

Cross-sectional analysis of risk factors for surgical site infection secondary to spinal internal fixation via the posterior approach

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Abstract

Objective: This study was performed to investigate the risk factors related to surgical site infection (SSI) secondary to spinal internal fixation via the posterior approach.

Methods: Patients who had undergone spinal internal fixation via the posterior approach were selected for inclusion in this cross-sectional study. Factors related to SSI were analysed using univariate and multivariate analyses.

Results: Among 4,350 patients, 66 had SSI (infection prevalence of 1.5%). Multivariate logistic regression analysis demonstrated that age of >60 years, surgical duration of >3 hours, haemoglobin concentration of <80 g/L, serum albumin concentration of <30 g/L, diabetes history, and blood loss of >1,000 mL were significantly correlated with SSI secondary to spinal internal fixation via the posterior approach.

Conclusions: This study provides information on SSI secondary to spinal internal fixation via the posterior approach. We found that age of >60 years, surgical duration of >3 hours, haemoglobin concentration of <80 g/L, serum albumin concentration of <30 g/L, diabetes history, and blood loss of >1,000 mL are directly correlated with SSI secondary to spinal internal fixation via the posterior approach.

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Keywords

Posterior spinal surgery, surgical site infection, risk factor, prevention, treatment, spinal internal fixation, cross-sectional study

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Introduction

Spinal internal fixation via the posterior approach is a commonly used surgical method for degenerative spinal diseases and spinal fractures in the clinical setting. However, the internal fixation device is a foreign body that increases the incidence of postoperative surgical site infection (SSI). At present, SSI is clinically defined as surgery-related infection within 1 year of internal fixation, and it includes superficial infection, deep infection, and interstitial infection of organs and tissues.¹ Studies have shown that the prevalence of SSI secondary to spinal internal fixation via the posterior approach is about 0.7% to 12.0%.^{2,3} For some patients undergoing spinal internal fixation via the posterior approach with subsequent fusion, the internal fixation device needs to be removed before the fixed segment meets the criteria for fusion because of severe infection, leading to the secondary loss of spinal stability.

Because of the limited medical resources in China, especially Northwest China, infection after spinal surgery increases the economic burden on patients and causes severe physical and psychological trauma to patients.^{4,5} Moreover, there is limited information about the risk factors related to SSI secondary to spinal internal fixation via the posterior approach in China. Understanding the specific factors associated with SSI secondary to spinal internal fixation via the posterior approach is important to help prevent postoperative spinal infection and can support hospitals and the government in their efforts to improve the current situation of such

infections. In this study, we examined the factors related to SSI secondary to spinal internal fixation via the posterior approach to provide a certain reference for the clinical prevention of SSI and to evaluate patients' demographic and clinical characteristics.

Materials and methods

Study participants

In this cross-sectional study, we collected the clinical data of patients who were undergoing spinal internal fixation via the posterior approach at the spinal centre of our hospital and were diagnosed with postoperative spinal infection based on clinical manifestations (body temperature change, pain in surgical area, and incision change), imaging examination (magnetic resonance imaging), laboratory examinations (routine blood testing, C-reactive protein, and erythrocyte sedimentation rate), and bacteriological culture. The following inclusion criteria were also applied: postoperative follow-up of >1 year, availability of complete imaging and laboratory data, residence in Northwest China, and antibiotics routinely administered 30 minutes before surgery and during surgery if the surgical duration exceeded 3 hours. However, antibiotic use should not exceed 72 hours after surgery. The exclusion criteria were malignant spinal tumours, no internal fixation, primary spinal infection, a history of spinal surgery or spinal tuberculosis, and abnormal immune system function. This study was approved by the Ethics Committee of Shaanxi Provincial People's Hospital

(No. 2020-0127). Each author certifies that all investigations were conducted in conformity with ethical principles. Written informed consent was obtained from all patients included in the study. The reporting of this study conforms to the STROBE guidelines.⁶

Data collection

The data were collected by trained personnel from Shaanxi Provincial People's Hospital from January 2004 to December 2019 under the guidance of the first author. Demographic data and surgery-related data were recorded. The following demographic data were obtained from the patients' medical records: age, sex, body mass index, serum albumin concentration, haemoglobin concentration, diabetes history, 72-hour postoperative peak blood glucose concentration of >12 mmol/L, smoking history, cardiac history, pulmonary history, renal history, prior infection history, haematologic history, hypertension history, and monthly income per person. The surgery-related factors were intraoperative allogeneic blood transfusion, number of fused segments, surgical site, blood loss, surgical duration, and beginning time of surgery.

Statistical analyses

The data were processed using IBM SPSS Statistics for Windows, Version 19.0 (IBM Corp., Armonk, NY, USA). Measurement data are expressed as mean \pm standard deviation and were analysed using the independent-samples t-test. Enumeration data are expressed as the number of cases and were analysed using the χ^2 test. Important factors in the univariate and correlation analyses were included in the stepwise multiple linear regression. A *P* value of <0.05 was considered statistically significant.

Results

In total, 4,350 patients were enrolled in this study, including 2,250 men and 2,100 women with an age range of 19 to 90 years (mean age, 45.2 ± 14.7 years). Among the 4,350 patients, 66 had SSI (prevalence rate of 1.5%), including 37 men and 29 women with an age range of 22 to 84 years (mean age, 47.4 ± 12.8 years).

Univariate analysis

The univariate analysis showed that sex, body mass index, number of fused segments, surgical site, surgery beginning time, smoking history, allogeneic blood transfusion, postoperative drainage duration, renal history, prior infection history, haematologic history, and monthly income were not correlated with infection. However, age of >60 years, surgical duration of >3 hours, serum albumin concentration of <30 g/L, haemoglobin concentration of <80 g/L, diabetes history, 72-hour postoperative peak blood glucose concentration of ≥ 12 mmol/L, blood loss of $>1,000$ mL, cardiac history, pulmonary history, and hypertension history were correlated with infection (Table 1).

Multivariate analysis

The multivariate logistic regression analysis demonstrated that age of >60 years, surgical duration of >3 hours, serum albumin concentration of <30 g/L, haemoglobin concentration of <80 g/L, diabetes history, and blood loss of $>1,000$ mL were significantly correlated with SSI secondary to spinal internal fixation via the posterior approach (Table 2).

Discussion

SSI secondary to spinal surgery is considered to be related to many factors,^{7,8} some of which are related to the patients

Table 1. Univariate analysis of factors related to SSI secondary to spinal internal fixation via the posterior approach.

	Number of patients	Number of infections	Rate of infection	P
Age (years)				
≤60	2670	26	1.0%	<0.05
>60	1680	40	2.4%	<0.05
Sex				
Male	2250	37	1.6%	>0.05
Female	2100	29	1.4%	>0.05
BMI (kg/m ²)				
<30	1689	28	1.7%	>0.05
25–30	1868	26	1.4%	>0.05
>30	793	12	1.5%	>0.05
Number of fused segments				
≤2	2308	38	1.6%	>0.05
>2	2042	28	1.4%	>0.05
Surgical site				
Cervical	134	2	1.5%	>0.05
Thoracic	1540	22	1.4%	>0.05
Lumbar	2676	42	1.6%	>0.05
Beginning time of surgery				
Before 12:00 pm	2256	32	1.4%	>0.05
After 12:00 pm	2094	34	1.6%	>0.05
Haemoglobin (g/L)				
<80	1784	32	1.8%	<0.05
≥80	2566	34	1.3%	<0.05
Serum albumin (g/L)				
<30	1140	35	3.1%	<0.05
≥30	3210	31	1.0%	<0.05
Smoking history				
Yes	1883	28	1.5%	>0.05
No	2467	38	1.5%	>0.05
Allogeneic blood transfusion				
Yes	2022	32	1.6%	>0.05
No	2328	34	1.5%	>0.05
Surgical duration (hours)				
>3	1951	41	2.1%	<0.05
≤3	2399	25	1.0%	<0.05
Postoperative drainage duration (hours)				
≤48	1987	28	1.4%	>0.05
>48	2363	38	1.6%	>0.05
Diabetes history				
Yes	983	34	3.5%	<0.05
No	3367	32	1.0%	<0.05
Peak blood glucose 72 hours after surgery (mmol/L)				
≤12	3781	47	1.2%	<0.05
>12	569	19	3.3%	<0.05

(continued)

Table 1. Continued.

	Number of patients	Number of infections	Rate of infection	P
Blood loss (mL)				
≤1000	3777	51	1.4%	<0.05
>1000	573	15	2.6%	<0.05
Cardiac history				
Yes	312	7	2.2%	<0.05
No	4038	59	1.5%	<0.05
Pulmonary history				
Yes	1510	29	1.9%	<0.05
No	2840	37	1.3%	<0.05
Renal history				
Yes	127	2	1.5%	>0.05
No	4223	64	1.5%	>0.05
Prior infection history				
Yes	63	1	1.6%	>0.05
No	4287	65	1.5%	>0.05
Haematologic history				
Yes	79	1	1.3%	>0.05
No	4271	65	1.5%	>0.05
Hypertension history				
Yes	357	8	2.2%	<0.05
No	3993	58	1.5%	<0.05
Monthly income				
≤500 US dollars	2510	35	1.4%	>0.05
>500 US dollars	1840	31	1.7%	>0.05

SSI, surgical site infection; BMI, body mass index.

Table 2. Multivariate logistic regression analysis of factors related to SSI secondary to spinal internal fixation via the posterior approach.

	B	Wald	P	OR	95% CI
Age of >60 years	1.096	4.836	0.029	2.98	1.144–7.959
Surgical duration of >3 hours	2.893	44.356	0.012	11.183	7.764–14.701
Serum albumin concentration of <30 g/L	1.121	4.998	0.014	3.322	1.368–4.738
Haemoglobin concentration of <80 g/L	1.11	4.879	0.015	2.998	1.247–6.269
Diabetes history	2.135	21.191	0.005	4.475	3.355–10.832
Blood loss of >1000 mL	2.458	26.353	0.013	10.522	4.452–30.815

SSI, surgical site infection; OR, odds ratio; CI, confidence interval.

themselves whereas some are related to the treatment methods. In this study, advanced age, surgical duration of >3 hours, serum albumin concentration of <30 g/L, haemoglobin concentration of <80 g/L, diabetes history, and blood loss of >1,000 mL were the independent risk factors for SSI after

spinal surgery in our hospital. Some studies have shown that age is an important factor that affects the incidence of SSI after spinal surgery.^{9,10} In particular, the incidence of SSI after spinal surgery is significantly higher for older patients aged >60 years. The risk of SSI after spinal surgery in

older patients aged ≥ 60 years is reportedly three times higher than that in younger patients.¹¹ Schoenfeld et al.¹² analysed 126 patients with SSI secondary to spinal internal fixation via the posterior approach and found that the risk of postoperative infection in patients aged 60 to 70 years, 71 to 80 years, and ≥ 81 years was significantly higher than that in patients aged ≤ 59 years. Fang et al.¹¹ reviewed 1,095 patients undergoing spinal internal fixation via the posterior approach, and the average age of the patients with SSI was 47.8 years. Among the 48 patients with SSI, 17 were >60 years old, accounting for 35.4% of the patients with infection. Thus, the authors concluded that patients aged >60 years had a higher risk of SSI.¹¹ In the present study, advanced age was also a risk factor for SSI following spinal surgery.

According to the logistic regression analysis, the odds ratio of SSI after spinal surgery in advanced-age patients in this study was about 3. The immune system of older patients degenerates, and such patients typically have multiple underlying diseases. Of the 4,350 patients undergoing spinal internal fixation via the posterior approach in our study, 1,680 were aged >60 years. Patients of advanced age always present with degeneration of the immune system, usually accompanied by multiple underlying diseases. Heart disease leads to be associated with a decline in the cardiac ejection capability and a decrease in the blood supply to the tissues. Moreover, the decrease in the local blood supply weakens the body's local resistance and self-healing ability, thereby increasing the infection risk. In addition, hypertension can cause vascular lesions and reduce the local blood supply to the surgical site.

A long surgical duration will increase the risk of SSI secondary to spinal internal fixation via the posterior approach. A long surgical duration increases the risk of wound infection, possibly because of the

extended tissue traction; furthermore, soft tissue traction leads to local tissue ischaemia and necrosis. A longer surgery also increases the risk of wound contamination. Our study showed that the rate of postoperative SSI significantly increased in patients with a surgical duration of >3 hours. Apisarnthanarak et al.¹³ reported that the incidence of postoperative infection significantly increased when the duration of spinal surgery was >3 hours. In addition, a diabetes history is an important risk factor for incisional infection in patients undergoing spinal surgery. One study showed that the risk of postoperative infection was much higher in patients with than without diabetes.¹⁴ Abdul-Jabbar et al.¹⁵ retrospectively analysed 6,628 hospitalised surgical patients and found that diabetes significantly increased the SSI risk. Olsen et al.¹⁴ considered diabetes to be an independent risk factor for SSI.

Our results showed that diabetes was correlated with SSI after spinal surgery. The odds ratio of patients with diabetes was 4.47, indicating that the risk of postoperative infection in patients with diabetes was nearly four times higher than that in patients without diabetes. SSI after spinal surgery in patients with diabetes is mainly associated with diabetes-related autoimmune disorders, decreased wound healing ability, and capillary lesions. Diabetic microangiopathy can cause local tissue ischaemia and hypoxia and reduce the antibiotic concentration in tissues.¹⁶ The immune cell function of patients with diabetes is damaged, leading to relative inhibition of the immune function of the body. If pathogen invasion occurs, the patient will be very prone to infection.¹⁷ The function of platelet-derived growth factors in patients with diabetes is also affected, resulting in a decline in the wound healing ability. Moreover, a serum albumin concentration of <30 g/L was an independent risk factor for postoperative SSI in the present

study, consistent with a report by Klein et al.¹⁸ Further, intraoperative blood loss of >1,000 mL combined with postoperative hidden blood loss¹⁹ is another independent risk factor for postoperative SSI. Severe anaemia can reduce tissue repair and anti-infection capabilities, increasing the risk of postoperative infection. Research has shown that when the haemoglobin level is <80 g/dL, the oxygen-carrying capacity of blood is seriously reduced, and local tissue hypoxia reduces the local resistance to infection.²⁰ In addition, patients with anaemia present with a severe shortage of transporters needed to repair tissues, thereby leading to reduced local repair capability and susceptibility to infection, consistent with the results of our study. In the present study, all patients underwent routine blood biochemical examination after the surgery; the postoperative changes in albumin, haemoglobin, and other nutritional status indicators were detected in a timely manner, and appropriate treatment was given. Moreover, the patients were asked to strengthen their nutritional status and eat a high-protein diet. Parenteral nutritional support was needed when the nutritional status indicators were very poor. Some patients also required albumin infusion and blood transfusion.

How to reduce the incidence of SSI secondary to spinal internal fixation via the posterior approach has always been a challenging issue. First, the surgical indications should be strictly grasped, and surgical treatment can be considered after ineffective conservative treatment. Second, underlying diseases should be controlled and treated. For advanced-age patients with anaemia and a low serum albumin concentration, the underlying diseases and general conditions should be strictly evaluated, blood glucose should be actively controlled, and anaemia and hypoalbuminaemia should be corrected. In this study, although smoking was not a risk factor for SSI

following spinal surgery, smoking cessation could effectively improve respiratory function, increase functional residual capacity, and reduce the incidence of postoperative pulmonary complications. Therefore, patients with long-term smoking should discontinue smoking for 2 weeks before the surgery.²¹ If necessary, lung computed tomography and lung function tests should be performed to evaluate the lung condition of patients. Our study showed that the beginning time of surgery was not a risk factor for SSI following spinal infection. In the morning, however, surgeons are usually more energetic and can perform the operation more precisely. Reasonable surgical plans, small incisions, and minimally invasive procedures are needed to reduce intraoperative blood loss and the surgical duration. The aseptic management of the operating room should be strengthened, and surgeons' and nurses' concept of asepsis should be improved. Furthermore, postoperative care should be strengthened, patients should be guided toward early activities, postoperative wound management should be improved, the wound status should be frequently monitored, and antibiotics should be administered reasonably according to the general condition of the wound and patient. The risk factors are sometimes relatively independent; more often, however, they are interrelated and influenced by one another. To reduce the infection rate, rather than controlling a certain factor in isolation, we need to understand the basic condition of patients with respect to all aspects and design a reasonable treatment plan according to the patient's condition. Only in this way can we effectively reduce the rate of SSI secondary to spinal internal fixation via the posterior approach.

This study has certain limitations, such as the fact that the study setting was a single spinal cord research centre in Western China. Considering the cross-sectional

nature of this study, causality between the results and the investigation variables could not be evaluated. To better understand the risk factors related to infection secondary to spinal internal fixation via the posterior approach in China, a longitudinal cohort study is required to gain a deeper understanding of the factors involved in such infections and the effects of these factors on the infection rate. Moreover, the inclusion of non-randomly selected participants may have led to unpredictable biases. Despite the above limitations, this study revealed factors closely related to infection secondary to spinal internal fixation via the posterior approach and proposed strategies for improvement and intervention measures that will ultimately reduce the infection rate after spinal surgery.

Conclusion

This study provides information regarding SSI secondary to spinal internal fixation via the posterior approach. We found that age of >60 years, surgical duration of >3 hours, serum albumin concentration of <30 g/L, haemoglobin concentration of <80 g/L, diabetes history, and blood loss of >1,000 mL are directly correlated with SSI secondary to spinal internal fixation via the posterior approach. These findings may contribute to discussions and actions that will help to reduce SSI secondary to spinal internal fixation via the posterior approach in the short or medium term.

Author contributions

XH and YZ participated in the patient recruitment and the data collection and analysis. All authors contributed to the study design and drafting of the manuscript. All authors read and approved the final manuscript.

Declaration of conflicting interests

The authors declare that they have no competing interests.

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Research ethics and patient consent

This study was approved by the Ethics Committee of Shaanxi Provincial People's Hospital (No. 2020-0127). Each author certifies that all investigations were conducted in conformity with ethical principles. Written informed consent for participation was obtained from all patients included in the study.

Consent for publication

All patients provided written informed consent to publish their personal details in this article.

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