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Comparative Safety of Simultaneous and Staged Anterior and Posterior Spinal Surgery

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Abstract

Study Design—Analysis of population based national hospital discharge data collected for the Nationwide Inpatient Sample.

Objective—To study perioperative outcomes of circumferential spine surgery performed on either the same or different days of the same hospitalization.

Summary of Background Data—Circumferential spine fusion surgery has been linked to an increased adjusted risk in perioperative morbidity and mortality compared to procedures involving only one site. In order to minimize these risks some surgeons elect to perform the two components of this procedure in separate sessions during the same hospitalization. The value of this approach is uncertain.

Methods—Data collected between 1998 and 2006 for the Nationwide Inpatient Sample were analyzed. Hospitalizations during which a circumferential non-cervical spine fusion was performed were identified. Patients were divided into those who had their anterior and posterior portion performed on the same and those performed on different days of the same hospitalization. The prevalence of patient and health care system related demographics were evaluated. Frequencies of procedure-related complications and mortality were determined. Multivariate regression models were created to identify if timing of procedures was associated with an independent increase in risk for adverse events.

Results—We identified a total of 11,265 entries for circumferential spine fusion. Of those, 71.2% (8022) were operated in one session. Complications were more frequent among staged versus same day surgery patients (28.4% vs. 21.7% $P < 0.0001$). The incidence of venous thrombosis, and ARDS was also increased among staged candidates while the trend toward higher

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IRB: As data used in this study are sufficiently de-identified, the use of this study was exempt from review by the institutional review board.

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mortality (0.5 vs. 0.4%) did not reach significance. In the regression model staged circumferential spine fusions were associated with a 29% increase in the odds morbidity and mortality compared to same day procedures.

Conclusion—Staging circumferential spine surgery procedures during the same hospitalization offers no mortality benefit, and may even expose patients to increased morbidity.

Keywords

Spinal Fusion; Staged; Simultaneous; Lumbar spine; Complications; Mortality; Morbidity

Introduction

Circumferential spine fusion surgery has been linked to an increased adjusted risk in perioperative morbidity and mortality compared to procedures involving only one site.¹ Because of their complexity and potential risk to the patient, these procedures are often performed in a staged manner in an attempt to diffuse the overall perioperative insults.

While previous studies have suggested that the risk of perioperative complications and mortality is increased after a simultaneously performed interventions in other orthopedic surgical settings, such as arthroplasty², it is unclear whether this applies to circumferential spinal procedures. In the absence of a clearly defined time interval between portions of the procedure that will decrease perioperative risk, some surgeons will perform the two components of the surgery on different days of the same hospitalization.³ Presently, the optimal approach for these procedures remains unclear.

A paucity of data exists for comparing the perioperative outcomes of circumferential spine surgery that is performed on either the same or different days of one hospitalization. The question of comparative safety of simultaneous versus staged approaches during the same hospitalization may be even more acute in this population. Patients undergoing spinal surgery will often not have the option of undergoing surgeries during repeated hospital visits as the spine may be considered mechanically unstable after the initial procedure has been performed, requiring that the second procedure be completed before patient mobilization and discharge.⁴

Therefore, the purpose of the present study was to determine the incidence of perioperative complications in a comparative fashion with staged versus simultaneous spinal surgery by using population based national hospital discharge data collected for the Nationwide Inpatient Sample, and to assess if timing of procedures was associated with an independent increase in risk for adverse events.

Materials and Methods

NIS annual data files were commercially obtained from the Hospital Cost and Utilization Project (HCUP). The NIS represents the largest all payer inpatient database in the United States and as part of the Hospital Cost and Utilization Project (HCUP) is sponsored by the Agency for Healthcare Research and Quality (AHRQ). In brief, the NIS contains information on inpatient discharges from approximately 8 million hospital admissions per year. Having grown since its inception in 1988, when it included data from 8 US states, the most recent data files represent a 20% stratified sample of approximately 1000 community hospitals in 38 states. The NIS provides weights that allow for nationally representative estimates. It includes over 100 clinical and non clinical data elements, such as diagnoses, procedures, admission and discharge status, patient demographics (e.g., gender, age, race), payment source, length of stay, and hospital characteristics (e.g., size, location, teaching

status). Detailed information on the NIS design can be found at www.hcup-us.ahrq.gov/nisoverview.jsp.⁵ As data used in this study are sufficiently de-identified, the use of this study was exempt from review by the institutional review board.

Study sample and Statistical methods

Data collected for each year between 1998 and 2006 were analyzed. Discharges with a procedure code (ICD-9-CM) for primary anterior and posterior non-cervical spine fusions (8104–8108) were identified and included in the sample. Identified entries were divided into those who had their anterior and posterior portion performed on the same day and those that were performed on different days of the same hospitalization. The prevalence of procedure sub-types (same vs. different days) and their respective patient demographic patterns (age, gender, race, disposition status, primary source of payment, distribution of procedures by hospital size, teaching status and location, and length of care) were evaluated.

Frequencies of procedure-related complications by procedure sub-types were analyzed by determining cases that listed ICD-9-CM diagnosis codes specifying complications of surgical and medical care (ICD-9-CM 996.X to 999.X) as reported previously.⁶

In addition, we studied the prevalence of any complication and/or death, and selected adverse diagnoses including pulmonary embolism, venous thrombosis, respiratory insufficiency after trauma or surgery/Adult Respiratory Distress Syndrome (ARDS), and acute post-hemorrhagic anemia, using the ICD-9-CM diagnosis code system. The indication for surgery was determined by the presence of ICD-9-CM diagnosis codes specifying degenerative disc disease (721.0-9, 722.0-9), spinal stenosis (724.0-09), scoliosis (737.0-9) acquired spondylolisthesis (738.4), trauma (800.0 – 899.9), and metastasis (198.3, 198.4, 198.5) as previously described.⁷

Comorbidity profiles were analyzed by determining the prevalence of a number of disease states as defined in the Clinical Classification Software and provided in the NIS dataset.⁵ In order to determine overall comorbidity burden, comorbidity indices were calculated as described by Charlson et al.⁸ and adjusted for use with administrative data by Deyo et al.⁹

Approximately 40% of entries in the race category were not available and were imputed as “white”. This step was based on an approach previously described and the fact that facilities with high rates of missing data for race served populations with higher than average white/black patient ratios.¹⁰ Another way of dealing with missing data is to create a separate ‘missing data’ category. Both approaches were utilized for this analysis. Continuous variables are presented as weighted means and weighted standard errors. Categorical variables are computed as weighted frequencies and percentages.

All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC). To facilitate analysis of data collected in a complex survey design (including stratification, clustering, replication, and unequal probabilities of selection) and to obtain consistent estimates of mean and variance parameters taking into account the complex survey data setting, SAS procedures SURVEYMEANS, SURVEYFREQ, and SURVEYLOGISTIC were utilized for descriptive analyses and modeling efforts. Weighted data were used for analysis, because it has been shown that when the sample is selected with unequal selection probabilities that are related to the values of the response variables even after conditioning on all the available design information, ignoring the sample selection scheme in the inference process, can yield misleading results.¹¹

Logistic regression models were fitted to elucidate if procedure sub-type was associated with independently increased odds for the composite outcome measures of mortality/

morbidity while controlling for age, gender, race, admission type, hospital location, hospital size, hospital teaching status, comorbidity index (or each NIS comorbidity), and spine pathology.¹² Results for all variables are shown in Table 3. We also explored interaction effect of age, hospital size, and hospital location with spine pathology. Since the number of parameters increased dramatically in assessing interaction effect, we fitted regression models aided by backward variable selection process and collapsed the age group of 65–75 and > 75 together. The Area Under the Receiver Operating Characteristic (ROC) Curve (AUC) also referred to as the C-statistic (or concordance index), was utilized for assessing the model's discriminatory power. For each individual predictor, odds ratio (OR), 95% CIs and p-value were computed. Due to the very large sample size in this study, we decided not to rely only on a conventional threshold of statistical significance (i.e., $p\text{-value} < 0.05$) to draw conclusions from the study findings. Instead, we reported p-values and use 95% confidence intervals (CI) as a measure of effect size and let the readers evaluate the significance of the findings.

Source of Funding

This study was performed with funds from the Center for Education and Research in Therapeutics (CERTs) (AHRQ RFA-HS-05-14) and Clinical Translational Science Center (CTSC) (NIH UL1-RR024996). No conflicts of interest arise from any part of this study for any of the authors.

Results

We identified a total of 23,247 entries for circumferential spinal fusion in the NIS database between 1998 and 2006. This represents a nationwide estimate of 113,991 procedures performed. Of those, 78,845 (69.2%) underwent both procedures in one session, with the remaining 35,146 (30.8%) performed in a staged fashion during the same hospitalization.

Patient characteristics

The average age was 43.72 (95% CI: 43.48, 43.97) years for admissions undergoing same day and 45.14 (95% CI: 44.74, 45.53) years for those undergoing staged procedures ($P < 0.0001$). Table 1 contains more detailed information on patient and health care system related demographics. Significant differences for several variables were noted between the two groups, with an exception being gender and the teaching status of the institution at which the procedures were performed. Notably, patients with emergent admissions, deformity, and traumatic surgical indications were more prevalent in the staged group. A higher proportion of admissions undergoing surgery on the same day were privately insured as compared to staged surgery recipients. Comparatively, more staged procedures were performed in rural centers. The average comorbidity index among admissions for same day fusions was 0.3 (95% CI: 0.29, 0.31) versus 0.33 (95% CI: 0.32, 0.35) ($P=0.002$).

In-Hospital Outcomes

A higher proportion of same day operation recipients were discharged to their primary residence compared to staged patients (Table 1). Length of hospital stay was significantly longer for staged procedures compared to same day surgeries (6.63 days (95% CI: 6.52, 6.73) vs. 9.88 days (95% CI: 9.63, 10.13) ($P<0.0001$).

Complications categorized as procedure related were more frequent among staged versus same day surgery patients (28.4% vs. 21.8%, $P<0.0001$). Table 2 details the incidence of such complications.

The incidence of venous thrombosis and ARDS was also increased among staged candidates, while the trend toward higher mortality and increased rates of pulmonary embolism did not reach significance (Figure 1). Acute posthemorrhagic anemia was coded at 18.1% after staged procedures versus 13% after same day approaches ($P<0.0001$)).

Risk Factors for Perioperative Morbidity/Mortality after Anterior/Posterior Fusion

Multivariate logistic regression revealed a number of independent risk factors for morbidity/mortality after circumferential spine surgery (Table 3). Staged circumferential spine fusions were associated with a 29% increase in the odds for morbidity/mortality compared to same day procedures when controlling for patient age, hospital location, hospital size, insurance type, comorbidity burden, surgical pathology, and interaction between age groups and spine pathology. The result did not change even when excluding procedures of presumably higher complexity, including those involving the thorax, emergent and urgent procedures, and those indicated for trauma, oncologic diagnoses and scoliosis (OR 1.4; CI: 1.30;1.54) ($P<0.0001$). Patient and hospital related factors that significantly increased the risk for perioperative morbidity and mortality were age over 65 years, procedures performed in rural and large hospitals compared to urban and small institutions. Indications for surgery that were associated with increased odds of experiencing morbidity and mortality were scoliosis and oncologic pathologies. Interaction of spinal pathology with age grouping was significant ($p=0.001$). Oncologic pathology remained significant only for age group of 0–44 years.

In addition, Table 4 shows a number of comorbidities which increased the risk of a fatal outcome after adjusting for demographic variables (not shown). Specifically, pulmonary circulatory disease and coagulopathies were associated with the highest increase in the adjusted risk for perioperative morbidity and mortality.

Discussion

Orthopedic procedures and related treatment choices have recently been identified as a prime target for comparative effectiveness research.¹³ While the focus lies on the evaluation of the success of a number of surgical implants and procedures, the subject of perioperative outcomes and safety of competing clinical decision making processes has received less attention. In this context, orthopedic procedures represent a unique entity in so far as multiple component surgeries can be performed during the same or different surgical sessions, i.e. bilateral total hip and knee arthroplasty as well as combined circumferential spinal procedures. In view of the paucity of data comparing the perioperative outcomes of circumferential spine surgery performed on either the same or different days of the same hospitalization, this study sought to analyze this entity utilizing data from the largest all payer database in the US.

The results of this study revealed that staging circumferential spine surgical procedures during the same hospitalization resulted in an increased overall morbidity without lower mortality rates. Indeed, the odds of either of these events occurring were found to be 29% higher among the staged group when compared to the population undergoing surgery during one session. This relationship was sustained even after controlling for several confounding factors, including patient characteristics, hospital specific demographics, admission type, comorbidity burden and surgical pathology. Patient and hospital related factors that significantly increased the risk for perioperative morbidity and mortality were advanced age and procedures performed in rural and large hospitals, as were deformity and oncologic indications. Pulmonary circulatory disease and coagulopathies were associated with the highest increase in the adjusted risk for perioperative morbidity and mortality with regards to associated medical comorbidities.

Limited data is available comparing the perioperative outcomes of circumferential spine surgery performed on either the same or different days of the same hospitalization. The previously published literature consists mainly of case reports,^{3,14,15} and series limited by small numbers without a control group for comparison.¹⁶ Shufflebarger et al.¹⁷ noted greater correction of deformity in those procedures performed on the same day compared with separate days, which was also subsequently seen in later series.¹⁶ One of the largest series was published by Wright.¹⁸ Among 14 patients, half were treated as simultaneous circumferential reconstructions while the remainders were treated with staged procedures. The findings reported in this series included an 86% complication rate among the staged group compared to no complications seen in the simultaneous group, as well as significantly increased length of stay and total operative duration in the former population. Improved neurological outcomes were also evident in the simultaneous group as was a diminished blood loss (although this did not reach significance). However, the findings of this study may have limited generalizability given the small sample size and single institution design.

This study identified several distinct patient and health care system related demographic patterns between the two groups. Patients with emergent admissions, deformity, and traumatic surgical indications were more prevalent in the staged group. To our knowledge, this finding has not been previously reported in the spine literature and no direct comparison can be made with the total joint arthroplasty data, given the different nature of the surgery and the overwhelming majority of diagnoses falling into the degenerative disease category.² In this context it is likely that emergent and traumatic admissions require treatment for associated injuries that are potentially life-threatening.¹⁹ This may limit the length and extent of surgery patients may tolerate at a single point in time. In addition, deformity cases are among the most complex and lengthy spinal procedures, which may predispose this patient population to a performance in a staged manner.¹⁶ Other differences noted between the two patient populations were that a higher proportion of admissions undergoing same day surgery were privately insured, and more staged procedures were performed in rural centers. Whether or not these differences are related to regional and/or economic disparities is beyond the scope of this study and merits further investigation.

Patient and hospital related factors that significantly increased the risk for perioperative morbidity and mortality were age over 65 years, and procedures performed in rural and large hospitals compared to urban and small institutions. Age greater than 65 years has been previously reported as a risk factor.^{1,20} It is thought that advanced age may be a risk factor for decreased end organ reserve. Interestingly, we noted that larger hospital size was associated with increased complication rates. Although high hospital volume has been associated with better outcomes in the past,¹ the relationship between size and outcomes has not been studied in detail. We speculate that this may be related to the inclusion of higher severity cases among these institutions. However, this conclusion cannot be reached from the available data. The findings among rural hospitals is likely related to a decrease in available resources as noted above, although further investigation is needed to demonstrate this relationship.

Indications for surgery that were associated with increased odds of experiencing morbidity and mortality were scoliosis and oncologic pathologies. This finding appears to be consistent with earlier reports.^{14,16} Increased complication rates have been previously noted in severe scoliosis cases treated with an circumferential approach due to the complexity of the deformity, abnormal anatomy, and potentially diminished physiological reserve in certain patients.¹⁶ With regards to oncologic procedures, it has been theorized that diminished physical reserve, a weakened immune system, and adjuvant therapy contribute to a higher rate of perioperative complications among this group.¹²

Among comorbidities, pulmonary circulatory disease and coagulopathies were associated with the highest increase in the adjusted risk for perioperative morbidity and mortality. This is consistent with recent findings based on NIS data used to compare mortality based on surgical approaches.¹ We hypothesized that patients with pulmonary hypertension and decreased right ventricular reserve may be less likely to deal with the consequences of pulmonary embolization of bone and marrow material during instrumentation, resulting in increases in pulmonary vascular resistance as shown in previous studies.^{21–23} It is intuitive that patients with coagulation abnormalities had increased complication rates. Although speculative, we attribute this to an increased propensity to bleeding complications, which have been associated with higher perioperative morbidity.²³ Interestingly, diminished blood loss has been previously documented in small series of simultaneous vs. staged circumferential spine procedures as well.¹⁷

In the setting of increased national concerns over total health care expenditures, it is noteworthy that several potentially relevant health care related characteristics were found to be favorable in the simultaneous group relative to the staged group. Specifically, a higher proportion of same day operation recipients were discharged to their primary residence compared to staged patients, thus eliminating the need for additional costs related to stay at an extended care facility. This finding has not been reported, to our knowledge, in the previously published smaller series. As would be expected, the total length of hospital stay was significantly longer (approximately 3 days) for staged procedures compared to same day surgeries. This observation is consistent with the previous findings of Shufflebarger et al.¹⁷ and Dick et al.¹⁶ Although a direct cost-comparison analysis was not performed in this study, these findings are noteworthy and may provide basis for future studies. Further, our results should be viewed in the context increased complication rates in the staged group, which can be expected to increase health care expenditures.

There are several inherent limitations to our study. Because only in-patient data are collected for the NIS, complications and events that occurred after discharge are not captured. In addition, detailed clinical information regarding the surgical procedure (i.e. type of anesthesia, estimated blood loss, length of surgery etc.) available in the NIS is limited and controlling for these factors in the analysis may have influenced our results. While it cannot be excluded that data entry may be subject to some form of coding or reporting bias, there is no reason to believe that reporting should differ between groups within the database, thus exposing both groups to the same bias within the same data collection construct. Comparative analysis should therefore be less likely affected by such bias. Further, the performance of simultaneous circumferential surgery may not always be practical depending on the surgical skills and practice design of the treating surgeon, as well as the resources of the institution. Such procedures are physically demanding on the surgical team and require a large block of the surgeon's schedule to be dedicated to the care of a single patient at one time. Several different surgical indications were included in our analysis thus representing a non-homogeneous population with inherent differences. We were careful to control for factors associated with high risk settings such as thoracic procedures, those involving trauma, scoliosis and oncologic indications as well as urgent and emergent surgeries in our initial analysis. In addition, we performed a secondary analysis excluding entries with the aforementioned characteristics without affecting our results and conclusions.

Additionally, the definition of complications utilizing ICD-9-CM diagnosis codes has its limitations and severity and exact details of such complications can often not be discerned. In order to test our hypothesis using a separate definition that focuses on major perioperative complications (cerebrovascular accident, pulmonary failure, cardiorespiratory arrest, pulmonary embolism, cardiac arrhythmias, myocardial infarction, sepsis and pneumonia) we reanalyzed data with this approach.²⁴ We found that staged procedures were again

associated with an increased rate (12.85% vs. 8.36%, $P < 0.0001$) and risk (OR 1.30 (1.17; 1.45) of adverse outcome compared to procedures performed on the same day.

Lastly, it has to be mentioned that no causal relationships can be established with data available in the NIS. In the setting of many crucial clinical variables missing that influence medical care, our results of increased morbidity after staged procedures should not be used as a case against performing complex surgeries in multiple surgical sessions.

Conclusion

According to the data reported in this study staging circumferential spine surgery procedures may expose patients to increased morbidity/mortality. This information is helpful for treating physicians to plan complex spinal reconstructive procedures with patient safety at the forefront, and to guide future research in this area. Answers to this and similar questions are also important, as they aid academic hospitals, where the majority of these procedures are performed, in their role as leaders in practice and policy development.

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Figure 1.

Depicted are the rates of mortality and selected adverse events among patients undergoing anterior and posterior spine fusion procedures on the same or different days of their hospitalization. $P < 0.0001$ between groups for DVT, ARDS. $P = 0.53$ for mortality, $P = 0.07$ for PE.

Table 1

Detailed are demographics of anterior and posterior spine surgery discharges.

Demographics of Anterior and Posterior Spine Surgery Discharges									
Total Knee Arthroplasty Type	Anterior/Post sameday			Anterior/post different day			p-value		
	16028 (78845)			7219 (35146)					
N =unweighted (weighted/percent)	F	WF	%	F	WF	%	<0.0001		
Age groups (years)									
0-44	8022	39599	50.2	3240	15760	44.9			
45-64	6548	32107	40.7	3045	14822	42.2			
65-75	1070	5226	6.6	664	3238	9.2			
>=75	385	1897	2.4	267	1311	3.7			
Gender							0.37		
Male	7416	36474	46.3	3295	16035	45.6			
Female	8611	42366	53.7	3924	19110	54.4			
Race							<0.0001		
White	13720	67731	85.9	6131	29855	84.9			
Black	701	3362	4.3	355	1718	4.9			
Hispanic	1063	5134	6.5	421	2051	5.8			
Other	544	2618	3.3	312	1522	4.3			
Insurance							<0.0001		
Medicare	1994	9760	12.5	1198	5814	16.6			
Medicaid	1206	5972	7.6	492	2410	6.9			
Private/HMO	9293	45853	58.6	4034	19650	56.0			
Other	3416	16691	21.3	1488	7238	20.6			
Discharge Status							<0.0001		
Routine	11633	57306	73.1	4640	22671	64.6			
Short Term Hospital	96	470	0.6	67	330	0.9			
Other Transfers	2125	10458	13.3	1406	6820	19.4			
Home Health Care	1995	9752	12.4	1056	5081	14.5			

Demographics of Anterior and Posterior Spine Surgery Discharges									
Total Knee Arthroplasty Type	Anterior/Post sameday			Anterior/post different day					
N =unweighted (weighted)	16028 (78845)			7219 (35146)					
N (unweighted/weighted/percent)	F	WF	%	F	WF	%	p-value		
Against Medical Advice	≠/ < 10	33	0.0	≠/ < 10	15	0.0			
Died in Hospital	67	334	0.4	34	171	0.5			
Alive, Destination Unknown	≠/ < 10	16	0.0	≠/ < 10	≠/ < 10	0.0			
Hospital Size									
Small	2690	12531	15.9	1226	5859	16.7	0.001		
Medium	3434	16574	21.0	1394	6729	19.1			
Large	9902	49731	63.1	4599	22557	64.2			
Hospital Location									
Rural	202	1019	1.3	197	985	2.8	<0.0001		
Urban	15824	77817	98.7	7022	34161	97.2			
Teaching Status									
Non-teaching	5935	28690	36.4	2721	12931	36.8	0.53		
Teaching	10091	50146	63.6	4498	22214	63.2			
Admission Type									
Emergency	569	2867	4.4	405	2014	7.1	<0.0001		
Urgent	937	4501	7.0	415	1991	7.0			
Elective	11602	57139	88.4	4993	24201	85.6			
Other	22	107	0.2	13	63	0.2			
Spine Diagnosis types									
Degenerative Disc Disease	8128	39820	50.5	3167	15388	43.8	<0001		
Spinal Stenosis	366	1826	2.3	128	623	1.8			
Scoliosis	1784	8886	11.3	1080	5269	15.0			
Spondylolisthesis	544	2678	3.4	202	1004	2.9			
Trauma	381	1901	2.4	293	1447	4.1			
Oncologic	245	1228	1.6	120	596	1.7			

Demographics of Anterior and Posterior Spine Surgery Discharges							
Total Knee Arthroplasty Type	Anterior/Post sameday			Anterior/post different day			
N =unweighted (weighted)	16028 (78845)			7219 (35146)			
N (unweighted/weighted/percent)	F	WF	%	F	WF	%	p-value
Combination of above	3432	16818	21.3	1660	8015	22.8	
Other	1148	5689	7.2	569	2804	8.0	

F=Frequency; WF=Weighted Frequency; %=percentage

Table 2

Shown are procedure related complications among anterior and posterior spine surgery discharges.

Procedure Related Complications Among Anterior and Posterior Spine Surgery Discharges							
N (unweighted/weighted/percent)	Anterior/Post sameday			Anterior/post different day			P-value
	F	WF	%	F	WF	%	
Device Related Complications							
Device Related	901	4426	5.6	494	2422	6.9	0.0002
Organ Specific Complications							
Any Complications	3486	17167	21.8	2044	9972	28.4	<0001
Cardiac	207	1032	1.3	135	670	1.9	0.0006
Respiratory	520	2563	3.3	371	1789	5.1	<0001
CNS	121	591	0.7	56	279	0.8	0.73
Peripheral Vascular	43	216	0.3	29	145	0.4	0.09
Gastrointestinal	831	4087	5.2	459	2243	6.4	0.0003
Genitourinary	180	909	1.2	98	478	1.4	0.19
Other Complications of Procedure							
Shock	24	117	0.1	16	80	0.2	0.18
Hematoma/Seroma	365	1801	2.3	251	1234	3.5	<0001
Puncture Vessel/Nerve	592	2918	3.7	343	1669	4.7	0.0002
Wound Dehiscence	73	360	0.5	52	247	0.7	0.02
Infection	162	804	1.0	116	568	1.6	0.0001
Other	314	1522	1.9	205	989	2.8	<0001
Medical Complication	39	195	0.2	33	165	0.5	0.01

F=Frequency; WF=Weighted Frequency; %=percentage

Table 3

Listed are the results of the multivariate logistic regression analysis for the outcome of morbidity and mortality (results from adjusting Deyo index are omitted). Odds ratios and confidence intervals are displayed.

Multivariate Logistic Regression Analysis-Risk Factors for Morbidity/Mortality*					
Variable Group	Variable	Odds Ratio	Lower 95% CI	Upper 95% CI	P-value
Timing of Surgery (reference: staged)	Same day	1.29	1.19	1.38	<0.0001
	0-44	0.72	0.66	0.78	<0.0001
	65-75	1.35	1.14	1.58	0.0004
Age group (reference: 45-64 years)	>75	1.46	1.17	1.82	0.0008
Gender (reference: female)	Male	1.09	1.02	1.18	0.0122
Race (reference: white)	Black	1.05	0.89	1.23	0.5294
	Hispanic	0.88	0.74	1.05	0.1670
	Other	0.79	0.64	0.97	0.0236
Hospital Location (reference: rural)	Urban	0.53	0.41	0.71	<0.0001
Hospital Size (reference: small)	Medium	1.12	0.99	1.26	0.0654
	Large	1.12	1.02	1.24	0.0186
Hospital Teaching Status (reference: teaching)	Non-Teaching	0.99	0.92	1.07	0.8155
Admission Type (reference: elective)	Emergency	1.14	0.96	1.34	0.1336
	Urgent	1.12	0.98	1.28	0.0916
	Medicaid	0.94	0.78	1.12	0.4775
Insurance Type (reference: Medicare)	Private/HMO	0.80	0.69	0.92	0.0014
	Other	1.12	0.98	1.28	0.0916
Spine pathology (reference: Degenerative Disc Disease)	Spinal Stenosis	1.26	0.99	1.60	0.0568
	Scoliosis	2.14	1.92	2.39	<0.0001
	Spondylolisthesis	0.96	0.78	1.19	0.7290
	Trauma	1.10	0.87	1.4	0.3997
	Oncologic	1.39	1.07	1.81	0.0152
	Combination	1.13	1.03	1.24	0.0112
	Other	2.16	1.90	2.46	<0.0001

* Deyo index was also in the model but results not reported in this table

Table 4

The odds ratios for the outcome of morbidity and mortality associated with a number of comorbidities from multivariate logistic regression are shown (adjusting demographic variables are omitted).

Risk Factors for Perioperative Mortality after Circumferential Spine Fusion-Comorbidities				
Comorbidity	Odds Ratio	Lower – 95%CI	Upper – 95%CI	P-Value
Alcohol Abuse	1.24	0.89	1.72	0.1987
Chronic Lung Disease	1.09	0.98	1.22	0.1052
Congestive Heart Failure	1.60	1.20	2.15	0.0016
Diabetes Mellitus	1.09	0.94	1.25	0.2680
Liver Disease	1.36	0.97	1.92	0.0784
Coagulopathy	2.21	1.78	2.73	<.0001
Neurologic Disorders	1.24	1.03	1.49	0.0218
Obesity	1.25	1.08	1.46	0.0033
Peripheral Vascular Disease	1.23	0.85	1.79	0.8297
Renal Disease	1.05	0.67	1.64	0.6798
Pulmonary Circulatory Disease	2.82	1.90	4.18	<0.0001
Cardiac Valvular Disorders	1.28	1.05	1.57	0.0170
Electrolyte/Fluid Abnormalities	1.98	1.77	2.20	<0.0001

* All variables listed in Table 3 were also adjusted in the model but results not reported in this table