

# Risk Factors and Prevention of Surgical Site Infections Following Spinal Procedures

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## Abstract

**Study Design:** Focused literature review.

**Objective:** The objective of this article was to help identify potential risk factors as well as strategies to help prevent surgical site infections (SSIs) in spine surgery.

**Methods:** An article search was performed using PubMed, EMBASE, and the Cochrane database of systematic reviews using the terms “surgery” OR “surgical” AND “spine” OR “spinal” AND “infection”. Systematic review articles, meta-analyses, and clinical trials with more than 100 patients were reviewed.

**Results:** Both patient and perioperative factors contribute to the development of SSIs. Patient factors such as smoking, obesity, diabetes, Methicillin-resistant *Staphylococcus aureus* (MRSA) colonization, and malnutrition are all modifiable risk factors that can lead to SSIs. Procedural steps, including preoperative MRSA screening and treatment for colonization, preoperative antibiotics, skin preparation, minimizing operative time, antibiotic or betadine irrigation, avoiding personnel turnover, and postoperative wound care have also been shown to decrease infection rates.

**Conclusion:** There are several measures a spine practitioner may be able to take in the preoperative, intraoperative, and postoperative settings. Protocols to counsel patients regarding modification of preexisting risk factors and ensure adequate antimicrobial therapy in the perioperative period may be developed to reduce SSIs in spine surgery.

## Keywords

spine infection, postoperative infection, surgical site infection, spine surgery

## Introduction

Surgical site infections (SSIs) are a potential source of patient morbidity and medical expenditures in spine surgery. Cited rates of SSI for spinal procedures range from 0.4% to 15%.<sup>1,2</sup> The cost to treat these complications may be as much as \$20 785 per patient.<sup>3,4</sup> It has been reported that 156 862 of these infections could be potentially averted with screening of certain preoperative risk factors, the understanding of managing postoperative spine infections starts with the decisions made before and during surgery.<sup>4,5</sup> In this review, we discuss both patient and procedural factors that increase the risk of SSIs in spine surgery and propose a protocol that may be implemented to reduce infections.

## Methods

An article search was performed using PubMed, EMBASE, and the Cochrane database of systematic reviews using the terms

“surgery” OR “surgical” AND “spine” OR “spinal” AND “infection”. Systematic review articles, meta-analyses, and clinical trials with more than 100 patients were reviewed.

## Results

### Patient Factors

**MRSA Colonization.** The most common organisms in SSIs are *Staphylococci*, *Streptococcus*, and *Enterococcus*<sup>1</sup> although gram-negative pathogens have been reported in up to 46.5%

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of SSIs,<sup>6,7</sup> and up to 48% are polymicrobial.<sup>6</sup> These infections may be avoided with the appropriate preventative measures. Methicillin-resistant *Staphylococcus aureus* (MRSA) is involved in as many as 19% of spine SSIs, and result in longer lengths of stay and additional treatment procedures compared with infections with other organisms.<sup>3</sup> Common MRSA prevention protocols recommend nasal culturing occurs 30 days prior to surgery and patients with a positive culture undergoing a 5-day treatment with mupirocin; this is combined with the use of chlorhexidine gluconate scrub to be used by all patients for daily bathing in the 5 days preceding operative intervention.<sup>8-10</sup> If a patient's MRSA colonization status is unknown but they are determined to be at high risk due to antibiotic use within the past 3 months, hospitalization during the past 12 months, a skin or soft-tissue infection at admission, or human immunodeficiency virus infection, the addition of vancomycin to cefazolin may reduce perioperative infections.<sup>11,12</sup> The concurrent use of cefazolin is recommended due to the bacteriostatic nature of vancomycin, with relatively low efficacy against non-MRSA *Staphylococcus* species.

**Malnutrition/Hypoalbuminemia.** Preoperative albumin levels may give the clinician insight into a patient's nutritional status prior to surgery. Albumin levels have been reported to be independent risks factors for delayed wound healing as well as readmission.<sup>3,13-16</sup> Hypoalbuminemia defined as less than 3.5 g/dL has been identified as the cut off for malnourished patients.<sup>13</sup> In a retrospective ACS NSQIP (American College of Surgeons National Surgical Quality Improvement Program) database study performed by Bohl et al<sup>13</sup> of 4310 patients, hypoalbuminemia was associated with infection and wound complications in the setting of lumbar fusion. Interestingly, malnourished can also present with obesity.<sup>13</sup> The precise mechanism for malnutrition in obesity has not been entirely delineated but is believed to be associated with an inflammatory process, which results in lower serum albumin levels.<sup>17</sup> Obese individuals may also have inadequate intake of protein despite the consumption of excessive calories.

**Diabetes.** Several studies identify diabetes as a risk factor SSI, likely due to compromised microvasculature. Olsen et al<sup>18</sup> reported that patients with diabetes have an 8-fold increase (odds ratio = 8.4) in developing a postoperative infection as compared with nondiabetics.<sup>18</sup> Specifically, adverse perioperative events have been reported in patients who have serum blood sugars >200 mg/dL.<sup>19</sup>

**Obesity.** Obesity has been frequently identified as a risk factor for postoperative spinal infections. Abdallah et al. reported a 21% increased risk of spinal SSI with a 5-point increase in body mass index (BMI) in a 2013 meta-analysis.<sup>4,5</sup> This may be due to poor vascularization of adipose tissue, which results in decreased collagen synthesis, impaired ability to generate an inflammatory response, and compromised wound healing. In support of this notion is the finding that increasing distance from the lamina to the skin surface at the level of L4 is a strong

risk factor for SSIs.<sup>20</sup> Increased tissue necrosis from retraction injury may also contribute.<sup>4,5</sup> However, some studies have failed to find a relationship between obesity and SSI.<sup>21,22</sup> These variable findings may be related to comorbid conditions that manifest with obesity, such as diabetes, as well as differences in surgical technique. There is limited evidence to suggest that minimally invasive procedures, likely by limiting dissection and the creation of dead space, may reduce infection rates in obese patients.<sup>23,24</sup> In a study of 187 patients treated with minimally invasive lumbar fusion, no difference in SSI was found between patients with a normal BMI, preobese BMI, and obese BMI, suggesting that this method may mitigate obesity-related infectious complications.

**Smoking.** Smoking has been identified as a risk factor for wound complications across many surgical fields. This may be due to peripheral vasoconstriction caused by nicotine, which induces local tissue hypoxia, decreased angiogenesis, and epithelialization.<sup>25,26</sup> Nicotine also attenuates inflammatory cell infiltration and alters the function of inflammatory cells leading to less phagocytic and bacteriocidal activity and decreased ability to fight infection.<sup>27</sup> In a large, multicenter prospectively collected clinical registry study of patients undergoing elective lumbar spine surgery, patients who were current smokers had a significantly higher rate of SSI and wound complications than those who had never smoked.<sup>28</sup> Other smaller studies have failed to find an effect of smoking on wound complications, though this may be attributable to small effect size and lack of statistical power.<sup>29</sup>

**Risk Calculation.** Using data from the NSQIP database, Piper et al<sup>30</sup> developed a surgical risk calculator for SSIs in spinal surgery. Ten separate factors were identified as risk factors for SSI. These were wound class  $\geq 2$ , operative time  $\geq 3$  hours, American Society of Anesthesiologists class  $\geq 3$ , BMI  $\geq 30$  kg/m<sup>2</sup>, hematocrit <38%, inpatient procedure, emergency case, current smoker, steroid use, and wound infection. A risk score of 0 conferred an SSI risk of 0.7%, while that of  $\geq 8$  conferred a risk of 17.5%.<sup>30</sup> Several other studies have reported similar SSI risk factors.<sup>31-33</sup> The use of a posterior approach has also been associated with greater infection rates than anterior approaches.<sup>34</sup> Finally, there is limited and conflicting evidence to suggest that blood transfusions may increase SSI rates.<sup>34-37</sup>

### Procedural-Related Measures to Reduce SSIs

**Preoperative Antibiotics.** The use of prophylactic antibiotics has been established to decrease the chance of an SSI, with efficacy related to the timing of administration. Inappropriately timed preoperative antibiotic prophylaxis has been reported to increase the SSI rate up to 5.5%.<sup>7,38,39</sup> In a study performed by Olsen et al,<sup>18</sup> the administration of antibiotics 1 hour prior to incision was demonstrated to reduce the risk of SSIs. The effect of the timing of antibiotics have been confirmed in laboratory studies, which demonstrate that preoperative administration of cefazolin or vancomycin given within 1 hour before surgery in

a rabbit model of postoperative disk space infection was effective, while additional postoperative doses were not.<sup>40</sup>

In addition, the antibiotic dosage (cefazolin <20 mg/kg), should be adjusted with regard to obese patients in order to further reduce the risk of infection.<sup>4,18</sup> It is also important to note the need to redose the antibiotics every 4 hours and, in spinal deformities, after 1500 mL of blood loss due to the washout effect.<sup>41,42</sup>

**Skin Cleansing.** Chlorhexidine gluconate (CHG) bathing for 5 days prior to surgery has been shown to decrease perioperative infection rates.<sup>8,43</sup> Chlorhexidine has also shown to be advantageous in prepping patients prior to surgery as compared with povidone-iodine solutions.<sup>44,45</sup> In a randomized, prospective trial, chlorhexidine had a 4.2% infection rate as compared with a 8.6% infection rate in povidone-iodine-prepped patients.<sup>44</sup> The prolonged properties of chlorhexidine potentially confer a benefit as compared with other solutions.<sup>45</sup>

**Operative Time.** It has been well documented that increased surgical time may increase adverse outcomes, including surgical infections.<sup>46</sup> Moreover, blood loss resulting in transfusion has been reported to increase the spinal SSI risk.<sup>4</sup> Agents such as tranexamic acid have been demonstrated to reduce intraoperative bleeding and perioperative blood transfusions.<sup>47</sup> Moreover, staged deformity operations have also been reported in the literature. Staging an anterior, lateral, or posterior approach may decrease the surgical times in each respective session.<sup>48</sup> However, staged deformity surgery has been reported to increase perioperative complications such as deep venous thrombosis.<sup>48</sup>

**Personnel Turnover.** In a review of 12 528 elective neurosurgical procedures, nursing staff turnovers were associated with an increased risk of SSI independent of procedure length.<sup>49</sup> In this study, each nursing turnover increased the odds of an SSI by 9.5%. The authors proposed that the contamination risks associated with gowning and gloving, as well as the potential circulation of infectious pathogens due to increased traffic in the operating room may have contributed to this finding. This is important to recognize, as it is an easily modifiable risk factor.

**Antimicrobial Irrigation and Powder.** Several authors have reported a benefit to irrigating the wound with a dilute (3.5%) betadine solution.<sup>43,50</sup> This protocol involves filling the wound with the betadine solution and allowing it to sit for 3 minutes prior to suctioning. Intrawound application of vancomycin powder has also been reported to decrease SSIs.<sup>51</sup> However, this finding is controversial. In a prospective, randomized study performed by Mirzashahi et al<sup>1</sup> of 388 patients, no clear benefit of vancomycin use was noted. In addition, the infection rate was slightly higher in the vancomycin group than in the group that did not receive intrawound antibiotics (5.2% vs 2.7%). Others have demonstrated no change in SSI rates, though a shift in the microbial profile from gram-positive organisms to gram-negative organisms or polymicrobial infections with the use of vancomycin powder.<sup>52</sup> At present, the literature does not

support the use of intraoperative vancomycin powder as an effective method to reducing spinal SSI.<sup>4,53</sup>

**Postoperative Care.** Agarwal et al<sup>8</sup> reported the implementation of a 3-stage protocol to minimize SSIs following spinal fusion at their institution. The first stage consisted of ensuring that all patients bathed with preoperative CHG for 5 days, nasal screening and decolonization, and the use of CHG-alcohol as the standard preoperative skin preparation. The second stage of the protocol, implemented 18 months later, involved the performance of daily dressing changes using sterile conditions for 7 days after each procedure. Finally, the third stage, implemented 2.5 years after the second stage, was a physician awareness program, consisting of notification of all attending and resident neurosurgeons of their individual infection rates and rankings, as well as notification of newly occurring infections that were copied to the department chair. With each stage of protocol implementation, a decrease in SSIs was noted. This finding reinforces the importance of postoperative attention to wound care and mindfulness in reducing SSIs.

### A Protocol to Reduce SSIs in Spine Surgery

Given the above information, we propose a generalized protocol to minimize SSIs as follows:

1. Modifying patient risk by encouraging smoking cessation, strict blood glucose control, weight loss, steroid cessation or minimization if possible, and nutrition assessment with intervention as needed.
2. MRSA screening 30 days prior to planned procedures with a 5-day decolonization treatment using mupirocin if necessary. If screening cannot occur, those patients with documented colonization or risk factors for colonization should receive preoperative vancomycin in addition to cefazolin.
3. CHG baths for 5 days prior to the procedure.
4. Antibiotic administration 1 hour prior to incision.
5. Skin preparation with CHG.
6. Intraoperative infection reducing measures including minimizing operative time, meticulous hemostasis to avoid transfusion, avoiding excessive personnel turnover, and potentially irrigation with dilute betadine in addition to antibiotic solution. Consideration of minimally invasive procedures, if appropriate, is also recommended for obese patients.
7. Postoperative attention to wound care, which may include daily sterile dressing changes, but minimally involves ensuring that the wound remains clean and dry.

### Conclusion

In summary, SSIs may be avoided following spine surgery by addressing both patient and procedural factors. Patients' preoperative risk may be decreased by nutritional optimization, smoking cessation, weight loss, strict blood glucose control,

minimizing perioperative steroid use, and MRSA decolonization. The surgeon may decrease the risk of SSIs by ensuring proper perioperative treatment with CHG baths preceding planned surgery, administration of preoperative antibiotics, and CHG skin preparation. Intraoperative minimization of procedural time, blood loss, and personnel turnover and postoperative attention to wound care are additionally beneficial. Attention to these measures is likely to decrease patient morbidity and minimize unnecessary health care expenditures related to SSIs.

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