Infection prevention in cervical spine surgery

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Contributions: (I) Conception and design: IS Aleem, A Nassr; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Surgical site infections (SSI) following cervical spine surgery can lead to significant patient morbidity and costs. Prevention of SSIs is multifactorial and can be divided in to preoperative patient optimization and intraoperative surgical factors. We performed a literature review to identify methods that can be used to prevent SSI development specifically in the cervical spine. We also present specific surgical pearls and techniques that have the potential to significantly decrease rates of cervical SSIs.

Keywords: Surgical site infection (SSI); cervical spine; infection

Submitted Nov 10, 2019. Accepted for publication Nov 23, 2019.
doi: 10.21037/jss.2020.01.13
View this article at: http://dx.doi.org/10.21037/jss.2020.01.13

Introduction

Surgical site infections (SSIs) result in significant patient morbidity and costs (1,2). The Centers for Disease Control and Prevention (CDC) classifies SSIs into incisional and organ/ space; incisional SSIs are further subdivided into those involving the skin and subcutaneous tissue only (superficial) and those involving deep soft tissues (e.g., fascia and muscle). Organ space would include involvement of any part of the deeper anatomy (e.g., bone) manipulated during the surgery (3). In the cervical spine, rates of SSI may be as low as 1% in anterior cervical surgery and up to 18% in posterior cervical surgery (4,5). Specific variables identified preoperatively, intraoperatively, and postoperatively have been identified that can significantly decrease rates of SSIs. A significant number of spinal infections could potentially be averted with appropriate screening and optimization of preoperative risk factors (6). This review focuses on preoperative patient optimization and surgical (intraoperative) factors that can be utilized to prevent SSI, with particular focus on posterior and anterior cervical spine surgery.

Preoperative optimization

The need to optimize patients preoperatively with the goal of improving surgical outcomes is widely recognized. From an infection standpoint, preoperative optimization includes smoking cessation, glycemic control, malnutrition/ obesity management, and screening and decolonization of organisms (7,8).

Smoking cessation

Tobacco smoking is associated with higher perioperative complications and morbidity postoperatively. Smoking significantly increases the risk of SSI after spine surgery by several mechanisms including vasoconstriction and local tissue hypoxia (6,9-11). In a study looking at 160 patients following anterior cervical corpectomy, Lau *et al.* found that smoking is independently associated with higher perioperative complications, and current smokers had a significantly higher rate of infections compared to nonsmokers and quitters (12). There is still a benefit to having patients quit smoking prior to surgery, demonstrated by a study that found that surgical complications were nearly halved in patients who stopped smoking prior to surgery compared to current smokers (13). Smoking cessation is a critical modifiable risk factor and should take place at least 4 weeks prior to surgery to be significantly important in decreasing infection risk (14).

Diabetes and glucose control

Diabetes mellitus is a chronic multi-system disease that directly affects both the peripheral nervous system and the microvascular system. Poor wound healing complications secondary to diabetes have been well described, although studies have focused more on the lumbar spine (15). Meng *et al.* showed significantly higher rates of infection among diabetic patients compared to nondiabetic patients after spine surgery in general (OR 2.04; 95% CI, 1.69–2.46) (7,16). In the lumbar spine, patients with a hemoglobin (Hb) A1C level of 7.5% or above had a significantly higher risk for development of SSI compared with those with HbA1C level less than 7.5% (OR 2.9; 95% CI, 1.8–4.9; P<0.01) (17). In an assessment evaluating key predictors of perioperative complications in patients with myelopathy, Tetreault *et al.* performed a survey of the AOSpine community and found that in 916 participants, 95% of respondents felt that the presence of diabetes are at higher risk for developing wound infections (18). Worley *et al.* performed a retrospective study of over 5,900 surgical cervical spondylotic myelopathy patients and found that diabetes is an independent driver associated with extended hospital length of stay and peri-operative complications. Although type and severity of diabetes was not a predictor for complication, patients with insulin-dependent diabetes were associated with an increased incidence of wound complications specifically (19). Another recent NSQIP study showed that patients with diabetes and higher ASA class were at increased risk for extended hospital length of stay and readmission within 30 days (20). Another NSQIP study of over 5,000 patients, however, did not find diabetes to be predictive of developing SSI in the cervical spine (21). Further study is required to specifically delineate the relationship of blood glucose monitoring and development of SSI in cervical spine surgery to inform guidelines.

Obesity

Although obesity is a well-known risk factor for development of SSI following lumbar spine surgery (7,22,23), less is known with regards to impact of body mass index (BMI) and cervical spine surgery. In a recent study looking at BMI and posterior cervical fusions, Sridharan *et al.* found significantly higher rates of deep SSIs (OR 4.61, P<0.05) in patients with a BMI ≥35.0 *vs.* BMI <25.0 (24). In a NSQIP study of over 5,000 patients, Sebastian *et al.* found that BMI >35, chronic steroid use, albumin <3, and hematocrit <33 were all associated with significantly higher rates of SSI in posterior cervical surgery (21). Similar to the lumbar spine, increased tissue necrosis from retraction injury in posterior cervical surgery may be a contributing factor (25). Further, increased BMI makes surgical exposures larger and more difficult thus increasing retraction time and operative time, resulting in seroma formation and prolonged wound drainage (26,27). Mehta *et al.* found that thickness of subcutaneous fat is an independent risk factor for infection in cervical spine surgery (28). Further, even in obese patients, malnutrition and hypoalbuminemia can be present (29), due to inadequate protein intake despite excessive calorie consumption (6).

Preoperative bacterial screening

Gram positive bacteria are the most common organisms in spinal SSI (30). Due to the continued preponderance of methicillin-sensitive S. aureus (MSSA) and methicillin-resistant S. aureus (MRSA) SSIs, current prevention screening protocols focus on these organisms. Nasal swab with culture 30 days prior to surgery may be obtained. Specific protocols may vary and be surgeon or center-dependent, but one protocol for patients with a positive culture is to treat with a 5-day course of 2% mupirocin ointment twice daily, combined with 2% chlorhexidine gluconate scrub daily for 5 days preceding surgery (6,31-33).

Preoperative antibiotics

Effective preoperative antimicrobial prophylaxis depends on the type, timing, dose, and redosing of the antibiotic (34-37). The timing and administration of prophylactic antibiotics within 30 minutes of surgical incision has been shown to significantly decrease the risk of SSI when compared to the timeframe of 30–60 minutes prior to incision (38). The standard antibiotic of choice is cefazolin, a first-generation cephalosporin, targeting treatment of gram positive bacteria (staphylococcus) (39). Antibiotic dosage needs to be adjusted appropriately in obese patients (40,41), with redosing every 4 hours (42).

Posterior cervical spine surgery

Posterior cervical spine surgery carries a much higher infection risk compared to anterior cervical procedures, with a reported infection rate up to 18% (5). This seems to be approach related, as opposed to the specific operation itself, as was found in a study comparing SSI rates in posterior cervical decompression *vs.* laminoplasty *vs.* arthrodesis in a NSQIP cohort of over 5,000 patients (21). Several potential factors contributing to the dramatic increase in infection for posterior cervical approaches include stripping of paraspinal cervical muscles and formation of dead space due to inadequate soft tissue approximation during wound closure. We present below some specific surgical techniques utilized by the senior author (KDR) during exposure and closure, that have dramatically lowered if not eliminated infections related to posterior cervical spine procedures, regardless of the case (43). Since 2005, in over 1,000 posterior cervical cases, there has not been a single posterior post-operative infection following the techniques below.

Skin preparation

Skin preparation begins with the patient shaving 1 to 2 days before the surgery, which allows the skin to heal and eliminates loose hair in the operating room. The surgical site is squared off with plastic drapes and preliminary preparation with alcohol foam is used over the surgical site and the surrounding plastic drapes. Preoperative skin preparation with iodine, chlorhexidine, and alcohol compounds are the most commonly used preparations used to sterilize the skin just prior to skin incision. In a recent meta-analysis, Sidhwa *et al.* found that alcohol-based agents are generally superior to aqueous solutions (44). Use of either DuraPrep or ChloraPrep therefore would provide adequate intraoperative skin preparation.

Exposure

The senior author (KDR) routinely uses a microscope from skin incision to wound closure. During exposure, the dissection is carried out using monopolar electrocautery on "cut" and every effort is made to preserve tissue vascularity and minimize trauma. Dissection is maintained in the avascular, amuscular midline plane to minimize bleeding and the need for electrocoagulation. Positioning the neck in flexion, if not otherwise contraindicated, significantly helps with maintaining the dissection in the avascular amuscular plane. Once this is carried down to the bifid spinous processes, the lateral tissue attachments of the bifid processes are preserved, and the tip of the bony bifid processes are cut with a bone cutter. The paraspinal muscle, attached to the tip of the cut spinous process is tagged with sutures and dissected sub-periosteally. These tips of the bifid processes attached to paraspinal muscles will serve as muscle anchor points and facilitate muscle re-approximation during the wound closure stage. Use of smooth self-retaining retractors are recommended, as opposed to sharp retractors. It is preferable to use hemostatic agents and cottonoid patties for hemostasis, as opposed to electrocautery whenever possible to minimize creation of de-vascularized tissue. Throughout the procedure, frequent irrigation is used to keep the tissues moist and to wash away any bacteria.

Closure

During closure, intra-wound vancomycin and cefazolin powder (1 gram, each) is routinely applied. If a gram-negative organism is suspected or the patient is allergic to cephalosporins, one can use Tobramycin (nebcin 7 mg/kg for patients with normal renal function). Dilute betadine irrigation may be considered as a simple, yet inexpensive form of SSI prophylaxis (45). Topical vancomycin provides a high local concentration of vancomycin with minimal systemic absorption. Intrawound vancomycin powder is applied subfascially, as well as suprafascially and provides a high local concentration of vancomycin (46-50). Surgical drain is placed to decrease post-operative seroma/hematoma formation. The use of intra-wound antibiotics and drains will substantially decrease but not eliminate infections. To eliminate infections, a multi-layered closure to eliminate dead space must be accomplished. The paraspinal muscles are first re-approximated by suturing around the "tagged" bifid processes during initial exposure on either side using 0-Vicryl suture and tying them together to pull the muscles back to the midline. The muscle sheaths, and not the muscle itself, is then pulled together using 0-Vicryl sutures to strengthen the muscle re-approximation. The fascial layer is then tightly closed with interrupted sutures in multiple layers. Subcutaneous layers are then brought together using 2-0 Vicryl sutures. Of note, each layer is tacked down to the previous layer, obliterating the dead space which can be space for hematoma, seroma, or nidus for infection. The skin is closed with a running 3-0 Monocryl suture and reinforced with Steri-strips and sterile dressing. In the senior author's clinical practice, it is not unusual to use over 140 sutures to close a 6" posterior cervical wound.

Surgical drain is removed when output is less than 30 cc per 8-hour shift, and postoperative antibiotics are continued for 24 hours post-operatively. Using the above technique will result in elimination of SSI in all but the most heavily contaminated cases.

Anterior cervical spine surgery

SSI associated with anterior cervical spine procedures are much rarer than posterior cervical SSIs with a reported prevalence of 0.1% to 1.6% in the literature.(51) Patients with anterior cervical SSI may present with neck and throat pain, incisional erythema and induration, wound drainage, fevers, chills, odynophagia, dysphagia, and possible neurological deficit due to epidural abscess. Further, anterior cervical SSI can often be present in the setting of esophageal injury, which is also very rare with an estimated prevalence of 0.02% to 1.15% of anterior cervical cases (1). Esophageal perforation should be ruled out when anterior cervical SSI is encountered and prompt treatment should be carried out to optimize clinical outcomes.

Like other spine surgeries, long operative time is a risk factor for anterior SSI due to increased bacterial load from the open wound, and specifically greater than 3 hours for anterior cervical surgery. After transverse incision along a neck crease and splitting of the platysma, meticulous dissection in the avascular plane between the anterior cervical musculature (specifically, the avascular plane between SCM laterally and strap muscles medially) can help to minimize surgical dead space and reduce formation of post-operative seroma/hematoma which can serve as a nidus for infection. Adequate release of longus coli muscle cuffs bilaterally and proper retractor placement can help to optimize surgical exposure and minimize the risk of iatrogenic esophageal injury. Excessive retraction of the tracheoesophageal bundle should be avoided and intermittent release of retractors during surgery can help to reduce post-operative dysphagia. The high-speed burr should not be used outside the disc space due to the potential risk of prevertebral soft tissue getting caught by the shaft of the high-speed burr and possible esophageal injury. During closure, vancomycin and ancef powder can be placed in the wound to further reduce risk of infection. This is used whenever we place intrawound steroids to decrease dysphagia. The senior author (KDR) prefers to use a ¼" Penrose drain, which has a larger diameter and is less likely to be clogged. The closure is performed carefully with approximation of the platysma and the skin.

Conclusions

SSI following spine surgery may lead to significant morbidity, mortality, and healthcare costs. Preoperative optimization includes smoking cessation, strict glucose control, weight loss, nutritional optimization, and MRSA decolonization. Intraoperative optimization includes preoperative antibiotics, skin antisepsis, meticulous dissection and closure, betadine irrigation, vancomycin powder, and use of closed suction drains. With careful attention to patient and surgeon factors, it is possible to significantly reduce SSI rates following spine surgery.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Lee A. Tan and Ilyas S. Aleem) for the series "Advanced Techniques in Complex Cervical Spine Surgery" published in *Journal of Spine Surgery*. The article was sent for external peer review organized by the Guest Editors and the editorial office.

Conflicts of Interest: The series "Advanced Techniques in Complex Cervical Spine Surgery" was commissioned by the editorial office without any funding or sponsorship. LAT serves as the unpaid editorial board member of *Journal of Spine Surgery* from Jan. 2019 to Jan. 2021. LAT and ISA served as the unpaid Guest Editors of the series. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Aleem IS, Tan LA, Nassr A, Riew KD. Infection prevention in cervical spine surgery. J Spine Surg 2020;6(1):334-339. doi: 10.21037/jss.2020.01.13