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SURGICAL SITE INFECTION AFTER SPINAL INSTRUMENTATION: REVIEW OF PATHOGENESIS, DIAGNOSIS, PREVENTION AND TREATMENT

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ABSTRACT

Objective: Despite the successful application of spinal instrumentation surgery, the development of surgical site infections (SSIs) remains inevitable even in the most experienced neurosurgery clinics. The aim of this study was to analyze potential risk factors, reassess diagnosis and treatment, and discuss outcomes in line with the literature.

Materials and Methods: The records of 1564 patients who underwent spinal instrumentation surgery between 2016 and 2023 were retrospectively reviewed. Among these patients, 297 developed superficial or deep SSIs in the postoperative period. Diagnosis was based on postoperative positive wound cultures, intraoperative cultures, serum procalcitonin and C-reactive protein (CRP) levels measured in the postoperative period, and gadolinium-enhanced magnetic resonance imaging (MRI) and computed tomography scan. Demographic characteristics and preoperative risk factors of the patients were analyzed.

Results: SSIs were observed in 297 (18.9%) out of 1564 patients who underwent spinal instrumentation surgery. Multiple risk factors for spinal infections following spinal instrumentation surgery, which can manifest in both the early and delayed postoperative periods, were identified. Early diagnosis and prompt initiation of appropriate treatment were associated with better prognosis in 215 patients. Among the 82 patients diagnosed late, all underwent revision surgery for spinal implant removal due to failed medical treatment, with clinical outcomes in 23 of these patients not meeting post-operative expectations. The relationship between early and delayed diagnosis and the need for reoperation were statistically significant ($p<0.001$). Reoperation was required in 92.7% of patients with delayed diagnosis compared with 15.3% of patients with early diagnosis, indicating an approximately 11.6-fold higher risk of reoperation in patients with delayed diagnosis.

Conclusion: Intraoperative culture results are the gold standard for diagnosing SSIs after spinal instrumentation surgery and are also valuable for selecting antimicrobial agents. Monitoring procalcitonin and CRP levels, along with MRI, is highly beneficial for diagnosis. Early detection requires fewer surgical interventions and improves clinical outcomes

Keywords: Procalcitonin, spinal instrumentation, surgical site infection

INTRODUCTION

Surgical site infections (SSIs) occur in 2% to 20% of patients following spinal instrumentation, commonly used in the surgical treatment of spine pathologies[1]. These infections can lead to complications such as pseudarthrosis, spondylodiscitis, neurological sequelae, and even death[2]. SSIs after spinal surgery are multifactorial and can manifest in both early and delayed post-operative periods[3]. Despite strict adherence to aseptic principles, it can occur postoperatively, leading to revision surgeries, prolonged hospital stays, and adverse economic outcomes[4]. The most common cause of postoperative SSIs is gram-positive bacteria originating from the patient's flora[5]. Among gram-positive bacteria, staphylococci are predominant, including *Staphylococcus aureus* and coagulase-negative staphylococci[6]. There is insufficient scientific research in the literature regarding prevention of postoperative SSIs. Additionally, consensus on postoperative care among spine surgeons remains elusive[7].

Complications of spinal surgery such as Dural tear and the use of Dural sealants have been identified as factors increasing the risk of spinal SSIs[8]. Risk factors in the postoperative period include patient incontinence, use of posterior surgical approach, surgical intervention for spinal tumor resection, and morbid obesity[9]. Furthermore, a retrospective study identified diabetes, heart disease, smoking, chronic lung diseases, advanced age, preoperative steroid use, prolonged postoperative hospital stays, multiple blood transfusions, and prolonged operative

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duration as risk factors[10]. Violation of sterile conditions during the use of fluoroscopy, intraoperative computed tomography (CT), and surgical microscopes in spinal surgery has also been shown to increase the risk of postoperative infections[1].

The aim of this retrospective study is to analyze SSIs following spinal instrumentation surgery in our neurosurgery clinic, identify potential risk factors, evaluate management strategies, reassess diagnosis and treatment, and discuss outcomes in line with the existing literature.

MATERIALS AND METHODS

Research and Editorial Ethics

Informed consent was obtained from all patients involved in this study. This study was conducted following the ethical standards set by the Ordu University Faculty of Medicine Non-interventional Clinical Research Ethics Committee (approval number: 168, date: 09.06.2023).

Patient Population

Records of 1564 patients who underwent spinal instrumentation surgery at Ordu University Training and Research Hospital Neurosurgery Clinic between January 1, 2016, and April 1, 2023, were retrospectively reviewed. Among these patients, 297 were identified to have developed superficial or deep SSIs in the postoperative period. Diagnosis involved postoperative positive wound cultures, intraoperative cultures, serum procalcitonin and C-reactive protein (CRP) levels measured in the postoperative period, and gadolinium-enhanced magnetic resonance imaging (MRI) and CT scans. Demographic characteristics and preoperative risk factors of the patients were analyzed.

The following criteria were used for diagnosis:

a) Positive postoperative wound culture results,

b) Intraoperative culture results as the gold standard for identifying the causative microorganism,

c) CRP and procalcitonin levels measured on the 3rd postoperative day, the 3rd week, the 3rd month, and the 6th month,

d) Postoperative gadolinium-enhanced MRI, and

e) Gadolinium-enhanced CT scans. Demographic characteristics of the patients and preoperative risk factors were analyzed.

Incidence, Definitions, and Classifications

In our study, early-onset infections were defined as infections occurring within the first 90 days post-surgery. Late-onset infections were those occurring after the 90th postoperative day. Posterior spinal instrumentation was associated with an increased risk of infection and higher revision surgery rates. Anterior spinal exposures were associated with a reduced infection risk and successful fusion. A total of 297 patients (18.9%) were identified with SSIs. Among these 297 patients, only 27 underwent anterior cervical surgery, and all 27 (9.1%) had superficial wound infections diagnosed within the first 90 days. The remaining 270 patients (90.9%) had undergone posterior spinal approaches. Clinical outcomes were assessed based on fusion quality, symptomatic improvement, neurological status, functional activities of daily living, and infection eradication. The relationship between early and late diagnosis and the need for reoperation was examined using the chi-square test, which showed a significant relationship ($p<0.001$).

Statistical Analysis

All calculations were performed using SPSS v28 (IBM Inc., Chicago, IL, USA). Relationships between categorical variables were examined using the chi-square test, and odds ratios were calculated with a 95% confidence interval for significant variables. A statistical significance level of 5% was considered in statistical tests and interpretation of results.

RESULTS

Demographics and Risk Factors for Post implantation Wound Infection

Between January 1, 2016, and April 1, 2023, records of 1564 patients who underwent spinal instrumentation surgery were retrospectively reviewed, revealing that 297 (18.9%) developed SSIs. Among these, only 27 (9.1%) of those who underwent anterior cervical surgery had superficial wound infections, all diagnosed within the first 90 days postoperatively and successfully treated with antibiotics without requiring reoperation. The remaining 270 (90.9%) patients underwent surgery via posterior spinal approaches: 42 for posterior cervical, 38 for thoracic, and 190 for lumbar surgeries. Of the 270 patients with posterior spinal approach and SSIs, 188 (69.6%) were diagnosed in the early period within the first 90 days, with only 33 (17.5%) requiring revision surgery. In contrast, 82 patients (30.3%) were diagnosed in the late period, more than 90 days postoperatively. Sixteen of these patients did not require surgical treatment but needed prolonged antibiotic therapy for at least 6 months. Among the late-diagnosed 82 patients, 66 (80.4%) underwent reoperation, and 23 (34.8%) of them did not achieve desired clinical outcomes, remaining symptomatic with pain, numbness, and weakness, leading to a diagnosis of failed back surgery syndrome.

Of the 297 patients with postoperative SSIs, 194 (65.3%) were female and 103 (34.8%) were male. All 99 patients who underwent revision surgery were operated on using posterior spinal approaches, with 63 (63.6%) due to spinal trauma and 36 (36.3%) due to spinal stenosis and degenerative spine conditions. Among those who underwent revision surgery, 11 (11.1%) involved 4 spinal segments, while the remaining 88 (88.9%) involved 3 or fewer spinal segments. Multiple risk factors associated with patients facilitated the development of postoperative SSIs following spinal instrumentation surgery. Risk factors for postoperative SSIs are shown in Table 1.

Positive wound culture results were reviewed from patients who developed postoperative superficial or deep SSIs. According to culture results, gram-positive bacteria were most commonly

isolated among the infected 297 patients, with 70 (72.9%) cases identified. Among these, *S. aureus*, including methicillin resistant *S. aureus*-positive cases, was found in 43 patients, *Staphylococcus epidermidis* in 21 patients, *Staphylococcus hemolytic* in 4 patients, and *Enterococcus faecalis* in 2 patients. Gram-negative bacteria were detected in 26 (27.1%) patients, including *Escherichia coli* in 17 patients, *Enterobacter cloacae* in 8 patients, and *Pseudomonas aeruginosa* in 1 patient.

The relationship between early and late diagnosis and the need for reoperation was analyzed using chi-square testing, revealing a significant association (p<0.001) (Table 2). While 84.7% of early-diagnosed patients did not require reoperation, 92.7% of late-diagnosed patients underwent reoperation. Late-diagnosed patients had approximately 11.6 times higher risk of requiring reoperation compared to early-diagnosed patients (Table 3).

Table 1. Risk factors for 99 re-operated patients

Risk factors	Number of patients
Elderly (age >60 years)	73 (17.5%)
Previous spinal surgery	27 (6.5%)
Smoking	26 (6.2%)
Spinal trauma	63 (15.1%)
Body mass index >30	39 (9.3%)
Diabetes mellitus	42 (10%)
Cardiovascular disease	22 (5.2%)
Chronic pulmonary diseases	19 (4.5%)
Steroid use	7 (1.6%)
Blood transfusion	74 (17.8%)
Alcohol use	13 (3.1%)
Hypothyroidism	3 (0.7%)
Concurrent urinary tract infection	8 (1.9%)

Table 2. Pathogenic microorganisms isolated

Gram-positive bacteria (70 patients) (72.9%)	Number of patients
Staphylococcus aureus (MRSA resistance included)	43 (61.4%)
Staphylococcus epidermidis	21 (30%)
Staphylococcus hemolytic	4 (5.7%)
Enterococcus faecalis	2 (2.9%)
Gram-negative bacteria (26 patients) (27.1%)	
Escherichia coli	17 (65%)
Enterobacter cloacae	8 (30.7%)
Pseudomonas aeruginosa	1 (3.8%)

MRSA: Methicillin resistant *Staphylococcus aureus*

DISCUSSION

In our study, laboratory, radiological, and clinical outcomes of 1564 patients who underwent spinal surgery using instrumentation at our clinic were retrospectively analyzed. It was determined that SSI developed in 297 (18.9%) patients. Our infection rates align with statistics reported in the literature[1,3]. When evaluating clinical outcomes, complete eradication of infection, symptomatic and neurological recovery of the patient, and repeat radiological examinations were considered. Early-onset infections in our study were defined as those developing within 90 days postoperatively, whereas late-onset infections were those occurring after 90 days postoperatively. We observed that patients diagnosed early and promptly treated (215 patients) had better prognoses. The timing of infection onset, whether early or late, has been highlighted as a crucial criterion in determining treatment approach[2,3].

Postoperative SSIs can lead to complications such as pseudarthrosis, instrumentation failure, undesirable neurological sequelae, and even death. Among our patients who developed SSIs and were diagnosed late (82 patients), 66 (80.4%) required reoperation. Among these, 23 (34.8%) did not achieve desired clinical responses, experiencing persistent symptoms of pain, numbness, and motor deficits, resulting in failed back surgery syndrome. Studies by Deng et al.[10] underscore the significant morbidity caused by post-spinal surgery infections, substantially impeding functional recovery. These infections are recognized by the Centers for Disease Control and Prevention as occurring within 12 months post-surgery, posing a potentially destructive complication risk[11].

During the postoperative period, measuring CRP levels early on is a reliable test for detecting SSIs and is crucial for early diagnosis[1,3,12]. Erythrocyte sedimentation rate (ESR) and total leukocyte count are routine tests used for diagnosis alongside CRP[1]. Procalcitonin has been found superior to CRP and ESR

Table 3. Relationship between early and late diagnosis and reoperation

	Re-operated patients		Non re-operated patients		Total		*p* value
	n	%	n	%	n	%	
Early diagnosis	33	15.3	182	84.7	215	100.0	**< 0.001[a]**
Late diagnosis	76	92.7	6	7.3	82	100.0	
Total	109	36.7	188	63.3	297	100.0	
OR (95% CI)	11.569 (5.344-25.047)						

[a]: Pearson's chi-squared test, OR: Odds ratio, CI: Confidence interval

as an early indicator of SSI in patients undergoing spinal surgery[13]. In our study, we observed that CRP levels typically peaked around 2-3 days post-surgery and normalized within 2-3 weeks in non-infected patients. ESR peaked around day 5 but took 3-6 weeks to return to normal in non-infected patients. However, in all 297 patients who developed postoperative SSI, CRP, procalcitonin, and ESR levels remained significantly elevated by the end of the first month. Twelve patients showed normal leukocyte counts, seven of whom had a history of long-term steroid use. Among the 143 patients who received prolonged antibiotic treatment, significant ESR reduction was not observed by the end of the third month.

CT and MRI are confidently used in diagnosing[3]. In our study, contrast-enhanced MRI was performed on all 297 patients who developed postoperative SSI, revealing positive signs of pedicle fluid in 163 patients. According to Aljabi et al.,[13] contrast-enhanced MRI is highly beneficial for diagnosing SSIs following spinal surgery[14]. Sierra-Hoffman et al.[15] suggest that early-onset can be treated with 4-6 weeks of intravenous (IV) antibiotics followed by 4-12 weeks of oral antibiotics, without necessitating instrumentation removal. Late-onset, however, may require instrumentation removal despite IV and oral antibiotic treatment[15]. All our patients diagnosed with early-onset SSI received at least 4 weeks of IV antibiotics followed by a minimum of 8 weeks of oral antibiotics.

Choi et al.[16]emphasize the importance of early diagnosis, noting that patients diagnosed late require longer antibiotic use. In our clinic, patients diagnosed late used antibiotics on average four times longer than those diagnosed early. Oikonomidis et al.[17] suggest that late infections may necessitate implant removal. Literature also includes authors recommending retaining instrumentation in cases of postoperative SSIs, achieving successful outcomes with surgical and specific antibiotic treatments[18,19]. Among our patients diagnosed late, 66 (80.4%) underwent reoperation, with complete implant removal in 21 (31.8%) of these cases.

Our study demonstrated that preserving instrumentation and initiating parenteral antibiotic therapy early in the course of spinal surgery lead to better clinical outcomes. Additionally, administering a single dose of prophylactic antibiotics one hour before surgery was found to be sufficient. The best approach to preventing postoperative infections involves thorough preoperative preparation and diligent postoperative monitoring of patients through laboratory, clinical, and radiological assessments. Preventing spinal implant infections should always remain a primary goal in neurosurgery. Early diagnosis of infections related to spinal instrumentation results in a better prognosis and requires fewer revisions.

CONCLUSION

The etiology of SSIs developing in the postoperative period of spinal surgery is multifactorial. Patients diagnosed early in this period generally have better prognoses. The gold standard for identifying the causative microorganism is intraoperative culture results, which are invaluable for selecting the appropriate antimicrobial therapy. Additionally, serum procalcitonin, CRP levels, and MRI are highly useful in diagnosing SSIs. When SSIs are diagnosed early, they often require less surgical intervention and yield better clinical outcomes.

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Ethics

Ethics Committee Approval: This study was conducted following the ethical standards set by the Ordu University Faculty of Medicine Non-interventional Clinical Research Ethics Committee (approval number: 168, date: 09.06.2023).

Informed Consent: Informed consent was obtained from all patients involved in this study.

Authorship Contributions

Surgical and Medical Practices: H.Ö., M.H., Concept: H.Ö., M.H., Design: H.Ö., M.H., Data Collection or Processing: H.Ö., Analysis or Interpretation: H.Ö., Literature Search: H.Ö., M.H., Writing: H.Ö., M.H.

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