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What is Associated with the Greatest Effect on Lengths of Stay after Total Knee Arthroplasty: The Hospital, the Surgeon, or the Patient

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Abstract

Introduction: Patient-, hospital-, and surgeon-related factors are each associated with the variable nature of length of stay (LOS) after total knee arthroplasty (TKA). However, there is a paucity of literature regarding these intertwined relationships. This study aimed to determine if the hospital, the surgeon, or the patient has the greatest association with LOS after TKA.

Materials and Methods: A total of 11,402 patients were identified from a multicenter prospectively collected institutional database between January 01, 2017, and April 01, 2019. Surgeons and hospitals were subdivided into three groups: (1) low volume (<10 and <100 cases, respectively), (2) intermediate volume (10–150 and 100–400 cases, respectively), and (3) high volume (>150 and >400 cases, respectively). Patient demographics, comorbidities, hospital academic status, and LOS were identified. Univariate and multivariate analyses were performed to compare hospital-, surgeon-, and patient-related factors.

Results: Neither hospital ($P = 0.173$) volume nor surgeon ($P = 0.413$) volume were significantly associated with LOS in multivariate analyses while controlling for patient-, surgeon-, and hospital-related factors. Patient medical factors including diabetes ($P < 0.001$), congestive heart failure ($P < 0.001$), peripheral vascular disease ($P < 0.001$), chronic kidney disease ($P < 0.001$), chronic obstructive pulmonary disease ($P < 0.001$), and anemia ($P < 0.033$), as well as academic teaching hospitals ($P < 0.001$) were associated with a significant increase in hospital LOS.

Conclusion: Patient's chronic medical conditions and hospital status as an academic teaching hospital were found to be the most important associated risk factors on post-operative hospital LOS after TKA. This study directs the focus onto pre-operative optimization and patient selection and helps demonstrate where to best allocate resources to successfully decrease LOS.

Keywords: Lengths of stay, total knee arthroplasty, pre-operative optimization, complications, high volume surgeon.

Introduction

Hospital lengths of stay (LOS) following total knee arthroplasty (TKA) are well known to be a major driver of costs in the perioperative period [1]. In recent years, there has been a major focus on pre-operative medical optimization, patient selection, and changes in intraoperative management to decrease the overall LOS [2]. Burn et al. identified 10,260 primary TKA patients through the National Health Service inpatient dataset and found that their average LOS decreased 66% from 16 days to 5.4 days from 1997 to 2014 [2]. Furthermore, the changes in 2018 from the U.S. Centers for Medicare and Medicaid Services removing TKA from the inpatient-only list made it even more important to determine the major variables influencing hospital LOS.

Patient-related factors (i.e., comorbidities, age, body mass index), hospital factors (i.e., volume or academic status), and surgeon annual operative volume are all associated with TKA patient hospital discharges and dispositions. Kreder et al. investigated 14,352 TKA patients and found longer LOS for patients with more medical comorbidities and increased age. More specifically, surgeons who performed <40th percentile volume (<14 TKAs/year) had an average LOS 1.4 days longer than that of surgeons in the >80th percentile (>42 TKAs/year) [3]. Another study comparing patient factors

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to provider characteristics in relation to hospital LOS included 322,894 primary TKA patients and again found that higher comorbidity level and low surgeon volume were associated with longer LOS. They concluded that a low surgeon volume in particular had the greatest association with LOS [4]. Hospital volumes have also been shown to potentially play a role. Yasunaga et al. found shorter LOS in hospitals with higher volumes, as well as hospitals that had a designated post-operative clinical pathway for total joint replacement patients [5].

LOS after TKA are a key driver in cost, which has been shown to continue to decrease in modern-day clinical pathways. This is why it is of the utmost importance to further examine and define the rate-limiting factors in post-operative hospital LOS, especially as pressure rises from hospital administrations, and as changes in CMS reimbursement reflect the movement to outpatient same-day total joint arthroplasty procedures. Therefore, our study aimed to compare: (1) patient characteristics, (2) hospital factors, and (3) surgeon volume to determine which has the greatest association with LOS after TKA. We hypothesized that patients with more comorbidities, lower volume academic hospitals, and low surgeon volume would be associated with a greater LOS after TKA.

Materials and Methods

Study population

This investigation was approved by the institutional review board. Patients undergoing primary TKA were evaluated using a prospectively collected institutional database within our health system comprising 15 hospitals. TKA patients were identified using ICD-10 diagnosis codes.

We identified 11,402 primary TKA patients between January 01, 2017, and April 01, 2019. Performing surgeons and hospitals were recorded. Each patient's chronic medical conditions were documented and included: diabetes, smoking, congestive heart failure (CHF), peripheral vascular disease (PVD), chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD), and anemia. The year of surgery and smoking status were also documented and recorded. Patient demographics, hospital academic statuses, and LOS were identified. Data regarding body mass index (BMI) were unavailable.

Surgeons and hospitals were subdivided into three groups. The volume per group was determined based on those reported in the existing literature. Low-volume surgeons performed <10 TKAs/year, and low-volume hospitals performed <100 TKAs/year. Intermediate-volume surgeons performed 10–150 TKAs/year, and intermediate-volume hospitals performed 100–400 TKAs/year. High-volume surgeons performed >150 TKAs/year, and high-volume hospitals performed >400 TKAs/year. Furthermore, hospital status (academic vs. community) was identified, defining academic hospitals as those with an orthopedic residency or fellowship based in the hospital.

Of the 11,402 primary TKA in this study, 165 were performed at a low-volume hospital (1.4%), 4452 at an intermediate-volume hospital (39%), and 6785 at a high-volume hospital (59.5%). A total of 365 patients had their TKA performed by low-volume surgeons (3%), 7226 cases were performed by intermediate-volume surgeons (63%), and 3811 by high-volume surgeons (33%). None of the hospitals in this study were ambulatory surgery centers.

Data analyses

Univariate analyses with independent Student's t-tests and one-way analysis of variance (continuous variables) were performed to compare the differences in mean LOS between different hospital volumes and that between different surgeon volumes. Multivariate analyses with multiple linear regression models were performed to calculate standardized coefficients (β), and 95% confidence intervals were used to compare hospital-, surgeon-, and patient-related factors while controlling for confounding variables. Significance was determined if a $P < 0.05$. All statistical analyses were performed using SPSS, version 22.0 for Windows (International Business Machines, Armonk, New York).

Results

Univariate analyses comparing LOS between hospitals of different volumes showed a significant difference in the average LOS after TKA ($P < 0.001$) (Table 1). The shortest LOS was found to be at low-volume hospitals (n = 165; LOS = 2), followed by high-volume hospitals (n = 6.785; LOS = 2.6), and then intermediate-volume hospitals (n = 4.452; LOS = 2.9) (Table 1). When controlling for potential confounding variables by performing a multivariate analyses, this study found that hospital volume was actually not significantly associated with LOS (P = 0.173) (Table 2). Although hospital volume was not

Table 1: Univariate analysis of mean LOS at different volume hospitals

Complication	Mean lengths of stay (days)	*P*-value[a]
Hospital volume		
Low (<100)	2.0±1.4	
n=165		
Intermediate (100–400)	2.9±1.8	**<0.001**
n=4.452		
High (>400)	2.6±1.6	
n=6785		
Surgeon volume		
Low (<10)	3.0±2.2	
n=365		
Medium (10–150)	2.7±1.5	**<0.001**
n=7226		
High (>150)	2.7±1.9	
n=3811		

P-value: [a]=one-way ANOVA: Analysis of variance,

associated with LOS, hospital academic status was found to be associated with an increased LOS (β = 0.155, P < 0.001) (Table 2).

Univariate analysis comparing LOS between surgeons who had different case volumes showed a significant difference in the average LOS after TKA (P < 0.001). The mean LOS for low-volume surgeons was the longest (n = 365; LOS = 3) relative to intermediate (n = 7.226; LOS = 2.7) and high (n = 3.811; LOS = 2.7) volume surgeons (Table 1). After controlling for potential confounding variables, multivariate analyses found that surgeon volume was not associated with patient LOS (P = 0.413) (Table 2).

Several patient-related factors were found to be associated with increased LOS including chronic medical conditions such as diabetes (β = 0.052, P < 0.001), CHF (β = 0.086, P < 0.001), PVD (β = 0.040, P < 0.001), CKD (β = 0.096, P < 0.001), COPD (β = 0.036, P < 0.001), and anemia (β = 0.019, P < 0.033). Furthermore, it was found that smoking history was a patient-related factor that was significantly associated with decreased hospital LOS (β = −0.18, P = 0.046) (Table 2).

Discussion

Attention has been placed on optimizing perioperative care to improve patient outcomes, with the idea being that decreasing hospital LOS will lead to an overall decrease in hospital costs. Hospital factors, surgeon volume, and patient-related characteristics have each been shown to be associated with LOS following TKA [2, 3, 4, 5]. Our study determined that a patient's chronic medical conditions, specifically congestive heart failure, PVD, CKD, COPD, and anemia along with a hospital's academic teaching status were associated with increased LOS. Neither hospital volume nor surgeon volume were found to be associated with LOS in multivariate analyses. Our study supports that patient characteristics and comorbidities are the main associated risk factor in decreasing LOS after TKA.

The results of our study are similar to that found in the literature. Piuzzi et al. found that patient-related risk factors were a significantly associated risk factor for increased LOS in patients who had older age, higher BMI, higher Charlson Comorbidity Index, lower VR-12 MCS, and female sex (P < 0.05) [6]. Furthermore, their univariate data analysis showed that high-volume hospital (average 1007, highest quartile) and surgeon (average 278, highest quartile) were associated with shorter LOS and more expeditious discharge to home. However, when they examined their dataset further in a multivariate analysis, they found that hospital and surgeon high volume were not factors in LOS, but rather just a predictor of the patient successfully following a standardized process-of-care protocol. This protocol included antibiotics on the day of surgery, continued antibiotics 24 h postoperatively, no beta blockers given to high-risk myocardial infarction patients within in first 2 days of surgery, and venous thromboembolism prevention given in the 2 days after surgery. A higher number of missed process of care measures were associated with worse combined outcomes irrespective of hospital and surgeon procedure volume [6]. Bozic et al. found similar results when looking at volume status in 182,146 primary TKA performed by 3,421 physicians at 312 hospitals over a 2-year period. They found that the higher volume practices had a better adherence to evidence-based processes of care which then resulted in improved clinical outcomes and shorter LOS. This finding was, again, independent of hospital or surgeon procedure volume [7]. Combining this information with our data, pre-operative medical optimization goes hand in hand with standardized post-operative protocols in terms of how to best minimize post-operative LOS.

Other studies have found that patient factors are associated with increased LOS after TKA. Prohaska et al. found that increasing BMI and poor physical component scores were significantly associated with increased LOS [8]. Winemaker et al. evaluated 1459 total joint arthroplasty patients and found that cardiovascular comorbidities were associated with increased LOS, while a history of current smoking was associated with decreased hospital stays [9]. This finding along with our study's similar finding regarding smoking status is likely due to the patient's desire to leave the hospital to continue smoking, regardless of their post-operative rehabilitation process.

Table 2: Multivariate analysis: Multiple linear regression model for LOS

Complication	Standardized coefficient (β)	Unstandardized coefficient	95% confidence interval		*P*-value
			Lower	Upper	
High volume hospital*	−0.13	−0.046	−0.111	0.02	0.173
High volume surgeon**	0.008	0.027	−0.038	0.092	0.413
Academic hospital status	0.155	0.541	0.475	0.607	**<0.001**
Year of surgery	−1.08	−0.257	−0.300	−0.214	**<0.001**
Diabetes	0.052	0.214	0.14	0.288	**<0.001**
Smoking	−0.18	−0.070	−0.138	−0.001	**0.046**
CHF	0.086	0.912	0.717	1.107	**<0.001**
PVD	0.04	0.42	0.229	0.612	**<0.001**
CKD	0.096	0.724	0.588	0.859	**<0.001**
COPD	0.036	0.298	0.149	0.447	**<0.001**
Anemia	0.019	0.149	0.012	0.286	**0.033**

*>400 TKAs/year; **>150 TKAs/year. LOS: Length of stay, CHF: Congestive heart failure, PVD: Peripheral vascular disease, CKD: Chronic kidney disease, COPD: Chronic obstructive pulmonary disease

Martino et al. examined hospital academic status and found similar results to our study. They looked at 796 TKA patients who at an orthopedic specialty hospital showed significantly lower costs and shorter LOS than at an academic institution (2.9 ± 1.0 days vs. 3.7 ± 1.7 days; P < 0.001). Furthermore, they also found that patient factors, represented by the American Society of Anesthesiologist scores of 3 and 4 versus a score of 1–2 were associated with the highest costs (P < 0.01) and the longest LOS (P < 0.004) [10].

Previous studies have refuted our findings and have identified the volume of either the surgeon or the hospital to have an association with LOS. Pamilo et al. studied 59,696 TKAs from two large databases in Finland. They found that hospitals who performed <100 TKAs/year had an average LOS nearly double that of their high-volume counterparts who performed more than 450 TKAs/year (8.60 days, 95% CI: 8.53–8.67; 4.51 days, 95% CI: 4.47–4.55) [11]. Although their baseline LOS being compared was 4× that reported in our study. Lavernia and Guzman assessed 19,925 primary total joint arthroplasty patients in a health care administration registry and found that 62% of surgeons had performed <10 primary cases in 1 year. Within this low-volume cohort, they had a significantly larger number of deaths, longer lengths of hospital stays, and increased costs. These data were published in 1995 and may not be as relevant to today's modern TKA perioperative care pathways [12]. Furthermore, Hervey et al. found that surgeons who performed at least 15 total joints per year and hospitals that performed at least 85 total joints per year had lower mortality rates (OR = 0.56 [0.24–1.31] for surgeon volume of > or = 60). Furthermore, as hospital and surgeon volume increased there was a decrease in hospital LOS, although this was not a strictly linear association [13].

Our study showed an average overall LOS of 2.0 days at low-volume hospitals extending to 2.6 at high-volume hospitals. While a statistically significant difference was achieved, we do not feel that the result is clinically significant and thus may be the reason our data differs from that in the previously published literature. Further, when multivariate analysis was performed, no difference was achieved, thus reflecting the fact that all the multiple locations included in the study were utilizing modern-day perioperative protocols which decrease hospital LOS.

The aforementioned perioperative protocols vary between each hospital in our study, but the general principles of the protocols remain the same. Preoperatively, patients are educated regarding expectations of the surgery itself and the early post-operative period. On the day of surgery, patients receive a proton pump inhibitor, a gabapentinoid, and a low-dose opioid medication. Intraoperatively, patients receive a peri-articular regional anesthetic injection, an intravenous steroid, and an intravenous non-steroidal anti-inflammatory medication (NSAID). Postoperatively, patients are fluid resuscitated with a series of 3 boluses and maintenance fluids and are treated with multimodal pain control including a variety of NSAIDs, low-does opioid medications, gabapentinoids, steroids, and proton pump inhibitors. Additionally, physical therapy is initiated on post-operative day 0 to encourage early ambulation, which has been proven to decrease post-operative complications.

Our study is not without its limitations. We performed a retrospective review on a prospectively collected institutional database which has inherent limitations. There is the risk of coding or billing errors and misreporting in the documentation. The data were prospectively collected with blinding; therefore, we were unable to collect additional information once the data was generated. In addition, the existing literature varies in terms of defining a low, intermediate, and high-volume surgeon. To maximize our generalizability to the modern TKA patient, we used the most current definition as reported in the literature [6]. Furthermore, although the data was prospectively collected, this was a retrospective analysis, so we were unable to identify the adherence to hospital standard clinical pathway and post-operative protocols which are typically implemented within our health system for total joint arthroplasty. All hospitals included in this study operate under the same umbrella hospital system, and thus orthopedic department leadership from each hospital meets quarterly to ensure modern-day perioperative protocols are implemented, even if the specific details are not standardized across all hospital centers. This has been shown to be a factor in patient LOS and would be a focus in a future prospective designed study investigating changes in pre-operative optimizations and post-operative protocols. In addition, our finding regarding a smoking history being associated with a decrease LOS can be anecdotally explained by the fact that those who smoke are more likely to leave the hospital more expeditiously to return to their smoking habits. However, there is no evidence to support this claim.

Conclusion

Our study compared the relationship between patient characteristics, hospital volume, and academic status, as well as surgeon volume and found that a patient's chronic medical condition and a hospital's academic teaching status had the greatest association on hospital LOS after TKA. Both surgeon and hospital volume did not have an association after controlling for various patient-related factors. Resources should be directed toward those patients presenting with unmodifiable and modifiable risk factors such as BMI, age, smoking, diabetes, kidney disease, anemia, heart failure,

PVD, and COPD to mitigate the potential increased needs of this population. That way, we will be able to decrease their potential increase in LOS requirements had they not been pre-operatively screened and appropriately optimized. This information is important to direct future research to focus on how specific patient pre-operative optimization interventions can decrease LOS after total knee replacement surgery.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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