Infection is one of the most common causes of morbidity in the acute phase following lumbar spine surgery. Wound infections of the spine can have devastating consequences on the outcome after procedures such as a simple discectomy or a multilevel decompression and instrumentation fusion. Once identified, rapid and definitive treatment offers the best hope for restoring the patient to the normal recovery process. Prevention is clearly better than treatment for this unfortunate complication, which continues to occur relatively frequently even in the presence of aseptic techniques and prophylactic antibiotic agents. As our surgery-related ability to manage more complex spinal disorders improves, the unfortunate potential for wound complications increases because these procedures often require prolonged operations and multisegmental internal fixation.

In this review, we discuss the incidence, risk factors, prophylactic antibiotic regimens, treatment, and outcomes associated with postoperative lumbar infections. Special attention is given to the impact of modern instrumentation-based procedures on postoperative infection rates. Guidelines, compiled from a review of the literature, are offered for prophylaxis and treatment of this unfortunate complication.

### Epidemiology and Risk Factors for Spinal Wound Infections

The rate of spinal wound infection in the literature ranges from 0.7 to 11.9%. Simple discectomy or a multilevel decompression and instrumentation fusion. Once identified, rapid and definitive treatment offers the best hope for restoring the patient to the normal recovery process. Prevention is clearly better than treatment for this unfortunate complication, which continues to occur relatively frequently even in the presence of aseptic techniques and prophylactic antibiotic agents. As our surgery-related ability to manage more complex spinal disorders improves, the unfortunate potential for wound complications increases because these procedures often require prolonged operations and multisegmental internal fixation.

In this review, we discuss the incidence, risk factors, prophylactic antibiotic regimens, treatment, and outcomes associated with postoperative lumbar infections. Special attention is given to the impact of modern instrumentation-based procedures on postoperative infection rates. Guidelines, compiled from a review of the literature, are offered for prophylaxis and treatment of this unfortunate complication.

### Key Words
- wound infection
- revision surgery
- lumbar spine
- antibiotic prophylactic therapy

### Abbreviations used in this paper:
- CPR = C-reactive protein
- CT = computerized tomography
- MR = magnetic resonance
Effects of Malnutrition

Malnourished patients are at extreme risk for postoperative infections of the spine. Protein and protein–calorie malnutrition are associated with poor wound healing, increased postoperative infections, and immune suppression. Assessment of the nutritional status of a patient should include measurement of albumin, prealbumin, and total lymphocyte counts. A serum albumin level lower than 3.5 g/dl and a total lymphocyte count lower than 1500 to 2000 cells/mm³ indicate malnourishment. Because prealbumin levels more rapidly respond to the patient’s nutrition, they may be used in the inpatient setting as a measure of successful ongoing nutritional replacement.

Staged spinal surgery is significantly associated with changes in a patient’s nutritional status. Mandelbaum, et al., reported that 84% of patients undergoing staged anterior–posterior spinal surgery became malnourished during their primary hospitalization; 27 of the 28 reported postoperative infections occurred in this malnourished group. In a different study, the authors compared same-day with staged anterior–posterior spinal surgery. Sixty-four percent of patients in the staged group and 77% of those in the same-day group experienced malnourishment after surgery. Hospital stay was longer and the infection rate higher in the staged-surgery group. The authors stressed that although many patients in both groups developed malnutrition, those requiring a second procedure suffered a greater number of complications. They recommended same-day anterior–posterior surgery whenever possible.

DIAGNOSIS

Postoperatively patients frequently complain of discomfort associated with a posterior lumbar incision and muscle dissection. When this pain increases or occurs after a period of comfort, postoperative wound infection may have developed. Patients typically present initially with signs and symptoms of an infection after a mean of 15 days from the index procedure, and 93% present with wound drainage. In most, however, no fever is present. Wound inflammation is common, and rarely is the wound benign in appearance. Because there are no pathognomonic symptoms or signs, laboratory studies are useful in helping the clinician to establish the correct diagnosis. The mean sedimentation rate in patients in one study was 71.5 mm/hour. When faced with abnormal values, one should have knowledge of the normal postoperative course of recovery of these indices. In a study of patients who underwent uncomplicated spinal surgery, none of whom developed a postprocedural infection, the postoperative values for CRP and erythrocyte sedimentation rate were quantified. The CRP level peaked at 2 to 3 days postoperatively and normalized between Days 5 and 14. The erythrocyte sedimentation rate peaked on Day 5 but declined at a much more variable rate than CRP, often staying elevated at 21 to 42 days postoperatively. These indices are considered sensitive but not specific. They can be elevated by an infection at any site, but when combined with an inflamed or draining lumbar wound within the appropriate time frame, elevation in the CRP or erythrocyte sedimentation rate can aid in the diagnosis by indicating the presence of a postoperative wound infection.

Diagnostic Imaging Modalities

Plain radiography, CT scanning, and MR imaging are often of limited value in the diagnosis of a postoperative wound infection in the setting of internal fixation. Plain radiography can assist in determining the presence of indirect indicators of a spinal infection such as early implant loosening, rapid loss of adjacent-level disc space height, or abnormal soft-tissue swelling. Plain radiography will also detect the presence of a retained foreign body in the spinal wound. Both CT and MR imaging can demonstrate whether a fluid collection exists. Some authors have strongly supported the immediate use of contrast-enhanced MR imaging when an epidural abscess is suspected. It is not usually possible, however, to differentiate between a postoperative fluid collection in the form of a sterile seroma and a postoperative abscess. Some authors, however, have reported success with CT and MR imaging in distinguishing between blood, purulent material, and granulation tissue. Unfortunately, the presence of instrument-related metal artifact often makes these advanced modalities of little value.

Gadolinium-enhanced MR imaging is of value in detecting an early-onset postoperative discitis even in cases in which posterior hardware has been placed. One should note, however, that following operative manipulation of the disc space, an increase in postcontrast MR imaging signal intensity or edema may not be indicative of an infection but in fact may be a normal postoperative finding. Because there is no optimal imaging modality for detecting a postoperative wound infection, these studies should be used to provide additional information when formulating a diagnosis of a postoperative spinal infection.
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**ANTIBIOTIC PROPHYLACTIC THERAPY**

As with other procedures, spinal surgeries can be divided into clean, clean–contaminated, and contaminated cases. A clean case indicates that there is no break in sterile technique, no open wound, and no entry into the respiratory, gastrointestinal, or genitourinary tracts. These procedures carry a risk of postoperative wound infection generally less than 1 to 5% in most hospitals. Despite the low risk of infection, most spine surgeons administer antibiotic prophylaxis in clean procedures. The origins and support of this practice can be found in several oft-referenced studies from the neurosurgical literature. At Mount Sinai Hospital, the antistaphylococcal agent lincomycin given at the start of clean neurosurgical procedures reduced the infection rate from 5.1 to 2.3%.20 Horowitz and Curtin1 documented a drop in postoperative spinal infections in discectomy-treated patients from 9.3% in those not receiving antibiotics to 1% in those receiving lincomycin. A randomized, placebo-controlled double-blind trial of clindamycin was reported by Savitz and Malis,19 who documented an infection rate of 10.9% in the placebo group and one of 1.2% in the clindamycin-treated group.

In perhaps the most referenced study regarding antibiotic prophylaxis, Malis13 developed a new antibiotic regimen at Mount Sinai Hospital. The author reported using 80 mg of gentamicin intramuscularly and 1 g of vancomycin intravenously at induction of anesthesia, and 50 mg/L of streptomycin was added to the irrigating saline. In 1732 patients treated, no single case of infection occurred. In later work,18 cefazolin (which has the longest half-life of the first-generation cephalosporins [1.9 hours]) was found to be effective against all staphylococcal infections if administered before skin incision was made. The authors concluded that gentamicin and vancomycin were not necessary in routine spinal procedures and that the effect of cefazolin was benign and adequate in the majority of cases. No study has been conducted to address the specific length of time postoperatively that antibiotic prophylaxis should be continued, if at all. At our institution, we routinely continue coverage for a 24-hour period depending on the extent of the surgery and the presence of instrumentation. A longer therapeutic antibiotic course increases the chances for selecting out resistant organisms.

**MICROBIOLOGY**

*Staphylococcus aureus* is by far the most common organism found in postoperative spinal wound infections, followed by *Staphylococcus epidermidis*. Most infections are single organism; only 8.3% are mixed positive and Gram-negative organisms (Table 2). Prophylaxis with a first-generation cephalosporin is both logical and supported by the literature.25

**TREATMENT**

Nonoperative treatment of postoperative spinal wound infections is rarely indicated and is generally limited to significantly immunocompromised patients following an initial procedure involving irrigation and debridement to allow open-wound healing through secondary intention, dressing changes, and wound packing. Early detection of a postoperative wound infection and the tailoring of the choice of antibiotic agent to operative cultures are imperative. Aggressive nutritional supplementation in any patient with a spinal infection cannot be overemphasized. Eradication of infection, however, nearly always requires careful debridement. Debate continues in the literature regarding the need for serial debridements and for the proper way, if any, to close the skin and fascial defect. There have been no randomized controlled trials to study this issue; all reported studies are retrospective in nature and document success or failure with various techniques.

Debridement should consist of aggressive removal of all necrotic tissue and foreign materials such as sutures. Once the superficial layer has been debrided and irrigated copiously, the fascial layer should be inspected. This may be left unopened only if the surgeon is absolutely sure that the infection is only superficial, a certainty that we have found rarely exists. Once the deep layer is opened, debridement of necrotic muscle and significantly necrotic bone graft should be performed. Consolidating bone graft and instrumentation should not be removed unless the infection is not clearing with repeated debridements.3,16,22 Instrumentation serves to stabilize the motion segment, theoretically decreasing inflammation and promoting bone healing. Some authors do not agree with leaving instrumentation in a contaminated wound. One group found it necessary to remove instrumentation in 35% of patients with recalcitrant postoperative infections.1

Repeated debridements may be necessary depending on the extent of the infection, the appearance of the wound, and the causative organism. In a study of 46 postoperative spinal infections in 2391 patients, the authors reported success with the following regimen.24 All infections were debrided and irrigated with 9 L of bacitracin-saline solution. Superficial infections were closed over drains, but all deep infections were packed with gauze and left open and were retreated with debridement and irrigation at 48 hours. If the wound appeared healthy, it was closed over a drain, otherwise, repeated packing and debridement were performed. All bone graft material that appeared viable was left in place and instrumentation was not removed. Deep infections were treated with a 6-week course of intravenous antibiotic agents. All wounds healed without further sequelae.24

Other authors have recommended using inflow–outflow irrigation systems (so-called “feed me–drain me systems”) to treat these infections. In a review of 22 patients with postoperative spinal wound infections, Massie, et al.16 followed debridement with continuous irrigation for 5 to 10 days. Using persistently positive cultures to dictate repeated debridements, they reported eventual healing of

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**TABLE 2**

<table>
<thead>
<tr>
<th>Microorganisms causing postoperative neurosurgical infections*</th>
<th>Percentage of Infections</th>
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<tbody>
<tr>
<td><em>S. aureus</em></td>
<td>49</td>
</tr>
<tr>
<td><em>S. epidermidis</em></td>
<td>28</td>
</tr>
<tr>
<td>gram negative only (all organisms)</td>
<td>8</td>
</tr>
<tr>
<td>mixed gram-negative &amp; gram-positive</td>
<td>8.3</td>
</tr>
</tbody>
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all wounds. Levi, et al., reported 17 infections in 452 cases in which spinal instrumentation was placed. They recommended using suction-irrigation systems for all deep infections after operative debridement and reported success in all cases.

Recently, vacuum-assisted closure of postoperative spinal wounds after infection has gained in popularity, although only isolated reports have appeared in the literature. The technique involves placing an occlusive dressing over a suction drainage system. The vacuum effect draws the edges of the wound together and removes any purulent tissue (Fig. 1). Success has been reported on a limited basis, but further trials need to be performed to determine any potential benefit compared with repeated debridement and tertiary closure or flap closure.

In our institution, we return all patients with suspected postoperative infections to the operating room to undergo debridement and irrigation with 9 L of bacitracin-saline solution, routinely opening the deep fascial layers in all cases. If the wound infection is diagnosed early (within the first 1–2 weeks after surgery) and the bed appears healthy at the end of the debridement, the wound is often primarily closed over deep and superficial drains. If the wound does not appear healthy, the patient is septic or cachectic, or the infection is diagnosed late (>2 weeks postoperatively), packing and dressing changes are used until repeated debridement is performed at 48 to 72 hours. We avoid the use of retention sutures in this setting, because the skin can almost always be closed, and retention sutures serve only to limit egress of purulent fluid. Plastic surgery consultation is frequently requested when any question of wound coverage arises, to provide a team-based approach to wound care. Practitioners of infectious disease control are involved with every patient to guide antibiotic choice.

CONCLUSIONS
Every surgeon should experience a high index of suspicion for a wound infection in patients who have just undergone spinal surgery. Risk factors, in particular malnourishment, should be identified and addressed prior to an elective spinal surgery. If possible, the surgeon should strive to limit soft-tissue injury and operative time. Antibiotic prophylactic therapy consisting of a first-generation cephalosporin should be administered prior to skin incision. Postoperatively, patients should be encouraged to ambulate and avoid lying on the incision site for extended periods of time to limit swelling and edema. Once a postoperative infection is suspected based on clinical and laboratory data, aggressive treatment is indicated. There is little merit in the “wait and see” approach with empiric oral antibiotic agents. Debridement and culture-directed parenteral antibiotic therapy are essential to the eradication of infection, restoring patients to normal recuperation after spinal surgery.

References
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Fig. 1. Photographs showing the components of a commercially available vacuum-assisted device (left) and their application in a posterior lumbar spinal wound (right).
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