Published in final edited form as:

Spine (Phila Pa 1976). 2014 September 15; 39(20): 1656–1665. doi:10.1097/BRS.0000000000000498.

The Impact of Diabetes Mellitus on Patients Undergoing Degenerative Cervical Spine Surgery

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Abstract

Study Design—Retrospective Administrative Database Analysis

Objective—To determine the impact of glycemic control on perioperative complications and outcomes in patients undergoing degenerative cervical spine surgery.

Summary of Background Data—Diabetes Mellitus (DM) is a highly prevalent systemic disease that has been shown to increase morbidity and mortality after spine surgery. Few studies have demonstrated negative effects on DM patients who undergo cervical spine procedures; however, whether glycemic control influences surgical outcome is still unknown.

Methods—The Nationwide Inpatient Sample was queried from 2002 to 2011. Patients who underwent cervical spine surgery for degenerative conditions were identified using the *ICD-9-CM* codes. Three surgical cohorts were chosen: controlled diabetics, uncontrolled diabetics and patients without diabetes. Patient demographics, surgical procedures, perioperative complications and postoperative outcomes were assessed.

Results—The prevalence of controlled and uncontrolled diabetics undergoing degenerative cervical spine surgery had been increasing significantly from 2002–2011. When compared to patients without diabetes, uncontrolled diabetics had significantly increased odds of respiratory, cardiac and genitourinary complications. Uncontrolled diabetics also had significantly increased risk of pulmonary embolism and postoperative infection. Uncontrolled diabetics had increased risk of inpatient mortality (odds ratio=6.39, 95% confidence interval=4.09–10.00, $p < .0001$) and increased mean length of stay (almost 5 days) when compared to non-diabetics. Similarly, controlled diabetics increased the odds of perioperative complications; however not nearly to the same degree. Controlled diabetics extended the mean length of stay by almost a day ($p < .0001$) and also significantly increased costs when compared to non-diabetics.

Conclusion—Poor glycemic control increases the odds of inpatient mortality and perioperative complications in patients undergoing degenerative cervical spine surgery. Controlling DM before degenerative cervical spine surgery may lead to better outcomes and decreased costs.

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The Manuscript submitted does not contain information about medical device(s)/drug(s). NIH/NIAMS grant funds were received in support of this work. Relevant financial activities outside the submitted work: board membership, consultancy, grants, royalties.

Keywords

Diabetes mellitus; glycemic control; uncontrolled DM; controlled DM; nationwide inpatient sample; complications; outcomes; national trends; inpatient mortality; costs; length of stay

Introduction

Diabetes mellitus (DM) is a metabolic disorder characterized by hyperglycemia due to defects in insulin secretion, insulin insensitivity or both. Chronic hyperglycemia is responsible for damage, dysfunction and failure of organ systems, including, but not limited to the cardiovascular, nervous and renal systems.¹ Factors that predispose individuals to DM include genetics, pancreatic disease, infection, hypertension, abnormal cholesterol levels, physical inactivity and obesity.

DM has also been shown to negatively impact the prognosis of spine surgery, especially with regards to surgical site infection, and often times resulting in prolonged length of stay (LOS), increased hospitalization costs and increased morbidity and mortality.^{2–5} However, there is a paucity of data between DM and outcomes following degenerative cervical spine surgery.⁶ Still sparser is the information on the effect of uncontrolled DM on patients undergoing degenerative cervical spine surgery.

In this study, we compared the perioperative outcomes of controlled and uncontrolled DM in patients undergoing degenerative cervical spine surgery using a national administrative database. We hypothesized that patients with uncontrolled DM would have worse outcomes, extended LOS and higher hospitalization costs when compared to patients with controlled DM or no DM.

Materials and Methods

The Nationwide Inpatient Sample (NIS) database, under the auspices of the Healthcare Cost and Utilization Project (HCUP) and administered by the Agency for Healthcare Research and Quality, was examined with time frame ranging from 2002 to 2011.⁷ The NIS contains data on 20% of all hospital discharges in the United States, approximating 8 million hospital stays each year unweighted and around 40 million hospitalizations weighted. The NIS contains information on, but not limited to charges, procedures, diagnoses and general patient characteristics.

Sample Selection

Hospitalizations were selected for the study based on International Classification of Diseases Ninth Revision, Clinical Modification (*ICD-9-CM*) procedural codes for cervical spine procedures and diagnosis codes for degenerative conditions of cervical spine. The following procedural codes were included: anterior cervical fusion (ACF, 81.02), posterior cervical fusion (PCF, 81.03), refusion of cervical spine anterior technique (81.32), refusion of cervical spine posterior technique (81.33), posterior cervical decompression (PCD) without fusion (03.09) excluding (81.01–03). Only hospitalizations of patients undergoing procedures for degenerative conditions including cervical spondylosis with and without

myelopathy (721.1, 721.0), intervertebral disc (IVD) displacement with and without myelopathy (722.71, 722.0), IVD degeneration (722.4), post laminectomy syndrome (722.81), calcification of IVD (722.91), other disorders of the cervical spine region including spinal stenosis (723.0–5) and ossification of the posterior longitudinal ligament (723.7) were selected. Hospitalizations of patients who had both anterior and posterior fusion were categorized as combined anterior posterior fusion hospitalizations.

Comparison analysis was based on three cohorts: degenerative cervical spine surgery patients that had *ICD-9-CM* diagnosis codes for controlled DM, uncontrolled DM or no DM. The American Hospital Association (AHA) describes uncontrolled diabetics as patients whose blood glucose levels are poorly managed and are not within physician recommended target range.⁸ It is a nonspecific *ICD-9-CM* code designation used by physicians to indicate patients that have suboptimal control of their diabetic condition. (See Appendix A for *ICD-9-CM* codes used).

Outcome Measures

We analyzed the incidence of uncontrolled DM, controlled DM and non-DM cohorts by patient age, insurance type, gender, race, mean Elixhauser Comorbidity Index, hospital characteristics and surgical procedure. The Elixhauser Comorbidity Index has been validated in its ability to predict mortality as well as patient burden of comorbidities in studies using administrative databases, with a larger index indicating those patients at greater risk of death.^{9–11} Major comorbidities were chosen using the NIS Comorbidity Software, Version 3.7.

Acute in-hospital complications are based on *ICD-9-CM* diagnosis codes (Appendix A). Hospitalization outcomes such as mean LOS, costs and mortality rates were also determined. Charges were adjusted for inflation using The United States Bureau of labor statistics yearly inflation calculator, presented in 2011 USD and further converted into costs with the HCUP cost to charge ratio tool.^{12,13}

Data Analysis

Statistical analysis was performed using SAS version 9.3 (SAS Institute, Cary, NC, USA). Chi-squared test was used for analysis of categorical variables and Student *t* test was used for continuous variables, both adjusting for the complex survey design. Regression modeling was done to examine odds ratios for complication covariates referencing controlled, uncontrolled DM and all diabetic patients (controlled and uncontrolled DM combined) with those patients without DM. Multivariate logistic regression analyses (age, race, gender, insurance, surgical approach, hospital bedsize, region, location and teaching status) was performed to assess the role uncontrolled or controlled DM had on inpatient mortality. Costs and LOS are reported as mean and median with interquartile range (IQR). The statistical analysis took into account the design of the NIS database. Procedures *surveyfreq*, *surveymeans* and *surveylogistic* were used for analysis. Discharge weights, strata and cluster (hospital ID) variables were included to correctly estimate variance and to produce national estimates. Statistical significance was maintained at $P < 0.05$.

Results

There were 1,602,145 patients that underwent degenerative cervical spine surgery from 2002–2011. From this total, 213,360 (13.3%) patients with controlled DM underwent degenerative cervical spine surgery (Table 1). Controlled diabetics were older than non-diabetics (59.5 *versus* 52.4, $p < 0.0001$) and were significantly more likely to be of Hispanic and Black race. Hospital size distribution was also significantly different between patients with controlled DM and those without DM. Procedure prevalence was significantly different between all groups, except posterior cervical fusion revision (Table 1).

In contrast to controlled diabetics, there were only 10,548 (0.66%) patients with uncontrolled DM that underwent degenerative cervical spine surgery from 2002–2011. Uncontrolled diabetics, like controlled diabetics, were also significantly older than patients without DM (60.2 *versus* 52.4, $p < 0.0001$) and much more likely to be of Black (16.9% *versus* 6.4% in non-diabetics) and Hispanic race (9.3% *versus* 3.6% in non-diabetics). Uncontrolled diabetics were more likely to undergo their procedures in teaching hospitals when compared to non-diabetics ($p = 0.035$). Additionally, uncontrolled diabetics had a greater prevalence of combined anterior and posterior fusion (3.97% *versus* 1.73%, $p < 0.0001$) (Table 1).

All major comorbidities were seen with greater prevalence in both controlled and uncontrolled diabetics when compared to non-diabetics (Table 2). However, when comparing DM groups only congestive heart failure, liver disease, neurological disorders, renal disease and obesity were significantly increased in uncontrolled diabetics. Controlled and uncontrolled diabetics had significantly increased odds of almost all major acute complications chosen for analysis with the exception of cerebrovascular complications, peripheral vascular complications, nervous system complications and postoperative shock (Table 3).

Inpatient mortality was significantly increased in both DM cohorts; however, uncontrolled DM had a much larger influence (odds ratio [OR]=6.4, 95% confidence interval [CI]=4.1–10.0, $p < 0.0001$). Increased costs and extended LOS were seen when both controlled and uncontrolled diabetics were compared non-diabetics with a greater effect in those patients with uncontrolled DM (Table 4). Multivariate logistic regression analysis identified uncontrolled DM as a significant risk factor increasing inpatient mortality (OR=2.6, 95 % CI=1.50–4.45, $p = 0.0006$) (Table 5). Controlled DM, however, was not shown to have this same effect (OR=1.1, 95% CI=0.89–1.39, $p = 0.377$) in a similar analysis.

Discussion

According to 2011 estimates by the Center for Disease Control (CDC), the prevalence of diabetes in the general population is estimated to be approximately 8.3%.¹⁴ From the aggregate population of patients undergoing degenerative cervical spine surgery, the prevalence of controlled diabetics was 13.3% while the prevalence of uncontrolled diabetics was 0.66%. As the prevalence of DM is increasing in the general population, it had also been significantly increasing in the population of patients undergoing degenerative cervical

spine surgery (Figure 1a and Figure 1b). These increases may be due to the relatively recent changes in criterion and thresholds for DM diagnosis, particularly the use of a hemoglobin A1C (HbA1c) as an accurate method of diagnosis.¹⁵ Moreover, these increases may be attributed to improved testing protocols for the diagnosis of diabetes and expanded surgical indications for cervical spine pathology.

Our study indicates that patients undergoing degenerative cervical spine surgery with uncontrolled DM are more likely to experience perioperative complications. Arnold et al.¹⁶ showed that mild DM is not a contraindication to surgical decompression of cervical spondylotic myelopathy. Although our study was not limited to cervical spondylotic myelopathy, we did confirm lower rates of perioperative complications in patients with controlled DM when compared to uncontrolled diabetics. This is reflected in studies of total hip arthroplasty (THA) and total knee arthroplasty (TKA), which revealed that uncontrolled diabetics had significantly higher odds ratio for major complications when compared to those patients with better glycemic control.^{17,18} Mraovic et al.¹⁹, studying THA and TKA, found that patients with preadmission blood glucose levels of at least 200mg/dL had a 3.19 times greater probability of getting a pulmonary embolism (PE). Our own analysis for PE in patients undergoing degenerative cervical spine surgery showed that controlled diabetics had an OR of 1.63, while uncontrolled diabetics had an OR of 4.56. In a study examining mean preoperative blood glucose and HbA1c % in total joint arthroplasty, Stryker et al.²⁰ found that complications in poorly controlled diabetics may be increased. From our investigation and other supportive orthopaedic studies, there appears to be a genuine increase in the risk of PE and other acute complications in patients undergoing degenerative cervical spine surgery whom have poor glycemic control.

In 2012, DM was estimated to cost \$245 billion: \$176 billion in direct medical costs and \$69 billion in reduced productivity.²¹ Total costs for patients with DM undergoing degenerative cervical spine surgery is approximately \$382,045,529/year. This is about 2.2% of the estimated direct costs for all patients with DM in 2012. Although direct comparisons cannot be made, as inflation rates differ each year, patients undergoing degenerative cervical spine procedures make up a considerable portion of direct costs and possibly an even larger proportion of costs due to reduced productivity. In our population, those patients with uncontrolled DM increased costs by approximately \$11,000 when compared to non-diabetics. Controlled diabetics increased costs by nearly \$2,500 more than those without DM ($p < 0.0001$, for both) (Figure 2). These increases may be due to extended LOS, particularly in the uncontrolled diabetic population; however, increased total costs may also be due to the distribution of surgical procedures performed in this population (Figure 3). There was a significant increase in prevalence of combined anterior posterior fusions in the uncontrolled DM group perhaps indicating increased severity of cervical pathology in these patients.

Controlled and uncontrolled DM significantly increases the odds of inpatient mortality when compared to non-diabetics. Multivariable analysis further showed the profound effect uncontrolled DM has on the risk of death after degenerative cervical spine procedures (Table 5). There are a few reasons for this increased risk of death. At baseline, uncontrolled diabetics are sicker when compared to non-diabetics, as indicated by the Elixhauser

Comorbidity Index (2.73 *versus* 0.44, $p < .0001$). Additionally, these patients undergo more posterior fusions and combined anterior posterior fusions when compared to controlled diabetics and patients without DM, both of which are more invasive and morbid procedures when compared to the other primary elective procedures represented. By being classified as uncontrolled diabetics, these surgical patients may also have relatively poor medical care with respect to their cervical pathology, and thus may represent the most difficult cases of the three cohorts chosen in our study. Indirectly supporting this notion is the increased prevalence of uncontrolled diabetic patients who are uninsured or have Medicaid when compared to controlled diabetics or patients without DM (Figure 4).

Our study has some limitations that need be addressed. Currently, the American Diabetes Association and American Association of Clinical Endocrinologists affirm the use of HbA1c $>6.5\%$ to diagnose DM; however, this criterion only became standard in the recent past and it does not provide a preoperative blood glucose or HbA1c % cutoff, which may have affected clinical coding of our surgical cohorts.^{22,23} Despite both of these societies' agreement on HbA1c percentage to diagnose diabetes, there is no *ICD-9-CM* coding standard or parameter in the clinical setting that provides standardization of "uncontrolled" or "controlled" diabetics. Furthermore, the NIS does not provide quantitative data on blood glucose levels or HbA1c percentage making it impossible to further stratify cohorts based on overall control of a patient's diabetic condition.

Despite the ability to analyze the prevalence of comorbidities and complications in our surgical cohorts, we are restricted by the temporal limitations of the NIS. There are some comorbidities for which it is difficult to distinguish whether they were present before or after an intervention during the hospitalization. Similarly, acute complications may be underestimated, as the NIS does not provide data beyond discharge. Therefore, complications such as deep venous thrombosis, PE and postoperative infection may be greater than what we reported as they can occur after discharge. Notwithstanding, the NIS provides valuable data with regards to acute complications and comorbidities.

Our data indicates that although it is not a contraindication for patients with uncontrolled diabetes to undergo degenerative cervical spine surgery, some glycemic control may be warranted due to increased risk of inpatient mortality and perioperative complications. Because our selection criterion eliminated cases of trauma and patients with more severe primary pathology that may need immediate attention, this potentially life-saving glycemic control may be possible before elective surgery is offered. There are obvious cases that will need urgent intervention despite our exclusion criteria, but patients with uncontrolled diabetes may have improved outcomes with some control of their diabetic condition. Controlled diabetics undergoing degenerative cervical spine surgery have only minimally increased odds of surgical complications and inpatient mortality, thus they are likely to respond to surgical intervention similarly to patients without DM.

Conclusion

To our knowledge, this study is the first to comprehensively demonstrate the demographics, incidence and perioperative complications in diabetic patients undergoing degenerative

cervical spine surgery. DM in these patients increases costs, LOS and acute complications. Patients with uncontrolled DM have a significantly increased risk of perioperative complications and inpatient mortality when compared to controlled diabetics and patients without DM. Controlled diabetics, representative of patients with better glycemic control, experience minimal increases in perioperative complications when compared to patients without DM. In general, better glycemic control seems to lead to superior outcomes in patients undergoing degenerative cervical spine surgery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Prevalence Trend of Uncontrolled Diabetic Patients Undergoing Degenerative Cervical Spine Surgery

Figure 1.

a. Prevalence of controlled diabetics undergoing degenerative cervical spine surgery from 2002–2011. Logistical regression trend analysis of prevalence by year indicates that there is a significant trend ($p < .0001$).

b. Prevalence of uncontrolled diabetics undergoing degenerative cervical spine surgery from 2002–2011. Logistical regression trend analysis of prevalence by year indicates that there is a significant trend ($p < .0001$).

Figure 2. Mean hospital costs for patients undergoing degenerative cervical spine surgery by surgical cohorts.

Figure 3.
Mean length of stay for patients undergoing degenerative cervical spine surgery by surgical cohorts.

Figure 4.

Prevalence of controlled diabetics, uncontrolled diabetics and patients without diabetes undergoing degenerative cervical spine surgery by insurance types. Controlled and uncontrolled diabetes pay schedules are significantly different when compared to the normal ($p < .0001$, for both). Pay Schedule "Other" are those patients that do not fall into other categories. Hospitalizations without insurance information fall into the "Missing" category.

Table 1

Demographic information of diabetic patients undergoing degenerative cervical spine surgery.

Demographics	Comparison 1			Comparison 2			Comparison 3		
	Norm	Cont DM	P value	Norm	Uncont DM	P value	Cont DM	Uncont DM	P value
Weighted N (%)	1,378,237	213,360		1,378,237	10,548		213,360	10,548	
Average age (yr)	52.40	59.50	<0.0001	52.40	60.18	<0.0001	59.50	60.18	0.005
Age group, yr (%)			<0.0001			<0.0001			<0.0001
0–18	0.15	0.01		0.15	0.00		0.01	0.00	
19–40	15.37	3.70		15.37	3.51		3.70	3.51	
41–60	59.99	50.32		59.99	47.90		50.32	47.90	
60+	24.43	45.97		24.43	48.59		45.97	48.59	
Sex (%)									
Female	51.19	45.79	<0.0001	51.19	45.87	<0.0001	45.79	45.87	0.875
Race (%)			<0.0001			<0.0001			<0.0001
White	63.10	58.38		63.10	49.70		58.38	49.70	
Black	6.43	11.45		6.43	16.91		11.45	16.91	
Hispanic	3.58	5.56		3.58	9.31		5.56	9.31	
Asian or Pacific	0.88	1.43		0.88	0.79		1.43	0.79	
Native American	0.28	0.43		0.28	0.83		0.43	0.83	
Other	1.72	1.87		1.72	1.81		1.87	1.81	
Missing Race	23.99	20.89		23.99	20.66		20.89	20.66	
Hospital teaching stat (%)			0.365			0.035			0.046
Nonteaching	46.73	46.23		46.73	42.34		46.23	42.34	
Teaching	53.27	53.77		53.27	57.66		53.77	57.66	
Hospital size (%)			0.010			0.161			0.407
Small	11.72	10.92		11.72	9.09		10.92	9.09	
Medium	21.98	21.37		21.98	20.80		21.37	20.80	
Large	66.29	67.71		66.29	70.12		67.71	70.12	
Mean Elixhauser Index	0.44	0.88	<0.0001	0.44	2.73	<0.0001	0.44	2.73	<0.0001

Demographics	Comparison 1			Comparison 2			Comparison 3		
	Norm	Cont DM	P value	Norm	Uncont DM	P value	Cont DM	Uncont DM	P value
Procedures (%)									
Anterior Cervical Fusion	77.32	72.09	<0.0001	77.32	60.40	<0.0001	72.09	60.40	<0.0001
Posterior Cervical Fusion	5.21	7.51	<0.0001	5.21	11.19	<0.0001	7.51	11.19	<0.0001
Cervical Decompression without Fusion	13.17	16.05	<0.0001	13.17	21.87	<0.0001	16.05	21.87	<0.0001
Anterior Cervical Fusion Revision	1.73	1.46	<0.0001	1.73	1.54	0.54	1.46	1.54	0.794
Posterior Cervical Fusion Revision	0.84	0.82	0.832	0.84	1.03	0.387	0.82	1.03	0.367
Combined Anterior Posterior Fusion	1.73	2.06	0.0004	1.73	3.97	<0.0001	2.06	3.97	<0.0001

Abbreviations: Cont=Controlled, DM=Diabetes Mellitus, Uncont=Uncontrolled, Yr=Year, Norm=Normal or *no diabetes

Table 2

Prevalence of comorbidities in patients undergoing degenerative cervical spine surgery.

Comorbidities	Comparison 1			Comparison 2			Comparison 3		
	Norm	Cont DM	P value	Norm	Uncont DM	P value	Cont DM	Uncont DM	P value
Congestive heart failure	0.91	3.80	<0.0001	0.91	8.27	<0.0001	3.80	8.27	<0.0001
Chronic lung disease	13.29	18.33	<0.0001	13.29	18.45	<0.0001	18.33	18.45	0.897
Liver disease	0.78	1.53	<0.0001	0.78	2.72	<0.0001	1.53	2.72	<0.0001
Neurological disorders	3.03	3.68	<0.0001	3.03	4.63	<0.0001	3.68	4.63	0.024
Renal disease	0.74	3.97	<0.0001	0.74	10.67	<0.0001	3.97	10.67	<0.0001
Obesity	5.97	16.30	<0.0001	5.97	21.88	<0.0001	16.30	21.88	<0.0001
Depression	10.38	11.98	<0.0001	10.38	11.73	0.051	11.98	11.73	0.743

Abbreviations: Cont=Controlled, DM=Diabetes Mellitus, Uncont=Uncontrolled, Norm=Normal or *no diabetes

Table 3

Acute complications in patients undergoing degenerative cervical spine surgery.

Complications	Controlled DM				Uncontrolled DM				All Diabetics			
	Odds Ratio	Low 95% CI	High 95% CI	P value	Odds Ratio	Low 95% CI	High 95% CI	P value	Odd Ratio	Low 95% CI	High 95% CI	P value
Cerebrovascular	1.26	0.82	1.95	0.291	1.20	0.17	8.35	0.865	1.26	0.82	1.93	0.949
Respiratory	1.63	1.40	1.86	<0.0001	3.72	2.58	5.36	<0.0001	1.73	1.53	1.97	<0.0001
Cardiac	1.78	1.55	2.04	<0.0001	2.37	1.50	3.75	0.0001	1.81	1.58	2.06	0.229
DVT	2.34	1.90	2.87	<0.0001	5.78	3.26	10.22	<0.0001	2.50	2.05	3.05	0.002
Peripheral Vascular	1.54	0.90	2.67	0.116	2.22	0.31	16.06	0.418	1.58	0.93	2.68	0.726
Nervous System	1.16	0.75	1.78	0.503	2.02	0.50	8.20	0.316	1.20	0.79	1.83	0.446
Genitourinary	1.34	1.17	1.54	<0.0001	2.24	1.50	3.37	<0.0001	0.38	1.21	1.58	0.016
Postoperative Shock	1.57	0.77	3.18	0.209	3.13	0.43	22.96	0.235	1.64	0.83	3.23	0.505
Pulmonary Embolism	1.63	1.24	2.15	0.0004	4.56	2.34	8.88	<0.0001	1.80	1.36	2.29	0.003
Postoperative Infection	1.91	1.54	2.37	<0.0001	4.90	2.84	8.46	<0.0001	2.06	1.66	2.53	0.001
Post-operative hemorrhage	1.67	1.54	1.82	<0.0001	6.50	5.40	7.81	<0.0001	1.90	1.74	2.05	<0.0001
Inpatient Mortality	1.86	1.53	2.27	<0.0001	6.39	4.09	10.00	<0.0001	2.08	1.72	2.50	<0.0001

Abbreviations: Cont=Controlled, DM=Diabetes Mellitus, Uncont=Uncontrolled, DVT= Deep Venous Thromboembolism. All surgical groups were references to patients without diabetes.

Table 4

Hospitalization outcomes of patients undergoing degenerative cervical spine surgery.

Procedures	Outcome	Normal	Controlled DM	P value	Normal	Uncontrolled DM	P value
All Procedures	Mean Costs	14,163	16,622	<0.0001	14,163	25,166	<0.0001
	Median Costs (IQR)	11,320(8,276–16,117)	12,931(9,261–19,079)	....	11,320(8,276–16,117)	18,393(12,014–30,071)	....
	Mean LOS	2.4	3.2	<0.0001	2.4	7.0	<0.0001
	Median LOS(IQR)	0.9(0.4–1.9)	1.3(0.6–2.9)	....	0.9(0.4–1.9)	3.7(1.5–8.4)	....
Anterior Cervical Fusion	Mean Costs	12,699	14,531	<0.0001	12,699	20,685	<0.0001
	Median Costs (IQR)	11,005(8,335–14,861)	12,263(9,209–16,895)	....	11,005(8,335–14,861)	16,136(11,362–23,979)	....
	Mean LOS	1.8	2.4	<0.0001	1.8	5.4	<0.0001
	Median LOS(IQR)	0.8(0.4–1.4)	0.9(0.4–1.9)	....	0.8(0.4–1.4)	2.4(1.0–6.2)	....
Posterior Cervical Fusion	Mean Costs	24,839	27,483	<0.0001	24,839	34,377	<0.0001
	Median Costs (IQR)	20,919(14,190–30,136)	23,199(16,421–33,367)	....	20,919(14,190–30,136)	28,348(20,494–37,876)	....
	Mean LOS	4.9	5.8	<0.0001	4.9	9.1	<0.0001
	Median LOS(IQR)	2.9(1.7–5.1)	3.6(2.2–6.3)	....	2.9(1.7–5.1)	6.2(3.3–10.8)	....
Anterior Cervical Fusion Revision	Mean Costs	16,462	19,368	<0.0001	16,462	18,549	0.398
	Median Costs (IQR)	12,912(9,504–18,451)	14,697(10,757–21,212)	....	12,912(9,504–18,451)	16,271(11,120–25,011)	....
	Mean LOS	2.5	3.6	<0.0001	2.5	5.2	<0.0001
	Median LOS(IQR)	1.0(0.5–2.0)	1.38(0.6–2.9)	....	1.0(0.5–2.0)	3.2(1.1–7.32)	....
Posterior Cervical Fusion Revision	Mean Costs	24,704	28,511	0.0001	24,704	43,164	<0.0001
	Median Costs (IQR)	19,613(13,408–29,654)	21,966(14,603–35,127)	....	19,613(13,408–29,654)	27,544(20,147–38,790)	....
	Mean LOS	4.3	5.5	<0.0001	4.3	8.5	<0.0001
	Median LOS(IQR)	2.5(1.5–4.1)	2.9(1.8–5.4)	....	2.5(1.5–4.1)	4.0(2.8–11.2)	....

Procedures	Outcome	Normal	Controlled DM	P value	Normal	Uncontrolled DM	P value
Cervical Decompression without Fusion	Mean Costs	14,217	16,605	< 0.0001	14,217	27,003	< 0.0001
	Median Costs (IQR)	9,753(6,217–16,540)	11,669(7,259–19,954)	....	9,753(6,217–16,540)	18,332(11,276–33,403)	....
	Mean LOS	3.8	4.9	< 0.0001	3.8	9.5	< 0.0001
	Median LOS(IQR)	1.80(0.8–3.6)	2.6(1.2–5.3)	....	1.80(0.8–3.6)	5.9(2.9–11.1)	....
Combined Anterior Posterior Fusion	Mean Costs	40,112	44,696	< 0.0001	40,112	54,328	< 0.0001
	Median Costs (IQR)	33,767(2,3641–48,337)	37,365(25,772–54,407)	....	33,767(2,3641–48,337)	47,813(35,112–64,671)	....
	Mean LOS	6.8	8.7	< 0.0001	6.8	12.2	< 0.0001
	Median LOS(IQR)	3.9(2.4–6.9)	5.0(2.8–9.0)	....	3.9(2.4–6.9)	8.0(4.9–15.0)	....

Abbreviations: DM=Diabetes Mellitus, LOS= Length of Stay, IQR=Interquartile Range. * Costs are adjusted for inflation and reported in 2011 (\$USD).

Table 5

Multivariate analysis for inpatient mortality in patients undergoing degenerative cervical spine surgery.

Risk factor	Odds Ratio	Lower 95% CI	Upper 95% CI	P Value
Uncontrolled DM (Reference = Normal)	2.59	1.50	4.45	0.001
Age	1.09	1.07	1.10	<0.0001
Race (Reference = White)				
Black	1.60	1.19	2.16	0.115
Hispanic	1.03	0.66	1.62	0.728
Asian or Pacific	0.98	0.46	2.07	0.689
Native American	0.78	0.11	5.35	0.652
Other	1.65	0.95	2.85	0.200
Female vs. Male	0.47	0.38	0.58	<0.0001
Hospital Bedsize (Reference = Large)				
Small	0.72	0.50	1.02	0.041
Medium	1.07	0.83	1.37	0.099
Hospital Region (Reference = Northeast)				
Midwest	1.08	0.75	1.55	0.959
South	1.08	0.80	1.45	0.924
West	1.13	0.80	1.60	0.600
Hospital Location (Reference = Rural)				
Urban	1.46	0.79	2.71	0.230
Hospital Teaching Status (Reference = Non-teaching)				
Academic	1.27	1.02	1.58	0.031
Pay Schedule				
(Reference = Private Insurance)				
Medicare	1.62	1.13	2.30	<0.0001
Medicaid	3.28	2.24	4.78	<0.0001
Uninsured	3.22	1.60	6.48	<0.0001
Other	0.74	0.38	1.43	0.0004
Missing	< 0.001	< 0.001	< 0.001	<0.0001
Surgical Approach				
Reference =Cervical Decompression without Fusion				
Anterior Cervical Fusion	0.61	0.47	0.78	<0.0001
Posterior Cervical Fusion	1.20	0.87	1.65	0.268
Anterior Cervical Fusion Revision	0.54	0.17	1.70	0.294
Posterior Cervical Fusion Revision	0.68	0.22	2.16	0.516
Combined Anterior Posterior Cervical Fusion	3.23	2.23	4.68	<0.0001

Abbreviations: CI=Confidence Interval, DM=Diabetes Mellitus