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ORIGINAL ARTICLE

The Need for a Step-up in Postoperative Medical Care is Predictable in Orthopedic Patients Undergoing Elective Surgery

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Abstract *Background:* The goal of elective orthopedic surgery is to return patients to their expected level of activity without an increased incidence of postoperative complications. The first step is identifying patient and/or surgical characteristics responsible for these complications. *Questions/Purposes:* This study sought to identify predictors of a step-up in medical care after non-ambulatory elective orthopedic surgery. *Methods:* At a single specialty orthopedic hospital, we identified all in-hospital postoperative patients who were transferred to a higher level of medical care ((PACU) post-anesthesia care unit). The characteristics of both transferred and non-transferred patients were compared. A model was built which incorporated predictors of return to a higher level of care. *Results:* During a 1-year period, 155 of 7967 patients (1.95%) required transfer to the PACU within 5 days of surgery. Cardiac complications were the major reason for transfer (50.3%), followed by pulmonary (11.0%) and neurological complications (9.7%). Patients who returned to the PACU were older, had more Exlihauser comorbidities, and had obstructive sleep apnea (OSA). In a model adjusting for all patient characteristics: age, American Society of Anesthesiologists (ASA) status, congestive heart failure (CHF), the Charlson comorbidity index and OSA predicted return to the PACU. *Conclusions:* In an elderly population with multiple comorbidities undergoing elective common major orthopedic procedures, approximately 2% of patients required readmission to the PACU. The most common problems requiring this step-up in care were cardiac and pulmonary, which resulted in an increased length of hospital stay. Patients with OSA and multiple comorbidities undergoing total knee arthroplasty carry an increased risk for postoperative complications.

Keywords total knee arthroplasty · obstructive sleep apnea · Charlson comorbidity index · Exlihauser comorbidity index · post-anesthesia care unit

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Level of Evidence: Prognostic study, level II

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Introduction

Total joint replacement is one of the most common surgical procedures in the USA with knee replacement now representing the single largest cost driver of Medicare expenditures. After total joint replacement surgery, spinal operations represent the next most frequently performed orthopedic procedure. These are highly effective procedures, and the expectation is a return to a full level of preoperative activities. Fixed costs aside, prolonged length of stay, complications, and readmissions all add to the financial burden of these procedures [9, 12]. The goal for surgical institutions is to develop multidisciplinary pathways which will impact the length of hospital stay and provide an early return of the patient to their expected level of activity without an increased incidence of postoperative complications or readmission. Many institutions are developing “fast-track” surgical care pathways for many common procedures (such as hip arthroplasty) to accelerate recovery and reduce the length of hospital stay [2].

However, because of either preoperative comorbidities or the magnitude of the procedure, not all patients can be managed by the same protocol nor are all patients candidates for a fast-track pathway. Several retrospective studies have identified patient comorbidities and surgical factors associated with an increased risk of postoperative complications [13, 14, 17]. We hypothesized that the identification of postoperative patients who required transfer to a higher level of hospital care after discharge from an anesthetic recovery room may be valuable in delineating patient characteristics that might be modifiable to improve outcome.

Therefore, we undertook an analysis of patients within our own institution to identify predictors of return to a higher level of care among in-patient elective orthopedic surgical patients undergoing common open procedures of the hip, knee, and spine. We proposed to identify risk factors for a postoperative step-up in care using a retrospective cohort study design.

Patients and Methods

With IRB approval, all patients at a single orthopedic specialty hospital undergoing non-ambulatory elective orthopedic procedures were identified between April 1, 2009 and March 31, 2010. Total hip arthroplasty (THA), total knee arthroplasty (TKA), and spinal fusion (SF) are the three most common non-ambulatory elective procedures performed at our institution. We therefore focused on these procedures for this analysis. ICD-9-CM coding was used to identify these patients from our hospital discharge abstraction system: THA (primary: ICD-9-CM 81.51; revision: 81.53, 00.70–00.73), TKA (primary: 81.54; revision 81.55, 00.80–00.84), and posterior spinal fusion, PSF (primary: 81.00–81.08; revision: 81.30–81.39). These 7967 patients represented our retrospective cohort.

Our outcome was return to the post-acute care unit (PACU), which represents the only unit in the hospital with continuous monitored care, after discharge to a general patient floor. Patients were transferred back to the PACU by any covering physician who identified a change in the patient’s medical condition which warranted hemodynamic monitoring. All transfers required prior approval by the critical care physician responsible for the unit. We identified 155 patients (1.95%) that were transferred back to the PACU within 5 days of surgery through Sunrise Medical Management (Allscripts) electronic transfer orders, which were then confirmed by chart review. We chose 5 days as an acute postoperative event. For each patient, a primary diagnosis for transfer back to a higher level of medical care was assigned after a history, physical examination and laboratory data were analyzed. A final diagnosis was derived from a retrospective chart review. Using a variety of hospital electronic systems, we identified patient factors: age, sex, race/ethnicity, body mass index (BMI), history of obstructive sleep apnea (OSA), and other comorbidities present on admission. We further identified clinical information: principal procedure, unilateral or bilateral procedure, American Society of Anesthesiologists (ASA) status, preoperative creatinine, preoperative hemoglobin, and the in-hospital use of continuous positive airway pressure (CPAP). We also calculated the Charlson comorbidity [10] and the Elixhauser comorbidity [3] indices. Patients without valid ASA status and preoperative hemoglobin and creatinine levels were excluded. Our final cohort consisted of 7281 patients, of which 138 returned to the PACU. We also conducted a sensitivity analysis by performing multiple imputations for missing hemoglobin and creatinine levels [4]. Each missing data point was replaced with a set of plausible values from a specified distribution. Results were combined from analyses of 5 different data sets imputed. This sensitivity analysis demonstrated no meaningful differences in our results and therefore is not presented for ease of interpretation.

Patient race was categorized as white, black, Hispanic, Asian, American Indian, and other. BMI was categorized using the World Health Organization criteria (underweight <18.5, normal 18–25, overweight >25, obesity class I (BMI 30–34.9), obesity class II (BMI 35–39.9), obesity class III morbid obesity (BMI ≥ 40). Underweight patients were subsequently collapsed into normal weight due to the very small number of patients in this category. All comorbidities were identified with simple binary (yes/no) indicator variables, except for sleep apnea, which was categorized as none, sleep apnea, and sleep apnea with CPAP use.

Hemoglobin levels were categorized as low (females $<$ 11.5 g/dl; males $<$ 13 g/dl) or normal. Creatinine levels were categorized as normal or high (>1.2 mg/dl). ASA score was categorized as ASA I–IV, but for inferential analysis, was converted to a binary variable (ASA I/II v. ASA III/IV). The Charlson comorbidity index was treated as a continuous variable in multivariable modeling.

Statistical Analysis

Preliminary descriptive statistical analysis consisted of frequency counts and percentages for discrete variables and median, intra-quartile range (IQR), and minimum and maximum values for continuous variables.

Crude inferential analysis consisted of chi-square tests for discrete comparisons and Mann-Whitney *U* tests for continuous variables. Adjusted inferential analysis was performed using multivariable logistic regression. For patients who had more than one admission during the study period, only one admission was randomly selected to be included in this logistic model. When the patient had a return to PACU in one of the admissions, this admission was chosen in order to retain power. An indicator for “previous admission” was also included in the model to adjust for patients with multiple procedures.

Prior to building a final predictive model, we compared the risk adjustment variables (ASA status, Charlson, Exlihauser) with one another for correlations. While correlations existed, none were so extreme that we suspected multicollinearity. Each was eligible for model inclusion with the others, though we hoped to find a single risk adjustment measurement that would serve this purpose. The authors did this by building out their model of all other patient and clinical variables and then including each of the risk adjustment variables in the model in turn. The authors used model diagnostics evaluating model fit, r-squared, and predicted probabilities to determine the best model fit. Significance was set at 0.05 for all analyses without multiple comparison adjustment since we were evaluating a single hypothesis: predictors of return to PACU. All analyses were performed using SAS 9.3 (Cary, NC).

Results

During the study period, 7967 patients had 8297 admissions for the designated procedures and underwent a total of 8563 surgeries. A total number of 7371 patients underwent a single unilateral procedure while 596 (7.5%) patients underwent bilateral procedures during the same admission. These bilateral patients returned to the PACU in 1.5% of their admissions. Of the 213 patients who had 2 admissions during the study period, none returned to the PACU in both admissions and only 4 returned to the PACU in one of their admissions (2.6%).

One hundred fifty-five of these 7967 patients (1.95%) required transfer from a hospital room to the PACU (an escalation in care) within 5 days of surgery, mean time of return 41±29 h after the original postoperative discharge from the PACU. Of the patients returning, 42% had been monitored in the PACU for the night after surgery for preoperative medical comorbidities (cardiac, OSA) and/or the complexity of orthopedic procedure (bilateral knee or hip replacement). Cardiac complications were the major reason for an escalation in care (50.3%), followed by pulmonary (11.0%) and neurological (delirium, CVA) complications (9.7%) (Fig. 1). Cardiac problems included chest pain, arrhythmias (mostly supraventricular tachycardia), and CHF. Of these patients, the final diagnosis was myocardial ischemia for 13% (10/78), CHF for 9% (7/78), and atrial fibrillation for 56% (44/78) of the returning patients. Patients with pulmonary issues included pneumonia, pulmonary embolism, and respiratory insufficiency. In most cases, the admitting diagnosis was similar to the final diagnosis. However, some of the patients who were admitted with a respiratory diagnosis were ultimately determined to have cardiogenic causes, such as cardiac ischemia with CHF. Delirium/confusion as the transfer diagnosis was often a "catch-basket" for other postoperative problems, including hypoxemia, intractable pain, and ischemia. For 10% (15/155) of the patients requiring transfer to a higher level of care, the authors were unable to assign a single final diagnosis. For example, such a patient might be both confused and exhibit evidence of myocardial ischemia.

In general, patients requiring transfer to the higher level of care were older and had OSA. One hundred thirty-eight of 7281 patients (1.9%) required an escalation in postoperative care (Table 1). Anemia (Hb<10g/dl) was the final diagnosis for transfer in 5.2% (8/155) of the patients (5.1%, 7/138 of the final cohort), and the requirement for transfusion was significantly higher. In addition, patients who required an escalation in care had higher creatinine levels. Undergoing a primary elective THA was associated with a low risk of requiring additional monitored care, in contrast to patients undergoing revision hip arthroplasty, primary TKA, SF, and revision SF who were all significantly more likely to be transferred to a higher level of care..

In comparing patient characteristics by procedure (Table 2), the TKA patients were older, had a higher BMI,

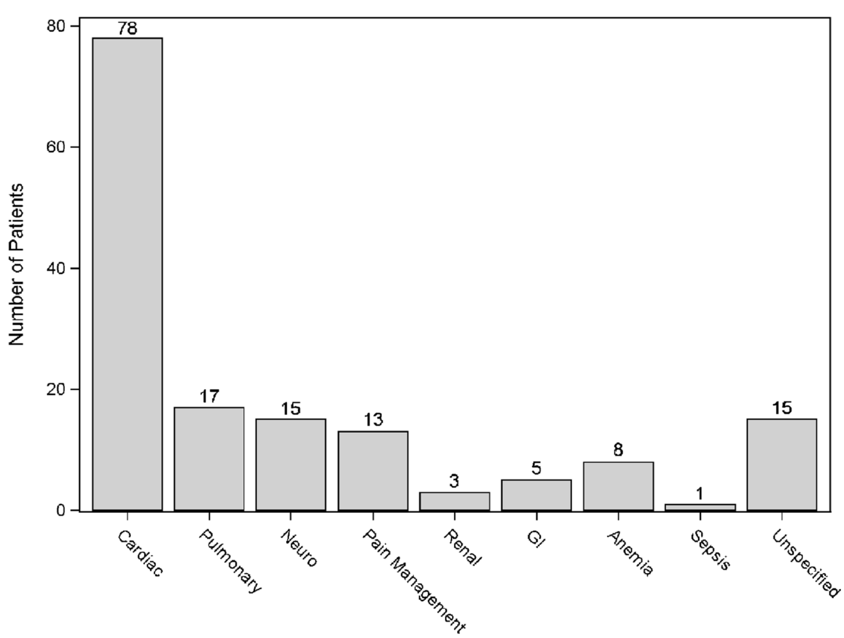

Fig. 1. Final diagnosis type of patients returning to the post-anesthesia care unit (PACU). N=155 patients.

Table 1 Patient demographics and study population

	Return to PACU (*n*=138)	Not return to PACU (*n*=7143)	All (*n*=7281)	*P* value
Age, *n* (%)				<0.001
Median age, years	73	68	68	
<65	33 (23.9%)	2730 (38.2%)	2763 (38.0%)	
65–75	46 (33.3%)	2504 (35.1%)	2550 (35.0%)	
75–85	42 (30.4%)	1600 (22.4%)	1642 (22.6%)	
>85	17 (12.3%)	309 (4.3%)	326 (4.5%)	
Female, *n* (%)	79 (57.3%)	4193 (58.7%)	4272 (58.7%)	0.731
Race/ethnicity, *n* (%)				0.794
White	116 (84.1%)	6119 (85.7%)	6235 (85.6%)	
Black	11 (8.0%)	428 (6.0%)	439 (6.0%)	
Hispanic	5 (3.6%)	244 (3.4%)	249 (3.4%)	
Other	6 (4.4%)	352 (4.9%)	358 (4.9%)	
BMI, *n* (%)				0.415
Normal	29 (21.0%)	1871 (26.2%)	1900 (26.1%)	
Overweight	60 (43.5%)	2575 (36.1%)	2635 (36.2%)	
Class I obesity	30 (21.7%)	1595 (22.3%)	1625 (22.3%)	
Class II obesity	11 (8.0%)	698 (9.8%)	709 (9.7%)	
Class III obesity	8 (5.8%)	404 (5.7%)	412 (5.7%)	
History of sleep apnea, *n* (%)				0.001
None	116 (84.1%)	6576 (92.1%)	6692 (91.9%)	
Sleep apnea	12 (8.7%)	364 (5.1%)	376 (5.2%)	
Sleep apnea and CPAP use	10 (7.3%)	203 (2.8%)	213 (2.9%)	
Type of procedure, *n* (%)				<0.001
Total hip replacement	29 (21.0%)	2660 (37.2%)	2689 (36.9%)	
Revision of hip replacement	8 (5.8%)	277 (3.9%)	285 (3.9%)	
Total knee replacement	64 (46.4%)	2924 (40.9%)	2988 (41.0%)	
Revision of knee replacement	2 (1.5%)	223 (3.1%)	225 (3.1%)	
Spine fusion	31 (22.5%)	1024 (14.3%)	1055 (14.5%)	
Spine refusion	4 (2.9%)	35 (0.5%)	39 (0.5%)	
Bilateral surgery, *n* (%)	7 (5.1%)	533 (7.5%)	540 (7.4%)	0.289
Previous admission, *n* (%)	2 (1.5%)	74 (1.0%)	76 (1.0%)	0.656
Hemoglobin level, *n* (%)				<0.001
Low	47 (34.1%)	1485 (20.8%)	1532 (21.0%)	
Normal	91 (65.9%)	5632 (78.9%)	5723 (78.6%)	
High	0 (0.0%)	26 (0.4%)	26 (0.4%)	
Creatinine Level, *n* (%)				0.003
Low	0 (0.0%)	5 (0.1%)	5 (0.1%)	
Normal	107 (77.5%)	6280 (87.9%)	6387 (87.7%)	
High	31 (22.5%)	858 (12.0%)	889 (12.2%)	
Length of stay, days				<0.001
Median	6	4	4	
IQR	(5, 9)	(3, 5)	(3, 5)	
(Min, max)	(2, 21)	(1, 53)	(1, 53)	

PACU post-anesthesia care unit, *BMI* body mass index, *CPAP* continuous positive airway pressure

and were more likely to have an ASA III rating. The length of hospital stay (LOS) was significantly prolonged for those patients who required an escalation in care.

Table 2 Comparison of characteristics in TKA and THA patients

	TKA		THA		P value
	Return (*n*=64)	All (*n*=2924)	Return (*n*=29)	All (*n*=2660)	
Age±SD	73.8±9	69.9±10	70.4±13	67.5±12	<0.001
BMI	30.4±6	30.6±6	29.1±5	27.9±6	<0.001
ASA III	44.9%	23.5%	47.2%	19.9%	<0.001

TKA total knee arthroplasty, *THA* total hip arthroplasty, *BMI* body mass index, *ASA* American Society of Anesthesiologists class III

When risk assessment indicators were evaluated, ASA score, Charlson index, and 10 of the Elixhauser comorbidities were significantly associated with an escalation in care (Table 3). The strongest indicators were CHF, diabetes, renal failure, and chronic pulmonary disease.

In order to better understand the relative predictive ability of these scores, we tested each in models adjusting for all patient and clinical characteristics (Table 4). Due to the limited number of events available for multivariable modeling, a semi-parsimonious model was built with non-significant factors being removed systematically until a stable model with acceptable model fit was achieved. Having more than one admission during the study period was retained in the model to adjust for people with multiple opportunities to be transferred to a higher level of care. Age and sex were also retained in the final model.

Table 3 Risk adjustment indicators

	Return to PACU (*n*=138)	Not return to PACU (*n*=7143)	All (*n*=7281)	*P* value
ASA score, *n* (%)				<0.001
I	1 (0.7%)	389 (5.5%)	390 (5.4%)	
II	74 (53.6%)	5205 (72.9%)	5279 (72.5%)	
III	62 (44.9%)	1541 (21.6%)	1603 (22.0%)	
IV	1 (0.7%)	8 (0.1%)	9 (0.1%)	
Charlson comorbidity index, *n* (%)				<0.001
0	69 (50.0%)	5138 (71.9%)	5207 (71.5%)	
1	36 (26.1%)	1461 (20.5%)	1497 (20.6%)	
2	16 (11.6%)	335 (4.7%)	351 (4.8%)	
3	6 (4.4%)	87 (1.2%)	93 (1.3%)	
4+	11 (8.0%)	122 (1.7%)	133 (1.8%)	
Elixhauser comorbidity, *n* (%)				
Congestive heart failure	7 (5.1%)	41 (0.6%)	48 (0.7%)	<0.001
Valvular disease	17 (12.3%)	538 (7.5%)	555 (7.6%)	0.049
Pulmonary circulation disease	5 (3.6%)	93 (1.3%)	98 (1.4%)	0.038
Peripheral vascular disease	5 (3.6%)	99 (1.4%)	104 (1.4%)	0.047
Paralysis	8 (5.8%)	125 (1.8%)	133 (1.8%)	0.004
Other neurological disorders	7 (5.1%)	181 (2.5%)	188 (2.6%)	0.092
Chronic pulmonary disease	27 (19.6%)	781 (10.9%)	808 (11.1%)	0.004
Diabetes	27 (19.6%)	762 (10.7%)	789 (10.8%)	0.002
Hypothyroidism	25 (18.1%)	1010 (14.1%)	1035 (14.2%)	0.177
Renal failure	16 (11.6%)	198 (2.8%)	214 (2.9%)	<0.001
Rheumatic diseases	6 (4.4%)	307 (4.3%)	313 (4.3%)	0.834
Coagulopathy	4 (2.9%)	80 (1.1%)	84 (1.2%)	0.075
Obesity	22 (15.9%)	940 (13.2%)	962 (13.2%)	0.312
Deficiency anemia	8 (5.8%)	253 (3.5%)	261 (3.6%)	0.161
Psychoses	1 (0.7%)	83 (1.2%)	84 (1.2%)	1.000
Depression	26 (18.8%)	907 (12.7%)	933 (12.8%)	0.039
Hypertension	83 (60.1%)	3681 (51.5%)	3764 (51.7%)	0.048

Statistically significant patient and clinical factors for an escalation in care were as follows: age (>75 vs. <65), ASA (I, II vs. III, IV), CHF; Charlson comorbidity index, OSA with CPAP use, primary total knee arthroplasty, SF, and revision SF. The odds ratio for transfer for an OSA patients using CPAP was 2.24. However, respiratory complications were the transferring diagnosis in only 18% of the OSA patients, while 54% were transferred for cardiac complications.

Discussion

Patient outcomes after surgical procedures are affected by multiple variables. Since many orthopedic procedures are elective, the goal for these procedures is a return to "better" than their preoperative functional status. Hence, it is important from both a patient-benefit perspective and a reduction in health resource utilization to determine which variables can be modified to improve outcome after elective orthopedic surgery. One marker of poor outcome after elective orthopedic surgery may be a requirement for the return to a higher level of medical care. We then asked why these patients required a step-up in medical care, were there specific surgeries with increased postoperative complications, and could one delineate those preoperative risk factors associated with a poor outcome.

The population studied was elderly patients (median age of 68) with multiple comorbidities (ASA≥II for 95% of the patients) who underwent the most common elective major orthopedic procedures: hip arthroplasty, knee arthroplasty, and spinal fusions. During the 1-year study period, 1.95% of these orthopedic surgical patients required readmission to a higher level of medical care within 5 days of surgery. The most common diagnosis which initiated transfer was cardiac, including heart failure, myocardial ischemia, and arrhythmias, followed by pulmonary and neurological problems. These patients were significantly older (73 vs. 68 years) and had significantly more preoperative medical comorbidities, including CHF, pulmonary disease, diabetes mellitus, and renal failure.

Our study has potential limitations. We focused our attention on the major elective orthopedic procedures performed at this institution, but other orthopedic procedures (such as trauma) not included in this analysis may have different risk factors associated with a postoperative return to a higher level of care. Since there are no standardized criteria for an escalation in care, the transfer was provider dependent. In order to evaluate the postoperative risks for an escalation in care, we had to utilize parameters which could be easily identified and quantitated in both populations (return and non-returners). Hence, specific risk factors which may be important in postoperative outcome were not included in the analysis (e.g., angina, inducible myocardial ischemia, coronary artery stents). Furthermore, the preoperative assessment of ASA status is subject to inter-rater reliability. In addition, we did not assess the effects of

Table 4 Logistic regression model (n=7281)

	OR (95%CI)	*P* value
Age		
65–75 v. <65	1.44 (0.90, 2.13)	0.133
75–85 v. <65	1.75 (1.05, 2.91)	0.031
>85 v. <65	3.15 (1.59, 6.23)	0.001
Female	1.30 (0.89, 1.90)	0.181
BMI		
Overweight v. Normal	1.58 (0.99, 2.51)	0.056
Class I obesity v. Normal	1.14 (0.65, 1.98)	0.656
Class II obesity v. Normal	0.79 (0.37, 1.69)	0.542
Class III obesity v. Normal	0.78 (0.32, 1.88)	0.575
Type of procedure		
Revision of hip replacement v. THR	1.76 (0.77, 4.01)	0.181
Total knee replacement v. THR	1.80 (1.14, 2.84)	0.012
Revision of knee replacement v. THR	0.76 (0.17, 3.35)	0.719
Spine fusion v. THR	2.88 (1.64, 5.06)	<0.001
Spine refusion v. THR	13.75 (4.37, 43.27)	<0.001
Bilateral surgery	0.95 (0.42, 2.12)	0.890
Had prior surgery	1.12 (0.26, 4.82)	0.877
ASA score		
III/IV v. I/II	1.89 (1.28, 2.79)	0.001
Creatinine level		
High v. Normal	1.07 (0.62, 1.85)	0.803
Hemoglobin level		
Low v. Normal	0.70 (0.47, 1.04)	0.077
History of sleep apnea		
Sleep apnea v. None	1.70 (0.88, 3.28)	0.115
Sleep apnea and CPAP use v. None	2.24 (1.09, 4.64)	0.029
Elixhauser comorbidity		
Congestive heart failure	3.48 (1.40, 8.65)	0.007
Paralysis	1.76 (0.76, 4.08)	0.189
Chronic pulmonary disease	1.38 (0.87, 2.21)	0.176
Diabetes w and w/o chronic complications	1.28 (0.78, 2.10)	0.336
Renal failure	1.49 (0.70, 3.16)	0.297
Coagulopathy	1.95 (0.66, 5.78)	0.226
Charlson comorbidity index	1.20 (1.04, 1.38)	0.014

perioperative management on outcome (beta blocker utilization, pain management).

Although published reports have not assessed the incidence for a step-up in care while in the hospital after major orthopedic surgery, there are reports examining the reasons and incidence for readmission to the hospital. Excluding joint infection and joint stiffness, others have noted that the most common post THA and TKA reason for a 30-day readmission to the hospital is cardiopulmonary, incidence 1.6% [23, 24]. In the report of Zmistowski et al. [24], when stiffness and joint infection were excluded, the Charlson comorbidity index was an independent predictor of readmission. In addition, longer hospital stay was also a predictor of readmission suggesting that this was a marker for in-hospital complications. In this study as well as the report by O'Malley et al. [17], increased age and comorbidities were associated with both in-hospital complications and increased length of stay.

Global indices such as the Charlson comorbidity index and the ASA score were predictive of an escalation in care, while independent risk factors except for CHF were not. Despite extensive literature linking obesity with poor outcome after orthopedic surgery, we were unable to identify obesity as an independent risk factor for an escalation in care [19, 20]. A recent study by Friedman et al. [6] reported that morbidly obese patients undergoing THA or TKA were also not at an increased risk for in-hospital major life threatening complications. Morbid obesity is often associated with other comorbidities, including hypertension, diabetes, cardiac disease, and OSA [18]. In our study, OSA was an independent risk for a transfer to a higher level of care. This was despite the fact that CPAP-dependent OSA patients were monitored in the PACU on the night of surgery, suggesting that this was insufficient monitoring time after surgery to prevent complications. A recent meta-analysis supports the assumption that OSA is a risk factor for increased postoperative complications [8]. In addition, the majority of our OSA patients transferred for reasons other than respiratory complications, suggesting that OSA may be a marker for other comorbidities including "the metabolic syndrome" which includes obesity and has been shown to be an independent predictor for major complications after THA and TKA [7]. Risk factors for postoperative respiratory depression in OSA patients included severity of the OSA, the systemic administration of opioids, and sedatives and pre-existing comorbidities. Modification of some of these factors and/or longer monitored observation in selected OSA patient may reduce postoperative complications.

Renal dysfunction is a risk factor for poor outcome after non-cardiac surgery and is included in the Revised Cardiac Risk Index as a significant predictor of outcome [5, 11, 16]. Reduced renal function is often the result of reduced left ventricular function and heart failure and is an indicator of the ability of a patient to tolerate fluid shifts and hemodynamic instability, a more common problem in our TKA and SF patients. Both renal dysfunction (elevated creatinine) and CHF were risk adjusted indicators for an escalation in care in this study, and only CHF was retained as an independent predictor in logistic regression analysis.

Patients undergoing a THA were the least likely to require a postoperative return to monitored care, compared to TKR and SF patients. Both the TKA and THA patients received neuraxial anesthetics, while the SF patients received a general anesthetic. Regional anesthesia for orthopedic surgery has been associated with reduced postoperative mortality and morbidity compared to general anesthesia [15]. The TKA patients were also older and had a higher BMI and more preoperative comorbidities. Spine fusion patients experience more blood loss, hemodynamic instability, and pain than arthroplasty patients, which may explain the increased incidence of postoperative complications [22].

Considerable evidence suggests that simultaneous bilateral arthroplasty procedures result in an increased incidence of morbidity and mortality [1]. However, in our analysis, patients undergoing bilateral procedures were not at an increased risk for an escalation in care. For the past 10 years, we have excluded patients with multiple comorbidities and/or an ASA of ≥III from undergoing simultaneous bilateral TKR [21]. In addition, all patients who do undergo bilateral arthroplasty are monitored for at least the night of surgery in the PACU with careful attention to hemodynamic stability and adequate volume resuscitation. These factors probably reduce the risks and hence postoperative return for complications.

In conclusion, at one institution over a 1-year period, 2% of the patients after undergoing major orthopedic surgery required transfer to a higher level of care. Cardiac complications were the primary reason for readmission to the PACU. Patients undergoing TKA and PSF were more likely to return than those undergoing THA. In addition, older patients, patients with increased comorbidities, and patients with OSA using CPAP were more likely to require an escalation in care (OR 2.24, p=0.03). Many of these factors are not modifiable (e.g., age, comorbidities), but this information may direct us to identifying particular groups of patients at risk for postoperative complications with the goal of improving outcome. Since many of these high risk patients who returned were originally monitored the night of surgery in the PACU, pulse oximetry and respiratory monitoring may be required until they are considered ready for hospital discharge, as well as a re-examination of fluid therapy, pain management, and hemodynamic control. This may represent a first step in the modification of the postoperative care for subsets of orthopedic patients

Disclosures

Conflict of Interest: Michael K. Urban, MD, PhD, Michele Mangini-Vendel, ACNP-BC, DNP, Stephen Lyman, PhD, Ting Jung Pan, MPH and Steven K. Magid, MD have declared that they have no conflict of interest.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was waived from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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