Risk factors for hospital admission in patients undergoing outpatient anterior cruciate ligament reconstruction: A national database study

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ABSTRACT

Introduction: Anterior Cruciate Ligament Reconstructions (ACLR) are routinely performed in an outpatient setting with low 90-day readmission rates (2.3%); however, admissions rates in the immediate perioperative period have been previously reported as high as 13.1%. Despite the surprisingly high number of patients requiring immediate perioperative admission, there has been a lack of recent literature specifically examining the associated risk factors for admission.

Methods: Using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, a query for patients who underwent ACLR from 2011 through 2018 was performed using Current Procedural Terminology codes. The following concomitant procedures were included: meniscectomy, meniscal repair, diagnostic arthroscopy, loose body removal, synovectomy, chondroplasty, abrasion chondroplasty, drilling for osteochondritis dissecans. Demographics including age, sex, race, body mass index (BMI) and comorbidities were collected. Perioperative factors collected were anesthesia type and operative times. Patient demographic and perioperative data were compared using Fisher's exact test and Pearson's chi-square test. Multivariate logistic regressions were used to calculate odds ratios (OR) and 95% confidence intervals (CI) of independent risk factors for postoperative admission. Holm-Bonferroni method yielded adjusted p-value thresholds for significance.

Results: Of the 20,819 patients undergoing ACLR with and without concomitant procedures, 3.8% of patients were admitted to the hospital in the immediate postoperative period. Following multivariate regression analysis, increased odds of admission were demonstrated with the use of regional anesthesia alone (OR = 2.77, 95%CI: 2.22–3.44; $p < 0.001$), increasing concurrent procedures (Table 1), and obesity classes II (OR = 1.62, 95%CI: 1.26–2.10; $p < 0.001$) and III (OR = 1.81, 95%CI: 1.33–2.47; $p < 0.001$). Subsequent subgroup analysis of the isolated ACLR procedures (N = 9,423) demonstrated a 3.3% postoperative admission rate. Multivariate regressions demonstrated increased odds of admission with regional anesthesia use only (OR = 2.62, 95%CI: 1.90–3.60; $p < 0.001$), obesity class II (OR = 2.22, 95%CI: 1.51–3.26; $p < 0.001$), and increasing minutes of operative time (OR = 1.01, 95%CI: 1.01–1.01; $p < 0.001$). Table 2 demonstrates increasing rates and odds of admission with increasing operative time in hours.

Conclusion: Anterior Cruciate Ligament Reconstructions are routinely performed in an outpatient setting; nevertheless, a subset of ACLR patients is admitted postoperatively. We found an increased risk of admission with the use of regional anesthesia alone, increasing concurrent procedures and obesity classes II and III. A further understanding of patient risk factors for those undergoing ACLR allows orthopedic surgeons to better develop a preoperative plan and discuss patient expectations, which will lead to more efficient resource allocation and improved patient satisfaction.

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1. Introduction

It is estimated that there are between 60,000 and 200,000 anterior cruciate ligament (ACL) injuries annually in the United States.¹ With modern advancements, ACL reconstruction (ACLR) is considered a relatively safe surgical procedure and the majority of cases are performed on an outpatient basis.^{2–4} The volume of surgical procedures performed in the ambulatory setting has been increasing and, therefore, careful screening of patients for ambulatory surgery is crucial in order to ensure efficient use of resources while maximizing patient safety.⁵

The majority of literature regarding ACLR complications addresses long-term complications such as reinjury, graft failure, and the development of degenerative arthritis.^{6–9} With regards to short term complications, ACLR has a low incidence of complications (1.34%) in the early postoperative period, with the most common being symptomatic venous thromboembolic disease requiring treatment, return to the operating room, and infections.¹⁰ As the majority of literature has focused on these complications, there remains a lack of focus on the admission rates following ACLR.

ACLRs are routinely performed in an outpatient setting with low 90-day readmission rates (2.3%); however, admissions rates in the immediate perioperative period have been previously reported as 13.1%.^{11,12} Despite the surprisingly high number of patients requiring perioperative admission, there has been a paucity of literature specifically examining the associated risk factors. Prior literature has suggested factors such as Hispanic ethnicity, use of epidural anesthesia, and history of bleeding disorders as major independent risk factors for admission after ACL.¹¹ However, the availability of a larger sample of patients, with a focused approach to concurrent procedures in the outpatient setting has prompted a re-evaluation. As ACLR is an elective procedure, in addition to the anticipated benefits of undergoing the procedure, it is crucially important for patients and clinicians to have knowledge of the specific risks of admission.

Therefore, the purpose of this study was to evaluate perioperative and short-term postoperative outcomes in ACLR patients and to better understand risk factors for admission following ACLR. This study employed a prospectively collected national database to review outcomes of patients undergoing outpatient primary ACLR.

2. Methods

2.1. Database

This study utilized the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. The purpose of this database is to advance the quality of care delivered to the surgical patient. Data is collected from over 700 participating hospitals, by trained clinical reviewers, including demographics, comorbidities, diagnoses in International Classification of Disease 9th and 10th revision (ICD-9, ICD-10) codes, surgery in Current Procedural Terminology (CPT) codes, and surgical outcomes through 30 days postoperatively.¹³

2.2. Patient population

The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) was queried for patients who underwent ACLR from 2011 through 2018 using Current Procedural Terminology (CPT) codes. A query for all ACLR cases in the database was done with CPT 29888 in all fields, yielding 27,331 cases. ACLR performed with concurrent procedures by another surgical team (N = 107) were excluded, other than concurrently coded peripheral blocks: CPT 64445, 64446, 64447, 64448, 64449, 64450. Cases undergoing emergency cases (N = 50) or sepsis on presentation (N = 52) were not included in the study. Other procedures performed by the same surgical team were excluded based on bilateral ACLR. ACLR with concomitant procedures including concurrent meniscectomy (29880, 29881), meniscal repair

(29882, 29883), diagnostic arthroscopy (29870), loose body removal (29874), synovectomy (29875, 29876), chondroplasty (18777, G0289), abrasion chondroplasty (29879, 29884), drilling for osteochondritis dissecans (29885, 29886, 29887) were separately analyzed. Due to changes in NSQIP data collection and subsequent missing data found before 2011, the years 2010 and older were excluded from the study leaving 22,494 cases. Inpatient cases were excluded due to marked differences in admission rates after ACLR (N = 981). Missing data for variables needed for BMI calculation (N = 501), operative length (N = 2), or LOS (N = 12) was noted with 514 cases additional cases excluded. Subsequently patients greater than 60 BMI (N = 21), less than 18.5 (N = 96), greater than 6 h of surgery N = 36), and less than 10 min (N = 27) were excluded to control confounding factors and allow for more accurate analysis. This gave us our sample size of 20,819 cases of ACLR with and without concomitant procedures.

2.3. Variables collected

Demographics and comorbidities collected included age, sex, race, body mass index (BMI) categories (18.50–24.99 kg/m², 25.00–29.99 kg/m², 30.00–34.99 kg/m², 35.00–39.99 kg/m², and greater than 40.00 kg/m²), bleeding disorders, dyspnea (and chronic obstructive pulmonary disease), diabetes, hypertension, smoking status, and chronic steroid use. There were no patients undergoing outpatient ACLR with noted history of cancer, congestive heart failure, dialysis, myocardial infarction, or cerebrovascular accident. Perioperative factors collected were anesthesia type (combining primary and secondary anesthesia into: General alone, Regional alone, General and Regional combined), and operative times.

2.4. Statistical analysis

Patient demographic and perioperative data between patients who were and were not admitted after ACLR was compared using Fisher's exact test and Pearson's chi-square test. Multivariate logistic regressions were used to calculate odds ratios (OR) and 95% confidence intervals (CI) of independent risk factors for postoperative admission. To further examine the influence of operative time, a subgroup analysis was done for isolated ACLR. While the regression model demonstrated appropriate goodness of fit test ($p < 0.05$) for both populations, variance explained by model (Nagelkerke R^2) decreased from 5.9% to 5.0% for the isolated ACLR population. A two-tailed p-value threshold of 0.05 was considered statistically significant. To reduce the probability of a type I error in multivariate regressions, Holm-Bonferroni method was used to adjust for multiple comparisons at an alpha level of 0.05, yielding adjusted p-value thresholds for significance ($p \leq 0.005$). All statistical analyses were performed with SPSS version 26 (IBM Corporation, Armonk, New York).

3. Results

Among the 20,819 patients included in our initial study population, 800 were admitted postoperatively corresponding to an admission rate of 3.8%. From this initial population, isolated ACLR (N = 9,423) were also selected for additional analysis, demonstrating an admission rate of 3.3% (N = 308). Demographic, comorbid, and perioperative factors are presented for both populations in Table 1.

3.1. Demographics (ACLR with concomitant procedures)

According to the univariate analysis, there were significant differences in gender, Body Mass Index (BMI), race, dyspnea/COPD, diabetes, and hypertension between patients who required inpatient hospital admission versus discharge.

Table 1
Characteristics of patients undergoing anterior cruciate ligament reconstruction (ACLR).

	ACLR with and without Concomitant Procedures					Isolated ACLR				
	Not Admitted (N = 20019)		Admitted (N = 800)		p-value*	Not Admitted (N = 9115)		Admitted (N = 308)		p-value*
	N	Percent	N	Percent		N	Percent	N	Percent	
Mean Age, year (SD)	32.0	(10.7)	33.0	(11.3)	0.022	31.4	(10.1)	32.3	(10.2)	0.126
Age, year										
<25	6048	30.2%	233	29.1%	0.256	2822	31.0%	86	27.9%	0.393
25–34	6664	33.3%	246	30.8%		3207	35.2%	105	34.1%	
35–44	4397	22.0%	192	24.0%		1996	21.9%	82	26.6%	
45–54	2256	11.3%	96	12.0%		875	9.6%	28	9.1%	
≥55	654	3.3%	33	4.1%		215	2.4%	7	2.3%	
Sex										
Female	7181	35.9%	333	41.6%	0.001	3581	39.3%	131	42.5%	0.260
Male	12838	64.1%	467	58.4%		5534	60.7%	177	57.5%	
Mean BMI, kg/m ² (SD)	28.21	(5.56)	29.88	(6.94)	<0.001	27.89	(5.45)	29.54	(6.87)	<0.001
BMI, kg/m ²										
18.50–24.99	5941	29.7%	203	25.4%	<0.001	2918	32.0%	83	26.9%	<0.001
25.00–29.99	8265	41.3%	277	34.6%		3742	41.1%	108	35.1%	
30.00–34.99	3677	18.4%	163	20.4%		1597	17.5%	55	17.9%	
35.00–39.99	1352	6.8%	89	11.1%		544	6.0%	40	13.0%	
≥40.00	784	3.9%	68	8.5%		314	3.4%	22	7.1%	
Race										
White	11608	58.0%	570	71.3%	<0.001	5218	57.2%	213	69.2%	<0.001
Black	1799	9.0%	76	9.5%		797	8.7%	27	8.8%	
Asian	1020	5.1%	31	3.9%		445	4.9%	11	3.6%	
Ame Ind/Pac Isl	620	3.1%	22	2.8%		252	2.8%	6	1.9%	
Unknown	4972	24.8%	101	12.6%		2403	26.4%	51	16.6%	
Hispanic										
Yes	2175	10.9%	109	13.6%	<0.001	5481	60.1%	208	67.5%	0.001
Unknown	5654	28.2%	123	15.4%		777	8.5%	33	10.7%	
Comorbidities										
Bleeding Disorder	31	0.2%	5	0.6%	0.012	16	0.2%	2	0.6%	0.116
Dyspnea/COPD	110	0.5%	12	1.5%	0.003	39	0.4%	4	1.3%	0.051
Diabetes	277	1.4%	23	2.9%	0.002	100	1.1%	8	2.6%	0.025
Hypertension	1200	6.0%	82	10.3%	<0.001	460	5.0%	27	8.8%	0.008
Current Smoker	3346	16.7%	152	19.0%	0.090	1460	16.0%	58	18.8%	0.181
Steroid Use	76	0.4%	5	0.6%	0.242	30	0.3%	4	1.3%	0.024
Anesthesia Type										
General	15192	75.9%	625	78.1%	<0.001	6887	75.6%	240	77.9%	<0.001
Regional	817	4.1%	76	9.5%		423	4.6%	29	9.4%	
General and Regional	4010	20.0%	99	12.4%		1805	19.8%	39	12.7%	
Op Time, minutes (SD)	100.0	(42.6)	115.8	(54.0)	<0.001	97.4	(41.4)	111.0	(50.7)	<0.001
Op Time, hours										
<1	2776	13.9%	84	10.5%	<0.001	1416	15.5%	40	13.0%	<0.001
1–2	11954	59.7%	393	49.1%		5503	60.4%	159	51.6%	
2–3	4257	21.3%	234	29.3%		1781	19.5%	76	24.7%	
3–4	836	4.2%	66	8.3%		344	3.8%	25	8.1%	
≥4	196	1.0%	23	2.9%		71	0.8%	8	2.6%	

* = p-values reflect difference between admitted and not admitted using Pearson's chi-squared or Fisher's exact test for categorical variables, and independent samples *t*-test for continuous variables. SD = standard deviation; BMI = body mass index; Ame Ind/Pac Isl = American Indian/Pacific Islander; Op Time = operative time. ACLR with concomitant procedures including concurrent meniscectomy (29880, 29881), meniscal repair (29882, 29883), diagnostic arthroscopy (29870), loose body removal (29874), synovectomy (29875, 29876), chondroplasty (18777, G0289), abrasion chondroplasty (29879, 29884), drilling for osteochondritis dissecans (29885, 29886, 29887) were separately analyzed.

3.2. Demographics (isolated ACLR)

According to the univariate analysis, there were significant differences in Body Mass Index (BMI) and race between patients who required inpatient hospital admission versus discharge.

3.3. Medical comorbidities

Finally, multiple medical comorbidities were more commonly found among the admitted population, particularly, Dyspnea/COPD, Diabetes, and Hypertension (Table 1). This was not a significant finding in the isolated ACLR group.

3.4. Independent risk factors for admission

Across both populations, increasing rates for postoperative admission increased with increasing BMI and operative time. Additionally,

patients who received only regional anesthesia had more than twice the incidence of admission when compared to general alone, and more than three times compared to combined anesthesia modalities (Table 2).

A multivariate regression was subsequently used to evaluate the influence of these patient factors while controlling for age, race, ethnicity, and comorbidities (Table 2). BMI, anesthesia type, and operative times were found to be significant factors influencing risk of admission following ACLR. Female sex was a significant risk factor for post-operative admission in patients undergoing ACLR (OR: 1.24, 95% CI: 1.07–1.44; *p* = 0.005), but this was not noted when evaluating isolated procedures alone.

While obesity type II (35.00–39.99 kg/m², OR: 1.65, 95% CI: 1.26–2.15; *p* < 0.001), and obesity type III (≥40.00 kg/m², OR: 2.00, 95% CI: (1.48–2.70); *p* < 0.001) were found to be significant risk factors for admission in ACLR combined population, a BMI above 40 was less impactful for the isolated ACLR population (OR: 1.92, 95% CI: (1.16–3.19), *p* = 0.011). Similarly, while the combined population had

Table 2

Admission rates and multivariate regression evaluating influence of factors on admission in patients undergoing anterior cruciate ligament reconstruction (ACLR).

	ACLR with and without Concomitant Procedures				Isolated ACLR			
	Incidence	Odds of Admission			Incidence	Odds of Admission		
	Percent	OR	95% CI	p-value	Percent	OR	95% CI	p-value
Sex, ref Male	3.5%				3.1%			
Female	4.4%	1.24	(1.07–1.44)	0.005	3.5%	1.11	(0.87–1.41)	0.416
BMI, kg/m ² , ref 18.50–24.99	3.3%				2.8%			
25.00–29.99	3.2%	1.00	(0.83–1.21)	0.980	2.8%	0.97	(0.72–1.31)	0.859
30.00–34.99	4.2%	1.23	(0.99–1.53)	0.064	3.3%	1.07	(0.75–1.54)	0.702
35.00–39.99	6.2%	1.65	(1.26–2.15)	<0.001	6.8%	2.13	(1.42–3.20)	<0.001
≥40.00	8.0%	2.00	(1.48–2.70)	<0.001	6.5%	1.92	(1.16–3.19)	0.011
Anesthesia Type, ref General	4.0%				3.4%			
Regional	8.5%	2.41	(1.87–3.11)	<0.001	6.4%	2.12	(1.42–3.18)	<0.001
General and Regional	2.4%	0.57	(0.46–0.71)	<0.001	2.1%	0.60	(0.42–0.85)	0.004
Op Time, hours, ref <1	2.9%				2.7%			
1–2	3.2%	1.19	(0.93–1.52)	0.166	2.8%	1.08	(0.75–1.55)	0.676
2–3	5.2%	2.07	(1.59–2.69)	<0.001	4.1%	1.69	(1.13–2.53)	0.011
3–4	7.3%	3.17	(2.25–4.47)	<0.001	6.8%	3.03	(1.78–5.16)	<0.001
≥4	10.5%	4.59	(2.79–7.55)	<0.001	10.1%	4.63	(2.04–10.51)	<0.001

While controlling for age, race, ethnicity, and comorbidities. OR = odds ratio; CI = confidence interval; BMI = body mass index; Op Time = operative time.

significantly increased risk of admission for procedures lasting 2–3 h (OR: 2.07, 95% CI: 1.59–2.69, $p < 0.001$), only operative times lasting 3 h or longer showed significant influence on admissions after isolated ACLR (Table 2).

When compared to general anesthesia, both populations demonstrated a more than two-fold increased odds of admission following the use of regional anesthesia alone, while a combined general and regional modality was associated with almost half the risk (Table 2).

4. Discussion

In the United States, outpatient ACLRs are performed with a surprisingly high rate of conversion from planned outpatient surgery to unexpected admissions. Utilizing the ACS-NSQIP database from 2011 to 2018, the goal of our study was to evaluate the risk factors for patient admission following outpatient ACLR. During the study period, the admission rate for ACLR with concomitant procedures and isolated ACLR were 3.8% and 3.3%, respectively. This compares to a similar NSQIP database evaluation from 2005 to 2015, which showed a higher unplanned overnight admission rate of 13.1% in patients undergoing ACLR.⁶ Following multivariate regression, patients that received regional anesthesia alone, had BMIs greater than 35, or had longer operative times had higher odds of admission. The findings in our study can further provide surgeons with knowledge of potentially modifiable and non-modifiable risk factors when discussing ACLR with patients. Knowledge of these risk factors is important when setting patient expectations preoperatively and for optimizing care to obtain the best short-term outcome.

Although our study benefited from a large number of surgical cases, certain limitations need to be considered. First, there are limitations inherent to the NSQIP database. CPT codes are used to identify patients in the NSQIP database, and when potential miscoding is considered, incomplete patient capture is a risk. In addition, misclassification of data is a concern when using database information. However, interrater reliability disagreement within ACS-NSQIP has previously been shown to be less than 1.8%.¹³ Because the database is reported by individual hospitals, the retrievable data may reflect the data only of those participating institutions, rather than a true representation of a larger population. However, with the increasing number of institutions submitting cases, the data becomes more generalizable. Exclusion of patients may introduce unintended bias, nevertheless, to further focus the study population, the outpatient setting with concomitant procedures provides clarity on ACLR procedures. Furthermore, this careful approach to the database patient population allowed for a modest variance explained ($R^2 = 5.9\%$) which was unreported in similar studies

or improved when compared to prior studies studying ACLR readmission ($R^2 = 3.9\%$).^{11,14} Lastly, the NSQIP database does not provide reason for admission under its current platform for data reporting. However, in regards to the identified risk factors in our present study, an extrapolation of potential reasons for admission can be postulated.

Recent data demonstrates that the prevalence of obesity in the adult population in the United States is 39.6% and 18.5% in the youth population, with an increasing yearly trend in the adult population.¹⁵ Similar to previous authors, we found a progressive likelihood of admission as BMI increased in both isolated ACLR and ACLR with concomitant procedures. In an analysis of 9,000 patients undergoing ACLR from 2007 to 2014, authors similarly found that a BMI over 40 had three times increased risk of 30-day readmission when compared with patients with normal weight.¹⁴ Gabriel et al. also examined risk factors for admission following joint arthroscopy and concluded that a BMI ≥ 50 kg/m² may be used as a sole factor for patient selection in patients undergoing joint arthroscopy.¹⁶ Boddapati et al. similarly reported obesity as a risk factor for both hospital readmission and overnight hospital stay after ACLR.¹⁵ Conversely, Bokshan et al. reported BMI only as a minor predictor of admission after ACLR (OR 1.03, $P < 0.001$), and did not report results as BMI categories.¹¹ The authors of this study suggested that due to the proximity to the OR of 1, this finding did not hold a strong association. Nevertheless, the presentation of increasing risk in accordance with an increase of 1 unit of the BMI scale may have underrepresented the importance as a risk factor. Furthermore, stratification of patient factors into clinically relevant categories allows for clearer interpretation, and our study demonstrates that obesity class II and III are strong predictors of postoperative admission. Thus, patient BMI should be considered a significant prognostic risk factor in perioperative outcomes and admission following outpatient ACLR, and deserves attention during surgical planning and should be taken into consideration when explaining the risks to potential ACLR patients.

Longer operative times during outpatient orthopedic procedures have been associated with higher readmission rates, complications rates, and adverse events.^{11,18–20} Operative time has been suggested as a surrogate measure of surgical complexity, thus possibly proving to be a useful perioperative variable in postoperative risk stratification and presurgical counseling.¹⁷ A previous study by Bokshan et al. found operative time to be a minor predictor of admission (OR 1.012, $P < 0.004$)¹¹; However, their assessment was based on increasing odds of admission with increasing operative time of 1 min. Our study represents operative time as hour categories, allowing for ease of interpretation, and our methodology distinguishes complexity of cases further (by excluding inpatient and certain procedures), focusing on a more selective group of the ACLR patient population. When compared to our

results, their higher average operative time for their admitted population (131.7 min) but similar operative times for those that were not admitted, demonstrate a higher complexity in their cases and, therefore, higher possibility of confounding factors. In reference to operative time less than 1 h, those with operative times between 2 to 3 h had more than twice the odds of admission, with increasing OR for operative times greater than 3 h. For isolated ACLR procedures, operative times lasting three or more hours were significant predictors of admission. Similar to our results, surgical duration >120 min carried an increased risk of overnight hospital stay after isolated PCL reconstructions (OR 5.04, CI 2.44–10.40; $p < 0.001$).²¹ A database analysis looking at 12,077 primary ACLR reported that longer operative times (≥ 90 min) more than doubled the incidence of overnight hospital stays (16.2% v 6.0%, $p < 0.001$) as well as increased the risk of 30-day complications.¹⁷ Similarly, Cooper et al. reported a decreased risk of readmission for patients undergoing ACLR with operative times less than 80 min (OR 0.40).¹⁴ In regards to operative time, a NSQIP study looking at all arthroscopic knee procedures found that a 15-min increase in operative time lead to an increased risk of readmission and extended length of stay, as well as an overall increase in risk of adverse events.²⁰ Furthermore, using the NSQIP database, Agarwalla et al. found that 15-min incremental increases in operative time were associated with increased readmission rates and an extended length of stay, as well as risk of deep vein thrombosis, surgical site infections and sepsis.¹⁹ There is adequate literature supporting the finding that longer operative times are associated with adverse perioperative events. While NSQIP does not track the reason for admission, our data supports the current understanding that longer operative duration increases the risk for admission following ACLR. Interestingly, we found that for the more “standardized” isolated ACLR procedures, operative time may have a smaller degree of influence on the admission rate. Based on our findings, well devised, careful surgical planning may be vital in decreasing operative times and may benefit the patient by limiting the risk of these perioperative adverse events.

Modern analgesic care of orthopedic patients has evolved from a model predominantly focused on opioids, subsequently complemented by peripheral nerve blocks such as femoral nerve block and then adductor canal block, all in the context of a multimodal analgesic regimen.²² The paradigm shift towards the new aged approach of pain control in such patients has likely played an important role in the decreasing rate of admissions. Our study found that in both ACLR with concomitant procedures and isolated ACLR, the use of regional anesthesia alone was a significant risk factor for admission. However, the use of combined general and regional anesthesia, decreased the risk of admission by about half in both populations. The previous study by Bokshan et al. found the usage of epidural anesthesia alone to be a significant risk factor for admission following ACLR; the use of regional and general anesthesia were not significant risk factors.¹¹ Our study combined primary and secondary methods of anesthesia to determine anesthesia type as general alone, regional alone, and combined general and regional. This distinction allows for a more accurate representation of the operative anesthesia type and the combined benefits of both modalities. Similar to our findings, previous authors found that the use of regional analgesia reduced PACU admission to 18% and decreased unplanned hospital admission rates from 17% to 4% with a hospital cost reduction of 12%.²³ Similarly, in a single center retrospective study evaluating hospital admission following pediatric ACLR, Hall-Burton et al. demonstrated that regional anesthesia based pain management was associated with lower rates of unplanned hospital admissions, less time in the postanesthesia care unit and a reduction in narcotic consumption.²⁴ Conversely, one prospective, multicenter study found that 3.4% of ACLR patients were not discharged on the day of surgery, however no correlation was found with the anesthesia technique used.²⁵ In our study, it appears the sole use of general anesthesia was associated with a higher risk for admission. Our findings suggest the benefits of a combined approach to anesthesia, in that it may decrease the risk of

unanticipated hospital admission after ACLR. As eluded to previously, readers can extrapolate that a combined anesthesia approach (i.e. peripheral nerve blocks) may reduce the risk for admission attributed to inadequate postoperative pain control being the reason unanticipated admission.

Despite the analogous aspects of our study to previous work, there were some considerable differences in our findings that distinguishes it from previous investigations. Most importantly, we did not find age to be a contributing risk factor for admission. In a similar study by Bokshan et al. they did find age to be a minor contributor to postoperative admissions with older age having a small odds ratio of 1.008.¹¹ Even with this significant finding, it is unlikely to have a strong contributing risk for admission. Conversely, others have found age to be related to readmission rates in the short term postoperative period. In an epidemiological study by Lyman et al. attempting to examine trends in ACLR complications and readmissions, age was a strong predictor of readmission within ninety days, with patients forty years of age and older being readmitted more often than younger patients, independent of other factors.²⁶ Conversely, based on the NSQIP database study by Cooper et al. older patients ($> / = 65$) undergoing ACLR had operative times that were 32.75 min shorter on average than that of younger patients (< 25 years old).¹⁴ The same study showed that longer operative times lead to increased readmissions, thereby demonstrating that younger patients had a higher risk of readmission. This was further supported by data from a cohort study using patients from a Kaiser Permanente ACLR Registry, which showed that patients aged < 21 years, had a 7.76 times higher risk of revision surgery compared to patients aged > 40 years.²⁷

5. Conclusion

Unanticipated overnight admissions for ACLR were evaluated in our study in order to identify risk factors associated with unplanned admissions and provide the groundwork for possible solutions. Although modern ACLR is generally performed on an outpatient basis, the admission rates immediately after surgery make up a surprisingly high number of patients undergoing the procedure. Our study focusing on outpatient procedures found that 3.8% of the patients undergoing ACLR with concurrent procedures and 3.3% of patients undergoing isolated ACLR procedures required immediate post operative admission. Over the past 30 years the analgesic care of ACLR patients has evolved, utilizing a more multimodal analgesic model.²² This change in approach of pain control in such patients has likely played an important role in the decreasing rate of admissions. The results of our multivariate regression showed patients that received regional anesthesia alone, had BMIs greater than 35, or had longer operative times had higher odds of admission. Better knowledge of these risk factors can potentially improve analgesic requirements and management, prevent unanticipated admissions, save hospital resources and promote patient and surgeon satisfaction. Cost and resource savings, though not discussed in this study, is also a major potential benefit. Thus, further studies are required to better understand how these risk factors interplay in influencing the outcomes of ACLR. In summary, we recognize that certain identified risk factors may be out of the hands of surgeons to strategically modify. However, based on the results of this study, the authors suggest constantly striving to improve surgical times with high quality preparation and accurate surgical technique. In addition, a collaborative approach with the anesthesia team using state of the art and contemporary pain control techniques will help reduce the risk of admission for patients undergoing ACLR.

Declaration of competing interest

None Reported.

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