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Comparative Analysis of 30-Day Readmission, Reoperation, and Morbidity Between Lumbar Disc Arthroplasty Performed in the Inpatient and Outpatient Settings Utilizing the ACS-NSQIP Dataset

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Abstract

Study Design: Retrospective cohort study.

Objective: Spine surgery has been increasingly performed in the outpatient setting, providing greater control over cost, efficiency, and resource utilization. However, research evaluating the safety of this trend is limited. The objective of this study is to compare 30-day readmission, reoperation, and morbidity for patients undergoing lumbar disc arthroplasty (LDA) in the inpatient versus outpatient settings.

Methods: Patients who underwent LDA from 2005 to 2018 were identified using the ACS-NSQIP (American College of Surgeons National Surgical Quality Improvement Program) database. Regression was utilized to compare readmission, reoperation, and morbidity between surgical settings, and to evaluate for predictors thereof.

Results: We identified 751 patients. There were no significant differences between inpatient and outpatient LDA in rates of readmission, reoperation, or morbidity on univariate or multivariate analyses. There were also no significant differences in rates of specific complications. Inpatient operative time (138 $\pm$ 75 minutes) was significantly ($P < .001$) longer than outpatient operative time (106 $\pm$ 43 minutes). In multivariate analysis, diabetes ($P < .001$, OR = 7.365), baseline dyspnea ($P = .039$, OR = 6.447), and increased platelet count ($P = .048$, OR = 1.007) predicted readmission. Diabetes ($P = .016$, OR = 6.533) and baseline dyspnea ($P = .046$, OR = 13.814) predicted reoperation. Baseline dyspnea ($P = .021$, OR = 8.188) and ASA (American Society of Anesthesiologists) class $\geq$3 ($P = .014$, OR = 3.515) predicted morbidity. Decreased hematocrit ($P = .008$) and increased operative time ($P = .003$) were associated with morbidity in univariate analysis, but not in multivariate analysis.

Conclusions: Readmission, reoperation, and morbidity were statistically similar between surgical setting, indicating that LDA can be safely performed in the outpatient setting. Higher ASA class and specific comorbidities predicted poorer 30-day outcomes. These findings can guide choice of surgical setting given specific patient factors.

Keywords

lumbar, disc replacement, disc arthroplasty, readmission, reoperation, morbidity, complication, NSQIP, outpatient, inpatient

Introduction

Lumbar degenerative disc disease is one of the most commonly treated pathologies of the lumbar spine, with fusion as a widely utilized treatment modality.[1-7] However, concern exists for the acceleration of adjacent segment disease due to the absence of motion at the level of fusion.[3,8-10] Consequently, lumbar disc

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Table 1. Baseline Differences in Patient Demographic, Comorbidity, Laboratory, and Procedural Factors, and Primary Outcomes, Compared by Surgical Setting.

	Outpatient (N = 101), n (%)	Inpatient (N = 650), n (%)	P[a]	Cases available
Demographics				
Age, years, mean ± SD	43.0 ± 12.6	44.4 ± 13.1	.324	751
Obese	43 (42.6)	270 (41.5)	.844	751
Non-White race	12 (13.6)	63 (12.3)	.727	600
Male gender	71 (70.3)	408 (62.8)	.143	751
Comorbidities[b]				
Smoker	19 (18.8)	137 (21.1)	.602	751
Dyspnea	2 (2.0)	7 (1.1)	.346[c]	751
Diabetes mellitus	9 (8.9)	61 (9.4)	.879	751
COPD	0	8 (1.2)	.607[c]	751
Heart failure	0	1 (0.2)	1.000[c]	751
Hypertension	26 (25.7)	182 (28.0)	.637	751
Disseminated cancer	0	2 (0.3)	1.000[c]	751
Open wound infection	0	1 (0.2)	1.000[c]	751
Chronic steroid use	1 (1.0)	5 (0.8)	.581[c]	751
Bleeding disorder	0	3 (0.5)	1.000[c]	751
ASA class ≥3	26 (25.7)	129 (19.8)	.173	751
Lab values, mean ± SD				
Creatinine	0.91 ± 0.20	0.91 ± 0.43	.937	751
White cell count	7.17 ± 2.47	7.35 ± 2.28	.512	751
Hematocrit	42.79 ± 4.88	42.40 ± 4.05	.424	751
Platelet	246 ± 62	250 ± 63	.620	751
Procedural factors				
Operative time, min, mean ± SD	106 ± 43	138 ± 75	**<.001**	751
Primary outcomes				
Readmission	6 (6.3)	16 (2.7)	.108[c]	682
Reoperation	3 (3.0)	5 (0.8)	.080[c]	751
Morbidity	4 (4.0)	28 (4.3)	1.000[c]	751

Abbreviations: ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease.
[a] Boldfaced values indicate significance ($P < .05$).
[b] There were no instances of patients with the following comorbidities: preoperative transfusion, renal failure, on dialysis, ascites, ventilator dependence, or unexpected weight loss >10%.
[c] Fisher's exact test.

arthroplasty (LDA) was developed as a way to mitigate such stress on adjacent segments while restoring segmental stability, disc motion, and disc height.[4,10-12]

Spine surgery in general has been increasingly performed in the outpatient setting.[4-7,13-16] In the appropriate patient population, outpatient spine surgery offers greater control over cost, efficiency, and productivity, all of which are necessary to keep up with the demands of an aging population and a changing health care payment and delivery landscape.[7,14,15,17] However, short-term outcomes-research evaluating the safety of this trend is limited, particularly with regard to LDA.

Outcomes for LDA have demonstrated clinically significant improvements in pain and functionality, with minimal complication rates and high patient satisfaction.[4,13,18-21] However, there is also a paucity of data directly evaluating short-term outcomes for LDA. Moreover, there are currently no large-scale database studies that have compared short-term outcomes between LDA performed in the inpatient and outpatient settings. Therefore, the purpose of this study was to compare inpatient and outpatient LDA on the basis of 30-day readmission, reoperation, and morbidity. In addition, given that lumbar spine procedures are increasingly being performed on higher-risk patient populations, this study also explored predictors of readmission, reoperation, and morbidity. The results of this study will provide insight into the safety of performing LDA in the outpatient setting and into patient selection for those undergoing LDA.

Materials and Methods

Study Design and Population

This is a retrospective analysis of patient data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, from 2005 to 2018. This project is exempt from institutional review board approval as this database is de-identified and no direct patient involvement occurred.[2,22]

Patients ≥18 years old who underwent elective LDA were included and identified based on the Current Procedural Terminology (CPT) code of 22 857. Patients were excluded if they underwent multilevel, emergent, or revision surgery, had evidence of prior infection, or underwent additional procedures including cervical procedures, osteotomies, fusion, or posterior procedures (Supplementary Material A).

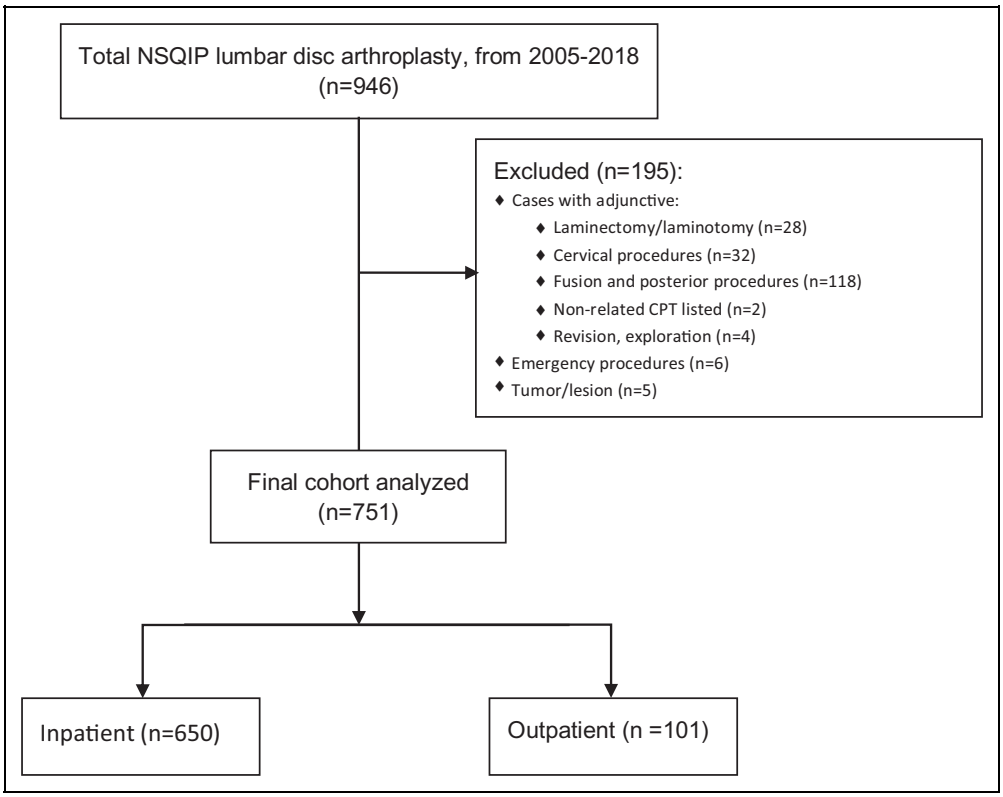

Figure 1. Flowchart demonstrating exclusion of patients. Adapted from the CONSORT 2010 flow diagram.

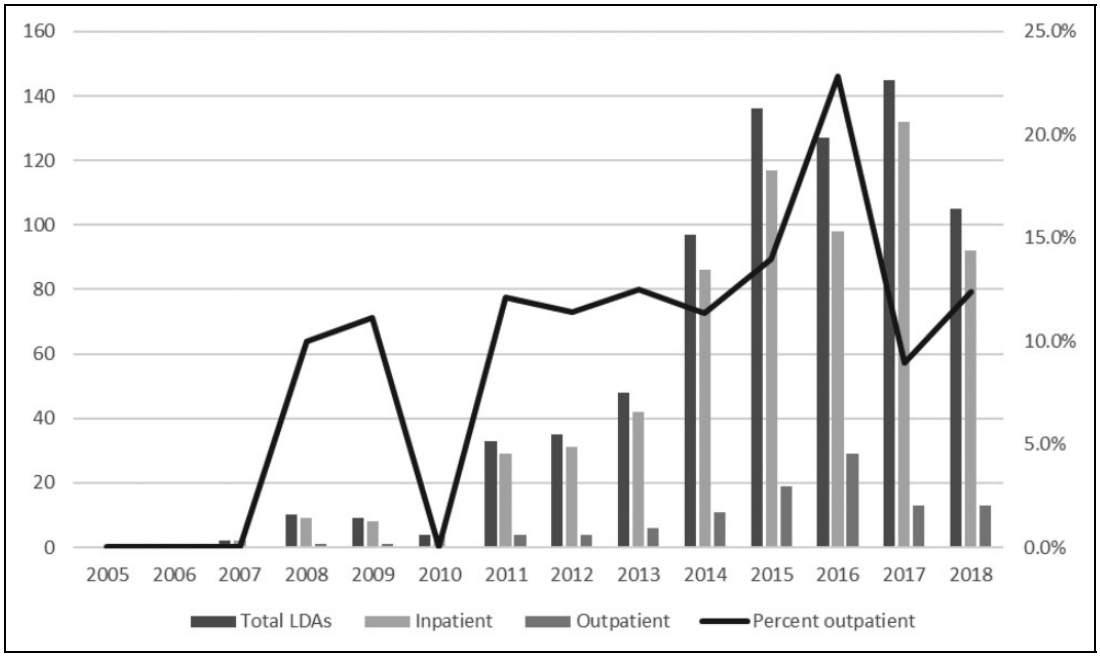

Figure 2. Number of lumbar disc arthroplasties (LDAs) performed in the inpatient and outpatient settings over duration of the study period from 2005 to 2018.

Outcomes and Variables

The NSQIP database provides data on whether patients were treated as inpatient or outpatient as defined by the NSQIP Participant Use Data File.[23] Patients were categorized into either inpatient or outpatient based on the provided variable.

Primary outcomes were 30-day readmission, reoperation, and morbidity. Readmission includes any inpatient stay to the

Table 2. Univariate and Multivariate Analysis of Specific Complications by Surgical Setting.

Specific complications[a]	Outpatient, n (%)	Inpatient, n (%)	P[b]
Site-related complication	3 (3.0)	11 (1.7)	.418
Superficial site infections	3 (3.0)	7 (1.1)	.140
Deep wound infections	0	1 (0.2)	1.000
Organ space infections	0	2 (0.3)	1.000
Dehiscence	0	1 (0.2)	1.000
Pulmonary complication	1 (1.0)	4 (0.6)	.515
Pneumonia	1 (1.0)	1 (0.2)	.251
Reintubations	0	1 (0.2)	1.000
Pulmonary embolism	0	3 (0.5)	1.000
Urinary tract infection	0	2 (0.3)	1.000
Cardiac arrest requiring CPR	0	1 (0.2)	1.000
Bleeding transfusions	0	11 (1.7)	.376
DVT/thrombophlebitis	0	2 (0.3)	1.000

Abbreviations: CPR, cardiopulmonary resuscitation; DVT, deep venous thrombosis.
[a] No complications were observed for the following variables: On ventilator >48 hours, progressive renal insufficiency, acute kidney injury, stroke/cerebrovascular accident, myocardial infarction, or sepsis.
[b] Fischer's exact test.

same or another hospital related to the surgical procedure.[23] The NSQIP database did not collect readmission data until 2011. Reoperation and morbidity outcomes were collected from the start of the dataset in 2005. Reoperation includes all major surgical procedures requiring unplanned return to the operating room.[23] Morbidity includes infectious, pulmonary, cardiac, renal, neurological, hematologic, and thromboembolic complications reported in the ACS-NSQIP dataset.[23,24] Primary outcomes, as well as specific complications, were compared between inpatient and outpatient LDA.

Predictors of primary outcomes were analyzed amongst the entire cohort. Variables evaluated as potential predictors included patient demographic, comorbidity, preoperative lab values, and procedural factors (Table 1). Variables with <80% of data available were excluded from multivariate analysis to avoid skewing of results.[24]

Statistical Analysis

Analyses were completed in SPSS (IBM Corp.). Demographic, comorbidity, laboratory, and procedural factors were individually analyzed for baseline differences between inpatients and outpatients using Student *t* test for continuous and chi-square or Fisher's exact test for categorical variables. The above factors were also individually analyzed for association with the primary outcomes using univariate logistic regression. Potential predictor variables from the univariate analyses that were either significant ($P < .05$) or trended toward significance ($P < .10$),[14] as well as surgical setting, were then evaluated for significance ($P < .05$) as independent predictors and control variables in a series of multivariate logistic regression analyses of the primary outcomes.

Results

We identified 751 patients (650 inpatient) who underwent LDA (Figure 1). With the exceptions of 2016 and 2018, the total number of LDAs performed yearly increased since the start of the dataset (Figure 2). The proportion of LDAs performed on an outpatient basis remained relatively steady year over year. Baseline group differences and unadjusted primary outcomes are provided in Table 1. Inpatient operative time (138 $\pm$ 75 minutes) was significantly ($P < .001$) longer than outpatient operative time (106 $\pm$ 43 minutes).

Primary Outcomes

Unadjusted analysis (Table 1) revealed that inpatients and outpatients had statistically similar rates of readmission (2.7% vs 6.3%, $P = .108$), reoperation (0.8% vs 3.0%, $P = .080$), and morbidity (4.3% vs 4.0%, $P = 1.000$), respectively. Surgical setting was not associated with any specific complications (Table 2). Rates of readmission (odds ratio [OR] = 1.862, $P = .326$), reoperation (OR = 4.566, $P = .068$), and morbidity (OR = 1.124, $P = .876$) remained statistically similar after adjusting for trending and significant patient-related factors on multivariate analysis (Tables 3-5).

Predictor Analysis

There were 22 readmissions (3.2%) in 682 patients. On multivariate analysis (Table 3), baseline dyspnea (OR = 7.365, $P = .039$), diabetes (OR = 6.447, $P < .001$), and increased platelet count (OR = 1.007, $P = .048$) independently predicted readmission. Decreased hematocrit was associated with readmission on univariate analysis, did not predict readmission on multivariate analysis.

Morbidity occurred in 32 of 751 patients (4.3%). On multivariate analysis (Table 5), baseline dyspnea (OR = 8.188, $P = .021$), ASA (American Society of Anesthesiologists) class ≥ 3 (OR = 3.515, $P = .014$), and increasing length of stay (OR = 1.144, $P = .014$) independently predicted morbidity. Decreased hematocrit, increased white cell count, and increased operative time were associated with morbidity on univariate analysis, but not on multivariate analysis.

Discussion

Comparison of Setting: Primary Outcomes

Despite an increasing trend toward performing outpatient lumbar spine surgeries, literature evaluating outpatient LDA is limited. In the present study, 30-day outcomes were statistically similar between inpatients and outpatients, indicating that LDA can safely be performed in the outpatient setting. This is further supported by the observation that there is significant variability in surgical outcomes between outpatient surgery centers, even after adjusting for patient factors and procedural complexity.[25] This may be related to equipment availability, access to laboratory draws, device access, support of specialty physicians, and so forth. In addition, we observed that the rate

Table 3. Univariate and Multivariate Analysis of Predictors of Readmission.

	Univariate				Multivariate
	Not readmitted (N = 660), n (%)	Readmitted (N = 22), n (%)	P^a	Odds ratio (95% CI)	P^a
Demographics					
Age, years, mean ± SD	44 ± 13	48 ± 15	.183		
Obese	279 (42.3)	9 (40.9)	.899		
Non-White race	67 (12.6)	2 (10.0)	1.000[b]		
Male gender	418 (63.3)	11 (50.0)	.203		
Comorbidities					
Smoker	136 (20.6)	5 (22.7)	.790		
Dyspnea	7 (1.1)	2 (9.1)	**.031**[b]	7.365 (1.102, 49.240)	**.039**
Diabetes	55 (8.3)	7 (31.8)	**.002**[b]	6.447 (2.312, 17.976)	**<.001**
COPD	5 (0.8)	0	1.000[b]		
Heart failure	1 (0.2)	0	1.000[b]		
Hypertension	175 (26.5)	9 (40.9)	.135		
Disseminated cancer	2 (0.3)	0	1.000[b]		
Open wound infection	0	0			
Chronic steroid use	4 (0.6)	1 (4.5)	.152[b]		
Bleeding disorder	2 (0.3)	0	1.000[b]		
ASA class ≥3	131 (19.8)	8 (36.4)	.100[b]		
Lab values, mean ± SD					
Creatinine	0.91 ± 0.42	0.87 ± 0.24	.614		
White cell count	7.29 ± 2.28	7.75 ± 2.29	.373		
Hematocrit	42.52 ± 4.14	40.17 ± 5.86	**.015**	0.937 (0.846, 1.036)	.205
Platelet	248 ± 62	279 ± 96	**.029**	1.007 (1.000, 1.014)	**.048**
Procedural factors					
Surgical setting			.108[b]	1.862 (0.538, 6.452)	.326
Inpatient	570	16 (2.7[c])			
Outpatient	90	6 (6.3[c])			
Operative time, minutes, mean ± SD	134 ± 72	161 ± 102	.092	1.004 (0.999, 1.009)	.112
Length of stay, days, mean ± SD	2.1 ± 3.0	2.5 ± 1.8	.618	0.989 (0.864, 1.131)	.989

Abbreviations: ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease.
[a] Boldfaced values indicate significance ($P < .05$).
[b] Fischer's exact test.
[c] Percent readmitted within inpatient and outpatient surgical settings.

of LDAs being performed in the outpatient setting had remained relatively static over the study period despite an overall increase in the total number of LDAs being performed. Given the lack of research on the safety of performing outpatient LDAs, this observation was not surprising.

The outcomes observed in the present study are consistent with literature for other outpatient spine procedures.[26-30] Bovonratwet et al[26] demonstrated significantly lower rates of bleeding events requiring transfusion for outpatient posterior lumbar fusion, with no significant difference between inpatient and outpatient readmission or reoperation rates. Pugley et al[28] demonstrated significantly greater rates of complication for inpatient compared with outpatient lumbar discectomy, with no difference in rates of reoperation. Low complication rates for outpatient discectomy have been well described.[27-30] Moreover, Segal et al[14] demonstrated no significant difference in rates of readmission, reoperation, or complication when comparing inpatient to outpatient cervical disc replacement.

Long-term studies of LDA have demonstrated rates of reoperation ranging from 6% to 16%.[3,19,21,31,32] Our early reoperation rate of 1.1% for the entire cohort is in line with these findings. The LDA literature provides scant data on readmission and varying data on complication rates. In a long-term follow-up study, Siepe et al[21] reported a complication rate of 14%, with half of complications related to the device itself. In a long-term and predominantly outpatient setting, Tohmeh et al[13] revealed zero intraoperative complications, but almost 16% of patients experienced transient postoperative neurological deficits. These figures exceed the 4.26% complication rate observed in the present study. Comparatively, in the cervical disc replacement literature, Chin et al[16] reported no complications or hospital admissions in a 2-year period and Segal et al[14] reported a low 1.1% complication rate from the NSQIP dataset.

Predictor Variables

Few studies have reported on predictors of poor early outcomes in LDA. Eliasberg et al[31] found that older age, Medicare insurance, diabetes, and psychiatric illness predicted a need for subsequent lumbar surgery following LDA and fusion. We similarly found

Table 4. Univariate and Multivariate Analysis of Predictors of Reoperation.

	Univariate			Multivariate	
	No reoperation (N = 743), n (%)	Reoperation (N = 8), n (%)	P[a]	Odds ratio (95% CI)	P
Demographics					
Age, years, mean ± SD	44 ± 13	49 ± 12	.283		
Obese	309 (41.6)	4 (50.0)	.725[b]		
Non-White race	74 (12.5)	1 (14.3)	1.000[b]		
Male gender	473 (63.4)	6 (75.0)	.718[b]		
Comorbidities					
Smoker	153 (20.6)	3 (37.5)	.373[b]		
Dyspnea	8 (1.1)	1 (12.5)	.092[b]	13.814 (1.049 181.946)	**.046**
Diabetes	67 (9.0)	3 (37.5)	**.031**[b]	6.533 (1.425, 29.952)	**.016**
COPD	8 (1.1)	0	1.000[b]		
Heart failure	1 (0.1)	0	1.000[b]		
Hypertension	206 (27.7)	2 (25.0)	1.000[b]		
Disseminated cancer	2 (0.3)	0	1.000[b]		
Open wound infection	1 (0.1)	0	1.000[b]		
Chronic steroid use	6 (0.8)	0	1.000[b]		
Bleeding disorder	3 (0.4)	0	1.000[b]		
ASA class ≥3	153 (20.6)	2 (25.0)	.672[b]		
Lab values, mean ± SD					
Creatinine	0.91 ± 0.41	0.88 ± 0.20	.787		
White cell count	7.32 ± 2.30	7.56 ± 2.56	.792		
Hematocrit	42.46 ± 4.15	41.60 ± 5.80	.583		
Platelet	249 ± 63	250 ± 64	.964		
Procedural factors					
Surgical setting			.080[b]	4.566 (0.894, 23.256)	.068
Inpatient	645	5 (0.8[c])			
Outpatient	98	3 (3.0[c])			
Operative time, minutes, mean ± SD	133 ± 72	166 ± 98	.207	1.007 (0.999, 1.014)	.078
Length of stay, days, mean ± SD	2.1 ± 2.9	1.6 ± 1.2	.584	0.742 (0.382, 1.440)	.377

Abbreviations: ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease.
[a] Boldfaced values indicate significance ($P < .05$).
[b] Fischer's exact test.
[c] Percent requiring reoperation within inpatient and outpatient surgical setting.

that diabetes independently predicted reoperation, as well as readmission, but did not obtain a similar finding for older age. Diabetes is a known risk factor for early reoperation in spine surgery and may affect bony integration secondary to impaired bone remodeling from microangiopathic disease of bone tissue.[33,34]

While health status often affects whether a patient is selected for inpatient or outpatient surgery, analysis revealed that this was not the case in our present study. There were no baseline differences in potential demographic or health-related predictor variables between the inpatient and outpatient groups, and the entire cohort was healthy to begin with. Both groups had similar rates of obesity and ASA status. This is not unexpected as patients indicated for LDA are generally healthier and younger at baseline than patients undergoing other spine procedures, ultimately producing less-confounding factors for analysis.[9]

Procedural Factors

Operative time was longer in the inpatient group. This finding was also observed when comparing inpatient to outpatient cervical disc replacement.[14] Outpatient spine surgery offers reduced operative time in general, about 30 minutes faster on average.[7] We similarly found that outpatient LDA was 32 minutes faster on average. While this may be due to more complex cases being performed on an inpatient basis, the narrow indications for lumbar disc replacement and the similar baseline demographic and medical comorbidities between the inpatient and outpatient cohorts supports the idea that the outpatient setting provides greater efficiency.

Limitations

The NSQIP database provides access to a large number of nationally represented patients from multiple institutions and highly relevant variables, allowing for generalizability and the development of meaningful predictive models.[9,35] Trained reviewers collect data for the database while adhering to stringent variable definitions, rendering it as more reliable than other large-scale administrative databases.[36,37]

Limitations exist with the NSQIP database. The NSQIP dataset cannot distinguish between different surgical approaches, which have different complication profiles.[13,38,39] Furthermore, the NSQIP dataset uses hospital billing data to

Table 5. Univariate and Multivariate Analysis of Predictors of Morbidity.

	Univariate			Multivariate	
	No morbidity (N = 719), n (%)	Morbidity (N = 32), n (%)	P[a]	Odds ratio (95% CI)	P
Demographics					
Age, years, mean ± SD	44 ± 13	46 ± 14	.322		
Obese	297 (41.3)	16 (50.0)	.329		
Non-White race	69 (12.0)	6 (26.1)	.055[b]	1.596 (0.474, 5.375)	.451
Male gender	461 (64.1)	18 (56.3)	.579		
Comorbidities					
Smoker	148 (20.6)	8 (25.0)	.547		
Dyspnea	6 (0.8)	3 (9.4)	**.005**[b]	8.188 (1.373, 48.824)	**.021**
Diabetes	64 (8.9)	6 (18.8)	.109[b]		
COPD	7 (1.0)	1 (3.1)	.295[b]		
Heart failure	1 (0.1)	0	1.000[b]		
Hypertension	197 (27.4)	11 (34.4)	.388		
Disseminated cancer	2 (0.3)	0	1.000[b]		
Open wound infection	1 (0.1)	0	1.000[b]		
Chronic steroid use	5 (0.7)	1 (3.1)	.231[b]		
Bleeding disorder	3 (0.4)	0	1.000[b]		
ASA class ≥3	139 (19.3)	16 (50.0)	**<.001**	3.515 (1.283, 9.626)	**.014**
Lab values, mean ± SD					
Creatinine	0.91 ± 0.41	0.87 ± 0.21	.551		
White cell count	7.29 ± 2.28	8.08 ± 2.65	.062	1.190 (0.969, 1.461)	.098
Hematocrit	42.55 ± 4.01	40.49 ± 6.38	**.008**	0.959 (0.857, 1.072)	.460
Platelet	248 ± 81	277 ± 89	**.012**	1.002 (0.994, 1.010)	.571
Procedural factors					
Surgical setting			1.000[b]	1.124 (0.260, 4.859)	.876
Inpatient	622	28 (4.3[c])			
Outpatient	97	4 (4.0[c])			
Operative time, minutes, mean ± SD	132 ± 70	173 ± 102	**.003**	1.002 (0.996, 1.008)	.501
Length of stay, days, mean ± SD	2.0 ± 2.6	5.1 ± 5.8	**<.001**	1.144 (1.028, 1.274)	**.014**

Abbreviations: ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease.
[a] Boldfaced values indicate significance ($P < .05$).
[b] Fischer's exact test.
[c] Percent of patients who experienced morbidity within inpatient and outpatient surgical setting.

capture inpatient and outpatient status, which may not accurately reflect length of stay.[26,40] Consequently, some researchers have treated only patients with a length of stay as zero days as outpatient, and greater than zero as inpatient.[26,28] However, this method can introduce a potential bias by creating modified inpatient and outpatient groups, with less and more healthier patients, respectively. In addition, while it is impossible to determine if an unexpected negative intraoperative event would have resulted in an intended outpatient case to require inpatient admission, the utilization of billing data to determine inpatient-versus-outpatient status would suggest that the vast majority of any outpatient-converted-to-inpatient patient stay would have been appropriately coded as inpatient. Therefore, we used the inpatient versus outpatient variable provided by the NSQIP dataset as-is, as has been done previously.[14,28]

Conclusion

This study compared 30-day outcomes between inpatient and outpatient LDA. Rates of readmission, reoperation, and morbidity remained statistically similar between inpatients and outpatients, even after accounting for potential patient confounders through multivariate logistic regression. These findings suggest that LDA can be safely performed in the outpatient setting.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

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