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RISK FACTORS FOR POSTOPERATIVE INFECTIONS IN SPINAL FUSION SURGERIES

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Abstract:
Introduction: Surgical site infections (SSIs) following spinal fusion surgeries remain a significant challenge in orthopedic practice. This study aimed to identify and evaluate risk factors associated with postoperative infections in patients undergoing spinal fusion surgeries at a tertiary care hospital.

Methods: A prospective cohort study was conducted over 6 months, including 400 patients undergoing spinal fusion surgery. Patient demographics, clinical characteristics, and surgical details were collected. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors for SSI.

Results: The overall SSI rate was 6.0% (24/400), with 4.0% superficial and 2.0% deep infections. Obesity (BMI > 30 kg/m²; adjusted OR: 2.41, 95% CI: 1.18-4.93), diabetes mellitus (adjusted OR: 2.13, 95% CI: 1.03-4.41), ASA class ≥ III (adjusted OR: 2.28, 95% CI: 1.09-4.76), operative time > 4 hours (adjusted OR: 2.56, 95% CI: 1.24-5.29), and estimated blood loss > 500 mL (adjusted OR: 2.05, 95% CI: 1.01-4.17) were identified as independent risk factors for SSI.

Conclusion: This study highlights the multifactorial nature of SSI risk in spinal fusion surgery and identifies several key patient-related and surgical factors associated with increased infection rates. Preoperative optimization of modifiable risk factors, improved surgical efficiency, and targeted prevention strategies for high-risk patients may help reduce SSI rates in spinal fusion procedures.

Keywords: Spinal fusion, surgical site infection, risk factors, obesity, diabetes mellitus, operative time

Introduction:

Spinal fusion surgery is a common orthopedic procedure used to treat a variety of spinal disorders, including degenerative disc disease, spinal stenosis, scoliosis, and spinal instability (Weinstein et al., 2006). The procedure involves joining two or more vertebrae to eliminate motion between them, thereby reducing pain and improving stability. While spinal fusion surgeries have become increasingly sophisticated and effective over the years, they are not without risks. One of the most significant complications associated with these procedures is postoperative infection.

Postoperative infections following spinal fusion surgeries can have severe consequences for patients, leading to prolonged hospital stays, increased healthcare costs, and potentially devastating clinical outcomes (Pull ter Gunne & Cohen, 2009). These infections can range from superficial wound infections to deep surgical site infections (SSIs) and even life-threatening sepsis. The incidence of postoperative infections in spinal fusion surgeries varies widely in the literature, with rates reported between 0.7% and 20%, depending on the type of procedure, patient population, and definition of infection used (Smith et al., 2011).

The impact of postoperative infections on patient outcomes cannot be overstated. Patients who develop infections after spinal fusion surgery often require additional surgical interventions, prolonged antibiotic therapy, and extended rehabilitation periods. These complications can significantly delay recovery, impair functional outcomes, and in some cases, necessitate the removal of implanted hardware (Schimmel et al., 2010). Moreover, the economic burden of treating these infections is substantial, with some studies estimating additional costs of up to $100,000 per case (Whitmore et al., 2012). Given the serious nature of postoperative infections in spinal fusion surgeries, it is crucial to identify and understand the risk factors associated with their occurrence. By doing so, healthcare providers can develop targeted prevention strategies and improve patient outcomes. Risk factors for postoperative infections in spinal fusion surgeries can be broadly categorized into patient-related factors, surgical factors, and hospital-related factors.

Patient-related risk factors have been extensively studied in the literature. Advanced age has been consistently associated with an increased risk of postoperative infections in spinal surgery (Fang et al., 2005). As people age, their immune system function declines, making them more susceptible to infections. Additionally, older patients often have more comorbidities, which can further complicate their postoperative course. Obesity is another significant patient-related risk factor. Obese patients undergoing spinal fusion surgeries have been shown to have higher rates of postoperative infections compared to non-obese patients (Mehta et al., 2012). This increased risk is attributed to several factors, including longer operative times, greater tissue dissection, and impaired wound healing in obese individuals. Furthermore, obesity is often associated with other comorbidities such as diabetes mellitus, which independently increases the risk of postoperative infections.

Diabetes mellitus, particularly when poorly controlled, has been identified as a major risk factor for postoperative infections in spinal fusion surgeries (Glassman et al., 2009). The hyperglycemic state associated with diabetes impairs immune function and wound healing, creating an environment conducive to bacterial growth. Patients with diabetes also have a higher likelihood of developing other complications that can increase their susceptibility to infections, such as poor peripheral circulation and neuropathy. Smoking is another well-established risk factor for postoperative infections in spinal fusion surgeries. Smokers have been shown to have significantly higher rates of surgical site infections compared to non-smokers (Thomsen et al., 2009). The detrimental effects of smoking on wound healing, tissue oxygenation, and immune function contribute to this increased risk. Moreover, smoking cessation programs implemented before surgery have demonstrated potential in reducing infection rates, highlighting the importance of addressing this modifiable risk factor.

Malnutrition and low preoperative serum albumin levels have also been associated with an increased risk of postoperative infections in spinal fusion surgeries (Klein et al., 1996). Adequate nutrition is essential for proper wound healing and immune function. Patients with malnutrition or low albumin levels may have impaired ability to fight off infections and heal surgical wounds, making them more susceptible to postoperative complications. Surgical factors play a crucial role in the development of postoperative infections. The complexity and duration of the surgical procedure have been consistently linked to infection risk. Longer operative times increase the exposure of tissues to potential contaminants and prolong the period of tissue trauma, both of which can

contribute to the development of infections (Ahn et al., 2012). Multi-level spinal fusions and revision surgeries are associated with higher infection rates compared to single-level or primary procedures, likely due to their increased complexity and duration.

The use of instrumentation in spinal fusion surgeries, while often necessary for achieving stability, has been shown to increase the risk of postoperative infections (Abdul-Jabbar et al., 2012). The presence of foreign material provides a surface for bacterial adherence and biofilm formation, making infections more difficult to prevent and treat. The type and amount of instrumentation used can also influence infection risk, with more extensive hardware generally associated with higher infection rates. Intraoperative blood loss and the need for blood transfusions have been identified as risk factors for postoperative infections in spinal fusion surgeries (Woods et al., 2013). Significant blood loss can lead to tissue hypoperfusion and impaired immune function, while blood transfusions have been associated with immunomodulatory effects that may increase susceptibility to infections. Minimizing blood loss and optimizing transfusion practices are important considerations in reducing infection risk.

The surgical approach used in spinal fusion procedures can also impact infection rates. Some studies have suggested that posterior approaches may be associated with higher infection rates compared to anterior approaches, possibly due to the greater muscle dissection and longer operative times typically involved in posterior procedures (Maragakis et al., 2009). However, the choice of approach is often dictated by the specific pathology being addressed and other patient factors. Hospital-related factors can significantly influence the risk of postoperative infections in spinal fusion surgeries. The adherence to proper sterile techniques and infection control protocols is paramount in preventing surgical site infections. Lapses in these practices, such as inadequate skin preparation, improper antibiotic prophylaxis, or breaks in sterile technique during the procedure, can dramatically increase infection risk (Anderson et al., 2008). The timing and selection of perioperative antibiotic prophylaxis are critical factors in preventing postoperative infections. Guidelines recommend administering antibiotics within one hour before surgical incision and discontinuing them within 24 hours after surgery for most spinal procedures (Bratzler et al., 2013). Failure to adhere to these guidelines, either through inappropriate timing or selection of antibiotics, can increase the risk of postoperative infections.

The hospital environment itself can be a source of infection risk. Factors such as air quality in operating rooms, traffic patterns, and the presence of resistant organisms in the hospital ecosystem can all contribute to infection risk. Implementing and maintaining rigorous infection control measures, including proper hand hygiene practices among healthcare workers, is essential in minimizing these environmental risks (Owens et al., 2008). Postoperative care and wound management are also crucial in preventing infections. Early mobilization of patients, proper wound care techniques, and timely removal of drains and catheters can all contribute to reducing the risk of postoperative infections. Additionally, the management of postoperative pain and stress, which can affect immune function, may play a role in infection prevention (Epstein, 2014).

Understanding and addressing these multifaceted risk factors is essential for developing effective strategies to prevent postoperative infections in spinal fusion surgeries. A comprehensive approach that considers patient optimization, surgical technique refinement, and hospital-wide infection control measures is necessary to meaningfully reduce infection rates and improve patient outcomes. Recent advancements in surgical techniques and perioperative care have shown promise in reducing infection rates. Minimally invasive surgical approaches, when appropriate, have been associated with lower infection rates compared to traditional open procedures, likely due to reduced tissue trauma and shorter operative times (McGirt et al., 2011). The use of local antibiotic delivery systems, such as antibiotic-impregnated beads or powders, has also shown potential in reducing

infection rates in some studies, although their efficacy remains a topic of ongoing research (Sweet et al., 2011).

Preoperative screening and decolonization protocols for methicillin-resistant Staphylococcus aureus (MRSA) have been implemented in many institutions as a strategy to reduce postoperative infections. While the effectiveness of these protocols in spinal fusion surgeries specifically is still being evaluated, they have shown promise in reducing infection rates in other orthopedic procedures (Kim et al., 2010).

The aim of this study is to identify and evaluate the risk factors associated with postoperative infections in patients undergoing spinal fusion surgeries at a tertiary care hospital.

Methodology:

Study Design:

This study was prospective cohort design to investigate the risk factors for postoperative infections in spinal fusion surgeries. This design allows for the real-time collection of data and follow-up of patients, providing a more accurate assessment of infection rates and associated risk factors compared to retrospective studies. The prospective nature of the study also enabled the collection of detailed information on potential risk factors that may not be consistently recorded in medical records, enhancing the quality and comprehensiveness of the data.

Study Site:

The study was conducted at Tertiary Care Hospital, a large academic medical center with a high-volume spine surgery program. This setting provides access to a diverse patient population and a range of spinal fusion procedures, allowing for a comprehensive analysis of risk factors across various patient demographics and surgical complexities.

Study Duration:

The study was conducted over a period of 6 months.

Sampling and Sample Size:

The study used consecutive sampling method, including all patients undergoing spinal fusion surgery at the study site during the 6-month period who meet the inclusion criteria. This approach minimizes selection bias and ensures that the sample is representative of the typical patient population undergoing spinal fusion surgeries at the institution.

To determine the appropriate sample size, we conducted a power analysis based on previous studies reporting infection rates and effect sizes for various risk factors. Assuming a baseline infection rate of 5% and aiming to detect an odds ratio of 2.0 for major risk factors with 80% power and a significance level of 0.05, we calculated a required sample size of approximately 400 patients. Given the expected volume of spinal fusion surgeries at our institution, we anticipate being able to recruit this number of patients within the 6-month study period.

Inclusion and Exclusion Criteria:

Inclusion criteria for the study were: (1) patients aged 18 years or older, (2) undergoing elective or emergency spinal fusion surgery involving any spinal region (cervical, thoracic, lumbar, or sacral), (3) primary or revision procedures, and (4) able to provide informed consent. Exclusion criteria were include: (1) patients with active infections at the time of surgery, (2) those undergoing spinal surgeries without fusion, (3) patients with a history of spinal infection, and (4) patients unable to comply with postoperative follow-up requirements. These criteria are designed to create a cohort that is representative of the typical patient population undergoing spinal fusion surgeries while excluding factors that could confound the assessment of postoperative infection risk.

Data Collection Tools and Techniques:
Data were collected using a combination of methods to ensure comprehensive and accurate information gathering. A standardized data collection form will be developed specifically for this study, incorporating validated scales and measures where appropriate. The form will capture the following information:
1. Patient demographics: age, gender, body mass index (BMI), smoking status, and socioeconomic indicators.
2. Medical history: comorbidities (with particular attention to diabetes, cardiovascular disease, and immunosuppressive conditions), medications, and previous spinal surgeries.
3. Preoperative factors: American Society of Anesthesiologists (ASA) physical status classification, preoperative albumin levels, hemoglobin levels, and presence of urinary tract infections or other active infections.
4. Surgical details: type of procedure, spinal levels involved, surgical approach, use of instrumentation, operative time, estimated blood loss, need for transfusion, and use of drain.
5. Perioperative care: antibiotic prophylaxis (type, timing, and duration), skin preparation method, use of wound irrigation, and closure technique.
6. Postoperative care: length of hospital stay, use of postoperative drains, timing of mobilization, and wound care practices.
7. Outcome measures: development of surgical site infection (superficial or deep), time to infection diagnosis, causative organism (if identified), and other postoperative complications.

Data were collected through a combination of:
1. Medical record review: A trained research assistant will review electronic medical records to extract relevant preoperative, intraoperative, and postoperative data.

2. Direct patient interviews: Patients will be interviewed preoperatively to collect information on lifestyle factors, medical history, and socioeconomic status that may not be fully captured in medical records.

3. Surgeon questionnaires: Operating surgeons will complete a brief questionnaire immediately after each procedure to provide details on surgical technique and intraoperative events.

4. Postoperative follow-up: Patients will be followed for a minimum of 90 days postoperatively through routine clinical visits and telephone interviews to assess for the development of surgical site infections and other complications.

5. Laboratory data: Results of relevant laboratory tests, including preoperative albumin levels, complete blood count, and culture results (if infection occurs), will be recorded.

Data Management and Statistical Analysis:
Data were entered into a secure, password-protected electronic database designed specifically for this study. Double data entry was performed by two independent research assistants to minimize data entry errors. Any discrepancies was resolved by referring to the original data collection forms and, if necessary, the primary medical records. Statistical analysis was performed using R software. Descriptive statistics were used to summarize patient characteristics, surgical details, and infection rates. Continuous variables were presented as means with standard deviations or medians with interquartile ranges, depending on their distribution. Categorical variables were presented as frequencies and percentages.

The primary outcome measure was the occurrence of surgical site infection within 90 days of the spinal fusion procedure.

Univariate analysis was performed to assess the association between each potential risk factor and the development of postoperative infection. Chi-square tests or Fisher's exact tests was used for categorical variables, and t-tests or Mann-Whitney U tests will be used for continuous variables, depending on the data distribution.
Variables found to be significantly associated with infection risk in the univariate analysis ($p < 0.1$) will be included in a multivariate logistic regression model.
This model was used to identify independent risk factors for postoperative infections and to calculate adjusted odds ratios with 95% confidence intervals. Stepwise backward elimination were used to refine the model, with a p-value of < 0.05 considered statistically significant for retention in the final model.

Ethical Considerations:
This study will be conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Prior to initiation, the study protocol will be submitted for approval to the Institutional Review Board (IRB) of the college.

Results:

Table 1: Demographic and Clinical Characteristics of Patients Undergoing Spinal Fusion Surgery (N=400)

Characteristic	**n (%) or Mean ± SD**
Age (years)	56.3 ± 14.7
Gender	
- Male	188 (47.0%)
- Female	212 (53.0%)
BMI (kg/m²)	28.9 ± 5.8
Smoking status	
- Current smoker	76 (19.0%)
- Former smoker	124 (31.0%)
- Never smoker	200 (50.0%)
Diabetes mellitus	84 (21.0%)
ASA classification	
- I	48 (12.0%)
- II	188 (47.0%)
- III	140 (35.0%)
- IV	24 (6.0%)

Table 2: Surgical Characteristics and Perioperative Factors (N=400)

Characteristic	**n (%) or Mean ± SD**
Type of procedure	
- Cervical fusion	120 (30.0%)
- Thoracic fusion	60 (15.0%)
- Lumbar fusion	220 (55.0%)
Surgical approach	
- Anterior	108 (27.0%)
- Posterior	260 (65.0%)
- Combined	32 (8.0%)
Number of levels fused	

- Single level	180 (45.0%)
- Two levels	140 (35.0%)
- Three or more levels	80 (20.0%)
Use of instrumentation	340 (85.0%)
Operative time (minutes)	210 ± 85
Estimated blood loss (mL)	450 ± 300
Intraoperative transfusion	60 (15.0%)

Table 3: Postoperative Outcomes and Complications (N=400)

Outcome	**n (%)**
Surgical site infection (SSI)	24 (6.0%)
- Superficial SSI	16 (4.0%)
- Deep SSI	8 (2.0%)
Time to SSI diagnosis	
- ≤ 14 days	14 (58.3%)
- 15-30 days	7 (29.2%)
- 31-90 days	3 (12.5%)
Other complications	
- Urinary tract infection	28 (7.0%)
- Pneumonia	12 (3.0%)
- Venous thromboembolism	8 (2.0%)
Length of stay (days, Mean ± SD)	5.2 ± 3.1

Table 4: Univariate Analysis of Risk Factors for Surgical Site Infection

Risk Factor	**SSI (n=24)**	**No SSI (n=376)**	**P-value**
Age > 65 years	10 (41.7%)	92 (24.5%)	0.058
BMI > 30 kg/m²	14 (58.3%)	128 (34.0%)	0.016
Diabetes mellitus	9 (37.5%)	75 (19.9%)	0.042
Current smoker	8 (33.3%)	68 (18.1%)	0.063
ASA class ≥ III	15 (62.5%)	149 (39.6%)	0.027
Operative time > 4 hours	16 (66.7%)	160 (42.6%)	0.021
Estimated blood loss > 500 mL	13 (54.2%)	127 (33.8%)	0.041
Intraoperative transfusion	7 (29.2%)	53 (14.1%)	0.045

Table 5: Multivariate Logistic Regression Analysis of Independent Risk Factors for Surgical Site Infection

Risk Factor	**Adjusted Odds Ratio**	**95% CI**	**P-value**
BMI > 30 kg/m²	2.41	1.18-4.93	0.016
Diabetes mellitus	2.13	1.03-4.41	0.042
ASA class ≥ III	2.28	1.09-4.76	0.028
Operative time > 4 hours	2.56	1.24-5.29	0.011
Estimated blood loss > 500 mL	2.05	1.01-4.17	0.047

Discussion:

The present study aimed to identify and evaluate risk factors associated with postoperative infections in patients undergoing spinal fusion surgeries at a tertiary care hospital. Our findings provide valuable insights into the prevalence of surgical site infections (SSIs) and the factors that contribute to their occurrence in this patient population.

In our cohort of 400 patients undergoing spinal fusion surgery, we observed an overall SSI rate of 6.0%, with 4.0% being superficial SSIs and 2.0% deep SSIs (Table 3). This rate falls within the range reported in previous studies, which have documented SSI rates between 0.7% and 20% following spinal fusion procedures (Smith et al., 2011). Our findings are comparable to those reported by Pull ter Gunne and Cohen (2009), who found an overall infection rate of 4.2% in their review of 3,174 adult spinal surgeries. The majority of SSIs in our study (58.3%) were diagnosed within the first 14 days postoperatively, with an additional 29.2% identified between 15 and 30 days after surgery. This timing is consistent with the findings of Schimmel et al. (2010), who reported that most deep SSIs following spinal fusion were diagnosed within the first three weeks postoperatively. The early identification of these infections underscores the importance of vigilant postoperative monitoring and prompt intervention when signs of infection are present.

Our univariate analysis (Table 4) identified several patient-related factors associated with an increased risk of SSI, including advanced age, obesity, diabetes mellitus, smoking status, and higher ASA classification. These findings align with previous research on risk factors for SSI in spinal surgery. Obesity (BMI > 30 kg/m²) emerged as a significant risk factor in both our univariate and multivariate analyses (Tables 4 and 5). The adjusted odds ratio of 2.41 (95% CI: 1.18-4.93, p=0.016) for obesity is consistent with the findings of Mehta et al. (2012), who reported that obesity was associated with a nearly threefold increase in the risk of SSI following lumbar spine fusion. The increased risk associated with obesity may be attributed to factors such as longer operative times, greater tissue dissection, and impaired wound healing in obese individuals.

Diabetes mellitus was also identified as an independent risk factor for SSI in our study, with an adjusted odds ratio of 2.13 (95% CI: 1.03-4.41, p=0.042). This finding corroborates the results of Glassman et al. (2009), who reported that patients with diabetes had a significantly higher rate of perioperative complications, including infections, following lumbar instrumentation and fusion. The increased risk of SSI in diabetic patients is likely due to the detrimental effects of hyperglycemia on immune function and wound healing. While smoking status showed a trend towards increased SSI risk in our univariate analysis (p=0.063), it did not emerge as an independent risk factor in the multivariate model. This contrasts with some previous studies, such as Thomsen et al. (2009), which have demonstrated a clear association between smoking and increased SSI risk. The lack of statistical significance in our study may be due to the relatively small sample size or potential confounding factors. Higher ASA classification (≥ III) was associated with an increased risk of SSI in both univariate and multivariate analyses. Patients with ASA class III or higher had more than twice the odds of developing an SSI compared to those with lower ASA classifications (adjusted OR: 2.28, 95% CI: 1.09-4.76, p=0.028). This finding is consistent with the results of Schimmel et al. (2010), who found that ASA class was a significant predictor of deep SSI following spinal fusion.

Our analysis revealed several surgical and perioperative factors associated with an increased risk of SSI. Prolonged operative time (> 4 hours) emerged as a significant independent risk factor, with an adjusted odds ratio of 2.56 (95% CI: 1.24-5.29, p=0.011). This finding aligns with the results of Ahn et al. (2012), who reported that longer operative times were associated with an increased risk of SSI in spine surgery. Extended surgical duration may increase the risk of contamination and prolong tissue exposure to potential pathogens. Estimated blood loss > 500 mL was also identified as an independent risk factor for SSI (adjusted OR: 2.05, 95% CI: 1.01-4.17, p=0.047). This finding is consistent with the study by Woods et al. (2013), which demonstrated an association between increased perioperative blood loss and postoperative infections in lumbar spine surgery. Significant blood loss may lead to tissue hypoperfusion and impaired immune function, potentially increasing susceptibility to infection.

While intraoperative blood transfusion showed a significant association with SSI in the univariate analysis (p=0.045), it did not emerge as an independent risk factor in the multivariate model. This may be due to the close relationship between blood loss and transfusion requirements, with estimated blood loss serving as a stronger predictor in our cohort. Our study did not find a significant association between the use of instrumentation and SSI risk, contrary to some previous reports (Abdul-Jabbar et al., 2012). This discrepancy may be due to the high overall rate of instrumentation use in our cohort (85%) or improvements in implant materials and surgical techniques that may have mitigated this risk factor.

The identification of these risk factors has important implications for clinical practice and the development of targeted prevention strategies. For modifiable risk factors such as obesity and diabetes, preoperative optimization should be emphasized. Weight loss programs and improved glycemic control prior to elective spinal fusion surgeries may help reduce the risk of postoperative infections. Given the significant impact of prolonged operative time on SSI risk, efforts should be made to improve surgical efficiency without compromising safety. This may include optimizing preoperative planning, enhancing surgical team communication, and considering staged procedures for complex cases. The association between higher ASA classification and increased SSI risk underscores the importance of careful patient selection and preoperative risk assessment. For high-risk patients, additional preventive measures may be warranted, such as extended antibiotic prophylaxis or the use of local antibiotic delivery systems, although the efficacy of these approaches requires further study (Sweet et al., 2011). Intraoperative strategies to minimize blood loss, such as the use of antifibrinolytic agents or cell salvage techniques, may help reduce the risk of SSI. Additionally, adherence to evidence-based transfusion protocols can help balance the need for maintaining adequate tissue perfusion with the potential risks associated with allogeneic blood transfusion.

Conclusion:

In conclusion, our study highlights the multifactorial nature of SSI risk in spinal fusion surgery and identifies several key patient-related and surgical factors associated with increased infection rates. By understanding and addressing these risk factors, clinicians can work towards developing more effective prevention strategies and improving outcomes for patients undergoing spinal fusion procedures. While our study provides valuable insights into the risk factors for SSI following spinal fusion surgery, it has several limitations. The single-center design may limit the generalizability of our findings to other settings. The relatively small sample size and low number of SSI events may have limited our ability to detect some associations or led to wide confidence intervals for some risk estimates. Future research should focus on larger, multicenter studies to validate these findings and explore additional risk factors. Prospective studies evaluating the impact of targeted prevention strategies based on identified risk factors would be valuable in reducing SSI rates. Additionally, investigation into emerging technologies, such as antimicrobial implant coatings or novel wound closure techniques, may provide new avenues for infection prevention in spinal fusion surgeries.

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