Risk Factors for Surgical Site Infections Following Spinal Fusion Procedures: A Case-Control Study

Shilpa B. Rao,1 Gustavo Vasquez,1 James Harrop,2 Mitchell Maltenfort,2 Natalie Stein,1 George Kaliyadan,3 Frank Klibert,4 Richard Epstein,5 Ashwini Sharan,2 Alexander Vaccaro,6 and Phyllis Flomenberg1

1Department of Medicine, 2Department of Neurological Surgery, 3Jefferson Medical College, 4Department of Infection Control, 5Department of Anesthesia, and 6Department of Orthopedic Surgery, Thomas Jefferson University, Philadelphia, Pennsylvania

Background. Spinal fusion procedures are associated with a significant rate of surgical site infection (SSI) (1%–12%). The goal of this study was to identify modifiable risk factors for spinal fusion SSIs at a large tertiary care center.

Methods. A retrospective, case-control (1:3 ratio) analysis of SSIs following posterior spine fusion procedures was performed over a 1-year period. Clinical and surgical data were collected through electronic database and chart review. Variables were evaluated by univariate analysis and multivariable logistic regression.

Results. In total, 57 deep SSIs were identified out of 1587 procedures (3.6%). Infections were diagnosed a mean of 13.5 ± 8 days postprocedure. Staphylococcus aureus was the predominant pathogen (63%); 1/3 of these isolates were methicillin resistant. Significant patient risk factors for infection by univariate analysis included ASA score ≥2 and male gender. Among surgical variables, infected cases had significantly higher proportions of staged procedures and thoracic level surgeries and had a greater number of vertebrae fused. Notably, infected fusion procedures had a longer duration of closed suction drains than controls (5.1 ± 2 days vs 3.4 ± 1 day, respectively; P < .001). Drain duration (unit odds ratio [OR], 1.6 per day drain present; 95% confidence interval [CI], 1.3–1.9), body mass index (OR, 1.1; 95% CI, 1.0–1.1), and male gender (OR, 2.7; 95% CI, 1.4–5.6) were significant risk factors in the multivariate analysis.

Conclusions. Prolonged duration of closed suction drains is a strong independent risk factor for SSI following instrumented spinal fusion procedures. Therefore, removing drains as early as possible may lower infection rates.
Patients undergoing fusion surgery for infection and infection rate than procedures involving a posterior approach were excluded from this study because additionally, patients who underwent anterior approach only fusion procedures with instrumentation and/or bone graft. The goal was to elucidate SSI factors specific to these procedures in order to develop effective prevention strategies for this patient population.

**MATERIALS AND METHODS**

**Setting and Study Population**

The study was performed in an 800 bed, university-based, level I trauma center in Philadelphia, Pennsylvania. Spine fusion procedures were performed by 11 different surgeons from both the Neurological and Orthopedic Surgery departments. Approval for this study was obtained from the university’s Institutional Review Board.

Patients in whom postoperative wound infections occurred following spinal fusion surgery were identified prospectively by the hospital’s Infection Control department based on standardized NHSN criteria [8]. Cases were identified by monitoring positive wound culture reports and readmissions postprocedure for up to one year. The analysis was restricted to patients who developed a deep primary incisional SSI (below the fascia). Cases with superficial primary incisional or secondary incisional infections (only) were excluded. Additionally, patients who underwent anterior approach only fusion procedures were excluded from this study because anterior approach procedures have a significantly lower infection rate than procedures involving a posterior approach [9]. Patients undergoing fusion surgery for infection and cases with negative wound cultures were also excluded from analysis. A relapsed infection was defined as a case that required repeated surgical drainage >6 weeks after the index infection.

For each case patient, 3 noninfected controls were randomly selected from a database of all patients who underwent spinal fusion surgery. Patients who had anterior approach only spinal fusion procedures or a diagnosis of spine infection were excluded. Case and control patients were matched only by calendar year of surgery (all case patients and control participants had procedures performed from 1 January 2008 through 31 December 2008).

**Patient-Specific Variables and Definitions**

Electronic and paper medical records were retrospectively reviewed for all case and control patients. Data points for analysis included patient demographic data, body mass index (BMI) category, ASA score, diabetes, hypertension, chronic obstructive pulmonary disease, coronary artery disease, active malignancy, current tobacco use, and previous fusion at the index surgical site. The indication for each surgical procedure was categorized as spinal deformity, degenerative spine disease, infection, trauma, or malignancy. For analysis purposes, deformity and degenerative indications were considered elective procedures, while the latter 3 indications were considered urgent/emergent procedures.

**Perioperative and Postoperative Variables and Definitions**

Intraoperative parameters collected included the surgical service performing procedure (orthopedics, neurosurgery, or combined), surgical approach (posterior or anterior/posterior), use of staging (spine surgery performed on 2 separate days), vertebral region involved, number of vertebra fused, duration of surgery, nadir intra-operative body temperature, estimated intraoperative blood loss (EBL), and blood transfusion requirements. In addition, the types of bone graft used (autograft, allograft, or both), and use of an iliac crest bone graft (ICBG) were recorded. Postoperative risk factors assessed included total hospital length of stay, fasting blood glucose the morning after the procedure, and the placement and duration of closed suction drains (captured from nursing documentation on an electronic inpatient database). The timing of antibiotic prophylaxis was considered appropriate if intravenous (IV) cefazolin (or clindamycin) was administered within 60 minutes of incision (and cefazolin was re-dosed for procedures exceeding 240 minutes) or if IV vancomycin was initiated 16–120 minutes prior to surgical incision. Initiation of the one hour vancomycin infusion 15 minutes or less prior to incision has been associated with an increased risk of SSI [10].

**Statistical Analysis**

Appropriate bivariate tests (t test for continuous data, $\chi^2$ test for categorical variables) were performed using the JMP statistical package (v 7.02, SAS Institute). Parsimonious multivariate models were determined by systematically pruning the least significant variables out of a multiple logistic regression model that initially included all variables.

**RESULTS**

**Characteristics of Infected Cases**

During the study period, 57 (3.6%) of 1587 patients who underwent spine fusion procedures were identified with a deep SSI based on study inclusion criteria and NHSN surveillance definitions. The clinical details of the infected cases are summarized...
Univariate Analysis of Patient-Specific Risk Factors

Patient variables from infected cases were compared with a panel of control patients (~1:3 ratio) who underwent spinal fusion procedures during the same time period. All controls had instrumented fusions except 2 patients who had bone graft alone. An ASA score >2 was a statistically significant risk factor for SSI (Table 2). Male gender was also identified as a risk factor, but higher proportions of males also had an ASA score >2 (OR, 1.9; CI, 1.1–3.1) and required emergency/urgent surgery (OR, 2.2; CI, 1.2–4.4). There were nonsignificant trends toward higher BMI and morbid obesity among infected cases. Unexpectedly, there were a significant lower proportion of active smokers in the infected cohort, but prior smoking history data were not collected.

Univariate Analysis of Surgery-Specific Risk Factors

The surgical parameters analyzed for the case and control subjects are shown in Table 3. There was no difference in the proportions of patients who underwent anterior/posterior approach procedures (about 1/3 in each group) versus posterior approach only procedures. However, staged procedures (anterior/posterior approach procedures performed on 2 separate days) demonstrated a statistically significant increased risk for SSI (17% of cases vs 8% of controls, P = .04). Although there was no overall difference in procedure duration between the index infected cases and controls, staged procedures had a substantially longer total operating room time (combined duration of both procedures) than nonstaged procedures (OR, 3.7; CI, 1.9–7.3; P < .0001). Additionally, infected cases had higher proportions of thoracic level procedures and a greater number of vertebral levels fused compared with controls, both of which were also associated with staged procedures (data not shown).

Univariate Analysis of Postoperative Risk Factors

Although the majority of patients in both groups received 1 or more closed suction drains, drains stayed in place for a longer time period in the infected group (Table 3). The mean duration of drains in infected cases was 5.1 days compared with 3.4 days in controls (P ≤.0001). The unit OR for infection was 1.9 for each day a drain was left in place. Although there was a significant difference between groups in total LOS, this difference disappeared after excluding cases diagnosed with infection during the same hospitalization as the index surgery.

Multivariate Analysis of SSI Risk Factors

An initial full model was created using all the variables from Tables 2 and 3. The model was then pruned, removing least significant variables systematically until only significant variables were left. As in the univariate case, the duration of closed suction drains was a significant risk factor in the multivariate model (unit OR, 1.6 per day drain present; 95% CI, 1.3–1.9). Male gender also remained associated with a higher risk of infection (OR, 2.7; 95% CI, 1.4–5.6). In contrast, higher BMI was significant only in the multivariate case (OR, 1.1; 95% CI, 1.0–1.1).

Subgroup Analysis on Surgeries Performed for Degenerative Disease

Because patients undergoing elective surgical fusion for degenerative disease were a large, more homogeneous population, a subgroup analysis was performed for these 178 patients (39 cases and 139 controls). An ASA score >2 (OR, 2.4; 95% CI, 1.1–5.3) remained a patient risk factor for SSI by univariate analysis, whereas male gender was no longer statistically
significant. Diabetes (OR, 3.0; 95% CI, 1.3–6.9) was also a significant patient risk factor. Staged procedures (OR, 6.7; 95% CI, 1.5–29.3), involvement of thoracic spine (OR, 3.0; 95% CI, 1.3–6.9), and number of vertebrae (unit OR, 1.3 per vertebrae; 95% CI, 1.1–1.6) remained surgery-related risk factors. There was a significant correlation between infection risk and duration of drains in patients with degenerative spine disease (unit OR, 2.3 per day; 95% CI, 1.7–3.2). Multivariate analysis confirmed that the duration of drains was an independent risk factor for infection in patients undergoing fusion exclusively for degenerative spinal disease (unit OR, 2.1; 95% CI, 1.6–3.1).

**DISCUSSION**

Postoperative wound infections after spine surgery are a serious and not uncommon complication [11]. In order to identify modifiable risk factors for surgical site infection, we performed a case-control study focused exclusively on posterior and anterior/posterior approach spinal fusions, procedures that are associated with the highest risk of infection. We found that, in addition to known patient and surgical risk factors, the duration of closed suction drains is an independent risk factor for infection.

An ASA score >2 was a statistically significant risk factor for SSI by univariate analysis, consistent with previous studies of SSIs in general, as well as following spine surgery [9, 12–14]. In the largest published study to date, an analysis of 24 774 laminectomy and fusion spinal surgeries in the Veterans Administration (VA) NSQIP database identified an ASA score >2, insulin dependent diabetes, and disseminated cancer as independent patient risk factors for infection, as well as weight loss, preoperative hematocrit <36, and current smoking [7].

Higher BMI (OR, 1.1; 95% CI, 1.0–1.1) and male gender (OR, 2.7; 95% CI, 1.4–5.6) were significant patient risk factors in the multivariate analysis. Higher BMI has not been consistently demonstrated as a SSI risk factor. Although inadequate dosing of antimicrobial prophylaxis in obese patients has been identified as an issue, cefazolin was dosed appropriately by weight using a standardized protocol at this institution. High BMI may pose a unique risk factor in posterior approach spinal fusion surgery due to the challenging location of the spine surgical site, in combination with reduced patient mobility secondary to obesity. We have also previously found an association between obesity and overall postoperative complications following spine surgery [15]. The association of male gender with increased infection risk was confounded by the higher proportions of males undergoing spine fusion following trauma and having ASA scores >2. Moreover, male gender was not a significant risk factor in the subset analysis of procedures performed for degenerative disease.
Staging of procedures (anterior and posterior procedures performed on 2 separate days), thoracic level procedures, and fusion of a larger number of vertebrae were found to be significant surgical risk factors for SSI by univariate analysis, consistent with prior studies [6, 7, 9]. None were significant in the multivariate analysis, likely related to the confounding associations among these variables. These data suggest that more extensive and prolonged spinal fusion procedures carry a higher risk of infection.

Notably, the duration of closed suction drains was a strong independent risk factor for SSI post spinal fusion procedure by multivariate analysis. The majority of patients in both groups (85%–89%) had closed suction drains placed at the end of the procedure. However, the longer the drains remained in place, the higher the risk of postoperative wound infection in the study population (unit OR 1.6 per day drain present; 95% CI, 1.3–1.8). Moreover, the association between drain duration and infection risk was confirmed in the subset analysis of patients with degenerative spinal disease. Given the retrospective study design, however, it remains possible that other unidentified variables or confounding associations may exist that led to an increased duration of drains. Although there was no defined protocol for drain removal among the 11 different surgeons, drain removal primarily depended on the amount of drain output (typically <100 cc/day). It is unlikely that there were significant surgeon-specific differences, because residents and fellows working with multiple surgeons typically lead post-surgical management, including drain removal. The association

<table>
<thead>
<tr>
<th>Table 3. Univariate Analysis of Surgery-Related Risk Factors Associated With Spinal Fusion Surgical Site Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>Appropriate timing of prophylactic antibiotics</td>
</tr>
<tr>
<td>Service</td>
</tr>
<tr>
<td>Orthopedics alone</td>
</tr>
<tr>
<td>Neurosurgery alone</td>
</tr>
<tr>
<td>Both services</td>
</tr>
<tr>
<td>Anterior/posterior approach procedures</td>
</tr>
<tr>
<td>Staged procedures*</td>
</tr>
<tr>
<td>Fusion involving thoracic spine</td>
</tr>
<tr>
<td>No. of levels, mean ± SD</td>
</tr>
<tr>
<td>Bone graft type</td>
</tr>
<tr>
<td>Autograft alone</td>
</tr>
<tr>
<td>Allograft alone</td>
</tr>
<tr>
<td>Both autograft and allograft</td>
</tr>
<tr>
<td>Iliac crest bone graft</td>
</tr>
<tr>
<td>Estimated blood loss, mean ml ± SD</td>
</tr>
<tr>
<td>Intraoperative blood transfusion</td>
</tr>
<tr>
<td>Beginning intraoperative temperature, mean degrees Celsius ± SD</td>
</tr>
<tr>
<td>Nadir intraoperative temperature, mean degrees Celsius ± SD</td>
</tr>
<tr>
<td>Surgery duration, mean min ± SD</td>
</tr>
<tr>
<td>Index surgery, all procedures</td>
</tr>
<tr>
<td>Index surgery, non-staged procedures only</td>
</tr>
<tr>
<td>Staged (2) procedures*</td>
</tr>
<tr>
<td>Placement of closed suction drain(s)</td>
</tr>
<tr>
<td>Drain duration, mean days ± SD</td>
</tr>
<tr>
<td>Fasting glucose POD 1, mean ± SD</td>
</tr>
<tr>
<td>LOS, mean days ± SD</td>
</tr>
<tr>
<td>Total LOS</td>
</tr>
<tr>
<td>Total LOS, excluding same admission SSIs</td>
</tr>
</tbody>
</table>

Data are no. (%) of patients unless otherwise indicated. Abbreviations: CI, confidence interval; LOS, length of stay; ns, not significant; POD, postoperative day; SD, standard deviation.

* Staged procedures are anterior/posterior approach procedures performed on 2 separate days.

* Duration of staged procedures was calculated by adding the duration of the two procedures performed on separate days.
may reflect greater drain output in patients who underwent more extensive procedures, for example, staged procedures or procedures involving greater number of vertebrae, although neither individual variable was significant in the multivariate analysis. Therefore, it will be important to confirm this finding in a randomized, prospective study.

Closed suction drains are commonly used in orthopedic procedures to reduce hematoma formation and manage dead space while simultaneously providing a channel for drainage from the wound [16]. In theory, reduced hematoma formation should decrease the risk of postoperative SSI and wound breakdown. However, this practice has not been documented to be of benefit in the orthopedic literature [17, 18], and limited data exist in the spine literature specifically. A meta-analysis including 18 studies of hip and knee arthroplasties found that closed suction drainage did not, in fact, reduce hematomas or reoperations for wound complications, and there was no difference in the length of hospital stay [19]. Patients receiving drains did, however, have higher blood transfusion requirements. There was no significant difference in SSI rates in this meta-analysis. However, one case control study has documented an increased risk of SSI with placement and prolonged use (>24 hours) of closed surgical drains in hip and knee arthroplasty procedures [20].

Unlike other orthopedic procedures, hematoma formation in spinal surgery may result in potentially serious spinal cord injury. Therefore, the use of prophylactic closed wound suction drainage after spine surgery has become the standard of care. However, a prospective, randomized trial showed no significant difference in wound healing or SSI in patients undergoing single-level lumbar laminectomy with or without drains [21]. A more recent prospective randomized trial again showed no significant difference in the incidence of hematoma, neurologic deficit, or SSI in patients undergoing more extensive lumbar spine surgery with and without drain placement [22]. Both studies, however, were limited by smaller numbers of patients. In contrast, a recent study of both laminectomy and spinal fusion procedures identified drain duration >3 days as a risk factor for SSI in the univariate but not multivariate analysis [14].

This study identifies the prolonged use of closed suction drains as an independent risk factor for infection following spinal fusion surgery with instrumentation. Drains may increase the risk of infection by causing local tissue inflammation and/or providing direct access to the surgical site for bacteria by ascending the drain tract [20]. Studies have shown that bacterial colonization of drains increases with the duration that the drain stays in place and that SSIs are frequently caused by the same organisms isolated from the drain [18, 23]. In particular, the presence of a fresh implant in spinal fusions (and joint arthroplasties) may allow for a smaller inoculum of microorganisms to establish an infection in comparison to procedures without instrumentation. The above spine surgery studies did not find that closed suction drains decrease rates of hematoma formation or cord compression. Thus, reducing the placement of drains and limiting duration of drains seems a logical step to decrease the risk of SSI following spinal fusion surgery.

It is clear, however, that programs designed to decrease SSI post spinal fusion surgery need to be multifaceted. The care of posterior spine surgical wounds is especially challenging due to their difficult location and frequent need for bracing, which can cause wound irritation. Therefore, protocols should be optimized to decrease wound contamination. Nasal decolonization with mupirocin and preoperative chlorhexidine cleansing may help reduce skin colonization and wound contamination [24, 25]. Other strategies under investigation for decreasing SSIs post spinal fusion surgery include the use of antibiotic-loaded allograft [26] and the development of minimally invasive techniques utilizing thorascopy or video-assisted thorascopic surgery [27].

LIMITATIONS

The major limitation of this study was its retrospective design. This study had a well-defined, high-risk patient population that focused exclusively on posterior and anterior/posterior approach spinal fusions. All procedures included in this study were instrumented (except 2 controls with bone graft alone). However, because this was a retrospective study, the accuracy of the data was dependent on the documentation entered into electronic and paper medical records. Additionally, this was only a single institution study. Finally, there was a limited data set, and the lack of significance of some of the parameters of potential interest may reflect insufficient statistical power.

CONCLUSIONS

These data suggest that removing closed suction drains as early as possible may decrease the risk of SSI after posterior spinal fusion procedures. We advocate further investigation of the risks and benefits of closed suction drains following spinal fusion surgery in a randomized, prospective clinical trial.

Notes

Acknowledgments. We thank the members of the Spine Surgery team and Infection Control department for their helpful discussions.

Potential conflicts of interest. All authors: No reported conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References