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Retrospective, Demographic, and Clinical Investigation of the Causes of Postoperative Infection in Patients With Lumbar Spinal Stenosis Who Underwent Posterior Stabilization

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Abstract: Owing to the increasing population of elderly patients, a large number of patients with degenerative spondylosis are currently being surgically treated. Although basic measures for decreasing postoperative surgical infections (PSIs) are considered, it still remains among the leading causes of morbidity and mortality. The aim of this retrospective analysis is to present possible causes leading to PSI in patients who underwent surgery for lumbar degenerative spondylosis and highlight how it can be avoided to decrease morbidity and mortality.

The study included 540 patients who underwent posterior stabilization due to degenerative lumbar stenosis between January 2013 and January 2014. The data before and after surgery was retrieved from the hospital charts. Patients with degenerative lumbar stenosis who were operated upon in this study had >2 levels of laminectomy and facetectomy. For this reason, posterior stabilization was performed for all the patients included in this study.

Determining the causes of postoperative infection (PI) following spinal surgeries performed with instrumentation is a struggle. Seventeen different parameters that may be related to PI were evaluated in this study. The presence of systemic diseases, unknown glove perforations, and perioperative blood transfusions were among the parameters that increased the prevalence of PI. Alternatively, prolene sutures, double-layered gloves, and the use of rifampicin Sv (RIS) decreased the incidence of PI.

Although the presence of systemic diseases, unnoticed glove perforations, and perioperative blood transfusions increased PIs, prolene suture material, double-layered gloves, and the use of RIS decreased PIs.

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Abbreviations: DM = diabetes mellitus, DSSI = deep surgical-site infection, IRI = implant-related infection, RIS = rifampicin Sv 250 mg and 500 mL NaCl, SSSI = superficial surgical-site infection.

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INTRODUCTION

Increasing number of patients with degenerative spondylosis today are treated surgically because of the increasing population of elderly patients. The most commonly used surgical methods in these patients are total laminectomy, facetectomy, and the use of posterior transpedicular dynamic stabilization systems for avoiding any instability that may occur. Although all hospitals take basic measures in order to decrease postoperative surgical infections (PSIs), it is still one of the leading causes of morbidity and mortality in these patients.

The rates of superficial wound infection, paravertebral abscess, and spondylodiscitis occurring after spinal surgery are substantially increasing. This is because a greater number of spinal operations are being performed in the modern era, and also physicians can better diagnose PSI with the development of enhanced diagnostic methods.[1–3] In the presence of PSI, socioeconomic as well as medicolegal issues occur because of the long duration of the treatment period. PSI can cause patients to remain hospitalized for a long time and thus increase economic burden. In addition, the clinical situation becomes more complex with respect to both diagnosis and treatment if a graft was applied, a recurrent operation was performed, radiotherapy and/or chemotherapy was given, and a foreign body was inserted.[2]

It is difficult to determine the true incidence of PSI for several reasons: a patient's pain may not be taken into account, the course of the disease may be silent, and the disease may heal spontaneously without being noticed. Some patients may also visit another institution where they were not originally treated surgically. In addition, patients may be treated for a diagnosis other than a PSI.

In the United States, 750,000 PSI cases are observed every year. These patients are hospitalized for a combined total of an extra 3.7 million days, and it is estimated that treatments cost >$1.6 billion. The main methods for reducing the risk of surgical-site infection are effective and permanent surgical techniques, skin antisepsis that includes timely and appropriate antimicrobial prophylaxis, and determining strategies for adjuvant care for the reduction of wound contamination and stimulating wound healing.[4]

The aim of this study was to examine the parameters that were thought to be effective in preventing or decreasing both superficial wound and deep surgical-site infections (DSSIs).

MATERIALS AND METHODS

This retrospective analysis included 540 patients who underwent posterior lumbar stabilization due to degenerative lumbar stenosis between January 2013 and January 2014. As this is a retrospective analysis, our ethic committee did not require patients' approval. As patients who have lumbar degenerative stenosis are generally older, systemic examinations in all patients were performed by internal physicians to diagnose any systemic illness before surgery. One-gram cephazolin sodium was given to all the patients 1 hour before and continued twice a day for 24 hours after surgery. As a routine follow-up, all patients were seen in the outpatient clinic 14 and 30 days after surgery.

In the follow-up, skin incision was evaluated by both the neurosurgeon and the dermatologist for the existence of superficial incisional infection. If no infection was noted, skin sutures were removed on the 14th day of surgery. But in case of wound infection, skin dressing was changed daily and was closely followed-up in the outpatient clinic. The patients with DSSI were hospitalized and were given appropriate antibiotics according to their antibiogram results. If there was no growth in the antibiogram, the patients were treated with broad-spectrum antibiotics according to the recommendations from the infectious disease specialist. Serious wound infections were also treated in the hospital and in case of no healing, wound debridement was performed.

The following parameters were retrieved from the patients' charts: age, sex, systemic illnesses, surgical duration, perioperative blood transfusions, dural injuries, the use of perioperative fibrin tissue glue (Tisseel LYO, Eczacıbaşı - Baxter Hospital Products © 2006) due to a dural tear, the use of a Hemovac drain, the types of surgical gloves used (Maxitex Duplex PF, Multikan Medical Products, proffit® ; Beybi, Beybi company®), the types of sutures used (Vicryl Plus(© Ethicon US), Ruschmed silk suture(© Suzhou Hengxiang Medical Device Co), Ethicon prolene suture(© Ethicon US)), the use of drapes during surgery, the presence of tears in the gloves (in our clinic, gloves are routinely checked by filling with water [water test] in the postoperative period for all patients), the use of rifampicin Sv (RIS) 250 mg and 500mL NaCl in the fluid used for irrigation during surgery, and the duration of hospitalization following surgery.

The criteria of the patients who were included for surgical treatment as posterior stabilization included all patients who had been operated upon for degenerative lumbar stenosis and had undergone >2 levels of laminectomy and facetectomy in this study.[5]

Statistical Analysis

The Number Cruncher Statistical System (2007) and Power Analysis and Sample Size (2008) Statistical Software (Kaysville, UT) programs were used for statistical analysis. The Student *t* test was used for comparison of quantitative data and comparison of parameters with a normal distribution. The Mann–Whitney *U* test was used for comparisons of parameters without a normal distribution. In the comparison of qualitative data, Pearson χ^2 test and Yates continuity correction test were used. For multivariate analysis and the effects of other risk factors on the presence and severity of PSI, stepwise logistic regression analysis was performed. Significance was considered at $P < 0.01$ and $P < 0.05$.

RESULTS

The ages of the patients participating in the study ranged from 28 to 84 years; the mean age was 56.45 ± 9.81 years. Descriptive characteristics of patients are summarized in Table 1. Posterior lumbar interbody fusion was performed in 487 of 540 patients, and allografts were used for all patients during the surgery. Tisseel LYO was used in 15.2% (n = 82) of cases, and the RIS, staples, Hemovac drain, drape with iodine, and noniodized drape were observed in 82.2% (n = 444), 89.8% (n = 485), 75.9% (n = 410), 79.8% (n = 431), and 9.8% (n = 53) of patients, respectively. The use of vicryl, silk, and prolene (as skin surface closures) as suture materials were used in 93% (n = 502), 1.9% (n = 10), and 5.2% (n = 28) of patients, respectively. Blood transfusions were needed in 40.2% (n = 217) of patients, and dural injuries occurred in 26.1% (n = 141).

TABLE 1. Distribution of the Identifier Properties

	Min–Max	Mean ± SD (Standart Deviation)
Age, y	28–84	56.45 ± 9.81
Time of surgery, min	50–180	98.89 ± 22.88
First stay at hospital, d	2–20	4.19 ± 1.53
Second stay at hospital, d (day) (n = 14)	12–45	23.43 ± 9.97
	n	**%**
Sex		
Male	391	72.4
Female	149	27.6
Systemic disease		
None	386	71.5
Hypertension	42	7.8
Diabetes	76	14.1
HT + DM	36	6.7

DM = diabetes, HT = hypertension.

The superficial skin infection in 4 patients was treated with a daily dressing. Debridement was performed once for 7 patients and twice for 2 patients. The instrumentation of one of the patients who had undergone debridement twice was removed. Thirty days of hyperbaric oxygen therapy was provided for 2 patients who had undergone debridement twice, and for 1 patient who had undergone debridement once. One patient died from multiple organ failure due to sepsis. The average length of stay for patients with DSSI was 23.43 ± 9.97 (12–45) days.

PSI Assessments

Age, sex, use of Tisseel LYO drapes, Hemovac drain, and rates of dural injury did not have an effect on the PSI rate. Presence of systemic illness significantly increased the rate of PSI ($P = 0.003$). Presence of hypertension did not affect the PSI rate ($P > 0.05$) but diabetes mellitus (DM) increased the rate of PSI significantly ($P = 0.003$).

The rate of PSI was significantly lower in those who were given RIS compared with those who were not ($P = 0.001$). Use of staples for skin closure significantly decreased the rate of PSI ($P = 0.02$; $P < 0.05$).

The occurrence of PSI was associated with the type of suture material used. The rate of PSI was significantly lower in those who had vicryl sutures compared with those who did not ($P = 0.001$; $P < 0.01$). The rate of wound infections was significantly higher in those who had prolene sutures compared

TABLE 2. Evaluation of the Efficient Risk Factors That Affect the Wound Infection

		Wound Infection Yes (n = 63) n (%)	Wound Infection No (n = 477) n (%)	P
Tisseel	Yes	6 (9.5)	76 (15.9)	0.252[a]
	No	57 (90.5)	401 (84.1)	
Drape	No	7 (11.1)	49 (10.3)	1.000[b]
	Noniodized drape	6 (9.5)	47 (9.9)	
	Iodized drape	50 (79.4)	381 (79.9)	
Rifocin	Yes	38 (60.3)	406 (85.1)	0.001[b,**]
	No	25 (39.7)	71 (14.9)	
Stapler	Yes	51 (81.0)	434 (91.0)	0.024[a,*]
	No	12 (19.0)	43 (9.0)	
Suture material	Vicryl	51 (81.0)	451 (94.5)	0.001[c,**]
	Silk	1 (1.6)	9 (1.9)	
	Prolene	11 (17.5)	17 (3.8)	
Hemovac	Yes	49 (77.8)	361 (75.7)	0.834[a]
	No	14 (22.2)	116 (24.3)	
Dural injury	Yes	12 (19.0)	129 (27.0)	0.228[a]
	No	51 (81.0)	348 (73.0)	
Blood transfusion	Yes	34 (54.0)	183 (38.4)	0.018[b,*]
	No	29 (46.0)	294 (61.6)	

[a] Yates continuity correction test.
[b] Pearson χ^2.
[c] Fisher exact test.
* $P < 0.05$.
** $P < 0.01$.

TABLE 3. Evaluation of the Gloves That Are Used in Operations According to the Wound Infection

	Wound Infection Yes (n = 63) n (%)	Wound Infection No (n = 477) n (%)	P
Dual protection			
No hole	34 (54.0)	266 (55.8)	0.859[a]
With hole	29 (46.1)	211(44.3)	
Single protection			
No hole	10 (15.9)	273 (57.2)	0.001[b,**]
With hole	53 (74.4)	204 (42.8)	0.001[b,**]

[a] Fisher Freeman Halton test (Monte Carlo).
[b] Yates continuity correction test.
** $P < 0.01$.

to those who did not ($P = 0.001$). There were no significant differences between the rates when silk was used as a suture material ($P > 0.05$). The PSI rate was significantly higher in those with blood transfusions compared to those without ($P = 0.01$; $P < 0.05$). Table 2 summarizes the statistical results.

A total of 2986 surgical gloves were used for all of the cases. During the postoperative period, 1080 Maxitex Duplex PF double-layered gloves and 1620 single-layered Beybi latex gloves were examined. Double-layered gloves were used by surgeons performing the surgery and Beybi latex gloves were used by auxiliary surgical staff. No significant difference was found between the glove type used with respect to tears in the water test ($P > 0.05$) but the rate of PSI was significantly lower with the single-layered gloves used by auxiliary surgical staff during surgery ($P = 0.001$; $P < 0.01$). The rates of infection were significantly higher in the single-layer gloves ($P = 0.001$; $P < 0.01$). Overall, the rate of infection was significantly lower in those without glove tears ($P = 0.001$; $P < 0.01$). When double-layered gloves were used, there was no significant difference between the rates of infection in cases involving a tear for only 1 surgeon ($P = 0.759$; $P > 0.05$). The rates of infection were significantly higher, however, in those that had tears for both the surgeons ($P = 0.001$; $P < 0.01$). These data are summarized in Table 3.

Logistic Regression Analysis for the Risk Factors Affecting PSI Rates

The backward stepwise logistic regression analysis was performed to see any effect of the presence of systemic diseases, RIS usage, surgery duration, length of hospital stay, staple usage, suture material used, and blood transfusion on the rate of PSI.

The ODDS rate of the effect of the presence of systemic disease on postoperative infection (PI), no use of RIS, a hospitalization time under 3 days, the use of prolene sutures, and a blood transfusion were found to be 3.987 (95% confidence interval [CI]: 2.021–7.863), 4.167 (95% CI: 2.041–8.508), 7.543 (95% CI: 3.956–14.382), 75.012 (95% CI: 1.289–4365.87), and 2.654 (95% CI: 1.401–5.028), respectively (Table 4).

Assessments According to the Severity of PSI

Older patients had more severe infection and more DSSI than those who were younger ($P = 0.033$; $P < 0.05$).

A statistically significant difference was not found between the duration of surgery relative to the PSI severity

TABLE 4. Logistic Regression Analysis of the Risk Factors That Effect the Wound Infection

	P	ODDS	95% CI Lower	95% CI Upper
Systemic disease			2.021	7.863
Rifocin used (−)	0.001**	4.167	2.041	8.508
Time of surgery (<96 min)	0.950	0.980	0.522	1.840
Stay at hospital (<3 d)	0.001**	7.543	3.956	14.382
Stapler used (−)	0.228	0.090	0.002	4.480
Suture material				
Vicryl	0.106			
Silk	0.189	14.274	0.270	756.031
Prolene	0.037*	75.012	1.289	4365.875
Blood transfusion	0.003**	2.654	1.401	5.028

CI = confidence interval, MR = Magnetic resonance.

($P > 0.05$). Comparing the patients with DSSI and superficial surgical-site infection (SSSI), the effects of duration of stay before the infection, sex, the use of Tisseel LYO, drape usage, the use of a Hemovac drain, perioperative dural injury, and the severity of the PI did not show significant difference ($P > 0.05$). For the perioperative dural injury, there was a cell having expected value <5, therefore Fischer exact test was reported instead of Pearson χ^2 test. The P value for the Fisher exact test was found to be 1.00, but revised as 0.999.

Blood transfusions showed an effect on the severity of PSI that blood transfusion increased the possibility of occurrence of DSSI ($P = 0.003$; $P < 0.01$). A statistically significant difference was also found between the different suture materials used and the PSI severity ($P = 0.026$; $P < 0.05$). The rate of DSSI was higher in those cases in which vicryl was used compared to those who had no vicryl suture. Table 5 shows the summary of the statistical results.

DISCUSSION

Implant-related infections (IRIs) still appear to be a major problem in spinal surgery, even though the infection rate has been reported to be around 1%. However, postsurgical infection rate increases upto 2.1% to 8% as the frequently performed spine surgeries such as laminectomies and discectomies with implantation increases.[6–9] Dead space in the surgical field, foreign bodies, necrotic tissue, and prolonged surgical procedures are among the factors that increase the risk of IRI.[5] Implant use in spinal surgery increases the risk of infection about 3-fold.[10–12] These infections extend the length of hospital stays, require long-term medications, and badly affect surgical results, all of which can lead to socioeconomic losses. Furthermore, infections that do not respond to medical treatment often require a revision surgery.[13,14]

Basic clinical information suggests that wounds that bleed will heal more easily than wounds that do not bleed. There is a need for oxygen support in the wound healing process and to avoid the development of infections. In other words, if there is a delay in wound healing, or if the infection is in question, the risk of microcirculation failure is always present. Microcirculation must be rebuilt for the proper continuation of the healing process and to provide resistance to infection; therefore, sufficient oxygen must reach this zone.[15,16]

Fat, loose areolar tissue, and a rich venous plexus are present in the epidural space. The rich venous plexus provides a suitable environment for infections. The colonization of the spinal epidural space by microorganisms occurs via hematogenous spread to the neighboring regions. Diabetic patients with suppressed immune systems and patients using alcohol and intravenous drugs are the most at-risk group in terms of developing spinal epidural abscesses.[10] Hyperglycemia may impair phagocytic activity and chemotaxis. Although some studies have reported an increased incidence of infection in diabetic patients,[17–21] it is still controversial whether DM by itself is a risk factor.[19,22,23] Studies have also reported that blood glucose levels >200 mg/dL in the first 48-hour perioperative and postoperative periods increased the incidence of infection.[24,25] In the study by Trick et al,[26] preoperative blood glucose levels >200 mg/dL were an independent risk factor increasing infections after coronary artery bypass surgery. One study found that the risk of developing an infection increased 1.5-fold in DM patients, and the control of preoperative blood glucose levels may eliminate this risk.[12] In our study, 76 patients were diabetic; DM was present in 7 of the 14 patients with DSSI and in 14 of the 49 patients with SSSI. This presence of DM was statistically significant in patients with DSSI. Patients with DM were operated upon after consultation with an internal medicine specialist for the regulation of blood glucose levels.

Microorganisms responsible for infections are often dependent upon the operative field and the surgical procedure used. The resources of the pathogens are often caused by the patient's endogenous flora of the skin and the intestinal tract. Microorganisms on the patient's own skin are the most important reservoir for surgical wound infection. Exogenous flora primarily consists of aerobes; in particular, gram-positive microorganisms such as *Staphylococcus* and *Streptococcus* are often observed. Fungi, which are endogenous and exogenous in origin, rarely cause infections.[27,28] *Staphylococcus aureus* is the most common microorganism in PSI. According to National Nosocomial Infection Surveillance data, the most frequently isolated pathogens in wound infections in the last decade are (in order of frequency) *Staph aureus* (9%–50.3%), coagulase-negative staphylococci (12%–25%), *Enterococcus spp*. (3%–12%), and *Escherichia coli* (8%–10%).[17,20,29,30] According to the culture results from 14 DSSI patients in our study, *Staph epidermidis*, *E coli*, normal

TABLE 5. Evaluation of the Materials Used in Operations According to the Severeness of the Wound Infection

		Severeness of the Wound Infection		
		DSSI (n = 14)	SSSI (n = 49)	
		n (%)	n (%)	P
Tisseel	Yes	2 (14.3)	4 (8.2)	0.607[a]
	No	12 (85.7)	45 (91.8)	
Drape	No drape	1 (7.1)	6 (12.2)	0.478[b]
	Noniodized drape	0 (0.0)	6 (12.2)	
	Iodized drape	13 (92.9)	37 (75.5)	
RIS	Yes	8 (57.1)	30 (61.2)	1.000[c]
	No	6 (42.9)	19 (38.8)	
Stapler	Yes	13 (92.9)	38 (77.6)	0.270[a]
	No	1 (7.1)	11 (22.4)	
Suture material	Vicryl	13 (92.9)	38 (77.6)	0.029[b,*]
	Silk	1 (7.1)	0 (0.0)	
	Prolene	0 (0.0)	11 (22.4)	
Hemovac	Yes	13 (92.9)	36 (73.5)	0.162[a]
	No	1 (7.1)	13 (26.5)	
Dural injury	Yes	2 (14.3)	10 (20.4)	0.999[a]
	No	12 (85.7)	39 (79.6)	
Blood transfusion	Yes	13 (92.9)	21 (42.9)	0.003[c,**]
	No	1 (7.1)	28 (57.1)	

DSSI = deep surgical-site infection, RIS = rifampicin Sv, SSSI = superficial surgical-site infection.
[a] Fisher exact test.
[b] Fisher Freeman Halton test (Monte Carlo).
[c] Yates continuity correction test.
* $P < 0.05$.
** $P < 0.01$.

skin flora, *Enterococcus*, and *Morganella morganii* were found in 4, 2, 2, and 1 patient, respectively. The culture results of 4 patients were negative (Table 6).

According to the literature, several methods have been used to prevent IRIs. Many of these methods are based on the use of antibiotic-impregnated biomaterials, or topical and systemic agents.[31,32] Most studies have accepted that the use of ultraclean laminar flow ventilation, a sterile hood, and a body-exhaust system lead to a significant reduction in infections. Waterproof aprons have also been shown to be effective against the transfer of organisms between patients and surgeons.[33] In our study, a titanium transpedicular screw system was used routinely in all cases; also we have an ultraclean laminar flow ventilation system in our operating room.

Surgical gloves are the most important barrier between the surgeon and the patient; gloves are the most important tool in the prevention of infection on both the sides. Many previous studies have reported that the use of double-layered surgical gloves significantly reduced the risk of developing PSIs, and that there was a significant relationship between length of surgery and glove perforations in terms of PSI development.[34] An early study by Brewer[35] observed a significant reduction in PSIs following the use of surgical gloves.[14] During surgical interventions, gloves may become perforated, often without the surgeon's knowledge; as a result, the risk of infection increases. In addition, a direct penetration by the penetrating tool or a perforation of the gloves without the surgeon's knowledge of this occurrence is possible. In cases where glove perforation happens without the surgeon's knowledge, the use of double-layered gloves has been shown to significantly reduce the infection risk after surgery. In the literature, the perforation rates for neurosurgery, ophthalmic surgery, obstetrics and gynecology, plastic surgery, general surgery, and orthopedic surgery were 29%, 10%, 13.3%, 21.5%, 12.7%, and 26%, respectively.[33,36–39] Although the use of double-layered gloves during surgery causes a decreased infection rate, undetected tears are still an important problem. In a randomized study conducted by Al-Maiyah et al,[18] changing gloves at 20-minute intervals was successful in preventing unseen tears. Based on the results of some studies, longer surgical duration increased the risk of glove perforation; some studies have recommended changing gloves in surgical interventions lasting >90 minutes.[40]

For surgical procedures in general, it has been reported that gloved fingertips became contaminated in 52% of operations. During joint replacements, Davis et al[2] reported that 28.7% of gloves used for preparation were contaminated. Also incidence of outer glove contamination ranged from 4.8% to 12%.[6,18] In our study, the infection rates detected after surgery with single-layered gloves were significantly higher compared to double-layered gloves. There was no relation between PSI development and surgical duration. Our study demonstrated that wearing double-layered gloves reduced the possibility of developing infections caused by an unknown glove perforation.

Surgical sutures are sterile strands used to close wounds and provide support during the healing process. Strands are classified in accordance with their deterioration rate, if they are absorbable or nonabsorbable, their composition, and their structure. Sutures may be multifilament or monofilament. Absorbable sutures are broken down by hydrolysis, enzymatic digestion, and from various tissue reactions. Silk sutures do not induce inflammatory responses. Some studies have reported microbial adhesion to surgical suture surfaces, especially in the past 30 years. The degree of bacterial infection remains lower in comparison with other sutures. Many authors have suggested that the risk of wound infection is dependent upon the degree of bacterial adhesion and the nature of the suture material.

Specifically, the monofilament suture tissue response produces fewer inflammatory reactions compared to materials with multifilament. All antibacterial studies clearly indicate that silver-plated sutures have clinical advantages in terms of preventing bacterial infections.[41]

Gristina et al[20] reported that percutaneous sutures approximating skin edges were often colonized from the body surface into the wound track by strains of *Staph epidermidis* that were capable of producing an amorphous extracellular matrix (biofilm). This matrix protected the microbial populations from host defense factors. In a study conducted by Storch et al,[39] triclosan-coated polyglactin 910 surgical sutures had a sufficient antibacterial activity in preventing bacterial colonization in an in vivo rat model by using standard laboratory reference strains of *Staph aureus* and *Staph epidermidis*. This study was also supported by another study of Edmiston et al.[40] When the relationship between the development of infection and suture materials used in our study was examined, the incidence of infection with prolene suture was significantly higher. This is in contrast to results found in the literature. Our study reported that the possibility of developing infections was lower in patients when vicryl was used, and there was no significant difference in patients when silk was used. The PSI occurrence rates were significantly lower in patients when staples were used.

Antibiotic prophylaxis is an important method in preventing PIs. Antibiotics used for prophylaxis should not disturb wound healing; they should be effective against the most common factors, effective against the patient's flora that are expected in the surgical field, easily accessible, and cost effective.

These expectations are met by the first and second-generation cephalosporins. Antibiotics should be found in high concentrations in the serum during surgery. The proliferation of bacteria that contaminate the surgical field during the operation is prevented by antibiotics arriving there via bleeding or serum leakage. Prophylaxis should be done 30 to 120 minutes before the surgery. Although the usage of prophylaxis in the postoperative period is controversial, it is beneficial to continue treatments 24 hours postoperatively.[8,42] In our study, cephazolin sodium (1 g) was administered intravenously to all patients 30 to 60 minutes prior to surgery, and it was continued postoperatively at a dose of twice a day at 12-hour intervals for 24 hours. Studies have reported that the immunosuppressive effects of perioperative blood transfusions may increase the risk of infection at least 2-fold.[43,44] In a study with 44,003 patients who underwent cardiac surgery, the risk of mediastinitis was found to increase 2.5-fold in patients who had undergone blood transfusions ≥ 3 units of blood.[45] Another study reported that the implementation of a perioperative blood transfusion increased PSI development in patients who underwent elective colorectal resection.[46] In our study, similar to the literature, the development of infections in patients with perioperative blood transfusions was significantly higher.

Few studies in the literature have been conducted on the contents of the irrigating solution used in spinal surgery.[47] We prepared an antibiotic solution by adding 250 mg of RIS per 500 mL of liquid to irrigate the surgical field. As a result, we found that the PSI occurrence rates were significantly lower in patients who had antibiotic solutions used for surgical irrigation.

TABLE 6. General Summation of the Risk Factors, Pathogenesis, and Treatment Modalities

Case No.	Age/Sex	Systemic Disease	Diagnosis	Macroscopic Findings	Medical Treatment	Surgical Treatment	Additional Factors According to Statistical Results	Hospital Stay, d	Culture Result	Result
1	62/M	Diabetes mellitus	Epidural abscess	Epidural abscess		Abscess drainage + debridement	Sefozolin sodium 1 g (3 d), vancomycin (17 d)	20	None	Cured
2	58/M	None	Wound infection	Inflammation at paravertebral area	Ampicillin/sulbactam 1 g + gentamicin 160 (3 d), meropenem (10 d), second-generation cephalosporin (7 d)	Debridement		13	*Escherichia coli*	Cured
3	66/F	None	Wound infection	Inflammation at paravertebral area		Debridement	Ceftriaxone 1 g (31 d) + gentamicin (16 d)	22	Normal skin flora	Cured
4	69/F	None	Wound infection	Inflammation at paravertebral area + necrotic area + pus	7 d ceftriaxone 1 g + ertapenem 1 g (32 d), vancomycin (27 d) + ciprofloxacin (15 d)	Debridement + secondary granulation		32	First, culture *E coli*; second, entorococcus	Exitus
5	67/F	Diabetes mellitus	Wound infection	Inflammation at paravertebral area	Cefazol-gentamicin iv + second-generation cephalosporin (7 d)	Debridement		10	*Staphylococcus epidermidis*	Cured
6	52/F	Diabetes mellitus	Wound infection	Inflammation at paravertebral area	1 g ampicillin/sulbactam (10 d)	None		10	*Staph epidermidis*	Cured
7	63/F	Diabetes mellitus	MR: discitis	No surgery	Vancomycin (26 d)	None		26	None	Cured
8	58/F	Diabetes mellitus	MR: epidural abscess	Epidural abscess + discitis	Cefozolin sodium 1 g (3 d), vancomycin (21 d)	Abscess drainage + debridement		23	None	Cured
9	69/M	Diabetes mellitus + hypertension	MR: discitis	No surgery	Vancomycin (22 d)	None		22	None	Cured
10	64/F	Diabetes mellitus	Wound infection	Inflammation at paravertebral area + pus		Debridement	Ceftriaxone 1 g (17 d)	20	Normal skin flora	Cured
11	52/M	Diabetes mellitus	Wound infection	Inflammation at paravertebral area		Debridement	Ampicillin/sulbactam 1 g (15 d)	19	*Staph epidermidis*	Cured

Case No.	Age/Sex	Systemic Disease	Diagnosis	Macroscopic Findings	Medical Treatment	Surgical Treatment	Additional Factors According to Statistical Results	Hospital Stay, d	Culture Result	Result
12	61/M	Diabetes mellitus + hypertension	Wound infection + cellulitis	Inflammation at paravertebral area		Debridement	Ampicillin/sulbactam 1 g (18 d)	19	*Staph epidermidis*	Cured
13	48/F	None	Wound infection	Inflammation at paravertebral area		Debridement + primary suture	Ampicillin/sulbactam 1 g (10 d)	12	None	Cured
14	61/F	None	Wound infection	Inflammation at paravertebral area + necrotic areas + pus		Debridement + secondary granulation	Cefazolin sodium (17 d), cef-triaxone (10 d), piperacillin/tazobactam (7 d)	45	*Morganella morganii*	Cured

Today, various sterile drapes are used to prevent contamination at the surgical surface. No studies have examined infection prevention by sterile drapes. Although we used iodized and noniodized drapes in our study, we found that there was no significant difference between the different drapes used (iodized or noniodized) in our study.

CONCLUSION

Preventing PSI in spinal surgery, especially where implantation is used, is an ongoing debate. Seventeen different parameters that may affect PSI development were evaluated in this study. Although the presence of systemic diseases, unnoticed glove perforations, and perioperative blood transfusions were among the parameters that increased the incidence of PSI, prolene sutures, double-layered gloves, and the use of RIS decreased PSI incidents. After we had these results, we developed a new strategy for the materials to use or not to use in order to decrease the infection rate and economic burden. Future studies are warranted to examine other factors that we might have overlooked.

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