Risk factors for surgical site infection following spine surgery: efficacy of intraoperative saline irrigation

Clinical article

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Object. The purpose of this study was to identify risk factors for surgical site infection after spine surgery, noting the amount of saline used for intraoperative irrigation to minimize wound contamination.

Methods. The authors studied 223 consecutive spine operations from January 2006 through December 2006 at our institute. For a case to meet inclusion criteria as a site infection, it needed to require surgical incision and drainage and show positive intraoperative cultures. Preoperative and intraoperative data regarding each patient were collected. Patient characteristics recorded included age, sex, and body mass index (BMI). Preoperative risk factors included preoperative hospital stay, history of smoking, presence of diabetes, and an operation for a traumatized spine. Intraoperative factors that might have been risk factors for infection were collected and analyzed; these included type of procedure, estimated blood loss, duration of operation, and mean amount of saline used for irrigation per hour. Data were subjected to univariate and multivariate logistic regressions analyses.

Results. The incidence of surgical site infection in this population was 6.3%. According to the univariate analysis, there was a significant difference in the mean duration of operation and intraoperative blood loss, but not in patient age, BMI, or preoperative hospital stay. The mean amount of saline used for irrigation in the infected group was less than in the noninfected group, but was not significantly different. In the multivariate analysis, sex, advanced age (> 60 years), smoking history, and obesity (BMI > 25 kg/m²) did not show significant differences. In the analysis of patient characteristics, only diabetes (patients receiving any medications or insulin therapy at the time of surgery) was independently associated with an increased risk of surgical site infection (OR 4.88). In the comparison of trauma and elective surgery, trauma showed a significant association with surgical site infection (OR 9.42). In the analysis of surgical factors, a sufficient amount of saline for irrigation (mean > 2000 ml/hour) showed a strong association with the prevention of surgical site infection (OR 0.08), but prolonged operation time (> 3 hours), high blood loss (> 300 g), and instrumentation were not associated with surgical site infection.

Conclusions. Diabetes, trauma, and insufficient intraoperative irrigation of the surgical wound were independent and direct risk factors for surgical site infection following spine surgery. To prevent surgical site infection in spine surgery, it is important to control the perioperative serum glucose levels in patients with diabetes, avoid any delay of surgery in patients with trauma, and decrease intraoperative contamination by irrigating > 2000 ml/hour of saline in all patients. (DOI: 10.3171/2009.11.SPINE09308)

Key Words • surgical site infection • risk factor • contamination • wound irrigation

POSTOPERATIVE surgical site infection is a serious complication in all kinds of surgery. During spine surgery, surgical site infection also causes specific problems, including the need for long-term intravenous antibiotics, sepsis, repeated surgical procedures, hardware removal, pseudarthrodesis, progression of deformity, and prolonged hospitalization. The cost of care may increase more than 4-fold with surgical site infection, and the overall mortality risk is doubled. Rates of surgical site infection reported from individual institutions have ranged from 0 to 15%, depending on the reason for the operation, the site, the approach, and the use of instrumentation. Known risk factors for infection after spine surgery include advanced age, drug and alcohol abuse, smoking history, diabetes, obesity, malnutrition, immunological insufficiency, an operation for traumatized spine, prolonged surgical time, high

Abbreviation used in this paper: BMI = body mass index.
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blood loss, posterior approach, use of instrumentation, and a high volume of personnel moving through the operating rooms. Awareness of risk factors may allow for the modification of preoperative conditions and allow close attention to surgical procedures. We believe that following strict techniques—including copious irrigation and meticulous debridement of nonviable tissue, experienced operating room personnel, and short operating times—will reduce the incidence of postoperative infections. However, there are only a few reports of the impact of surgical technique on surgical site infection because most technical factors are difficult to objectively evaluate. It is believed that most postoperative infections result from organisms in the operating room, which enter the wound at the time of surgery. Although there are some reports concerning the efficacy of irrigation with saline containing povidone-iodine or antibiotics, an association between the amount of saline used for irrigation and surgical site infection has not been reported.

The purpose of this study was to identify risk factors for surgical site infection in patients who had previously undergone spine surgery, focusing attention on the amount of saline used for decreasing wound contamination by intraoperative irrigation.

Methods

Study Population

Our case series included 223 consecutive spinal operations performed at our institution between January 2006 and December 2006. There were 147 male and 76 female patients. The mean age of the patients at the time of surgery was 53 years (range 12–90 years). The preoperative diagnoses and surgical procedures are shown in Table 1. The Centers for Disease Control and Prevention definition of surgical site infection was used; wound infection occurring within 1 year of hardware implantation or within 30 days after noninstrumented fusions were considered surgical site infections. We followed up all patients for more than 1 year. For a case to meet inclusion criteria as a site infection, it had to require surgical incision and drainage and to show a positive intraoperative deep culture. Preoperative and intraoperative data regarding each patient were collected using patient charts, electronic patient records, and operative logs. Patient characteristics recorded included age, sex, and BMI. The preoperative risk factors reviewed included preoperative hospital stay, history of smoking, presence of diabetes, and operation for a traumatized spine. Intraoperative factors that were possible risk factors for infection were collected and analyzed, including the type of procedure, estimated blood loss, duration of operation, and mean amount of saline for irrigation per hour. To determine this mean amount of saline per hour, we divided the total amount of saline used for surgical site irrigation by the duration of surgery. No additives to irrigation, such as antibiotics or antiseptics, were used in any cases. The study protocol was approved by the committee on ethics and the institutional review board of Tokai University School of Medicine.

Analysis of Variables

Univariate analysis was used to evaluate potential risk factors associated with infection. For quantitative variables, means and SDs were calculated for patients with and without postoperative infections. Differences were tested using the Student t-test for symmetrically distributed variables and the nonparametric Wilcoxon test for those that were not. Factors analyzed included preoperative hospital stay (days), duration of operation (minutes), estimated blood loss during surgery (in grams), and mean amount of saline used for irrigation per hour (in milliliters). We measured intraoperative blood loss in grams according to the weight of the gauze before and after absorption of blood, and the intraoperative vacuum suction system.

Multivariate logistic regression analysis was used to identify independent risk factors for surgical site infection. For this analysis, variables that were originally quantitative were categorized by splitting possible values into 2 to 3 categories based on frequency. The patient categories included age (> 60 years), smoking history, diabetes (patients receiving any medications or insulin therapy at the time of surgery), and obesity (BMI > 25 kg/m²). Operative variables (surgical factors) included trauma or elective spine surgery, use of instrumentation, long duration of operation (> 3 hours), high estimated intraoperative blood loss (> 300 g), and sufficient irrigation of surgical site (mean amount of saline for irrigation per hour < 1000 ml, 1000–2000 ml, or > 2000 ml).

Statistical Analysis

Data were analyzed using the statistical software Dr. SPSS II (SPSS, Inc.) and statistical significance was set at a p value < 0.05. A backward stepwise regression procedure eliminated variables that were not related independently to infection. Odds ratios > 1 indicated increased risk, whereas ORs < 1 indicated decreased risk. The final model was checked for goodness of fit with the Hosmer-Lemeshow test and by colinearity and residual diagnostics to ensure it was well-specified and fit the data.

Results

The incidence of surgical site infection after spine surgery was 6.3% (14 of 223). Infection occurred on average 19 days after the index procedure (range 3–150 days) and most cases (12 of 14) occurred within 2 weeks. Wound discharge, dehiscence, and erythema at the incision site were the most common presenting features. Methicillin-resistant Staphylococcus aureus was cultured from 10 cases, methicillin-resistant S. epidermidis from 3 cases, and combined infection with Proteus mirabilis and Enterobacter cloacae from 1 case. The preoperative diagnosis and surgical procedures in the total cohort, noninfected group (209 patients), and infected group (14 patients) are shown in Table 1. There was no case of infection when using the anterior approach for spine surgery.

Univariate analysis showed 6 factors of importance (Table 2). The mean age of patients in the infected group was 49 years, which was younger than in the noninfected...
group (53 years) but this difference was not statistically significant. There were 9 male and 5 female patients in the infected group compared with 138 and 71, respectively, in the noninfected group. The average BMI was 23.9 kg/m² in the infected group and 23.1 kg/m² in the noninfected group. The average preoperative hospital stay was 11.1 days in the infected group and 5.7 days in the noninfected group. There was no significant difference in these factors for a patient with multisystem trauma in the infected group who had been hospitalized for 65 days preoperatively. For surgical factors, there was a significant difference in the average duration of the operation and in the mean intraoperative blood loss. The mean amount of saline used for irrigation was 1459 ml in the infected group, which was less than that in the noninfected group (2044 ml), but this difference was not statistically significant according to the univariate analysis.

The numbers of patients in each categorized factor in each group and the results of multivariate analysis to identify independent risk factors for surgical site infection are shown in Table 3. There was a higher proportion of male patients in both groups, but sex did not appear to be a risk factor (OR 0.82, 95% CI 0.18–3.69; p = 0.791). Advanced age (> 60 years), smoking history, and obesity (BMI > 25 kg/m²) also did not show significant differences between groups. In terms of patient characteristics, only diabetes (patients who were receiving any medication or insulin therapy at the time of surgery) was independently associated with an increased risk of surgical site infection (OR 4.88, 95% CI 1.01–23.51; p = 0.048). Comparing patients with trauma and those receiving elective surgery, trauma demonstrated a strong association with surgical site infection (OR 9.42, 95% CI 1.59–55.73; p = 0.013). Among surgical factors, the rate of using instrumentation, prolonged surgery, and large amounts of blood loss were higher in the infected group. Although the duration of operation and intraoperative estimated blood loss showed significant differences according to the univariate analysis, prolonged surgery, high blood loss, and instrumentation did not show any direct or independent associations with an increased risk of surgical site infection. Using a sufficient amount of saline for irrigation (mean > 2000 ml/hour) showed a strong association with surgical site infection (OR 0.08, 95% CI 0.01–0.61; p = 0.015). Lavage of the surgical site contamination with > 2000 ml of saline per hour decreased the risk of surgical site infection below 10%, compared with irrigation of < 1000 ml/hour. The model had good predictive ability; the Hosmer-Lemeshow goodness-of-fit p value was 0.759 (8 degrees of freedom) and the Nagelkerke R² = 0.280.

**Discussion**

Spinal procedures have historically resulted in higher rates of infection than other orthopedic procedures. Surgical site infections following spine surgery can have devastating sequelae for the patient, including failure of fixation, osteomyelitis, pseudarthrosis, revision surgical procedures, long-term intravenous antibiotics, sepsis, and death.1,4,17,20,34,44 These outcomes translate into increased hospital stays, recovery times, and costs for the patient and the health care system.4,11 The most recent National Nosocomial Infections Surveillance System summary by the Centers for Disease Control and Prevention reported a 1.25% rate of surgical site infection after laminectomy and a 2.1% rate following spinal arthrodesis.25 In the literature, the overall rate of postoperative wound infections is 2.5%, with most authors agreeing on a rate of 1–6%.1,2,10,13,15,23,32,39–44 The rate of deep infection following spine surgery was 6.3% in this series, which is relatively high compared with the rates in the literature. The focus of our study was to define further significant preoperative and intraoperative factors contributing to an increased incidence of postoperative infection.

### TABLE 1: Patient diagnoses and surgical procedures in noninfected and infected groups

<table>
<thead>
<tr>
<th>Diagnosis &amp; Op</th>
<th>Total Cohort</th>
<th>Noninfected (209)</th>
<th>Infected (14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper cervical lesion</td>
<td>5</td>
<td>4</td>
<td>1 (trauma)</td>
</tr>
<tr>
<td>atlantoaxial arthrodesis</td>
<td>3</td>
<td>3</td>
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</tr>
<tr>
<td>occipitoxial arthrodesis</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>cervical degenerative disease</td>
<td>50</td>
<td>49</td>
<td>1</td>
</tr>
<tr>
<td>anterior fusion</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>laminoplasty</td>
<td>41</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>posterior fusion</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>cervical trauma</td>
<td>7</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>dense screw fixation</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>anterior fusion</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>posterior fusion</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>thoracic disease</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>anterior fusion</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>posterior fusion</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>posterior decompression</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>thoracic trauma</td>
<td>12</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>anterior fusion</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>posterior fusion</td>
<td>10</td>
<td>7</td>
<td>3</td>
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<tr>
<td>lumbar disease</td>
<td>111</td>
<td>106</td>
<td>5</td>
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<tr>
<td>posterior discectomy</td>
<td>31</td>
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<td>endoscopic discectomy</td>
<td>9</td>
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<td>0</td>
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<tr>
<td>posterior decompression</td>
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<tr>
<td>lumbar trauma</td>
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<tr>
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</tr>
<tr>
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<td>11</td>
<td>0</td>
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</table>
Risk factors for surgical site infection after spine surgery are reported to be diabetes, morbid obesity, rheumatoid arthritis, long-term steroid medications, alcohol abuse, malnutrition, smoking history, previous infection, previous spinal surgery, extended preoperative hospitalization, surgery for tumor resections, surgery for trauma, using a posterior approach, the addition of a fusion procedure, use of instrumentation, high blood loss, prolonged operative time, and postoperative incontinence, 2,5,10,20,21,26–28,44

Awareness of these risk factors will help to optimize the patient’s preoperative condition and surgical procedure and help decrease surgical site infections during spinal surgery. Advanced age (> 60 years) was also reported to be a risk factor for infections.10,16,19,37,44 Klein et al.18 found that 25% of the patients in their study undergoing elective lumbar surgery were malnourished, according to their criteria. This percentage was higher in the older patients. Although older patients have a poorer response to infection due to many comorbidities and malnourishment compared with young adults, advanced age was not a significant risk factor in this study. Olsen et al.26,27 reported morbid obesity (BMI > 35 kg/m²) as an independent risk factor. However, a statistically significant difference was not recognized in the present series because persons with morbid obesity are very rare in the Japanese population. Smoking history has also reported to be a risk factor for surgical site infection, 10,44 but in this study we could not evaluate the actual Brinkman smoking index, so our analysis did not indicate smoking history as a significant risk factor.

Many authors have reported diabetes to be a risk factor for surgical site infection.10,16,19,37,44 Olsen et al.27 identified diabetes with a preoperative serum glucose level of > 125 mg/dl or a postoperative serum glucose level > 200 mg/dl as a risk factor in orthopedic spinal surgery (OR 3.5), and stated that the role of hyperglycemia as a risk factor for surgical site infection in patients not previously diagnosed with diabetes should be investigated further. Because we included only patients who were receiving medication or insulin therapy at the time of surgery but did not include patients with hyperglycemia in this series, a relatively high OR was found (4.88). Investigation of serum glucose levels, as well as hemoglobin type A1c and a history of diabetes, will be necessary for the further evaluation of these risk factors for surgical site infection.

There are a few reports on patients with spinal trauma in terms of the incidence of infection.2,21,30,31 Blam et al.2 reported that the 9.4% rate of infection in 256 patients with trauma was significantly higher than the infection rate of 3.7% in the 2990 patients who underwent elective spinal surgery during the same period at the same hospital. In our study, multivariate analysis showed a strong association between trauma and surgical site infection (OR 9.42); thus, 8 (24%) of 33 patients with trauma underwent debridement for surgical site infection in our series. This was why our rate of surgical site infection was relatively higher than that generally reported. Lim et al.21 reviewed the reasons for a higher incidence of infections in patients with a traumatized spine compared with those receiving elective surgery. These cases included patients with multisystem trauma, concomitant open wounds, burns, head injury, sepsis, and cardiopulmonary instability. Urinary tract infections, decubitus ulcers, and pneumonia are potential sources of hematogenous bacterial seeding of the postsurgical hematoma and surgical site in the patients with complete paralysis.9,30 As severe general conditions caused by multisystem trauma delayed surgery, the preoperative hospital stay in patients with spinal trauma was long, averaging 13.7 days in this series. Blam et al.2 reported that surgical treatment more than 1 week after injury increased the likelihood of infection more than 8 times higher than in patients for whom treatment began within 48 hours of injury. Bed rest in the intensive care unit and the long-term impossibility of taking a shower makes the patient’s back unclean. Moreover, patients who have spinal trauma are not usually allowed to ingest anything through the mouth for several days. Rechtine et al.31 reported that the average perioperative period without in-
gesting anything through the mouth among patients with spinal trauma was 6.4 days. Malnutrition is also associated with surgical site infections. In patients with a traumatized spine, it is important to make every attempt to avoid delaying the surgery as soon as other life-threatening injuries are stabilized and decrease the perioperative stay in the intensive care unit.

Wimmer et al.44 indicated prolonged operative time (> 3 hours) as a risk factor for infections. On the other hand, prolonged surgery did not emerge as a significant risk factor for wound infections in several other studies.2,5,13 As prolonged surgery times increase the chance of contamination in surgical wounds, it is thought to predispose to infection. In our univariate study, surgical duration was significantly higher in the infected group. However, the multivariate study showed no association between surgical time and increased infection rate.

Wimmer et al.44 reported 19 of 22 infected cases with > 1000 g of intraoperative blood loss. However, Fang et al.10 reported that high intraoperative blood loss was not a risk factor for surgical site infection. Blood loss in our patient series was significantly higher in the infected group, but multivariate analysis did not identify it as a risk factor. Because excess bleeding prevents the meticulous debridement of nonviable tissue, and the postoperative hematoma on the approximated sidewalls serves to transmit bacteria, it might predispose patients to surgical site infections with prolonged surgery.

For many years, it has been widely recognized that bacteria originating from the patient’s own skin, surgeons’ gloves, and airborne dust particles in the operating theater frequently contaminate operative wounds. The key to successful outcomes is the prevention of any infection through meticulous techniques of reducing intraoperative wound contamination and debriding nonviable tissues.3 Blam et al.2 reported a significantly lower rate of postsurgical infections in surgery with combined teams of surgeons (neurosurgical and orthopedic). Multiple surgeons tend to inspect the wound, debride nonviable tissue thoroughly, and give repeated irrigation. These factors likely lead to decreased bacterial contamination. There is no literature on the association between surgical debridement in a first operation and surgical site infection to our knowledge, because objective assessment of this is difficult. Regarding the intraoperative lavage of the site of surgery, although there are some reports about the efficacy of povidone-iodine6–8,12,31,38 or antibiotics22,24,36,45 added to saline for irrigation, no association between the amount of saline used for irrigation and surgical site infection. In the univariate study, the mean amount of saline used for irrigation was lower in the infected group, but the difference was not statistically significant. For the multivariate logistic regression analysis, we categorized the mean amount of saline used for irrigation per hour in each category, the infection risk for the group with > 2000 ml was significantly associated with surgical site infection. Using the group with < 1000 ml/hour as the reference category, the infection risk for the group with > 2000 ml/hour decreased below 10% (OR 0.08). Considering the previously published advice,3 we strongly recommend the irrigation of surgical wounds every 15 minutes with at least 500 ml of saline to prevent surgical site infection following spinal surgery.

### Conclusions

In this study, we performed univariate and multivariate analysis to assess the risk factors for surgical site infection. There were significant differences in the duration of surgery and intraoperative blood loss according to univariate analysis but not according to multivariate analysis. These factors might not be associated directly with surgical site infections following spinal surgery but tend to increase the risk. On the other hand, in multivari-
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ate analysis, diabetes (OR 4.9; p = 0.048), trauma (OR 9.4; p = 0.013), and insufficient intraoperative irrigation of the surgical wound (mean amount of saline for irrigation per hour > 2000 ml; OR 0.08; p = 0.015) were independent and direct risk factors for surgical site infections. Although the association does not imply causation, for the prevention of surgical site infections it is important to control the perioperative serum glucose levels in patients with diabetes, to avoid any delay in surgery in patients with trauma, and to reduce any intraoperative contaminations by irrigating with > 2000 ml/hour of saline in all cases of spine surgery.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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