Risk factors for surgical site infection in spinal surgery

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Object. The objective of this study was to identify specific independent risk factors for surgical site infections (SSIs) occurring after laminectomy or spinal fusion.

Methods. The authors performed a retrospective case-control study of data obtained in patients between 1996 and 1999 who had undergone laminectomy and/or spinal fusion. Forty-one patients with SSI or meningitis were identified, and data were compared with those acquired in 178 uninfected control patients. Risk factors for SSI were determined using univariate analyses and multivariate logistic regression.

The spinal surgery–related SSI rate (incisional and organ space) during the 4-year study period was 2.8%. Independent risk factors for SSI identified by multivariate analysis were postoperative incontinence (odds ratio [OR] 8.2, 95% confidence interval [CI] 2.9–22.8), posterior approach (OR 8.2, 95% CI 2–33.5), procedure for tumor resection (OR 6.2, 95% CI 1.7–22.3), and morbid obesity (OR 5.2, 95% CI 1.9–14.2). In patients with SSI the postoperative hospital length of stay was significantly longer than that in uninfected patients (median 6 and 3 days, respectively; p < 0.001) and were readmitted to the hospital for a median additional 6 days for treatment of their infection. Repeated surgery due to the infection was required in the majority (73%) of infected patients.

Conclusions. Postoperative incontinence, posterior approach, surgery for tumor resection, and morbid obesity were independent risk factors predictive of SSI following spinal surgery. Interventions to reduce the risk for these potentially devastating infections need to be developed.

KEY WORDS • laminectomy • spinal fusion • infection • risk factor
of a variety of different surgical procedures in some studies (that is, shunt placement, craniotomy, and other procedures in addition to spinal surgery), making it difficult to identify risk factors unique to laminectomy and fusion.

To delineate better independent risk factors and outcomes of SSI after laminectomy and spinal fusion, we performed a case-control study of patients who had undergone spinal surgery at a single institution during a 4-year period. This design allows for better assessment of the associations between potential risk factors and infection than can be achieved by descriptive or cross-sectional studies and is especially useful in situations such as this, when the outcome is rare.

**Clinical Material and Methods**

**Study Population**

This study was conducted at Barnes–Jewish Hospital, a 1442-bed tertiary care hospital affiliated with the Washington University School of Medicine, between January 1996 and December 1999. Patients eligible for the study had undergone a laminectomy (International Classification of Diseases–9 codes 0300-0302, 0309, 8050-51), spinal fusion (International Classification of Diseases–9 codes 8100-8109), or both during the study period, and all were performed by a neurosurgeon. Other neurosurgical procedures, laminectomies, and fusions performed by orthopedic surgeons were excluded. Data were collected from the medical records by two research assistants and the lead author (M.A.O.) who used a standard data collection tool. Infection control specialists identified all SSIs through prospective surveillance by using Centers for Disease Control and Prevention/National Nosocomial Infection Surveillance definitions of deep and superficial SSIs. Fifty-three patients with an infection at the surgical site were initially identified, but 12 were excluded because medical records were missing or a preexisting SSI existed. One hundred seventy-nine control patients without SSI were randomly selected from those patients with the same eligibility criteria as the cases (~ four uninfected controls/case). Approval for the study was obtained from the Washington University School of Medicine institutional review board.

**Risk Factors for SSIs**

Potential risk factors for neurosurgical SSI included in the analysis are listed in Table 1. The potential risk factors were assembled after a thorough review of the infection control and neurosurgical literature. All variables thought to be associated with SSI or deemed plausible as a risk factor of infection following spinal surgery were included in the data collection tool used to abstract information from the patient charts. All of the patients in the study received at least one dose of a prophylactic antibiotic agent; cefazolin was the most common, given alone in 156 patients (71%) and in combination with an aminoglycoside in 21 patients (10%). Other prophylactic antibiotics were vancomycin (25 patients), vancomycin combined with an aminoglycoside (12 patients), and other miscellaneous antibiotics (five patients). The outcomes of infection studied in this analysis included postoperative days in the ICU, postoperative hospitalization (including length of readmissions due to SSI), repeated surgery due to SSI, and mortality.

**Data Analysis**

Associations between SSI and potential risk factors were analyzed using the chi-square test, and calculation of ORs and 95% CIs. Significant differences for continuous variables were determined by the t-test or Mann–Whitney U-test. A probability value less than 0.05 was considered statistically significant in all statistical tests. Bonferroni correction was used to adjust the probability values obtained in the univariate analyses for multiple testing, because the greater the number of comparisons, the greater the likelihood a test will have a probability value.
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less than 0.05 by chance alone. Bonferroni correction was performed by dividing the probability value obtained in the univariate analysis by the number of statistical tests performed.15 Multivariate stepwise logistic regression was used to identify independent risk factors for SSI; a probability value of 0.05 was used for entry and 0.1 for exclusion from the models.11 Variables eligible for inclusion in the multivariate models included those associated with increased risk of SSI obtained in the literature and those variables with p values less than 0.2 in the univariate analyses. Risk factors with fewer than five occurrences in any cell of the contingency tables were excluded from the multivariate analysis, because of the inability to make statistical inferences with such small numbers. All statistical analyses were performed using SPSS software (version 11.0; SPSS Inc., Chicago, IL).

Results

During the 4-year period of the study, 1918 spinal surgeries (laminectomy and/or spinal fusion) were performed at Barnes–Jewish Hospital. During the study period, the incidence of SSI associated with these procedures was 2.76% (53 SSI/1918 procedures), with no significant variation in SSI rates during the 4 years of the study and no outbreaks identified. Eleven surgeries in patients with SSI were excluded from the study because of preexisting SSI, and one infected patient’ s chart could not be located, resulting in 41 infected cases for analysis.

The microorganisms isolated from the infected patients in whom cultures were obtained from the surgical wound are listed in Table 2. *Staphylococcus aureus* (methicillin sensitive or resistant) was isolated in 38% of patients with SSI in whom cultures were obtained (15 of 39 patients; Table 2). Gram-negative rods and/or anaerobes were present in cultures from 17 (44%) of 39 patients. Gram-negative rods and/or anaerobes were present significantly more often in specimens obtained in patients who underwent lumbar or lumbosacral procedures as opposed to thoracic or cervical procedures (15 of 24 compared with two of 15; p < 0.001, Fisher exact test). Gram-negative rods and/or anaerobes were isolated in seven of eight patients with postoperative incontinence who had undergone surgery below the thoracic level, compared with eight of 16 patients who had undergone surgery below the thoracic level but without documented incontinence (p = 0.178, Fisher exact test).

Twenty-five (61%) of the 41 SSIs were classified as deep incisional infections, nine (22%) were classified as organ space (including two cases of meningitis), and seven (17%) as superficial incisional infections. The most common physical sign in patients with SSI (excluding the two cases of meningitis) was wound site drainage in 35 (90%) of 39 cases. Local pain was documented in approximately two thirds (25) of the 39 nonmeningitis cases and almost half suffered fever (18 cases). Erythema at the wound site was present in approximately 40% (15 cases) of patients with SSI. The median time from surgery to onset of infection was 14 days (range of 2–83 days). All infected patients received antibiotic therapy for treatment of their SSI, and the majority (30 [77%]) underwent repeated surgery because of their infections. Thirty of the 41 patients were readmitted to the hospital at least once for wound care treatment, resulting in a mean readmission LOS of 8.5 days (median 6 days, range 0–45 days).

The results of the univariate analyses of risk factors for SSI are shown in Table 3. After correction for multiple testing, higher ASA class, surgery involving more than two intervertebral spaces, incontinence, and PRBC transfusions (intraoperative and any PRBC transfusions) were significantly associated with SSI by univariate analysis. Postoperative incontinence conferred the greatest risk of infection (OR 8.8) in the univariate analysis, but individuals incontinent preoperatively also had significantly increased risk of developing a SSI (OR 3.4). Smoking (current or past) was associated with a significantly decreased risk of SSI in the univariate analysis but did not remain significant after correction for multiple testing.

Table 4 provides a comparison of continuous variables for infected and uninfected control patients. Preoperative LOS and duration of surgery were both significantly longer, and surgery involved a significantly greater number of intervertebral spaces in the study patients than in the uninfected control patients. The LOS during the surgical admission in the ICU and in the hospital postoperatively were also both significantly longer for patients with SSI than for those without infection.

Fusion was not significantly associated with SSI in this patient population, and among the fusion patients there was no increased risk of SSI associated with the use of instrumentation (Table 3). Fusion was not a risk factor for SSI, even after excluding patients with complicated surgery (that is, tumor resection or excision of other spinal lesions) from the analysis (p = 0.663). There was no association between SSI and other operative factors such as timing of prophylactic antibiotic administration, surgery for injury or trauma, intraoperative hypothermia, and dural opening (dural tear or durotomy). In contrast, patients in whom surgery involved use of an operating microscope were significantly less likely to develop SSI (p = 0.008). Seventy-five percent of anterior cervical procedures involved the use of an operating microscope, whereas this was true only in 30% of posterior procedures, and thus the protective effect of an operating microscope was most likely due to the type of surgery in which a microscope was used.

### TABLE 2

Microbiological characteristics of spinal SSI

<table>
<thead>
<tr>
<th>Agent</th>
<th>No. of Cases*</th>
</tr>
</thead>
<tbody>
<tr>
<td>mixed culture containing ≥3 organisms</td>
<td>11†</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>9</td>
</tr>
<tr>
<td>&amp; <em>P. aeruginosa</em></td>
<td>1</td>
</tr>
<tr>
<td>coagulase-negative <em>Staphylococcus</em></td>
<td>2</td>
</tr>
<tr>
<td>peptostreptococcus species</td>
<td>2</td>
</tr>
<tr>
<td><em>Streptococcus mitis</em></td>
<td>1</td>
</tr>
<tr>
<td>methicillin-resistant <em>S. aureus</em> &amp; coagulase-negative <em>S. series</em></td>
<td>1</td>
</tr>
<tr>
<td>&amp; <em>P. aeruginosa</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Nocardia asteroides</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>1</td>
</tr>
<tr>
<td>&amp; <em>P. aeruginosa</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Enterobacter cloacae</em></td>
<td>1</td>
</tr>
</tbody>
</table>

* In two cases of SSI cultures were not obtained from the wound, and in four with SSI no organisms were isolated from wound cultures.
† In two of the nine specimens with mixed flora *S. aureus* was reported.
A posterior approach was identified as a risk factor for SSI in the univariate analysis, as shown in Table 3. Of the 84 patients who underwent cervical procedures, two (3.4%) of 59 patients developed SSI following an anterior approach, compared with eight (32%) of 25 in whom an SSI developed after a posterior cervical approach (p = 0.001); the remaining SSI occurred after a transoral approach. In 120 patients surgery was performed below the cervical spine via a posterior approach, and 28 (23.3%) of those patients developed SSI postoperatively (p = 0.001 compared with anterior cervical procedure). Fifteen patients are listed in Table 3 as having undergone a surgi-
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TABLE 4
Univariate analysis of continuous variables and association with increased risk of SSI after spinal surgery

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>W/ SSI</th>
<th>W/o SSI</th>
<th>W/ SSI</th>
<th>W/o SSI</th>
<th>p Value†</th>
<th>Mean ± SD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean age in yrs</td>
<td>56.4 (17–84)</td>
<td>52.9 (18–83)</td>
<td>54.3 (18.2)</td>
<td>52.9 (14.8)</td>
<td>0.493</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>27.8 (17.3–71.3)</td>
<td>27.4 (15.6–47.6)</td>
<td>31.1 (10.3)</td>
<td>27.7 (5.4)</td>
<td>0.080</td>
<td></td>
</tr>
<tr>
<td>preop LOS</td>
<td>0 (0–35)</td>
<td>0 (0–27)</td>
<td>2.4 (6.0)</td>
<td>0.9 (3.1)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>no. of intervertebral spaces</td>
<td>2 (1–10)</td>
<td>1 (1–7)</td>
<td>2.8 (2.1)</td>
<td>1.7 (1.2)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>length of op in hrs</td>
<td>3.7 (1.2–9.6)</td>
<td>2.9 (1.0–8.2)</td>
<td>4.4 (2.2)</td>
<td>3.1 (1.3)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>lowest intraop temp</td>
<td>35.4 (33.7–36.9)</td>
<td>35.3 (32.7–36.7)</td>
<td>35.3 (0.8)</td>
<td>35.2 (0.7)</td>
<td>0.571</td>
<td></td>
</tr>
<tr>
<td>postop LOS in ICU</td>
<td>0 (0–34)</td>
<td>0 (0–18)</td>
<td>2.1 (5.9)</td>
<td>0.4 (1.7)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>LOS after surgery (surgical admission)</td>
<td>6 (1–34)</td>
<td>3 (1–98)</td>
<td>8.0 (6.6)</td>
<td>4.6 (9.2)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

* SD = standard deviation.
† Probability values derived using the Mann–Whitney U-test.

Discussion

In this study we demonstrated that specific risk factors for SSI in patients undergoing spinal surgery exist, some of which are potentially amenable to risk-reducing interventions. Surgical site infections occurred predominantly in procedures conducted via posterior approaches, and almost half of the wounds cultured contained gram-negative rods or anaerobes, consistent with contamination with fecal or urinary flora. More than 80% of the SSIs detected were deep incisional or organ space infections, resulting in an increased morbidity rate, increased LOS (combination of longer stay during the original admission and a median additional LOS of 6 days during readmission[s]) and repeated surgery in the majority of patients.

Risk Factors and Prevention

Postoperative incontinence, posterior approach, morbid obesity, and surgery for tumor resection were found in multivariate analyses to be independent predictors of SSI following laminectomy and/or spinal fusion. Postoperative incontinence conferred approximately an eightfold increased risk of SSI, most likely through contamination of the skin in the area of the posterior wound with fecal microorganisms. Because indwelling urethral catheters were in place following surgery in the majority of incontinent patients, the most likely source of contaminating microorganisms was fecal flora. Perry, et al.,19 have previously demonstrated that incontinence is a risk factor for postoperative wound infections after segmental spinal instrumentation is placed in patients with scoliosis. Theoretically a combination of occlusive dressings to protect the wound from contamination and the use of leak-proof diapers to contain fecal contents may serve to reduce the risk of SSI in incontinent patients.

Morbid obesity was also shown to be associated with approximately a fivefold increased risk of SSI after spinal surgery. Obesity has been previously reported to increase this risk following spinal surgery,22 although the numbers of reported cases of infection in the previous studies have not been sufficient to analyze the results according to different levels of BMI. In our study morbid obesity greatly increased the risk of SSI, but in patients with a BMI of patients (63% of those with an SSI and 89% of those without infection were correctly classified).
between 30 and 35 the risk of SSI was not increased. Because morbidly obese individuals were also much more likely to have high serum glucose levels, the increased risk in only morbidly obese patients could at least partially be due to uncontrolled serum glucose, as has been demonstrated in patients who undergo coronary artery bypass surgery.25 Approximately one fifth of the patients in this study did not undergo serum glucose testing perioperatively and thus the exact association of serum glucose levels and risk of spinal SSI is not clear.

One potential strategy to prevent SSI in morbidly obese patients is to ensure that these patients receive higher doses of prophylactic antibiotic agents (that is, 2 g cefazolin instead of 1 g), because antibiotic penetration in fat is relatively poor.6 Insulin-delivery drips or pumps can be used to maintain serum glucose levels less than 200 mg/dl, as this has been shown to be highly effective in reducing the risk of deep sternal SSI after coronary artery bypass.7 Institution of an insulin pump protocol would necessitate routine perioperative serum glucose testing, particularly in obese patients, to monitor glucose levels pre- and postoperatively.

A posterior surgical approach was independently associated with approximately an eightfold increased risk of SSI, confirming previous findings. Levi and colleagues14 found that all deep wound infections in patients in whom surgery involved spinal instrumentation occurred after a posterior approach. Wimmer, et al.,24 similarly reported that most of the SSIs in their institution occurred in patients in whom surgeries involved posterior fusion and placement of instrumentation. Interventions to reduce the risk of infection must focus on methods to reduce contamination of the posterior wound with fecal, urinary, or skin flora. Strict attention to antisepsis of the posterior wounds must also be emphasized, both in the hospital and by caregivers after discharge.

Finally, surgery for tumor resection was shown to confer an increased risk of SSI in this study. McPhee, et al.,16 have previously noted that SSI occurred in more than 10% of patients undergoing resection of spinal tumors, although these authors made no comparison with the rates in uncomplicated spinal surgeries. The increased risk of SSI in our study could be partly due to the prolonged duration of these surgeries, as well as to the extensive resection required in such procedures. Redosing of prophylactic cefazolin is indicated for surgeries longer than 3 to 4 hours to maintain therapeutic intraoperative levels in tissue,13 and thus careful attention to the proper timing for redosing of prophylactic antibiotics may help decrease the risk of SSI in these patients.

Reported Potential Risk Factors Not Confirmed by Multivariate Analysis

In contrast to previous publications, fusion and instrumentation were not associated with increased risk of infection in our study, even after excluding complicated surgeries from the analysis. Possibly this was because of the routine use of prophylactic antibiotics in all spinal surgeries at our institution, the use of bacitracin irrigation at the operative site in most surgeries, or other unknown factors. In keeping with previous studies, the duration of surgery was found to be significantly greater in cases involving infection compared with the controls, although after controlling for tumor resection, duration of surgery did not remain independently associated with SSI. Older age3,5 and previous spinal surgery,2,5,11 identified in previous studies as risk factors for SSI, were not found to be associated with an increased risk of infection in this study. One explanation for the finding of significant associations in previous studies is the small number of infected cases or the inclusion of multiple types of surgery (that is, all “clean” neurosurgery) in the previous reports. We focused on SSI in only laminectomy and fusion surgeries performed by neurosurgeons at our institution to determine specific risk factors for those procedures, and conducted the study during a 4-year period to accrue enough infected cases to perform a meaningful statistical analysis. The use of these techniques hopefully reduced the chance of detecting spurious associations between potential risk factors and development of SSI. In addition, we corrected for multiple testing in the univariate analysis, because the larger the number of statistical tests performed, the greater the likelihood of detecting significant associations (as defined by p < 0.05) by chance alone. This technique allows for the elimination of the significance of factors such as smoking history, with a probability value of less than 0.05 by simple univariate analysis, which lacks biological plausibility.

Limitations and Advantages of This Study

Limitations of this study include the acquisition of cases and controls in a period of 4 years, during which changes in procedures and personnel necessarily occurred. As always in retrospective studies, the data were limited by the nature and quality of information obtained from the medical records. The advantages of this study include the much larger number of cases of SSI relative to most other studies in the literature, as well as the extensive nature of the potential risk factors analyzed. In addition, the use of multivariate analysis allowed for the identification of independent risk factors for SSI after controlling for the occurrence of multiple risk factors in individual patients. To our knowledge, only one previous publication on risk factors for SSI in spinal surgery has included a multivariate analysis.13 In that study, in addition to our present work, the authors presented more convincing evidence for the association between the implicated risk factors and development of SSI than in previous publications involving only univariate analyses. In addition, we focused on

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**TABLE 5**  
Multivariate logistic regression model for developing SSI after spinal surgery

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Adjusted OR (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>postop incontinence</td>
<td>8.2 (2.9–22.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>posterior approach†</td>
<td>8.2 (2.0–33.5)</td>
<td>0.003</td>
</tr>
<tr>
<td>tumor resection</td>
<td>6.2 (1.7–22.3)</td>
<td>0.005</td>
</tr>
<tr>
<td>BMI ≥35</td>
<td>5.2 (1.9–14.2)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* The model correctly identified 84% of individuals according to infection status (89% of uninfected controls and 63% of patients with SSI).
† Posterior approach includes five patients with more than one surgical incision, in whom one of the approaches was posterior (four with both anterior–posterior approaches and one patient with posterior retroperitoneal approach).
risk factors for SSI in only laminectomy and fusion spinal surgeries and excluded other clean neurosurgical procedures to identify risk factors unique to these specific procedures and this patient population.

Conclusions

Using multivariate analysis and a retrospective case-control study design, we have shown that morbidity, postoperative incontinence, posterior approach, and tumor resection independently increase the risk of SSI after laminectomy or spinal fusion. Identification of these risk factors should allow for the development of specific interventions to decrease the risk of these infections involving the surgical incision, with the goal of decreasing morbidity, hospital LOS, and hospital costs in spinal surgery patients.

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References


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