Operative Time as an Independent and Modifiable Risk Factor for Short-Term Complications After Knee Arthroscopy

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Purpose: To determine whether operative time is an independent risk factor for 30-day complications after arthroscopic surgical procedures on the knee. **Methods:** The American College of Surgeons National Surgical Quality Improvement Program database was queried between 2005 and 2016 for all arthroscopic knee procedures including lateral release, loose body removal, synovectomy, chondroplasty, microfracture, and meniscectomy. Cases with concomitant procedures were excluded. Correlations between operative time and adverse events were controlled for variables such as age, sex, body mass index, patient comorbidities, and procedure using a multivariate Poisson regression with robust error variance. **Results:** A total of 78,864 procedures met our inclusion and exclusion criteria. The mean age of patients was 51.0 ± 14.3 years; mean operative time, 31.2 ± 18.1 minutes; and mean body mass index, 31.0 ± 7.8. Arthroscopic lateral release (coefficient, 5.8; 95% confidence interval [CI], 4.8-6.8; $P < .001$), removal of loose bodies (coefficient, 4.2; 95% CI, 3.2-5.3; $P < .001$), synovectomy (coefficient, 1.8; 95% CI, 1.2-2.3; $P < .001$), and microfracture (coefficient, 6.5; 95% CI, 5.8-7.2; $P < .001$) had significantly greater durations of surgery in comparison with meniscectomy. The overall rate of adverse events was 1.24%. After we adjusted for demographic characteristics and the procedure, a 15-minute increase in operative duration was associated with an increased risk of transfusion (relative risk [RR], 1.5; 95% CI, 1.3-1.8; $P < .001$), death (RR, 1.6; 95% CI, 1.2-2.1; $P = .005$), dehiscence (RR, 1.6; 95% CI, 1.2-2.2; $P = .002$), surgical-site infection (RR, 1.3; 95% CI, 1.2-1.3; $P = .001$), sepsis (RR, 1.3; 95% CI, 1.2-1.4; $P < .001$), readmission (RR, 1.1; 95% CI, 1.1-1.2; $P < .001$), and extended length of stay (RR, 1.4; 95% CI, 1.3-1.4; $P < .001$). **Conclusions:** Marginal increases in operative time are associated with an increased risk of adverse events such as surgical-site infection, sepsis, extended length of stay, and readmission. Efforts should be made to maximize surgical efficiency. **Level of Evidence:** Level IV, retrospective database study.

See commentary on page 2099

Over the past 2 decades, there has been a stark increase in the number of knee arthroscopies performed by more than 150%, particularly in the ambulatory setting.[1] Orthopaedic procedures with minimal complication rates may be favorably performed in ambulatory surgical centers because they are more convenient for the patient and place less economic burden on health care providers.[2] Furthermore, minimizing complication rates is beneficial for patient safety and maximization of clinical outcomes

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after orthopaedic procedures. The Bundled Payments for Care Improvement Initiative, initiated in 2013, emphasizes reimbursement based on quality and minimization of postoperative complications.[3-5] Therefore, identification of modifiable risk factors becomes increasingly important.[6]

A longer operative time, most commonly defined as the time from incision to wound closure, has previously been identified as a risk factor for short-term complications in the orthopaedic and non-orthopaedic literature.[7-11] However, this relation is poorly understood, and it is unknown whether operative time is truly a modifiable risk factor for complications or a confounding variable for complicated cases. Without a proper understanding of this relation, few recommendations can be made to advance surgical care. A composite list of procedures in general surgery, otolaryngology, urology, cardiothoracic surgery, and vascular surgery has previously shown a 14-fold increase in the risk of development of a surgical-site infection for each hour in which surgery is performed.[12] Furthermore, in a comparison of hospitals with high rates of surgical-site infections versus those with low rates, operative duration was significantly longer in sites with more surgical-site infections.[13]

Although arthroscopic knee procedures are relatively quick, it is paramount to minimize the complication risk to maximize patient safety and outcomes of operative management. Meniscectomy is the most common arthroscopic knee procedure,[14,15] and even in this population, body mass index (BMI) has been the only modifiable risk factor identified to minimize postoperative complication.[15] Complications after arthroscopic knee surgery include deep vein thrombosis (DVT), hemarthrosis, surgical-site infection, and nerve paresthesia.[16,17] It has been previously described that younger age, ligamentous repair, operations involving 3 or more Current Procedural Terminology (CPT) codes, and obstructive sleep apnea are risk factors for complications after arthroscopic knee surgery.[16-18] Identification of operative time as an independent risk factor would emphasize the need for efficiency within the operating room and the need for surgical planning prior to incision.

The purpose of this study was to determine whether operative time is an independent risk factor for short-term complications after arthroscopic surgical procedures on the knee. The hypothesis of this investigation was that there would be a positive linear correlation between operative time and the risk of development of a surgical-site infection and adverse events after knee arthroscopy.

Methods

Study Design

This study is a retrospective database analysis of the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database. This database is composed of prospectively collected data from a growing network of 687 participating hospitals. Participating hospitals are required to staff clinical reviewers with a background in health care to collect over 274 variables from surgical procedures, including complications, readmissions, and reoperations that occur within 30 days of the index procedure. The ACS NSQIP has several quality-assurance programs in place, such as random internal audits performed twice a week, which have reported less than 1.8% disagreement between raters.[19,20] The information in the ACS NSQIP database is deidentified; therefore, institutional review board approval was not necessary for this investigation.

Data Collection

The ACS NSQIP database was queried between 2005 and 2016 for all arthroscopic knee procedures, including arthroscopic lateral release, removal of loose bodies, synovectomy, chondroplasty, microfracture, meniscectomy, and meniscal repair, as denoted by their respective CPT codes (Table 1). Secondary CPT codes were queried for only "null" to eliminate bias created from concomitant procedures. Anterior cruciate ligament reconstruction and posterior cruciate ligament reconstruction were not included as procedures because their results may be confounded by graft selection and technique, which cannot be accounted for using the ACS NSQIP database. Meniscal repairs were also excluded to eliminate confounding from variations in incisions among the all-inside, inside-out, and outside-in techniques. Procedures were excluded if any of the following variables were missing: American Society of Anesthesiologists (ASA) classification, sex, BMI, operative time, and type of anesthetic. Operative time was defined as the duration, in minutes, from skin incision to wound closure. This was collected as a continuous variable. During analysis, operative time was segmented into 15-minute increments to determine marginal increases in the complication risk after a 15-minute extension in operative duration.[7,21] Cases were excluded if the operative time was more than 120 minutes because they likely represented complicated revision procedures or procedures with concomitant procedures that were unaccounted for. The

Table 1. Initial Query of CPT Codes as Part of ACS NSQIP

Description	CPT Code	No. of Cases (%)
Lateral release	29873	1,284 (1.63)
Removal of loose body	29874	1,103 (1.40)
Synovectomy	29875 or 29876	4,779 (6.06)
Chondroplasty	29877	6,903 (8.75)
Microfracture	29879	2,637 (3.34)
Meniscectomy	29880 or 29881	62,158 (78.82)

ACS, American College of Surgeons; CPT, Current Procedural Terminology; NSQIP, National Surgical Quality Improvement Program.

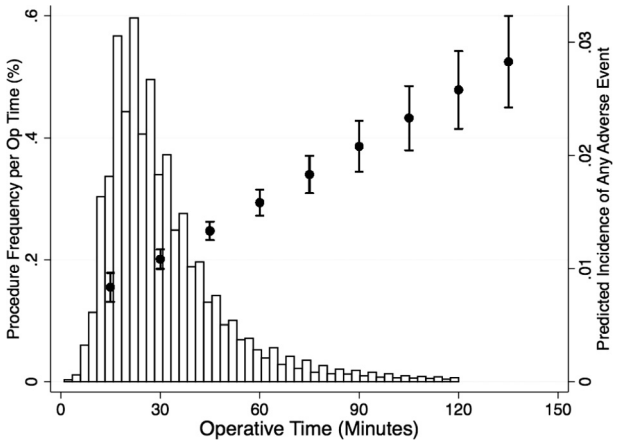

Fig 1. Predicted linear correlation between operative (Op) time and frequency of any adverse event in comparison with distribution of operative time. The constructed Poisson regression graph yielded the following equation, with $P < .001$: Adverse event incidence = 0.0003 + 0.002 (Operative time).

threshold of 120 minutes was reached because this is the nearest whole number equal to greater than 3 times the standard deviation of the pre-exclusion operative time. These cases would skew the linear model implemented in this investigation. Diagnosis codes were manually stratified into 1 of 6 categories: meniscal derangement, chondromalacia, loose body or plica removal, synovitis, osteoarthritis, and infectious. Post hoc analysis was performed to examine which diagnosis codes were associated with outlier operative times. Initial query of the database yielded 79,858 cases, of which 837 were excluded because of unknown anesthesia type; 113, no operative time recorded; 749, unknown functional status; 68, unknown ASA classification; and 994, operative time greater than 120 minutes.

Complications

Complications were reported within 30 days of the index procedure. These 30-day complications included anemia requiring transfusion, cardiac arrest requiring cardiopulmonary resuscitation, death, cerebrovascular accident, wound dehiscence, DVT, pneumonia, myocardial infarction, renal insufficiency, pulmonary embolism, surgical-site infection, sepsis, urinary tract infection, unplanned intubation, hospital readmission, and extended length of stay in the hospital. Extended hospital length of stay was defined as a hospital stay of 2 days or greater. This definition was used to exclude patients who were kept in the hospital for a 23-hour observation period from being considered as having complications.

Statistical Analysis

Stata software (version 13.1; StataCorp, College Station, TX) was used to perform statistical analysis in this study. Demographic and comorbidity variables—such as age, sex, BMI, ASA classification, smoking status, procedure performed, functional dependence, anesthesia administered, history of diabetes mellitus, history of chronic obstructive pulmonary disease, history of hypertension, history of dyspnea on exertion, and history of anemia—were correlated with operative duration by bivariate and multivariate linear regression. Bivariate analysis was then performed on operative duration and risk of development of each short-term complication. Multivariate Poisson regression with robust error variance was used to determine the relative risk (RR) of development of each complication while accounting for correlated demographic variables. Poisson regression with robust error variance was used because it has previously been shown to be most efficacious in epidemiologic analysis of binary variables and it allows for calculation of the RR.[22] Analysis was performed with clustering to stratify by procedure performed. A goodness-of-fit χ-square test was performed to determine the strength of our multivariate regression relating operative time and adverse events, wherein a significant result shows a poor fit of the regression model to the data.

Results

Demographic Information

After exclusions, 78,864 procedures performed between 2005 and 2016 were included in the analysis (Table 1). The mean age of patients was 51.0 ± 14.3 years, and the mean BMI was 31.0 ± 7.8. The mean operative time was 31.2 ± 18.1 minutes (Fig 1). The youngest population (aged 18-40 years) had the greatest operative duration (coefficient, 7.4; 95% confidence interval [CI], 7.0-7.8; $P < .001$). In addition, patients with ASA class 4 (coefficient, 2.8; 95% CI, 1.3-4.3), patients with non—insulin-dependent diabetes mellitus (RR, 0.8; 95% CI, 0.3-1.3), patients with a history of anemia (coefficient, 2.7; 95% CI, 2.1-3.3), patients classified as functionally dependent (coefficient, 2.6; 95% CI, 2.1-3.3), and patients receiving general anesthesia (coefficient, 2.3; 95% CI, 1.9-2.8) all had greater operative times (Fig 2). Patients who were current smokers had a decreased operative time (coefficient, −0.559; 95% CI, −0.9 to −0.2) (Table 2).

Procedures

Regarding procedures, meniscectomy had the shortest operative time and was used as a reference. In comparison, arthroscopic lateral release (coefficient, 5.8; 95% CI, 4.8-6.8; $P < .001$), removal of loose bodies (coefficient, 4.2; 95% CI, 3.2-5.3; $P < .001$), synovectomy (coefficient, 1.8; 95% CI, 1.2-2.3; $P < .001$), and microfracture (coefficient, 6.5; 95% CI, 5.8-7.2; $P < .001$) had significantly greater durations of surgery (Table 2).

Complications

The overall rate of all adverse events was 1.24% among all procedures. The complication with the greatest frequency was DVT, which occurred in 0.39% of procedures. The incidence of readmission was 0.90% within 30 days, and the incidence of an extended length of stay (>2 days) was 1.02%. Within the 30-day period, 34 patients (0.0005%) returned to the operating room for arthroscopic lavage whereas 21 patients (0.0003%) returned for open arthrotomy. After multivariate regression analysis and accounting for confounding demographic characteristics, comorbidities, and influence of the procedure, a 15-minute increase in operative duration was associated with an increased risk of anemia requiring transfusion (RR, 1.6; 95% CI, 1.3-1.8; $P < .001$), death (RR, 1.6; 95% CI, 1.0-2.5; $P = .039$), wound dehiscence (RR, 1.7; 95% CI, 1.3-2.2; $P < .001$), surgical-site infection (RR, 1.3; 95% CI, 1.2-1.4; $P = .001$), and sepsis (RR, 1.3; 95% CI, 1.2-1.5; $P < .001$). The same incremental increase resulted in a significantly greater readmission rate (RR, 1.1; 95% CI, 1.1-1.2; $P < .001$) and extended length of stay (RR, 1.4; 95% CI, 1.3-1.5; $P < .001$) (Table 3). A multivariate regression model for variables associated with the incidence of adverse events showed an increased risk with lengthier procedures (RR, 1.2; 95% CI, 1.1-1.3; $P < .001$), in smokers (RR, 1.5; 95% CI, 1.2-1.7; $P < .001$), in patients with preoperative anemia (RR, 7.3; 95% CI, 6.2-8.6; $P < .001$), in patients with insulin-dependent diabetes mellitus (RR, 1.8; 95% CI, 1.5-2.2; $P < .001$), in ASA class 3 patients (RR, 2.7; 95% CI, 2.0-3.6; $P < .001$), in ASA class 4 patients (RR, 4.7; 95% CI, 3.2-6.8; $P < .001$), in functionally dependent patients (RR, 2.1; 95% CI, 1.7-2.7; $P < .001$), and in patients with an infectious-related diagnosis (RR, 4.9; 95% CI, 3.6-6.5; $P < .001$). A reduced incidence of adverse events was found in patients aged between 18 and 40 years (RR, 0.7; 95% CI, 0.5-0.9; $P < .001$), female patients (RR, 0.8; 95% CI, 0.7-0.9; $P = .001$), and patients with meniscus-related diagnoses (RR, 0.5; 95% CI, 0.5-0.7; $P < .001$). Of note, no influence on the rate of adverse events was found with respect to BMI ($P = .081$), history of dyspnea ($P = .768$), history of hypertension ($P = .555$), history of chronic obstructive pulmonary disease ($P = .830$), and use of general versus local anesthesia ($P = .072$). The goodness-of-fit test of this multivariate regression model yielded $P = .635$.

Discussion

The principal findings of this study are the identification of operative time as an independent risk factor for postoperative, short-term complications and the increase in complications that a 15-minute marginal increment would pose. Several preoperative variables were associated with longer operative times, such as younger age, male patients, patients with ASA class 4, patients undergoing general anesthesia, and patients with a history of anemia. When we adjusted for these variables, increased operative time was still found to be associated with increased transfusion risk, wound dehiscence, death, surgical-site infection, sepsis, hospital readmission, and extended length of stay. It should be noted that the RRs of these complications were low (range, 1.1-1.6), which is indicative of the low rate of complications after arthroscopic knee surgery. Moreover, the association with operative time was found to be linear, which allows for the assessment of RR by 15-minute intervals. Steps taken toward minimizing the complication risk through adjusting modifiable risk factors can further decrease the complication risk.

The operative duration in laparoscopic procedures—minimally invasive procedures analogous to knee arthroscopy—has been associated with an increased risk of pneumonia, reintubation, unplanned intubation, surgical-site infection, and extended length of stay.[23-25] A previous study that analyzed the effect of variables on the incidence of pulmonary embolism after knee arthroscopy using the New York State Department of Health Statewide Planning and Research Cooperative System database found an operating time greater than 90 minutes to be associated with a 3-fold increase in the incidence of pulmonary embolism.[26] Although the findings of that investigation are important, there is limited clinical utility to be ascertained from that study because the findings showed that approximately 2.5% of knee arthroscopies lasted more than 90 minutes. Moreover, our study did not find either DVT or pulmonary embolism to be linearly associated with operative time. Similar corollaries exist in shoulder arthroscopy, which suggest that surgical procedures lasting greater than 90 minutes have a greater risk of any complication, surgical-site infection, readmission, extended length of stay, DVT, and pulmonary embolus formation compared with surgical procedures lasting between 45 and 90 minutes.[11] Linear regressions formulated within this study illustrate a more practical application of the influence of operative time toward these adverse events, particularly when controlling for confounding variables. Implementing a linear model allows for a clinically interpretable result because clinicians are able to understand and easily apply the results of this investigation in a clinical setting.

The incidence of surgical-site infections and sepsis after knee arthroscopy is significant because it emphasizes that even minimally invasive procedures are susceptible to these complications. It follows logically that an increased duration of an open wound during surgery would lead to increased infections, as shown by the findings of our study. The incidence of surgical-site infections after knee arthroscopy has not been previously established using a large national database, although adverse events after meniscectomy have been

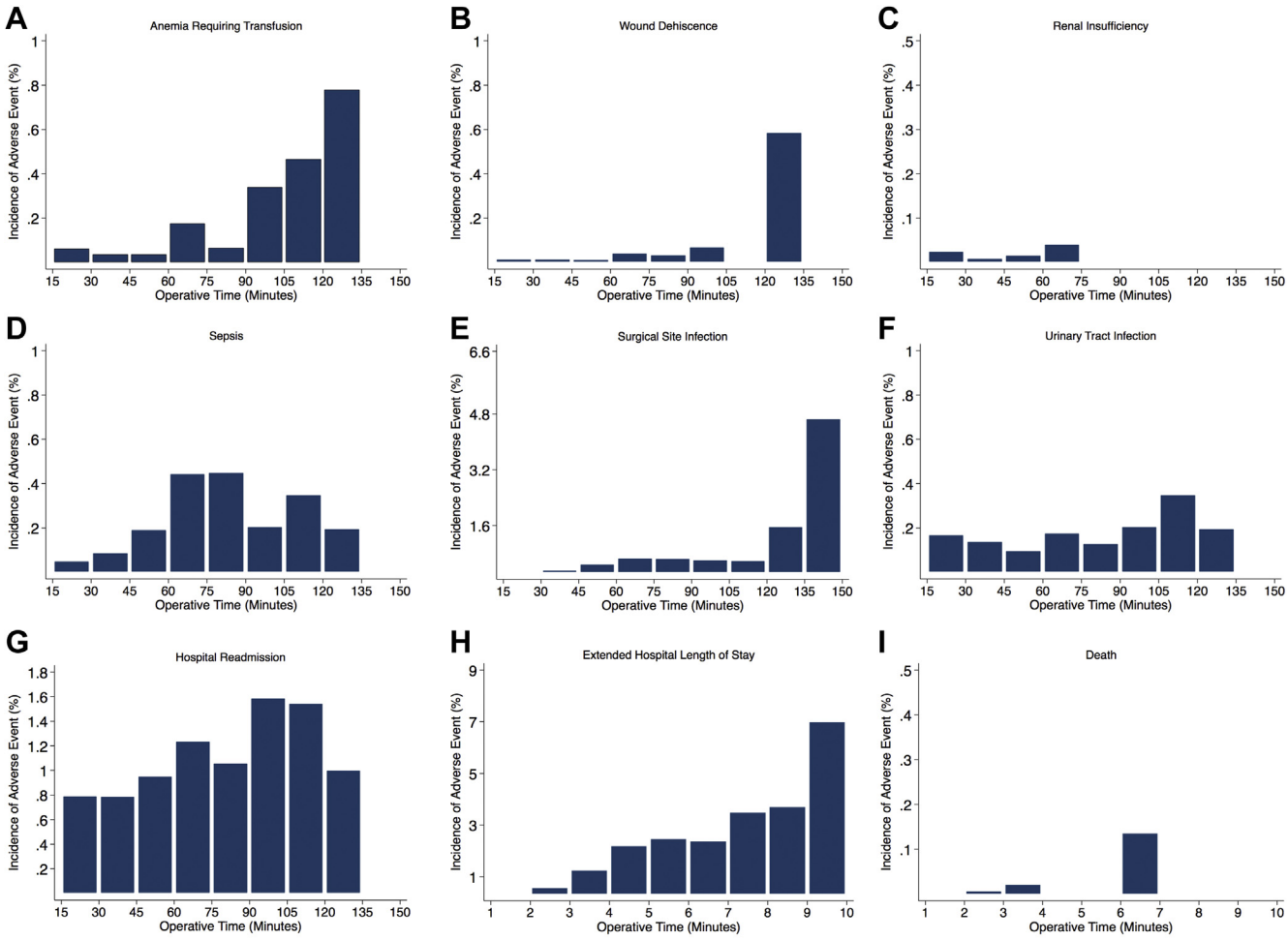

Fig 2. Influence of operative time on incidence of anemia requiring transfusion (A), wound dehiscence (B), renal insufficiency (C), sepsis (D), surgical-site infection (E), urinary tract infection (F), hospital readmission (G), extended hospital length of stay (H), and death (I).

associated with BMI higher than 35, ASA classification greater than 3, history of diabetes, and history of pulmonary disease.[15] This investigation also showed that increases in operative time were not associated with an increased risk of DVT. Operative time has previously been shown to increase the incidence of DVT after anterior cruciate ligament reconstruction.[27] This effect may be a result of tourniquet use because this may favor thrombus formation owing to the compressive nature of the tourniquet, which may damage vascular endothelial cells, deform red blood cells, and promote vascular stasis.[28,29] Operative time may not increase the rate of DVT in simple knee arthroscopy owing to variability in the use of tourniquets or the short duration of this procedure.[30] Moreover, tourniquet time was not specifically reported in the database, so definitive conclusions regarding this may not be made. In this investigation, 1.02% of cases required a hospital stay of 2 days or greater. The reason for an extended length of stay was unable to be determined from the database. There are few medical complications that would necessitate a hospital stay longer than 2 days, and some of these hospital stays may have been a result of social reasons.

This study provides valuable information toward patient selection for procedures at ambulatory surgery centers. Ambulatory sites are preferred for patients with a reduced risk of postoperative complications because these sites are not equipped for overnight admissions. Younger patients, male patients, patients with a greater ASA classification, patients with a history of anemia, and patients undergoing either meniscal repair, microfracture, lateral release, or removal of loose bodies were associated with a prolonged operative time; these findings may be used to influence patient selection at ambulatory centers.[31] The finding that a younger population was associated with an increased operative time deserves further evaluation. However, it has previously been shown that younger patients have a prolonged operative time when undergoing knee arthroplasty, cervical fusion, and shoulder arthroscopy.[7,11,21] On post hoc analysis, diagnosis codes representing discoid

Table 2. Operative Time by Demographic, Comorbidity, and Procedural Characteristics

			Statistical Comparisons			
			Bivariate	Multivariate*		
	No.	Operative Time, Mean ± SD, min	*P* Value	Coefficient	95% CI	*P* Value
Overall	78,864					
Age			<.001			<.001†
18-40 yr	16,479	36.8 ± 22.4		7.415	7.0 to 7.8	
41-60 yr	39,842	30.4 ± 16.9		1.586	1.3 to 1.9	
61-80 yr	21,400	28.7 ± 15.4		Ref	—	
>80 yr	1,143	29.5 ± 17.0		−0.061	−1.1 to 1.0	
Sex			<.001			<.001†
Female	37,414	30.1 ± 17.2		Ref	—	
Male	41,450	32.3 ± 18.8		1.781	1.5 to 2.0	
BMI			<.001			.875
<25	13,909	32.4 ± 19.4		0.809	0.3 to 1.3	
25-30	25,749	31.2 ± 18.3		0.064	−0.4 to 0.5	
31-35	19,834	30.9 ± 17.7		0.110	−0.3 to 0.5	
36-40	10,591	30.7 ± 17.3		Ref	—	
>40	8,781	30.9 ± 16.9		−0.163	−0.7 to 0.3	
ASA class			<.001			<.001†
1	16,094	33.1 ± 20.3		−1.089	−1.6 to −0.6	
2	45,266	30.8 ± 17.6		−0.811	−1.2 to −0.5	
3	16,941	30.5 ± 16.8		Ref	—	
4	563	33.7 ± 18.4		2.788	1.3 to 4.3	
Current smoker			.004			.002†
No	65,966	31.2 ± 17.9		Ref	—	
Yes	12,898	31.7 ± 18.9		−0.559	−0.9 to −0.2	
Diabetes mellitus			<.001			.002†
No	71,319	31.4 ± 18.2		0.824	0.3 to 1.3	
NIDDM	5,345	29.4 ± 16.2		Ref	—	
IDDM	2,200	30.0 ± 16.7		0.042	−0.8 to 0.9	
COPD			.001			.777
No	77,419	31.3 ± 18.1		Ref	—	
Yes	1,445	29.6 ± 16.4		−0.139	−1.1 to 0.8	
Hypertension			<.001			.919
No	52,342	31.9 ± 18.8		Ref	—	
Yes	26,522	29.9 ± 16.4		−0.016	−0.3 to 0.3	
Dyspnea on exertion			<.001			.172
No	76,802	31.3 ± 18.1		Ref	—	
Yes	2,062	29.6 ± 16.5		−0.562	−1.4 to 0.2	
Anemia			<.001			<.001†
No	74,743	31.3 ± 18.0		Ref	—	
Yes	4,121	33.2 ± 18.8		2.688	2.1 to 3.3	
Functionally dependent			.001			.005†
No	78,478	31.2 ± 18.1		Ref	—	
Yes	386	34.2 ± 18.6		2.572	0.8 to 4.4	
Anesthesia			.001			<.001†
Regional only	4,316	28.7 ± 17.7		Ref	—	
General	45,713	31.5 ± 18.1		2.323	1.9 to 2.8	
Diagnosis			<.001			<.001†
Unspecified	15,747	36.8 ± 22.9		Ref	—	
Meniscal injury	53,615	29.4 ± 15.9		−6.242	−6.6 to −5.9	
Chondromalacia	3,548	32.0 ± 18.6		−5.035	−5.7 to −4.4	
Loose body or plica	1,573	31.1 ± 17.4		−7.201	−8.2 to −6.2	
Synovitis	702	34.3 ± 19.3		−1.911	−3.3 to −0.5	
Osteoarthritis	3,304	31.1 ± 19.0		−3.494	−4.2 to −2.8	
Infectious	375	44.3 ± 19.7		−7.872	6.0 to 9.7	
Procedure			<.001			<.001†
Lateral release	1,284	38.5 ± 22.2		5.790	4.8 to 6.8	
Loose body removal	1,103	36.5 ± 20.4		4.211	3.2 to 5.3	
Synovectomy	4,779	33.7 ± 19.7		1.761	1.2 to 2.3	
Chondroplasty	6,903	32.2 ± 19.2		0.635	0.2 to 1.1	

(continued)

Table 2. Continued

			Statistical Comparisons			
			Bivariate	Multivariate*		
	No.	Operative Time, Mean ± SD, min	*P* Value	Coefficient	95% CI	*P* Value
Microfracture	2,637	37.8 ± 21.6		6.481	5.8 to 7.2	
Meniscectomy	48,639	30.4 ± 17.4		Ref	—	

ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; IDDM, insulin-dependent diabetes mellitus; NIDDM, non–insulin-dependent diabetes mellitus; Ref, reference; SD, standard deviation.

*Adjusted for all baseline and procedural characteristics listed in table.

†Statistically significant.

meniscus were associated with a significantly increased operative time and reduced age. This finding reflects the fact that not all procedures are of equal difficulty, for example, discoid menisci may require a greater operative time to perform saucerization of the meniscus.[32] However, discoid meniscus may not be the sole explanation for the increased operative time in this population because other confounding factors not investigated in this study may contribute to this finding.

The recent Bundled Payments for Care Improvement Initiative, initiated in 2013, emphasizes the need for reductions in short-term readmission rates after surgery.[5] Knee arthroscopies are predominantly performed in ambulatory surgical centers.[1] These centers are partially or completely owned by practicing physicians, thereby placing greater accountability for patient outcomes and consequential penalties, reimbursement of services, or complications on physicians.[33] The findings of this study show that the time from incision to closure should be spent efficiently by coordinating staff appropriately while maintaining patient safety. For this reason, operative time may be considered a "proxy outcome" because it is a reflection of surgical efficiency, staff training, and patient or injury characteristics.[13] An additional consideration is resident or fellow involvement in surgical procedures. Studies have shown mixed findings of the effect of resident involvement on the operative time of shoulder arthroplasty, treatment of adolescent idiopathic scoliosis, supracondylar humeral fracture treatment, and posterior cervical fusion.[34-37] Although no literature exists on arthroscopic procedures and resident involvement, our study suggests that learners should spend time preoperatively familiarizing themselves with arthroscopy so that the operating time is spent addressing pathology rather than familiarizing themselves with the arthroscope. Several studies have suggested that arthroscopic simulation is capable of improving resident speed of operation.[38-41] Teaching

Table 3. Association of 15-Minute Increase in Operative Time With Rate of Each Adverse Event or Hospital Metric

		Association of 15-min Increase in Operative Time With Rate of Adverse Event or Hospital Metric					
		Unadjusted (Bivariate) Analysis			Adjusted (Multivariate) Analysis*		
	Rate, %	RR	95% CI	*P* Value	RR	95% CI	*P* Value
Adverse event	1.24	1.20	1.15-1.25	<.001†	1.19	1.14-1.24	<.001†
Anemia requiring transfusion	0.07	1.61	1.40-1.85	<.001†	1.56	1.34-1.82	<.001†
Cerebrovascular accident	0.01	0.97	0.64-1.48	.887	0.94	0.53-1.67	.832
Death	0.01	1.54	1.12-2.13	.009†	1.61	1.02-2.51	.039†
Deep vein thrombosis	0.39	1.08	0.99-1.17	.093	1.07	0.98-1.17	.114
Dehiscence	0.02	1.69	1.29-2.22	<.001†	1.68	1.31-2.16	<.001†
Myocardial infarction	0.03	1.16	0.89-1.50	.271	1.26	0.95-1.67	.111
Pneumonia	0.07	1.11	0.93-1.33	.260	1.04	0.85-1.29	.663
Pulmonary embolism	0.10	1.12	0.97-1.29	.125	1.17	0.99-1.38	.062
Renal insufficiency	0.01	1.10	0.80-1.51	.555	1.02	0.63-1.67	.927
Sepsis	0.16	1.42	1.32-1.53	<.001†	1.33	1.20-1.48	<.001†
Surgical-site infection	0.41	1.27	1.19-1.36	<.001†	1.26	1.18-1.36	.001†
Unplanned intubation	0.02	1.30	1.02-1.66	.032	1.27	0.92-1.76	.140
Urinary tract infection	0.14	1.05	0.88-1.24	.599	1.07	0.91-1.24	.411
Adverse hospital metric							
Hospital readmission	0.90	1.14	1.07-1.20	<.001†	1.14	1.08-1.22	<.001†
Extended length of stay	1.02	1.46	1.42-1.51	<.001†	1.41	1.36-1.48	<.001†

CI, confidence interval; RR, relative risk.

*Adjusted for all demographic, comorbidity, and procedural characteristics listed in Table 2.

†Statistically significant.

facilities thereby should be encouraged to provide these instruments to minimize operating time and, consequently, short-term complications.

Limitations

Limitations of this study include the retrospective nature in which analysis was performed in a large national database. For this reason, specific patient variables are unknown. There is likely large variability in patient characteristics prior to surgery. Established risk factors for long-term outcomes such as preoperative chondral damage, alignment, and extent of osteoarthritis were not collected as part of this study.[42] However, it has not been shown that these factors have any bearing on short-term complication rates. Furthermore, the details of each case, such as the degree of infection or tear pattern, as well as the technical difficulty and surgeon experience, were unknown. These variables may impact operative time; however, they were unable to be queried within the ACS NSQIP database. This investigation included several arthroscopic knee procedures that may contribute to variability in the study population. However, different operative procedures were controlled for in the multivariate analysis. In addition, we were unable to adjust for specific variables occurring at the time of surgery, such as the pain control protocol and use of blood thinners. Use of these treatments may affect the complication rate, patient length of stay, and/or need for admission. The use of a retrospective database was essential to the fruition of this study because complication rates are so low in knee arthroscopy. Operative time was assessed as the time from skin incision to wound closure; however, tourniquet time was unable to be queried in the database. Tourniquet time may be a more significant variable in identifying the relation of operative time to postoperative complications. The incidence and RR of complications in this investigation were low. Statistical significance may have been achieved because of the large sample size of this investigation; thus, the clinical significance of these results should be interpreted with caution. Although the results of this investigation establish patient demographic characteristics that may contribute to a prolonged operative time, it is important to interpret these results with caution because statistical significance may not equate to clinical significance. The ACS NSQIP database provides high quality—assured data on complications that are powered to address trends in uncommon complication rates. Despite the high-quality data and spread of institutions included, this database is subject to selection bias because higher-volume centers may be more selectively included in this study. Data in this investigation were from hospitals and ambulatory surgery centers within hospital systems. Arthroscopic knee surgery in this setting may include patients with more medical comorbidities than patients in outpatient surgery centers. Thus, the external validity of these results to outpatient surgery centers must be interpreted with caution. In addition, the outcomes of this study were limited to short-term complications. Long-term outcomes such as failure rates of surgery, reoperations, and other procedure-specific factors were not addressed. The complications queried in this investigation may be related to anesthesia instead of the operative management directly.

Conclusions

Marginal increases in operative time are associated with an increased risk of adverse events such as surgical-site infection, sepsis, extended length of stay, and readmission. Efforts should be made to maximize surgical efficiency.

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