The Use of Vacuum Dressings for Dead Space Management in Deep Surgical Site Infections Allows Implant and Bone Graft Retention

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Abstract

**Study Design:** Retrospective, descriptive study.

**Objectives:** Managing early surgical site infection following elective lumbar spine surgery remains a challenge with controversy regarding retention of instrumentation and bone graft. Wound closure may also pose considerable challenges. We aim to report on our method of managing deep surgical site infections complicating elective spine surgery with surgeon assembled deep vacuum dressings. Identification of causative organisms with their sensitivities was a secondary objective.

**Methods:** Patients were identified from a prospectively maintained, single-surgeon database from 2003-2015. Patients who had an infective or trauma related diagnosis, cervical procedures, and were younger than 18 years were excluded. Records were reviewed to identify bacteriology, laboratory tests performed, antibiotics administered, and type and frequency of surgical management. One thousand two hundred twenty patients qualified for inclusion, with 19 identified as having developed acute wound sepsis.

**Results:** All patients had surgical debridement on the day of presentation and the majority of wounds were managed with a vacuum dressing. In all but 1 patient was instrumentation retained. Specimens for culture were taken at each debridement and antibiotics changed accordingly. Patients received a minimum 6 weeks of antibiotics.

**Conclusions:** The management of deep surgical site infection is labor intensive and frustrating for both surgeon and patient due to the unexpected prolonged admission. Management goals are identification and eradication of the causative organism with subsequent healing of the surgical wound. This process is enhanced with the use of negative-suction dressings made from theatre stock replaced at regular intervals and allows retention of bone graft and instrumentation in the majority of cases.

**Keywords**
surgical site infection, early onset infection, vacuum dressing, retention of instrumentation, retention of bone graft

Introduction

Deep surgical site spinal infections affect up to 1.3 in 100 primary degenerative spinal surgeries, and this figure triples in revision surgery. Although seemingly low incidence, when it manifests it prolongs in-hospital management, increases cost of care, and negatively affects outcome. Although many articles have been published on this topic, no clear definitive approach to manage this dreaded complication exists.

We present our experience and approach to management of deep surgical site infection with emphasis on dead space management. As risk factors for developing surgical site infections are well researched, they will not be discussed in depth.

Materials and Methods

A retrospective, observational study was performed on a single surgeon’s prospectively maintained database. Records from 2003 to 2015 were audited to identify those treated for acute surgical site infection. Adult patients older than 18

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having undergone elective thoracolumbar-, lumbar-, or lumbosacral procedures and developed wound infection within the first 3 months postoperative were included in the study. Patients were excluded if they had preexisting infection (discitis, spondylodiscitis, and chronic postoperative infection). As the senior author and sole surgeon seldom performs surgery on traumatic injuries and thus with only a small number in the database, these were also excluded from the study. Traumatic spinal injuries are associated with an increased risk of surgical site infection, but we felt that this small number of patients would not be representative of a true spinal trauma load.

Demographic detail, surgical site, elapsed time to diagnosis, laboratory investigations, and treatment methods were studied. Theatre and clinical notes were reviewed to record the treatment routine including the number of surgical debridements, surgical method, antibiotic treatment, and cultured organisms.

Clinical symptoms and signs of increasing surgical site pain, neurological deterioration, increasing erythema, and wound discharge alerted us to possible wound infection. A baseline quantified C-reactive protein (CRP) value was established. Where fever was the only presenting complaint, a full septic workup would follow including blood culture and urinalysis with microscopy and culture. On occasion, recovered central venous catheter tips were also investigated for organisms, though none of them had shown any growth. Time until definitive secondary wound closure and the absence of microorganisms from wound samples was recorded.

Results

Of the 3448 procedures in the database, 1220 qualified as adult elective thoracic, lumbar, or sacral. In these, 19 deep postoperative wound infections were identified, 7 being revision cases. In all cases, prophylactic antibiotics were given for 24 hours at the index procedure. Of the 19, 15 procedures involved the sacral area and only 3 procedures involved less than 2 vertebrae. Only one patient was a smoker at the time of surgery with 7 patients on treatment for non–insulin-dependent diabetes mellitus. The index surgery took an average of 217 minutes with a mean blood loss of 2553 ± 80 minutes with a mean blood loss of 2553 ± 1880 mL. Of the 19 cases, 4 involved pedicle subtraction osteotomies and 4 were for correction of scoliosis with extensive decortication to prepare for fusion. Unfortunately, it could not be established which of the patients had received allogenic blood transfusion. Closed suction drains were utilized in 11 patients and all were removed within 48 hours. Unintentional durotomy was recorded in 5 cases, though all were repaired at time of diagnosis. In all patients a mixture of auto- and allogenic bone graft was used.

Time of diagnosis was defined as the day of first surgical debridement as our policy was immediate intervention, with the mean time elapsed to diagnosis being 13.7 ± 9 days. As can be seen from Figure 1, clinical presentation was variable, with 11 patients presenting with a wound discharge. Four had ongoing wound swelling and a dull, crescendo-type pain. Of the remaining 4 patients, one had wound dehiscence, 2 increasing neurological dysfunction, and another presented with fever only. Altogether, 7 patients had fever as part of their presentation. A CRP was requested as soon as there was a suspicion of wound infection. The average CRP at first debridement was 122 ± 94 mg/L. As soon as the provisional diagnosis of deep wound infection was made (clinical signs together with a raised CRP), the patient was prepared for same-day wound debridement in theatre.

For the initial washout, patients were positioned in the prone position to ensure optimal access to the wound and facilitate the debridement process. Subsequent debridements were performed with the patient in the lateral decubitus position, thereby decreasing anesthetic requirements such as laryngeal mask instead of endotracheal intubation. Once the incision was opened, the first pus swab was opened and removed from the sterile packaging by the surgeon. Care was taken not to touch the tip or shaft of the pus swab. This minimized the risk of contamination. At least 2 swabs as well as tissue samples were taken at the onset of the procedure; these were immediately closed and handed off to the floor nurse. Specimens were taken from the superficial and deep layers, that is, above and below the erector spinae muscles. They were sent for microscopy, culture, and sensitivity. The anesthetist was then requested to administer an empiric choice of antibiotic intravenously.

In most instances the antibiotic of choice was cloxacillin, with a combination of amoxicillin and clavulanic acid used where cloxacillin was out of stock. Vancomycin or ciprofloxacin was used where penicillin allergy existed. The full spectrum of antibiotic use can be seen in Table 1.

![Figure 1. Clinical presentation.](image)

| Debridement Method          | Empiric | Sensitivities |
|----------------------------|---------|---------------|
| Autoclar                   | 5       | 2             |
| Ciprobroxide               | 6       | 8             |
| Cloxacillin                | 5       | 0             |
| Rifampicin                 | 7       | 4             |
| Vancomycin                 | 1       | 2             |
| Meropenem                  | 1       | 1             |
| Linezolid                  | 2       | 2             |
| Gentamycin                 | 1       | 1             |
| Cefapime                   | 1       |               |
| Colistin                   | 1       |               |
| Ertapenem                  |         | 2             |
| Bactrim                    |         | 1             |
| Tobramycin                 |         | 1             |
| Cefazadime                 |         | 1             |

![Table 1. Empiric and Culture-Specific Antibiotics Used.](image)
Irrigation was performed with a bulb syringe and warm saline, taking care to remove all hematoma and devitalized tissue. Bone graft was left in situ. In no case was instrumentation removed. When the decision was to close the wound definitively (when little fluid/pus and healthy looking tissue was present), closure was done with Vicryl 1 (Ethicon US, LLC, Gauteng, South Africa) for the deep muscle layer, 2/0 Vicryl for the subcutaneous fat layer, and 3/0 undyed Vicryl for subcutaneous skin closure. If a large pus collection was found or dehiscence of the deep muscle layer present, the wound was approximated, unsutured, with a vacuum dressing placed in the deep layer between the erector spinae muscles on the posterior elements of the spine.

The vacuum dressing was made up of readily available material: 6.3 mm perforated polyvinyl chloride drain tubing, Coldex sponge, Ioban incise drapes, skin clips, and general suction tubing. Where excessive sweating was expected or where the incision was very close to the intergluteal cleft, a frame of Comfeel Plus hydrocolloid dressing was also used. A “sandwich” was fashioned with the sponge, enclosing the perforated tubing, with the edges held together with skin clips. The sponge was further cut to shape and size to fit snugly into or onto the wound. With the first washout, the sponge was placed deep to the muscle and fascia. At subsequent debridements, if assessed as clean, the deep layer would be tacked and the vacuum reapplied in the superficial layer and finally on the skin once the wound closed. With the assistant securing the sponge to the wound, holding the tubing in the air off the skin, the incise drape was applied. No dressing was ever secured to the skin other than with the occlusive incise drape. Care was taken to fold the drape around the tubing in order to form a mesentery, allowing free movement of the tubing without disturbing the vacuum seal. At this point the tubing was connected to suction, the dressing activated and examined for leaks. The method of application is summarized in Figures 2 to 4. Where it was deemed necessary to use the hydrocolloid dressing, these were cut in 3- to 4-cm-wide wide strips and applied in the shape of a frame along the borders of the wound, prior to applying the rest of the dressing. From Figure 5, it is obvious how well the hydrocolloid dressing absorbs excess moisture, protecting the vacuum seal.

**Figures 2-5.** Sponge sandwich made from Coldex and polyvinyl chloride tubing (2, 3). Final appearance after applying Ioban incise drape and activating suction (4). Vacuum dressing applied over moisture-absorbing hydrocolloid dressing (5).
Repeat washout and debridement was done at 2.8 ± 1.8 day intervals, but on rare occasion it was necessary to reapply a new vacuum dressing in the ward. Out of 41 procedures, 27 involved application of vacuum dressings. Excessive dead space was managed with deep 6.3 mm perforated polyvinyl chloride drains in 7 procedures. Time elapsed from diagnosis of wound infection to time of definitive wound closure averaged 10 ± 15.4 days.

At time of diagnosing wound infection, no patient had evidence of other sources of infection, as confirmed by negative urine and blood cultures. Later, on follow-up cultures, several specimens grew organisms though only a very few of them were simultaneously found in the surgical site. Most notably were pseudomonas aeruginosa and klebsiella pneumonia ESBL (extended spectrum beta-lactamase producing), cultured in urine, and Serratia marcescens, cultured on blood samples. The majority of surgical specimens cultured gram negative organisms, as summarized in Table 2. It is important to note that organisms cultured at subsequent debridements changed in 6 patients, from gram positive to negative and vice versa. This stresses the importance of repeat wound samples at each and every theatre episode.

Antibiotics were administered for 6 weeks. This was initially intravenously but converted to orals once the wound was closed. In the rare situation where there were no oral options due to limited bacterial sensitivity, a subcutaneous port was inserted for prolonged outpatient intravenous administration.

Discussion

Overall, the incidence of surgical site infection in elective degenerative spinal surgery is low (1.4%), but this figure increases 65% with revision surgery (3.7%). In the lumbosacral area, the risk is further increased: 15 of 19 infected patients in our series had had lumbosacral procedures. It may be worthwhile to identify those at risk for infection as this will assist in stratifying the host and may aid the decision-making process with regard to risk to benefit ratios. Unfortunately, many high-risk patients will still require surgery. There can also be other unexpected causes. Two patients developed ESBL infections 2 weeks apart. Investigation discovered a long stay patient in the intensive care unit with this infection. As this was a de-escalation period during our festive season, our high care unit and intensive care unit had been consolidated and we ascribed the transmission to our patients as a breakdown in nursing care.

The mainstay of managing postsurgical infection is surgical debridement and systemic antibiotics. At the time of surgical debridement, it is important to avoid contamination of sampled specimens. Swabs should only be opened once needed, in a sterile fashion, and directly handed to the surgeon. After taking a pus/tissue swab and/or tissue specimen, it should be closed immediately in a sterile container and handed off. With each successive debridement, a new set of specimens should be taken. We found that there was often a change in bacteria present in the wound as management progressed, often requiring a change in antibiotics. One should follow-up on previously taken specimens even if a prominent bacterium has been flagged, as some organisms may manifest with prolonged culture.

As the offending organism may only be identified once culture is performed, one needs to empirically start based on the expected result. Gram positive bacteria are present in 85% of cases, whereas gram negative cultures are found in 30%. The most common bacteria reported to be present are Staphylococcus aureus, methicillin-resistant Staphylococcus aureus, and epidermidis and Staphylococcus epidermidis. It is therefore reasonable to commence a broad-spectrum antibiotic with adequate staphylococcal cover as soon as the first specimens have been taken. Based on available literature, cloxacillin combined with rifampicin is a good empiric choice, with vancomycin indicated where penicillin allergy exists. It has also been advised that vancomycin be given where infection sets in after revision surgery, as these infections are often caused by methicillin-resistant organisms. Adding rifampicin has been shown to increase the cure rate of infections caused by staphylococci, though its efficacy has been found to be unpredictable in some studies. It is also useful to synergistically potentiate antibiotic glycocalyx penetration when instrumentation is present. Duration of antibiotics is a contentious issue, but most studies support a treatment course of 6 weeks. This should still be individualized to the patient’s response to treatment. During the course of treatment, clinical response can be monitored with weekly CRP values, which is expected to dramatically decrease as the bacteria are eradicated.

As there is often an area devoid of tissue and bone following spinal surgery, dead space management is an important component of eradicating infection. This dead space is caused by surgical exposure, resection of the posterior elements for decompression, and restoration of lordosis. The potential space allows hematoma to form, creating the perfect growth medium for organisms. Management should be directed at decreasing the potential space and removing excessive fluid, without putting tissues under tension. This can be accomplished with a vacuum dressing applied after irrigation and debridement of the surgical wound.

The mechanisms by which vacuum dressings assist with wound healing consist of removal of excess interstitial fluid,
stimulation of growth by mechanical stimulation, maintenance of a moist wound environment, and decreasing the number of colony forming organisms.\textsuperscript{16,17} Fortunately, application of a negative pressure dressing is easy and can be made up of everyday theatre supplies. Basic requirements are the following: porous hydrophilic sponge, rigid suction catheter (to prevent collapse from negative pressure), and occlusive, nonpermeable dressing. We have found it useful to add a frame of hydrocolloid dressing before applying the occlusive dressing, especially where the wound is close to the intergluteal crease. This serves to absorb sweat and wound fluid, thereby retaining an airtight seal. This dressing is replaced at 3- to 5-day intervals, most often coinciding with the times of surgical debridement. It has been shown in other surgical disciplines\textsuperscript{18,19} that both time to wound healing and hospital stay is significantly shorter where vacuum dressings are used as opposed to conventional wound dressing. Intuitively, one would also expect that the number of surgical debridements would therefore also be decreased. Based on our own as well as previously published series,\textsuperscript{20} one can expect to perform 2 to 3 debridements on average on patients where vacuum dressings are also utilized.

Only one of the patients in our series required removal of instrumentation at 13 months following the index procedure, with complete resolution of his methicillin-resistant \textit{Staphylococcus aureus} infection. Retention of instrumentation in the infected spine is supported by numerous studies,\textsuperscript{2,21} but removal may have to be considered where there is ongoing infection in a stable spine with solid bony fusion. During wound debridement, no conscious effort was made to remove bone graft. As bone graft placement is not only limited to posterior elements but also often used to achieve interbody fusion, removal may be counterproductive and risk nonunion. Opinions on this topic appear to be divided, though sufficient data exists to support leaving bone graft in place.\textsuperscript{22,23}

**Conclusion**

The management of surgical site infection following spinal surgery is labor intensive and frustrating for both surgeon and patient due to the unexpected prolonged admission. The goals of management are identification and eradication of the causative organism with subsequent healing of the surgical wound. This process is enhanced with the use of negative-suction dressings made from theatre stock replaced at regular intervals and allows retention of bone graft and instrumentation in the majority of cases.

**Authors’ Note**

Ethics approval was obtained from the Human Research Ethics Committee, University of Cape Town: HREC 120/2016, substudy linked R039/2013.

**Declaration of Conflicting Interests**

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