Analysis of influencing factors of incision infection in combined anterior-posterior surgery for subaxial cervical fracture dislocation

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Research article

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Abstract

Background: To explore the impact of related factors on the surgical site infection (SSI) after combined anterior-posterior surgery for subaxial cervical fracture dislocation (SCFD), and to provide a basis for formulating preventive measures.

Methods: A total of 841 patients (531 males and 310 females, aged 24-68 years) with SCFD who received combined anterior-posterior surgery from January 2014 to May 2018 were retrospectively analyzed. According to whether the postoperative SSI occurred, they were divided into two groups. Demographic data, American spinal injury association (ASIA) neurological impairment scale, comorbidity, diet nursing and operating room related factors (time interval from skin preparation to operation, whether preoperative urinary catheterization was performed, whether was the consecutive operation, the total number of person in the operating room, operating room temperature, relative humidity, operational duration, and whether there was an intern nurse involved in the operation) the of patients in the two groups were analyzed by Logistic regression for the factors related to perioperative SSI.

Result: SSI occurred in 44 patients with the rate of 5.2% (44/841). The results of univariate analysis showed that there were statistically significant differences between the two groups in the grade of ASIA scale, diabetes, lack of dietary care, time interval from skin preparation to operation, preoperative urinary catheterization, consecutive operation and the total number of person in the operating room (all $P<0.01$). Multivariable Logistic regression analysis results show that the severity of spinal cord injury (grade A OR value = 78.431, grade B OR value =24.120, grade C OR value = 5.342, $P < 0.05$, respectively), diabetes (OR value = 3.114, $p=0.014$), lack of dietary care (OR value = 2.275 $p=0.023$), time interval from skin preparation to operation $\geq$ 6h (OR value = 2.342, $p=0.022$), preoperative urinary catheterization (OR value = 4.476, $P <0.001$) and the total number of person in the operating room $\geq$ 8 (OR value = 2.921, $P = 0.014$) were positively correlated with perioperative SSI.

Conclusion: The severity of spinal cord injury (ASIA grade A,B and C), diabetes, lack of dietary care, time interval from skin preparation to operation $\geq$ 6 hours, preoperative urinary catheterization and the total number of person in the operating room $\geq$ 8 are the risk factors for SSI after combined anterior-posterior surgery for SCFD.

Background

Subaxial cervical fracture dislocations (SCFD) is characterized with a displacement or translation of one vertebral body relative to the other in any direction. As the tension bands are disrupted bilaterally, this type of injury is extremely unstable. Combined anterior-posterior surgery can simultaneously achieve neural decompression and effective mechanical reconstruction, which is considered to be a reliable treatment method of SCFD. However, surgical site infection (SSI) is one of the most common postoperative complications due to the long operational duration and large surgical trauma of circumferential reconstruction surgery. The current risk factors of SSI after spinal surgery mainly include the patient's

own factors and perioperative management factors. Few studies have systematically explored operating room factors associated with postoperative SSI after combined anterior-posterior surgery. The purpose of this study was to retrospectively analyze the patients with SCFD who underwent circumferential reconstruction surgery in our hospital, and to explore the possible risk factors of SSI.

Methods

This study was approved by the institutional review board of our hospital, and informed consent was obtained from all patients. Inclusion criteria: (1) SCFD accompanying with traumatic disc herniation and severe injury of posterior ligamentous and bony structures; (2) follow-up time greater than 12 months. Exclusion criteria: (1) anterior-only or posterior only surgery; (2) patients with multiple injuries other than SCFD; (3) follow-up time less than 6 months. Similar to the reduction techniques described by Reindl[1], anterior decompression, reduction and fixation was first attempted in all patients. The additional posterior fixation and fusion was secondarily performed. According to the inclusion and exclusion criteria, a total of 841 patients (531 males and 310 females, aged 24–68 years) from January 2014 to May 2018 were included. According to whether the postoperative SSI occurred, they were divided into two groups.

Observation index

Demographic data, American spinal injury association (ASIA) neurological impairment scale, comorbidity, diet nursing and operating room related factors (time interval from skin preparation to operation, whether preoperative urinary catheterization was performed, the total number of person in the operating room, operating room temperature, relative humidity, operational duration, and whether there was an intern nurse involved in the operation) the of patients in the two groups were recorded. Dietary nursing is indicated that is, daily monitoring of the patient's finger blood glucose during admission to ensure adequate nutrition and fluid supplementation, to maintain normal fluid balance and promote the recovery of metabolic function of the body as the goal, for dietary guidance. For patients with hyperglycemia, dietary guidance is performed in conjunction with the Nutrition Dietetics Department to strictly limit carbohydrate intake and make personalized adjustments to the dietary regimen based on blood glucose.

Statistical Analysis

All statistical analyses were performed using GraphPad Prism version 7.0 (GraphPad Software Inc., La Jolla, CA, USA). The measurement data were expressed as Mean ± SD, analysis of variance or t-test was used. The enumeration data were analyzed by rank sum test. $p < 0.05$ was considered statistical signifcance. Logistic regression analysis was carried out for the correlation factors with statistically significant.

Results

Basic information

Among the 841 patients who were included in the study, 44 patients (5.2%, 44/841) had SSI and were classified as the infection group, 28 males and 16 females, aged 34 to 65 years, with an average of 49.5 ± 5.2 years; AISA grade: 19 cases of grade A, 12 cases of grade B, 7 cases of grade C, 4 cases of grade D, and 2 case of grade E; the remaining 797 patients were classified as the no-infection group: 503 males and 294 females, aged 24 to 68 years, with an average of 50.1 ± 4.8 years; AISA grade: 47 cases of grade A, 81 cases of grade B, 195 cases of grade C, 233 cases of grade D, and 241 cases of grade E.

Univariate analysis

There was no significant difference in age, gender, height, body mass index, dislocation level, hypertension, chronic obstructive pulmonary disease (COPD), operating room temperature, operating room relative humidity and whether there was an intern nurse involved in the surgery between the two groups ($P > 0.05$, respectively). There were significant differences between the two groups in ASIA grade, diabetes, diet nursing, time interval from skin preparation to operation, preoperative urinary catheterization and the total number of person in the operating room($P < 0.05$, respectively).(Tables 1 and 2)

Table 1
Univariate analysis of basic information, complications and diet nursing of patients in two groups

Parameter	Infection group (n = 44)	No infection group (n = 797)	t/u_c	P
Age	49.5 ± 5.2	50.1 ± 4.8	0.511	0.523
Sex			0.071	0.944
Male	28	503		
Famale	16	294		
Height	161.0 ± 4.8	162.6 ± 5.8	0.311	0.799
Body mass index	61.6 ± 4.5	62.4 ± 4.3	0.213	0.845
Dislocation level			0.902	0.368
C3	2	58		
C4	5	154		
C5	8	189		
C6	8	228		
C7	5	97		
ASIA grade			7.413	0.000
A	19	47		
B	12	81		
C	7	195		
D	4	233		
E	2	241		
Hypertension			0.944	0.346
Yes	10	234		
No	34	563		
Diabetes			3.86	0.000
Yes	15	105		
No	29	692		
COPD			0.022	0.988
Yes	6	108		

Parameter	Infection group (n = 44)	No infection group (n = 797)	t/u_c	P
No	38	639		
Diet nursing				
Yes	9	311	2.47	0.014
No	35	486		

Table 2
Univariate analysis of operating room-related factors in the two groups

Parameter	Infection group (n = 44)	No infection group (n = 797)	t/u_c	P
Time interval from skin preparation to operation			4.428	0.000
≥ 6 hours	34	344		
< 6 hours	10	453		
Preoperative urinary catheterization			3.973	0.000
Yes	28	187		
No	16	539		
The total number of person in the operating room			2.712	0.007
≥ 8	30	376		
< 8	14	421		
Operating room temperature			1.011	0.314
22℃~25℃	38	639		
< 22℃ or > 25℃	6	158		
Operating room relative humidity			1.393	0.165
50%~60%	36	575		
< 50% or > 60%	8	221		
Operation time			0.751	0.450
≥ 3 hours	42	776		
< 3 hours	2	21		
Intern nurse involved in the surgery			1.891	0.059
Yes	17	205		
No	27	592		

Multivariable Logistic regression

Multivariable Logistic regression analysis results show that the severity of spinal cord injury (grade A OR value = 78.431, grade B OR value = 24.120, grade C OR value = 5.342, P < 0.05, respectively), diabetes (OR value = 3.114, p = 0.014), lack of dietary care (OR value = 2.275,p = 0.023), time interval from skin

preparation to operation ≥ 6 h (OR value = 2.342, p = 0.022), preoperative urinary catheterization (OR value = 4.476, P < 0.001) and the total number of person in the operating room ≥ 8 (OR value = 2.921, P = 0.014) were positively correlated with perioperative SSI. (Table 3)

Table 3
Multivariate Logistic Regression Analysis of Factors Associated with SSI after Posterior Cervical Fracture and Dislocation Surgery

Risk factors	Regression Coefficient	Standard error	Wald Value	OR Value	95%CI	P Value
ASIA grade						
A	1.588	0.432	32.341	78.431	9.521 ~ 589.430	0.000
B	1.488	0.552	15.251	24.120	3.451 ~ 187.211	0.000
C	1.342	0.487	6.473	5.342	0.532 ~ 42.331	0.003
D	1.288	0.342	2.341	1.465	0.157 ~ 4.231	0.082
E	\	\	\	1	\	\
Diabetes	1.444	0.493	4.321	3.114	0.672 ~ 5.123	0.014
Time interval from skin preparation to operation ≥ 6 hours	1.323	0.364	3.341	2.342	0.498 ~ 4.182	0.022
Preoperative indwelling catheter	1.532	0.501	5.214	4.476	0.587 ~ 38.343	0.000
The total number of person in the operating room ≥ 8	1.503	0.589	4.231	2.921	1.102 ~ 6.521	0.014
Lack of dietary care	1.349	0.519	3.321	2.275	0.533 ~ 4.523	0.023

Discussion

SSI is one of the common complications after anterior-posterior surgery for SCFD. Few published studies have systematically analyzed perioperative factors that may be associated with SSI. In this study, the severity of spinal cord injury (ASIA grade A,B and C), diabetes, lack of dietary care, time interval from skin preparation to operation ≥ 6 hours, preoperative urinary catheterization and the total number of person in the operating room ≥ 8.

In our study, the degree of spinal cord injury was positively correlated with the risk of postoperative SSI. The risk of SSI in patients with ASIA grade A is is more than 70 times that of patients with grade E. Due to

severe traumatic violence, patients with SCFD are prone to varying degrees of neurological dysfunction. Patients with spinal cord injury above C5 level will also have varying degrees of paralysis of diaphragm and accessory respiratory muscles, while patients with injury below C5 level will also have varying degrees of paralysis of intercostal and abdominal muscles[2]. The paralysis of these respiratory muscles can impede the excretion of respiratory secretions and increase the risk of pulmonary infection. For patients with ASIA grade C or below, prolonged bed rest after surgery may further increase the risk of hypostatic pneumonia[3, 4]. The pathogenic bacteria may spread through sputum or blood dissemination, leading to the SSI. Therefore, perioperative airway management is of vital importance for the prevention of SSI in patients with SCFD combined with spinal cord injury. Of note, we found that respiratory and motor functions were largely preserved in the patients with AISA grade D, although the risk of SSI was 1.465 times higher than that of AISA grade E, the difference was not statistically significant ($P = 0.082$).

Diabetic patients are prone to SSI due to low immune function, poor microvascular circulation and reduced wound healing potential. That can also reduced antibiotic concentration in the tissue. Meng et al found that diabetic patients were twice as likely to be infected as healthy people by conducting a meta-analysis of 25 RCT studies[5]. Browne et al. also demonstrated in an analysis of 200,000 patients undergoing lumbar fusion surgery across the United States that the presence of diabetes increases the risk of infection by more than 50% [6]. However, the use of diabetes as a dichotomous variable does describe only chronic glycemic control, since the diagnosis is made by continuous blood glucose measurements or hemoglobin A1C measurements, which reflect average circulating glucose levels within120 days. Thus, glycosylated hemoglobin A1C has therefore been studied as a predictor of SSI risk [7–13]. Blood glucose, as the most direct indicator, is associated with the diagnosis of diabetes and glycosylated hemoglobin A1C. For patients with SCFD, traumatic stress can cause the increase of blood glucose; for patients with spinal cord injury, the use of glucocorticoids will further aggravate the disturbance of blood glucose metabolism, resulting in further increase of hyperglycemia. Pennington et al found that postoperative hyperglycemia and poor postoperative glycemic control were independent risk factors for SSI after surgery for degenerative spine disease by multivariate analysis[14]. This also suggests that perioperative glycemic control may reduce the risk of postoperative SSI. Our study confirms that diabetes and lack of dietary care are risk factors for SSI after after anterior-posterior surgery. Thus, we believe that strict dietary care should not be limited to diabetic patients, and for patients with SCFD, close monitoring of blood glucose during admission, and timely adjustment of dietary structure and control of blood glucose are of positive significance for reducing the occurrence of SSI.

Time interval from skin preparation to operation > 6 h was associated with a 1.542-fold increased risk of SSI. Since there is a certain time limit for the germicidal effect of disinfectants used for skin preparation, too long an interval from skin preparation to the beginning of surgery may lead to an increase in colonized bacteria in the skin.

The total number of person in the operating room is positively associated with post-operative SSI risk. Our study confirmed that when the total number of person in the operating room ≥ 8, the risk of SSI was

2.921 times that of fewer than eight people at the operating room (P = 0.014). There are bacterial colonies on the surface of human skin. The increase in the number of people in the operating room will increase the total number of bacterial colonies in the air of the operating room[15–17]. In addition, the number of bacterial colonies in the operating room has a certain rule during the operation, which is manifested as the maximum at the beginning, a decrease during the operation, and a peak value at the end. This shows that the movement of people is the main factor of air pollution in operating rooms. This requires that on the basis of minimizing the number of visitors during the operation, the surgical nurse should also put all the items needed during the operation into the room before the operation, all kinds of operation should be gentle, and reduce the flipping of patients.

The risk of preoperative indwelling catheter was 4.476 times higher than that without indwelling urine, with a significant difference between the two (P < 0.001). It can be explained as follows: patients with preoperative indwelling catheter tend to have more severe injuries, and there is a positive correlation between their own postoperative SSI and the degree of spinal cord injury [18–21]. Urinary tract infection occurred in 4.1% of patients on the first day of indwelling catheterization, and the incidence of infection was as high as 72.0% at 11 days. Meanwhile, studies have shown that there is a direct relationship between urinary tract infection and urinary catheter retention time, and the longer the retention time, the higher the infection rate [22]. Furthermore, the immune system of paraplegia patients is weakened, and bacteria are easy to spread through the blood to the incision. Therefore, the SSI rate of these patients is significantly higher than that of patients without indwelling catheter before surgery.

Limitation

This study is a retrospective, single-center study, and only the most common factors that may be associated with SSI are included in this study, without involving the specific treatment process of patients.

Conclusion

The severity of spinal cord injury (ASIA grade A,B and C), diabetes, lack of dietary care, time interval from skin preparation to operation ≥ 6 hours, preoperative urinary catheterization, consecutive operation and the total number of person in the operating room ≥ 8 are the risk factors for SSI after combined anterior-posterior surgery for SCFD. Therefore, in order to prevent SSI after anterior-posterior surgery, more attention should be paid to perioperative nursing. Besides the airway management, the dietary care is essential, especially for patients with severe nerve injury below Grade D in ASIA scale or those with diabetes. In addition, from the perspective of operating room management, in order to reduce the occurrence of SSI, the operating room management should be optimized, and the time interval from skin preparation to operation should be shortened to 6 hours as far as possible, and the total person in the operation room should be controlled, especially when the operation duration is over 3 hours.

Abbreviations

Subaxial cervical fracture dislocations (SCFD)

Surgical site infection (SSI)

American spinal injury association (ASIA)

Chronic obstructive pulmonary disease (COPD)

Declarations

Ethics approval and consent to participate:

The Medical Ethics Committee of Honghui Hospital of Xi'an Jiaotong University approved the study in accordance with the relevant guidelines and regulations. Informed consent was obtained from all patients.

Consent for publication:

Not applicable

Availability of data and materials:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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Author’s contributions:

Yuan-Ting Zhao, Ding-Jun Hao and Baorong He conceived the study design. Jing Wang, Jing Hu, Dongmei Wei, Han-Lin Gong, Qing-Da Li and Jun-Song Yang supervised the data collection and literature review. Jun-Song Yang and Shuixia Li drafted the manuscript. Yuan-Ting Zhao is responsible for this article.

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