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Impact of Postoperative Length of Stay on Patient-Reported and Clinical Outcomes After Anterior Lumbar Interbody Fusion

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ABSTRACT

Background: Existing literature has not yet evaluated the impact of postoperative length of stay (LOS) on patient-reported outcome measures (PROMs) and minimum clinically important difference (MCID) in patients undergoing anterior lumbar interbody fusion (ALIF). The authors investigates the influence of postoperative LOS following ALIF on PROMs and MCID achievement rates.

Methods: A single-surgeon database was retrospectively reviewed for patients undergoing single-level ALIF. The following 2 cohorts were studied: patients with LOS <45 hours and patients with LOS ≥45 hours. The following PROMs were recorded at preoperative and 6-week, 12-week, 6-month, 1-year, and 2-year postoperative timepoints: visual analog scale (VAS) back and leg, Oswestry Disability Index (ODI), 12-item short form (SF-12) physical composite score (PCS), and patient-reported outcome measurement information system physical function. MCID achievement was compared by LOS grouping using χ^2 analysis. The rates of complications by LOS grouping and the relative risk among demographic and perioperative characteristics for a longer hospital stay of ≥45 hours were calculated.

Results: A total of 52 subjects were included in each cohort. LOS ≥45 hours demonstrated worse ODI at 6 weeks and SF-12 PCS preoperative and at 12 weeks ($P \le 0.026$, all). LOS <45 hours demonstrated greater MCID rates for all PROMs except VAS back ($P \le 0.004$, all). Postoperative urinary retention (POUR), fever, and total complications ($P \le 0.003$, all) were associated with increased LOS. Diabetes ($P = 0.037$), preoperative VAS neck ≥7 ($P = 0.012$), and American Society of Anesthesiologists classification ≥2 ($P = 0.003$) served as preoperative risk factors for postoperative stay ≥45 hours.

Conclusion: Following single-level ALIF, patients with shorter LOS demonstrated significantly greater overall MCID achievement for most PROMs. POUR, fever, and total complications were associated with longer LOS and greater blood loss. Diabetes and higher preoperative leg pain were identified as risk factors for longer LOS.

Clinical Relevance: Patients undergoing ALIF with shorter LOS had greater MCID achievement for disability, physical function, and leg pain outcomes. Patients with greater preoperative leg pain and diabetes may be at risk for longer LOS.

Level of Evidence: 3.

Lumbar Spine

Keywords: ALIF, length of stay, PROMs, MCID, relative risk

INTRODUCTION

Patients with low back pain resulting from etiologies such as degenerative lumbar disease may experience severe symptoms refractory to conservative treatment, potentially necessitating spinal surgery.[1] In many cases, interbody fusion of the vertebrae is effective in the management of low back pain.[2] Of the numerous approaches available, anterior lumbar interbody fusion (ALIF) has been one approach with growing interest and potential. ALIF advantageously provides broad access to the entire ventral surface of the intervertebral disc to be removed and replaced.[2] ALIF also spares the posterior back muscles, as well as the psoas muscle, to mitigate pain and disability postoperatively.[2]

The effectiveness of ALIF can also be assessed through patient-reported outcome measures (PROMs). By evaluating the patient's self-perception of quality-of-life (QOL) measures, PROMs help quantify surgical success from patient perspective.[3] Commonly used PROMs in lumbar spinal care include Oswestry Disability Index (ODI), patient-reported outcome measurement information system physical function (PROMIS-PF), visual analog scale (VAS) back and leg measures for pain, and the 12-item short form (SF-12) physical composite score (PCS) .[4] With regard to such PROMs, ALIF has been shown to be superior or comparable with other lumbar fusion approaches in existing literature.[5,6]

Postoperative hospital length of stay (LOS) is an additional variable of particular interest. Of note, several factors may play a role in LOS after spinal surgery. Comorbid conditions, such as anemia, anxiety diagnosis, high body mass index, diabetes mellitus (DM), illness severity, intraoperative complications after surgery, and multilevel fusion procedures can also impact LOS.[7,8] Many studies have analyzed LOS in ALIF patients as the dependent variable in conjunction with PROMs. However, no studies have used LOS as a comparison variable.[9] Due to its association and influence on complications, LOS could potentially have a significant impact on PROMs; therefore, a trial of this kind would be beneficial. The present study therefore aims to examine PROMs, MCID achievement, and complications by LOS and determine risk factors associated with longer LOS following ALIF.

METHODS

Patient Population

Prior to study onset, informed patient consent and Institutional Review Board approval (Office of Research Affairs No. 14051301) were obtained. A prospectively maintained, retrospective single-surgeon database was used to identify and recruit patients who underwent single-level ALIF from April 2007 to November 2020 at a single academic center. The study excluded patients who underwent surgery because of infection, trauma, or cancer. We performed descriptive statistics to determine the median value for LOS among patients meeting selection criteria, whereby 45 hours of postoperative stay was determined as the cutoff value. Patients were subsequently divided into the following 2 cohorts: LOS <45 vs LOS ≥45 hours.

Data Collection

Patient demographics collected include age, gender, ethnicity, smoking status, hypertension, American Society of Anesthesiologists (ASA) score, ageless Charlson Comorbidity Index, and insurance type. Surgical characteristics as listed were also recorded: diagnosis of spinal pathology, operating time (minutes), estimated blood loss (milliliters), postoperative LOS (hours), and day of discharge. Among the spinal pathologies observed were degenerative spondylolisthesis, isthmic spondylolysis, recurring herniated nucleus pulposus, and scoliosis. The following mean PROMs were recorded preoperatively as well as at 6-week, 12-week, 6-month, 1-year, and 2-year postoperative timepoints: VAS back and leg, ODI, SF-12 PCS, and PROMIS-PF. Complication rates among cohorts were reported and consisted of the following: urinary retention, urinary tract infection, acute respiratory failure, acute renal failure, ileus, deep vein thrombosis, transfusion, arrhythmia, pneumonia, pneumothorax, altered mental status, durotomy, surgical site infection, neurological disease, and fever. Finally, relative risk ratios among demographic and perioperative factors were determined for longer hospital stays ≥45 hours.

Statistical Analysis

Stata 16.0 (StataCorp LP, College Station, TX) was used for the analysis of data. χ^2 analysis was used with categorical variables, and a Student's *t* test for independent samples was used for continuous variables to compare the demographic and perioperative characteristics between the 2 cohorts. Statistical differences among mean PROMs were evaluated using Student's *t* test for independent samples. Delta PROMs were calculated as the difference from preoperative to postoperative values and utilized in determination of MCID achievement based on the following established threshold values: VAS leg = 1.6,[10] VAS back = 1.2,[10] ODI = 12.8,[10] SF-12 PCS = 4.9,[10] and PROMIS-PF = 4.5.[11] Differences among MCID achievement rates by LOS grouping were determined using χ^2 analysis. Complication rates between the LOS groups were analyzed with Fisher's exact test. Based on a Poisson regression model with robust error variance, relative risk ratios for longer hospital stays of ≥45 hours were determined for demographic and perioperative characteristics.

RESULTS

Descriptive Analysis

A total of 104 patients were enrolled with 52 participants in the LOS <45 hours group and 52 in the LOS ≥45 hours group. Mean ages of 50.3 and 50.6 years were calculated for the LOS ≥45 hours and LOS <45 cohorts, respectively. No significant differences were observed among demographic variables between groups (Table 1).

Perioperative characteristics are outlined in Table 2. The most common spinal pathology among both groups was central stenosis, with 73.1% and 80.8% for longer and shorter LOS groups, respectively. Proportion of patients with foraminal stenosis was significantly different between the groups ($P < 0.003$). Longer and shorter LOS groups had respective mean operative times of

Table 1. Patient demographics.

Characteristic	LOS ≥45 h (n = 52)	LOS <45 h (n = 52)	P Value[a]
Age, y, mean ± SD	50.3 ± 11.6	50.6 ± 12.5	0.880
Gender			0.844
Women	48.1% (25)	50.0% (26)	
Men	51.9% (27)	50.0% (26)	
Ethnicity			0.566
African American	11.5% (6)	7.7% (4)	
Asian	3.9% (2)	3.9% (2)	
Hispanic	5.8% (3)	9.6% (5)	
White	75.0% (39)	78.9% (41)	
Other	3.9% (2)	0.0% (0)	
Diabetic status			0.085
Nondiabetic	80.8% (42)	92.3% (48)	
Diabetic	19.2% (10)	7.7% (4)	
Smoking status			0.446
Nonsmoker	84.6% (44)	78.9% (41)	
Smoker	15.4% (8)	21.2% (11)	
Blood pressure			0.083
Normotensive	63.5% (33)	78.9% (41)	
Hypertensive	36.5% (19)	21.2% (11)	
American Society of Anesthesiologists score			0.356
<1	8.0% (4)	13.7% (7)	
≥1	92.0% (46)	86.3% (44)	
Charlson Comorbidity Index score			0.848
<1	20.5% (9)	22.2% (8)	
≥1	79.6% (35)	77.8% (28)	
Insurance type			0.624
Medicare/Medicaid	7.7% (4)	7.7% (4)	
Workers' compensation	25.0% (13)	17.3% (9)	
Private	67.3% (35)	75.0% (39)	

Abbreviation: LOS, length of stay.
Note: Data reported as % (n) unless otherwise noted.
[a] P value calculated using χ^2 analysis or Student's t test for independent samples for categorical and continuous variables, respectively.

Table 2. Perioperative characteristics.

Characteristic	LOS ≥45 h (n = 52)	LOS <45 h (n = 52)	P Value[a]
Spinal pathology			
Degenerative spondylolisthesis	23.1% (12)	9.6% (5)	0.063
Isthmic spondylolisthesis	36.5% (19)	50.0% (26)	0.166
Recurrent herniated nucleus pulposus	5.8% (3)	7.7% (4)	0.696
Scoliosis	1.9% (1)	11.5% (6)	0.050
Central stenosis	73.1% (38)	80.8% (42)	0.352
Foraminal stenosis	40.4% (21)	69.2% (36)	**0.003**
Operative time, min	126.3 ± 37.4	128.1 ± 40.1	0.816
Estimated blood loss, mL	73.5 ± 50.2	52.1 ± 31.1	**0.014**
LOS (h)	65.1 ± 29.9	26.8 ± 7.6	**<0.001**
Day of discharge			**<0.001**
POD 0	0.0% (0)	9.6% (5)	
POD 1	2.1% (1)	82.7% (43)	
POD 2	66.0% (31)	7.7% (4)	
POD 3	14.9% (7)	0.0% (0)	
POD 4	14.9% (7)	0.0% (0)	
POD 9	2.1% (1)	0.0% (0)	

Abbreviations: LOS, length of stay; POD, postoperative day of discharge.
Note: Data presented as % (n) or mean ± SD. **Boldface** indicates statistical significance.
[a] P value calculated using χ^2 analysis or Student's t test for independent samples for categorical and continuous variables, respectively.

Table 3. Impact of LOS on PROMs.

PROM	LOS ≥45 h, Mean ± SD	LOS <45 h, Mean ± SD	P Value[a]
VAS back			
Preoperative	6.5 ± 2.3	6.7 ± 2.6	0.673
6 wk	4.3 ± 2.7	3.8 ± 2.5	0.257
12 wk	4.0 ± 2.6	3.3 ± 2.6	0.212
6 mo	3.0 ± 2.6	3.4 ± 2.8	0.511
1 y	3.0 ± 3.5	2.1 ± 3.0	0.657
2 y	8.5 ± 0.0	6.4 ± 1.6	0.377
VAS leg			
Preoperative	5.1 ± 2.7	4.5 ± 3.4	0.813
6 wk	4.5 ± 4.3	3.3 ± 2.4	0.263
12 wk	3.2 ± 2.8	2.5 ± 2.6	0.662
6 mo	2.0 ± 2.6	2.6 ± 3.1	0.613
1 y	2.2 ± 3.7	1.1 ± 1.7	0.489
2 y	6.5 ± 0.0	6.3 ± 2.6	0.964
ODI			
Preoperative	39.4 ± 17.5	35.7 ± 15.8	0.477
6 wk	45.1 ± 32.5	28.3 ± 14.8	**0.024**
12 wk	29.3 ± 16.1	20.3 ± 12.4	0.082
6 mo	22.3 ± 20.2	20.2 ± 15.8	0.739
1 y	30.5 ± 24.2	14.9 ± 16.2	0.153
2 y	40.0 ± 0.0	28.5 ± 13.7	0.507
SF-12 PCS			
Preoperative	27.1 ± 6.3	32.6 ± 9.5	**0.046**
6 wk	34.0 ± 11.8	34.8 ± 8.4	0.838
12 wk	32.2 ± 5.1	41.5 ± 8.7	**0.014**
6 mo	40.3 ± 8.1	40.0 ± 9.5	0.920
1 y	37.6 ± 9.1	45.9 ± 11.0	0.193
2 y	36.2 ± 2.5	44.6 ± 11.8	0.271
PROMIS-PF			
Preoperative	34.4 ± 5.0	38.4 ± 5.8	0.072
6 wk	40.8 ± 2.6	40.0 ± 5.9	0.847
12 wk	40.2 ± 4.6	44.6 ± 9.2	0.271
6 mo	43.0 ± 7.2	47.2 ± 6.5	0.199
1 y	44.0 ± 9.1	48.7 ± 11.0	0.411
2 y	47.2 ± 9.0	49.6 ± 12.2	0.823

Abbreviations: LOS, length of stay; ODI, Oswestry Disability Index; PROMIS-PF, patient-reported outcome measurement information system physical function; PROMs, patient-reported outcome measures; SF-12 PCS, 12-item short form physical composite score; VAS, visual analog scale.
Note: **Boldface** indicates statistical significance.
[a] P values calculated using Student's t test for independent samples.

126.3 and 128.1 minutes, with average blood losses of 73.5 and 52.0 mL, respectively. Estimated blood loss, overall LOS, and date of discharge ($P \leq 0.014$, all) also differed significantly among cohorts.

Primary Outcome Measures

Mean PROM comparisons only demonstrated significant differences for ODI at 6 weeks ($P = 0.024$) and SF-12 PCS preoperatively and at 12 weeks ($P \leq 0.026$, both), with inferior outcomes in the longer LOS cohort (Table 3). Significantly greater overall MCID achievement rates were recorded in the shorter LOS cohort across all PROM except VAS back ($P \leq 0.004$, all) (Table 4). Postoperative urinary retention (POUR; $P = 0.016$), fever ($P = 0.003$), and total complications ($P = 0.001$) had a significant association with the increased LOS cohort (Table 5). DM ($P = 0.037$), preoperative neck VAS ≥7 ($P = 0.012$), and ASA classification ≥2 (P

Table 4. Minimum clinically important difference.

Patient-Reported Outcome Measures	LOS ≥45 h, % (n)	LOS <45 h, % (n)	P Value[a]
ODI			
6 wk	28.6% (2)	71.4% (5)	0.703
12 wk	10.0% (1)	90.0% (9)	0.375
6 mo	37.5% (3)	62.5% (5)	0.561
1 y	14.3% (1)	85.7% (6)	0.515
2 y	0.0% (0)	0.0% (0)	-
Overall	17.7% (3)	82.4% (14)	**0.004**
PROMIS-PF			
6 wk	9.1% (1)	90.9% (10)	0.747
12 wk	22.2% (2)	77.8% (7)	0.964
6 mo	16.7% (2)	83.3% (10)	0.137
1 y	22.2% (2)	77.8% (7)	0.480
2 y	33.3% (1)	66.7% (2)	1.000
Overall	18.2% (4)	81.8% (18)	**0.001**
SF-12 PCS			
6 wk	25.0% (3)	75.0% (9)	0.527
12 wk	14.3% (2)	85.7% (12)	0.490
6 mo	32.3% (6)	64.7% (11)	0.394
1 y	11.1% (1)	88.9% (8)	0.522
2 y	25.0% (1)	75.0% (3)	0.809
Overall	24.1% (7)	75.9% (22)	**0.001**
VAS back			
6 wk	44.0% (22)	56.0% (28)	0.201
12 wk	47.1% (24)	52.9% (27)	0.566
6 mo	51.1% (23)	48.9% (22)	0.222
1 y	22.2% (2)	77.8% (7)	0.913
2 y	0.0% (0)	100.0% (1)	0.505
Overall	43.7% (31)	56.3% (40)	0.058
VAS leg			
6 wk	31.3% (5)	68.8% (11)	0.312
12 wk	18.8% (3)	81.3% (13)	0.925
6 mo	33.3% (5)	66.7% (10)	0.637
1 y	25.0% (2)	75.0% (6)	0.707
2 y	100.0% (1)	100.0% (1)	-
Overall	27.6% (8)	72.4% (21)	**0.004**

Abbreviations: LOS, length of stay; ODI, Oswestry Disability Index; PROMIS-PF, patient-reported outcome measurement information system physical function; SF-12 PCS, 12-item short form physical composite score; VAS, visual analog scale.
Note: **Boldface** indicates statistical significance.
[a]*P* values calculated using χ^2 analysis.

Table 5. Complication rates.

Complication	LOS <45 h (n = 52)	LOS ≥45 h (n = 52)	P Value[a]
Urinary retention	1.9% (1)	15.7% (8)	**0.016**
Urinary tract infection	0.0% (0)	0.0% (0)	-
Acute respiratory failure	0.0% (0)	0.0% (0)	-
Acute renal failure	0.0% (0)	0.0% (0)	-
Ileus	0.0% (0)	0.0% (0)	-
Deep vein thrombosis	0.0% (0)	0.0% (0)	-
Transfusion	0.0% (0)	0.0% (0)	-
Arrhythmia	0.0% (0)	2.0% (1)	0.496
Pneumonia	0.0% (0)	0.0% (0)	-
Pneumothorax	0.0% (0)	0.0% (0)	-
Altered mental status	0.0% (0)	0.0% (0)	-
Durotomy	0.0% (0)	0.0% (0)	-
Surgical site infection	0.0% (0)	0.0% (0)	-
Neurological disease	1.9% (1)	1.9% (1)	-
Fever	0.0% (0)	15.7% (8)	**0.003**
Total complications	3.9% (2)	28.9% (15)	**0.001**

Abbreviation: LOS, length of stay (h).
Note: **Boldface** indicates statistical significance.
[a]*P* value calculated using Fisher's exact test.

= 0.003) were determined as significant risk factors for postoperative stay ≥45 hours (Table 6).

DISCUSSION

ALIF procedures are becoming increasingly common for treating lumbar degenerative disc disease and spondylolisthesis, among other indications, growing at an average rate of 24% annually from 2007 to 2014.[12] With a clinical success rate of 85% over a 2-year period and low occurrences of adverse complications, mortality, and rehospitalizations, ALIF has been proven efficacious while demonstrating reductions in postoperative pain and operative blood loss compared with posterior approaches.[12,13] Postoperative LOS can strongly influence how patients recover after surgery, with protocols such as enhanced recovery after surgery created to optimize perioperative care and patient experience/satisfaction to minimize LOS.[14] Understanding and reducing LOS may aid in preventing adverse outcomes, patient dissatisfaction, and financial burdens. In 1 study, Boylan et al found that an additional day of hospitalization after spinal surgery increased the risk of readmission by 28% and of surgical revision by 57%.[15] Longer postoperative stay is also economically disadvantageous for both patients and hospital systems, with each additional day associated with an $11,033 increase in insurance costs and a $5198 increase in hospital-related costs for certain spine surgeries.[15,16] While LOS has been evaluated as a dependent variable, with 1 study demonstrating a significantly greater postoperative stay in ALIF vs transforaminal lumbar interbody fusion (TLIF) patients, it has yet to be assessed as an independent variable affecting postoperative outcomes.[9] One way to measure surgical effectiveness is via PROMs. PROMs provide an assessment of outcomes through the patient perspective, focusing on the QOL at a specific given time.[17] MCIDs are used to evaluate the significance between data sets that use PROMs and focus on differences in clinical interventions that directly affect the patient.[18] While studies have examined the influence of independent variables on postoperative PROMs, no prior studies have focused on how stratification by postoperative LOS influences 6-week to 2-year PROM and MCID achievement results following ALIF surgery.

PROMs and MCID Achievement

Prior literature in spinal surgery has reported comparable PROMs and MCID achievement regardless of postoperative LOS. Eckman et al demonstrated that patients undergoing TLIFs had comparable PROMs

Table 6. Bivariate analysis of risk ratio for demographic and perioperative characteristics.

Characteristic	Among Extended Length of Stays, %	Relative Risk	CI	*P* Value[a]
Age				
<50 y	42.3%	Reference		
≥50 y	57.7%	1.1	(0.8–1.7)	0.559
Gender				
Women	48.1%	Reference		
Men	51.9%	1.0	(0.7–1.5)	0.845
Body mass index				
<30 kg/m^2	53.9%	Reference		
≥30 kg/m^2	46.2%	0.9	(0.6–1.4)	0.697
Smoking status				
Nonsmoker	84.6%	Reference		
Smoker	15.4%	0.8	(0.5–1.4)	0.476
American Society of Anesthesiologists score				
<2	**71.2%**	**Reference**		
≥2	**28.9%**	**1.7**	**(1.2–2.4)**	**0.003**
Charlson Comorbidity Index score				
<1	20.5%	Reference		
≥1	79.6%	1.0	(0.6–1.7)	0.851
Hypertension				
Nonhypertensive	63.5%	Reference		
Hypertensive	36.5%	1.4	(1.0–2.1)	0.066
Diabetes				
Nondiabetic	**80.8%**	**Reference**		
Diabetic	**19.2%**	**1.5**	**(1.0–2.3)**	**0.037**
Preoperative VAS back[b]				
<7	-	-	-	-
≥7	-	-	-	-
Preoperative VAS leg				
<7	**17.3%**	**Reference**		
≥7	**82.7%**	**2.1**	**(1.2–3.8)**	**0.012**
Operative time				
≤127 min	44.2%	Reference		
>127 min	55.8%	1.1	(0.8–1.7)	0.560
Estimated blood loss				
≤63 mL	57.7%	Reference		
>63 mL	42.3%	1.2	(0.8–1.7)	0.415

Abbreviation: VAS, visual analog scale.
Note: **Boldface** indicates statistical significance.
[a]P value calculated using Poisson's regression.
[b]Unable to perform Poisson's regression due to collinearity.

regardless of LOS grouping, with no statistically significant difference found in postoperative disability and pain scores measured by ODI and VAS back and leg, respectively.[19] A separate study examining lumbar fusions showed that a same-day discharge following the procedures was not significantly different from traditional, more extended hospital stays for VAS pain scores the day after surgery.[20] Hoggett et al noted that patients recovering from lumbar discectomies with a longer LOS had more inferior PROM results: longer LOS was associated with higher VAS leg pain scores and increased disability (as measured via ODI).[21] Dial et al discovered that among patients undergoing anterior cervical discectomy and fusion, increasing LOS was associated with lower postoperative patient satisfaction and increased costs.[22] While reducing costs is undoubtedly of tremendous value to hospitals/patients, it is more challenging to interpret clinical implications of decreased postoperative patient satisfaction. While MCID has never been evaluated by LOS grouping in the setting of ALIF, recent articles have suggested MCID as a valuable measurement of determining whether treatment outcomes are clinically meaningful, thus assisting clinicians in linking PROMs to clinical outcomes and long-term success.[23] Little information exists regarding the influence of differing LOS on postoperative QOL outcomes (ie, PROMs) and achievement of clinically meaningful recovery (ie, MCID) following ALIF surgery, indicating a need for further investigation.

In our study, while the vast majority of PROMs did not significantly differ by LOS, patients with extended stays reported significantly worse disability and physical functioning during the early postoperative period. Furthermore, mean PROMs were generally favorable across all cohorts of patients with a shorter LOS; however, such differences did not reach statistical significance. In light of this finding, patients and care teams can expect comparable or even better postoperative recovery when hospital stay following ALIF is shortened. Similarly, although rates of MCID achievement did not significantly differ by LOS across individual timepoints for PROMs, the majority of PROMs demonstrated higher rates of overall MCID attainment among those with shorter LOS. Our results in concert with published findings thus signify that early discharge when medically indicated may not hinder postoperative PROM scores and allow patients to achieve more clinically meaningful improvements, potentially leading to higher patient satisfaction, higher QOL, and lower cost burdens.

Perioperative Complications

ALIF may cause multiple postoperative complications, which may contribute to prolonged hospital stays. McDonnell et al found that 11% of patients who underwent lumbar fusion with an anterior approach had major complications and almost one-fourth (24%) had minor complications.[24] Stefano et al reported that between ALIF and posterior lumbar interbody fusion, ALIF resulted in increased hospital costs, prolonged LOS, and greater rates of the following complications: mortality, dehiscence, hematoma, seroma, and pseudarthrosis.[25] Mortazavi et al discovered that 95 of 362 patients receiving ALIF from 2017 to 2019 (26%) had from complications, with surgical site infection, nerve damage, vascular injury, and urinary tract infections being the most common. The authors further found that between patients with and without complications, the former experienced longer postoperative stay and delayed discharge.[26] Our findings align with existing literature, as patients with higher incidence of POUR, postoperative fever, and total complications were at higher risk for longer postoperative stay. Thus, awareness and future investigation on lifestyle, pharmacological, and operative methodologies to mitigate modifiable risk factors for reported ALIF complications may inadvertently reduce incidence of such adverse events and subsequently shorten LOS. For instance, minimally invasive lumbar fusions have been shown to reduce blood loss, number of complications, and LOS, and outpatient surgery allows for same-day discharge without compromised PROMs, these techniques represent potential solutions.[19,27] Given the patient is a suitable candidate, the performance of mini-open ALIF in an outpatient setting may thus decrease burden of LOS while offering comparable efficacy. While studies on this possibility remain scarce, Vieli et al discovered satisfactory safety and efficacy in performance of ALIF in a short-stay setting with enhanced recovery after surgery protocol (78% MCID achievement, 2.3% complication rate).[28] Nevertheless, the authors concluded that its utility was only demonstrated in patients with specific qualifying characteristics, and further studies on benefits of short-stay surgical environments are necessary.[28]

Total Blood Loss

Total blood loss is hard to estimate in ALIF procedures and can cause potential complications among patients.[29] Our study demonstrated that patients with a shorter LOS had less estimated blood loss compared with longer LOS counterparts. While we did not find this to be a significant risk factor in determining longer LOS, the statistically significant differences between populations are noteworthy. Blood loss is an inevitable cost of any surgery, with spine surgeries not being an exception. During spinal surgery, considerable blood loss can increase morbidity and mortality.[30] Numerous studies have highlighted the importance of managing blood loss, particularly in spine surgery. Studies recommended additional steps be taken preoperatively for hemostasis and techniques, such as minimally invasive procedures, to decrease operative time.[30]

While measures can be taken intraoperatively, steps should also be taken preoperatively to mitigate a patient's risk factors for increased blood loss. A study by Qato et al found that more than 90% of Americans aged 50 to 80 years regularly use at least 1 medication, with the majority taking cardiovascular drugs, including aspirin, a known antiplatelet agent.[31] Increased utilization of blood-thinning medications among the general population and the age grouping of 50 to 80 years old have significant overlap with our patient population, emphasizing preoperative investigation into current hemostasis and coagulation medication use, along with addressing their potential effects on blood loss. Additional considerations should be taken to reduce blood loss as there are also implications in determining LOS for patients postoperatively. Multiple studies have confirmed a reduction in blood loss can lead to a short LOS.[32,33] The techniques used to reduce blood loss were notable for advancements in anesthesia, surgical procedures, reductions in operative time, decreases in iatrogenic tissue damage, and postoperative hemostatic methods leading to a significant decrease in stay, reducing stay by nearly an entire day.[32,33]

Risk Factors

High preoperative leg pain (VAS leg ≥7), DM, and ASA score (≥2) were identified as risk factors for longer

LOS in the present study, with significantly higher relative risk scores. Lim et al showed that preoperative leg pain can predict patient satisfaction for lumbar fusion[34] and is essential to address before surgery. While postoperative improvements in leg pain have been demonstrated among ALIF patients, Jacob et al noted inferior MCID achievement rates for VAS leg among patients receiving ALIF vs minimally invasive surgery TLIF.[35–37] Moses et al further indicated that ALIF may be used over TLIF among patients with higher preoperative radicular pain, suggesting a potential reasoning for inferior VAS leg improvements among ALIF patients.[38] Prior literature has stated the influence of postoperative pain on discharge status and functional recovery following spine surgery, with 1 study demonstrating that use of intravenous vs oral acetaminophen for pain control significantly reduced opioid utilization, costs, and enabled an average of 0.68 less days of postoperative stay.[39] Thus, as ALIF patients may experience relatively higher amounts of baseline and postoperative radicular pain, such heighted pain levels may necessitate prolonged stay. Through improved optimization efforts of preoperative and perioperative pain levels, surgeons may thus be able to mitigate prolonged stays following ALIF.

The prevalence of DM is increasing worldwide,[40] increasing the number of patients with DM undergoing spinal surgery. Worley et al reported increased complications among diabetic patients receiving spine surgery, indicating these patients are more likely to experience pneumonia, intubation, ventilation >2 days, urinary tract infection, and bleeding necessitating transfusion.[41] Upon controlling for comorbidities among nearly 6000 patients from >350 hospitals, the authors also demonstrated that diabetes was significantly associated with prolonged LOS.[41] Golinvaux et al similarly found that postoperative complications were significantly more frequent and severe among diabetic patients, while also concluding an increased LOS of up to 5 days among diabetic patients receiving elective lumbar fusion.[42] Such studies highlight that the increased complication profile among diabetic patients may implicate longer hospital stays. Few studies to our knowledge have reported on the association of diabetes and LOS within an ALIF population. Our data align with these aforementioned findings, concluding that DM is an independent risk factor for longer LOS. Increased efforts on preoperative management of diabetes may thus be imperative in preventing extended stay following ALIF. For patients presenting with diabetes, preoperative discussion of increased risk for prolonged stay may allow for better alignment of patient expectations with realistic perioperative outcomes.

The ASA classifications of 1, 2, 3, 4, and 5 correlate to completely healthy patients, those with mild systemic illness, those with severe but not incapacitating systemic illness, those with severe and incapacitating systemic illness, and those expected to pass away within 24 hours, respectively.[43] Higher ASA scores have been demonstrated to significantly predict higher complication rates, postoperative LOS, and delays in return to function following orthopedic surgery.[44] In a study by McDonald et al, a 1-unit increase in ASA classification translated to an average increased stay of 3.42 days following ankle surgery, incurring an additional $15,000 charge.[44] Somani et al studied the influence of ASA scores among adult spinal deformity surgeries, concluding via multivariate logistic regression that higher ASA classification was associated with increased morbidity and wound, heart, lung, bleeding, and infection complications.[45] The authors reported that higher ASA classification patients were more at risk for LOS ≥5 days and concluded that increased compilation rates can play a role in prolonged discharge.[45]

Kobayashi et al similarly discovered that ASA score ≥3 was significantly associated with extended LOS among posterior lumbar interbody fusion/TLIF patients.[46] Rajpal et al discovered similar conclusions among 240 patients undergoing TLIF.[47] However, to the best of our knowledge, the relationship between ASA classification and LOS specifically pertaining to ALIF has yet to be explored in literature. Nevertheless, our study is consistent with aforementioned findings, indicating that ASA ≥2 was a risk factor for longer LOS. Thus, ALIF surgical candidates with comorbid mild-to-severe systemic illness should be cautioned in the preoperative phase that discharge will likely be delayed. Communicating this information to patients with higher ASA early in the preoperative planning process is critical, as patients with unrealistic baseline expectations of early discharge may experience poorer postoperative satisfaction if LOS is prolonged.

The application of a preoperative educational program for patients has the potential to decrease the burden of risk factors on extended postoperative stay. Jones et al prospectively analyzed data from 472 patients undergoing knee joint arthroplasty divided into groups based on receiving vs not receiving preoperative education on care pathway, pain control, and expected discharge and found that the education group had significantly reduced LOS.[48] Patients receiving education were discharged on average 2 days before their counterparts, with 20% more patients in this group experiencing earlier discharge.[48] Therefore, by discussing potential risk factors associated with prolonged discharge and presenting implications of longer LOS on PROM and MCID achievement results to patients, patients may experience improved discharge status following ALIF. However, this association remains uninvestigated among spine surgeries and thus requires further clinical inquiry.

Limitations

There are limitations to the present study. With data from a single-surgeon database, generalizability is limited. All procedures were performed at a single academic institution, further limiting external validity. ASA score differed among cohorts, acting as a potential confounder to our findings. In addition, complication rates reported were of minimal statistical power due to a low incidence of complications present in this study population. While this may limit our findings, increased complications among patients with extended LOS are well supported and established in the literature. Finally, PROMs are prone to subjectivity and recall bias, as are MCID variables grounded on change of PROMs from preoperative to postoperative timepoints.

CONCLUSION

Patients with shorter LOS (<45 hours) following ALIF generally demonstrated comparable PROMs throughout the early and long-term postoperative period while achieving higher rates of overall MCID for the majority of PROMs assessed. Meanwhile, total complications, POUR, postoperative fever, and intraoperative blood loss were significantly more associated with extended LOS (≥45 hours). Severe preoperative leg pain and diabetic status were demonstrated to be statistically significant for longer LOS following ALIF. Comprehensive preoperative education on risk factors, expected outcomes, and complications associated with prolonged discharge status should be discussed prior to ALIF to encourage reduction of modifiable risk factors and better align expectations with realistic perioperative/postoperative outcomes.

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