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CERVICAL SPINE

Outcomes of Cervical Spine Surgery in Teaching and Non-Teaching Hospitals

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Study Design. Retrospective national database analysis.

Objective. A national population-based database was analyzed to characterize cervical spine procedures performed at teaching and nonteaching hospitals with regards to patient demographics, clinical outcomes/complications, resource use, and costs.

Summary of Background Data. There are mixed reports in the literature regarding the quality and costs of health care provided by teaching hospitals in the United States. However, outcomes of cervical spine surgery based upon teaching status remains largely unknown.

Methods. Data from the Nationwide Inpatient Sample were obtained from 2002–2009. Patients undergoing elective anterior or posterior cervical fusion, or posterior cervical decompression (*i.e.*, laminoforaminotomy, laminectomy, laminoplasty) for a diagnosis of cervical myelopathy and/or radiculopathy were identified and separated into 2 cohorts (teaching and nonteaching hospitals). Patient demographics, comorbidities, complications, length of hospitalization, costs, and mortality were compared for both groups. Regression analysis was performed to assess independent predictors of mortality.

Results. A total of 212,385 cervical procedures were identified from 2002–2009 in the United States, with 54.6% performed at teaching hospitals. More multilevel fusions and posterior approaches were performed in teaching hospitals ($P < 0.0005$). Patients treated in teaching hospitals trended toward male sex, increased costs, and hospitalizations. Overall, procedure-related complications and inhospital mortality were increased in teaching hospitals. Regression analysis revealed that significant predictors of mortality were age 65 years or more (odds ratio = 3.0) and multiple comorbidities. Teaching status was not a significant predictor of mortality ($P = 0.07$).

Conclusion. Patients treated in teaching hospitals for cervical spine surgery demonstrated longer hospitalizations, increased costs, and mortality compared with patients treated in nonteaching hospitals. Incidences of postoperative complications were identified to be higher in teaching hospitals. Possible explanations for these findings are an increased complexity of procedures performed at teaching hospitals. Older age and presence of comorbidities were more significant predictors of inhospital mortality than teaching status. Future studies should identify long-term complications and costs beyond an inpatient setting to assess if differences extend beyond the perioperative period.

Key words: teaching hospital, cervical spine surgery, complications, mortality, anterior cervical fusion, posterior cervical fusion, posterior cervical decompression, risk factors.

Level of Evidence: 4

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Extensive debate exists within the health care community regarding outcomes between teaching and nonteaching hospitals. Teaching hospitals play a major role in the US health care delivery system and claim to provide better quality care than nonteaching hospitals.[1] Teaching hospitals educate the next generation of physicians, make substantial contributions to the advancement of health care technologies, and are uniquely adept at providing highly specialized services for complex patients.[2] Information provided by large-scale epidemiological studies may help determine if differences between hospitals based on teaching status affects patient outcomes.

Existing studies have demonstrated inconsistent results between teaching and nonteaching hospitals with regards to mortality and complication rates. Dimick *et al*[3] demonstrated that teaching status is not a significant factor affecting the likelihood of perioperative mortality, whereas a meta-analysis further reported that teaching status has no bearing on patient outcomes.[4] A review by Ayanian *et al*[5] concluded that teaching hospitals had superior outcomes to nonteaching hospitals for several common medical conditions (congestive heart failure and pneumonia). McGuire *et al*[6] compared 6-month outcomes between patients treated at teaching and nonteaching hospitals for hip fractures and found that although overall

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costs were greater, 6-month mortality was lower when treated at teaching hospitals. Numerous studies have demonstrated that teaching hospitals produced better results for complex surgical procedures (*e.g.*, esophagectomy, pancreatectomy, and lung resection), but failed to show superiority in more common and less complex procedures (*e.g.*, hysterectomy).[4,7,8] On the contrary, other investigations have reported a spike of fatal medication errors at teaching hospitals in July associated with resident turnover.[9]

Our hypothesis is that there are significant differences in patient demographics and outcomes between teaching and nonteaching hospitals. The purpose of this study is to determine the associations that may exist between hospital teaching status, patient demographics, postoperative complications, and mortality of cervical spine surgery.

TABLE 1. List of *ICD-9-CM* Codes Used to Identify Postoperative Complications

Complication	*ICD-9-CM* Codes
Pulmonary embolism	415.1, 415.11–19
Deep vein thrombosis	451.1, 451.11, 451.19, 451.2, 451.81, 451.9, 453.40–42, 453.9
Infection	324.1, 682.1–2, 730.0, 996.67, 998.5, 998.51–59
Cardiac complication	410, 410.0–9, 997.1, 998.0
Hemorrhage/hematoma	998.1, 998.10–13
Neurological complication	997.0, 997.00–09

MATERIALS AND METHODS

The Nationwide Inpatient Sample (NIS) database is part of the Healthcare Cost and Utilization Project governed by the Agency for Healthcare Research and Quality.[10] The NIS is the largest all-payer health care database in the United States; it contains data from approximately 8 million hospital discharges each year from 45 states, approximating a 20% stratified sample of all discharges. Each entry in the NIS contains data from a single hospital admission on patient demographics, comorbidities, diagnoses, surgical procedures, measurable outcomes (*e.g.*, length of hospitalization, cost), and hospital characteristics (*e.g.*, teaching status, size, location). Diagnoses and procedural codes from the *International Classification of Disease-9th Revision-Clinical Modification* (*ICD-9-CM*) are included in the NIS.

Data Collection

Data from the NIS were obtained from 2002 to 2009. Database entries were selected according to *ICD-9-CM* procedural codes for anterior cervical fusion (ACF, 81.02), posterior cervical fusion (PCF, 81.03), or a posterior cervical decompression (PCD) procedure without fusion (03.09). Only elective procedures were included. Patients undergoing both ACF and PCF in the same hospitalization were included in the PCF group. The *ICD-9-CM* code 03.09 is not a specific identifier as it describes "other exploration and decompression of spinal canal"; this includes laminotomy, laminectomy, laminoplasty, foraminotomy, or exploration of the nerve root. Because the code 03.09 is often used in conjunction with fusion codes (*e.g.*, laminectomy and fusion), the PCD group was identified by including patients in whom code 03.09 was used in the absence of a coexisting fusion code (81.02 or 81.03). Patients were further stratified by *ICD-9-CM* diagnosis codes to include only patients undergoing surgery for degenerative etiologies of cervical myelopathy and/or radiculopathy (721.0–1, 722.0, 722.4, 722.71, 722.81, 722.91, 723.x). Patients under the age of 18 were excluded from the study. Entries containing *ICD-9-CM* codes for diagnoses of tumor/pathological fracture (170.2, 198.3, 198.5, 733.13, 739.2–4) or cervical trauma (805.xx and 806.xx) were excluded from our analysis.

Patients' age, sex, ethnicity, comorbid risk factors, primary payer, and disposition were compared between teaching or nonteaching hospitals. Comorbidity scores were calculated using a modified Charlson Comorbidity Index (CCI) using data from the NIS Disease Severity Measure Files.[11] The CCI predicts the 10-year mortality of patients based on the presence of 22 comorbidities and age.[12] Multilevel fusions (3+ levels) were identified in the ACF and PCF groups using the *ICD-9-CM* code for "fusion of 4–8 vertebrae" (81.63). Length of stay (LOS), hospital costs, and the incidence of inhospital mortality were also compared between groups. Six categories of postoperative complications were also tabulated using *ICD-9-CM* diagnosis codes for pulmonary embolism, deep vein thrombosis (DVT), infection, cardiac complications (*e.g.*, acute myocardial infarction), hemorrhage/hematoma, and neurological complications (*e.g.*, cerebrovascular infarction) (Table 1). All complications and mortality rates are described as the incidence per 1000 cases.

All of the entries identified were then divided into 2 groups: teaching and nonteaching hospitals. Beginning in 1998, the NIS considered a hospital to be a teaching hospital if it meets any of the following criteria: (1) approval for residency training by the Accreditation Council for Graduate Medical Education (ACGME), (2) is a member in the Council of Teaching Hospital, or (3) has a ratio of interns/residents to beds of 0.25 or greater.[10]

Data Analysis

Statistical analysis was performed using SPSS version 20 (Chicago, IL). Differences between teaching and nonteaching hospitals were assessed. Independent t test was used to identify significant differences between discrete variables and χ^2 test for categorical data. Median LOS and costs were also calculated for each group. Binary logistic regression was performed to determine independent risk factors for mortality. To control for confounding variables, all variables including patients' age ($\geq$65 yr), sex, race, comorbidities, complications, as well as hospital location, size, and teaching status were included simultaneously in the regression model. Adjusted odds ratios were reported only for the variables that reached statistical

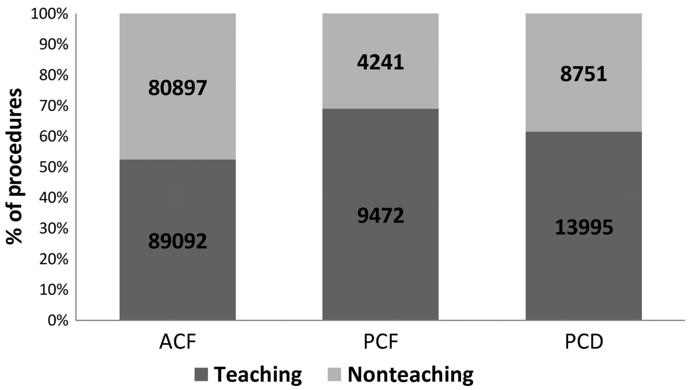

Figure 1. Frequency of ACF, PCF, and PCD at teaching and nonteaching hospitals. ACF indicates anterior cervical fusion; PCF, posterior cervical fusion; and PCD, posterior cervical decompression.

significance unless otherwise noted. A *P* value of 0.0005 or less was used to determine statistical significance because of the large sample size.

RESULTS

A total of 212,385 elective cervical procedures were identified between 2002 and 2009. Data regarding teaching status were not available for 761 patients; therefore, these entries were omitted from the final analysis. Of the remaining 211,624 entries, 115,451 (54.6%) procedures were performed at teaching hospitals and 96,173 (45.4%) procedures were performed at nonteaching hospitals (Table 2). Only 30.2% of hospitals in the NIS were designated as teaching hospitals. The majority of cervical procedures were ACFs accounting for 170,697 (82.4%) surgical procedures, followed by 22,764 PCDs (11.0%) and 13,739 PCFs (6.5%) (Table 3). Within individual procedural groups, 52.4% (89,092) of ACFs, 61.5% (13,995) of PCDs, and 69.1% (9472) of PCFs were performed at teaching hospitals (Figure 1). A significantly greater percentage of ACFs (10.2% *vs*. 9.9%) and PCFs (42.4% *vs*. 36.3%) performed at teaching hospitals were 3+ level fusions ($P < 0.0005$).

There were several demographic characteristics that differed between patients treated at teaching and nonteaching hospitals. Sex distribution between teaching and nonteaching hospitals demonstrated a statistically significant trend toward more males being treated at teaching hospitals (49.9 *vs*. 47.8%, $P < 0.0005$) (Table 2). ACF-treated patients were predominantly female, whereas the majority of PCF and PCD-treated patients were male (Table 3). The ACF and PCD groups demonstrated a greater percentage of male patients treated at teaching hospitals than nonteaching hospitals, whereas there was no difference in the PCF group ($P = 0.73$). Overall, patients treated in teaching hospitals were statistically younger ($P < 0.0005$), although only by 0.2 years (52.3 *vs*. 52.5 yr, $P < 0.0005$). ACF-treated patients were the youngest (51.1 and 51.7 yr at teaching and nonteaching hospitals, respectively, $P < 0.0005$), followed by patients who underwent PCD (55.9 and 56.9 yr, $P < 0.0005$), and patients who underwent PCF were the oldest (58.7 and 58.9

TABLE 2. Patient Characteristics, Complications, and Mortality of Cervical Spine Surgery at Teaching and Nonteaching Hospitals from 2002–2009

	Teaching	Nonteaching	Significance
Count (n)	115,451	96,173	
% male	49.9%	47.8%	<0.0005
% female	50.1%	52.2%	<0.0005
Age (yr)	52.3	52.5	<0.0005
Mean comorbidity score	2.10	2.10	0.53
Race			
White	82.3%	86.7%	
Black	9.7%	6.8%	
Hispanic	4.2%	3.3%	<0.0005
Asian/Pacific Islander	0.9%	0.6%	
Native American	0.4%	0.4%	
Other	2.4%	2.2%	
Payer (%)			
Medicare	21.5%	23.9%	
Medicaid	5.1%	4.3%	<0.0005
Private (HMO, PPO)	61.8%	58.4%	
Other	11.5%	13.4%	
Mean length of stay (d)	2.1	1.8	<0.0005
Median length of stay (d)	1.0	1.0	…
Mean costs ($)	$12,437	$11,975	<0.0005
Median costs ($)	$10,315	$10,188	…
Disposition after discharge (%)			
Routine	90.3%	91.8%	
Transfer to short-term hospital	0.2%	0.2%	<0.0005
Skilled nursing	5.2%	3.3%	
Home health	4.1%	4.5%	
Left AMA	0.1%	0.0%	
Inhospital mortality	0.1%	0.1%	
Complications (per 1000 cases)			
Total	24.7	17.4	<0.0005
PE	0.8	0.5	0.01
DVT	1.6	0.9	<0.0005
Infection	2.7	1.5	<0.0005
Cardiac	4.4	3.4	<0.0005
Hemorrhage/hematoma	6.2	5.5	0.05
Neurological	3.1	1.9	<0.0005
Mortality (per 1000 cases)	1.2	0.6	<0.0005

HMO indicates health maintenance organization; PPO, preferred provider organization; AMA, against medical advice; PE, pulmonary embolism; DVT, deep vein thrombosis.

TABLE 3. Comparison of Anterior Cervical Fusion, Posterior Cervical Fusion, and Posterior Cervical Decompression Between Teaching and Nonteaching Hospitals from 2002–2009

	Anterior Cervical Fusion			Posterior Cervical Fusion			Posterior Decompression		
	Teaching	Nonteaching	Significance	Teaching	Nonteaching	Significance	Teaching	Nonteaching	Significance
Count (n)	89,092	80,897		9,472	4241		13,995	8751	
% male	47.7%	46.4%	<0.0005	55.4%	55.7%	0.73	60.8%	58.3%	<0.0005
% female	52.3%	53.6%	<0.0005	44.6%	44.3%	0.73	39.2%	41.7%	<0.0005
Age (yr)	51.1	51.7	<0.0005	58.7	58.9	0.40	55.9	56.9	<0.0005
Mean comorbidity score	1.96	2.01	<0.0005	2.94	2.92	0.49	2.50	2.61	<0.0005
3+ level fusions (%)	10.2%	9.9%	<0.0005	42.4%	36.3%	<0.0005	...	...	...
Race									
White	82.6%	86.7%			84.5%		82.6%	87.7%	
Black	9.5%	6.8%		78.9%	8.3%		9.6%	6.4%	
Hispanic	4.3%	3.3%	<0.0005	12.5%	4.3%	<0.0005	3.9%	3.4%	<0.0005
Asian/Pacific Islander	1.0%	0.6%		4.5%	0.8%		0.7%	0.7%	
Native American	0.4%	0.4%		1.0%	0.2%		0.4%	0.4%	
Other	2.3%			0.6%	1.9%		2.8%	1.5%	
Payer (%)									
Medicare	18.3%	21.9%		40.2%	41.1%		29.7%	34.8%	
Medicaid	5.1%	4.2%	<0.0005	6.0%	5.0%	<0.0005	4.4%	4.2%	<0.0005
Private (HMO, PPO)	64.6%	60.1%		44.9%	42.8%		56.3%	50.8%	
Other	12.0%	13.7%		8.9%	11.1%		9.4%	10.1%	
Mean length of stay (d)	1.8	1.6	<0.0005	4.4	3.6	<0.0005	2.5	2.3	<0.0005
Median length of stay (d)	1.0	1.0	...	3.0	3.0	...	2.0	2.0	...
Mean costs ($)	$11,917	$11,933	0.69	$22,030	$19,875	<0.0005	$8247	$7749	<0.0005
Median costs ($)	$10,312	$10,319	...	$18,861	$17,214	...	$6507	$6367	...
Disposition after discharge (%)									
Routine	93.9%	93.8%		65.0%	68.6%		84.7%	84.9%	
Transfer to short-term hospital	0.1%	0.1%	<0.0005	0.6%	0.6%	<0.0005	0.4%	0.3%	0.18
Skilled nursing	2.8%	2.0%		21.9%	17.3%		9.7%	9.2%	
Home health	3.0%	4.0%		12.1%	13.2%		5.1%	5.4%	

(Continued)

TABLE 3. (*Continued*)

	Anterior Cervical Fusion			Posterior Cervical Fusion			Posterior Decompression		
	Teaching	**Nonteaching**	**Significance**	**Teaching**	**Nonteaching**	**Significance**	**Teaching**	**Nonteaching**	**Significance**
AMA	0.1%	0.0%		0.1%	0.0%		0.0	0.1%	
Inhospital mortality	0.1%	0.1%		0.3%	0.3%		0.2%	0.1%	
Complications (per 1000 cases)									
Total	**18.0**	**14.3**	**<0.0005**	**67.3**	**47.9**	**<0.0005**	**37.1**	**30.6**	**0.02**
PE	0.6	0.4	0.07	3.1	2.8	0.82	1.0	1.0	0.94
DVT	1.1	0.7	0.006	5.0	4.2	0.57	2.7	1.5	0.06
Infection	1.5	0.9	0.001	10.1	5.2	0.004	3.7	3.7	0.94
Cardiac	3.4	2.9	0.07	11.9	10.1	0.36	5.6	4.7	0.37
Hemorrhage/hematoma	5.0	5.0	0.92	13.4	11.1	0.26	8.6	7.2	0.24
Neurological	2.1	1.5	0.007	9.8	3.8	<0.0005	5.2	3.9	0.15
Mortality (per 1000 cases)	0.9	0.5	0.002	3.1	3.3	0.81	1.6	0.7	0.06

HMO indicates health maintenance organization; PPO, preferred provider organization; AMA, against medical advice; PE, pulmonary embolism; DVT, deep vein thrombosis.

yr, $P = 0.40$) but not statistically different between teaching and nonteaching hospitals. Overall, the mean CCI of patients was equivalent between teaching and nonteaching hospitals. However, CCI scores were lower in patients treated in teaching hospitals in the ACF (1.96 *vs*. 2.01, $P < 0.0005$) and PCD (2.50 *vs*. 2.61, $P < 0.0005$) cohorts. Although a large majority of patients were of white ethnicity, there was a statistically significant trend toward a greater percentage of minorities being treated at teaching hospitals in all surgical groups.

Significant differences in the hospitalization characteristics were observed between teaching and nonteaching hospital cohorts. Patients treated in teaching hospitals were hospitalized on average 0.3 days longer than those treated in nonteaching hospitals ($P < 0.0005$). The ACF groups, which had the shortest overall LOS, were admitted 1.8 days in teaching hospitals and 1.6 days in nonteaching hospitals ($P < 0.0005$). PCF-treated patients had the longest postoperative hospitalizations (4.4 and 3.6 days at teaching and nonteaching hospitals, respectively, $P < 0.0005$). Median LOS was equivalent between teaching and nonteaching hospitals in all groups and was 1 day per ACF, 2 days per PCD, and 3 days per PCF. The average cost of admission after cervical spine surgery in teaching hospitals was $12,437 and in nonteaching hospitals was $11,975; a difference of $462 ($P < 0.0005$). Median costs were $10,315 and $10,188 at teaching and nonteaching hospitals, respectively. Hospital costs were greatest for the PCF groups: $22,030 and $19,875 at teaching and nonteaching hospitals, respectively; a difference of $2155 ($P < 0.0005$). ACF-treated patients incurred an average cost of $11,917 and $11,933 at teaching and nonteaching hospitals, respectively which was not statistically different ($P = 0.69$). The lowest costs were incurred by the PCD groups: $8247 and $7749 at teaching and nonteaching hospitals, respectively ($P < 0.0005$). Median costs for each surgical group were less than the mean (Table 3). In general, patients treated in teaching hospitals were less likely to be discharged routinely (90.3% *vs*. 91.8%, $P < 0.0005$) and more likely to be discharged to a skilled nursing facility (5.2% *vs*. 3.3%, $P < 0.0005$).

Mortality and morbidity had a greater incidence in teaching hospitals. The overall mortality in teaching hospitals (1.2 per 1000) was double the rate in nonteaching hospitals (0.6 per 1000, $P < 0.0005$). However, this difference was not statistically significant in any of the surgical subgroups. Mortality was greatest in the PCF group; 3.1 and 3.3 per 1000 at teaching and nonteaching hospitals, respectively ($P = 0.81$). ACF-treated patients also had greater mortality at teaching hospitals (0.9 *vs*. 0.5 per 1000) that approached statistical significance ($P = 0.002$). PCD-treated patients did not demonstrate any significant difference based on teaching status (1.6 *vs*. 0.7 per 1000, $P = 0.06$). The overall incidence of inhospital complications examined in this study was significantly greater in the teaching hospital cohort (24.7 *vs*. 17.4 per 1000, $P < 0.0005$). Specifically, the incidences of DVT (1.6 *vs*. 0.9 per 1000), wound infection (2.7 *vs*. 1.5 per 1000), cardiac events (4.4 *vs*. 3.4 per 1000), and neurological complications (3.1 *vs*. 1.9 per 1000) were significantly greater at teaching hospitals ($P < 0.0005$). Overall complications were the

TABLE 4. Predictors of Perioperative Mortality After Cervical Spine Surgery

Risk Factor	OR	95% CI	*P*
Age ≥65 yr	3.0	2.1–4.5	<0.0005
Teaching hospital	1.4	1.0–2.1	0.07
Comorbidities			
CHF	3.6	2.1–6.3	<0.0005
Chronic lung disease	1.8	1.2–2.7	0.006
Coagulopathy	9.2	4.8–17.5	<0.0005
Fluid/electrolyte disorder	4.9	3.1–7.7	<0.0005
Neurological disorder	2.6	1.5–4.7	0.001
Weight loss	8.4	4.2–16.8	<0.0005
Postoperative complications			
PE	23.4	8.2–66.9	<0.0005
DVT	1.2	0.4–4.0	0.77
Wound infection	1.6	0.5–4.5	0.41
Cardiac	22.8	13.9–37.5	<0.0005
Hemorrhage/hematoma	4.5	2.3–8.8	<0.0005
Neurological complication	10.7	5.0–23.0	<0.0005

OR indicates odds ratio; CI, confidence interval; CHF, congestive heart failure; PE, pulmonary embolism; DVT, deep vein thrombosis.

greatest for patients who underwent PCF; 67.3 and 47.9 per 1000 in teaching and nonteaching hospitals, respectively ($P < 0.0005$). However, only the increased rate of neurological complications in teaching hospitals reached statistical significance, whereas rates of wound infections approached significance ($P = 0.004$). Total complication rates were significantly greater at teaching hospitals within the ACF group, which had the lowest rate of complications of the 3 surgical groups (18.0 *vs*. 14.3 per 1000, $P < 0.0005$), although for specific complications, only rates of DVT (1.1 *vs*. 0.7, $P = 0.006$), infection (1.5 *vs*. 0.9, $P = 0.001$), and neurological complications (2.0 *vs*. 1.5, $P = 0.007$) approached significance. There was no difference in complication rates between teaching and nonteaching hospitals in the PCD group (37.1 *vs*. 30.6 per 1000, $P = 0.02$).

Logistic regression identified independent predictors of mortality among patients undergoing cervical spine surgery (Table 4). Teaching status was not a predictor of mortality (OR = 1.4; CI = 1.0–2.1; $P = 0.07$). Not surprisingly, age 65 years or more was a significant risk factor for mortality (OR = 3.0; CI = 2.1–4.5; $P < 0.0005$). Multiple comorbid diseases were significant predictors of mortality including coagulopathy (OR = 9.2; CI = 4.8–17.5; $P < 0.0005$), unintentional weight loss (OR = 8.4; CI = 4.2–16.8; $P < 0.0005$), fluid/electrolyte disorders (OR = 4.9; CI = 3.1–7.7), congestive heart failure (OR = 3.6; CI = 2.1–6.3; $P < 0.0005$), neurological disorders (OR = 2.6; CI = 1.5–4.7; $P = 0.001$), and chronic lung disease (OR = 1.8; CI = 1.2–2.7; $P = 0.006$). Postoperative complications that were the greatest predictors of mortality were pulmonary embolism (OR = 23.4; CI8.2–66.9; $P < 0.0005$), cardiac complications (OR = 22.8; CI = 13.9–37.5; $P < 0.0005$), and neurological complications (OR = 10.7; CI = 5.0–23.0; $P < 0.0005$). DVT (OR = 1.2; CI = 0.4–4.0; $P = 0.77$) and wound infections (OR = 1.6; CI = 0.5–4.5; $P = 0.41$) did not independently impact mortality.

DISCUSSION

Teaching hospitals are valuable assets to the US health care system: they educate future generations of health care professionals, conduct state-of-the-art research to discover cures and advance surgical techniques, provide care to the nation's underserved and uninsured populations, and serve as referral centers for complex and severely ill or injured patients.[13–18] Still, perception biases exist regarding the quality of medical care in academic settings. Patients are understandably concerned about their health care and that participation of a surgeon-in-training in their procedures may adversely affect their outcomes. The results presented in this study highlight several differences in patient demographics and inhospital outcomes based on a hospital's teaching status. To our knowledge, this is the first study to examine these differences on a large scale for cervical spine surgery.[8,19–23]

Between 2002 and 2009, 54.6% of cervical procedures recorded in the NIS were performed in teaching hospitals. The NIS represents a 20% stratified sample of US hospitals;[10] however, it remains unclear whether the hospitals sampled accurately reflects the distribution of teaching hospitals. The Association of American Medical Colleges represents nearly 400 of the nation's major teaching hospitals; comprising only 6% of US hospitals.[2] We identified 30.2% of hospitals in the NIS as teaching hospitals, although the criteria for teaching status dictated by the NIS (listed previously) extends beyond just Association of American Medical College hospitals. Therefore, our results cannot definitively determine that the total number of cervical spine procedures is greater at teaching hospitals in the United States. Although, we can conclude that teaching hospitals treat a higher volume of patients as 54.6% of surgical procedures were performed in only 30.2% of hospitals in the NIS.

Despite the stigma frequently associated with teaching hospitals, it may be inappropriate to attribute our results to inexperience by a surgeon-in-training. This study is merely a correlation of patient demographics and outcomes of elective cervical spine surgery as recorded in the NIS database. We were not able to identify whether a resident or fellow was even involved in the surgical or postoperative care at teaching hospitals. Furthermore, the NIS is limited in that it does not identify the presence of particular residency programs, therefore some teaching hospitals may not even have orthopedic or neurosurgical trainees. Other differences between teaching and nonteaching hospitals may contribute to the results. There may be variations in the accuracy of administrative coding between teaching and nonteaching hospitals and increased complications may represent greater scrutiny or more accurate documentation practiced at teaching hospitals. Additional measures of surgical complexity, such as multilevel fusions, which were observed more frequently at teaching hospitals, may also contribute to greater complications creating statistical outliers. Additional confounding variables that could not be measured, such as indications for surgery may differ between teaching and nonteaching hospitals. Lastly, differences in resource allocation and coordination of care may account for the longer length of stay and greater costs seen in teaching hospitals.

Teaching hospitals have, to the contrary, demonstrated superior outcomes for complex surgical procedures.[4,7,8] Meguid *et al*[8] demonstrated that patients treated for lung cancer resection did better at hospitals with thoracic surgery residency programs. Factors contributing to surgical complexity cannot be measured through *ICD-9-CM* coding such as the degree of degeneration and preoperative functional scores. ACF is often considered the "gold standard" procedure for cervical spondylosis as it affords the surgeon the ability to decompress the canal while restoring both disc height and sagittal alignment. Therefore, it is not surprising that ACF was the most commonly performed procedure (82.4%) and the distribution of ACFs performed at teaching and nonteaching hospitals was almost equivalent (52.4% *vs*. 47.6%) (Figure 1). Posterior surgical techniques are often used for multiple-level pathology that cannot be addressed anteriorly and therefore represent more challenging cases.[24,25] As such, posterior-based approaches to the cervical spine are performed less frequently, as was observed in this study. Of the posterior cervical surgical procedures identified, 61.5% of PCDs and 69.1% of PCFs were performed in teaching hospitals. Furthermore, a greater percentage of fusions performed at teaching hospitals are 3+ levels (Table 3). This trend toward more posterior procedures and multilevel fusions performed in teaching hospitals suggests that these hospitals are, in fact, performing more of the complex surgical procedures.

There were several small but statistically significant differences in demographics between patients treated in teaching and nonteaching hospitals. Compared with nonteaching hospitals, there were trends for teaching hospitals to treat patients who were slightly younger (0.2 yr), had equivalent comorbidity scores (CCI = 2.10), and a greater percentage of male and minority patients. It is important to remember that differences based on teaching status are quite small, but reached statistical significance due to the very large sample size.

Admission characteristics also differed between teaching and nonteaching hospitals. On average, LOS was 0.3 days greater, hospital costs were $462 greater, and more patients were discharged to skilled nursing facilities when treated in teaching hospitals. There are likely several reasons for these findings. As previously mentioned, more complex surgical procedures are typically performed in teaching hospital settings that may incur greater hospitalization days and costs.[26] The fact that median LOS and costs were much lower than the mean for all groups suggests that outlying patients with extended admissions likely skewed the mean. Median LOS was equivalent between teaching and nonteaching hospitals suggesting most patients stay 1 day after an ACF, 2 days after a PCD, and 3 days after a PCF. Median costs were still slightly higher in teaching hospitals. Medicare diagnosis-related group payments are uniformly higher in teaching hospitals, as they fund graduate medical education.[27] As such, it is expected that hospital costs for the same care is expected to be greater at teaching hospitals.

Overall, morbidity and mortality was greater in teaching hospitals. It is important to remember that complication and mortality rates are reported as incidence per 1000 cases. As such, these differences are actually quite small, but reached statistical significance due to the extremely large sample size. The total inhospital complication rate was 2.4% and 1.7% in teaching and nonteaching hospitals, respectively; a difference of 0.7%. When examining specific complications rates, the differences between teaching and nonteaching hospitals was typically less than 0.1% higher at teaching hospitals. The difference in the overall mortality rate is 0.06%. Once again, these differences may be due to an increased surgical complexity.

There are limitations to using the NIS database for research. First, the NIS only provides a cross-sectional analysis of patients at the time of discharge. Readmissions cannot be identified, as each admission is included as a separate entry in the database. Complication rates are expected to increase with longer follow-up.[28,29] As such, it is difficult to distinguish if the increased complications observed at teaching hospitals is because of a greater average LOS or other factors. Another limitation to research with administrative databases is the use of *ICD-9-CM* coding for data collection. Studies have demonstrated low sensitivities and positive predictive values for *ICD-9-CM* codes in capturing perioperative complications in administratively coded data.[30,31] Because of these limitations, the complication rates identified in this study likely underestimate the true incidences.

CONCLUSION

The results of this study identified subtle, yet significant differences between teaching and nonteaching hospitals. Patients treated in teaching hospitals had a greater percentage of 3+ level fusions, longer hospitalizations, increased costs, and increased mortality *versus* patients treated in nonteaching hospitals. Incidences of postoperative complications were also identified as slightly higher in teaching hospitals. Each type of hospital has its own strengths and serves a unique and critical role in its community.[32] Future studies should identify long-term complication, cost, and outcome differences between teaching and nonteaching hospitals beyond the perioperative time period. Additionally, future investigations should clarify baseline differences in patients (*e.g.*, disease severity, functional scores, insurance status) that may also exist between teaching and nonteaching hospitals and control for these confounding variables. However, a large prospective study would prove difficult to execute, as it requires multicenter involvement of both academic and private surgeons; therefore, longitudinal administrative databases are needed to perform this observational research.

➢ Key Points

- ❑ The NIS database was analyzed to identify differences based on hospital teaching status for patients undergoing cervical spine surgery.
- ❑ Teaching hospitals perform a higher volume of cervical spine procedures than nonteaching hospitals.
- ❑ Due to the large sample size, many small but statistically significant differences were identified on the basis of teaching status.
- ❑ Patients treated at teaching hospitals demonstrated increased hospitalization stays, costs, complication rates, and mortality compared with patients treated at nonteaching hospitals.
- ❑ Possible explanations for these differences are that more multilevel fusions and a greater number of posterior approaches are performed at teaching hospitals.

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