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Incidence of Surgical Site Infection After Spine Surgery: What Is the Impact of the Definition of Infection?

Sjoerd P. F. T. Nota MD, Yvonne Braun MD,
David Ring MD, PhD, Joseph H. Schwab MD, MS

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Abstract

Background Orthopaedic surgical site infections (SSIs) can delay recovery, add impairments, and decrease quality of life, particularly in patients undergoing spine surgery, in whom SSIs may also be more common. Efforts to prevent and treat SSIs of the spine rely on the identification and registration of these adverse events in large databases. The effective use of these databases to answer clinical questions depends on how the conditions in question, such as infection, are defined in the databases queried, but the degree to which different definitions of infection might cause different risk factors to be identified by those databases has not been evaluated.

Questions/purposes The purpose of this study was to determine whether different definitions of SSI identify different risk factors for SSI. Specifically, we compared the International Classification of Diseases, 9th Revision (ICD-9) coding, Centers for Disease Control and Prevention (CDC) criteria for deep infection, and incision and débridement for infection to determine if each is associated with distinct risk factors for SSI.

Methods In this single-center retrospective study, a sample of 5761 adult patients who had an orthopaedic spine surgery between January 2003 and August 2013 were identified from our institutional database. The mean age of the patients was 56 years (± 16 SD), and slightly more than half were men. We applied three different definitions of infection: ICD-9 code for SSI, the CDC criteria for deep infection, and incision and débridement for infection. Three hundred sixty-one (6%) of the 5761 surgeries received an ICD-9 code for SSI within 90 days of surgery. After review of the medical records of these 361 patients, 216 (4%) met the CDC criteria for deep SSI, and 189 (3%) were taken to the operating room for irrigation and débridement within 180 days of the day of surgery.

Results We found the Charlson Comorbidity Index, the duration of the operation, obesity, and posterior surgical approach were independently associated with a higher risk of infection for each of the three definitions of SSI. The influence of malnutrition, smoking, specific procedures, and specific surgeons varied by definition of infection. These elements accounted for approximately 6% of the variability in the risk of developing an infection.

Conclusions The frequency of SSI after spine surgery varied according to the definition of an infection, but the most important risk factors did not. We conclude that large

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S. P. F. T. Nota, J. H. Schwab
Orthopaedic Spine Service & Orthopaedic Oncology Service, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

S. P. F. T. Nota, Y. Braun, D. Ring (✉)
Orthopaedic Hand and Upper Extremity Service, Massachusetts General Hospital, Harvard Medical School, Yawkey Center, Suite 2100, 55 Fruit Street, Boston, MA 02114, USA
e-mail: dring@mgh.harvard.edu; dring@partners.org

database studies may be better suited for identifying risk factors than for determining absolute numbers of infections.
Level of Evidence Level III, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Patients with orthopaedic surgical site infections (SSIs) have substantially greater physical limitations and a distinct decrease in quality of life [1]. In orthopaedic surgery, spine surgery has a relatively high incidence of SSIs [13]. The risk of SSI after spine surgery increases with the complexity of the patients and the procedure [10, 12]. Prior research has identified several factors associated with an increased risk of SSI after spine surgery: increased age [5], obesity [3, 7], diabetes mellitus [11, 14], smoking [16], malnutrition [8], corticosteroid use [15] and prolonged duration of surgery [10], although these are somewhat inconsistent from study to study.

Efforts to prevent and treat SSIs of the spine rely on the identification and registration of these adverse events in large databases. The use of large databases relies on the methods by which coding data are translated into diagnoses. For instance, an SSI can be defined based on billing codes (International Classification of Diseases, 9th Revision system [ICD-9]), the Centers for Disease Control and Prevention (CDC) criteria for SSI, CDC criteria for deep SSI, and billing codes for irrigation and débridement (I&D) of infection (Current Procedural Terminology). Do these different definitions lead to different numbers of infections? Perhaps even more importantly, does statistical analysis identify different factors associated with different definitions of SSIs after spine surgery?

We therefore sought to determine whether different definitions of SSI would identify different risk factors for SSI. Specifically, we compared the ICD-9 coding, CDC criteria for deep infection, and I&D for infection to see whether each would be associated with different risk factors for SSI.

Material and Methods

Study Design

In this institutional review board-approved retrospective study, a sample of 9155 patients who had orthopaedic spine surgery between January 2003 and August 2013 were identified using Current Procedural Terminology (CPT) procedure codes (Appendix 1 [Supplemental materials are available with the online version of CORR®.]). We excluded 229 procedures with a code for infection or abscess on the day of operation (ie, the indication for surgery was infection). We excluded 453 procedures in patients who were younger than 18 resulting in a provisional cohort of 8473 procedures.

For patients who had more than one spinal procedure, we tracked the first spine operation as the index procedure. This resulted in a final cohort of 5761 spinal procedures in 5761 patients. The mean age of the patients was 56 ± 16 (SD) years (range, 18–97 years and 1811 [31%] of the 5761 patients who were older than 65 years old), and slightly more than half were men (Table 1). The mean followup for the cohort was 3 years (median 2 years), where 87% of the cohort was followed for more than 90 days and 80% of the patients were followed for more than 180 days.

Three hundred sixty-one (6%) of the 5761 surgeries received an ICD-9 code (998.5, 998.51, 998.59, 996.60, 996.66, 996.67) for SSI within 90 days of surgery in our institutional database. After reviewing the medical records of these 361 patients, 216 (3.8%) met the CDC criteria for deep SSI and 189 (3.2%) were taken to the operating room for I&D within 180 days of the day of surgery. The CDC criteria for deep infection are purulent drainage from the deep incision or a deep incision that spontaneously dehisces or is deliberately opened by a surgeon and is either culture-positive or not cultured but the patient has a fever (> 38° C) and/or localized pain or tenderness. One hundred eighty days was chosen for I&D based on our clinical experience of the development of SSIs and these wounds were considered infected if the wound cultures were positive and/or the attending surgeon deemed the wound to be grossly infected on direct inspection during surgery. Depending on the endpoint, respectively, 361 (6%) (Table 1), 216 (4%) (Table 2), and 189 (3%) (Table 3) of the patients developed a SSI after surgery.

Patient-related Factors

In addition to demographics, we accounted for a patient's combined comorbidities (including diabetes mellitus) at the moment of orthopaedic spine surgery by calculating the Charlson Comorbidity Index (CCI) [4] based on our own developed ICD-9 code-driven algorithm. We also studied the effect of corticosteroid use, obesity, malnutrition, and smoking based on ICD-9 codes.

Technical Factors

The type of spine surgery performed was categorized as follows: anterior versus posterior approach; cervical versus

Table 1. Bivariate analyses: ICD-9 code for infection (n = 5761)

Parameter	No (n = 5400 [94%])		Yes (n = 361 [6.3%])		
	Mean (SD)	Range	Mean (SD)	Range	p value
Age (years)	55 (16)	18–97	56 (17)	19–96	0.48
Charlson index	1.7 (2.5)	0–14	2.9 (3.1)	0–15	< 0.001
Duration (hours), n = 5214	3.5 (2.1)	0.22–18	4.3 (2.6)	0.65–15	< 0.001
	Number	Percent	Number	Percent	
Sex					
Male	2844	53	197	55	0.48
Female	2556	47	164	45	
Smoking					
Yes	430	8.0	43	12	0.008
No	4970	92	318	88	
Malnutrition					
Yes	332	6.1	35	10	0.008
No	5068	94	326	90	
Obesity					
Yes	81	1.5	19	5.3	< 0.001
No	5319	99	342	95	
Steroid use					
Yes	19	0.35	4	1.1	0.052
No	5381	100	357	99	
Morselized graft use					
Yes	1809	34	147	41	0.005
No	3591	67	214	59	
Structural graft use					
Yes	836	15	45	12	0.12
No	4564	85	316	88	
Vancomycin prophylaxis					
Yes	81	1.5	3	0.83	0.49
No	5319	99	358	99	
Type of procedure					
Anterior	1348	25	65	18	0.003
Posterior	2004	37	183	51	< 0.001
Cervical	1446	27	85	24	0.18
Thoracic	575	11	68	19	< 0.001
Lumbar	3699	69	234	65	0.15
Sacral	49	0.91	11	3.0	< 0.001
Single level	4437	82	301	83	0.56
Laminectomy/discectomy/partial excision vertebra	4894	91	316	88	0.053
Fusion/arthrodesis	2580	48	190	53	0.074
Osteotomy	124	2.3	19	5.3	< 0.001
Instrumentation	2894	54	209	58	0.11
Trauma	250	4.6	21	5.8	0.30
Oncology	287	5.3	43	12	< 0.001
Oncology—benign	83	1.5	10	2.8	0.072
Other	2487	46	186	52	0.044

ICD-9 = International Classification of Diseases, 9th Revision.

Table 2. Bivariate analyses: CDC criteria for deep infection (n = 5761)

Parameter	No (n = 5545 [96%])		Yes (n = 216 [3.7%])		
	Mean (SD)	Range	Mean (SD)	Range	p value
Age (years)	55 (16)	18–97	57 (17)	20–96	0.10
Charlson index	1.8 (2.5)	0–15	2.9 (3.1)	0–11	< 0.001
Duration (hours), n = 5214	3.5 (2.1)	0.22–18	4.4 (2.7)	0.75–15	< 0.001
	Number	Percent	Number	Percent	
Sex					
Male	2920	53	121	56	0.33
Female	2625	47	95	44	
Smoking					
Yes	443	8.0	30	14	0.002
No	5102	92	186	86	
Malnutrition					
Yes	342	6.2	25	12	0.001
No	5203	94	191	88	
Obesity					
Yes	90	1.6	10	4.6	0.001
No	5455	98	206	95	
Steroid use					
Yes	20	0.36	213	99	0.053
No	5525	100	3	1.4	
Morselized graft use					
Yes	1863	34	93	43	0.004
No	3682	66	123	57	
Structural graft use					
Yes	860	16	21	10	0.020
No	4685	84	195	90	
Vancomycin prophylaxis					
Yes	84	1.5	0	0	0.077
No	5461	98	216	100	
Type of procedure					
Anterior	1380	25	33	15	0.001
Posterior	2070	37	117	54	< 0.001
Cervical	1486	27	45	21	0.052
Thoracic	605	11	38	18	0.002
Lumbar	3786	68	147	68	0.95
Sacral	51	0.92	9	4.2	< 0.001
Single level	4551	82	187	87	0.090
Laminectomy/discectomy/partial excision vertebra	5025	91	185	86	0.015
Fusion/arthrodesis	2656	48	114	53	0.16
Osteotomy	129	2.3	14	6.5	< 0.001
Instrumentation	2977	54	126	58	0.18
Trauma	261	4.7	10	4.6	0.96
Oncology	302	5.4	28	13	< 0.001
Oncology—benign	89	1.6	4	1.9	0.78
Other	2558	46	115	53	0.040

CDC = Centers for Disease Control and Prevention.

Table 3. Bivariate analyses: Irrigation and débridement (n = 5761)

Parameter	No (n = 5572 [97%])		Yes (n = 189 [3.3%])		p value
	Mean (SD)	Range	Mean (SD)	Range	
Age (years)	55 (16)	18–97	57 (17)	20–96	0.12
Charlson index	1.8 (2.5)	0–15	2.9 (3.1)	0–11	< 0.001
Duration (hours), n = 5214	3.5 (2.1)	0.22–18	4.5 (2.7)	0.75–15	< 0.001
	Number	Percent	Number	Percent	
Sex					
Male	2937	53	104	55	0.53
Female	2635	47	85	45	
Smoking					
Yes	447	8.0	26	14	0.005
No	5125	92	163	86	
Malnutrition					
Yes	345	6.2	22	12	0.003
No	5227	94	167	88	
Obesity					
Yes	91	1.6	9	4.8	0.005
No	5481	98	180	95	
Steroid use					
Yes	20	0.36	3	1.6	0.038
No	5552	100	186	98	
Morselized graft use					
Yes	1874	34	82	43	0.005
No	3698	66	107	57	
Structural graft use					
Yes	861	15	20	11	0.067
No	4711	85	169	89	
Vancomycin prophylaxis					
Yes	84	1.5	0	0	0.12
No	5488	98	189	100	
Type of procedure					
Anterior	1385	25	28	15	0.002
Posterior	2082	37	105	56	< 0.001
Cervical	1496	27	35	19	0.011
Thoracic	609	11	34	18	0.002
Lumbar	3800	68	133	70	0.53
Sacral	54	1.0	6	3.2	0.003
Single level	4573	82	165	87	0.064
Laminectomy/discectomy/partial excision vertebra	5050	91	160	85	0.006
Fusion/arthrodesis	2669	48	101	53	0.13
Osteotomy	130	2.3	13	6.9	< 0.001
Instrumentation	2990	54	113	60	0.10
Trauma	262	4.7	9	4.8	0.97
Oncology	308	5.5	22	12	< 0.001
Oncology—benign	90	1.6	3	1.6	0.98
Other	2570	46	103	54	0.023

thoracic versus lumbar versus sacral procedure; instrumentation; single-level procedure, laminectomy/formaminotomy/discectomy/partial excision, fusion/arthrodesis, osteotomy, structural graft used, morcelized graft used, trauma procedure, oncology procedure, oncology–benign procedure, and other procedures. On average multiple procedures codes were given per patient. Bone grafting was monitored using CPT coding. We also studied the use of vancomycin powder in the wound (which initiated in 2012). In addition to these technical factors, we investigated if there were any differences in infection rates among surgeons by the different definition of infection by categorizing all surgeons who performed at least 100 procedures in this 10-year timeframe (ICD-9 coding [Appendix 2; all supplemental materials are available with the online version of CORR®.], CDC criteria for deep infection [Appendix 3], and I&D for infection [Appendix 4]). All surgeons who performed less than 100 surgeries were aggregated to one group.

Statistical Analysis

Normality of our continuous data was tested using the Shapiro-Wilk test. We decided to use nonparametric tests because all continuous data showed a nonparametric distribution. For continuous variables, we used the Mann-Whitney U test in bivariate analysis and for categorical variables a chi square or Fisher's exact test when applicable was used.

Baseline characteristics of study patients were summarized with frequencies and percentages for categorical variables and as mean ± SD for continuous variables.

Duration of surgery was missing for 547 surgeries. We used mean imputation to include this variable in the multivariable analysis model.

In bivariate analysis, factors associated with SSI by all three definitions included: higher CCI, duration of the procedure, smoking, malnutrition, obesity, current and long-term use of corticosteroids (ICD-9 code), morcelized graft use, structural graft use, specific type of procedures, and specific surgeons. Variables with $p < 0.05$ were entered in a backward, stepwise, logistic regression analysis to assess their ability to predict the variation in SSI.

Results

After controlling for likely confounding variables using the multivariable analysis the CCI, the duration of the operation, obesity, and an anterior approach were retained in models based on each of the three definitions of SSI (pseudo R^2, respectively, ICD-9 [Table 4], CDC [Table 5], and I&D [Table 6]; 0.061, 0.063, 0.064; $p < 0.001$). Each of these three models accounted for approximately 6% of the variability of developing an infection. The inclusion of malnutrition, smoking, specific procedures, and specific surgeons in the multivariable models varied by definition of infection.

Table 4. Multivariable analysis for predicting SSI: ICD-9 code for infection (n = 5761)

Parameter	Odds ratio	SE	p value	95% CI		Pseudo R^2
Duration (hours)	1.1	0.028	< 0.001	1.0	1.2	0.061
Charlson index	1.1	0.021	< 0.001	1.1	1.2	
Surgeon 7	0.43	0.17	0.030	0.20	0.92	
Malnutrition	1.7	0.32	0.007	1.1	2.4	
Obesity	3.4	0.93	< 0.001	2.0	5.8	
Surgeon 16	2.2	0.54	0.001	1.4	3.6	
Type of procedure: anterior	0.55	0.082	< 0.001	0.41	0.73	
Type of procedure: other	2.0	0.56	0.010	1.2	3.5	
Others operated 1–100 ×	1.3	0.15	0.026	1.0	1.6	
Surgeon 2	0.62	0.14	0.034	0.40	1.0	

SSI = surgical site infection; ICD-9 = International Classification of Diseases, 9th Revision; CI = confidence interval.

Table 5. Multivariable analysis for predicting SSI: CDC criteria for deep infection (n = 5761)

Parameter	Odds ratio	SE	p value	95% CI		Pseudo R^2
Duration (hours)	1.1	0.036	< 0.001	1.1	1.2	0.063
Charlson index	1.1	0.027	0.004	1.0	1.1	
Smoking	2.0	0.41	0.001	1.3	3.0	
Type of procedure: other	2.6	0.85	0.003	1.4	4.9	
Obesity	2.9	1.0	0.002	1.5	5.7	
Surgeon 16	2.2	0.67	0.007	1.2	4.0	
Surgeon 4	1.8	0.40	0.004	1.2	2.8	
Type of procedure: anterior	0.42	0.086	< 0.001	0.29	0.63	
Others operated 1–100 ×	1.5	0.22	0.004	1.1	2.0	

SSI = surgical site infection; CDC = Centers for Disease Control and Prevention; CI = confidence interval.

Discussion

SSI delays recovery and can increase impairment after spine surgery [1]. Knowledge of risk factors for infection can inform preventive measures. Large databases have the

Table 6. Multivariable analysis for predicting SSI: irrigation and débridement (n = 5761)

Parameter	Odds ratio	SE	p value	95% CI		Pseudo R^2
Duration (hours)	1.1	0.037	< 0.001	1.1	1.2	0.064
Charlson index	1.1	0.028	0.001	1.0	1.1	
Type of procedure: osteotomy	2.8	0.93	0.002	1.5	5.4	
Malnutrition	2.0	0.49	0.003	1.3	3.3	
Obesity	2.9	1.1	0.004	1.4	5.9	
Others operated 1–100 ×	1.4	0.21	0.033	1.0	1.9	
Surgeon 4	2.4	0.51	< 0.001	1.6	3.6	
Type of procedure: anterior	0.41	0.090	< 0.001	0.27	0.63	

SSI = surgical site infection; CI = confidence interval.

potential to generate more accurate and reliable assessments of risk factors for SSI, but they depend on definitions of infection based on easily searchable codes and other indexed data. We studied three different definitions of SSI based on coding data and the data easily abstracted from the medical record and found different numbers of infections but relatively consistent risk factors for infection.

This study should be interpreted with its limitations in mind. The data registry is representing a single center that might not be representative of the average center. We used ICD-9 and CPT codes to identify the initial diagnoses and procedures rather than review of the medical records. We imputed the mean for a considerable amount of data concerning the duration of surgery resulting from missing operation reports in our database. Furthermore, we only reviewed the medical records of patients who received the ICD-9 infection code (within 90 days of their initial surgery) and we might have missed infections diagnosed with CDC criteria and I&D cases who did not receive the ICD-9 infection code. There is a possibility that some patients with SSI are treated outside of our system, but this is unlikely given that 87% of the cohort was followed for more than 90 days and 80% of the patients were followed for more than 180 days.

Our observed infection rates are within the range of reported infection rates (< 1%–11%) reported by Schuster et al. in their systematic review [13]. The rate of infection depends on the definition of infection. ICD-9 coding tended to include more infections than the other two criteria, because it included superficial infection and may also have included suspected but unconfirmed infections. The CDC criteria for deep infection and the return to the operating room for I&D can be considered more stringent criteria. There is more subjectivity in the interpretation of skin changes and wound drainage than there is with the discovery of purulent drainage at surgery.

The duration of the operation, malnutrition, obesity, smoking, and the CCI as predictors of SSI were consistent with prior research [6–9, 15], but some were inconsistent in our study depending on the definition of infection used. The difference in risk factors arising from the different definitions of infection emphasizes both the clinical and scientific impact of the selected definition of infection. It is arguable that the same risk factors will surface if the cohort is of considerable size. On the other hand a small number of events (infections in our study) can have a substantial influence when the number of patients is small. The limitations of the selected definition of infection should be taken into account when designing a study and should be recognized when interpreting it.

As shown by Bohl et al. [2], by comparing two large nationwide orthopaedic databases for interdatabase reliability addressing hip fractures, there are large differences in comorbidities and adverse events reported between databases. We found that risk factors differ not only between databases, but also within databases depending on how a diagnosis or outcome is defined.

Observed differences in infection rate for several surgeons in bivariate analysis uncommonly persisted in multivariable analysis that accounted for confounding factors, suggesting that patient complexity is a more important factor in developing infections than individual surgeons. In our opinion, our analysis confirms the ability to identify whether certain surgeons are more or less prone to SSI than others, but we also realize that there may be variations in patient or surgery factors that are important and unaccounted for in our analysis. For instance, the surgeons with higher infection rates in our study were all orthopaedic oncologists. The fact that specific surgeon remained significant in the multivariable model indicates either that factors such as malignancy, chemotherapy, and radiation do not fully capture the risk associated with infection or that these surgeons have an infection risk over and above these other factors.

By comparing different definitions of infection in the same database we show that in reasonably large databases, there is similarity in the investigated risk factors independently of the definition of infection. This is an important finding when interpreting data extracted with a comparable methodology and might imply that ICD-9 codes based on large databases are suitable for investigating specific factors in spine surgery. Also the Centers for Medicare & Medicaid Services uses ICD-9 codes 996.67 (infection resulting from implant) and 998.59 (other postoperative infection) in combination with procedure codes for spinal fusion, arthrodesis of the shoulder/elbow, and repair of the shoulder/elbow in their Never Events program. An improved understanding of the risk factors of spine SSIs can inform preventive strategies and help with counseling of patients. We found that the study of SSI is influenced by the definition of infection, but the major risk factors are not altered as much as the frequency of infection. When studying SSIs, researchers might want to determine infections by different definitions for quality assurance purposes.

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