamycin is given in cases with anaerobes. The classic regimen in TB includes isoniazid, rifampicin, ethambutol and pyrazinamide because it has a higher resistance. Amoxicillin and streptomycin or gentamicin are useful in Brucella infection, and amphotericin B or

azole are needed in fungal osteodiscitis (14). If the patient is not stable, antibiotic treatment is performed and the biopsy should be performed approximately 48 hours after the most recent dose of antibiotic (12)(14)(25). The duration of antibiotic therapy varies from case to case, mean time 6-8 weeks of intravenous therapy, others propose 6-8 weeks of intravenous antibiotics followed by 2 months or more of oral therapy, depending on clinical and laboratory responses, up to a year, depending on the complexity of the infection, its resistance to antibiotics, to prevent recurrence and to allow complete healing of POD, especially in immunocompromised patients (3)(12)(14). In cases where treatment begins within 2 weeks of the onset of symptoms, 6 weeks of treatment is considered sufficient. If treatment is delayed 6-7 weeks after the onset of symptoms, then antibiotic therapy for 4-8 weeks is associated with an increased recurrence rate compared to treatment for 12 weeks or more (3-5)(7)(24). Failure of medical treatment should be considered in patients with prolonged back pain, increased inflammatory markers after treatment, important destruction of the vertebral body, damage to the nerve root, progressive kyphosis. It is to avoid prolonged rest leading to skin ulcers, colitis, kidney failure, allergic reactions, deep vein thrombosis, pulmonary embolism, pneumonia, pseudoarthrosis, instability with spinal deformities, chronic pain back, also unwanted psychosocial aspects (11).

Some authors argue that early surgical debridement, followed by antibiotics, is superior to conservative antibiotic-only treatment. In cases where treatment begins within 2 weeks of the onset of symptoms, 6 weeks of treatment is considered sufficient. If treatment is delayed 6-7 weeks after the onset of symptoms, then antibiotic therapy for 4-8 weeks is associated with an increased recurrence rate compared to treatment for 12 weeks or more (3-5)(7)(24).

Surgery is performed to patients with conservative treatment failure - resistant to antibiotic therapy, as those with neurological complications: acute paraplegia, pain resistance to analgetics, acute sepsis, anterior abscess larger than 2.5 cm on lumbar MRI and epidural abcesses, spinal instability, severe kyphosis. Lumbar POD are positively associated with extended hospitalizations, increased morbidity and healthcare costs, poorer long-term outcomes, and greater dissatisfaction with the initial operative procedure (2); for these reasons early surgery permit rapid pain relief, infection control before extensive destruction of the vertebrae, spinal instability and kyphotic deformity appear (3-8)(13)(21-24). Especially in piogenic POD exploration by a posterior approach, debridement of all inflammatory tissues, the epidural abscesses are evacuated, the disc space should be irrigated with gentamicin mixed with normal saline (0.9% NaCl), betadine irrigation, dispersing powdered Vancomycin into the wound just prior to closure (2), followed by interbody fusion with titanium banana cage, autogenous spongy bone grafts or posterolateral fusion by graft bone, posterior instrumentation - antimicrobial coated implants, with pedicle screws and rods, vertebral bodies were included above and below the affected segment, then perioperative smears and tissue samples were taken for histological and microbiological evaluation. (3) Instrumentation of the spine has a higher success rate after complete debridement and concomitant antibiotic therapy (12). After surgery, patients received 2-3 weeks of broad-spectrum intravenous antibiotics consisting of ceftriaxone/meropenem with flucloxacillin for gram-positive and gram-negative organisms and metronidazole for anaerobic coverage.The dose and duration of treatment were based on the patient's weight, kidney, and liver condition, followed by 3 weeks of oral antibiotics or until ESR and CRP levels improved or back pain decreased significantly (3)(8). POD surgical treatment offer more patient satisfaction because the duration of healing and the administration of antibiotics was shorter than in the case of those treated conservatively, but it can also be risky because there are cases of postoperative recurrence of the infection. The duration of the procedure, which lasts more than five hours, the attempt of a minimally invasive intervention, a more aggressive operation, delayed or incomplete debridement, diabetes, smoking, the advanced age of the patients led to serious postoperative complications (3)(8)(12). Surgery at L4 / L5 and L5 / S1 by anterior approach are quite difficult, morbidity being increased and therefore POD was operated by posterior approach. Even if there is an active infection, instrumentation after radical debridement will not lead to an increased risk of recurrent infection, as it speeds up the healing process. Percutaneous transpediculary discectomy and drainage lead to rapid pain relief (3)(8)(10).

However, in lumbar POD suited by prostheses-based biofilm, especially most infectious disease physicians now recommend removal of the underlying spinal instrumentation (2), increasing the chance of eradicating the infection. Nevertheless, this potential advantage must be weighed against the risks of prematurely removing spinal instrumentation, essential for maintaining normal spinal alignment and preserving spinal stability.

Conclusions

The diagnosis of lumbar POD is based on history and physical examination, biochemical markers, neuroradiologic studies, using appropriate MRI imaging. Most cases of lumbar POD can be managed by conservative treatment with antibiotics after causative germ isolation and antibiogram. Surgery is performed to patients with conservative treatment failure - resistant to antibiotic therapy, as those with neurological complications: acute paraplegia, pain resistance to analgetics, acute sepsis, abscesses, spinal instability, severe kyphosis. Early surgery with wound irrigation/debridement are more readily able to disrupt biofilm formation and facilitate penetration of systemic antimicrobials to allow for resolution of the infection, vacuum-assisted closure facilitates wound healing and eradicates spinal infections, decrease the rate of complications, permit rapid pain relief, while preserving the instrumentation/stability, better clinical outcomes, infection control before extensive destruction of the vertebrae, spinal instability and kyphotic deformity appear. Instrumentation can usually be preserved in patients with early infections (e.g., <6 weeks), but instrumentation removal should be considered for infections presenting in a delayed fashion (e.g., >6 weeks to even years) PSII. Patients should be adequately followed for one postoperative year, to ensure that the infection has been fully eradicated. Implant sonication provides cultures for direct identification of active and/or persistent biofilm, while the introduction of enzymes that dissolve the biofilm matrix (e.g., DNase and alginate lyase) and quorum-sensing inhibitors that increase biofilm susceptibility to antibiotics may further help manage postoperative infection (2) (27-31).

Abbreviations

POD postoperative discitis OM ostemyelitis
OD osteofyscitis SD spondylodiscitis
OD vertebral osteomyelitis SSIs surgical site infections IVDU intravenous drug users
ASA American Society of Anesthesiology score ICU intensive care unit
TLC total leukocyte count CRP C reactive protein
ESR erhrytrocites sedimentation rate
CT tomograph computer
MRI magnetic nuclear resonance
PSII postoperative spinal implant infections

Conflicts of interest

There are no conflicts of interest.

Authors contributions

All authors contributed equally.

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