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The Management of Early Post-Operative Spinal Infection in the Presence of Implants, Interbody Cages, and Bone Grafting

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Introduction

Post-operative surgical site infection (SSI) is a potentially devastating complication that can compromise patient outcomes and result in pseudarthrosis and adverse neurologic sequelae. In addition, it leads to increased utilization of healthcare resources and prolonged hospitalization. In the United States, the burden to the healthcare system is estimated to be upwards of $50,000 in additional healthcare costs per patient, with an estimated $130–$845 million spent annually to manage SSI.[1,2] In spine fusion surgery, SSI is further complicated by instrumentation and implants such as rods, screws, and cages that are necessary to achieve stability until fusion has occurred. Implants are foreign bodies that provide a favorable environment for adhesion of bacteria with multi-layered cell proliferation and subsequent biofilm formation, allowing infection to evade the host immune response.[3–6] Detecting initial signs of infection, establishing the diagnosis, performing irrigation and wound debridement, and starting appropriate antibiotic therapy in a timely fashion is imperative to controlling infection and increasing the chances of salvaging spinal implants.3–6 Therefore, the distinction between early and late infection is vital. While there are no exact definitions to differentiate between the two, we generally assume that postoperative infections identified within 30 days can be treated as early infections. Considering the increasing incidence of spine surgery and the increasing use of implants, SSI has become a major issue to manage despite the few clear guidelines for spine surgery. [7]

In order to ascertain regional variations in treatment of early spinal infection around the world, the senior author (Alexander R. Vaccaro (ARV)) from AOSpine North America contacted six members from other AOSpine world regions (Andrei F. Joaquim (AJ) from Latin America, Vafa Rahimi-Movaghar (VRM) from Middle East and Northern Africa, F. Cumhur Oner (FCO) from Europe and Southern Africa, Gregory M. Malham (GM), Kazuhiro Chiba (KC) and Shanmuganathan Rajasekaran (SR) from Asia Pacific to determine how different case scenarios would be ideally treated. For this review, we identified three case scenarios where patients had recently undergone spine surgery and presented with clinical signs of infection. For each case, salient aspects of treatment are highlighted and treatment guidelines are suggested.

Case 1

A 55-year old obese female presented to clinic with complaints of severe left leg pain and left foot weakness in the setting of lumbar degenerative scoliotic deformity. The patient underwent L4-S1 posterior lumbar decompression and fusion with transforaminal lumbar interbody fusion (TLIF) (**Figure 5.1**). Two weeks postoperatively, the patient developed worsening back pain and subjective fevers over the course of 2–3 days. On examination, the patient had peri-incisional erythema and drainage from the posterior lumbar wound (**Fig 5.2**) and was neurologically intact with a baseline level of strength and sensation. Labs showed a white blood cell (WBC) count of 10.0 (x 10^3/μL) with 72% neutrophils and 15% lymphocytes, C-reactive protein (CRP) of 17.6 mg/dL, and erythrocyte sedimentation rate (ESR) of 85 mm/hr.

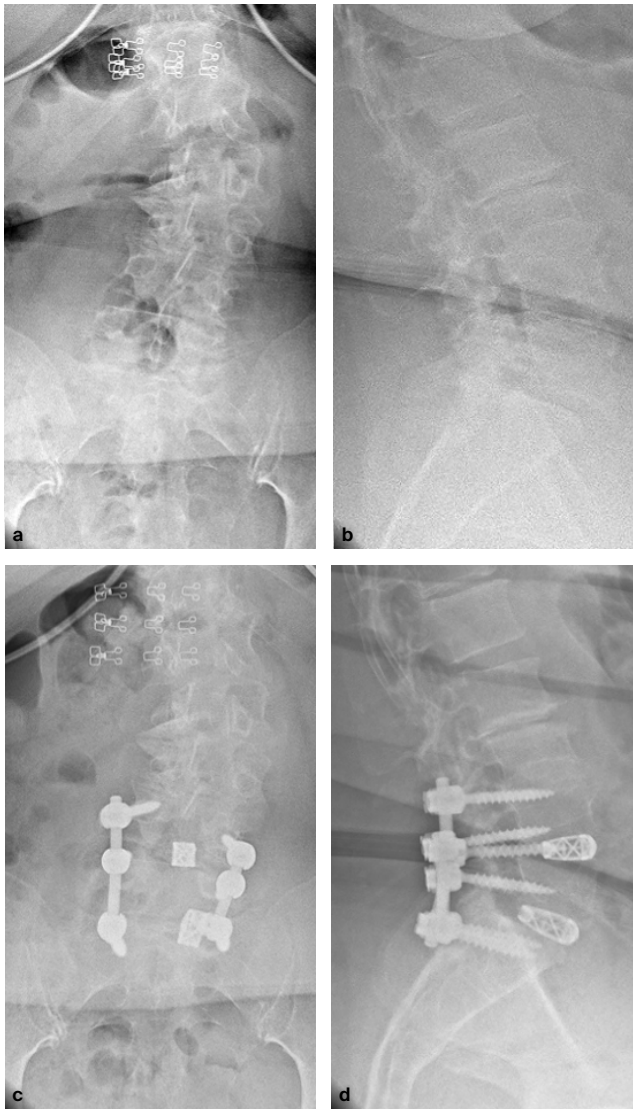

Fig 5.1 Preoperative (**a**, **b**) and postoperative (**c**, **d**) radiographs of 55-year old obese female undergoing L4-S1 posterior lumbar decompression and fusion with TLIF.

Comments from experts

KC:

After gram staining and culture of the wound discharge, debridement and thorough irrigation of the wound should be performed immediately. If extensive purulence and inflammation are found, continuous irrigation should be installed and maintained for at least a week. The patient should immediately start broad spectrum antibiotic (e.g., meropenem) and once the result of culture becomes available, change to sensitive antibiotics. If methicillin-resistant Staphylococcus aureus (MRSA) is found, the use of intravenous (IV) teicoplanin or linezolid for 3–4 weeks is recommended. When inflammation subsides, change to oral antibiotics, but if it persists, consider removing all the implants.

FCO:

Surgical debridement and irrigation should be performed, and the implants retained. Antibiotics according to the culture results should be used for 12 weeks, with at least one week of IV antibiotics depending on the microorganisms found. A second debridement may be necessary if CRP remains elevated after the initial debridement.

GM:

This is an established infection that occurred at the time of surgery. The protocol is to perform wound culture swabs and blood cultures, and assess antibiotic sensitivities with the assistance of an Infectious Disease (ID) physician consult. Aggressive wound debridement with excision of wound edges is then performed. The procedure consists of curettage of the wound, removal of any posterolateral bone graft, pulsatile lavage with 4 Liters of fluid, then reassess the wound followed by a Betadine wash and an additional 2 Liters of fluid irrigation. The spinal implants are retained and deep wound drain(s) are placed. The deep muscle and fascia are closed with mono-

Fig 5.2 Posterior lumbar wound with purulent drainage from superior aspect of wound.

filament #1 PDS. Superficial drain(s) are placed, and the subcutaneous tissue and skin is closed with 2-0 nylon in an interrupted vertical mattress fashion. A peripherally inserted central catheter (PICC) line is placed for IV antibiotics (broad spectrum then tailored to sensitivities) for 6 weeks, then transitioned to oral antibiotics for 6 weeks. The drains are removed after 5 days and the skin sutures are removed at 2 weeks.

VRM:
Gram stain and culture of purulent discharge should be performed in the emergency room with subsequent hospitalization of the patient. Emergent consultation with ID specialist and clinical pharmacologist is recommended. Blood cultures x3 along with lab tests for infection/inflammation should be ordered (i.e., ESR, CRP). Imaging should also ordered, including lumbar X-rays and lumbar magnetic resonance imaging (MRI) with and without gadolinium. Medical therapy should be initiated according to the above-mentioned specialists, with daily supervision to monitor antibiotic efficacy. Discussion with the initial treating surgeon, fellow, and residents may reveal the possible origin of infection, such as: glove torn during operation, intraoperative contamination, other similar infection(s) from the same day in the operating room, or unsterile instruments. Risk factors for the patient should also be noted: e.g., for obese patients, an operation is not performed at this time unless the ID specialist asks me about the need for reoperation, or our team consultation indicates that debridement with or without removal of instruments is recommended.

AJ:
Wound debridement and retention of the hardware, followed by 4 weeks of IV antibiotics and four weeks of oral antibiotics guided by intraoperative cultures if positive.

SR:
There is clear evidence of SSI in this patient and she should be counselled for admission and outcomes. Gram stain cultures from the wound and blood culture should be obtained in the emergency room and a thorough debridement should be done on the same day. We are in favor of doing a preoperative MRI in all cases requiring reoperation, as it often gives an indication of the extent of infection and the location of any collections. Intraoperative cultures would be obtained and an assessment has to be done regarding the severity of infection. If the muscles and tissues show evidence of infection, there is a role for leaving the wound open or applying a wound vacuum-assisted closure (VAC) for 48–72 hours, which has been very useful in our experience. We have had good results with the application of VAC even in early infections where there are a lot of tissue changes or where the cultures are not available with very good results. In all probability, the implants will be stable and can be preserved. The choice and duration of antibiotics should be according to the culture results.

ARV:
This case presents evidence of an early postoperative SSI. Typically, the patient would be examined in the clinic or emergency room with the following labs ordered: complete blood count (CBC) with differential, ESR, and CRP. An MRI with gadolinium contrast is ordered to assess for possible fluid collections and to determine treatment strategy and approach. If the patient is clinically stable, antibiotics are held until the patient undergoes irrigation and debridement in the operating room. Antibiotics are administered after deep and superficial cultures are obtained. Unless gross instability is noted, hardware is retained. The duration of intravenous antibiotics is routinely 4–6 weeks followed by oral antibiotics, which may be administered up to a year postoperatively depending on the patient's clinical response.

What was done

The patient was admitted to the hospital and underwent irrigation and debridement with retention of hardware and placement of postoperative drains. No gross purulence was seen above or deep below the fascia. Superficial and deep intraoperative cultures were sent and intraoperative gram stain showed gram positive cocci. Postoperatively, the patient was started on IV cefazolin after consultation with the infectious diseases team. Final speciation of intraoperative cultures showed MRSA, and the patient's antibiotic regiment was changed to IV daptomycin prior to discharge. The patient continued to improve clinically after discharge with downtrending ESR and CRP levels. After 6 weeks of IV daptomycin therapy, the patient was switched to oral doxycycline suppression therapy with a total duration plan of 12 months. The lumbar incision healed uneventfully and the patient was symptom free at the 6-month follow-up with no changes in hardware position (**Fig 5.3**).

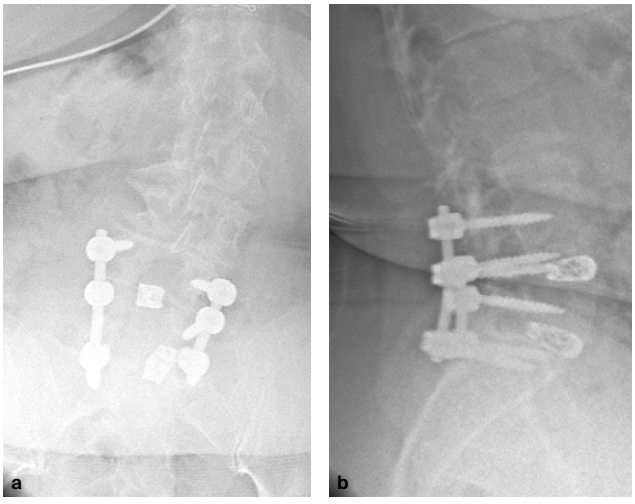

Fig 5.3 **a**) Anteroposterior and **b**) lateral lumbar radiographs showing no changes in hardware position at 6-month follow-up after irrigation and debridement for early post-operative infection.

Case 2

A 70-year old man with a five-year history of low back pain and bilateral buttock and posterior leg pain caused by instability and stenosis at L4/5 underwent posterior lumbar interbody fusion (PLIF) with pedicle screw instrumentation (**Fig 5.4**). He started to develop low back pain on postoperative day 5 and had a temperature of 38.5°C on postoperative day 6. Laboratory test results were: CRP 10.85 mg/dl, WBC 5.76 (x 10^3 / µL), and WBC fractions—neutrophil 64%, lymphocyte 20%. An MRI at this time showed no signs of infection. The patient was carefully observed. The patient continued to have low grade temperatures around 37.5°C and two days later, his labs were: WBC 6.33 (x 10^3 / µL), with 79.4% neutrophils and 11.0% lymphocytes, and CRP 15.11 mg/dl. At this point, a broad-spectrum antibiotic, meropenem, was started, and the patient underwent operative irrigation and wound debridement. No abscess or necrotic tissue suggestive of infection were found and implants were stable. The wound was irrigated with a large amount of saline and the wound was closed primarily. Intraoperative cultures were negative; however, blood cultures were positive for methicillin-resistant coagulase-negative staphylococcus (MRCNS) and the antibiotic was changed to teicoplanin and rifampin according to sensitivity testing. After the irrigation, his fever subsided, CRP decreased to 2.0–3.0 mg/dl, and WBC counts stayed within normal limits; however, % neutrophil remained high and % lymphocyte remained low, and moderate low back pain persisted. Sulfamethoxazole/trimethoprim was started and teicoplanin was changed to vancomycin. One month after the initial and three weeks after the second surgery, the patient spiked a fever reaching 39.0°C. Although the CRP remained relatively low at 2.32 mg/dl and the WBC at 3.15 (x 10^3 / µL), a repeat MRI showed increased T2 signal involving the L4 and L5 vertebral body adjacent to the cage, suggesting the presence of active inflammation and edema (**Fig 5.5**).

Comments from experts

KC:

This was my own case. MRI taken at postop day 5 when the patient developed fever was inconclusive, showing postoperative inflammation but without fluid collection indicating abscess. CRP was high but WBC was in the normal range. We decided to open the wound 2 days later because WBC fractions became suggestive of infection. During debridement, however, we did not find any signs of infection; screws and rods were stable, and cultures of surgical specimens were negative. We ultimately decided to remove the implant because blood culture was positive for MRCNS and follow-up MRI was suggestive of infection in the anterior spinal column. At the second exploration, there were also no signs of infection in the posterior deep wound and the implants were stable, so we removed the intervertebral cage only. This was a rare case of SSI, in which the infection was confined to the anterior spinal column only. If a similar case is encountered in the future, it would be important to examine the anterior disc space more carefully and remove the cage. Although anterior bone graft was unnecessary in this case, if a patient develops any clinical symptoms or imaging signs of screw loosening, iliac bone graft through an anterior approach should be considered.

FCO:

Immediate wound debridement and irrigation followed by antibiotics and retainment of implants. Although the initial interbody implant in this case was metal, the presence of polyether-ether-ketone (PEEK) implants may make it more difficult to predict the subsequent clinical course with this type of treatment. Although there is no evidence in the literature, it is my impression that polymer cages are more difficult to eradicate of infection than titanium cages and are one reason why primary SSI treatment may fail. If a second debridement is necessary, I would remove all implants including the cage, and put in new screws and a new titanium cage.

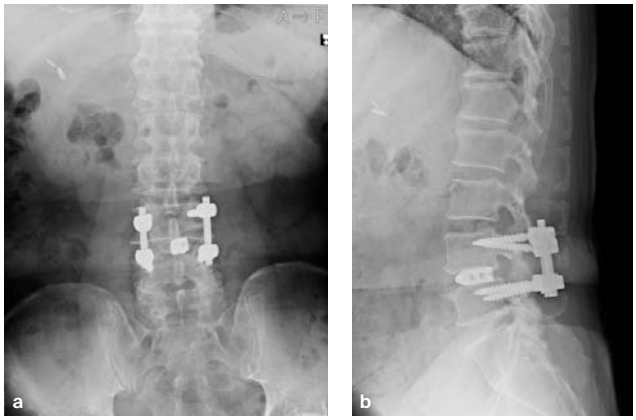

Fig 5.4 **a**) Anteroposterior and **b**) lateral lumbar views of L4-5 PLIF with posterior pedicle screw and rod instrumentation for degenerative spondylolisthesis

Fig 5.5 Repeat MRI obtained 1 month after initial surgery and 3 weeks after irrigation and debridement. **a**) Sagittal STIR showing increased bony edema and inflammation in L4 and L5 vertebral body and **b**) sagittal T1 showing decreased T1 signal in same area.

GM:
This is a rare case of early cage anterior column infection without involvement of posterior hardware or instability. First, I would remove the posterior rods and then distract the interspace to inspect the cage. It may be possible to easily remove the cage posteriorly, given the presence of inflammation/edema on the MRI. However, the dura may be friable or attenuated, and be at high risk for tearing and subsequent neural injury. In this case I would have a low threshold to turn the patient supine for an anterior approach, and remove the interbody cage. I would then turn the patient prone and place larger pedicle screws along with posterolateral bone grafting. I would brace for 6–12 weeks and give IV antibiotics for 6 weeks followed by oral antibiotics for 3–6 months for a tentative diagnosis of osteomyelitis. I would consider an anterior lumbar interbody fusion (ALIF) at 6 months only in the presence of increasing pain, instability, or deformity.

VRM:
Extensive surgery and removal of all implants, including pedicle screws and interbody cage, and possibly all grafting material. A thorough irrigation and debridement is then performed. A 70-year old male with a 39.0°C fever is clearly infected and there is no more time to wait and watch.

AJ:
Wound debridement and retention of the hardware followed by 4 weeks of IV antibiotics and four weeks of oral antibiotics guided by intraoperative cultures. Persistent infection would require removal of the cage by an anterior approach. I would avoid another anterior interbody graft or consider a titanium ALIF cage. I generally remove a PLIF cage or TLIF cage by an anterior lumbar approach to avoid scar tissue and nerve root injury.

SR:
This is a situation with an established infection in the anterior disc space with a metal cage. The MRI has also documented extension of the infection into the disc space. This will require an immediate debridement and removal of the cage. Computed tomography (CT) and MRI evaluation is routinely performed in all cases requiring debridement, to investigate the possibility of implant loosening and presence of collection. It is the protocol in our unit to do debridement of the disc space from the posterior approach only during the first debridement procedure. A bilateral TLIF approach with removal of the facets, distraction of the disc space, and use of microscope allows very thorough debridement; and we have found no specific need for a separate anterior approach. Following debridement, whether another cage will be introduced depends on the status of the end plate and the extent of infection. If the infection is florid, we avoid reinsertion of a cage or bone graft. We rarely remove the pedicle screws if they are stable, as this often increases perioperative morbidity. Instead, it is our practice to remove the screws, debride the screw tracts, and then reinsert new and larger screws.

ARV:
In this case, the patient did not improve after the initial early debridement. At this point, repeat imaging showed retained infection in the disc space in the setting of a metal cage. For this scenario, an anterior approach to the disc space with subsequent cage removal is an appropriate treatment strategy to adequately debride the infection. After removal of the cage and debridement of all infected material, if I had any concern that the posterior wound was involved with the infection process, I would also do a posterior debridement; but from the information provided I would not do it in this case. I would only use an autologous iliac crest strut bone graft as a grafting material for increased stability. The duration of intravenous antibiotics is routinely 4–6 weeks followed by oral antibiotics, which may be administered up to a year postoperatively depending on the patient's clinical response.

What was done

Due to persistent infection and failure of initial irrigation and debridement, the decision was made to remove the implants. During repeat surgical exploration, no abscess or necrotic tissue mass was found. The pedicle screw-rod construct was stable without loosening. On exposure of the disc space, the cage was found to be mobile and could be extracted easily. There was no purulence in the intervertebral space. The disc space was extensively irrigated and a drain was placed. The decision was made not to graft the interspace and wait until inflammation resolved. After cage removal, the patient's low back pain improved significantly and all lab data normalized by 4 weeks postoperatively. Antibiotic therapy was changed to oral minocycline and the patient was discharged. Minocycline was continued for 4 weeks after discharge. The patient wore a brace for a total of six months. The patient was informed that if instability developed, an anterior fusion with an autologous bone graft would be performed; however, this was unnecessary, and 4 years after the initial PLIF, the patient has not experienced implant failure and has no back or leg pain (Fig 5.6). He is able to walk as much as he wants and plays golf.

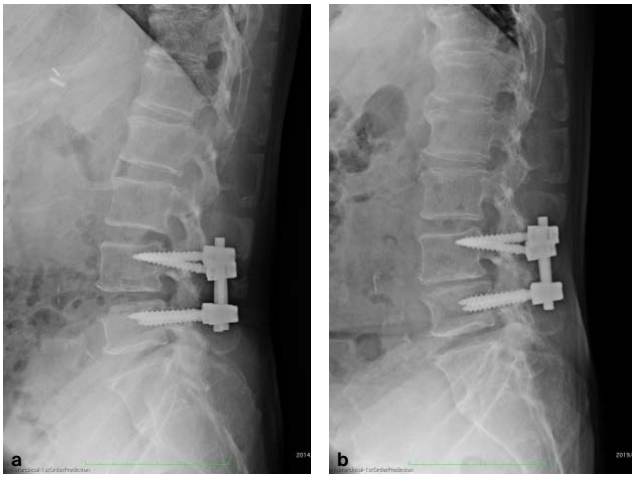

Fig 5.6 **a**) Postoperative lateral view immediately after cage removal and **b**) 4-years postoperatively.

Case 3

A 58-year old male was referred from a previous institution due to progressive back and leg pain in the setting of persistent postoperative infection. Three months prior to presentation, the patient underwent a posterior lumbar interbody fusion with PEEK cages with local autograft along with pedicle screw/rod fixation. The patient was subsequently diagnosed with an early postoperative infection at an outside institution and underwent surgical debridement and IV antibiotic treatment. All implants were retained at that time. Afterwards, the patient continued to have progressive back and leg pain. Repeat radiographs and a CT scan demonstrated loosening of the implants and significant bone loss leading to an obvious deformity (**Fig 5.7**).

Comments from experts

KC:
This is a patient with a three-month old chronic infection. The surgeon should remove all implants including the anterior PEEK cages, especially if the pathogen is MRSA. The patient should then be placed in a hard brace to minimize symptoms arising from instability. After a few months of antibiotic therapy and confirmation of subsidence of infection, a revision surgery with instrumentation should then be considered.

Fig 5.7 **a**) Lateral lumbar radiograph and **b**) sagittal CT scan of patient presenting with persistent infection after L5-S1 PLIF. Note the significant bony erosion on CT of the L4 and L5 endplates. Patient underwent irrigation and debridement with retention of all implants in the early postoperative period at an outside institution.

FCO:
In this case there is persistent infection after surgical debridement, along with radiological signs of bone loss and mechanical instability. All implants should be removed and a stable osteosynthesis should be created via an anterior support, either through the posterior incision or through an ALIF approach. Proper antibiotics should be administered for at least 12 weeks.

GM:
This is now an established chronic infection at 3 months postoperatively that failed initial wound irrigation and debridement. There is a high risk of dural tear and/or neural injury secondary to scarring if a cage removal is attempted via a posterior approach. This case requires a back-front-back revision surgery for instability. The first procedure involves removal of loose, infected pedicle-rod fixation with facetectomies, then an anterior approach is performed for removal of the PEEK cages under distraction, with insertion of a large wide-footprint ALIF cage (integrated or with buttress plate) given the associated bone loss. Then the patient is turned prone for insertion of larger pedicle screw-rod fixation with posterolateral grafting. IV antibiotics are administered for 6 weeks followed by oral antibiotics for 3–6 months.

VRM:
This is a case of an early infection. The patient should undergo flexion and extension plain X-rays to determine if there is instability. If instability exists, the implants should be removed and a re-instrumentation should be performed. The cage should be removed and no further bone grafting should be performed. IV antibiotic treatment followed by oral suppressive antibiotics should be provided.

AJ:
I would recommend a posterior debridement and removal of pedicle screws, followed by an anterior approach with removal of the interbody cage and four to eight weeks of antibiotics. After that, I would consider re-instrumentation of the spine if the L5-S1 interspace did not autofuse. I would re-instrument if the patient complained of severe mechanical pain 2–3 months after the initial removal of instrumentation.

SR:
This is an established infection of three months duration. The patient has already undergone an earlier debridement with retention of implants. The CT scan at present shows loosening of all the implants. We strongly feel that an MRI is essential in these patients, as it often provides valuable information regarding the extent of infectious involvement of bone and soft tissue, along with the location and size of any infectious collection. This will help us plan the surgery. Our plan for this patient would be to do a thorough debridement including removal of the PEEK cage. If possible, we would revise the pedicle screw instrumentation and if necessary, extend the instrumentation to the more proximal and distal levels. After a thorough debridement, we would consider placing a larger cage for enhanced stability. There is a definite role for VAC in this patient. After re-instrumentation, a wound VAC would be placed for a period of three to seven days followed by wound closure.

ARV:
The patient at this stage has failed treatment for an early postoperative infection and is now considered chronically infected. With significant loosening and bone loss that is visible on the CT scan, implant removal and re-stabilization is needed. An MRI would be ordered to determine the extent of infection. I would then proceed with a single-stage anterior and posterior debridement and stabilization procedure by first removing the PEEK cages through an anterior approach with placement of an autologous iliac crest strut bone graft. Posteriorly, the pedicle screws would be removed and upsized, or additional levels of fixation would be used until good purchase is obtained. Obtaining early stability in combination with guided antibiotic treatment is key for eradicating this infection.

What was done

The patient was taken to the operating room for irrigation, debridement, and revision surgery. At the time of surgery, all implants were removed including the interbody cages and bone graft. The patient was re-instrumented from L3-S1 with titanium mesh cages used at the L5-S1 disc space. Autologous iliac crest bone was harvested from the same incision and used as bone graft. Intraoperative cultures grew Propionibacterium acnes (P. acnes) and the patient was treated with intravenous antibiotics for 12 weeks. Fig 5.8 demonstrates postoperative imaging with new instrumentation and interbody cages. At 6 months, the patient still had some residual back pain but no radicular symptoms and negative blood markers for infection. X-rays at 6 months showed some subsidence of the mesh cages with signs of bony fusion at the L5-S1 level.

Fig 5.8 **a**) Anteroposterior and **b**) lateral lumbar radiograph after removal of infected PEEK interbody cages and posterior instrumentation at L5-S1 with placement of titanium mesh cages with autologous iliac crest graft and reinstrumentation from L3-S1

Discussion

As seen in case 1, the primary symptom of early infection is increasing, non-localized pain. Fever may be present but is not always a reliable indicator. Patients may also complain of associated chills, and generalized malaise. In addition, there may be significant pain with range of motion. Wound drainage is the most common sign of SSI, typically occurs around 10–14 days after surgery, and can be indicative of superficial or deep SSI.8 Other associated signs can include incisional warmth and erythema, tenderness to palpation, and edema.[9,10] Deep infections may lack many of these signs, further highlighting the importance of maintaining a high clinical suspicion. Laboratory tests are valuable in determining the diagnosis of infection. Patients may present with elevated WBC counts as well as escalating levels of serum inflammatory markers such as ESR and CRP. WBC fractions such as neutrophil count over 75% and/or lymphocyte count below 20% are highly suggestive of infection. While elevation of WBC levels may only occur in about 50% of cases, CRP and ESR are much more sensitive for determining infection.11 In particular, CRP typically normalizes one week after surgery, therefore persistent elevation after this timepoint is suspicious of infection.[11] One threshold used by the authors of this manuscript to indicate a suspected SSI is a CRP or WBC level higher than the post-operative day 2 value. Current evidence suggests that timely irrigation, debridement, and implant retention in early infections (< 30 days) provides the best potential for acceptable outcomes.[12] After this period, the chances of a mature biofilm formation increase significantly, resulting in difficulty with retaining implants. This is especially true in the case of resistant microorganisms such as MRSA or low-grade virulent microorganisms such as P. acnes.[13]

MRI with gadolinium remains the gold standard for diagnosis of SSI.[11] Compared to CT or positron-emission tomography (PET), MRI provides superior soft tissue contrast and does not use ionizing radiation. The most frequent findings of infection include a rim-enhancing fluid collection with low T1 signal and high T2 signal in the subcutaneous fat, paraspinal muscle tissue, or decompression site. The "pedicle screw sign" is a common term that refers to a fluid collection at the head of a pedicle screw seen on axial imaging and has a high sensitivity and specificity for diagnosing infection.[11] However, MRI also poses a significant challenge with early postoperative infection as fluid collections (e.g. seroma, hematoma, cerebrospinal fluid leak) or inflammatory changes are common after surgery. In addition, as highlighted in case 2, a fluid collection may not always be visible. Low T1 and high T2 signal changes to vertebral body indicate inflammation or edema and are suggestive of continued infection in this scenario.

For situations like case 3, extensive experience and principles from general orthopedic and trauma surgery can be utilized and adapted to the spinal column. Although most literature is about periprosthetic infections, implant infections after fracture fixation of the appendicular skeleton is a more appropriate comparison to spinal surgery. Akin to fracture fixation, implants in spine surgery provide stability until fusion, and are immobile unlike arthroplasty implants. Central aims of treatment for infected implants in trauma surgery have been summarized as: fracture consolidation, eradication of infection or in certain cases suppression of infection until fracture consolidation is achieved, healing of the soft-tissue envelope, prevention of chronic osteomyelitis, and restoration of functionality.[7] If we replace 'fracture' with 'spinal segment' then these principles are also valid for spinal fusion procedures. Similar to fracture fixation, implant stability is important for eradication of infection. The only scenario worse than a stable infection is an unstable infection. Therefore, it is better to retain stable implants and replace unstable ones. Implants such as arthroplasty devices or interspinous spacer devices should be seen as 'unstable' and should be removed. In case 3, the patient developed significant instability and deformity in the setting of persistent infection, which thus necessitated replacement of instrumentation with a more stable construct.

In general, management of surgical site infection depends on whether it is superficial or deep. Superficial SSI can be treated non-operatively in the majority of cases, initially with a trial of IV methicillin-resistant (Staphylococcus aureus) antibiotics for 48 hours, followed by oral antibiotics (flucloxacillin or clindamycin) for 7–10 days.[14] For patients with continued wound dehiscence, healing by secondary intention is appropriate. This may include the use of standard wet-to-dry wound dressings for superficial, granulating wounds, and negative pressure wound therapy (NPWT) for deeper wounds.

The key principles for treating a deep SSI include early identification and diagnosis. An MRI should be considered for any patient who requires an early debridement for infection. Loosening of implants can be determined at the time of surgery. In the setting of a delayed infection, a CT is also ordered to access fusion status and implant stability. In patients with equivocal signs of deep infection, broad spectrum antibiotics such as vancomycin and ceftazidime may be started.[14] This may be especially beneficial in preventing "over treatment" of spinal seromas that are easily confounded with spinal infections.

However, in cases with clear signs of deep infection, the essential first step in treatment involves thorough wound irrigation and debridement. If the patient is clinically stable, broad spectrum antibiotics can be deferred until after intraoperative cultures are obtained. After exposure is obtained, grossly purulent material and all necrotic tissue must be removed. Spinal implants are retained if the infection is determined to be early (<30 days postoperatively) and the implants are not loose. Implant retention is critical for preserving stability in cases where the fusion mass has not developed. Increased stability helps eradicate infection, prevent deformity and pseudarthrosis, and decrease pain. After culture specimens are obtained, broad spectrum antibiotics are initiated and tailored after subsequent identification of a specific pathogen. Intrawound vancomycin powder (500 mg to 2 g) can also be used at the time of wound closure.[15] Wound suction drains are used to drain accumulating fluid and obliterate dead space. If a patient is obese, placing an additional drain superficial to the fascia is beneficial. Drains are usually left in situ for longer than usual (e.g. 5 days as compared to 1–2 days for elective cases).

The total duration of IV antibiotics are important, with the standard postoperative treatment ranging from 4–6 weeks, followed by oral antibiotic suppression therapy.16 The duration of oral suppression therapy depends on the implants that were retained. For example, if interbody cages were retained, prolonged therapy lasting from 6 months to lifelong can be considered.[14] While IV vancomycin is still widely administered for treatment of MRSA infections, recent studies have suggested that due to the low bioavailability of vancomycin in musculoskeletal tissues, other antibiotic options may have increased bioavailability: linezolid, teicoplanin, sulfamethoxazole/trimethoprim, rifampicin, clindamycin, minocycline, and levofloxacin.[16]

In some cases of early post-operative infections where implants are retained, a second surgical debridement may be necessary. Usually this occurs in patients with significant medical comorbidities reducing immunocompetence such as diabetes or patients on chronic corticosteroids. The addition of antifungal therapy can also be considered in these patients. If an additional (third) debridement is required, implant removal may be necessary at this point. If a solid fusion has not occurred and there is persistent instability with the risk of deformity and neurologic deterioration, new implants can be placed. This algorithm is depicted in Fig 5.9. It is important for the surgeon to note that even in a solidly fused deformity case, removal of hardware can still result in a loss of correction. Interbody grafts usually do not require removal, however posterior instrumentation should be removed. The material of the implant may also play a significant factor. For example, PEEK implants are thought to have a higher proclivity for bacterial adhesion than metal surfaces such as titanium and therefore it may be clinically harder to eradicate infection in patients with PEEK implants.[17,18]

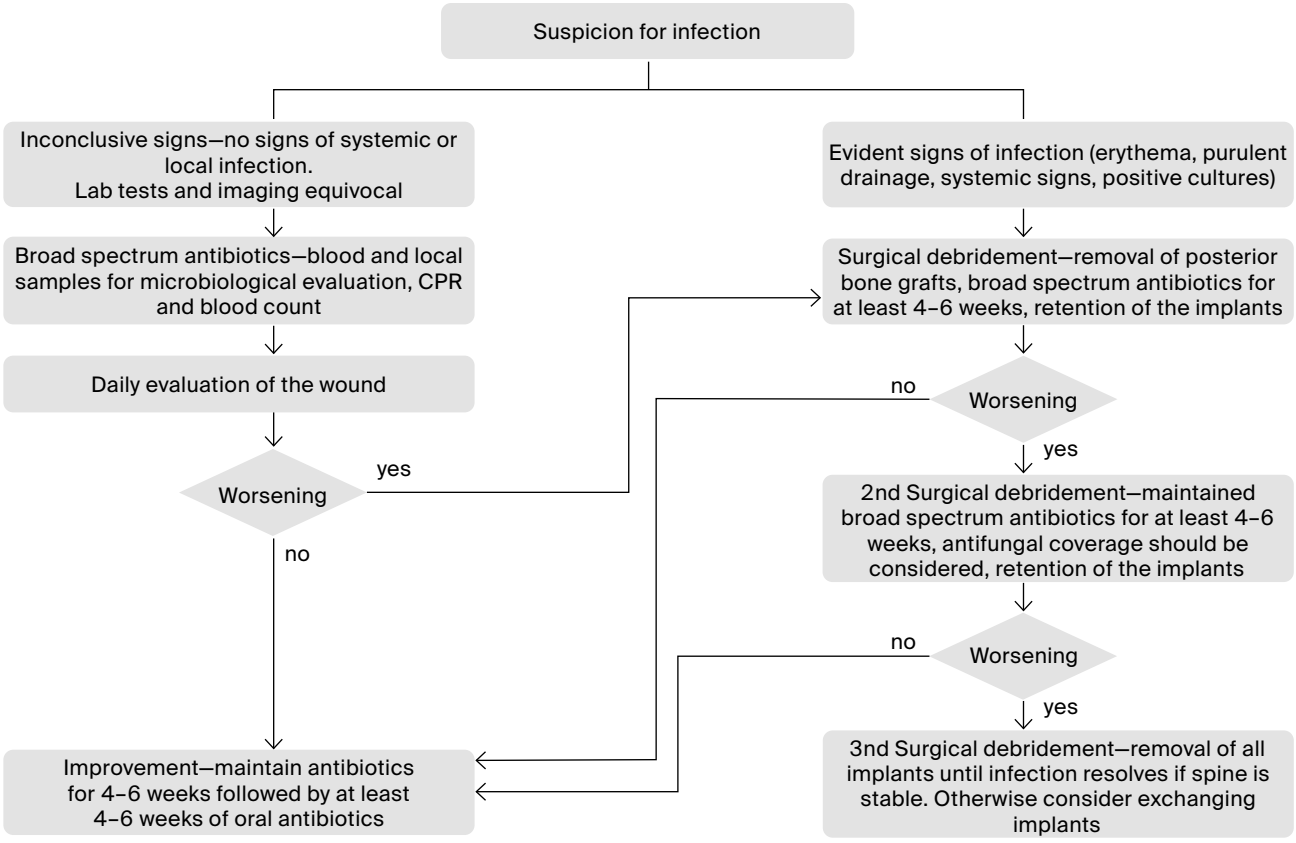

Fig 5.9 Suggested treatment algorithm

Tips and Tricks

- It is important to establish early diagnosis, explore the wound, and obtain specimens for culture.
- WBC fractions may be helpful for determining presence of infection: % neutrophil > 75% and/or % lymphocytes < 20%.
- Irrigation and wound debridement along with antibiotic therapy should be started as soon as possible and used aggressively.
- Important surgical techniques:
  - Excise skin edges.
  - Remove any infected loose tissue.
  - A large curette can be used to remove necrotic tissue until healthy, bleeding tissue is observed. If done early, by the time lavage is completed, bleeding will have settled.
  - If successful conversion to a clean wound is achieved, primary closure is preferred unless gross purulence is observed. The decision to close the wound is then decided on the second irrigation and debridement.
  - Close deep fascia with heavy monofilament suture.
  - Consider skin tension sutures in obese patients.
  - For skin closure use interrupted monofilament nylon rather than staples or a continuous monofilament suture. Consider heavier sutures (e.g. 2-0 nylon) that are more widely spaced.
  - If uncertain about wound integrity, consider negative pressure wound therapy for 72 hours, then return to operating room for reassessment.
- For early infections, implants should be preserved unless loosening is observed during surgery.
- Antibiotics should be tailored to the specific pathogen and sensitivity testing.
- If an interbody implant is infected, removal from an anterior approach followed by anterior autologous iliac crest bone grafting is suggested. The posterior wound is usually infected and therefore should be explored and irrigated with inspection of the instrumentation.

Conclusions

Early and accurate identification of a post-operative spine infection results in satisfactory outcomes when aggressive treatment with irrigation, debridement, and intravenous antibiotics is employed. At the time of surgical debridement, intraoperative cultures should be sent and all necrotic tissue and bone graft should be removed. Hardware can be retained, provided that it is not loose and spinal stability is maintained. Prolonged antibiotic therapy tailored to the specific pathogen should be continued. Failure to eradicate infection should prompt repeat surgical intervention with removal and exchange of implants with continued antibiotic therapy. Overall, early post-operative infection can be successfully managed with careful monitoring and intervention.

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