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Predictors and Risk Factors of Surgical Site Infection (SSI) Following Adult Spine Surgery

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ABSTRACT

Introduction: *Surgical Site Infections (SSI) is a major cause of morbidity and mortality as it is known to increase the length of hospital stay, revision surgery, and re-operation. Identifying patients at risk of developing SSI before surgery is the key to prevent SSI.* ***Methodology:*** *This is a cross-sectional study that was performed at the orthopedic department in King Khalid University Hospital, Riyadh, Saudi Arabia. SSIs were defined according to The Centers for Disease Control (CDC) case definition for surgical site infection. Potential risk factors for postoperative wound infection were collected. All the data were analyzed by SPSS 23.0, in which p<0.05 was considered to be statistically significant.* ***Results:*** *A total of 214 patients were included in the study and the incidence of surgical site infection following spine surgery was (N=21, 9.81%). Obesity, Diabetes, location of surgery, and ASA score duration of surgery, length of hospital stay, and location/level of operated vertebrae were all found to have a significant correlation with the SSI p<0.05.* ***Discussion:*** *Surgical Site Infection (SSI) following spine surgery is not an uncommon complication as rates of spinal surgical site infection reported from different centers have varied from 0% to 15%, depending on the indication of the surgery, the site, the approach, and the use of instrumentation. Many risk factors are reported; patient-related risk factors like diabetes mellitus, obesity, and older age, other surgical risk factors including prolonged operative time, and improper aseptic techniques in the operating room.* ***Conclusion:*** *Having a strong background of SSI risk factors and predictors is core to preventing the incidence of SSI and further enhance and optimize operative outcomes, as well as increasing the cost-effectiveness of the surgical intervention.*

Keywords: Surgical site infection, Morbidity, Mortality, Spine surgery, Complications, Risk factors, Cost-effectiveness

INTRODUCTION

Surgical Site Infections (SSI) comes among the most common hospital-acquired infection, surgical site infection following spine surgery is a major cause of morbidity and mortality, besides, and it results in increased hospital stay, re-admission, and re-operation [1]. Surgical site infections can be broadly divided into superficial and deep. Superficial spine infections are those localized at the skin or subcutaneous tissue, deep infections are those reaching the fascia and causing inflammation of the intervertebral disks and associated soft and articular tissues leading to discitis, spondylitis, and epidural abscess [2].

Diagnosing SSI can be difficult this might be attributed to including the insufficiency of the physical findings, resemblances of non-infective conditions, patients not seeking medical attention, irregular or lack of follow-up in some institutions, and the dependence on plain that have a low sensitivity for diagnosing SSI [3].

The most common presenting complaint about SSI following spine surgery is back pain, and it usually begins one month following the procedure ranging from 2 days to over 3 months post-intervention [4]. Other signs and symptoms of SSI may include fever, erythema, edema, warmth, tenderness to palpation, or wound discharge. Certain laboratory tests may be used to assist in diagnosing SSI like White Blood Cell count (WBC), C-Reactive Protein (CRP), Erythrocyte Sedimentation Rate (ESR) but are of limited value as they are usually elevated in any postoperative period [5].

During the early postoperative period, many typical markers of infection are unreliable which makes aspiration culture of limited use as some authors have reported a success rate of only 70% [6]. When a deep infection and abscess is suspected obtaining a Computed Tomogram (CT) assisted aspiration for gram-stain and culture is indicated [7]. This difficulty in diagnosing SSI and the high risk of it going undetected, demands physicians to have a high index of suspicion, especially in patients presenting with back pain after an invasive therapeutic or diagnostic procedure to the spine [8]. Although this complication can be prevented by following certain preventive measures, it remains a devastating complication, those techniques include, strict adherence to the aseptic technique in the operating room, optimizing the patient's status before surgery, proper use of prophylactic antibiotics, and regular follow-up to examine the wound [9-11]. Knowledge of the factors involved gives us a better opportunity to control them. Patient-related risk factors are nutritional status, co-morbidities i.e. diabetes mellitus, obesity, and older age, other surgical risk factors including prolonged operative time and improper aseptic techniques in the operating room [12].

Some other factors are more specific to spine surgery. Smith et al. observed higher SSI among trauma patients 9.4% followed by metastatic tumor and acute osteodiscitis which constituted around 5%, they also found that surgeries which were conducted around the thoracic region had higher rates of infections, followed by lumbar then cervical [13]. Furthermore, SSI rates were higher in operations requiring spinal fusion, among those, anterior spinal fusion was noted to be less associated with infections and this can be attributed to less muscle dissection for bone exposure and higher vascularity of the anterior spine [14,15].

Surgical site infection is a multifactorial process in which patient factors, surgical factors, and some other factors play a role. Identifying risk factors and predictors of SSI can prove an important preventive measure.

METHODOLOGY

After obtaining ethical approval from our hospital's IRB committee, a review of all spine surgeries performed at the orthopedic department in King Khalid University Hospital from the period between Jan-2018 till Jan-2020 to identify patients who developed SSI. All surgeries were performed by a consultant of spine surgery. A total of 304 patients who underwent elective spine surgeries were identified by searching the hospital's medical records.

A total of 214 patients were identified to fit our criteria and have complete data in their records.

SSIs were defined according to The Centres for Disease Control case definition for surgical site infection [16].

The medical records of the 214 patients were reviewed individually for data on potential risk factors for postoperative wound infection. Body mass index was calculated for each patient. All the medical records of comorbidities were considered by assigning ASA score by an anesthetist.

Data Collection

Patients were selected according to the following criteria: patients with complete data who underwent any elective spinal surgery. Patients with primary infections, such as spine tuberculosis or discitis, and patients with secondary surgeries were excluded.

Risk factors were analyzed, including patient-related risk factors such as sex, age, Body Mass Index (BMI), diagnosis, smoking, diabetes, and ASA score. Also, procedure-related risk factors such as operative time, intraoperative estimated blood loss, the level that the operation was performed at, type of approach, and length of hospital stay.

T-test was used to calculate the differences for quantitative variables, means, and standard deviations were also calculated for the patients with and those without SSI infections for categorical variables, the chi-square test was used to assess the association. To eliminate confounding and to identify the independent risk factors of spinal postoperative surgical site infections we used binary logistic regression (Tables 1 and 2). All the data were analyzed by SPSS 23.0, in which $p<0.05$ was considered to be statistically significant.

Table 1 The differences of risk factors in the infection and non-infection groups were analyzed by Chi-square test (categorical variables)

Variable		Non-SSI	SSI	χ2 Value	p-Value
DM	No	140	9	7.89	0.005
	Yes	53	12		
Location/level	Cervical	29	1	9.287	0.026
	Thoracic or thoracolumbar	63	3		
	lumbar	46	11		
	Lumbosacral or lumbar and lumbosacral	55	6		
Sex	Male	74	5	1.718	0.19
	Female	119	16		
ASA score	1	83	5	8.538	0.036
	2	84	9		
	3	25	6		
	4	1	1		
Diagnosis	Degenerative	71	11	12.504	0.186
	Scoliosis	61	3		
	Stenosis	22	4		
	Spondylothesis	11	0		
	Spine trauma	18	0		
	Disc prolapse	8	2		
	Spine tumor	2	1		
Smoking	No	178	18	1.043	0.307
	Yes	15	3		
Approach	Posterior	167	20	1.303	0.254
	Anterior	26	1		

Table 2 The differences of risk factors in the infection and non-infection groups were analyzed by t-test (continuous variables)

	Wound Healing	N	Mean	Std. Deviation	p-value
Blood loss	optimal	193	432.13	375.547	0.003
	not optimal	21	690.95	369.404	
Duration of surgery	optimal	193	242.82	102.729	0.007
	not optimal	21	308.24	128.186	
Length of stay	optimal	193	5.55	3.285	0
	not optimal	21	12.14	10.947	
Age	optimal	193	46.18	18.477	0.036
	not optimal	21	55.05	16.735	
BMI	optimal	193	28.34	6.951	0.005
	not optimal	21	33.05	9.052	

RESULTS

A total of 214 patients were included in the study and the incidence of surgical site infection following spine surgery was (N=21, 9.81%).

The majority of the patients were females (63%) with an average age of 47. Patients presented with multiple primary diagnoses as follow: Degenerative spine disease (38.3%), Scoliosis (29.9%), Spinal Stenosis (12.1%), Spondylolisthesis (5.1%), trauma (8.4%), Prolapsed Intervertebral Disc (PIVD) (4.6%) and Spine tumors (1.4%). Most of the patients (87.4%) were operated on by the posterior approach, only a minority was approached anteriorly. All of the anteriorly approached patients were operated on at the cervical level.

Univariate analysis showed that some of the factors such as obesity, diabetes, location of surgery, and ASA (American

Society of Anaesthesiology) score have a significant correlation with the SSI. However, the other factors like gender, diagnosis, smoking, and surgical approach did not have a significant correlation with SSI. Blood loss, duration of surgery, length of stay, age, and BMI are also crucial in determining SSI ($p<0.05$). The higher SSI rates were observed at the lumbar level (19.2%) followed by lumbosacral or lumber and lumbosacral combined (9.8%). Patients who were operated at cervical level and thoracic or thoracolumbar levels had the least SSI rates (3.3%), (4.5%) respectively. A regression analysis test was used on the factors that were found significant by univariate analysis to find differences between infected and non-infected groups. Therefore, parameters evaluated by multivariate analysis included age, ASA score, location, DM, BMI, duration of operation, estimated blood loss, and length of stay at the hospital. Three independent risk factors were identified by this analysis: duration of surgery, length of stay at the hospital, and location/level of surgery (Table 3).

Table 3 Logistic regression model for the development of SSI after elective spine surgeries

		p-value	Exp (B)	95% C.I. for EXP (B)	
				Lower	Upper
Patient-related risk factors	Diabetes mellitus	0.473	0.532	0.095	2.982
	age	0.81	1.008	0.947	1.072
	BMI	0.729	1.025	0.89	1.181
Procedure-related risk factors	Blood loss	0.06	1.003	1	1.006
	Duration of surgery	0.012	1.015	1.003	1.027
	Length of stay	0.016	1.276	1.046	1.557
	Lumber level	0.011	12.908	1.803	92.439

DISCUSSION

Surgical Site Infection (SSI) following spine surgery is not an uncommon complication as rates of spinal surgical site infection reported from different centers have varied from 0% to 15%, depending on the indication of the surgery, the site, the approach, and the use of instrumentation which correlates with our results (9.81%) [17-21].

Patients having diabetes were at significantly increased risk for developing surgical site infection as reported in the literature [20-22]. Diabetes is known to cripple wound healing by causing local tissue ischemia at the site of the surgical wound as well as lowering the tissue concentration of antibiotics. Moreover, platelet-derived growth factor functions are impaired as a result of blunted granulocyte function [5]. Even though serum glucose levels of diabetic patients who underwent surgery were controlled before surgery, perhaps this might be attributed to peri-operative hyperglycemia as previously suggested by Olsen MA, proper control of peri-operative glucose might decrease the risk [23].

A significantly higher amount of intra-operative blood loss was noticed in patients who developed surgical site infection which is considered as a risk factor for SSI [20]. It is thought that profuse bleeding hinders thorough debridement of devitalized tissue, as well as the increased risk of developing a postoperative hematoma, the hematoma, and the necrotic tissue will serve as a proper medium for infectious agents to grow [24]. Furthermore, blood loss that requires allogeneic blood transfusion might contribute to immunosuppression, as studies have found significant relationships between blood transfusion and higher rates of SSI following spine surgery [25,26].

Complementary with the literature, obesity was observed in patients who developed SSI [17,27,28]. Hence it is recommended by Surgical Care Improvement Project (SCIP) advisory panel that a patient who weighs ≥ 80 kg should receive a 2-gram prophylactic dose of cefazolin [29]. However, a recent study showed that subcutaneous fat thickness might be a better predictor of SSI than BMI [30].

Higher American Society of Anaesthesiologists (ASA) score was also a significant predictor for developing surgical site infection [27,31-33]. We believe that this is not by itself a risk factor as the patient who scores high in ASA suffers from already established SSI risk factors such as diabetes mellitus and obesity, etc.

Despite that tobacco smoking is a well-established risk factor for developing SSI [34,21]. We did not find a relationship between smoking and developing SSI, perhaps this could be ought to the fact that the majority of our sample (63%) were females, and smoking rates among Saudi females is reported to be as low as 1.5%, although smoking was not significant, 16.7% of the smokers had SSI which is still higher compared to non-smokers 9.1% [35].

Increased hospital length of stay is a costly result of SSI, it is estimated that the average cost of healthcare for single readmission for the management of SSI following spine surgery was $13,302, the authors however did not include the physician's fee or the costs for administering long-term outpatient antibiotics, which makes that number an underestimate [36]. In the current study, we found that the duration of surgery was certainly a significant risk factor for SSIs, which correlates to previous reports [37,38]. The prolonged tissue exposure, as well as surgical team exhaustion, might be the reasons why prolonged operative time is related to more SSI [39]. Hence it is recommended that senior and experienced surgeons should assist those with less experience to reduce the duration of surgery and the risk of SSI [40]. However, it is worth mentioning that it has been reported that there is no relationship between the duration of surgery and having an increased risk to develop SSI [41]. One interesting finding of our present study is that we noticed significantly higher rates of SSI following operations that were performed on the (lumbar) vertebrae followed by Lumbosacral or lumber and lumbosacral combined (19.2%), (9.8%) respectively. This variable has not been reported adequately in the literature, we believe that the difficulty to clean and disinfect that area, as well as the proximity to the anal verge, might impose a higher risk of contamination.

Lastly, taking preventive measures against SSI and knowledge about SSI risk factors are essential, according to the Center for Disease Control (CDC) guidelines, updated in 2017. Strict pre- and perioperative glycemic control, maintaining intra-operative normothermia, administering anti-microbial prophylaxis when appropriate and anti-septic prophylaxis are all crucial to prevent SSI. The guidelines also stressed refrainment from withholding blood transfusion in situations where it is required just for the sake of preventing SSI [42].

CONCLUSION

Our study shows that diabetes, obesity, prolonged duration of operation, increased length of hospital stay, higher ASA scores, surgeries are done at the lumbar vertebrae and higher blood loss volume, are all risk factors for developing SSI following spine surgery. Knowledge of these risk factors will enable surgeons to properly assess and evaluate high-risk patients, and then develop preventive measures to reduce the rate of SSI.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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