Predictors of inpatient admission in the setting of anterior lumbar interbody fusion: a Minimally Invasive Spine Study Group (MISSG) investigation

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OBJECTIVE While the anterior lumbar interbody fusion (ALIF) procedure may be amenable to ambulatory surgery, it has been hypothesized that limitations such as the risk of postoperative ileus and vascular complications have hindered transition of this procedure to the outpatient setting. Identification of independent risk factors predisposing patients to inpatient stays of ≥ 24 hours after ALIF may facilitate better postsurgical outcomes, target modifiable risk factors, and assist in the development of screening tools to transition appropriate patients to the ambulatory surgery center (ASC) setting for this procedure. The purpose of this study was to identify the most relevant risk factors that predispose patients to ≥ 24 -hour admission following ALIF.

METHODS A prospectively maintained surgical registry was reviewed for patients undergoing single ALIF between May 2006 and December 2019. Demographics, preoperative diagnosis, perioperative variables, and postoperative complications were evaluated according to their relative risk (RR) elevation for an inpatient stay of ≥ 24 hours. A Poisson regression model was used to evaluate predictors of inpatient stays of ≥ 24 hours. Risk factors for inpatient admission of ≥ 24 hours were identified with a stepwise backward regression model.

RESULTS A total of 111 patients underwent single-level ALIF (50.9% female and 52.6% male, ≤ 50 years old). Eleven (9.5%) patients were discharged in < 24 hours and 116 remained admitted for ≥ 24 hours. The average inpatient stay was > 2 days (53.7 hours). The most common postoperative complications were fever (body temperature $\geq 100.4^\circ\text{F}$; $n = 4$, 3.5%) and blood transfusions ($n = 4$, 3.5%). Bivariate analysis revealed a preoperative diagnosis of retrolisthesis or lateral listhesis to elevate the RR for an inpatient stay of ≥ 24 hours (RR 1.11, $p = 0.001$, both diagnoses). Stepwise multivariate analysis demonstrated significant predictors for inpatient stays of ≥ 24 hours to be an operation on L4–5, coexisting degenerative disc disease (DDD) with foraminal stenosis, and herniated nucleus pulposus (RR 1.11, 95% CI 1.03–1.20, $p = 0.009$, all covariates).

CONCLUSIONS This study provides data regarding the incidence of demographic and perioperative characteristics and postoperative complications as they pertain to patients undergoing single-level ALIF. This preliminary investigation identified the most relevant risk factors to be considered before appropriately transitioning ALIF procedures to the ASC. Further studies of preoperative characteristics are needed to elucidate ideal ASC ALIF patients.

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KEYWORDS ALIF; ambulatory surgery center; anterior lumbar interbody fusion; complication; inpatient; morbidity; outpatient; spine

ANTERIOR lumbar interbody fusion (ALIF) procedures have become increasingly prevalent due to a combination of advantages afforded by the procedure itself^{1–5} and because cases indicating elective spinal fusion as an effective treatment have increased more

than 60% over the past decade.⁶ Lumbar interbody fusion remains an efficacious surgical treatment that produces reasonable clinical and radiological outcomes for spinal degenerative pathologies that become symptomatic. Lumbar degenerative spine disease (DSD) causes significant

ABBREVIATIONS ALIF = anterior lumbar interbody fusion; ASA = American Society of Anesthesiologists; ASC = ambulatory surgery center; CCI = Charlson Comorbidity Index; DDD = degenerative disc disease; DSD = degenerative spine disease; EBL = estimated blood loss; LLIF = lateral lumbar interbody fusion; PLIF = posterior lumbar interbody fusion; TLIF = transforaminal lumbar interbody fusion; VAS = visual analog scale.

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worldwide disability and is associated with numerous clinical symptoms, such as extremity pain and low-back pain.⁷ Underlying pathologies for which lumbar fusion procedures are indicated include degenerative disc disease (DDD), foraminal stenosis, and spondylolisthesis.⁸ There are multiple techniques and approaches that can be used to accomplish spinal fusion. In response to a complex multifactorial exchange between medical, practical, and socioeconomic factors, the prevalence of outpatient spine surgery has also increased within the past 2 decades. Hence, the most attractive procedures to transition to the outpatient setting are those that can accomplish surgical goals while facilitating discharge within < 24 hours.

Posterior approaches, such as minimally invasive transforaminal lumbar interbody fusions (TLIF), represent a significant achievement in fusion surgery, because they offer many benefits afforded by open procedures and can be performed within the outpatient environment. Although posterior approaches have numerous advantages, they also have been observed to result in higher rates of paravertebral musculature injury, sagittal imbalance, and pseudarthrosis, and greater overall morbidity. Within the past 2 decades, the use of ALIF has increased at a rate disproportionate to that of the aging population.⁹ Much of the increase in ALIF prevalence has been related to its use as an alternative to other approaches associated with higher morbidity, along with the increased access to MRI and new cage designs.^{9–11}

The ALIF surgical procedure also permits efficient discectomy to target discogenic back pain and incorporates favorable geometry that allows for the angulated placement of lordotic stabilizing devices, increased bone graft area, high fusion rates, and enhanced overall visualization.^{12,13} Unfortunately, ALIF is contraindicated in several specific patient groups, including patients who have unfavorable abdominal or vascular anatomy or pathologies.¹² Other difficulties with the ALIF procedures are related to complexities involved in attaining retroperitoneal access. These occur most often at the more caudal levels because the aortic bifurcation and its associated vasculature require extensive distraction and manipulation. Other complications associated with the procedure include adjacent segment degeneration, subsidence, and retrograde ejaculation.^{8,14,15}

In several investigations it was observed that ALIF can be associated with impaired fusion rates, an outcome that apparently required more instrumentation. The increased potentials for adjacent segment disease and implant failure have been hypothesized to be associated with the greater dissection requirements.^{11,16,17} Compared with posterior lumbar interbody fusion (PLIF), ALIF procedures with either posterior pedicle screw fixation or anterior tension band plating have been observed to deliver nearly equivalent outcomes.^{17,18} Hence, ALIF techniques have been developed as “standalone” methods that use little instrumentation other than threaded or intracorporeal screws.¹⁹ These newer techniques address the limitations of tapered or threaded cages while exhibiting stable biomechanical properties and favorable clinical outcomes.^{16,20}

At present, the spine literature is supportive of ALIF, with reports of disability and pain reductions and improved

outcomes. Although enhanced disc height restoration and better rates of fusion have been reported, the supporting data are largely preliminary. Furthermore, ALIF is continuing to evolve, with techniques such as the endoscopic ALIF and the “mini ALIF.” These procedures could potentially be performed in the outpatient setting, though few data supporting this option have been produced. It is hypothesized that possible barriers to adapting ALIF to the outpatient setting include the requirement for postoperative observation to detect possible ileus or vascular complications. Identification of independent risk factors that predispose patients to inpatient stays of ≥ 24 hours in the setting of ALIF may facilitate better postsurgical outcomes and targeting of modifiable risk factors and assist in the development of screening tools to identify patients for whom the ALIF procedure may be transitioned to the ambulatory surgery center (ASC) setting. The purpose of this study was to identify the most relevant risk factors that predispose patients to ≥ 24 -hour admission following ALIF.

Methods

Patient Population

After institutional review board approval was obtained (ORA 14051301), a prospectively maintained surgical registry was retrospectively reviewed for patients undergoing single-level ALIF between May 2006 and December 2019. Inclusion criteria were patients who had undergone elective, primary, single- or multilevel ALIFs for degenerative spine pathologies. Patients were excluded if they had undergone surgery due to trauma, infection, or metastasis.

Data Collection

Recorded variables included the following baseline demographic characteristics: age, sex, BMI, smoking status, American Society of Anesthesiologists (ASA) score, Charlson Comorbidity Index (CCI) score, spinal pathology diagnosis, preoperative visual analog scale (VAS) pain scores, and preoperative diagnosis of hypertension or diabetes. Spinal pathology was determined during the preoperative visit through the evaluation of radiographic imaging. Perioperative variables included operative duration (from skin incision to closure), estimated blood loss (EBL), number of operative levels, location of operative level, and duration of postoperative inpatient stay. All postoperative complications that occurred during the patient's hospital stay were recorded.

Statistical Analysis

Stata 16.0 (StataCorp) was used to perform all calculations and statistical analyses. Descriptive statistics, including proportions, means, and ranges, were reported for baseline demographics and perioperative variables. Patients may have been diagnosed with more than one medical or spinal pathology. A bivariate Poisson regression model with robust error variance was used to evaluate predictors of inpatient stays of ≥ 24 hours. Demographics, preoperative diagnosis, perioperative variables, and postoperative complications were evaluated according to how much they elevated the relative risk of an inpatient

TABLE 1. Patient demographic and perioperative characteristics

	No. of Patients (%)	Mean (range)
Total no. of patients	116	
Age, yrs		59.7 (25.9–71.7)
≤50	61 (52.6%)	
>50	55 (47.4%)	
Sex		
Male	57 (49.1%)	
Female	59 (50.9%)	
BMI, kg/m ²		30.4 (18.9–49.9)
<30	64 (55.2%)	
≥30	52 (44.8%)	
Smoking status		
Nonsmoker	90 (77.6%)	
Smoker	26 (22.4%)	
Postop observation, hrs		53.7 (8.7–430.1)
<24	11 (9.5%)	
≥24	105 (90.5%)	
ASA score		2.0 (1–4)
≤2	93 (80.2%)	
>2	23 (19.8%)	
CCI score		1.0 (0–7)
<1	38 (38.4%)	
≥1	61 (61.6%)	
Hypertension		
Nonhypertensive	84 (72.4%)	
Hypertensive	32 (27.6%)	
Diabetes		
Nondiabetic	102 (87.9%)	
Diabetic	14 (12.1%)	
Preop VAS pain score		7.2 (1–10)
<7	30 (30.9%)	
≥7	67 (69.1%)	
Op duration, mins		158.4 (55–562)
≤105	34 (29.3%)	
>105	82 (70.7%)	
EBL, mL		105.0 (25–2500)
≤50	61 (52.6%)	
>50	55 (47.4%)	

stay ≥ 24 hours. A stepwise backward Poisson regression model with robust error variance was then used to identify independent risk factors for an inpatient admission of ≥ 24 hours. Patients with DDD and any additional spinal diagnosis were analyzed as unique diagnosis groups reflecting coexisting diagnoses (e.g., those with DDD alone, those with DDD and foraminal stenosis, etc.) in the regression analysis. Statistical significance was set at $p < 0.05$.

Surgical Technique

Patients were placed on a flat table in the supine po-

TABLE 2. Rates of preoperative spinal pathologies

Pathology	No. of Patients (%)
DDD	78 (67.2%)
Degenerative spondylolisthesis	73 (63.0%)
Isthmic spondylolisthesis	53 (45.7%)
Foraminal stenosis	49 (42.2%)
Retrolisthesis	7 (6.0%)
Herniated nucleus pulposus	7 (6.0%)
Lateral listhesis	1 (0.9%)

sition. The appropriate disc level(s) was (were) preoperatively localized via fluoroscopy and an anterior paramedian approach was performed. An annulotomy was then performed at the disc space. The vertebral endplates were then defined with a Cobb elevator, and a pituitary rongeur was utilized to remove the remaining disc fragments. Sequential trial implants were placed for sizing, and the preparation of the final interbody was completed with allograft. Screw placement was accomplished within the interbody screw holds. One screw was positioned into the superior and 1 screw was positioned into the inferior vertebral body.

Results

Demographic Characteristics

Our cohort included a total of 111 patients who underwent a single-level ALIF procedure (50.9% female, 52.6% ≤ 50 years old, mean age 59.7 years [range 25.9–71.7 years], Table 1). The majority of patients had a BMI < 30 kg/m² (55.2%) and were nonsmokers (77.6%). A greater proportion of patients had an ASA score of ≤ 2 (80.2%), a CCI score of ≥ 1 (61.6%), and were nonhypertensive (72.4%) and nondiabetic (87.9%). The mean preoperative VAS pain score was 7, with 69.1% of patients scoring ≥ 7. The 3 most common spinal pathologies were DDD (67.2%), degenerative spondylolisthesis (63.0%), and isthmic spondylolisthesis (45.7%, Table 2).

Perioperative Characteristics

The mean operative time was 158.4 minutes, with the majority of procedures (70.7%) taking longer than 105 minutes (Table 1). Eleven (9.5%) patients were discharged in < 24 hours and 105 (90.5%) remained admitted for ≥ 24 hours. The average inpatient stay was > 2 days. There was 1 patient outlier for length of stay, with a duration of 17 days.

Complications

The most common postoperative complications were fever (temperature ≥ 100.4°F, $n = 4$, 3.5%, Table 3) and blood transfusions ($n = 4$, 3.5%). Our criteria for fever included a temperature ≥ 100.4°F and undergoing at least 1 part of a fever workup (e.g., chest radiograph, urinalysis, or cultures). Infectious pathologies were not associated with any fever case. Other postoperative complications

TABLE 3. Rates of postoperative complications

Complication	No. of Patients (%)
Fever	4 (3.5%)
Blood transfusion	4 (3.5%)
Urinary retention requiring catheterization	1 (0.8%)
Cardiac arrhythmia	1 (0.8%)
Vascular complication	1 (0.8%)
Ileus	0 (0.0%)
Urinary tract infection	0 (0.0%)
Acute renal failure	0 (0.0%)
Aspiration	0 (0.0%)
Deep vein thrombosis	0 (0.0%)
Aspiration	0 (0.0%)
Pneumothorax	0 (0.0%)
Pneumonia	0 (0.0%)
Altered mental status	0 (0.0%)
Durotomy	0 (0.0%)
Surgical site infection	0 (0.0%)

occurred in 1 patient each. These complications included cardiac arrhythmia, vascular complications, and urinary retention. The 1 patient diagnosed with postoperative urinary retention required placement of an indwelling catheter. It is also important to point out that this patient had a history of receiving treatment for benign prostatic hyperplasia (BPH). The 1 patient with a vascular complication was also the outlier for length of stay, with a 17-day admission. This patient's vascular complication occurred due to a plaque disruption and thrombosis of the left common and external iliac arteries and required vascular surgery, including a thrombectomy, endarterectomy, pericardial patch angioplasty, and covered stent placement.

Predictors of Extended Inpatient Stay

Assessment with bivariate analysis indicated that the preoperative spinal pathologies retrolisthesis (RR 1.11, $p = 0.001$, Table 4) and lateral listhesis (RR 1.11, $p = 0.001$) had the largest RR elevations associated with an inpatient stay of ≥ 24 hours. Stepwise multivariate analysis revealed the following conditions to be the most significant predictors for an inpatient stay of ≥ 24 hours: operative level L4–5, coexisting degenerative disc disease with foraminal stenosis, and herniated nucleus pulposus (Table 5, RR 1.11, 95% CI 1.03–1.20, all $p = 0.009$).

Discussion

Using the anterior approach for an interbody fusion has numerous advantages, including better operative visualization and increased ability to correct lumbar lordosis and sagittal parameters, as well as decreased manipulation of posterior nerves. The invasive nature of gaining anterior access has, in some cases, been observed to increase the risk of poor postoperative outcomes compared to those for posterior fusion procedures. While multiple studies have

attempted to identify the risk factors for postoperative complications in the setting of ALIF, to our knowledge, none have assessed which complications are most associated with inpatient admissions of ≥ 24 hours.

Pre- and Perioperative Risk Factors for ALIF Postoperative Complications

The risk factors that are most associated with poor ALIF outcomes vary by study design. Because this is, to our knowledge, the first study to evaluate risk factors associated with a ≥ 24 -hour inpatient stay, the potential to make direct comparisons is limited. Our full patient cohort had considerable variation in discharge times (mean 53.7, range 8.7–430.1 hours). We selected hours as the unit of measure for time duration from surgery completion until hospital discharge. The ambulatory surgical setting is limited to a postoperative observation time of < 24 hours. Measuring hours instead of postoperative days assisted in providing meaningful accuracy in this context. Additionally, measuring length of admission by postoperative days can be misleading. For example, patient A could be admitted after surgery at 7 AM, and be discharged on postoperative day (POD) 1, at 10 PM. Patient B might be admitted at 4 PM and could be discharged on POD 1 at 7 AM. In these cases, although both patients were discharged on POD 1, patient A has an admission time of 39 hours, while patient B has an admission time of 16 hours. To our knowledge, analysis focused on a 24-hour discharge cutoff is not reported in other ALIF investigations. However, at least 3 studies have elaborated preoperative risk factors as predictors of complications following ALIF.

The studies that have elaborated on risk factors were predominantly derived from analyses of the American College of Surgeons (ACS) National Surgical Quality Improvement Project (NSQIP) database.^{21,22} Following multivariate regression, Phan et al. found statistically significant predictors of complications following ALIF to be obesity (BMI > 40.0 kg/m², $p = 0.002$), alcohol use (> 2 drinks/day in 2 weeks before admission, $p = 0.004$), and diabetes ($p = 0.001$).²² In their analysis of 2042 patients, Garcia et al. found that their multivariable logistic analysis revealed that only pneumonia diagnosed after surgery ($p < 0.001$) and superficial wound infections ($p < 0.001$) were predictive of complications that required readmission within 30 days.²¹ Finally, Choy et al. observed that according to multivariable logistic regression analysis, variables that contributed to surgical complications following ALIF included diabetes ($p = 0.009$), corticosteroid use for chronic conditions ($p = 0.003$), transfusion (> 4 units packed red blood cells, $p = 0.016$), long operating times ($p < 0.001$), preoperative anemia ($p < 0.001$), male sex ($p = 0.012$), smoking ($p = 0.013$), $> 10\%$ body weight loss (> 6 months preoperatively, $p = 0.049$), and ASA classifications of 3 or greater ($p < 0.001$).²³

At least one previously reported study focused on the influence of a single risk factor. In their assessment of the influence of obesity on complications and clinical and radiographic outcomes after ALIF, Phan et al. found no differences in patient-reported outcomes or complication rates among normal, overweight, and obese individuals.²⁴ However, Phan et al. did observe significantly different an-

TABLE 4. Bivariate analysis of demographic data, preoperative diagnoses, and postoperative complications

	Inpatient Stay ≥ 24 Hrs	RR	95% CI	p Value
Age, yrs				
≤5	52.6%	Ref		
>50	47.4%	1.01	0.89–1.13	0.891
Sex				
Male	49.1%	0.91	0.81–1.03	0.130
Female	50.9%	Ref		
BMI, kg/m ²				
<30	55.2%	Ref		
≥30	44.8%	1.1	0.96–1.21	0.206
Smoking status				
Nonsmoker	77.6%	Ref		
Smoker	22.4%	1.0	0.90–1.17	0.705
ASA score				
≤2	80.1%	Ref		
>2	19.8%	1.07	0.95–1.20	0.228
CCI score				
<1	67.2%	Ref		
≥1	32.8%	1.02	0.89–1.16	0.795
Hypertension				
Nonhypertensive	72.4%	Ref		
Hypertensive	27.6%	1.05	0.93–1.18	0.412
Diabetes status				
Nondiabetic	87.9%	Ref		
Diabetic	12.1%	1.03	0.88–1.21	0.721
Preop VAS pain score				
<7	69.1%	Ref		
≥7	30.9%	1.00	0.86–1.15	0.946
Spinal pathology				
DDD	67.2%	1.02	0.89–1.16	0.795
Degenerative spondylolisthesis	63.9%	1.04	0.92–1.17	0.527
Isthmic spondylolisthesis	45.7%	1.00	0.89–1.13	0.987
Retrolisthesis	6.0%	1.11	1.04–1.18	0.001
Lateral listhesis	0.9%	1.11	1.04–1.17	0.001
Foraminal stenosis	45.7%	0.89	0.78–1.01	0.076
Herniated nucleus pulposus	6.0%	0.94	0.69–1.29	0.713
Op duration, mins				
≤105	29.3%	Ref		
>105	70.7%	0.99	0.87–1.12	0.874
Op level				
L3–4	3.5%	0.54	0.20–1.46	0.226
L4–5	14.7%	1.05	0.91–1.20	0.510
L5–S1	81.9%	1.07	0.89–1.28	0.485

Values are presented as percentages of patients unless otherwise indicated. Boldface indicates statistical significance; p values calculated using bivariate Poisson regression with robust error variance.

TABLE 5. Multivariate analysis for independent risk factors for ≥ 24 -hour inpatient stay

	RR	95% CI	p Value
L4–5 op level	1.11	1.03–1.20	0.009
Coexisting DDD & foraminal stenosis	1.11	1.03–1.20	0.009
Herniated nucleus pulposus	1.11	1.03–1.20	0.009

Boldface indicates statistical significance; p values calculated using backward stepwise Poisson regression with robust error variance.

terior disc heights at the final follow-up between normal weight (14.44 mm), overweight (17.05 mm), and obese patients (11.33 mm, $p = 0.004$).²⁴ In addition, the proportion of patients achieving successful fusion was significantly different between normal weight (88.2%), overweight (76%), and obese patients (60%, $p = 0.014$).²⁴ While the aforementioned obesity investigation examined numerous outcomes, our study did not reveal BMI as a statistically significant predictor for our outcome of interest (e.g., inpatient stays ≥ 24 hours).

In our study, statistically significant preoperative risk factors associated with inpatient stays of ≥ 24 hours were operations at L4–5, coexisting DDD with foraminal stenosis, and herniated nucleus pulposus (RR 1.11, 95% CI 1.03–1.20, $p = 0.009$, all covariates). Our outcome of interest, however, was inpatient stays ≥ 24 hours in duration, whereas the aforementioned investigations assessed risk factors that contributed to complications that ultimately led to increased readmission rates.

Spinal Pathologies With Associated Complications

The literature is scarce regarding the possible association of spinal pathologies with postoperative complications following ALIF. During our bivariate risk factor analysis, several spinal pathologies were found to be statistically significant, including retrolisthesis and lateral listhesis ($p = 0.001$). Other pathologies were significant during subsequent multivariable regression, including coexisting foraminal stenosis with DDD and herniated nucleus pulposus ($p = 0.009$).

While DDD is also among the most common indications for ALIF,^{3,26} we observed that patients in our study with coexisting DDD and foraminal stenosis had a slight increase in their chances of a > 24 -hour inpatient stay (RR 1.11, $p = 0.009$). DDD, without the presence of foraminal stenosis, can cause chronic mechanical lower-back pain. Mechanical loading to these areas can cause delamination, disc degeneration, and annular posterior fissuring. DDD coupled with foraminal stenosis may be associated with disc bulging and compression as well as narrowing of the foramina. Annular receptors may become sensitized at any point during these changes.²⁷ Further degenerative processes that can potentiate pain include neovascularization, nerve demyelination, and Schwann cell neoinnervation.²⁸ In consideration of the mechanisms addressing pain associated with this pathology, it could be that patients undergoing ALIF with DDD required ≥ 24 hours of inpatient observation time due to residual pain. Further subanalyses

are necessary to investigate the relationship between DDD and other pathologies with inpatient stays of ≥ 24 hours.

Complications Associated With Worse ALIF Outcomes

Although the literature is scarce regarding preoperative risk factors, ALIF literature more often includes reported investigations of the most frequent complications resulting in worse outcomes or higher readmission rates. While our study was based on 111 patients, most ALIF research is supported by individual studies with limited patient sample sizes ($n \leq 100$) and heterogeneous patient or disease-specific populations.^{14,29–34} Outcomes also vary among individual ALIF studies, systematic reviews, and meta-analysis studies. For example, individual investigations often focus on complications in general, larger data studies tend to focus on complications as they relate to readmission, and systematic reviews and meta-analyses attempt to address ALIF feasibility concerns.

Fever

Early ALIF literature includes reports of fever in association with infections hypothesized to arise from peritoneal perforations in high-risk patients.³⁵ While recent ALIF literature includes reports of systemic complications, including sepsis, pneumonia, or other infectious etiologies,²² mention of transiently elevated postoperative temperature in these reports is scarce. In the present study, although 4 patients had an elevated temperature, none of their workups resulted in a fever-associated diagnosis prior to discharge. In order to be considered to have a postoperative fever, patients were screened for having any postoperative temperature reading indicative of fever ($\geq 100.4^\circ\text{F}$) and at least 1 diagnostic fever workup test. Postoperative, inpatient, and outpatient notes were reviewed for any one of the following components: blood culture, chest CT, chest radiograph, sputum culture, urinalysis, urine culture, or venous duplex ultrasound. Patients were observed until the transient elevation in temperature dissipated or until the workup revealed no identifiable underlying cause. All 4 of the patients with fever were discharged home uneventfully.

Blood Transfusion

One of the most typical concerns with exposure of the anterior spine is blood loss due to retraction of the internal viscera and blood vessels. Reports in the literature are divided regarding the frequency of blood transfusions. We observed blood transfusions to have occurred in 4 (3.5%) cases, though the rates reported in the ALIF literature are variable, ranging from 0%²¹ to 18%.²² While rates as high as 14%–18% have been reported in some studies, blood transfusion has not been observed to be a statistically significant predictor for 30-day readmissions²² or discharge to inpatient care facilities.²⁵ Other investigators have examined blood transfusions in this setting and determined that transfusions were not associated with any complication differences between ALIF/direct lateral interbody fusions and PLIF/TLIF procedures.³⁶

Vascular Complications

The nature of the anterior approach exposes vulnerable

vasculature, such as the iliac artery and veins, which frequently necessitates the assistance of an access surgeon to safely navigate down to the disc space. In our study, 1 patient experienced vascular complications, which resulted in thrombosis of the left common and external iliac arteries, resulting in a 17-day postoperative stay. In a study of 1315 patients undergoing ALIFs, Brau et al. reported a vascular injury rate of 1.9%, of which 76% of injuries were venous in nature.³⁷ Quraishi et al. observed a vascular injury rate of 4.6% in 304 consecutive ALIFs,² and Hamdan et al. reported a rate of 1.9% for major vascular injuries in 480 ALIFs.³⁸ The reported overall vascular injury rate is 3%,³⁹ which is slightly more than the rate observed in our study (2.2%).

Comparison to the Lateral Transposas Approach

Indications for the lateral transposas approach used in lateral lumbar interbody fusions (LLIF) overlap with those for ALIFs, albeit with a different approach-related complication profile. Investigations of leg weakness or sensory dysesthesia from LLIFs have identified substantially varied rates, ranging from 12.5% to 75%.^{39,40} This variation could, in part, be related to variations in the proximity to the lumbar plexus and disruption of the psoas muscle. The lateral positioning required for the LLIF approach allows gravity to move the abdominal viscera downward and away from the spine. This positioning can reduce the need for retraction of abdominal viscera.⁴¹ A study by Chin et al. evaluated the outcomes of LLIFs in the ASC setting and found an overall complication rate of 7.0% compared to that for inpatient LLIFs at 20%.⁴² The most common complication for LLIFs performed in both inpatient and ASC settings was dermatomal numbness.⁴² The patient selection criteria for ASC LLIFs used by Chin et al. included a maximum BMI of 42 kg/m², single-level fusions, and the ability to perform a procedure that avoids involving L5–S1.⁴² The lateral transposas approach is predominantly not a viable option for L5–S1 procedures due to the obstructing iliac crests.^{39,41}

Interestingly, for ALIFs, an operation at L5–S1 is often more straightforward because it provides the surgeon with the largest working space, requires less bowel manipulation than ALIFs at other levels, and does not require iliolumbar vein ligation. When performing an ALIF on more superior levels (e.g., L4–5, L3–4), however, more extensive retraction of abdominal viscera is often required to provide adequate visualization.³⁹ The L4–5 level also introduces greater vascular risk given the bifurcation of the aorta into the iliac vessels.⁴¹ Persistent postoperative ileus is a complication that should be considered following ALIF due to the prolonged retraction of intestinal viscera. The rate of ileus following ALIF is relatively low, with reported rates ranging from 0.6% to 17.3%.^{43–45}

Study Limitations

This study has limitations that should be considered when evaluating our results. The retrospective nature of this study may lead to observer bias. Unblinded investigators can be more likely to observe results they expect. This topic could more rigorously be addressed with a blinded prospective study design in order to investigate risk factors

that contribute to an extended hospital length of stay following ALIFs. Secondly, a number of comparison studies reported 30-day readmission rates that were attributable to slower-evolving complications. Our study was limited to only those complications that patients experienced while in the hospital. Additionally, preoperative data that might be derived from patient-reported outcome measures (PROM) for mental health, disability, or preoperative narcotic usage were limited. As a result, we were unable to include PROM scores as variables in our analysis. It would be beneficial for future prospective investigations to evaluate the influence of multiple realms of health (as reflected by PROM scores) on the lengths of inpatient stays following ALIF.

Conclusions

In summary, ALIF has numerous benefits and can be performed safely among the correct patient population. In this study, we assessed baseline demographics, perioperative characteristics, and complications in the postoperative setting in order to identify which patients were most likely to require inpatient admissions of ≥ 24 hours in duration. Preoperative factors that were observed to favor inpatient admissions of ≥ 24 hours included operations at L4–5, coexisting DDD with foraminal stenosis, and herniated nucleus pulposus. Although this study serves as an initial analysis to discern the most relevant factors that warrant consideration when moving ALIF procedures to the ASC, further studies are needed to address which patient characteristics are most likely to facilitate a post-ALIF discharge in < 24 hours.

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