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Clinical Study

Body mass index and the risk of deep surgical site infection following posterior cervical instrumented fusion

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Abstract

BACKGROUND: Surgical site infection (SSI) following spine surgery is associated with increased morbidity, reoperation rates, hospital readmissions, and cost. The incidence of SSI following posterior cervical spine surgery is higher than anterior cervical spine surgery, with rates from 4.5% to 18%. It is well documented that higher body mass index (BMI) is associated with increased risk of SSI after spine surgery. There are only a few studies that examine the correlation of BMI and SSI after posterior cervical instrumented fusion (PCIF) using national databases, however, none that compare trauma and nontraumatic patients.

PURPOSE: The purpose of this study is to determine the odds of developing SSI with increasing BMI after PCIF, and to determine the risk of SSI in both trauma and nontraumatic adult patients.

STUDY DESIGN: This is a retrospective cohort study of a prospective surgical database collected at one academic institution.

PATIENT SAMPLE: The patient sample is from a prospectively collected surgical registry from one institution, which includes patients who underwent PCIF from April 2011 to October 2017.

OUTCOME MEASURES: A SSI that required return to the operating room for surgical debridement.

METHODS: This is a retrospective cohort study using a prospectively collected database of all spine surgeries performed at our institution from April 2011 to October 2017. We identified 1,406 patients, who underwent PCIF for both traumatic injuries and nontraumatic pathologies using International Classification of Diseases 9 and 10 procedural codes. Thirty-day readmission data were obtained. Patient's demographics, BMI, presence of diabetes, preoperative diagnosis, and surgical procedures performed were identified. Using logistic regression analysis, the risk of SSI associated with every one-unit increase in BMI was determined. This study received no funding. All the authors in this study report no conflict of interests relevant to this study.

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RESULTS: Of the 1,406 patients identified, 1,143 met our inclusion criteria. Of those patients, 688 had PCIF for traumatic injuries and 454 for nontraumatic pathologies. The incidence of SSI for all patients, who underwent PCIF was 3.9%. There was no significant difference in the rate of SSI between our trauma group and nontraumatic group. There was a higher rate of infection in patients, who were diabetic and with BMI ≥ 30 kg/m^2. The presence of both diabetes and BMI ≥ 30 kg/m^2 had an added effect on the risk of developing SSI in all patients, who underwent PCIF. Additionally, logistic regression analysis showed that there was a positive difference measure between BMI and SSI. Our results demonstrate that for one-unit increase in BMI, the odds of having a SSI is 1.048 (95% CI: 1.007–1.092, p=.023).

CONCLUSIONS: Our study demonstrates that our rate of SSI after PCIF is within the range of what is cited in the literature. Interestingly, we did not see a statistically significant difference in the rate of infection between our trauma and nontrauma group. Overall, diabetes and elevated BMI are associated with increased risk of SSI in all patients, who underwent PCIF with even a higher risk in patient, who are both diabetic and obese. Obese patients should be counseled on elevated SSI risk after PCIF, and those with diabetes should be medically optimized before and after surgery when possible to minimize SSI.

Keywords: Body mass index; Cervical spine surgery; Cervical fusion; Posterior cervical; Surgical site infection; Trauma.

Introduction

Surgical site infection (SSI) following spine surgery is associated with increased morbidity, reoperation rates, hospital readmission, and increased cost. SSIs are common complications. Among patients, who are readmitted 30 days after all spine surgeries, 48% are for SSI [1]. Additionally, the management of SSI increases the health-care cost by twofold to fourfold [2,3]. Kuhns et al. reported a difference in cost of $12,616 between patients with and without SSI after posterior cervical fusion [4].

There are numerous studies that have sought to identify risks factors for SSI following all spine surgeries in order to develop preventive measures to decrease SSI [5–10]. Commonly cited risk factors include diabetes, obesity, tobacco use, chronic steroid use, long operative time, high blood loss, and Medicaid patients [5–12]. Due to a high prevalence rate of obesity in the United States, its role as a risk factor for spinal SSI has been examined by several studies and systematic reviews [5–8]. Obese patients frequently present with comorbidities such as diabetes, other metabolic diseases, and immune dysfunctions making them susceptible to infections [13,14]. Body mass index (BMI) is a measure of weight-for-height and there are two common BMI classifications [15,16]. In this paper, we will follow the classification used by the World Health Organization: underweight (BMI < 18.5 kg/m^2), normal (18.5 < BMI < 25.0 kg/m^2), overweight (25.0 < BMI < 30 kg/m^2), and obese (BMI ≥ 30 kg/m^2) [15].

Although, BMI is not the most accurate indicator of body adiposity, studies have shown that BMI is moderately associated with other more direct tools for measuring body fat, such as measuring skinfold thickness, bioelectrical impedance absorptiometry, and dual energy X-ray absorptiometry [17–19]. BMI has also been shown to have a strong association with various metabolic diseases similar to other more direct measurements of body fat [20,21]. BMI remains the most inexpensive and easy-to-perform method of screening for weight category. Prior studies have established BMI defined obesity as a statistically significant factor for SSI [5–7,22].

With increasing BMI, there is also an increase thickness in subcutaneous tissue. Increase thickness of the subcutaneous tissue at the surgical site has been shown to increase surgical exposure, retraction time, and the risk of tissue necrosis [23]. Thicker subcutaneous tissue also leads to larger dead space after closure, which has been shown to increase the risk of SSI [24]. Mehta et al. demonstrated that the thickness of subcutaneous fat at the surgical site is a factor in the development of SSI after posterior cervical spine fusion [25]. This finding contributes to a higher incidence of SSI after posterior cervical spine surgery compared with anterior cervical spine surgery, with SSI occurring at 4.5% to 18% compared with 0% to 1%, respectively [4,26–30].

Establishing the strength of the association between BMI and the risk of SSI after posterior cervical instrumented fusion (PCIF) remains relevant for clinical practice. The purpose of this study is to review and quantify the association between BMI and risk of SSI following posterior cervical instrument fusion in both traumatic and nontraumatic adult population. We performed a retrospective cohort study to calculate the risk of SSI in adults associated with every one-unit increase in BMI.

Methods

Patient population

A retrospective review of all 1,406 consecutive patients, who had undergone PCIF at Harborview Medical Center from April 2011 to October 2017, was performed. Patients were identified using International Classification of Disease 9th and 10th procedural codes (Appendix A). This study

was performed at a single and only Level I trauma center in the state of Washington that also serves as the regional trauma center for Alaska, Montana and Idaho with about 65,000 emergency room visits a year. Patient demographics, medical history, diagnosis, and procedures were retrieved from the electronic medical record using the Microsoft Amalga Unified Intelligence System software (Microsoft, Redmond, WA, USA)

The definition for SSI developed by the Centers for Disease Control and Prevention were used to make this diagnosis [31]. The Centers for Disease Control and Prevention defined SSI as infection occurring within 30 days after index surgery with purulent drainage, isolation of organisms, signs or symptoms of infection (such as pain, swelling and/or erythema), positive cultures, and/or diagnosis by a surgeon or attending physician.

Patients who had surgery for tumors (n=38) and osteomyelitis, discitis, or epidural abscess (n=83) were excluded. Patients who were less than 18 years of age (n=34), SSI greater than 30 days out from index surgery (n=19), superficial infection involving only the skin and subcutaneous tissue (n=16), and cervicothoracic fusion with the fixation starting at C6 or C7 and extending down to the thoracic spine (n=73) were excluded. Any fusion construct from occiput to C7 and any cervicothoracic fusion that included C5 were included in the study. After eliminating patients who met our exclusion criteria, we had 1,143 patients (Fig. 1).

Data retrieved from the electronic medical records included age, gender, past medical history of diabetes, reason for surgery, and number of days from index surgery to the patient were taken to surgery for irrigation and debridement. Patient's height and weight at time of index surgery was recorded and was used to calculate BMI. Based on the diagnosis, patients were divided into trauma patients and nontrauma patients. Those who had surgery for fractures, subluxation or dislocations, spinal cord injury, or central cord syndrome were defined as trauma. Those who had surgery for myelopathy, stenosis, radiculopathy, or degenerative disease were defined as nontrauma. Our trauma groups include both poly-trauma patients and isolated spine trauma patients. This study was approved by the institutional review board at University of Washington.

Statistical analysis

Bivariate analysis was performed to identify the association between age, gender, diabetes status, and BMI to the development of SSI. Student *t* test was used to analyze differences in normally distributed continuous variables (age and BMI) and the chi-square test was used for categorical variables (gender, diabetes status, and levels fused) between infected and noninfected group. Findings were considered statistically significant when $p < .05$. Logistic regression analysis was performed to determine the odds of SSI with increase in BMI. Statistical analysis was conducted using IBM SPSS Statistics Version 24.0 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, USA)

Results

Among the 1,143 patients who met our inclusion criteria, 45 (3.9%) developed SSI from April 2011 to October 2017. Out of the 1,143 patients, 688 (60.2%) were trauma patients and 454 (39.7%) were nontrauma patients. Twenty two (3.2%) out of the 688 trauma patients developed infections and 23 (5.1%) out of the 454 nontrauma patients developed infections (Fig. 1). The overall rate of infection was not significantly different between trauma and nontrauma patients (Table 3). The mean age of the cohort was 60.4±17.2 years with 37.8% of patients being female. The percentage of patients with diabetes was 9.3%. Mean BMI was 28.0±6.2 kg/m^2 (Table 1). Three hundred and three patients (26.5%) had a BMI between 30 and 39 kg/m^2 and 52 patients (4.5%) had a BMI ≥ 40 kg/m^2.

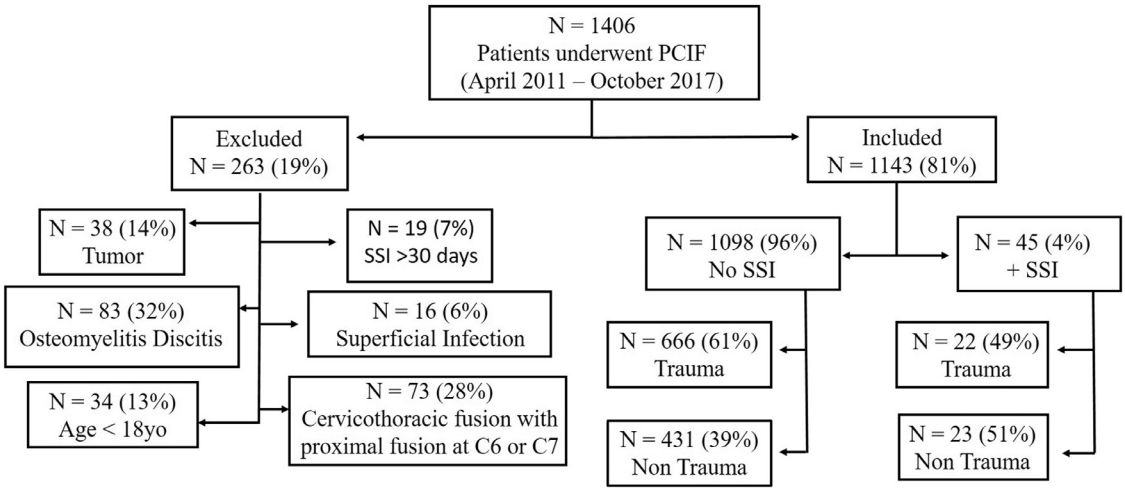

Fig. 1. Patient flow diagram illustrating the inclusion and exclusion criteria. Trauma included cervical fractures, dislocations, and central cord syndrome. Nontrauma included myelopathy, stenosis, radiculopathy, or degenerative disease. PCIF, posterior cervical instrumented fusion; SSI, surgical site infection.

Table 1
Patient demographics (N=1,143)

Age (mean±SD)	60.4±17.2 y
Female (%)	433 (37.8%)
Diabetes (%)	106 (9.3%)
BMI (mean±SD)	28.0±6.2 kg/m^2
BMI < 18.5 (%)	18 (1.6%)
BMI 18.5–24.9 (%)	372 (32.5%)
BMI 25–29.9 (%)	392 (34.3%)
BMI 30–50 (%)	361 (31.6%)

BMI, body mass index; SD, standard deviation.

In all patients who underwent PCIF, there were no significant differences in mean age and gender in patients, who developed SSI compared with those who did not. The mean time to infection was 19±8 days (Table 2). Significant differences were seen in the number of patients with diabetes and mean BMI, with a greater number of patients with diabetes in the infection group (20.0% vs 8.8%; p=.03). Additionally, the mean BMI in the SSI group (30.1±6.7 kg/m^2) was significantly greater than the mean BMI in the group without SSI (27.9±6.2 kg/m^2; p=.02). Logistic regression analysis was performed on all patients that underwent PCIF, it was determined that for one-unit increase in BMI the odds of having a SSI is 1.048 (95% CI 1.007–1.092, p=.02). The rate of infection in patients with diabetes was greater than those without diabetes (8.5% vs 3.5%; p=.01). The rate of infection in obese patients (BMI ≥ 30 kg/m^2) was also greater than those who are not obese (BMI < 30 kg/m^2) (6.2% vs 2.9%; p=.01). In patients who are obese (BMI ≥ 30 kg/m^2) and with diabetes, the rate of infection was significantly greater than those who are not obese (BMI < 30 kg/m^2) and without diabetes (11.3 % and 4.6%, respectively; p=.03).

In trauma patients there were no significant differences in mean age, gender, number of patients with diabetes, and mean BMI between patients with and without infection (Table 3). The number of days till infection in the trauma group was 19±8 days (Table 3). In the nontrauma group there were no significant differences in gender and mean BMI between the SSI group and the group without SSI (Table 3). However, there were significant differences in age and number of patients with diabetes in nontraumatic patients with SSI and without SSI (Table 3). Patients in the nontrauma group without SSI were older (62±12 years) than patients in the SSI group (57±9 years; p=.02). The percentage of diabetic patients in the SSI group (34.5%) was significantly greater than the group without SSI (15.8%; p=.04) (Table 2). The most common organism involved in both trauma and nontrauma patients were coagulase negative staphylococcus follow by *Staphylococcus aureus* (Table 4).

In comparing trauma and nontrauma patients who developed SSI, there was no difference in the number of cervical spine levels fused. There was an average of 5.9±3.7 levels fused in infected trauma group and an average of 6.1±1.9 levels fused in the infected nontrauma group. Ten out of the 23 (43.5%) infected nontrauma patients compared with 1 out of 22 (4.6%) infected trauma patient had single staged anterior-posterior cervical fusion (Table 3). Of those who developed SSI, 5 out of the 23 (21.7%) infected nontrauma patients had revision posterior cervical fusion surgery compare to none of the infected trauma patients had revision surgery. Out of the five patients who had revision surgery, two patients developed nonunion whereas, three patients had hardware loosening (Table 4).

Discussion

Obesity is a growing public health problem with an increasing shift in our patient population toward higher BMI, resulting in a rise in the number of obese patients undergoing spine surgery [23]. Therefore, we are interested in understanding if there is an association between BMI and the risk of SSI after PCIF. Additionally, we reviewed

Table 2
Univariate analysis of risk factors for posterior cervical SSI in all patients who underwent posterior cervical instrumented fusion

Variable (N=1,143)	SSI (N=45)	No SSI (N=1098)	p value
Mean age (y)±SD	59±16	60±17	.588
18–39 (%)	5 (11.1%)	147 (13.4%)	
40–64 (%)	25 (55.6%)	456 (41.5%)	
> 65 (%)	15 (33.3%)	495 (45.1%)	
Gender			.521
Male (%)	30 (66.7%)	680 (61.9%)	
Female (%)	15 (33.3%)	418 (38.1%)	
Days to infection	19±8	n/a	n/a
Diabetes			.030
Yes (%)	9 (20.0%)	97 (8.8%)	
No (%)	36 (80.0%)	1001 (91.2%)	
Mean BMI (kg/m^2)±SD	30.1±6.7	27.9±6.2	.022
< 18.5 (%)	1 (2.2%)	17 (1.6%)	
18.5–24.9 (%)	9 (20.0%)	363 (33.1%)	
25–29.9 (%)	15 (33.3%)	377 (34.3%)	
30–50 (%)	20 (44.4%)	341 (31.1%)	

SSI, surgical site infection; BMI, body mass index; SD, standard deviation.

Table 3
Univariate analysis of risk factors trauma and nontrauma patients with and without SSI after posterior cervical instrumented fusion

Variable	Trauma (N=688)			Nontrauma (N=454)		
	SSI (N=22)	No SSI (N=666)	p value	SSI (N=23)	No SSI (N=431)	p value
Mean Age (y)±SD	61±20	60±20	.708	57±9	62±12	.016
18–39 (%)	4 (18.2%)	136 (20.4%)		1 (4.3%)	10 (2.3%)	
40–64 (%)	7 (31.8%)	214 (32.1%)		18 (78.3%)	242 (56.2%)	
>65 (%)	11 (50.0%)	316 (47.5%)		4 (17.4%)	179 (41.5%)	
Gender			.965			.200
Male (%)	15 (68.2%)	457 (68.6%)		15 (65.2%)	222 (51.5%)	
Female (%)	7 (31.8%)	209 (31.4%)		8 (34.8%)	209 (48.5%)	
Days to infection	19±8	n/a	n/a	18±8	n/a	n/a
Diabetes			.966			.038
Yes (%)	1 (4.6%)	29 (4.4%)		8 (34.8%)	68 (15.8%)	
No (%)	21 (95.4%)	637 (95.6%)		15 (65.2%)	363 (84.2%)	
Mean BMI (kg/m^2)±SD	28.8±5.4	27.5±5.7	.268	31.4±7.7	28.7±7	.069
<18.5 (%)	1 (4.6%)	12 (1.8%)		0 (0.0%)	5 (1.2%)	
18.5–24.9 (%)	3 (13.6%)	226 (33.9%)		6 (26.1%)	140 (32.5%)	
25–29.9 (%)	11 (50.0%)	249 (37.4%)		4 (17.4)	130 (30.2%)	
30–50 (%)	7 (31.8%)	179 (26.9%)		13 (56.5%)	156 (36.2%)	
Number of levels fused						.084
1–2 (%)	5 (22.7%)			1 (4.3%)		
3–4 (%)	2 (9.1%)			5 (21.7%)		
5–6 (%)	4 (18.2%)			1 (4.3%)		
≥7 (%)	11 (50.0%)			16 (69.6%)		
Single stage anterior/posterior (%)	1 (4.6%)			10 (43.5%)		.020

SSI, surgical site infection; BMI, body mass index; SD, standard deviation.

the incidence of SSI for traumatic and nontraumatic adult patients undergoing PCIF.

In this study, we specifically looked at patients with deep or organ space infections extending down to instrumentation and bony structures. Unlike superficial infections, deep SSI routinely requires surgical debridement and treatment with intravenous antibiotics, which increases length of hospital stay and cost. Patients who had surgery for osteomyelitis, discitis, epidural abscess, primary, or metastatic tumors were excluded due to their inherent risk of SSI [32,33].

In our cohort, the time to diagnosis of deep SSI was on average a little greater than two weeks after index surgery. This time frame is usually before our first postoperative follow-up at three weeks. This is consistent with previous studies showing that presentation of SSI after both cervical and lumbar spine surgery occurs between one to four weeks postoperatively [8,34,35]. With regard to SSI following PCIF, our overall infection rate was 3.9% over a six-year period, which is relatively consistent with previously reported rates after PCIF. Sebastian et al. reviewed 5,441 patients who underwent posterior cervical surgery, of those who underwent instrumented fusion, they reported an infection rate of 3.7% over a seven-year period [8]. Gruskay et al. reviewed 2,544 cervical fusions and found an infection rate of 6.0% for patient, who underwent PCIF over a four-year period [36]. Whereas, a retrospective study by Xu et al. reported an infection rate of 10.9% after PCIF over a four-year period [37].

In comparing trauma and nontrauma patients, the incidence of infection from April 2011 to October 2017 were 3.2% and 5.1%, respectively. Although the incidence of infection was greater in the nontrauma group, the difference was not significant because we did not have enough power to detect a 1.9% difference in SSI between trauma and nontrauma patients. Our results differ compared with those previously reported, because trauma patients who undergo cervical or lumbar spinal surgery have been reported to have higher risk of infection compare to those undergoing elective surgery due to localized tissue hypoxia secondary to soft tissue injury [38–40]. Additionally, SSI can occur from seeding from nosocomial infections such as urinary and upper respiratory tract infections which are twice as common in trauma patients [41]. Lee et al. found that trauma patients who underwent cervical or lumbar surgery had higher odds of SSI compare to patients who had elective spine surgery [9]. Blam et al. reported a 9.4% rate of SSI in patients with acute spinal injury compare to 3.7% rate of SSI in patient who had elective spinal surgery, however, these results included a combination of cervical, thoracic and the lumbar spine surgeries [38]. The higher incidence of infection in nontrauma PCIF compare to trauma PCIF was likely due to a greater number of patients with diabetes (34.8% vs 4.6%) and a higher mean BMI (31.4±7.7 vs 28.8±5.4). We found that the presence of diabetes and BMI alone increases your risk of SSI and when combine can have an additive affect.

With further review of trauma and nontrauma patients with SSI, we did not see a significant difference in the number of cervical spine levels fused in those who developed SSI. Fifty percent of trauma and 69.6% of nontrauma

Table 4
Revision surgery after SSI and micro-organisms cultured from surgical site in both trauma and nontrauma patients

	Trauma SSI (N=22)	Nontrauma SSI (N=23)	p value
Need for revision surgery (%)	0 (0.0%)	5 (21.7%)	.02
Hardware Failure (%)		3 (60.0%)	
Pseudoarthrosis (%)		2 (40.0%)	
Micro-organisms			
CoNS (%)	8 (36.4%)	8 (34.8%)	
S. aureus (%)	6 (27.3%)	6 (26.1%)	
Serratia (%)	0 (0.0%)	1 (4.3%)	
Pseudomonas (%)	0 (0.0%)	1 (4.3%)	
Prosteus mirabilis (%)	1 (4.6%)	0 (0.0%)	
Propionibacterium (%)	3 (13.6%)	4 (17.4%)	
Klebsiella (%)	1 (4.6%)	0 (0.0%)	
E. coli (%)	0 (0.0%)	1 (4.3%)	
Enterobacter (%)	3 (13.6%)	0 (0.0%)	
Corynebacterium (%)	0 (0.0%)	2 (8.7%)	

SSI, surgical site infection; CoNS, coagulase negative staphylococcus; *S. aureus, Staphylococcus aureus*; E. coli, *Escherichia coli*.

patients who developed SSI had seven or more levels fused. Unfortunately, we do not have all the data to determine the association between the number of levels fused and the rate of infection. Previous studies in cervical and lumbar surgery have reported increased risk of SSI when seven or more vertebral levels are fused [42–44]. Additionally, we found a greater number of patients in the nontrauma group that underwent single staged anterior-posterior cervical fusion (Table 3), which may contribute to the higher rate of infection due to longer operative time. Zhou et al. reported increased blood loss, operative time, and infection rate with single-staged combined anterior and posterior cervical fusion compared with posterior alone for cervical myelopathy [45]. On the other hand, our trauma patients are usually not as medically stable and optimized as our nontrauma patients and would normally undergo a single approach fixation if possible, resulting in shorter operative time and lower risk of infection. Unfortunately, we did not have the operative time for all the patients to determine the effect of operative time on SSI.

Previous studies have demonstrated higher rates of SSI in patients with higher BMI following spine surgery [8,29,46–48]. In our study, we found that mean BMI was significantly higher in our SSI group compare to our no SSI group in all patients who underwent PCIF (Table 2). Meng et al. and Piper et al. both reported increased risk of SSI after cervical and lumbar spine surgery in patients with BMI > 30 kg/m^2 [49,50]. When looking specifically at posterior cervical infection, Sebastian et al. reported that BMI > 35 kg/m^2 was an independent predictor of SSI with odd ratio of 1.60, which they attribute to difficult surgical exposure due to thicker subcutaneous tissue [8]. Mehta et al found that the thickness of the subcutaneous fat at the level of C5 vertebra and the ratio of the fat thickness to lamina-to-skin distance were significant risk factors for SSI after posterior cervical surgery [25]. Increase in thickness at the surgical site increases surgical time, requires larger incisions and soft tissue dissection, which may cause formations of large seroma and prolonged wound drainage [51–53]. Additionally, obese patients have poorly vascularized subcutaneous fat and have decrease oxygen tension compare to nonobese patients, which can increase risk of fat necrosis and wound complications post operatively [54].

Diabetes has previously been shown to be a strong independent risk factor for SSI [6,42,55]. Meng et al. reported an odds ratio of 2.04 with a 95% confidence interval of 1.69 to 2.46 of increased infection rates among patients with diabetes [49]. In our study, 20.0% of all patients who underwent PCIF who developed SSI were diabetic compared with 8.8% in our group without infection (Table 2). We saw a similar trend in our nontrauma group with 34.8% of patients with diabetes in the SSI group compare to 15.8%. However, in our trauma group, there were a similar number of patients with diabetes in the SSI and no SSI group. Interestingly, five out of the eight patients with diabetes who developed SSI in the nontrauma group and the one trauma patient with diabetes and SSI, all underwent single stage anterior posterior cervical fusion. Satake et al. looked at predisposing factors for SSI after spinal surgery in patients with diabetes and reported that long operative time and high estimated blood loss were significantly higher in their SSI group compare to their non-SSI group [56]. Although, we do not have the recorded operative time, 63% of the nontrauma patients who developed SSI and were diabetic underwent single stage combine anterior-posterior cervical fusion which theoretically would have a longer operative time than posterior cervical fusion alone. This could account for a higher infection rate in our nontrauma group compare to our trauma group.

The most common organism cultured from the infected wounds was coagulase negative staphylococcus follow by *Staphylococcus aureus* in both our trauma and nontrauma group (Table 4). Previous studies have shown *Staphylococcus aureus* to be more common in SSI [39,43]. Infected

patients were treated with surgical debridement and intravenous antibiotics. We did not see any patients with reinfection after treatment. Five out of the 23 patients with SSI in the nontrauma group underwent revision surgery. Three out of the five underwent revision surgery for hardware loosening and two for pseudoarthrosis (Table 4). Interestingly, none of the patients with SSI in the trauma group underwent revision surgery after their infections were treated.

The present study has several limitations. Our cohort consists of patients who were treated by different surgeons, and therefore we cannot account for the variations in each surgeon's practices in terms of perioperative and postoperative care and how these factors may impact outcomes. For instance, although all our patients received perioperative antibiotics, we are unable to determine if intrawound vancomycin powder was used during closure, which has been found to decrease risk of SSI [57–59]. The use of a cervical collar post operatively was not consistently recorded, which have been shown to increase risk of SSI [39]. In addition, our data are limited to less than one-year follow-up due to poor patient compliance as well as geographic restraints, because some of our patients are from Alaska, Montana and Idaho, making it difficult for more frequent or longer follow ups. The geographic restraints also make it difficult to capture patients who may have presented to other institutions for SSI or revision surgeries. Another limitation is that our database lacks specific variables such as operative time, intraoperative blood loss, tobacco use, nutritional status, and additional confounding comorbidities as well as laboratory values such as hemoglobin A1c or blood glucose levels.

In this review of 1,143 patients who underwent PCIF we had a 3.9% incidence of 30-day SSI over a six-year period at a single institution. Patients with diabetes and who are obese were at higher risk of developing SSI. Additionally, we also saw a higher rate of SSI in our nontrauma PCIF compare to our trauma PCIF, however this difference was not significant. We attribute this difference to the nontrauma group having a greater number of patients with diabetes and higher mean BMI which together have an additive effect on the rate of SSI. We also determined that with increased BMI there is an increased risk of spinal SSI after PCIF. With one-unit increase in BMI, the odds of developing a SSI is 1.048. These findings underscore the importance of appropriate counseling of patients with elevated BMI and their risk of infection in addition to the importance of optimizing medical comorbidities, such as diabetes, before and after surgery when possible. However, it is understandable that during situations where there is a surgical emergency, BMI and diabetes cannot be optimized.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.spinee.2018.09.014.

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