Surgeon Specialty Effect on Early Outcomes of Elective Posterior/Transforaminal Lumbar Interbody Fusions: An Updated Propensity-Matched and Subgroup Analysis of 13,072 Patients.

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Abstract

Comparative effectiveness research has a vital role in recent health reform and policies. Specialty training is one of these provider-side variables and surgeons who were trained in different specialties may have different outcomes upon performing the same procedure. The objective of this retrospective 1:1 propensity score-matched cohort study was to investigate the impact of spine surgeon specialty (neurosurgery vs orthopedic surgery) on early perioperative outcome measures of elective posterior/transforaminal lumbar interbody fusion for degenerative spine diseases. 22,176 patients were reviewed from ACS-NSQIP database. Propensity score matching and subgroup analysis were utilized. After controlling for baseline characteristics in both groups (single/multi-level PLIF/TLIF), patients operated on by neurosurgeons were more likely to have longer operation time (239 vs 205 minutes / 276 vs 254 minutes), shorter total hospital stay (75 vs 96 hours / 85 vs 103 hours), lower return to operating room rates within the same admission (2.2% vs 4.2% / 2.5% vs 4.3%), lower non-home discharge (8.8% vs 12.7% / 10.8% vs 18.2%), lower discharge rate after postoperative day 3 (28% vs 31.8% / 38.1% vs 43.9%), lower readmission rates (4.4% vs 6.5% / 4.5% vs 7.5%) and lower perioperative blood transfusion rate (2.7% vs 6.0% / 11.0% vs 14.1%), ($p < 0.05$). Other outcome measures and mortality rates were similar among the 2 cohorts in both groups. Our analysis found significant differences in early perioperative outcomes of patients undergoing PLIF/TLIF by neurosurgeons and orthopedic surgeons. These differences have significant clinical and cost implications for patients, physicians, program directors, payors and health systems.

Introduction

Degenerative disease of the spine is one of the common and costly condition in the United States.[29,17] Although instrumented PLF has been historically the most commonly used approach for lumbar fusion, recent developments of interbody fusion techniques, including PLIF/TLIF, have increased in popularity.[12]

Spine surgery is performed by specialists credentialed in either neurological or orthopedic surgery. Given the differences in training between neurological and orthopedic surgeons including training duration, case volume, and fellowship requirements, several studies have investigated the impact of specialty training on procedural/patient outcomes of spinal fusion. [18,15,31] However, these studies have been limited by including multiple spinal fusion levels (cervical, thoracic, and lumbar) and multiple surgical technique in the same analysis.[18,15,31] Moreover, the results have been limited by confounding of preoperative functional status (independent versus dependent) and urgency of surgery (elective versus emergent) [18,15]. Both factors affect outcomes in reported literature [13]. One of the previous studies reported unadjusted odds ratios for outcomes, without an adjusted odds ratio accounting for multivariate regression models [15]. Prior studies also excluded post-operative measures associated with patient outcomes including the proportion of patients requiring ICU admission, hospital discharge destination [18,15,31].

This present study used the most recent data the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to examine the effect of spine surgeon specialty on early morbidity and mortality after elective PLIF/TLIF utilizing strict propensity score matching analysis and subgroup analysis to minimize the effects of any preoperative characteristic differences between cohorts [2]. We hypothesized that there is no significant difference in patient perioperative outcomes between orthopedic and neurological surgeons performing PLIF/TLIF.

Material And Methods

Data Acquisition and Patient Selection

The ACS-NSQIP database provides reliable surgical outcomes data submitted from participating hospitals. In 2017, 708 hospitals contributed data on patient demographics, preoperative health status, risk factors, and 30-day postoperative mortality and morbidity outcomes [16,33] . All variables were used as defined in the ACS-NSQIP User Guide, and outcomes were reported for 30 days after the index surgery. [16] Data from 2015 through 2018, were analyzed using current procedural terminology (CPT) codes for PLIF/TLIF (22630/ Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar), (22633/ Arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; lumbar). The secondary Current Procedure Terminology codes for an additional level (22632/ Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar, each additional interspace), (22634/ Arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; lumbar) were then used to stratify the cohort into 2 groups (single/multi-level). Patient undergoing emergency surgeries, other spinal procedures, spinal procedures at multiple sites, oncologic spine surgeries, and patients with missing perioperative data were excluded. NSQIP Data use agreement was approved. De-identified patient information is freely available to all institutional members who comply with the ACS NSQIP Data Use Agreement. The Data Use Agreement implements the protections afforded by the Health Insurance Portability and Accountability Act of 1996 and the ACS NSQIP Hospital Participation Agreement. Institutional IRB and Patients’ consents were not required. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Outcome Variables

Thirty-day postoperative morbidity and mortality outcomes were analyzed. Complications included pulmonary embolism, DVT/ thrombophlebitis, perioperative blood transfusion, myocardial infarction, stroke with neurological deficit, unplanned intubation, pneumonia, urinary tract infection, surgical site infection, sepsis, return to operating room, and death. Hospital course data, including operative time, the total length of hospital stay, the proportion of patients requiring ICU admission, the proportion of patients discharged to other than home and discharged after postoperative day 3 were also noted. Readmission data was included. These outcome variables are predefined in the ACS-NSQIP database [26], except for the discharge event after postoperative day 3, which was considered to be any discharge event occurring after a total hospital stay of 96 hours.

Statistical Analysis

The specialty of spine surgeon (neurosurgery vs orthopedic surgery) performing the procedure was used as group indicator resulting in 2 cohorts of PLIF/TLIF cases. To minimize the effects of any preoperative characteristic differences between the cohorts, propensity score matching was used before evaluating outcomes differences using SPSS Statistics for Windows, Version 26.0 (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp)/ Statistics Regression module and the Python Essentials. All preoperative categorical variables were dichotomized to either present or absent. Variables included in propensity score matching were age, gender, ethnicity, race, body mass index, diabetes mellitus, hypertension, smoking status, steroid use, history of chronic obstructive pulmonary disease, history of congestive heart failure, disseminated caner, bleeding disorders, inpatient versus outpatient status, American Society of Anesthesiologists (ASA) class, and pre-operative functional status. Match tolerance was set at 0.01. Pearson chi-squared or Fisher exact tests (when appropriate) were used for categorical variables, and student's *t* tests were used for continuous variables to measure the statistical differences between the 2 cohorts [38,3,36]. A p value $\leq$ 0.05 was considered to be statistically significant. The effect of pre-operative functional health status of the patients on outcomes was further identified using regression models to explain the difference in the results between our study and the prior published studies. In addition, the association between pre-operative functional health status and surgeon specialty was identified through Chi-Square Test or Fisher Exact Test (when appropriate) on the unmatched dataset.

Results

22,176 PLIF/TLIF cases met inclusion criteria and were reviewed. 15,216 cases underwent single-level PLIF/TLIF, and 6,960 cases underwent multilevel PLIF/TLIF. In the single-level group, there were 10,043 patients (66%) and 5,173 patients (34%) in the neurosurgery and orthopedic surgery cohorts, respectively. In the multi-level group, there were 4,315 patients (62%) and 2,645 patients (38%) in the neurosurgery and orthopedic surgery cohorts, respectively. (Table 1).

Table 1

Baseline demographics of patients with single/multi-level TLIF/PLIF.

	Single-Level TLIF/PLIF (n=15,216)			Multi-Level TLIF/PLIF (n=6,960)		
	Neurosurgery (n=10,043), (66%)	**Orthopedic Surgery (n =5,173), (34%)**	**P Value**	**Neurosurgery (n =4,315), (62%)**	**Orthopedic Surgery (n=2,645), (38%)**	**P Value**
Demographics						
Age (years)	58.2±10.5	54.4±11.2	**<0.001**	62.9±10.4	60±10.2	**<0.001**
BMI (kg/m^2)	31.7±5.9	29.2±5.6	**<0.001**	31.4±5.4	28.0±5.1	**<0.001**
Hispanic ethnicity	452 (5.4%)	316 (6.1%)	0.08	237 (5.5%)	140 (5.3%)	0.72
Race						
White	7733 (77.0%)	3678 (71.1%)	**<0.001**	3228 (74.8%)	1878 (71%)	**<0.001**
Gender						
Male	4429 (44.1%)	2571 (49.7%)	**<0.001**	2067 (47.9%)	1307 (49.4%)	0.22
Perioperative factors						
Admission Status: Inpatient	9611 (95.7%)	4920 (95.1%)	0.09	4220 (97.8%)	2592 (98%)	0.57
ASA Classification status ≥3	4831 (48.1%)	2126 (41.1%)	**<0.001**	2252 (52.2%)	1217 (46 %)	**<0.001**
Current Smoker within 1 year	2199 (21.9%)	1004 (19.4%)	**<0.001**	872 (20.2%)	428 (16.2%)	**<0.001**
Diabetes Treated with Medication	1758 (17.5%)	859 (16.6%)	0.16	854 (19.8%)	428 (16.2%)	**<0.001**
Dyspnea	582 (5.8%)	134 (2.6%)	**<0.001**	211 (4.9%)	124 (4.7%)	0.71
Disseminated Cancer	10 (0.1%)	10 (0.2%)	0.11	13 (0.3%)	5 (0.2%)	0.43
History of COPD	452 (4.5%)	150 (2.9%)	**<0.001**	186 (4.3%)	103 (3.9%)	0.42
History of CHF	30 (0.3%)	21 (0.4%)	0.31	13 (0.3%)	5 (0.2%)	0.43
HTN Requiring Medication	5524 (55%)	2461 (47.6) %	**<0.001**	2710 (62.8) %	1484 (56.1%)	**<0.001**

Steroid Use	412 (4.1%)	197 (3.8%)	0.37	181 (4.2%)	108 (4.1%)	0.84
Bleeding Disorders	121 (1.2%)	47 (0.9%)	0.09	65 (1.5%)	37 (1.4%)	0.74
Functionally Dependent Prior to Surgery	352 (3.5%)	83 (1.6%)	**<0.001**	168 (3.9%)	37 (1.4%)	**<0.001**

- Age and body mass index (BMI) reported as mean values ±SD. Remaining data are reported as counts (n) and percentages (%).

- ASA: American Society of Anesthesiologists; COPD: chronic obstructive pulmonary disease, CHF: congestive heart failure, HTN: hypertension.

∗ Statistically significant ($P < 0.05$).

Demographics and Baseline Characteristics

In both single/multi-level groups, patients in the neurosurgery cohort were more likely to be older, have higher BMI, be of white race, have an ASA class 3 or more, be a smoker, have hypertension, and be functionally dependent. In the single-level groups, patients in the neurosurgery cohort were more likely to be male, have COPD and have baseline dyspnea ($P < 0.05$), while in multi-level groups, patients in the neurosurgery cohort were more likely to have diabetes mellitus.

Propensity score matching was subsequently performed. Well-matched cohorts (neurosurgery/orthopedic surgery) were obtained in both groups (single/multi-level PLIF/TLIF). After matching, no demographic variables or comorbidities varied significantly between the two cohorts (Table 2).

Table 2

Baseline demographics of propensity-matched patients with single/multi-level TLIF/PLIF.

	Single-Level TLIF/PLIF (n=9060)			Multi-Level TLIF/PLIF (n=4012)		
	Neurosurgery (n=4530), (50%)	Orthopedic Surgery (n=4530), (50%)	P Value	Neurosurgery (n=2006), (50%)	Orthopedic Surgery (n=2006), (50%)	P Value
Demographics						
Age (years)	54.4±10.1	54.7±9.9	0.2	60.6±8.1	60.4±7.5	0.4
BMI (kg/m^2)	30.8±4.5	30.7±4.9	0.3	30.9±5.1	30.8±4.8	0.5
Hispanic ethnicity	236 (5.2%)	249 (5.5%)	0.53	120 (6.0%)	110 (5.5%)	0.5
Race						
White	3289 (72.6%)	3234 (71.4%)	0.2	1406 (70.1%)	1412 (70.4%)	0.84
Gender						
Male	2274 (50.2%)	2242 (49.5%)	0.51	977 (48.7%)	991 (49.4%)	0.66
Perioperative factors						
Admission Status: Inpatient	4331 (95.6%)	4317 (95.3%)	0.49	1972 (98.3%)	1968 (98.1%)	0.63
ASA Classification status ≥3	1889 (41.7%)	1857 (41%)	0.5	973 (48.5%)	967 (48.2%)	0.85
Current Smoker within 1 year	883 (19.5%)	865 (19.1%)	0.63	337 (16.8%)	329 (16.4%)	0.73
Diabetes Treated with Medication	775 (17.1%)	729 (16.1%)	0.2	367 (18.3%)	371 (18.5%)	0.87
Dyspnea	145 (3.2%)	127 (2.8%)	0.26	82 (4.1%)	88 (4.4%)	0.64
Disseminated Cancer	5 (0.1%)	6 (0.1%)	>0.99	4 (0.2%)	2 (0.1%)	0.41
History of COPD	154 (3.4%)	136 (3%)	0.28	68 (3.4%)	74 (3.7%)	0.61
History of CHF	14 (0.3%)	18 (0.4%)	0.42	8 (0.4%)	4 (0.2%)	0.24
HTN Requiring Medication	2211 (48.8%)	2179 (48.1%)	0.51	1157 (57.7%)	1159 (57.8%)	0.95

Steroid Use	186 (4.1%)	172 (3.8%)	0.46	96 (4.8%)	90 (4.5%)	0.65
Bleeding Disorders	27 (0.6%)	36 (0.8%)	0.25	36 (1.8%)	32 (1.6%)	0.62
Functionally Dependent Prior to Surgery	95 (2.1%)	77 (1.7%)	0.2	26 (1.3%)	28 (1.4%)	0.78

- Age and body mass index (BMI) reported as mean values ±SD. Remaining data are reported as counts (n) and percentages (%).

- ASA: American Society of Anesthesiologists; COPD: chronic obstructive pulmonary disease, CHF: congestive heart failure, HTN: hypertension.

∗ Statistically significant ($P < 0.05$).

Outcome Measures

Thirty-day postoperative outcomes are demonstrated in Table 3. In both groups (single/multi-level PLIF/TLIF), patients operated on by neurosurgeons were more likely to have longer operation time (239 vs 205 minutes / 276 vs 254 minutes), shorter total hospital stay (75 vs 96 hours / 85 vs 103 hours), lower return to operating room rates within the same admission (2.2% vs 4.2% / 2.5% vs 4.3%), lower non-home discharge (8.8% vs 12.7% / 10.8% vs 18.2%), lower discharge rate after postoperative day 3 (28% vs 31.8% / 38.1% vs 43.9%), lower readmission rates (4.4% vs 6.5% / 4.5% vs 7.5%) and lower perioperative blood transfusion rate (2.7% vs 6.0% / 11.0% vs 14.1%), ($p < 0.05$). Other outcome measures and mortality rates were similar among the 2 cohorts in both groups.

Table 3

TLIF/PLIF outcome by specialty.

	Single-Level TLIF/PLIF (n=9060)			Multi-Level TLIF/PLIF (n=4012)		
	Neurosurgery (n=4530), (50%)	**Orthopedic Surgery (n=4530), (50%)**	**P Value**	**Neurosurgery (n=2006), (50%)**	**Orthopedic Surgery (n=2006), (50%)**	**P Value**
Hospital Course						
Length of hospital stay (hours)	75±68.4	96±67.9	**<0.001**	85±68.5	103±60.5	**<0.001**
Total operation time (minutes)	239±60.1	205±61.2	**<0.001**	276±62.2	254±61.3	**<0.001**
Return to operating room	100 (2.2%)	190 (4.2%)	**<0.001**	50 (2.5%)	86 (4.3%)	**0.002**
Need for ICU	18 (0.4%)	14 (0.3%)	0.42	10 (0.5%)	12 (0.6%)	0.67
Discharge Measures						
Discharged other than home	399 (8.8%)	575(12.7%)	**<0.001**	36 (10.8%)	365 (18.2%)	**<0.001**
Discharged >3 postoperative day	1268 (28%)	1441 (31.8%)	**<0.001**	764(38.1%)	881 (43.9%)	**<0.001**
Remained in hospital more than 30 days	5 (.1%)	9 (0.2%)	0.22	6 (0.3%)	4 (0.2%)	0.53
Unplanned readmission	199 (4.4%)	294 (6.5%)	**<0.001**	90 (4.5%)	150 (7.5%)	**<0.001**
Medical Complications						
Perioperative blood transfusion	122 (2.7%)	272 (6%)	**<0.001**	221 (11%)	283 (14.1%)	**0.003**
Pulmonary embolism	9 (0.2%)	14 (0.3%)	0.34	4 (0.2%)	8 (0.4%)	0.25
DVT/ thrombophlebitis	27 (0.6%)	18 (0.4%)	0.18	6 (0.3%)	10 (0.5%)	0.32
Myocardial Infarction	5 (0.1%)	6 (0.1)	>0.99	8 (0.4%)	12 (0.6%)	0.37
Stroke with neurological deficit	5 (0.1%)	9 (0.2%)	0.22	6 (0.3%)	4 (0.2%)	0.53

Unplanned Intubation	18 (0.4%)	9 (0.2%)	0.08	14 (0.7%)	8 (0.4%)	0.2
Pneumonia	18 (0.4%)	23 (0.5%)	0.5	28(1.4%)	18 (0.9%)	0.14
Urinary Tract Infection	45 (1%)	54 (1.2%)	0.36	42 (2.1%)	38 (1.9%)	0.65
Surgical Site Infection (SSI)						
Deep	23 (0.5%)	27 (0.6%)	0.52	4 (0.2%)	8 (0.4%)	0.25
Superficial	63 (1.4%)	59 (1.3%)	0.68	38 (1.9%)	26 (1.3%)	0.13
Systemic Complications – Mortality						
Sepsis	27 (0.6%)	18 (0.4%)	0.17	18 (0.9%)	16 (0.8%)	0.73
Septic Shock	5 (0.1%)	9 (0.2%)	0.22	4 (0.2%)	2 (0.1%)	0.41
Death	9 (0.2%)	14 (0.3%)	0.34	8 (0.4%)	6 (0.3%)	0.6
Continuous variables reported as mean values ±SD.						

Effect of functional health status on outcomes

The impact of pre-operative functional health status (independent vs dependent) of the patients on outcomes were further investigated using regression models. Being functionally dependent predicted worse postoperative outcomes, Table 4. In addition, the association between functional health status and surgeon specialty was identified through Chi-Square Test or Fisher Exact Test (when appropriate) on the unmatched dataset. Patients operated on by neurosurgeons were significantly more likely to be dependent when compared to patients operated on by orthopedic surgeons, Table 1.

Table 4

The effect of pre-operative functional health status on thirty-day postoperative outcomes in patients undergoing PLIF/TLIF.

Outcome	Bivariate Logistic Regression		Multivariate Logistic Regression	
	OR	P	OR	P
Need for ICU	3.5	0.08	1.4	0.7
Length of hospital stay			5.9*	**0.001**
Discharged other than home	12.1	**0.001**	5.4	**0.001**
Discharged >3 postoperative day	5.1	**0.001**	3.1	**0.01**
Return to operating room	4.4	**0.001**	2.5	**0.03**
Unplanned readmission	4.2	**0.001**	2.9	**0.001**
Pulmonary embolism	2.3	0.4	2.1	0.5
DVT/ thrombophlebitis	5.1	**0.02**	1.1	0.2
Myocardial Infarction	7.0	**0.002**	1.7	0.6
Stroke with neurological deficit	—	–	–	–
Unplanned Intubation	9.3	**0.001**	1.2	0.2
Pneumonia	8.8	**0.001**	2.3	0.1
Urinary Tract Infection	5.0	**0.001**	2.1	0.09
Surgical Site Infection (SSI)				
Deep	–	–	–	–
Superficial	1.3	0.8	1.6	0.5
Sepsis	4.9	**0.001**	2.9	0.09

*Coefficients in linear regression.

Univariate and multivariate regression were used to demonstrate the effect of functional health status as a predictor on each of the outcome measures in the tables. The regression analysis was conducted on the unmatched cohorts with age, ASA class and number of levels (single vs. multiple) adjusted in all regression models. Additional predictors were included for regression analysis for some outcomes if they had relative high prevalence rate.

Discussion

It was estimated that the percentage of patients undergoing lumbar interbody fusion for degenerative spondylolisthesis increased from 13 % to more than 30% between 1999 and 2011.[10] Recently, there has been a significant increase in use of lumbar interbody fusion, and this was accompanied by an increase in the age and number of comorbidities in patients undergoing this procedure. [17,22] Therefore, postoperative morbidity and mortality measures of lumbar fusions have been the focus of recent research. [35,18]

Specialty training is considered an important provider-side variable driving differences in comparative effectiveness between surgeons [8]. The effect of surgeon specialty on outcomes of spinal fusion surgeries has been examined by several studies [18,31]. A recent study conducted on MarketScan database[15] included patients undergoing lumbar laminectomy or lumbar fusion surgeries, reported that lumbar fusion cases operated by neurosurgeons have slightly higher odds of experiencing any complication (OR, 1.1) and higher revision surgery rate (OR, 1.14), however, this study was limited by reporting the bivariate logistic regression results only and without adjusting for any potential confounding through multivariate logistic regression, despite the fact that the patients in the neurosurgery cohort where significantly more comorbid than the orthopedic cohort [15]. Other studies concluded that spine surgeon specialty is not a risk factor for any of the reported postoperative complications in patients undergoing spinal fusions except for the observed higher rate of perioperative blood transfusion [18,31], and slightly higher odds for prolonged length of stay among orthopedic surgeons [31]. Similar to previous reports in the spine literature [18,31], our analysis showed that PLIF/TLIF patients operated by orthopedic surgeons were more likely to receive perioperative blood transfusion when compared to similar patients operated by neurosurgeons. Moreover, while a previous study [31] reported that patients undergoing spinal fusions have slightly higher odds for prolonged length of stay among orthopedic surgeons, our study added that PLIF/TLIF patients operated by orthopedic surgeons were more likely to have higher return to operating room rates within the same admission, be discharged to destination other than home, be discharged after postoperative day 3, and higher readmission rates.

The differences in results between our current study and previous studies might be explained by several reasons. It is worth mention that previous studies have been limited by significant heterogeneity since they included different spinal fusion levels (cervical, thoracic and lumbar), number of operative levels, and surgical techniques in the same analysis [18,31]. In contrast, we included a homogenous cohort of patients undergoing PLIF/TLIF for degenerative spine disease and we further stratified the cohort into single- and multi-level groups to account for these limitations in previous reports. In addition, previous studies did not control for the preoperative functional health status (independent / dependent), and surgery status (elective/emergency) [18] which several studies showed that they have significant effect on the outcomes [13]. In fact, our analysis on patients undergoing PLIF/TLIF showed that patients operated on by neurosurgeons were significantly more likely to be dependent and that being dependent predicts worse outcomes, Tables (1, 4). Therefore, adjusting for such confounding variables are important to avoid biased results. We also limited our cohort to elective surgeries to avoid the confounding of this variable that was present in previous reports.

These differences between the cohorts might be attributed to different trends in spine surgery training during neurological and orthopedic surgery residencies. Although both residency specialties are exposed to subspecialty spine training, the length of training as well as the level of exposure of spinal pathology itself have been found to vary greatly.[5,14,21,34,30] A recent study [20] included a ten-year analysis of ACGME case log data and found that case volume of spine surgery procedures is significantly larger for neurological surgery residencies when compared to the orthopedic counterparts. Moreover, they found that this discrepancy in case volume is enlarging over time, [20] which might explain that these differences between the 2 cohorts were apparent in our updated analysis, while they were not present in previous similar studies. Despite that case volume alone cannot solely determine the quality of training, it is considered one of the key measures to assess opportunities to develop optimal surgical education[20]. Another study [6], which evaluated self-assessed surgical competence of senior neurosurgery and orthopedic residents by mail-out questionnaire, concluded that neurosurgery residents graduate with a significantly higher level of confidence to perform spine surgery (which included cervical and lumbar fusions), while orthopedic residents report significantly higher need for additional training in spine surgery.

Moreover, our study showed that nationally, nearly 2 times as many PLIF/TLIF procedures are performed by neurosurgeons than orthopedic surgeons. One possibility is that ACS-NSQIP database includes cases from larger or academic institutions [18,19] that might employ more neurosurgeons who perform spine procedures than orthopedic surgeons.

Although the reasons behind these differences between the two cohorts remain largely unknown and might be beyond the scope of this study, it is worth mentioning that these outcome measures might have significant clinical and cost implications for patients, physicians, program directors, hospitals and payors [28,37,27,1]. The higher incidence of blood transfusion among orthopedic cohort is of interest since it may represent a potentially modifiable practice. Purvis et al reported that higher perioperative blood transfusion might be associated with increased morbidity in patients undergoing spine surgery and that modification of transfusion practice may be a potential area for improving patient outcomes and reducing costs [25,24]. This is concordant with a study by Corwin et al which concluded that packed red blood cell transfusion is an independent risk factor for increase in patient morbidity, mortality, and length of stay [4]. In addition, a more recent institutional study showed more than $2 million savings when packed red blood cell transfusions were decreased by one third.[23] Shields et al [32] recently demonstrated that each hour of decreased length of hospital stay following lumbar fusion directly correlated with cost savings. Moreover, Hydrick et al found that 90-day readmissions were associated with an average of $96 152 in increased hospital costs per patient following lumbar fusion [7].

Overall, focused studies are encouraged in the future to address potential reasons and possible solutions for these differences between the two cohorts.

Limitations:

The retrospective design of the study is a major limitation. In addition, selection bias, confounding and reliability of data collection remain potential concerns. However, a strict propensity score matching (match tolerance of 1%) was applied to minimize bias and confounding of different variables, yielding similar, matched cohorts, and improving the internal validity of the paper. The ACS-NSQIP database provides data with high rates of inter-rater reliability and validation sets performed. Per NSQIP, audit reports have revealed an overall disagreement rate of less than 2% [9,33,11]. The ACS-NSQIP database does not include data on skill level of individual surgeons, such as years in practice, which may have an effect on the outcome. Moreover, the ACS-NSQIP database does not include several variables of interest specific to neurosurgery, including postoperative symptom relief, rates of neurological complications, such as postoperative sensory loss, weakness, or cerebrospinal fluid leak, and outcomes beyond the 30-day postoperative period. Finally, although ACS-NSQIP covers a broad base of hospitals –more than 700 hospitals-, only a fraction of hospitals participates in ACS-NSQIP, which might limit the (external validity) generalizability of these data.

Conclusion

This study represents an updated analysis of the surgeon specialty effect on a wide spectrum of early outcomes of PLIF/TLIF. We found that nearly two times as many PLIFs/TLIFs are performed by neurosurgeons than orthopedic surgeons. Although PLIFs/TLIFs patients operated by neurosurgeons had significantly more preoperative comorbidities, our analysis showed that, in both groups (single/multi-level PLIF/TLIF), patients undergoing elective PLIF/TLIF for degenerative spine disease by neurosurgeons were more likely to have longer operation time, shorter total hospital stay, lower return to operating room rates within the same admission, lower non-home discharge, lower discharge rate after postoperative day 3, lower readmission rates and lower perioperative blood transfusion rate. These outcome measures might have significant clinical and cost implications for patients, payors, hospitals and physicians. Focused studies are encouraged to address potential reasons and possible solutions for these differences between the cohorts.

Declarations

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Availability of data and material (data transparency):

NSQIP Database.

Code availability:

SPSS Statistics for Windows, Version 26.0 (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp)/ Statistics Regression module and the Python Essentials.

Ethics approval:

not applicable, NSQIP Data use agreement was approved. De-identified patient information is freely available to all institutional members who comply with the ACS NSQIP Data Use Agreement. The Data Use Agreement implements the protections afforded by the Health Insurance Portability and Accountability Act of 1996 and the ACS NSQIP Hospital Participation Agreement. Institutional IRB and Patients' consents were not required.

Consent to participate:

not applicable.

Consent for publication:

not applicable.

Authors' contributions (All authors must be mentioned)

Alomari and Planchard extracted the data, analyzed the data, and contributed to writing the manuscript.

Belzberg, Lo, Theodore, Sciubba,Witham, and Bydon contributed to the design of the study and writing the manuscript.

All authors reviewed the manuscript critically.

Bydon supervised the work.

Abbreviations

ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program, ASA: American Society of Anaesthesiologists, CPT: Current procedural terminology, PLF: Posterior Lumbar Fusion, PLIF: Posterior Lumbar Interbody Fusion, TLIF: Transforaminal Lumbar Interbody Fusion.

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