



Clinical presentation and diagnosis of acute postoperative spinal implant infection (PSII)

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Abstract: Acute postoperative infections after surgical interventions on the spinal column are associated with prolonged treatment duration, poor patient outcomes, and a high socioeconomic burden. In the field of joint replacement, guidelines have been established with recommendations for the diagnosis and treatment of such complications, but in spinal surgery there are no definitions permitting distinction between early and late infections and no specific instructions for their management. Various factors increase the risk of acute postoperative infection, including blood transfusions, leakage of cerebrospinal fluid, urinary tract infection, injury of the dura mater, an American Society of Anesthesiologists (ASA) score >2, obesity, diabetes mellitus, and surgical revision. We suggest defining all infections occurring within the first 4 weeks after spinal surgery as early infections. The symptoms are pain at rest, on motion, and/or pressure pain, abnormal warmth, local erythema, circumscribed swelling of the wound, and newly occurring secretion. Together with laboratory parameters such as C-reactive protein (CRP) and leukocytes, a central role is played by imaging in the form of magnetic resonance imaging (MRI), although diagnosis can be hampered by the presence of postoperative fluid collections such as edema or hematoma or by artifacts from an implant. Once an infection has been confirmed, immediate wound revision with debridement and rinsing (sodium hypochlorite) is essential. Intraoperatively it may prove advantageous to use jet lavage and administer vancomycin. We recommend leaving the implant in place in cases of acute postoperative infection. Patients who are not conditional for surgery can first receive antibiotic suppression treatment before surgery at a later date. In such cases initial computed tomography (CT)-guided aspiration or drain insertion can take place.

Keywords: Early infection; spine; implant; spondylolysis; antibiotics

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Introduction

Early or acute postoperative infection following spine surgery is a potentially serious complication that often requires prolonged treatment and is associated with a poor outcome for the patient (1). Moreover, in common with other septic complications in the field of orthopedic and

trauma surgery, it represents a considerable socioeconomic burden (2,3). The suspicion of early infection may be difficult to confirm, as not all cases involve pain or elevated laboratory parameters of inflammation. In addition, diagnostic imaging is hampered by implants and the artifacts they cause. In such cases it is difficult to differentiate hematoma, edema, and infection on a postoperative

Table 1 The most frequently occurring risk factors for postoperative infections of the spine (13-16)

Blood transfusion	Undernourishment
CSF leakage	Arterial hypertension
Urinary tract infection	History of smoking
Dura injury	Long operating time
ASA score >2	Blood loss
Obesity	Advanced patient age
Diabetes mellitus	Revision procedure

ASA, American Society of Anesthesiologists.

magnetic resonance imaging (MRI) scan (4). Furthermore, diagnostic aspiration and microbiological analysis alone, as practiced in infections following joint replacement, is not considered standard (5). The expert opinion emerging from the Second International Consensus Meeting (ICM) 2018 was that should surgical intervention become necessary in early or acute infection, wound revision with debridement and retention of the implant is recommended. On the one hand, leaving the implant in place includes the risk of chronic infection with implant loosening or even infectious non-union, but on the other hand removal of the implant usually leads to an unstable situation that may also culminate in pseudarthrosis, pain and neurologic disorders (6). Thus, there are various options for the treatment of early/acute postoperative infection, but no guidelines or specific management advice.

Epidemiology

The first description of superficial and deep wound infection was published by Turnbull in 1953 (7). The incidence of postoperative infections following surgical interventions on the spine was reported in the literature as 0.7–8.5% (8). Superficial infections are distinguished from deep subfascial infections (7). Depending on comorbidity, the extent, surgical access, and duration of the surgery, and whether the operation is a first or subsequent procedure, the risk of infection is as high as 8.5–12% for implant-based interventions (6,9,10).

Risk factors

Schuster *et al.* postulated that implant-based interventions involve no extra risk (11), but a number of different studies

have shown that this is not the case (12). Various factors have been demonstrated to elevate the risk of peri-spinal implant infection (PSII). These include, among others, blood transfusion, leakage of cerebrospinal fluid, urinary tract infection, injury of the dura mater, an American Society of Anesthesiologists (ASA) score >2, obesity, diabetes mellitus, and surgical revision (13). An overview can be found in *Table 1*.

Diagnostics

The clinical symptoms are the primary indicator for the presence of infection. These include fever, pain, and neural symptoms (e.g., because of local abscesses). Elevated inflammatory laboratory parameters are a clear sign of infection. The time at which the symptoms first occur may help to pinpoint the site of infection. Superficial infections often arise within 30 days after surgery, while deeper infections may occur early or at any later time (12). There is an established classification of infections after joint replacement of the large joints—early (≤ 3 months), delayed (>3 –24 months), and late (>24 months) (17,18)—but no such classification of infections according to the time of occurrence has yet been widely accepted for spinal surgery.

Clinical manifestations

Early diagnosis and treatment of postoperative surgical site infection (SSI) is impossible if the risk of this complication is not borne in mind. Although SSI is rare, its incidence varies greatly depending on the type of intervention and on the patient clientele. No patient collective has ever been described with no infections at all following surgical interventions on the spine. Early diagnosis of wound infection is crucial for the patient's recovery, and this aspect of postoperative follow-up must be firmly anchored in clinical routine. Besides anamnesis, clinical examination is the first step in any case of suspected wound infection. It is common for the findings (pain at rest, on motion, pressure pain; abnormal warmth; local erythema; circumscribed swelling; increased secretion; impaired articular function; and fever) to range anywhere between inconspicuous or concealed symptoms and the complete spectrum of inflammatory signs or septic shock. The diagnosis of infection subsequent to spinal surgery is hampered by the fact that the clinical signs can equally be positive during a “normal” postoperative course (19). Patients without infection may well display pain and swelling, or occasionally

Table 2 The relative importance of the findings in patients with acute postoperative wound infection (11,19,20)

Diagnostic work-up for early wound infections

Very important: anamnesis, severeness of patient's subjective symptoms, physical examination, microbiological findings

Important: laboratory parameters (CRP, leukocytes), radiologic findings (sonography, radiography, MRI)

Less important: radiologic findings (CT, scintigraphy)

Physical examination

Very important: inspection (erythema, swelling, secretion, restricted range of motion)

Important: palpation (abnormal warmth, pain, fluctuation)

Less important: measurement of temperature (local, systemic)

Clinical signs of acute surgical site infection

Very important: pain (postoperative increase), pus

Important: swelling, erythema, abnormal warmth, fever

Less important: laboratory parameters (with results in expected range after surgery)

CRP, C-reactive protein; MRI, magnetic resonance imaging; CT, computed tomography.

even abnormal warmth, erythema, and functional impairment (*Table 2*).

Investigation begins with the patient's account of their symptoms. For an objective valuation of the anamnesis it is helpful to observe the patient during this consultation carefully. Second, the possibly infected area of the body should be inspected and palpated. The patient must be asked about the nature of the pain, where it occurs, and when (at rest, on motion, persistently, at night). Pain that initially decreases after the surgery but then increases is not generally a normal postoperative finding.

Postoperative wound inspection

In patients under suspicion for an early SSI, the bandage is removed and the soft tissues are examined on each day after surgery. The bandage itself should be inspected and its state documented. A dry bandage does not exclude surgical infection. Local erythema, swelling, and/or secretion must be recorded. Objectively quantifiable changes, e.g., erythema increases, should be documented in centimeters. The changing extent of the discoloration can be monitored by marking the margin of the affected area. With respect to sterility, it is crucial to observe the postoperative course closely, with examination several times daily if required. Whenever clinical signs of inflammation are found in the postoperative phase, the presence of an infection must be assumed; only in this way postoperative SSI can be detected. Postoperative urinary tract infection and pneumonia

must be excluded by means of the appropriate diagnostic procedures. If two of the four classical parameters of infection (erythema, pain, abnormal warmth, swelling) are present as new findings requiring specific treatment (19), maybe accompanied by renewed secretion from the wound or demonstration of sepsis by postoperative blood tests (*Figure 1*) the working diagnosis must be manifest early SSI.

Laboratory parameters

The presence of pus is a certain sign of infection and may be manifested by an abscess, empyema, or a fistula. Another definite sign of infection is septicemia. Pronounced clinical symptoms do not always go hand in hand with large-scale tissue destruction, and equally it cannot be assumed that less conspicuous clinical findings mean only minor damage. Because the clinical signs of postoperative SSI are the only signs that can definitely be relied upon, laboratory findings play a subsidiary role. In general, elevated C-reactive protein (CRP) and leukocyte concentrations can be found a few days after surgery and are "normal" in the course of reparative processes. Fujita *et al.* investigated the postoperative CRP of 948 patients who had undergone spondylodesis and found a second rise in CRP level (CRP-SR) in 107 cases. Thirty-eight (35%) of the patients with CRP-SR had developed a SSI. The remainder either had other infections (urinary tract infection, pneumonia) or the reason for the CRP-SR was not identified. Among the patients with CRP-SR, the best diagnostic cut-off value



Figure 1 The local findings in a female patient with an early infection after spondylodesis. The skin is locally reddened and was found to be distinctly warm to the touch. The fibrin coating shows the lack of normal wound healing, with no adaptation of the wound margins. No secretion was detected in this case.

for detection of SSI was 30.4 mg/L (21). In this scenario the preoperative CRP level can, if required, be used as a reference value. Blood cultures are indispensable to establish the diagnosis and with it the necessary treatment procedures, as early identification of the pathogen with a resistogram enables the appropriate antibiotic therapy.

Imaging

The imaging modalities generally used to confirm a suspected infection are radiography, CT, and MRI. Standard radiographs usually show no abnormalities in the first 3 weeks despite the infection. If at all, gas-producing bacteria may form discernable pockets of gas in the soft tissues, which might be visible in X-ray images (20,22). Radiographs obtained later in the course of infection may visualize bony endplate destruction, bone resorption, or osteolysis in the interface between bone and implants. MRI

is currently the gold standard for detection of postoperative infection after spinal interventions, even in the early phase. It can depict not only epidural abscesses but also other destructive and infectious processes in the intervertebral disks and soft tissues (23). An infection may affect the soft tissues of the “surgical bed”, without involving the spinal structures. In such a case MRI with and without contrast medium is strongly recommended (24). Contrast enhancement increases the specificity for acute infection detection, facilitates diagnosis in the absence of severe edema, and is particularly helpful in delineation of epidural extension and identification of abscesses (25). MRI of a spinal epidural abscess yields a signal of low or moderate intensity in T1-weighted sequences and high or moderate intensity in T2-weighted sequences. The fluid component of an abscess is normally extremely hyperintense on T2-weighted images and hypointense on T1-weighted images (26). Although MRI is the most effective modality for determining the fluid component of abscesses and osseous edema, CT is the superior method for depiction of the bony destruction (27,28). However, metal artifacts always hamper assessment of the area around the implants (29,30). Furthermore, hematoma cannot always be confidently distinguished from pus etc. in the early postoperative phase (4).

Microbiology

To our knowledge, no study has yet distinguished the pathogen spectrum of acute infections following surgical interventions on the spine from that of chronic infections. For this reason, we refer here to the spectrum of pathogens in postoperative spinal infections in general. The pathogens most frequently demonstrated in implant-associated infections, both on sonication and on examination of tissue samples, are coagulase-negative staphylococci (CNS). Besides this, in general *Staphylococcus epidermidis* is found most often, followed by *Propionibacterium acnes* and *Staphylococcus aureus* (31-34). Interestingly, patients with recurrent *Staphylococcus aureus* bacteriuria and bacteremia have a higher rate of spinal infections than patients with only *Staphylococcus aureus* bacteremia caused by retrograde dissemination through the pelvic venous and lymphatic vessels that are connected to the intraspinal plexus (35).

Antiseptics are effective against these pathogens and are thus recommended for intraoperative use (36). Recently published studies have shown that sodium hypochlorite is superior to chlorhexidine with regard to destruction of the

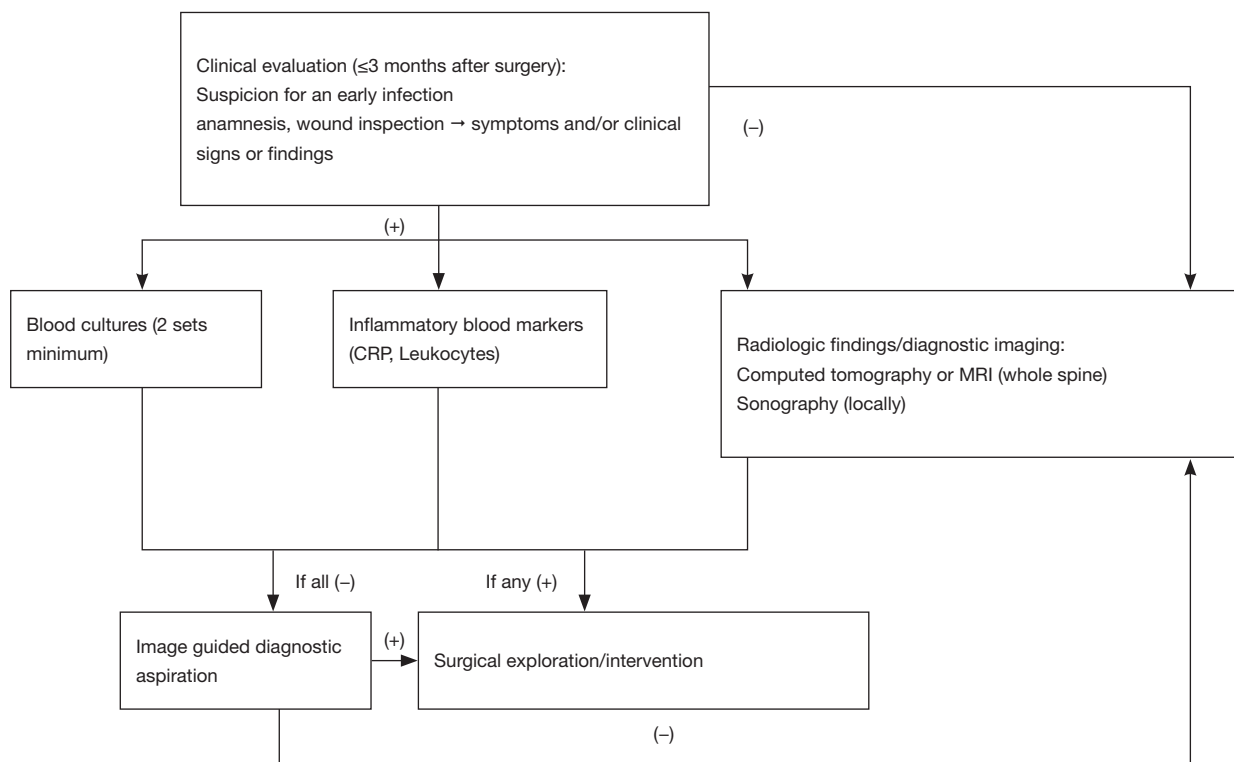


Figure 2 Decision making in acute postoperative spinal implant infection (PSII).

biofilm (37). Since some bacteria form an immature biofilm in the 4-week phase directly after primarily contaminating surgery already (38), sodium hypochlorite must be recommended for biofilm-forming bacterial species even in revision surgeries of early postoperative SSIs. The fact that sodium hypochlorite is a fast-acting antiseptic is an additional advantage.

Treatment recommendation and perspective

On the basis of the criteria outlined above, the following algorithm (Figure 2) can be proposed: Newly occurring pain that is accompanied by conspicuous findings at the incision site, e.g., secretion or poor wound healing, should, if backed up by the radiological signs, be interpreted as infection. Surgery is then indicated to shorten the otherwise prolonged treatment process. The operative intervention begins with exploration of the site and sampling of tissue for microbiological examination. Three to five samples should be obtained (5), followed by painstaking debridement concluding with antiseptic lavage or, if required, jet lavage (39). On the basis of recent findings,

local application of vancomycin is recommended (1,16,40). Finally, a drain is inserted and the wound is closed with cutaneous sutures. Non-loosened implants should be left in place when an early infection is treated, but loosened implants should be replaced. If an early infection persists after several revisions, one single replacement of the implant can be considered. Persisting infection often necessitates a “second-look” operation. If there is a large soft-tissue defect, elimination of the infection may have to be followed by plastic surgery. In the event of severe, practically uncontrollable infection, long-term suppression may be required until a status is achieved that permits removal of the implant(s). The same applies to a patient who is not conditional for surgery in general. In this case, sonographically or CT-guided aspiration or even drain insertion may help to harvest samples for identification of the pathogen or to relieve an abscess. In implant-preserving procedures, the Pro Implant Foundation (Trampuz *et al.*) recommends administration of antibiotics with biofilm activity for 2 weeks i.v. and then 10 weeks p.o. (16). In the absence of implants, or if the implant(s) can be removed in entirety, the current recommendation is that the oral

antibiotics should be given for 4 weeks.

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