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Which Risk Factors are Important in Spinal Infection?

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Abstract

Background: Infection is the most common complication of spinal surgeries. Surgical site infection (SSI) can result in high hospitalisation costs owing to prolonged hospital stays, repeated surgeries and an increase in the frequency of pseudoarthrosis.
Objectives: The purpose of this study was to identify the risk factors of SSI in patients treated with thoracolumbar posterior spinal instrumentation.
Methods: Inclusion criteria were treated by posterior thoracolumbar stabilization with transpedicular screw and posterolateral fusion in the neurosurgery clinic between March 2006 and June 2009. Overall, 260 consecutive patients were identified and 239 patients included in this study. Risk factors that may cause increase of rate of SSI were evaluated.
Results: There were 153 female and 86 male patients with 48.23 $\pm$ 16.77 year-old. In all patients, the SSI rate was 12.5% (n = 30). Ten out of these 30 patients (4.1%) had deep wound infections and 20 patients (8.4%) had superficial infections. The average duration of infection development was 13.26 $\pm$ 10.96 days. The most isolated bacteria was *Staphylococcus aureus* (n = 10). Trauma as primary diagnosis, diabetes mellitus and other concomitant chronic systemic diseases, long operation time, excess blood loss during operation and excess blood product transfusion, intraoperative dural injury and presence of additional operations after primary operation were risk factors in the development of SSI. Length of postoperative ICU stays was determined to be a significant risk factor also.
Conclusions: It is important to know the risk factors of the patient and the surgery to reduce the frequency of infection. The gold standard in infection control is to prevent development of SSI.

Keywords: Surgical Site Infection, Spinal Infection, Posterior Instrumentation, Surgical Wound Infection, Spine Surgery, Infection Risk Factors

1. Background

Surgical site infection (SSI) is a serious and frequent complication of spinal surgery. Previous studies have reported that SSI occurs in 0.7% - 14% of spinal surgeries with instrumentation (1-6). SSI can result in high hospitalisation costs owing to prolonged hospital stays, repeated surgeries and an increase in the frequency of pseudoarthrosis (7). Previous studies have reported that preoperative concomitant medical conditions (diabetes, malignancy, smoking, obesity, cardiovascular disease or steroid use) and perioperative risk factors were correlated with SSI (8, 9). The increased risk of infection after implant operations is due to a bacterial biofilm layer growing on the surface of the implant that causes antibiotic resistance (10, 11). The gold standard in infection control is to prevent the development of SSI. Consequently, it is important to know the risk factors for each patient prior to surgery.

2. Objectives

The purpose of this study was to identify the risk factors of SSI in patients treated with thoracolumbar posterior spinal instrumentation.

3. Methods

This study examined 260 consecutive patients treated by posterior thoracolumbar stabilisation with transpedicular screw and posterolateral fusion at the neurosurgery clinic of our hospital between March 2006 and June 2009. Eighteen patients were excluded because of a preoperative diagnosis of spondylodiscitis. In addition, three patients were excluded because they did not return for follow-up. Therefore, a total of 239 patients were included. Data were prospectively collected.

One gram of cefazolin sodium was intravenously injected to all patients 30 min before making the skin incision. One gram of cefazolin sodium was continued for 24 hours (3 × 1) postoperatively for routine prophylaxis. All operations were performed by same spinal surgeons. The skin for all patients was closed with 2/0 polypropylene (PROPİLEN®, Dogsan, Trabzon, Turkey). Drains were taken from all patients on the first day. Wounds in all patients were followed by authors daily until the final closure. The distinction between superficial and deep infections was performed by neurosurgeon with infectious disease specialist using macroscopy, MRI with contrast and laboratory parameters (eg culture, WBC, CRP, sedimentation). Culture samples from the operation site were examined in the hospital microbiology laboratory, and patients with SSI were treated by infectious disease specialists. Patients were followed average of 1.2 years (21 days-3.5 years; min-max) for SSI.

3.1. Study Parameters

Age, gender, primary diagnosis treated by thoracolumbar stabilisation, smoking habits and a history of diabetes and chronic illnesses were recorded in all patients. Body mass index (BMI) was calculated for each patient. Their neurological examinations were classified with reference to the American spinal injury association (ASIA) scale. One week after surgery, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) and blood glucose levels, white blood cell (WBC) count and haemoglobin and haematocrit values were examined. It was recorded whether the surgery was emergent or elective. The amount of intraoperative bleeding, number of transfusions, number of segments that were instrumented, whether intraoperative dural injury occurred and preoperative and postoperative length of hospital stay and intensive care unit (ICU) stay were noted.

3.2. Statistical Analyses

The conformity of variables to normal distribution was searched by the one-sample Kolmogorov-Smirnov Test. Associations of surgical site infection with potential risk factors were analysed with the use of the chi-square test and Fisher's exact test. Significant differences between continuous variables were determined with the t test or Mann-Whitney U test. Multivariate logistic regression analysis was used to identify independent risk factors for surgical site infection. $P < 0.05$ was considered to indicate statistical significance.

4. Results

There were 153 female and 86 male patients who were 48.23 ± 16.77 years old (mean ± standard deviation) included in this study. Primary diagnoses and associated disorders are shown in Table 1. In 26 patients (10.8%), additional interventions were performed after surgery owing to non-infectious reasons. In 20 patients (8.4%), screw revision was performed. In six patients, external lumbar drainage was introduced for cerebrospinal fluid leakage, and three of them were reoperated for duraplasty.

Table 1. Primary and Concomitant Diseases of the Patients

	No. (%)
Primary diseases	
Degenerative diseases	145 (60.7)
Spinal trauma	80 (33.5)
Spinal tumours	14 (5.8)
Concomitant diseases	
Cardiovascular diseases	58 (24.2)
Diabetes mellitus	28 (11.7)
Malignant diseases	14 (5.8)
Chronic obstructive pulmonary diseases	7 (2.9)
Psychosis	7 (2.9)
Smoking	43 (17.9)

In all patients, the SSI rate was 12.5% (n = 30). Ten out of these 30 patients (4.1%) had deep wound infections (extending under the paravertebral fascia) and 20 patients (8.4%) had superficial infections. The average duration of infection development was 13.26 ± 10.96 days. Wound debridement was carried out in all patients with deep infections and in four patients with superficial infections. The instrumentation system was removed in four patients with deep infection. One patient's wound was closed with a paravertebral muscle flap. One patient died 21 days post operation owing to sepsis. Proper wound closure occurred in 9.66 ± 2.04 days in patients without infection and in 32.33 ± 19.64 days in patients with SSI ($P < 0.001$). In 22 out of the 30 patients (73.3%), microorganisms were isolated from the operation sites. Multiple microorganisms were isolated in 12 patients. The most commonly isolated bacteria was *Staphylococcus aureus* (n = 10), and the others in the order of frequency were Coagulase negative *staphylococcus*, *Pseudomonas aeruginosa*, *Acinetobacter baumanii*, *Enterobacter cloacae*, *Echerichia coli*, *Proteus mirabilis*, *Enterococcus faecalis* and *Corynbacterium* species.

4.1. Risk Factors for Development of Infection

The preoperative and intraoperative risk factors for SSI are shown in Table 2. There was no correlation between the development of SSI and age, gender, BMI, or smoking habits. However, trauma as a primary diagnosis, the presence of at least one chronic systemic disease and preoperative high blood glucose levels (at or above 140 mg/dL) were risk factors for the development of SSI. A preoperative haemoglobin level under 12.2 g/dL was a significant risk factor for the development of deep SSI (P = 0.015), but not for superficial SSI. The preoperative hospitalisation period was no different in patients with and without SSI; however, the length of postoperative ICU stays were determined to be a significant risk factor in the development of SSI (P = 0.003). Operation time was significantly longer in patients with SSI, and operations longer than 4 h had a significant increase in SSI (P = 0.042). It was noted that there was a significant increase in surgery time in patients that required more vertebral screws (r = 0.36, P < 0.001). However, we could not find a relationship between the SSI rate and whether the surgery was emergent or elective.

The amount of bleeding, number of transfusions and presence of dural injury during operation were also important risk factors for SSI. It was noted that more than 2000 mL of intraoperative blood loss was associated with an increased risk of SSI (P = 0.02). There was also a dural injury in 70% of patients with deep infections and in 25% of patients with superficial infections. Additional postoperative surgeries were also associated with an increase in SSI rate. Whereas 45.2% of patients who received additional intervention had a SSI, only 7.7% of patients who did not receive an additional intervention had a SSI (P < 0.001).

Among postoperative infection markers, a WBC count above 10.0 K/μL was a risk factor for SSI. Likewise, postoperative CRP levels in patients with SSI were significantly higher than patients without SSI (P < 0.001). However, postoperative ESR levels in patients with and without SSI were not statistically different.

Table 2. Risk Factors for Infection in Patients With and Without Surgical Site Infection[a,b]

Risk Factor	Patients Without SSI (n = 209)	Patients with SSI (n = 30)	P Value
Age, y	49.5 ± 14.3	47.4 ± 16.6	0.46
Gender (F/M)	136 (65)/73 (35)	17 (57)/13 (43)	0.37
Primary diagnoses (Traumatic/nontraumatic)	65 (31)/144 (69)	15 (50)/15 (50)	0.04
BMI	28.5 ± 5.3	27.8 ± 5.2	0.53
Diabetes mellitus, +/-	21 (10)/188 (90)	8 (27)/22 (73)	0.009
Other Concomitant diseases, +/-	67 (32)/142 (68)	19 (63)/11 (37)	0.001
Smoking, +/-	38 (18)/171 (82)	5 (17)/25 (83)	0.53
ASIA grade (A-B/C-D-E)	10 (5)/199 (95)	5 (17)/25 (83)	0.02
Preoperative hospitalisation time, d	11 (0 - 28)	10 (0 - 31)	0.76
Operation category (emergent/elective)	19 (9)/190 (81)	4 (13)/26 (87)	0.50
N of instrumented segments, ≥ 5/< 5)	17 (8)/192 (92)	10 (33)/20 (67)	< 0.001
Transfusion (RBC), >3 unit bag/≤ 3 unit bag)	21 (10)/188 (90)	8 (27%)/22 (73)	0.01
Dural injury, +/-	22 (11)/187 (89)	12 (40)/18 (60)	< 0.001
Postoperative ICU stay, +/-	19 (9)/190 (81)	9 (30)/21 (70)	0.003
Additional surgeries, +/-	17 (8)/192 (92)	14 (47)/16 (53)	< 0.001
Postoperative WBC count	8.2 (3.3 - 18.8)	8.9 (1.7 - 19.5)	0.04
Postoperative CRP level	0.81 (0.31 - 18.8)	3.76 (0.31 - 19.4)	< 0.001
Postoperative ESR level	60 (2 - 401)	68 (12 - 120)	0.07

Abbreviations: ASIA, American spinal injury association; BMI, body mass index; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; ICU, intensive care unit; N, number; RBC, red blood cell; SD, standard deviation; WBC, white blood cell.
[a] Age and BMI data are presented with means ± standard deviations. Preoperative hospitalisation time and Postoperative WBC, CRP, ESR data are presented as median (range) and the others are presented as %.
[b] P values < 0.05 are significant.

5. Discussion

Infection is the most common complication of spinal surgeries. SSI prolongs hospital stays and increases morbidity and mortality (12-14). SSI frequency is higher after spinal surgeries with instrumentation. Rechtine et al. (15) ascertained that the SSI rate of thoracolumbar trauma operations was 10% in 235 patients. As all surgical interventions, simple or complex, on vertebra have the risk of infection, it is important to know the risk factors of the patient and the surgery to reduce the frequency of infections.

5.1. Risk Factors for Postoperative Infection

There are a lot of studies evaluating risk factors for postoperative wound infection in instrumented spinal surgery. Age is a frequently studied risk factor. As noted in previous studies, our study found that advanced age was

not a risk factor for SSI (16-18). However, Blam et al. (8) reported that patients over 55 years of age were at risk of SSI.

Patients with systemic diseases such as diabetes, malignancy and acquired immune deficiency syndrome (AIDS), and patients whose immune systems were repressed owing to chemotherapy or chronic steroid use had an increased risk of postoperative spine infection (19). In the study by Meng et al. (19), smoking, diabetes, obesity, cerebrospinal fluid (CSF) leak, hypertension and blood transfusions were evaluated as risk factors. In patients with diabetes mellitus, local changes in the tissues, along with neuropathy and angiopathy, increased the risk of infection. Previous studies reported that patients with poorly regulated blood glucose levels had a 10% - 20.9% SSI rate (9, 16, 20). Our study supported these results. In addition, we found that SSI was also high in patients with mental disorders. These patients were mostly brought into emergency as a result of a suicide attempt and often had vertebral fractures and motor deficits. Although there are some studies that have reported a relationship between SSI rate and obesity (19, 21) or smoking (22), we could not find a correlation in our study. However, this could be due to the fact that a majority of our patients were females, and culturally, women have lower rates of smoking in our society.

It has also been reported in previous studies that patients with multitrauma that had operations to repair vertebral fractures had a high rate of SSI and the frequency of SSI in patients with severe neurological damage was very high (5, 15). In our study, it was confirmed that a high rate of SSI was noted in trauma patients and in those who were classified as A or B on the ASIA scale. Trauma patients were at risk of infection even if they were operated on under elective conditions. This made us consider that trauma, as a primary diagnosis, is an important risk factor for the development of SSI.

It was observed that operation time was significantly longer in patients with SSI than in those without infection, and an operation time longer than 4 hours was a risk factor for the development of deep wound infections. In the literature, this duration has been reported to be over 5 hours (9, 23). In our study, the more segments that were instrumented the longer the duration of the operation. It was noted that when the duration of the operation was extended, the duration of soft tissue extraction also extended and perfusion of all soft tissues deteriorated at the surgical site (13, 22). These factors affect each other in terms of the development of infection. Excessive amounts of intraoperative blood loss and more transfusions of blood products were also reported as risk factors for SSI development (18). However, some studies reported contradictory results. Sponseller et al. (24) did not find an increase in infection risk with 1,500 mL or more blood loss. We observed in our study that the SSI rate was significantly higher if there was 2,000 mL of blood loss and if more than three unit bags were transfused.

Dural injury and CSF leakage from wounds are well-known risk factors for the development of infection in all neurosurgical operations. In our study, we confirmed that the presence of dural injury increased the risk of infection in concordance to the literature (19, 21).

Type of bone graft materials was evaluated in the literature as a risk factor for the development of infection because of the possibility that allografts or synthetic graft materials may provide a favourable environment for the growing of microorganisms. Dipaola et al. (25) reported that it was risky to use allografts for infection. However, in our study, we did not find a difference in SSI rates between allografts and autografts.

At our hospital, preoperative investigations for anaesthesia and surgery were done during hospitalisation. Therefore, the mean preoperative hospitalisation time of our patients was longer than usual. In some studies, longer preoperative hospitalisation times were reported to be a risk factor for an increase in postoperative infection rate (8, 26). However, these results were not supported in our study, postoperative hospitalisation in ICU was correlated with an increase in SSI rate.

5.2. Biochemical and Microbiological Investigations

According to the results of this study, postoperative CRP levels and WBC count were reliable indicators of infection. However, we could not find a connection between high postoperative ESR levels and the presence of a SSI. In concordance of our study, it was reported in the literature that CRP was more sensitive and specific than ESR when evaluating the response to the treatment of infection (27-29).

In the literature, the most common organisms reported as a causative agent in SSI were *Staphylococcus aureus* and *Staphylococcus epidermidis* (23, 30). In a study by Chen et al. (31) it was reported that Staphylococcus species were the most common causative agents of SSI and they were isolated in 58.3% of the patients. In our study, the most common isolated organism was also *Staphylococcus aureus*. On the other hand, the rate of negative cultures was high both in our study (26.7%) and in the literature. Gerometta et al. (32) reported that the percentage of negative cultures in their study was 0% - 31.4%.

After spine surgery, infections are one of the most important complications. The aim should be to prevent the development of infection. It is important to know the risk factors of the patient and the surgery to reduce infection rates. If risk factors are determined separately for each pa-

tient, prophylactic methods can be developed to reduce the incidence of SSI.

Footnote

Authors' Contribution: Study concept and design: Burak Eren, Feyza Karagöz Güzey; acquisition of data: Burak Eren, Serkan Kitiş; analysis and interpretation of data: Feyza Karagöz Güzey, Nezih Özkan; drafting of the manuscript: Burak Eren, Cafer Korkut; critical revision of the manuscript for important intellectual content: Feyza Karagöz Güzey, Nezih Özkan; statistical analysis: Feyza Karagöz Güzey, Burak Eren; administrative, technical, and material support: Serkan Kitiş, Cafer Korkut; study supervision: Nezih Özkan.

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