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Clinical Study

Risk factors for surgical site infection after posterior cervical spine surgery: an analysis of 5,441 patients from the ACS NSQIP 2005–2012

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Abstract

BACKGROUND CONTEXT: The incidence of surgical site infection (SSI) following posterior cervical surgery has been reported as high as 18% in the literature. Few large studies have specifically examined posterior cervical procedures.

PURPOSE: The study aims to examine the incidence, timing, and risk factors for SSI following posterior cervical surgery.

DESIGN: This is a retrospective cohort study of prospectively collected data in a national surgical outcomes database.

PATIENT SAMPLE: The sample includes patients who underwent posterior cervical spine surgery between 2005 and 2012 identified in the American College of Surgeons National Surgical Quality Improvement Project (ACS NSQIP) Participant Use Data File.

OUTCOME MEASURES: The 30-day rate of postoperative SSI, timing of diagnosis, and associated risk factors were determined.

METHODS: The ACS NSQIP was used to identify 5,441 patients who underwent posterior cervical spine surgery by Current Procedural Terminology codes from 2005 to 2012. Thirty-day readmission data were obtained for 2011–2012. The incidence and timing of SSI were determined. Multivariable logistic regression analysis was then performed to identify significant risk factors.

RESULTS: Of the 5,441 patients identified as having undergone posterior cervical surgery, 3,724 had a posterior cervical decompression, 1,310 had a posterior cervical fusion, and 407 underwent cervical laminoplasty. Surgical site infection within 30 days was identified in 160 patients (2.94%), with 80 of those cases being superficial SSI. There was no significant difference in SSI rate among the three procedure groups. The average time for diagnosis of SSI was over 2 weeks. In 2011–2012, 36.9% of patients with SSI were readmitted within 30 days. Several significant predictors of SSI were identified in univariate analysis, including body mass index (BMI) >35, chronic steroid use, albumin <3, hematocrit <33, platelets <100, higher American Society of Anesthesiologists class, longer operative time, and longer hospital admission. Independent risk factors, including BMI >35 (odds ratio [OR]=1.78, p=.003), chronic steroid use (OR=1.73, p=.049), and operative time >197 minutes (OR=2.08, p=.005), were identified in multivariable analysis.

CONCLUSIONS: Optimization of preoperative nutritional status, serum blood cell counts, and operative efficiency may lead to a reduction in SSI rates. Obese patients and patients on chronic steroid therapy should be counseled on elevated SSI risk.

Keywords: ACS-NSQIP; Cervical spine surgery; Obesity; Posterior cervical; Surgical site infection

FDA device/drug status: Not applicable.

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Introduction

Surgical site infection (SSI) following spine surgery is a major complication resulting in patient morbidity and mortality [1]. In addition, SSI often leads to prolonged hospital length of stay, readmission, or reoperation, significantly increasing cost of care as much as fourfold [1–5]. The SSI rates following cervical spine surgery have ranged from 1% to 7% in the literature [1,4,6,7]. However, SSI rates following posterior cervical spine surgery in comparison to anterior surgery is reported to be much higher, with rates as high as 18% [8–10]. As more quality metrics and performance measures are being introduced into the US health-care system, it will become imperative to establish differences in SSI rates for anterior and posterior cervical spine surgery in large national databases [3,11,12]. Appropriate risk stratification based on approach-related morbidity and directed prevention measures may possibly avoid lost reimbursement and improve patient outcomes.

The American College of Surgeons National Quality Improvement Project (ACS NSQIP) has been validated as a useful dataset for investigating patient outcomes following multiple orthopedic procedures including spine surgery [11,12]. The NSQIP dataset is collected prospectively using validated and systematically audited methods to ensure data accuracy. Thirty-day postoperative mortality, complications, and unplanned readmissions are collected, as well as patient demographics, comorbidities, and perioperative factors from over 400 participating institutions. Although several studies have examined complications following various spine procedures, no large database study has looked specifically at the incidence of and risk factors for SSI following posterior cervical spine surgery. Given the significantly higher incidence of infection reported in the literature following posterior cervical spine surgery [8,10,13], we hypothesize that there may be several unique risk factors predictive of SSI that have not been well defined. The purpose of the present study is to examine the incidence, timing, and risk factors for 30-day SSI following posterior cervical surgery using ACS NSQIP.

EVIDENCE & METHODS

Context

The authors present results following an analysis of the ACS-NSQIP evaluating risk factors for surgical site infections following posterior cervical spine surgery. The study was conducted using data from 2005–12 and considered more than 5,000 patients.

Contribution

The rate of infection following posterior cervical spine surgery was 2.9% (n = 160). Half of these were superficial infections. Patients with BMI>35, those on chronic steroids and those who had extended operative times were at greatest risk of infection.

Implications

These findings add to the growing body of literature derived from the NSQIP. This particular work extends over a 7–8 year time period. Readers should be aware that the design of the NSQIP is not intended to support research nor is the dataset considered nationally representative. Pooling of superficial and deep infection patients may not be appropriate and given the limited number of individuals with infections, the number of variables included means that the statistical model is overfit. Some statistical findings may not be translatable as a result. Given these limitations, this study presents level IV evidence.

—The Editors

Materials and methods

We identified patients who underwent posterior cervical spine surgery from the 2005–2012 ACS NSQIP Participant Use File using Current Procedural Terminology codes. The surgical procedures were broken down into categories to include posterior cervical decompression without fusion (63001, 63015, 63020, 63040, 63045, 63250, 63265, 63270, 63275, 63280, and 63285), cervical laminoplasty (63050 and 63051), and posterior cervical fusion (22548, 22590, 22595, and 22600). Patients with fusion codes were excluded from the decompression group, which included foraminotomies as well.

Patient demographic information, including age, sex, ethnicity, and medical comorbidities, was obtained in addition to preoperative laboratory values, transfusions, operative characteristics, and data on length of stay. The incidence and timing of 30-day postoperative SSI, both deep and superficial, were determined using established criteria from the ACS NSQIP database for each of the procedural categories. Superficial SSI is defined in ACS NSQIP as an infection involving only the skin or subcutaneous tissue of the incision. This includes diagnoses made by the surgeon or attending physician and must have some signs or symptoms of infection present, such as pain, induration, erythema, or drainage. Stitch abscesses and burn wounds are excluded from the diagnosis as were infections meeting the criteria for deep SSI. Deep SSI describes an infection involving the deep soft tissues extended to the fascia and muscle layers. Infections that involve both the deep and superficial spaces are considered deep SSI. Detailed data on 30-day unplanned readmissions for the cohort were available from 2011 to 2012.

The ACS NSQIP database is subject to rigorous oversight, and unlike administrative databases the data are collected by trained abstracters based on review of clinical documentation. Although the potential for erroneous entry cannot be perfectly quantified, ACS NSQIP undergoes rigorous oversight and auditing to ensure reliability of results. An article by Shiloach et al. in *JACS* 2010 looked at the interrater

reliability for overall and individual variables using the percentages of agreement between data collectors and auditors between 2005 through 2008 calendar years. They found that overall disagreement fell from 3.15% in 2005 to 1.56% in 2008. For superficial SSI, this went from 4.76% to 2.04%. For deep SSI, this went from 2.65% to 1.29%. Overall, this demonstrated high levels of interrater reliability.

Statistical analysis

Following descriptive analysis on the overall cohort, patient characteristics were compared using Student *t* tests for continuous variables, and chi-square or Fisher exact tests for categorical variables, to determine the characteristics of patients who developed SSI within 30 days of surgery. Based on the findings of univariate analysis (any variable with a p-value of <.05), multivariable logistic regression analysis was performed to identify independent risk factors for SSI events. The continuous variables of age and operative duration were categorized into approximate quartiles for multivariable regression analysis. Findings were considered statistically significant when p<.05. Analysis was conducted using Statistical Analysis Software version 9.2 (SAS Institute, Cary, NC, USA). The ACS NSQIP Participant Use File is de-identified and was therefore deemed exempt by our institutional review board [14].

Results

A total of 5,441 patients were identified in ACS NSQIP as having undergone posterior cervical spine surgery between 2005 and 2012. Of the 5,441 patients, 3,724 (68.4%) underwent posterior cervical decompression, 1,310 (24.1%) underwent posterior cervical fusion, and 407 (7.48%) underwent cervical laminoplasty. The average age of the cohort was 59.0±13.6 years, with 41.4% of patients being female. Morbid obesity, defined as a body mass index (BMI) >35, was identified in 844 patients (15.5%). Other comorbidities identified included smoking (25.7%), diabetes mellitus (15.9%), and chronic steroid use (5.2%). Of the patients, 51.7% were American Society of Anesthesiologists (ASA) class 3 or greater. Preoperative anemia (hematocrit <33) was found in 5.9% of patients with transfusions of four units or more occurring in 36 patients (0.7%). Of the patients, 2.5% were identified as paraplegic and 2.1% were quadriplegic. The mean operative time was 155.8±94.1 minutes, with a mean length of stay of 3.8±5.6 days.

Surgical site infection occurred within 30 days in 160 patients (2.94%), of which 80 patients were identified as having a superficial SSI (Fig. 1). No significant difference in SSI rate was found among the decompression, fusion, and laminoplasty groups. However, there was a trend toward a lower SSI rate in the laminoplasty group (1.72%) in comparison to the decompression (3.20%) and fusion (3.74%) groups. The mean time for diagnosis of a deep SSI was 17.0±7.7 days and 15.5±7.1 days for a superficial SSI. From 2011 to 2012, of the 219 patients (4%) who underwent an unplanned readmission within 30 days of surgery, 36.9% had a diagnosis of postoperative SSI (Table 1).

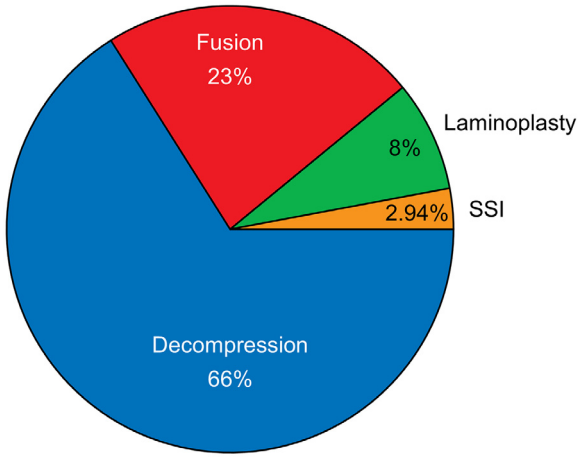

Fig. 1. Surgical site infection (SSI) occurred within 30 days in 160 patients (2.94%), of which 80 patients were identified as having a superficial SSI.

Univariate analysis of patient demographics revealed several significant predictors of SSI, including various medical comorbidities, preoperative laboratory values, and perioperative factors (Table 2). Several medical comorbidities were associated with SSI rates, including BMI >35 (25.0%, p=.002), chronic steroid use (10.0 %, p=.011), and ASA class 3 or greater (62.6%, p=.015). Preoperative laboratory values predictive of SSI included hematocrit <33 (11.3%, p=.009), platelets <100 (2.5%, p=.037), and albumin <3 (6.3%, p=.009) (Fig. 2). Perioperative factors predictive of SSI were longer operative times (186.7±104.2 minutes, p<.001) and longer length of stay (6.4±13.9 days, p<.001). No significant predictors of SSI were identified with respect to gender or race. Notable factors that were not predictive of SSI included diabetes mellitus, smoking, resident involvement, and paralysis. Multivariable logistic regression analysis identified four positive independent predictors of SSI, namely age 50–59 (odds ratio [OR]=1.50, p=.002), BMI >35 (OR=1.60, p=.015), chronic steroid use (OR=1.77, p=.041), and operative time >197 minutes (OR=1.41, p=.012). One predictor was found to be a negative predictor of SSI: age over 70 (OR=0.67, p=.017) (Table 3).

Discussion

Surgical site infection following spinal surgery is a common and serious postoperative complication increasing patient morbidity and mortality [15]. Previous studies have shown that the SSI rate following posterior cervical spine surgery is higher in comparison to anterior approaches, with rates between 6.0% and 18.2% [8,9,16]. However, the SSI rate in our study was relatively low (2.94%) in this large contemporary patient cohort. The patient sample in the present study is significantly greater than previous reports and does not have the potential selection bias limiting studies that examine single

Table 1
Patient demographics, comorbidities, and preoperative laboratory values (N=5,441)

Age (mean)	59.0±13.6 y
Female (%)	2,249 (41.4%)
Race (%)	
Caucasian	4,255 (78.2%)
African American	576 (10.6%)
Other	610 (11.2%)
BMI (mean)	29.1±6.3 kg/m^2
BMI >35 (%)	844 (15.5%)
BMI >40 (%)	304 (5.6%)
Current smoker (%)	1,397 (25.7%)
COPD (%)	296 (5.4%)
CHF (%)	22 (0.4%)
Hypertension (%)	2,771 (50.9%)
Diabetes mellitus (%)	
Non-insulin dependent	565 (10.4%)
Insulin dependent	301 (5.5%)
Chronic steroid use (%)	285 (5.2%)
Bleeding disorders (%)	138 (2.5%)
Transfusion (%)	36 (0.7%)
BUN >40 (%)	78 (1.4%)
Albumin <3 (%)	142 (2.6%)
WBC >12 (%)	344 (6.3%)
Hematocrit <33	323 (5.9%)
Platelets <100	43 (0.8%)
Creatinine >1.5	169 (3.1%)
ASA class	
1/2	2,605 (47.9%)
3	2,521 (46.4%)
4/5	308 (5.7%)
Unplanned readmission 2011–2012 (%)	219 (4.0%)
Operative time (mean)	155.8±94.1 min
Length of stay (mean)	3.8±5.6 d
Quadriplegia (%)	115 (2.1%)

BMI, body mass index; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; BUN, blood urea nitrogen; WBC, white blood cells; ASA, American Society of Anesthesiologists.

Table 2
Univariate analysis of risk factors for posterior cervical SSI

Variable (N=5,441)	No SSI (N=5,281)	SSI (N=160)	p-Value
Age	59.0±13.6	56.9±12.2	.022
Gender (female)	2,180 (41.3%)	69 (43.1%)	.684
Race			.885
African American	559 (10.6%)	17 (10.6%)	
Caucasian	4,128 (78.2%)	127 (79.4%)	
Other	594 (11.2%)	16 (10.0%)	
BMI >35	804 (15.2%)	40 (25.0%)	.002
Alcohol abuse	138 (2.6%)	9 (5.6%)	.068
Weight loss	47 (0.9%)	4 (2.5%)	.062
Current smoker	1,346 (25.5%)	51 (31.9%)	.080
COPD	283 (5.4%)	13 (8.1%)	.153
CHF	21 (0.4%)	1 (0.6%)	.482
Hypertension	2,690 (50.9%)	81 (50.6%)	1.000
Diabetes			.346
Insulin dependent	288 (5.5%)	13 (8.1%)	
Non-insulin	549 (10.4%)	16 (10.0%)	
Chronic steroid use	269 (5.1%)	16 (10.0%)	.011
Albumin <3	132 (2.5%)	10 (6.3%)	.009
WBC >12	330 (6.2%)	14 (8.8%)	.189
Hematocrit <33	305 (5.8%)	18 (11.3%)	.009
Platelets <100	39 (0.7%)	4 (2.5%)	.037
ASA			.015
1/2	2,545 (48.3%)	60 (37.5%)	
3	2,435 (46.2%)	86 (53.8%)	
4	294 (5.6%)	14 (8.8%)	
Resident involvement	1,233 (23.4%)	49 (30.6%)	.087
Operative time	154.8±93.6	186.7±104.2	<.001
Days until discharge	3.7±5.1	6.4±13.9	<.001
Quadriplegia	109 (2.1%)	6 (3.8%)	.344

SSI, surgical site infection; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; WBC, white blood cells; ASA, ASA, American Society of Anesthesiologists.

institution experiences, specific patient subgroups, or specialized surgical techniques. The SSI rate in this posterior cervical cohort is consistent with previous reports using national databases to examine different spine procedures [16]. Although several database studies have examined complications following spinal operations, this is the first study to specifically define the SSI rate for posterior cervical spine surgery and associated risk factors using the ACS NSQIP [12,16,17].

A significant difference in SSI rate among posterior cervical decompression, laminoplasty, and arthrodesis was not observed. However, a trend was identified toward decreased SSI rates in the laminoplasty group. With regard to the timing of diagnosis, both superficial and deep SSI were identified on average greater than 2 weeks postoperatively. This finding is consistent with previous studies showing that presentation of patients with a postoperative SSI often occurs between 1 week and 4 weeks [2,18]. This highlights the importance of careful patient monitoring following discharge as the average length of stay was less than 5 days. In addition, from 2011 to 2012, nearly half of the patients who developed an SSI had an unplanned readmission within 30 days, which is a known quality benchmark with significant cost of care implications [3,19].

Patients with severe obesity (BMI >35) were at significantly increased risk for developing SSI following posterior cervical surgery in the present study. Many recent studies

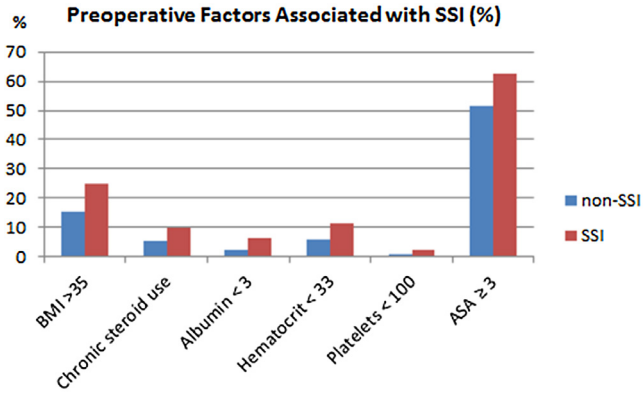

Fig. 2. Preoperative factors predictive of surgical site infection (SSI) included hematocrit <33 (11.3%, p=.004), platelets <100 (2.5%, p=.013), albumin <3 (6.3%, p=.003), American Society of Anesthesiologists (ASA) class 3 or 4 (62.6%, p=.015), chronic steroid use (10.0%, p=.011), and obesity (BMI >35) (25.0%, p=.002).

Table 3
Multivariable analysis—independent predictors for SSI

Risk factor	Odds ratio	95% CI	p-Value
Age 50–59 versus under 50	1.50	1.17–1.93	.002
Age 60–69 versus under 50	0.79	0.59–1.06	.117
Age 70+ versus under 50	0.67	0.48–0.93	.017
BMI >35	1.60	1.10–2.34	.015
Chronic steroid use	1.77	1.02–3.03	.041
Albumin <3	1.41	0.65–3.03	.383
Hematocrit <33	1.62	0.91–2.86	.101
Platelets <100	2.36	0.78–7.13	.129
ASA 3 versus 1–2	1.06	0.82–1.37	.635
ASA 4–5 versus 1–2	1.18	0.76–1.79	.437
Operative time 93–135 versus under 93 min	1.00	0.76–1.34	.981
Operative time 136–196 versus under 93 min	1.01	0.76–1.34	.955
Operative time >197 min	1.41	1.08–1.84	.012
LOS under 3 versus 3–5 d	0.89	0.69–1.14	.347
LOS over 6 versus 3–5 d	1.16	0.88–1.52	.287

SSI, surgical site infection; CI, confidence interval; BMI, body mass index; ASA, American Society of Anesthesiologists; LOS, length of stay.

have demonstrated higher rates of SSI in obese patients following spine surgery [1,12,20–24]. With regard to higher infection rates in obese patients, the reasons are likely multifactorial. Increased BMI makes surgical exposures more difficult, increasing operative times and often necessitating larger incisions and soft tissue dissection. This may cause large seroma formation and prolonged wound drainage [25–27]. Obese patients have been shown to have poorly vascularized subcutaneous fat and have decreased oxygen tension in comparison to non-obese patients [25,28]. Mehta et al. demonstrated posterior cervical subcutaneous fat thickness as an independent risk factor for SSI [10], and it is possible that BMI in our study is a surrogate for thicker subcutaneous fat. Patients with severe obesity often have obesity-related comorbidities, including diabetes and heart disease, which also increase risk of wound healing problems [29,30]. In addition, recent studies have demonstrated that obese patients can still be malnourished, another risk factor for postoperative infection [31]. Redundant soft tissues in the posterior neck of obese patients may create a poor wound healing environment and may make closure of the wound more challenging.

Chronic steroid use, which is defined as regular administration of oral or parenteral steroids for a chronic condition, was also demonstrated as risk factor for SSI. This is consistent with previous reports in the literature. A recent study reviewing over 600,000 cases in ACS NSQIP demonstrated a two- to threefold increase in SSI rate and a fourfold increase in mortality with chronic steroid use [32]. These findings likely relate to the suppressive effect steroids have on the immune system [33,34]. In addition, chronic steroids are used as therapy for a number of conditions, including rheumatoid arthritis, inflammatory bowel disease, chronic obstructive pulmonary disease, and various malignancies, which on their own are known to increase the risk of postoperative infection [35–37]. Last, management of steroid administration perioperatively can be difficult and lead to poor perioperative glycemic control, another well-demonstrated risk factor for postoperative SSI [1,38].

Although obesity and chronic steroid use are potentially modifiable risk factors, these are likely not modifiable in the short term. However, they do significantly increase risk for SSI following posterior cervical surgery. Patients should be counseled accordingly, and quality measures should take this into account. Future work directed at developing risk calculators for postoperative complications may help guide adjustable reimbursement models in an emerging era of bundled payments for care. In contrast, operative time, which was also found to be an independent risk factor, is a potentially modifiable risk factor. Previous studies have demonstrated the importance of operative efficiency with regard to minimizing postoperative complications [21,39,40]. However, these results should be interpreted with caution. Operative time reflects not only surgical efficiency but also case complexity. Future quality measures directed at operative efficiency should account for case complexity, something that cannot be adjusted for in the ACS NSQIP, so as to not create a disincentive for surgeons to take on challenging cases. Interestingly, several notable comorbidities and risk factors, such as diabetes, malnutrition (albumin <3), smoking, and elevated ASA, were not predictive of SSI in our study but have been reported in the literature [11,16,21,25].

The present study has several limitations. The use of national databases such as ACS NSQIP is vulnerable to coding errors, which could lead to both overreporting or underreporting of complications. Although the NSQIP is subject to high standards of oversight, the database cannot account for the variations in individual practices with regard to perioperative care and how those factors may impact outcomes. In addition, the data are limited to 30-day outcomes, which underlies our observed infection rate, lower than that reported currently in the literature, as NSQIP does not include more delayed presentations. Although previous studies would suggest this short-term follow-up should capture most of the postoperative infections, longer follow-up would be preferable. Also, specific variables of interest to spine surgeons, such as the number of levels, intraoperative blood loss, the use of local antibiotic therapy, and indications, are not captured in the ACS NSQIP.

In review of over 5,000 patients who underwent posterior cervical spine surgery, a 2.94% 30-day SSI rate was determined. Severe obesity (BMI >35), chronic steroid use, and prolonged operative times were all identified as independent risk factors for SSI. These findings underscore the importance of appropriate counseling and risk stratification for patients with medical comorbidities as well as surgical efficiency.

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