Original Article

The incidence and risk factors for surgical site infection after clean spinal operations: A prospective cohort study and review of the literature

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Abstract

Background: Postoperative infection is one of the most common complications after spine surgeries. In our study, surgical site infection (SSI) is described as; superficial (i.e., skin and subcutaneous tissues) and deep (i.e., fascia and muscles) infections occurring in the short term (i.e., 1-month) after spine surgeries (Centers for Disease Control and Prevention definition 81.00–81.08). To detect the risk factors for the occurrence of such a complication, studies require a large number of patients, a high quality of data and adequate analysis. In this study, we prospectively enrolled 987 patients undergoing spinal surgery over a 3 years period.

Methods: From November 2010 to November 2013, 987 patients had a variety of spinal operations that included; disc herniation, spinal stenosis, spondylolisthesis, fracture-dislocations, spine and spinal cord tumors, and syringomyelia. Patients under the age of 10, those with a recent history of infection and antibiotherapy, and patients with immunodeficiency disorders were excluded.

Results: Of the 987 spine procedures performed, 27 (2.73%) developed postoperative infections. Multi-variant data analysis indicated that multiple factors correlated with an increased risk of SSI in descending order; trauma, a past history of diabetes, smoking, being confined to bed, in the perioperative period, mean blood sugar levels above 120 mg/dl, longer lengths of incisions, and longer hospital stay.

Conclusion: Considering the preventable nature of most of the factors contributing to SSI, it should be possible to reduce these complications.

Key Words: Diabetes, discectomy, spine fusion, spine trauma, surgical site infection

INTRODUCTION

In spine surgery, following pneumonia and urinary tract infections, surgical site infection (SSI)[3] is the third most common and critical complication.[13,14,28] The incidence of SSI in clean procedures is variously reported

as between 1% and 10%.[18,19,21,23] Several studies identify the following risk factors that predispose patients to developing SSI: Diabetes mellitus (DM), a high body mass index (BMI), and longer duration of surgery.[13,18,19] However, most of these studies are retrospective and do not use proper bio-statistical methods.[6,7,9,12,14,16,19,21,26] In this prospective single-center study, we defined the major risk factors contributing to SSI following a wide variety of spinal procedures. The incidence and main causes of; superficial (i.e., skin and subcutaneous tissues) and deep (i.e., fascia and muscles) SSI were identified and defined only for the short term (i.e., 1-month according to Centers for Disease Control and Prevention definitions for SSI Surveillance).[2,3]

METHODS

Population from November 2010 to November 2013, 1042 patients underwent spine surgery at one institution. Patients were excluded due to: Death attributed to noninfectious causes (4 patients), those who received previous antibiotic-therapy/ had history of infection/those requiring prophylactic antibiotics (e.g., history of endocarditis) (19 patients), age under 10, immunodeficiency disorders, or lost to follow-up (19 patients). The 987 patients with variable symptoms [Table 1] various spine procedures addressing varied pathologies [Table 2]. A data sheath was filled for each patient to register demographic information, pre-, intra- and post-operative variables, and final outcomes.

Antibiotic therapy prophylaxis

Cephazolin (1 g for patients lighter than 70 kg and 2 g for those heavier) was injected intravenously half an hour prior to the skin incision.[2] This could be repeated every 3 h in case of prolonged surgery. Similar dosages were repeated 6–12 h postoperatively.

Surgical measures to reduce surgical site infection

The various prophylactic measures were undertaken to reduce the risk of SSI. These included; irrigation at the end of surgery with normal saline/gentamicin, utilization of a closed drainage system for 24 h, and routine discharge on the second postoperative day.

Postoperative follow-up

Postoperative surveillance for infection included; suture removal 2 weeks postoperatively and follow-up for the first postoperative month. Those with suspected SSI were hospitalized for further evaluation; both superficial and deep SSIs were considered "unfavorable outcomes" [Tables 3-5].

Statistical analysis

Data were imported to SPSS software version 20 (South Melbourne, Victoria: Cengage Learning Australia, 2012, SPSS Inc.) for statistical analysis. Chi-square (χ^2)

Table 1: Presenting signs and symptoms of the patients

Sign/symptom	Frequency (%)
Local pain	84
Radicular pain	73
Sensation disturbance	45
Claudication	24
Muscle weakness	12
Acute trauma	11
Sphincter dysfunction	7
Myelopathy	6
Gait disturbance	5

Table 2: Diagnosis based on clinical and radiological findings

Diagnosis		Frequency (%)
Disk herniation	443	45
Narrow spinal canal	213	21.5
Spondylolisthesis	115	11.5
Fracture/dislocation due to acute trauma	108	11
Spine and spinal cord tumor	95	9.5
Tethered spinal cord with or without syrinx	13	1.5
	987	100

Table 3: The incidence of SSI 'unfavorable outcome' in different pathologies

Pathology	Frequency (%)
Disk herniation	1.1
Narrow spinal canal	3.8
Spondylolisthesis	2.6
Fracture/dislocation due to acute trauma	5.6
Spine and spinal cord tumor	5.3
Tethered spinal cord with or without syrinx	0

SSI: Surgical site infection

Table 4: The incidence of SSI 'unfavorable outcome' in different surgical groups

Pathology	Frequency (%)	P value
Traumatic injuries	5.6	<0.035
Spine and spinal cord tumor	5.3	
Degenerative spinal diseases	2.1	

SSI: Surgical site infection

Table 5: The incidence of SSI 'unfavorable outcome' with different approaches

Surgical site	Approach	Frequency (%)	P value
Cervical	Anterior	1 case (1.8)	0.191
	Posterior	5 cases (6.6)	
Thoracic	Anterior	0	0.591
	Posterior	6 cases (8.8)	
Lumbosacral	Anterior	0	0.962
	Posterior	15 cases (1.9)	

SSI: Surgical site infection

test, analysis of variance, multi-variant and logistic regression analyses were utilized to compare the data when indicated. Considering the heterogeneity of the pathologies and the original diseases, measurement of the odd's ratio of each variable could not address any idea. Statistical significance was defined as $P < 0.05$. Data are presented as mean ± standard error of the mean or in average rates accordingly.

RESULTS

Demographics

Of the 978 patients included in the study 541 (54.8%) were male and 446 (46.2%) were female; ages ranged from 13 to 85 years (mean 46.6). Patients had surgery for a variety of diagnoses [Tables 3-5]. A total of 132 patients (13.4%) were smokers (not reliably described as mild or heavy smokers) and 33 (3.3%) were intravenous drug abusers.

Multiple surgical parameters

The average levels of discectomy, laminectomy, fusion, the previous surgeries were analyzed. Instrumentation was employed in 264 (26.7%) of patients [Table 6], and allograft or hydroxyapatite granules were employed in 210 cases (21.3%) [Table 7]. Dura was opened in 116 (11.8%) patients either deliberately (give the number) or traumatically. Patients exhibited the following average: Length of incision (9.16 cm), intra-operative blood loss (680 ± 350 ml), operative time (4 h; range 1–9.5 h), length of stay (10 days; range 2–60 days), and average transfusion requirements (packed cells [e.g., 0.70 ± 0.26 unit/patient]).

INFECTION PREVALENCE AND ORGANISMS

Twenty-seven (2.7%) patients developed either superficial (25 patients) or deep (2 patients) wound infections. All were treated with intravenous antibiotics (first empirically and then according to the results of culture and antibiogram). None of those with superficial infections developed subsequent deep infections (e.g., spondylodiscitis, osteomyelitis, or meningitis). Culture results included; *Staphylococcus aureus* in 14 (52%), *Acinetobacter* in 3 (11%), *Streptococcus pneumoniae* in 1 (4%) patients, and no organism 9 (33%). Seventeen patients (63%) underwent re-exploration for debridement of the necrotic infected tissues at the surgical site. Only 2 patients (7%) required removal of instrumentation.

Comorbid factors contributing to infection risk: The following comorbid factors correlated with an increased risk of SSI: 72 (7.3%) had DM, 87 (8.8%) hypertension [Table 8]. The season in which the surgery took place did not affect the outcome (χ^2, $P > 0.05$). Multi-variant and logistic regression analysis of the data

Table 6: The effect of instrumentation on the incidence of SSI

Surgical site	Type of surgery	Frequency (%)	P value
Cervical	With instrumentation	2 cases (4.9)	0.607
	Without instrumentation	4 cases (4.4)	
Thoracic	With instrumentation	4 cases (13.3)	0.177
	Without instrumentation	2 cases (4.5)	
Lumbosacral	With instrumentation	8 cases (4.1)	0.015
	Without instrumentation	7 cases (1.2)	

SSI: Surgical site infection

Table 7: The effect of allograft/hydroxyl apatite granules on the incidence of SSI

Surgical site	Type of surgery	Frequency (%)	P value
Cervical	With allograft/granules	2 cases (3.7)	0.525
	Without allograft/granules	4 cases (5.1)	
Thoracic	With allograft/granules	4 cases (16)	0.095
	Without allograft/granules	2 cases (4.1)	
Lumbosacral	With allograft/granules	8 cases (6.1)	0.001
	Without allograft/granules	7 cases (1.1)	

SSI: Surgical site infection

proved significant impact of various variables upon the risk of development of SSI [Table 8]:
- Trauma ($P < 0.05$)
- A prior history of diabetes ($P < 0.05$)
- Smoking in the preoperative period ($P < 0.0001$)
- Being bed ridden ($P < 0.05$) postoperatively
- Blood glucose levels higher than 120 mg/dl during the period of hospitalization ($P < 0.005$)
- The length of incision ($P < 0.01$)
- Hospital length of stay ($P < 0.005$).

There was no adequate documentation that allograft or hydroxyapatite granules increase the risk of SSI, ($P = 0.076$).

DISCUSSION

Incidence

The incidence of SSI is reported to be between 1% and 10% in different series.[8,11] This incidence has been 2.7% in our study. However, there are differences or biases in each of them. The population-bias is remarkable in several publications such as those limiting their cases to the cervical[28] or lumbosacral[27] region. Selection is another notifiable bias in some reports including only the diabetic[21] or traumatic[14] patients. Our series has been a heterogeneous group with cases coming in consequence including smaller numbers in each group without any selection bias, in regression analysis according to the different variants. The lower incidence of postoperative infection in our series may re-emphasize that administration of a single dose of antibiotic prior to skin incision in all cases with one repeat dosage 6 h

Table 8: the effect of various factors on SSI

Variable	Without infection	With infection	*P* value
Age, mean[1]	46.5 years	50.7 years	0.12
Sex		Male: 3.1%	0.437
		Female: 2.2%	
BMI	27.1 kg/m^2	29.9 kg/m^2	0.045*
Muscle weakness[2]		With muscle weakness: 8.8%	<0.0001*
		Without muscle weakness: 1.9%	
Sphincter dysfunction		With sphincter dysfunction: 12.5%	<0.0001*
		Without sphincter dysfunction: 2%	
Myelopathy		With myelopathy: 3.7%	0.69
		Without myelopathy: 2.8%	
Diabetes mellitus[3]		Diabetic patients: 9.7%	0.002*
		Non-diabetic patients: 2.2%	
Hypertension[3]		Hypertensive patients: 8%	0.007*
		Non-hypertensive patient: 2.2%	
Diabetes mellitus + hypertension		With diabetes and hypertension: 15.2%	<0.0001*
		Without diabetes and hypertension: 2.1%	
Smoking		Smokers: 8.3%	<0.0001*
		Non-smokers: 1.9%	
IV drug abuse		IV drug abusers: 6.1%	0.227
		Patients without IV drug abuse: 2.6%	
Bed ridden		Bed ridden patients: 19.6%	<0.0001*
		Non-bed ridden patient: 1.8%	
Plasma glucose level	105 mg/dl	122 mg/dl	0.004*
Hemoglobin level	13.6 mg/dl	14.2 mg/dl	0.103
Location		Cervical: 4.5%	<0.0001*
		Thoracic: 8.1%	
		Lumbosacral: 1.9%	
Approach		Posterior/postrolateral: 2.8%	0.467
		Anterior: 1.6%	
Instrumentation		With instrumentation: 5.3%	0.006*
		Without instrumentation: 1.8%	
Using allograft and granules		With allograft and granules: 6.7%	<0.0001*
		Without allograft and granules: 1.7%	
Dura opening[4]		Dura opened: 6%	0.03*
		Dura not opened: 2.3%	
Previous operation		With history of previous operation: 4.2%	0.257
		Without history of previous operation: 2.6%	
Revision surgery		With revision surgery: 5.6%	0.396
		Without revision surgery: 2.7%	
Average of length of incision	9.1 cm	12.3 cm	<0.0001*
Average of blood loss during surgery	672 ml	927 ml	<0.0001*
Transfusion		With transfusion: 7.6%	<0.0001*
		Without transfusion: 1.8%	
Average of levels of laminectomy	1.96	2.70	0.0006*
average of levels involved for fusion	0.97	2.04	0.001*
Average of levels of discectomy	0.69	0.37	0.016*
Time of surgery (morning or afternoon)		Between 8am-1pm: 2.4%	0.033*
		Between 1pm-8am: 8.7%	
Duration of anesthesia	4 hours	4.85 hours	0.002*
Postoperative bed rest period	2.5 days	6.5 days	<0.0001*
Average of hospital stay	10.5 days	17.7 days	<0.0001*

[1]The chance of surgical wound infection was significant in the age ranges of <20 and >50 (*p*=0.029). [2]In amounts that interfere with independent activity. [3]Diagnosis is based on standard criteria and received treatment for at least 6 months before surgery. [4]Either inadvertently or as controlled. *: Significant; Kg/m^2: Kilogram/square meters; IV: Intra-venous; mg/dl: Milligram/deciliter; cm: Centimeter; ml: Milliliter; SSI: Surgical site infection

postoperatively, however, several case–control studies have shown the ineffectiveness of repeated postoperative administration of antibiotics.[25,28]

Epidemiologic factors

Fang *et al*. reported age >60 as a predictor of postoperative infections[6] with a similar result in other studies as well.[13,14] In our study, the mean age of the patients with and without SSI did not differ significantly ($P > 0.05$) even though, our analysis showed that the rate of infection was higher in both extremes of life (<20 and >50) [Table 8].

Olsen *et al*. proposed the presence of more than one resident at surgeries as a risk factor.[17] In our department, all surgeries are performed while at least two residents are involved in the procedure. However, we did not have a control group to prove it.

Co-morbidities, underlying diseases, and drugs

Higher rate of infections in those younger than 20 in our study, relative immunodeficiency and disturbed defense mechanisms with aging, diabetes, and malignancies in the elderly can be explained by the higher rate of traumatic or tumoral etiologies in each extreme of age [Table 4].

Logistic regression analysis of the variants in our study, showed that being bed ridden for a long time before and after surgery is an independent imposing factor for SSI after spine surgeries ($P < 0.05$) [Table 8]. Our result is similar to the study by Lonjon G e*t al*. which included patients with traumatic spine injuries, with higher ASIA scores and long-term indwelling urinary catheters.[14,16,24] Trauma was an important independent risk factor for SSIs in our series ($P < 0.05$) [Tables 4 and 8] with the patients requiring instrumentation and allografts. In addition, the volume of blood loss, length of incision, and duration of operation is higher in this group of patients. They experience soft tissue injury and tissue hypoxia after trauma.[23] In the studies by Olsen *et al*. and Abdul-Jabbar *et al*., surgeries to resect spine tumors were associated with higher risk of infection[1,16] which is somehow consistent with our findings [Tables 4 and 8].

Regression analysis of our results showed DM as an independent risk factor for postoperative infections ($P < 0.005$) [Table 8], as indicated by others.[1,13,14,17,19,21]

A couple of studies have paid attention to the role of cardio-vascular diseases in the development of postoperative infections.[1,5,13] In our study, patients with persisting hypertension for at least 6 months before surgery experienced a higher rate of SSI. The role of hypertension in inducing infection by a higher rate of intra-operative bleeding and poor perfusion of soft tissues can be another reason. Aggressive treatment of hypertension during or after the operation may also lead to a reduction of perfusion in the skin and soft tissues and postpone wound

healing, increasing the rate of SSI. Notably, regression analysis of our data did not show hypertension to be an independent causative factor for SSI [Table 8].

Most studies suggest that high BMI promotes postoperative infections[6,13,16,18.19,23] as in our series [Table 8].

Analysis of our data shows that smoking is an independent risk factor for SSI ($P < 0.0001$) [Table 8]. Although high levels of serum nicotine results in leukocytosis, it reduces the function of leukocytes significantly.[25] Nicotine reduces serum immunoglobulin level and suppresses antibody production in response to antigens in long-term smokers.[10] This can reduce oxygenation and aerobic metabolism, disturbs immune cells migration and increases proteolytic enzymes.[23]

Anemia is considered as an important risk factor for SSI in head and neck, gynecologic, and colorectal surgeries.[7,9,15] Abdul-Jabbar *et al*. retrospective study considered anemia as a contributing factor to SSI after spine surgeries.[1] However, this result has not been confirmed after regression analysis in our patients [Table 8].

Surgical strategies and surgery-related factors

Posterior approaches are associated with higher chance of infection due to long time retraction of the skin and muscles.[16] Such an output was not achieved in our study, which may be explained by the low rate of anterior approaches in comparison with the posterior ones, and a higher number of degenerative diseases in the group who underwent posterior approaches.

Instrumentation has been considered as a risk factor for development of postoperative infections.[4,21] However, logistic regression of our data showed that the effects of instrumentation, hydroxyapatite granules, and allograft are not independent ($P = 0.076$) [Tables 6-8].

Leakage of cerebrospinal fluid (CSF) was not an independent factor in our analysis. However, the analysis by Koutsoumbelis *et al*. considered dural tear as an independent predictive factor SSI.[12]

The length of skin incision was an independent predictor factor of SSI in our series ($P < 0.01$) [Table 8]. Theoretically, a larger incision exposes a bigger area of skin and subcutaneous tissues in more complicated surgeries, to the environmental or normal flora of bacteria.[4]

Several studies have referred to the role of blood loss and transfusion in higher postoperative infection rate.[4,18,23,26] Woods *et al*. showed that after adjusting for preoperative hemoglobin and bleeding volume, the transfusion volume is independently correlated with the chance of infection[20,27] with the same results in our study [Table 8].

In our series, the increased number of laminectomies or fusions was accompanied by a higher rate of SSI, even

though not independently. Similar results were reported previously.[1,4,6,14,21,22,26]

Miscellaneous factors

Location of the spinal pathology is also believed to affect the rate of infection as the cervical surgeries with low risk[17] and the sacral surgeries with high risk[1] for SSI. In our series, even though thoracic surgeries were more prone to infection, but regression analysis of our data did not consider this factor as an independent predictor [Tables 5 and 8]. It can be explained by the fact that most thoracic surgeries were for traumatic or oncological reasons with less degenerative etiologies than in the lumbosacral region.

Longer postoperative immobility and catheterization can decrease wound perfusion ($P < 0.005$), but it does not seem to be an independent predictive factor for SSI. Immobile patients are those with advanced neurological deficits, CSF leakage and more complex surgeries which all contribute to the increased risk of wound infection.

Limitations

Even though the cases studied in this series is the largest reported in the literature, but it contains a heterogeneous group of patients treated consecutively in our department. Well, controlled larger cohorts may be needed for validation of our results especially without the bias of awareness of the surgeons to undertake anything more than the routine treatment protocol.

CONCLUSION

Most of the elucidated factors (even the rate of accidents in the younger age patients) can be somehow controlled to reduce the risk of infection. Advising the patients to wear correct helmets, lower speed of the motor vehicles, cease smoking before elective surgeries, tight control of blood sugar to <120 mg/dl, weight loosing, and earlier mobilization and rehabilitation after surgery which can reduce the SSI. A long surgery with excessive blood loss should be avoided as much as possible. Undoubtedly, the surgeon's experience and knowledge to make proper decisions in the optimal period of time is of utmost importance in reducing the complication rates including postoperative infections.

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