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Modifiable, Postoperative Risk Factors for Delayed Discharge Following Total Knee Arthroplasty: The Influence of Hypotension and Opioid Use

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Abstract

Background: We sought to identify independent modifiable risk factors for delayed discharge after total knee arthroplasty (TKA) that have been previously underrepresented in the literature, particularly postoperative opioid use, postoperative laboratory abnormalities, and the frequency of hypotensive events.

Methods: Data from 1033 patients undergoing TKA for primary osteoarthritis of the knee between June 2012 and August 2014 at an academic orthopedic specialty hospital were reviewed. Patient demographics, comorbidities, inpatient opioid medication, postoperative hypotensive events, and abnormalities in laboratory values, all occurring on postoperative day 0 or 1, were collected. Multivariate logistic regression analysis was performed to identify independent risk factors for a prolonged length of stay (LOS) >3 days.

Results: The average age of patients undergoing primary TKA in our cohort was 65.9 (standard deviation, 9.1) years, and 61.7% were women. The mean LOS for all patients was 2.64 days (standard deviation, 1.14; range, 1–9). And 15.3% of patients had a LOS >3 days. On multivariate logistic regression analysis, nonmodifiable risk factors associated with a prolonged LOS included nonwhite race (odds ratio [OR], 2.01), single marital status (OR, 1.53), and increasing age (OR, 1.47). Modifiable risk factors included every 5 postoperative hypotensive events (OR, 1.31), 10-mg increases in oral morphine equivalent consumption (OR, 1.04), and postoperative laboratory abnormalities (hypocalcemia: OR, 2.15; low hemoglobin: OR, 2.63).

Conclusion: This study identifies potentially modifiable factors that are associated with increased LOS after TKA. Doubling down on efforts to control the narcotic use and to use opioid alternatives when possible will likely have efficacy in reducing LOS. Attempts should be made to correct laboratory abnormalities and to be cognizant of patient opioid use, age, and race when considering potential avenues to reduce LOS.

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Keywords

total knee arthroplasty; opioid; hypotension; modifiable risk factors; length of stay; anemia

Total joint arthroplasty (TJA) is the most frequently performed inpatient medical procedure performed in the United States, with total knee arthroplasty (TKA) representing a majority of the cases with over 600,000 being performed in 2012 alone [1]. A recent analysis using the National Inpatient Sample estimated the growth in number of TKA performed in the United States to increase by 71% to 1.26 million annual procedures by the year 2030 [2]. Given this increasing demand, the annual national healthcare expenditure for TKA will increase with the rising incidence. In 2014 alone, the annual national healthcare expenditure for these operations was approximately 20 billion dollars, and this amount has been increasing annually [3].

One of the major drivers of the cost associated with TKA is the hospital length of stay (LOS) after the procedure. From 2002 to 2013, the hospital LOS after TKA decreased from a mean time of 4.06 to 2.97 days. Despite a 52.4% increase in mean costs of TKA in this same time period, the mean hospital costs would have increased a further 18.5% with hospital LOS kept at the 2002 level. Reducing the LOS appeared to be one successful approach to slowing the pace of ever-increasing hospital costs for TKA [4].

Despite recent reports of decreasing LOS for TKA in the United States, LOS remains high in other parts of the world. A recent study published in 2017 of a cohort of 1622 patients from Hong Kong receiving TKA was identified as having a mean LOS of 6.8 days after the procedure [5]. In a study using data from the National Health Institute in the United Kingdom, the mean hospital LOS remained high at 5.4 days [6]. While these reported numbers are higher than a previously reported mean LOS of 3.5 for TKA, LOS remains a variable of interest from a cost reduction standpoint. As the financial landscape of healthcare is set to undergo significant changes, efforts aimed at decreasing LOS after TKA is one potential target to help contain and potentially decrease healthcare costs associated with these procedures [7–10].

Much effort has been undertaken to analyze factors contributing to increased LOS in the hospital after orthopedic surgery [10–17]. Additionally, several articles have examined factors associated specifically with increased LOS for TKA [5,18–23]. Most investigate nonmodifiable patient characteristics, such as race, age, income, body mass index, various comorbidities, and insurance status. These factors, however, are not potential targets of modification from a cost and LOS reduction standpoint. Interestingly, less focus has been given to the study of potentially modifiable risk factors, such as opioid use, abnormal vital signs, or significantly altered postoperative laboratory values which may affect LOS. One factor particularly, postoperative hypotension, has been shown to increase LOS in other surgical fields, and in total hip arthroplasty [16,24,25]. There are clinical protocols that exist to facilitate fluid management after TJA, but the effect of postoperative hypotension specifically on LOS has been inadequately evaluated [26,27].

Therefore, this study used single-institution data from an academic orthopedic specialty hospital to identify individuals undergoing TKA and investigate potentially modifiable risk factors affecting LOS, with a focus on opioid use, postoperative laboratory abnormalities, and the frequency of hypotensive events. Our primary outcome measure was hospital LOS. We hypothesized that, similar to other surgical specialties, the number of acute postoperative hypotensive events after TKA would be correlated to an increase in the average patient LOS. We also hypothesized that increased narcotic consumption in the postoperative period would also be associated with an increased LOS. In seeking to determine whether an independent association existed between these modifiable risk factors and LOS, we also included other patient characteristics, such as demographic information, comorbidities, and insurance status in our analysis.

Patients and Methods

Upon acceptance from the institutional review board at our institution, all patients undergoing primary TKA between June 2012 and August 2014 were identified. All of these procedures were performed by 1 of the 4 fellowship-trained surgeons at our institution who all work and operate at an orthopedic specialty hospital. None of the 1033 patients were excluded from our analysis based on death resulting from their TKA procedure or the resulting hospital stay, given a mortality rate of 0.0%. Only patients receiving surgical TKA for primary knee osteoarthritis were included in final analyses.

The primary outcome measure of interest was hospital LOS. We chose to define this measure based categorically as number of days (0, 1, 2, 3, etc.). To determine hospital LOS, each night spent in the hospital after surgery was determined to be an increase in LOS of 1 day. To illustrate this, if a patient were to be discharged on the day following their procedure, they would have spent 1 night in the hospital and thus accrued a total LOS of 1 day. Despite potential value in determining hour-by-hour LOS after TKA, efforts were not made to distinguish exact timing of discharge due to lack of available, reliably accurate data of exact time of discharge. No patients were admitted to the hospital before the day of their TKA procedure.

After collection of data (patient demographics, comorbidities, inpatient opioid medication use, postoperative hypotension, and abnormal laboratory values) from retrospective chart review, a model was created to examine both modifiable and nonmodifiable predictors of LOS. In an effort to assess and account for patient comorbidities, the Charlson Comorbidity Index (CCI) was computed for each patient using International Classification of Diseases (ICD) categories [28,29]. To effectively assess opioid use, total narcotic medication used was converted to oral morphine equivalents (OME) for each patient [30]. Postoperative hypotensive events were noted and were recorded as a continuous variable. These events were defined as a systolic blood pressure less than 90 mmHg or a diastolic blood pressure less than 60 mmHg for any single reading [31,32].

The default threshold laboratory values coded within our institution's electronic medical record system (Cerner Systems) as clinical support tools were used as threshold values to determine patient laboratory result aberrancy. We have listed the thresholds used in our study

in Table 1. Abnormal high or abnormal low values (values deviating from threshold ranges) were then recorded categorically (either as “abnormal high” or “abnormal low”) for each postoperative day (POD) in a retrospective review of patient data during the hospital stay for TKA. Laboratory data were not recorded in a continuous fashion.

Abnormal laboratory variables that appeared infrequently (defined as appearing in less than 5% of the sample) were noted and such variables were excluded in an effort to preserve the reliability of our model. After removing infrequent variables, the presence of low calcium, high creatinine, high glucose, low hemoglobin, and low sodium the laboratory values occurring in at least 5% of our sample, and thus included in the final regression model. Baseline characteristics of all of the patients included in our sample can be seen in Table 2.

In grouping patients as having either increased or “normal” LOS, we chose to use a cutoff of LOS >3 days. As 84.7% (845/1033) of our cohort had a LOS ≤ 3 days, a sizable group of 188 patients were isolated and defined as having a prolonged LOS. See histogram (Figure 1) for LOS distribution.

Statistical Analysis

Statistical analysis was carried out by an institutional statistician using the R:A language and environment for statistical computing (R Foundation for Statistical Computing, <http://www.R-project.org>). χ^2 or Fisher exact tests were performed for categorical data, and Student *t*-tests were performed for parametric continuous data. After these initial tests, variables with a significance of $P < .05$ were then entered into a multivariate model. Specifically, a binary logistic regression analysis was used to identify independent risk factors for LOS >3 days. This model also serves to effectively control for confounding variables. Using this model, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for associations between each risk factor and outcomes of interest.

To indicate spread and reliability of the model, values are presented in this study as a mean with standard deviation (SD) or 95% CIs. Two-tailed *P* values < .05 were considered statistically significant. ORs for OME and age are presented per 10-unit increase (mg or years as applicable). ORs for hypotensive events on POD 0 or 1 are reported per 5 events. ORs for CCI is presented per 1-unit increase. Because laboratory abnormalities beyond POD 0 or 1 are unlikely to be related to potentially modifiable risk factors for increased LOS, only patients with laboratory abnormalities in POD 0 or 1 were considered to have laboratory aberrancy as a risk factor for prolonged LOS.

Results

One thousand and thirty-three patients underwent TKA for primary osteoarthritis of the knee between June 2012 and August 2014 at our academic orthopedic specialty hospital. The average age of patients undergoing primary TKA in our cohort was 65.9 (SD, 9.1) years; 61.7% were women, and 38.3% were men. The median for LOS was 2 days, and the mode for LOS was also 2 days. Also, 50.8% of patients were discharged before POD 3 (≤ 2 POD), 10.7% (111/1033) were discharged on POD 0 or 1, and 74.0% (764/1033) were discharged on POD 2 or 3. The remaining 15.3% (188/1033) made up the group of “high risk” patients

and were discharged on or above POD 4 (Figure 1). The mean LOS for all patients was 2.64 days (SD, 1.14; range, 1, 9). Surgeon performing the procedure did not significantly affect LOS.

Univariate analysis comparing patients with a prolonged LOS >3 days (“high risk” patients) to those with a LOS ≤3 days demonstrated numerous preoperative and postoperative factors associated with an increased LOS (Table 3). The postoperative modifiable risk factors correlated with a prolonged LOS included any narcotic use at all, OME, the number of hypotensive events, postoperative anemia, hypocalcemia, hyponatremia, high glucose, and high creatinine. The nonmodifiable variables which yielded an increase in LOS included an increasing age, female gender, Medicare insurance payer type, CCI, single marital status, and non-Caucasian race.

Multivariate binary logistic regression analysis effectively controlled for confounding factors and identified several independent risk factors for delayed discharge (Table 4).

Nonmodifiable risk factors included single marital status (52.6% increased odds) and nonwhite race (101.2% increased odds). For every 10-year increase in age, there was a 46.5% increased odds of an increased LOS. Insurance status, sex, and CCI score were not independent predictors of an increased LOS.

Additionally, and more importantly, we identified several modifiable risk factors for a prolonged LOS following TKA. For every 5 additional hypotensive events during POD 0 and 1, there was a 30.5% increased odds of a hospital LOS >3 days. Similarly, for every 10-mg increase in OME use during POD 0 and 1, there was a 4.4% increased odds of a LOS >2 days. Hypocalcemia occurring in POD 0 or 1 contributed to a 114.9% increased odds of a LOS past 3 days. The strongest association between any risk factor and LOS in our model was that of low hemoglobin; patients with low hemoglobin values on POD 0 or 1 had 2.625 increased odds of a LOS >3 days than those without abnormal hemoglobin values on those days. When controlling for the effect of other variables in our multivariate model, several potentially modifiable variables that were significant on univariate analysis were no longer significant predictors for delayed discharge, including high glucose, high creatinine, and low sodium.

Discussion

Hospital LOS is a modifiable risk factor in decreasing the rising hospital costs associated with TKA. As decreased LOS is not associated with an increased readmission rate or increased emergency room visits following TKA, identifying risk factors for an increased LOS after TKA can help constrain hospital costs while providing rapid discharge home [33].

Our patients had a mean LOS of 2.64 days—lower than published estimates, which have reported a mean LOS ranging from 3.17 days to 6.8 days for TKA [5,7,8,34]. This median LOS is also lower than published estimates in similar literature looking at risk factors associated with prolonged LOS [22,35]. The shorter LOS observed in our institution’s patients may be due partly to each surgeon’s fellowship training and that a majority of the surgeon’s surgical caseload was comprised of TKA. In addition, each surgeon worked in the

same orthopedic-specific hospital that employs an early, aggressive physical therapy protocol and uniformly defined clinical pathways, which has been reported to reduce LOS in patients undergoing TJA [20,36–38].

Modifiable Risk Factors

Most importantly, our results confirm additional and modifiable risk factors for increased hospital LOS after TKA. Specifically, postoperative hypotensive events, OME, and opioid use during the day of surgery and POD 1 were independent and significant risk factors for increased hospital stay. These data thus support future research into initiatives aimed at reducing early postoperative hypotension and opioid use in patients undergoing TKA.

Our analysis revealed a strong correlation between increasing use of OME and odds of LOS being greater than 3 days. Average OME for patients who had a LOS >3 days was 237.1 as compared to 101.1 OME in the cohort of patients with LOS between 0 and 1 days. Other studies have revealed similar findings across other fields of medicine, where opioid use is associated with increased LOS and readmission rate [39]. Additionally, opioid-related adverse events (constipation, nausea, confusion) have been determined to directly impact LOS in patients receiving orthopedic surgery [40]. Doubling down on efforts to control the narcotic epidemic and to use opioid alternatives when possible will likely have profound efficacy in reducing LOS. These replacements could include intraoperative dexamethasone, which has been supported as an effective conduit for reducing pain, nausea, and LOS (by up to 1.5 days) after TJA and was recently put in place at our institution after the study period of this article was completed [41]. There are certain deleterious side effects to be aware of when using any glucocorticoid, including infection, surgical site healing, or osteonecrosis. However, to our knowledge, no studies have found arthroplasty patients to be at increased risk of these complications and can be safely given to arthroplasty candidates in low-to-moderate doses [42–46]. One potential complication with intraoperative dexamethasone is fluctuations in blood glucose levels, which have been found to be higher at 24 hours [46].

Additionally, other opioid alternatives may play a role in reducing LOS via reducing opioid use. Consistent use of nonopioid analgesia, including nonsteroidal anti-inflammatories and acetaminophen, but also gabapentin and selective-serotonin reuptake inhibitors, has been shown to reduce postoperative opioid requirements [47–49]. Cryotherapy has been shown to reduce postoperative pain and opioid requirements, with no to minimal side effects, which can include discomfort, local skin reactions, or cold-related injuries, including case reports of frostbite that required debridement [50–53]. Furthermore, multimodal pain control strategies with a peripheral nerve block as the emphasis of pain control decreased opioid use and LOS [54]. Preoperative and postoperative opioid education has also been shown to be effective in reducing postoperative opioid use for a number of orthopedic procedures [55–57], in addition to the implementation of a hospital-wide opioid prescription protocol [58].

Our results also confirm that several laboratory values are independently associated with increased LOS, and protocols to correct these aberrant laboratory values could also prove valuable to reduce hospital stay after TKA. Specifically, as low postoperative hemoglobin had the highest correlation with increased LOS of any risk factor (OR, 2.63), research to determine an appropriate postoperative hemoglobin threshold for transfusion and a

subsequent postoperative TKA transfusion protocol to optimize patient outcomes and LOS may substantially reduce average hospital stay for patients undergoing TKA. Tranexamic acid has been found to decrease blood loss and control postoperative drops in hemoglobin and should be used to control intraoperative blood loss [59–61]; however, its role in reducing LOS remains undetermined. We do not use tourniquets for bleeding control because of a potential increased risk of thromboembolic events with no differences in postoperative blood loss [62,63]. Furthermore, TXA has been found to be superior to tourniquets in a randomized, controlled trial, with decreased blood loss and postoperative pain [64].

For the vast majority of our patients, a preoperative complete blood count is available from an outside provider or within the network. If this shows an anemia with a hemoglobin less than 12, the patient undergoes an anemic work-up before scheduling surgery. If they have a history of anemia symptomology, and they do not have a preoperative hemoglobin, a complete blood count is performed. We currently do not assess preoperative hemoglobin in asymptomatic without a laboratory value from an outside provider. Furthermore, to control hypotension, our routine practice is clear liquids up to 2 hours before surgery. Antihypertensives as a general rule are not resumed until the systolic blood pressure is above 160 mmHg or until they are discharged home.

In addition, our analysis confirmed other laboratory aberrancies are associated with a prolonged LOS. Hypocalcemia was the second single highest risk factor of prolonged LOS after a low postoperative hemoglobin (OR, 2.15). To this research team's knowledge, this has yet to be reported as a risk factor for prolonged LOS after TKA. We hypothesize that hypocalcemia indicates a state of patient frailty or of improper nutrition which may contribute to an increased LOS after TKA. Ensuring adequate control and treatment of both preoperative and postoperative hypocalcemia could further decrease LOS for patients undergoing TKA.

Nonmodifiable Risk Factors

In addition, our results confirm several previously identified nonmodifiable risk factors for increased hospital LOS after TKA. Specifically, non-Caucasian race, single marital status, and increasing age were all independently associated with increased hospital LOS in our model (Table 4). Of note, when studied in isolation, Medicare insurance holders had an increased LOS compared to private insurance holders; however, when adjusted for all other variables, these associations regarding insurance status were no longer statistically significant (Tables 3 and 4). This is in opposition to previously reported literature in the Nationwide Inpatient Sample database, which found Medicaid payer status to be a risk factor for prolonged LOS [65]. However, this study had a higher median LOS compared to our average of 2 days, and the multivariate analysis used in this study was looking for risk factors for increased LOS of over 4 days, a full day longer than our cutoff.

The CCI was associated with a prolonged LOS when studied in isolation; however, an increase in CCI had no statistically significant value in predicting an increased LOS when controlling for other variables. This may be in part laboratory abnormalities being included in our model, and these abnormality derangements may be a more concerning indicator of patient health than the CCI.

While more work needs to be done to determine appropriate protocols for reducing the impact of modifiable risk factors and potentially decreasing postoperative LOS, properly identifying modifiable targets as a first step is imperative. In attempting to do so, this study has several strengths. This study has a large sample size of 1033 patients giving it considerable power to detect the relative impact of various risk factors. Other single-institution studies investigating risk factors for prolonged LOS did not have the same sample size as this study [19,22]. Additionally, unlike national health databases with data aggregated from numerous facilities with varied protocols and orthopedic surgeons with heterogeneous caseloads, our patients were all treated by surgeons performing greater than 200 TKA procedures each year, at the same institution with the same protocols. Thus, more standardized data such as vital signs, laboratory values, and medication use can be gleaned and examined across our sample. This may explain why our data did not show low sodium, glucose, or high creatinine as a risk factor for prolonged LOS. Additionally, the different cut offs for statistical analysis may also explain the differing results in these studies.

Strengths and Limitations

Our study also has some limitations. These include the retrospective nature of the study and the fact that all patient information was derived from medical charts and records and not recorded prospectively at the time of operation. As such, not all variables of interest, such as the presence of orthostatic hypotension or time of first postoperative physical therapy session, were recorded uniformly and thus could not be included in our model unfortunately. Our study also employs a conservative threshold to define hypotension as any reading with a systolic pressure of 90 mmHg or less or a diastolic pressure of 60 mmHg or less. These thresholds have been defined previously in the literature [31,32]. Certainly, the possibility that blood pressure values that are greater than a systolic pressure of 90 mmHg or a diastolic pressure of 60 mmHg may still be considered an abnormality on the continuum of postoperative blood pressure. Many of the patients in our cohort have baseline hypertension, and so even values significantly higher than the aforementioned thresholds may still constitute a hypotensive event. Future research, therefore, could aim to control for preoperative hypertension in accounting for all possible events of postoperative hypotension. In this way, the survey could be adequately sampled, and patients who may not meet the threshold values for hypotension due to baseline hypertension would still be recorded correctly as having had a hypotensive event in the postoperative period. Other factors such as anesthesia type (general or spinal) and tranexamic acid (TXA) are other modifiable, physician-driven factors that have been shown to decrease LOS and reduce postoperative hemoglobin loss, respectively [60,66–68]. However, the use of spinal anesthesia or the use of TXA was implemented after the study period at our institution, so their effect on LOS could not be determined for the present study.

Lastly, laboratory values were coded as abnormal low, normal, or abnormal high as described above in a categorical fashion. Continuous laboratory data were not included in our model. Therefore, the magnitude of laboratory derangements remains unexplored in our multivariate model. Further investigation could aim to quantify the effect on hospital LOS of specific magnitudes of laboratory variable aberrance. Additionally, our estimations for abnormal values (based on default threshold laboratory values coded within our institution's

electronic medical record system) could be considered conservative in some cases, especially a hemoglobin cutoff of 11.4. Furthermore, there have been increases in outpatient TKA because the study period ended in 2014, so it is possible that some of the factors that we have found do not have meaning for the much shorter LOS in 2019. However, predictive models suggest that until the year 2026, over 50% of TJAs will take place in the inpatient setting; thus, the data presented here remains relevant [69].

We intend our study to serve as an initial examination of potentially modifiable risk factors for increased hospital LOS after TKA. We hope that further investigation will explore each variable documented in this study that was found to be correlated with hospital LOS in an effort to define specific contribution to LOS of various magnitudes of aberrancy. Such research could then be used to direct protocols and policies aimed at reducing hospital LOS and overall system burden of one of the most commonly performed procedures in the United States.

Conclusion

As TKA continues to grow in incidence throughout the United States, great import has been placed on attempting to reduce hospital LOS after this procedure and therefore restrain expenditures. This study demonstrates that increased opioid use, hypotensive events, and abnormal calcium and hemoglobin are all independently associated with a longer hospital LOS after TKA. It is important to identify these and other potentially modifiable factors that may improve patient safety while reducing potential burdens.

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Fig. 1.

Graph shows a histogram of length of stay after total knee arthroplasty. The dashed line is at 3 days and represents the cutoff used for statistical analysis.

Table 1

Laboratory Reference Ranges.

Lab Variable	Low ^a	High ^a
Albumin	3.5	5
Alkaline phosphatase	38	126
Anion gap	2	12
Osmolality, calculated	261	280
Bilirubin, total	0.2	1.3
Calcium, total	8.4	10.5
Chloride	98	107
Carbon dioxide	22	30
Creatinine	0.66	1.25
Glucose	74	106
Potassium	3.5	5.1
Protein, total	6.3	8.2
Aspartate aminotransferase	15	46
Alanine aminotransferase	21	72
Sodium	137	145
Blood urea nitrogen	9	20
Hemoglobin	11.4	16.1
Hematocrit	33.3	46.5

^aTo be classified as low or high, value must be below or above cutoff.

Table 2

Patient Baseline Characteristics.

Characteristic	Class	Mean $\pm$ SD (Min, Max) % (N)
No. of patients		1033
Age (y)		65.9 $\pm$ 9.11 (33.0, 89.0)
OME (mg); first 2 d		208.7 $\pm$ 137.1 (0, 1806)
Sex	Female	61.7% (637)
	Male	38.3% (396)
Race	White	72.2% (746)
	Nonwhite	27.8% (287)
Marital status	Married	68.9% (712)
	Not married	31.1% (321)
CCI score		0.60 $\pm$ 0.86 (0, 3)
Insurance	HMO/managed care	31.3% (323)
	Medicaid	1.6% (16)
	Medicare	55.5% (572)
	Other	11.6% (120)
Lab abnormalities; first 2 d	Low calcium	40.0% (413)
	High creatinine	66.55% (687)
	High glucose	55.7% (575)
	Low hemoglobin	73.7% (761)
	Low sodium	37.6% (388)
Days of IV narcotic use		1.46 $\pm$ 0.90 (0, 6)
Narcotic use on day 0/1		92.5% (955)

OME, oral morphine equivalents; CCI, Charlson Comorbidity Index; IV, intravenous; HMO, Health Maintenance Organization.

Table 3

Univariate Logistic Regression for Predictors of Delayed Discharge.

Characteristic	Class	LOS 0–1 d (N = 111)	LOS 2–3 d (N = 764)	LOS >3 d (N = 158)	OR (95% CI)	P Value
Hypotensive events (POD 0/1) ^{a,b}		2.32 (2.69)	3.15 (3.24)	3.96 (3.98)	1.545 (1.297–1.841)	<.0001
CCI score		0.39 (0.62)	0.57 (0.84)	0.87 (1.0)	1.469 (1.254–1.721)	<.0001
Sex	Male	63/111 (56.7%)	295/764 (38.6%)	38/158 (24.1%)	—	<.0001
	Female	48/111 (43.2%)	469/764 (61.4%)	120/158 (75.9%)	2.252 (1.672–3.03)	
Race	White	94/111 (84.7%)	556/764 (72.8%)	96/158 (60.8%)	1.988 (1.458–2.703)	<.0001
	Nonwhite	17/111 (15.3%)	208/764 (27.2%)	62/158 (39.2%)	1.988 (1.458–2.703)	
Marital status	Married	91/111 (82.0%)	533/764 (69.8%)	88/158 (55.7%)	—	<.0001
	Not married	20/111 (18.0%)	231/764 (30.2%)	70/158 (44.3%)	2.04 (1.511–2.755)	
Age ^{a,c}		63.9 (8.9)	65.7 (9.2)	68.5 (8.5)	1.38 (1.190–1.612)	<.0001
OME (mg) ^{a,c}		101.1 (64.5)	218.3 (138.6)	237.1 (133.6)	1.037 (1.026–1.049)	<.0001
Insurance	HMO/managed care	49/111 (44.1%)	235/762 (30.8%)	39/158 (24.7%)	1.171 (0.726–1.886)	<.0001
	Medicaid	2/111 (1.8%)	12/762 (1.6%)	2/158 (1.3%)	1.352 (0.409–4.470)	
	Medicare	42/111 (37.8%)	423/762 (55.5%)	107/158 (67.7%)	2.260 (1.436–3.558)	
	Other	18/111 (16.2%)	92/762 (12.1%)	10/158 (6.3%)	—	
Lab abnormalities	Low calcium	20/111 (18.0%)	306/764 (40.1%)	87/158 (55.1%)	2.413 (1.801–3.234)	<.0001
	High creatinine	60/111 (54.1%)	509/764 (66.6%)	118/158 (74.7%)	1.690 (1.255–2.275)	.0006
	High glucose	50/111 (45.1%)	420/764 (55.0%)	105/158 (66.5%)	1.667 (1.257–2.211)	.0004
	Low hemoglobin	39/111 (35.1%)	583/764 (76.3%)	139/158 (88.0%)	5.049 (3.546–7.190)	<.0001
	Low sodium	27/111 (24.3%)	285/764 (37.3%)	76/158 (48.1%)	1.779 (1.334–2.372)	<.0001
Narcotic use on day 0/1		88/111 (79.3%)	714/764 (93.5%)	153/158 (96.8%)	3.819 (2.307–6.320)	<.0001

LOS, length of stay; OR, odds ratio; CI, confidence interval; POD, postoperative day; CCI, Charlson Comorbidity Index; OME, oral morphine equivalents; SD, standard deviation; HMO, Health Maintenance Organization.

^aVariables presented as mean ± SD.^bOR reported per 5 events.^cOR reported per 10 units (years or mg as applicable).

Table 4

Multivariate Analysis of Risk Factors Significantly Associated With Length of Stay >3 Days.

Characteristic	Class	OR (95% CI)	P Value
Hypotensive events on POD 0/1 ^{a,b}		1.305 (1.036–1.645)	.0239
Race	Nonwhite vs white	2.012 (1.437–2.817)	<.0001
Marital status	Not married vs married	1.526 (1.101–2.119)	<.0001
Age ^{a,c}		1.465 (1.163–1.845)	<.0001
OME (mg) ^{a,c}		1.044 (1.030–1.058)	<.0001
Lab abnormalities	Low calcium	2.149 (1.463–3.157)	<.0001
	Low hemoglobin	2.625 (1.760–3.914)	<.0001
Narcotic use on day 0/1		1.903 (1.090–3.323)	<.0001

OR, odds ratio; CI, confidence interval; POD, postoperative day; OME, oral morphine equivalents; SD, standard deviation.

^aVariables presented as mean ± SD.^bOR reported per 5 additional events.^cOR reported per 10 units (years or mg as applicable).