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Readmission Rates for One Versus Two-Midnight Length of Stay for Primary Total Knee Arthroplasty

Analysis of the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) Database

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Background: The length of stay (LOS) in the hospital for total knee arthroplasty (TKA) has been declining over recent decades. The purpose of this study was to determine if patients with an LOS for TKA that includes only 1 midnight have an increased odds of 90-day readmission compared with those with a 2-midnight LOS. We also sought to identify any predictors of 90-day hospital readmission among those readmitted during our period of analysis.

Methods: A retrospective review of the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) database was performed to identify patients with a 1-midnight or 2-midnight LOS for TKA during a 5-year period. The primary end point of this study was inpatient readmission within the 90-day postoperative period. A multiple logistic regression model and propensity score matching were used to compare the odds of 90-day readmission between 1-midnight and 2-midnight LOS. The secondary end points of this study were 90-day complications.

Results: There were 96,250 TKA procedures identified in the database, and 46,709 met our inclusion criteria for LOS. No difference in 90-day-readmission odds between patients with a 1-midnight LOS and those with a 2-midnight LOS for primary TKA was identified. Male sex, single marital status, age of ≥80 years, type-I diabetes, previous smoking, narcotic use prior to surgery, and a higher American Society of Anesthesiologists (ASA) scores increased the odds of 90-day readmission. Patients in the age group of ≥50 to <65 years, those with a higher preoperative hemoglobin level, and those with a positive social history of alcohol use were found to have decreased odds of readmission.

Conclusions: We found no association between the LOS for primary TKA (1 midnight compared with 2 midnights) and the 90-day readmission risk.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

There has been a steady decline in the length of stay (LOS) in the hospital following total knee arthroplasty (TKA). The average LOS for TKA in the United States was 8.4 days in the 1990s, which was reported to have decreased to 4.2 days by 2004[1]. In 2015, El Bitar et al.[2] reported that >75% of patients treated with a primary TKA were discharged in ≤3 days. Recently, as a result of standardized rehabilitation and multimodal pain protocols, TKA is even being performed in the outpatient setting[3-8].

Multiple studies have addressed the risk factors for prolonged LOS[9-11]. Bini et al. demonstrated that a 2-day LOS for primary TKA was not inferior to a 3-day LOS with regard to the 30-day readmission rate[12], and a single, underpowered study, consisting of only 254 TKAs, revealed no difference between 1 and 2-midnight LOS with regard to 90-day readmission[13]. However, to our knowledge, the current literature lacks studies with an adequate sample size comparing the risk of readmission between 1 and 2-midnight LOS for TKA. With the introduction of bundled payments, it is imperative that we compare these readmission rates over a 90-day global period. Identifying patients at risk for readmission provides the opportunity to limit unnecessary inflation of episode-of-care costs.

Disclosure: No direct funding was provided for this study. However, as part of their Value Partnerships program, Blue Cross Blue Shield of Michigan funds the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI), which was responsible for the data collection. Although Blue Cross Blue Shield of Michigan (BCBS) and MARCQI work collaboratively, the opinions, beliefs and viewpoints expressed by the authors do not necessarily reflect the opinions, beliefs, and viewpoints of BCBSM or any of its employees. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/E912).

TABLE I Descriptive Statistics for Patients with 1-Midnight and 2-Midnight LOS

Variable	Overall (N = 46,709) No.	Overall (N = 46,709) Mean (SD)	1-Midnight LOS (N = 15,009 [32.1%]) No.	1-Midnight LOS (N = 15,009 [32.1%]) Mean (SD)	2-Midnight LOS (N = 31,700 [67.9%]) No.	2-Midnight LOS (N = 31,700 [67.9%]) Mean (SD)	Relative Differences *(%)*	P Value: Wilcoxon Rank-Sum Test	P Value: Wilcoxon Rank-Sum Test After Propensity Score Matching (1:1) (N = 26,306)
Age* *(yr)*	46,647	65.0 (12)	15,001	65.0 (12)	31,646	65.0 (12)	0	<0.0001	0.2706
BMI *(kg/m²)*	45,936	32.0 (8.7)	14,861	31.7 (8.2)	31,075	32.2 (8.9)	1.58	<0.0001	0.262
Preoperative albumin level† *(g/dL)*	24,105	4.1 (0.4)	7,746	4.2 (0.5)	16,359	4.1 (0.4)	2.38	<0.0001	0.0776
Preoperative creatinine level† *(mg/dL)*	42,405	0.9 (0.3)	13,908	0.9 (0.2)	28,497	0.9 (0.3)	0	<0.0001	<0.0001
HbA1c† *(%)*	11,309	5.9 (1.0)	3,628	5.8 (0.9)	7,681	5.9 (1.0)	1.72	0.002	0.1588
Preoperative Hb level *(g/dL)*	45,847	13.8 (1.8)	14,729	13.9 (1.7)	31,118	13.7 (1.7)	1.44	<0.0001	0.592
Postoperative Hb level† *(g/dL)*	45,946	11.1 (1.9)	14,651	11.7 (1.7)	31,295	10.9 (1.8)	6.84	<0.0001	<0.0001
Operation time, incision to closure† *(min)*	46,700	81.0 (31.0)	15,008	80.0 (28.0)	31,692	81.0 (33.0)	1.25	<0.0001	0.8689

*Age was de-identified. The mean (SD) was calculated after exclusion of patients with ages of ≥90 years. †Not used to create propensity scores.

We performed a retrospective study to determine if patients whose LOS for TKA encompassed 1 midnight had an increased odds of 90-day readmission compared with those whose LOS included 2 midnights. We hypothesized that there would be no difference in the 90-day readmission risk between a 1 and 2-midnight LOS after primary TKA. We also sought to identify any predictors of 90-day hospital readmission among those readmitted during the period of our analysis.

Materials and Methods

Institutional review board approval was granted prior to study initiation. The Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI), founded in 2011 as a Blue Cross Blue Shield of Michigan Value Partnership program, was responsible for the data collection. The MARCQI registry captures >95% of the joint arthroplasties performed in Michigan and includes 61 hospitals. Data are entered into the database by trained clinical data abstractors as well as with file-based uploads. More information on MARCQI was provided by Hughes et al.[14,15], who also presented details on the MARCQI quality assurance processes[14].

Patients who underwent primary TKA with an LOS that encompassed 1 or 2 midnights in the period from February 1, 2012 (the beginning of data collection for the MARCQI database) to May 8, 2017 (the last surgical date considered to allow for a complete data set to be authenticated) were included in the study. De-identified data were obtained. We excluded unicondylar, bicompartmental, and revision arthroplasties.

The primary end point of this study was inpatient readmission within the 90-day postoperative period. The secondary end points were 90-day postoperative complications. We also analyzed patient age, sex, marital status, body mass index (BMI), American Society of Anesthesiologists (ASA) score, medical comorbidities, substance use, and discharge disposition with regard to their effect on 90-day readmission risk.

The Wilcoxon rank-sum test ($\alpha = 0.05$) was used for comparison of means and standard deviations (SDs) of demographic and clinical characteristics. The chi-square test was utilized to compare secondary end points. The sample size for this study was based on the study group of 9,024 patients reported by Bini et al[12].; those patients had a readmission rate of 3.4% compared with a reference group of 11,804 patients who had a readmission rate of 3.2%. This sample size could identify a 20% difference in readmission rate. Thus, our target sample size was 9,000 for the group with a 1-midnight LOS.

Three logistic regression models were developed to assess the effect of LOS on 90-day readmission. Model 1 was a crude unadjusted model without other covariates taken into account. Model 2 was an adjusted multiple logistic regression model for the likelihood of readmission for a 1-midnight LOS compared with a 2-midnight LOS. The ratios of readmission between the 2 groups were calculated, and a Wald chi-square test was performed to analyze the contribution of each variable to the logistic regression model. For model 3, a 2-step strategy using multiple logistic regression modeling with propensity score matching was developed. In step 1, the propensity score model was fitted for LOS to determine the probability of patients being in either the 1-midnight or the 2-midnight-LOS group[16-18]. The following explanatory variables were used to derive this probability: age, BMI, preoperative hemoglobin (Hb) level, sex, ASA score, smoking status, insurance type, marital status,

TABLE II Comparison of 90-Day Complication Rates Between 1-Midnight and 2-Midnight LOS

	Overall (N = 46,709)		1-Midnight LOS (N = 15,009 [32.1%])		2-Midnight LOS (N = 31,700 [67.9%])		P Value: Chi-Square Test After Propensity Matching (1:1) (N = 26,306*)
	No.	%	No.	%	No.	%	
90-day event							
Yes	7,363	15.76	2,202	14.67	5,161	16.28	
No	39,258	84.05	12,780	85.15	26,478	83.53	0.0737
Missing	88	0.19	27	0.18	61	0.19	
Deep infection							
Yes	131	0.28	43	0.29	88	0.28	
No	46,490	99.53	14,939	99.53	31,551	99.53	0.5334
Missing	88	0.19	27	0.18	61	0.19	
DVT							
Yes	268	0.57	82	0.55	186	0.59	
No	46,353	99.24	14,900	99.27	31,453	99.22	0.5033
Missing	88	0.19	27	0.18	61	0.19	
Dislocation							
Yes	12	0.03	3	0.02	9	0.03	
No	46,609	99.79	14,979	99.80	31,630	99.78	0.1225
Missing	88	0.19	27	0.18	61	0.19	
ED visit							
Yes	4,479	9.59	1,393	9.28	3,086	9.74	
No	42,142	90.22	13,589	90.54	28,553	90.07	0.4993
Missing	88	0.19	27	0.18	61	0.19	
Fracture							
Yes	71	0.15	19	0.13	52	0.16	
No	46,550	99.66	14,963	99.69	31,587	99.64	0.0909
Missing	88	0.19	27	0.18	61	0.19	
Implant failure							
Yes	4	0.01	1	0.01	3	0.01	
No	46,617	99.80	14,981	99.81	31,636	99.80	0.3333
Missing	88	0.19	27	0.18	61	0.19	
Hematoma							
Yes	412	0.88	130	0.87	282	0.89	
No	46,209	98.93	14,852	98.95	31,357	98.92	0.4663
Missing	88	0.19	27	0.18	61	0.19	
PE							
Yes	104	0.22	20	0.13	84	0.26	
No	46,517	99.59	14,962	99.69	31,555	99.54	0.2658
Missing	88	0.19	27	0.18	61	0.19	
Urinary tract infection							
Yes	92	0.20	14	0.09	78	0.25	
No	46,529	99.61	14,968	99.73	31,561	99.56	0.0662
Missing	88	0.19	27	0.18	61	0.19	
Readmission within 90 days							
Yes	1,777	3.80	503	3.35	1,274	4.02	
No	44,844	96.01	14,479	96.47	30,365	95.79	0.2137
Missing	88	0.19	27	0.18	61	0.19	

*The n value for the propensity matching analysis is smaller than the overall n value for the study.

TABLE III OR of 90-Day Readmission Using Propensity Score Matching (1:1)

Variable*	OR	95% CI Lower Bound	95% CI Upper Bound	P Value
LOS: 1 midnight vs. 2 midnights	0.8720	0.7483	1.0162	0.0794
Age				
50 ≤ age < 65 vs. <50 yr	0.6300	0.4719	0.8412	0.0017
65 ≤ age < 80 vs. <50 yr	0.8147	0.6046	1.0978	0.1780
50 ≤ age < 65 vs. 65 ≤ age < 80 yr	0.7733	0.6256	0.9560	0.0175
≥80 vs. <50 yr	1.5130	1.0575	2.1648	0.0235
≥80 vs. 50 ≤ age < 65 yr	2.4016	1.7905	3.2211	<0.0001
≥80 vs. 65 ≤ age < 80 yr	1.8572	1.4734	2.3411	<0.0001
≥80 vs. all other ages	1.8898	1.4639	2.4395	<0.0001
50 ≤ age < 65 vs. all other ages	0.5876	0.4793	0.7203	<0.0001
Sex: male vs. female	1.6671	1.4218	1.9547	<0.0001
Marital status: single vs. married	1.3755	1.1782	1.6058	0.0001
BMI: continuous	0.9905	0.9784	1.0027	0.1274
ASA class: III/IV vs. I/II	1.8925	1.6264	2.2022	<0.0001
Diabetes mellitus				
Any diabetes vs. none	1.3226	0.9776	1.7894	0.0698
Type I vs. none	2.7452	1.5862	4.7510	0.0003
Type II vs. none	1.0468	0.8804	1.2446	0.6046
Preoperative narcotic use: yes vs. no	1.2428	1.0619	1.4545	0.0068
Preoperative use of assistive device: yes vs. no	1.5388	1.3259	1.7858	<0.0001
History of DVT/PE: yes vs. no	1.3740	1.0693	1.7655	0.0130
Alcohol use in social history: yes vs. no	0.8253	0.7169	0.9500	0.0075
Smoking				
Never vs. current	0.8963	0.6964	1.1536	0.3953
Previous vs. current	1.2667	0.9908	1.6193	0.0593
Previous vs. never	1.4131	1.2192	1.6379	<0.0001
Preoperative Hb level: continuous	0.9046	0.8562	0.9556	0.0003
Operative time: continuous	1.0024	0.9995	1.0053	0.1017
Surgeon caseload: ≥100/yr vs. <100/yr	1.0803	0.8837	1.3207	0.4510
Hospital caseload: ≥200/yr vs. <200/yr	2.1929	0.8172	5.8849	0.1190
Laterality: right vs. left	0.9856	0.8611	1.1282	0.8335
Discharge disposition: ECF vs. non-ECF	1.7898	0.9559	3.3511	0.0689
Preoperative anticoagulation use: yes vs. no	1.2403	0.9703	1.5854	0.0856
History of bleeding disorder: yes vs. no	1.0740	0.6575	1.7541	0.7756
TXA use: yes vs. no	0.9258	0.7726	1.1093	0.4031
Anesthesia type: general vs. any spinal	0.9723	0.8305	1.1382	0.7265
Blood transfusion: yes vs. no	4.5398	0.8834	23.329	0.0701
Primary payer				
Medicaid vs. commercial	1.0928	0.7166	1.6664	0.6802
Medicare vs. commercial	0.9945	0.8039	1.2303	0.9595
Other vs. commercial	1.0121	0.6867	1.4917	0.9515

*ECF = extended care facility, and TXA = tranexamic acid.

preoperative narcotic use, preoperative anticoagulation, bleeding disorder, history of deep venous thrombosis or pulmonary embolism (DVT/PE), use of assistive devices, use of tranexamic acid, general anesthesia, operative time, surgeon volume load, hospital volume load, alcohol use, laterality, discharge disposition, diabetes, blood transfusion, approach, bilaterality, and any intraoperative complications. We used 1:1 caliper matching to derive the matched cases, with the caliper width being 0.2 times the standard deviation of the logit of the propensity score to minimize the mean squared error of the estimated treatment effect[19,20]. In step 2, the hierarchical logistic regression model for the primary 90-day readmission outcome was fitted using the matched cases[21]. Quality of balancing was checked using a stratification test[22,23].

Odds ratios (ORs), Wald-based 95% confidence intervals (CIs), and p values were calculated. SAS version 9.4 and SAS macro language (SAS Institute) were used for the statistical analyses. Missing data points were analyzed, and the data were found to be of high quality; missing data were not imputed.

Results

A total of 96,250 TKA procedures were identified; 46,709 met our inclusion criteria. Of these, 15,009 patients had a 1-midnight LOS and 31,700 had a 2-midnight LOS. In the overall group, 58% of the patients were female, the average age was 65 years (SD = 12 years), and the mean BMI was 32 kg/m^2 (SD = 8.7 kg/m^2). The prevalence of diabetes mellitus was 19.2%, with 96.6% of the diabetes cases for which the type was known being type II. Spinal anesthesia was used in 67% of patients. The average operative time was 81 minutes (SD = 31 minutes). Overall, 97.1% of the patients were discharged to their homes. After the performance of propensity score matching, there was no significant difference between the 1-midnight and 2-midnight groups with regard to age, BMI, preoperative albumin level, HbA1c, preoperative Hb level, or operative time, indicating that the 2 groups were clinically similar according to the matched variables (Table I). The postoperative Hb level was found to be significantly lower in the 2-midnight group (Table I). The Appendix details the full descriptive statistics of the 2 groups and provides results of the simple bivariate analysis and adjusted multiple logistic regression model.

Overall, 9.59% of the patients visited the emergency department (ED) in the 90-day postoperative period, and the hospital readmission rate was 3.80%. In the 1-midnight group, 1,393 patients (9.28%) visited the ED and 503 (3.35%) were readmitted. In the 2-midnight group, 3,086 patients (9.74%) visited the ED and 1,274 (4.02%) were readmitted. After propensity score matching, no difference was found between the 2 groups with regard to visiting the ED or readmission (Table II). The principal diagnoses leading to readmission were deep infection, DVT, dislocation, fracture, implant failure, hematoma, PE, and urinary tract infection. No differences in the rates of these complications were noted between the groups (Table II). Table III presents the adjusted ORs for readmission based a multiple logistic regression model with propensity score matching. The 1-midnight group had a non-significantly decreased OR (0.8720) for 90-day readmission with a 95% Wald interval of 0.7483 to 1.0162 when compared with the 2-midnight group (p = 0.0794).

With regard to the patient variables analyzed for 90-day readmission risk, male compared with female sex (OR = 1.6671; CI = 1.4218, 1.9547), single compared with married status (OR = 1.3755; CI = 1.1782, 1.6058), type-I diabetes compared with no diabetes (OR = 2.7452; CI = 1.5862, 4.7510), or an ASA class of III or IV compared with class I or II (OR = 1.8925; CI = 1.6264, 2.2022) all increased the odds of readmission (Table III). Previous smoking compared with never smoking (OR = 1.4131; CI = 1.2192, 1.6379), a history of DVT/PE (OR = 1.3740; CI = 1.0693, 1.7655), preoperative narcotic use (OR = 1.2428; CI = 1.0619, 1.4545), or preoperative use of an assistive device (OR = 1.5388; CI = 1.3259, 1.7858) all increased the odds of 90-day readmission as well. Patients ≥80 years old had increased odds of readmission when compared with all other age groups (OR = 1.8898; CI = 1.4639, 2.4395), whereas patients who were ≥50 and <65 years old had significantly decreased odds of readmission when compared with all other age groups (OR = 0.5876; CI = 0.4793, 0.7203). Individuals with a higher preoperative Hb level (OR = 0.9046; CI = 0.8562, 0.9556) or a positive social history for alcohol (OR = 0.8253; CI = 0.7169, 0.9500) had decreased odds of 90-day readmission (Table III). BMI, operative time, surgeon caseload, hospital caseload, current smoking, laterality of surgery, type of primary payer, type-II diabetes, preoperative anticoagulation use, history of a bleeding disorder, use of tranexamic acid, anesthesia type, blood transfusion, and discharge to an extended care facility had no effect on the risk of readmission.

Discussion

We performed a retrospective analysis of the MARCQI database. The primary objective was to compare 1-midnight and 2-midnight LOS for TKA with regard to the odds of 90-day readmission. Secondarily, we analyzed patient characteristics, medical comorbidities, surgical and nonsurgical complications, substance use, and discharge disposition with regard to 90-day readmission.

Using multiple logistic regression modeling and propensity score matching, we found no difference in the adjusted OR for 90-day readmission between 1-midnight and 2-midnight LOS (p = 0.0794). While the utilization of propensity score matching is not new to the literature[24-29], most investigators evaluating readmission and LOS for joint arthroplasty have utilized multiple logistic regression modeling without it[12,30]. Propensity score matching helps balance the test groups by using covariates that may influence LOS. We also used hierarchical data modeling, which takes into account multilevel data structure (patients, surgeons, hospitals) and thus has unique advantages over traditional techniques[31,32]. Like us, Bini et al.[12], Sutton et al.[30], and Saucedo et al.[33] reported no increased risk of readmission in association with decreasing LOS. Bini et al. and Sutton et al. evaluated 30-day readmission rates whereas Saucedo et al. studied 90-day readmission rates. A 90-day postoperative period is better for capturing surgery-related readmissions, as supported by recent literature[34]. Sibia et al.[13] found results similar to ours, reporting no difference in 90-day readmission rates between 1 and 2-midnight LOS for TKA. However, their study was underpowered, with only 86 patients in their 1-midnight group and 168 in their 2-midnight group.

Our study is the first with an adequate sample size to compare 1-midnight and 2-midnight LOS for primary TKA.

Multiple patient characteristics were found to be independent variables increasing the risk of 90-day readmission. As in other studies, male sex[12,35-37], an age of ≥80 years[12,24,26,33,35,38,39], and ASA class III or IV[12,36] all independently increased the OR for readmission. Novel findings from our analysis include the increased odds associated with single marital status and a history of DVT/PE. While postoperative DVT/PE has been shown to increase mortality and 90-day readmissions, a preoperative history of DVT/PE has not been well studied with regard to readmission after TKA[40]. A single study, which included both hip and knee arthroplasty, demonstrated no difference in readmission risk in those with a history of PE[33]. We believe that we are the first to demonstrate a link between a preoperative history of DVT/PE and increased 90-day readmission odds. Unmarried Medicare beneficiaries have been shown to have increased readmission rates for general medical conditions[41,42]. To our knowledge, we are the first to report an association between single marital status and 90-day readmission after primary TKA. Further study is warranted to determine if having a support person at home, be it a spouse or "co-pilot," decreases the odds of readmission after TKA. In our study, as previously reported in the literature[43,44], preoperative narcotic use was found to increase the readmission risk. We found current smokers and those who had never smoked to have equivalent ORs for 90-day readmission. Contrary to our findings, Sahota et al.[25] found smokers to have an increased readmission risk compared with nonsmokers. However, their study was found to be underpowered. Other studies have also failed to show a causal relationship between smoking and readmission following TKA[38,45]. Jørgensen et al.[45] found an increase in the 30-day readmission rate among smokers but did not observe the same effect with a 90-day time frame.

Jørgensen et al.[45] showed no difference in the risk of readmission with alcohol intake, whereas we found alcohol to have a protective effect, a finding unique to this study. However, we could not discern the amount or type of alcohol that these patients consumed from the database. Thus, additional research is warranted to investigate this relationship. Similar to previous research, our study did not find a correlation between diabetes mellitus and the risk of readmission[33]. However, when diabetics were subdivided by type, type-I diabetics were found to be at an increased risk for readmission, as previously reported by Lovecchio et al.[46]. Bini et al.[12] found diabetes mellitus to be an independent risk factor for readmission, which conflicts with our results. However, Bini et al. did not differentiate between type-I and type-II diabetes mellitus, which may have led to an inaccurate conclusion. Multiple studies have evaluated BMI and its relationship to readmission, with many demonstrating an increased risk of readmission in the morbidly obese[33,36,47,48]. In our analysis, we assessed BMI as continuous data collapsed into 6 subgroups (<20, ≥20 and <25, ≥25 and <30, ≥30 and <35, ≥35 and <40, and ≥40 kg/m^2), and all of the pairwise multiple comparisons were found to be nonsignificant at $\alpha = 0.05$. Other reports are in agreement with our BMI finding[12,49,50]. Multiple studies have linked discharge to an extended care facility with increased readmission rates[12,51-53]. However, we did not find a significant association with discharge status in our study, although there was a trend toward significance. This may be due to selection bias, as patients discharged to an extended care facility commonly stay in the hospital for 3 midnights and were excluded from our study.

As with all retrospective reviews, this study has limitations. The accuracy of registry data is limited to the accuracy with which it is recorded. Although MARCQI has safeguards to ensure accuracy and completeness, there is still potential for inaccuracy. As is the case with all registry studies, there is the possibility of uncontrolled confounders (such as surgical technique or management protocols). Although we analyzed the data with regard to individual surgeon, surgeon volume, and hospital volume, these other aspects of care were outside the scope of our analysis. Also, the cohort made up just 49% of all TKAs performed during the study period. This indicates that more than half of patients undergoing TKA stay in the hospital for >2 midnights, and analysis of such patients was not part of this study. However, for completeness, we have included the characteristics of these patients in the Appendix for comparison with the study groups. Caution must be taken when generalizing our findings to all patients undergoing TKA. Selection bias is also possible as the patients with a 1-midnight LOS could have been "preselected" for success. Additionally, observational studies have substantial limitations with respect to causal inference. While propensity score matching mitigates confounding variables, it is still important to note that this study showed association rather than causation. Although a randomized prospective study would be ideal, it would have been extremely difficult to enroll the numbers of participants captured in this study. Lastly, these data were collected from 1 geographical region and may not represent the entire U.S.

We believe that this study has multiple strengths. We believe that our analysis is the only study with an appropriate sample size to compare 90-day readmission rates between a 1-midnight and 2-midnight LOS. Additionally, each hospital in the consortium has dedicated trained data abstractors, with annual data audits performed by MARCQI nurse auditors, to ensure high-quality data. This is an advantage over the sole utilization of billing/coding data, which often have inaccuracies[54]. Another strength of this study is that MARCQI mitigates the risk of missing readmissions by linking cases to the Michigan Inpatient Database, thereby capturing readmissions to any Michigan hospital even if it is not where the index operation was performed. Single-institution studies do not have this feature. Lastly, the data set includes all payers, encompassing all socioeconomic classes, and likely is representative of the true population.

Our analysis of 46,709 primary TKAs showed no difference in 90-day readmission risks between patients with a 1-midnight LOS and those with a 2-midnight LOS. Male sex, single marital status, an age of ≥80 years, type-I diabetes, previous smoking, narcotic use prior to surgery, and an ASA class of III or IV increased the odds of 90-day readmission. In contrast, an age of ≥50 and <65 years, a higher preoperative Hb level, and alcohol use were found to decrease the odds of readmission. Our novel findings of the influence of single marital status, previous smoking, a history of DVT/PE, alcohol use, and an age of 50 to 65 years add to the current literature. Additional study is needed to address the generalizability of these results, and investigators may also consider evaluating functional and/or patient-reported outcomes in the setting of decreasing LOS.

Appendix

eA Tables showing additional descriptive statistics for the included and excluded patients as well as the model-1 and 2 results are available with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/E913). ■

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