Rapid Recovery Is Feasible for Aseptic Revision Total Knee Arthroplasty at an Academic Medical Center

Josef Pontasch, BA a, Mario Sahlani, BA a, Sumon Nandi, MD, MBA b, *

a The University of Toledo College of Medicine and Life Sciences, Toledo, OH, USA
b Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, MD, USA

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ABSTRACT

Background: We reviewed the results of a primary total knee arthroplasty (TKA) rapid recovery care pathway applied to patients undergoing aseptic revision TKA. We sought to determine (1) the frequency of postoperative day (POD) 1 discharge, (2) the risk of adverse events, and (3) patient characteristics or surgical factors associated with failure to discharge on POD 1.

Methods: The source population was revision TKAs performed by a single surgeon at an academic medical center from 2016 to 2019 (n = 94). A primary TKA rapid recovery care pathway was applied to all patients who underwent aseptic revision TKA involving both femoral and tibial components (n = 33). Patients discharged on POD 1 (n = 21) were compared with those discharged on POD 2 or later (n = 12).

Results: The study cohort was 70% women, 12% under-represented minorities, and 70% government insured. Patients each had an average of 5 comorbidities. The average length of stay was 1.7 days, with 64% of patients discharged on POD 1. Ninety-seven percent of patients were discharged home. Although 18% of patients presented to the emergency room (ER) after discharge, there was no increased risk of readmission (P = .9336) or return to the ER (P = .9849) with POD 1 discharge. The LOS was unaffected by patient characteristics or complexity of surgical reconstruction.

Conclusions: Using a rapid recovery care pathway for aseptic revision TKA is feasible at an academic medical center. All patients may be considered for this pathway. Close postoperative monitoring is essential to minimizing ER visits, which are not uncommon.

Introduction

The frequency of revision total knee arthroplasty (TKA) is increasing at a rate even faster than that of primary TKA [1]. Revision TKA has higher associated morbidity and uses more expensive implants than primary TKA [2,3]. As a result, efforts to decrease the cost of revision TKA to both patients and the health-care system are imperative.

Enhanced recovery after surgery, or rapid recovery, is a practice consisting of multimodal interventions designed to improve the quality and speed of recovery while decreasing costs associated with prolonged hospital length of stay (LOS) [4,5]. Preoperatively, rapid recovery is comprised of robust patient education, nonopiate preemptive analgesia, and efforts to prevent postoperative nausea and vomiting. Intraoperatively, regional anesthesia and local anesthesia are used, as are blood conservation measures. Postoperatively, patients are mobilized immediately as they begin their rehabilitation.

Rapid recovery care pathways safety decrease LOS and allow home discharge after primary TKA [6,7]. Shorter LOS decreases the risk of venous thromboembolism [8]. Home discharge minimizes the risk of adverse events and readmission associated with rehabilitation facility discharge [9]. Thus, rapid recovery increases quality of care while decreasing episode of care cost. Revision TKA is a surgery more extensive and of longer duration than that of primary TKA. It is unknown if rapid recovery care pathways may be effectively applied to revision TKA to decrease morbidity and cost, although we hypothesize rapid recovery revision TKA is feasible.

To this end, we reviewed the results of a primary TKA rapid recovery care pathway applied to patients undergoing aseptic revision TKA. The aim of this study was to determine (1) the frequency of successful postoperative day (POD) 1 discharge, (2) the risk of adverse events, if any, and (3) patient characteristics or surgical factors associated with failure to discharge on POD 1.
Material and methods

Study design

A retrospective cohort study design approved by our institutional review board was used in this study. Our source population was all revision TKAs performed by a single adult reconstruction fellowship-trained surgeon at an academic orthopaedic tertiary referral center from 2016 to 2019 (n = 94). Inclusion criterion was aseptic revision TKA involving both femoral and tibial components. Exclusion criteria were two-stage revision TKA (explant or reimplantation), TKA irrigation and debridement with polyethylene liner exchange, other single-component revision TKA, or less than 90-day follow-up. This yielded a study cohort of 33 revision TKAs. All surgeries were performed using a single-design, varus and valgus constrained prosthesis (Triathlon Total Stabilizer, Stryker, Mahwah, NJ) with stemmed femoral and tibial components. Augments and metaphyseal cones were implanted as needed.

A rapid recovery care pathway used for primary TKA was applied to all patients who underwent revision TKA in the study cohort. A total joint replacement nurse coordinator performed one-on-one preoperative patient education and provided corresponding written material. The focus of these encounters was postoperative rehabilitation, wound care, as well as assessment and optimization of patients’ home environment including social support. Both the surgeon and nurse coordinator advised patients preoperatively they would ambulate the same day of surgery and be discharged home the following day by 11 am. Surgery was scheduled on a date that allowed friends or family to stay at home with the patient for 1 week afterward. Prescriptions for durable

Table 1
Univariate analysis of baseline patient characteristics between patients who underwent revision TKA discharged on POD 1 or later.

| Variable                              | POD 1 discharge (N = 21) | POD 2 or later discharge (N = 12) | P-value |
|---------------------------------------|--------------------------|-----------------------------------|---------|
| Age (mean, SD)                        | 64.9 (8.7)               | 68.3 (12.9)                       | .6153   |
| BMI (kg/m²) (mean, SD)                | 35.2 (5.4)               | 33.7 (8.3)                        | .6430   |
| Number of comorbidities (mean, SD)    | 5 (1.9)                  | 5 (2.7)                           | .8503   |
| Gender                                |                          |                                   | .7098   |
| Female                                | 14 (66.7%)               | 9 (75%)                           |         |
| Male                                  | 7 (33.3%)                | 3 (25%)                           |         |
| Insurance type                        |                          |                                   | .1022   |
| Medicare                              | 9 (42.9%)                | 8 (66.7%)                         |         |
| Medicaid                              | 9 (42.9%)                | 3 (25%)                           |         |
| Private                               | 3 (14.3%)                | 1 (8.3%)                          |         |
| Preoperative KOOS, Jr. score           |                          |                                   | .6382   |
| Missing                               | 8 (38.1%)                | 4 (33.3%)                         |         |
| 2                                     | 0 (0%)                   | 1 (8.3%)                          |         |
| 7                                     | 0 (0%)                   | 1 (8.3%)                          |         |
| 9                                     | 1 (4.8%)                 | 0 (0%)                            |         |
| 10                                    | 1 (4.8%)                 | 0 (0%)                            |         |
| 14                                    | 1 (4.8%)                 | 0 (0%)                            |         |
| 15                                    | 2 (9.5%)                 | 0 (0%)                            |         |
| 18                                    | 2 (9.5%)                 | 2 (16.7%)                         |         |
| 19                                    | 1 (4.8%)                 | 1 (8.3%)                          |         |
| 20                                    | 1 (4.8%)                 | 1 (8.3%)                          |         |
| 21                                    | 1 (4.8%)                 | 0 (0%)                            |         |
| 22                                    | 0 (0%)                   | 1 (8.3%)                          |         |
| 25                                    | 2 (9.5%)                 | 0 (0%)                            |         |
| 26                                    | 1 (4.8%)                 | 1 (8.3%)                          |         |
| Atrial fibrillation                   | 0 (0%)                   | 2 (16.7%)                         | .125    |
| Anxiety                               | 4 (19%)                  | 4 (33.3%)                         | .4196   |
| Cardiac arrhythmia                    | 1 (4.8%)                 | 1 (8.3%)                          |         |
| Asthma                                | 4 (19%)                  | 2 (16.7%)                         |         |
| Bipolar disorder                      | 2 (9.5%)                 | 0 (0%)                            | .5227   |
| Cancer                                | 2 (9.5%)                 | 3 (25%)                           | .3275   |
| Coronary artery disease               | 1 (4.8%)                 | 0 (0%)                            | 1       |
| COPD                                  | 6 (28.6%)                | 2 (16.7%)                         | .6776   |
| Dementia                              | 1 (4.8%)                 | 0 (0%)                            | 1       |
| Depression                            | 12 (57.1%)               | 8 (66.7%)                         | .7188   |
| Diabetes                              | 6 (28.6%)                | 3 (25%)                           | 1       |
| History of DVT                        | 1 (4.8%)                 | 2 (16.7%)                         | .5381   |
| GERD                                  | 9 (42.9%)                | 4 (33.3%)                         | .7188   |
| Hypercholesterolemia                  | 12 (57.1%)               | 7 (58.3%)                         | 1       |
| Heart failure                         | 1 (4.8%)                 | 2 (16.7%)                         | .5381   |
| Hypertension                          | 1 (4.8%)                 | 0 (0%)                            | 1       |
| Number of femoral augments            |                          |                                   | .2868   |
| 0                                     | 5 (23.8%)                | 3 (25%)                           |         |
| 1                                     | 2 (9.5%)                 | 1 (8.3%)                          |         |
| 2                                     | 4 (19%)                  | 5 (41.7%)                         |         |
| 3                                     | 4 (19%)                  | 3 (25%)                           |         |
| 4                                     | 6 (28.6%)                | 0 (0%)                            |         |
| Number of tibial augments             |                          |                                   | .6741   |
| 0                                     | 16 (76.2%)               | 10 (83.3%)                        |         |
| 1                                     | 1 (4.8%)                 | 1 (8.3%)                          |         |
| 2                                     | 4 (19%)                  | 1 (8.3%)                          |         |
| Use of tibial cone                    | 5 (23.8%)                | 1 (8.3%)                          | .3729   |

BMI, body mass index; COPD, chronic obstructive pulmonary disease; DVT, deep venous thrombosis; GERD, gastroesophageal reflux disease; SD, standard deviation. 

*P* < .05 considered significant.
medical equipment, including rolling walker, shower chair, and raised toilet seat, were given to patients before surgery. Multimodal pain management consisted of preoperative oral administration of 400 mg of celecoxib, 300 mg of gabapentin, and 1000 mg of aceta-
minophen; intraoperatively, 60 cc of 0.25% bupivacaine with epinephrine was injected into the periarticular tissues; post-
operatively, hydrocodone and acetaminophen 5 mg/325 mg, 1 to 2 tablets orally every 4 hours as needed was prescribed. Patients received an adductor canal nerve block in the preoperative holding area, 10 mg of intravenous (IV) dexamethasone and 1 g of IV tran-
examic acid during induction of general anesthesia, followed by another 1 g of IV tranexamic acid during wound closure. Foley catheter was removed in the operating room before transfer to the postanesthesia care unit. Day-of-surgery postoperative ambulation was performed with the assistance of physical therapy, nursing, or the surgical team. Hospital discharge occurred only if patients were medically stable and cleared by physical and occupational therapy.
Patients successfully discharged on POD 1 (n = 21) were compared with those discharged on POD 2 or later (n = 12).
Patient demographics, comorbidities, preoperative Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS, Jr.), implants, LOS, discharge disposition, readmission or reopa-
eration for any reason, and emergency room (ER) visits were recorded on a standard data collection form after systematic chart review. The LOS was determined by the POD of discharge and hours of hospitalization from post–anesthesia care unit admission to discharge.

Statistical analysis

Baseline demographic and clinical characteristics were compared between patients discharged on POD 1 and those discharged on POD 2 or later. Fisher’s exact test was used to compare categorical variables, and the Wilcoxon test was used to compare continuous variables. The primary outcome of this study was POD 1 discharge. Secondary outcomes included discharge location, complications, and 90-day readmission or ER visit. We used stepwise logistic regression to identify the proper predictors of POD 1 discharge and secondary outcomes. Potential predictors, including age, gender, body mass index, smoking status, comor-
biddies, insurance type, preoperative KOOS, Jr. score, the number of femoral augment, the number of tibial augment, and the use of tibial cone had to achieve a significance level of \( P = .1 \) to enter the model and remain in the final model. The power to detect a 50% absolute difference in the percent of patients requiring ER visits and readmissions between those discharged on POD 1 or later was 0.83.

Results

Univariate analysis of baseline demographics for patients suc-
cessfully discharged on POD 1 vs those discharged on POD 2 or later is given in Table 1. Seventy percent of our study patients were women, 12% were under-represented minorities, and 70% had government insurance. Each patient had an average of 5 comorbidities.

Table 2 shows unadjusted outcome comparisons between groups. The average LOS for all patients was 1.7 days. Sixty-four percent of patients were discharged on POD 1, 24% of patients were discharged on POD 2, and 12% of patients were discharged on POD 3 or later. The mean duration of admission was 22 hours for patients discharged on POD 1 and 43 hours for patients discharged on POD 2. Only 1 (3.0%) patient required discharge to a skilled nursing facility, whereas all others were discharged home.

Although 18% of all patients presented to the ER after discharge, multivariate analysis demonstrated no increased risk of read-
mission (\( P = .9336 \)) or return to the ER (\( P = .9849 \)) with POD 1 discharge (Table 3). Neither insurance status nor the use of aug-
ments or cones was associated with readmissions or ER visits. Reasons for return to the hospital within 90 days of revision TKA are outlined in Table 4.

No patient characteristics, including age, gender, body mass index, insurance status, comorbidities, or preoperative KOOS, Jr., were predictive of the LOS based on multivariate analysis. The LOS was unaffected by the use of augments (\( P = .5292 \)) or cones (\( P = .7195 \)) (Table 5).
Multivariate analysis of likelihood of POD 1 discharge after TKA revision.

| Variable | Odds ratio point estimate | 95% Wald confidence limits | P-value |
|----------|--------------------------|---------------------------|---------|
| Age      | 0.994                    | 0.909 - 1.088             | .893    |
| Insurance (Medicaid vs. Medicare) | 0.248 | 0.022 - 2.836 | .4962 |
| Insurance (private vs. Medicare) | 0.253 | 0.027 - 2.354 | .4754 |
| Number of femoral and tibial augment  | 1.170 | 0.718 - 1.907 | .5292 |
| Use of tibial cone | 1.494 | 0.167 - 13.386 | .7195 |

P < .05 considered significant.

Discussion

Aseptic revision TKA requires techniques to restore ligament balance and bone lost. More costly stemmed implants, with or without augments, metaphyseal cones, and increased levels of constraint, are also needed [3]. These measures, together with extensive soft-tissue exposure and dissection, increase the operative time of revision TKA compared with primary TKA. Our aim was to determine if revision TKA is amenable to a rapid recovery care pathway shown to effectively decrease the LOS, morbidity, and cost of primary TKA [6-8].

Application of a rapid recovery care pathway nonselectively to patients who underwent aseptic revision TKA resulted in an average LOS of 1.7 days, with 97% of patients being discharged home. On average, patients discharged on POD 1 were admitted for 22 hours, whereas patients discharged on POD 2 were admitted for 43 hours. This suggests POD 1 discharge may be possible regardless of the case start time, and POD 2 discharge may occur as a result of factors unrelated to the case start time. POD 1 discharge did not increase the likelihood of readmission or return to the ER after revision TKA in our study, or after primary TKA in multiple prior reports [7,10].

We did not find that patient characteristics or complexity of surgical reconstruction was predictive of the LOS after revision TKA. Bovonratwet et al found advanced age was a risk factor for increased LOS and readmission after primary TKA, although we did not find this to be the case in our patient cohort [11]. Per recent report, utilization of standardized care pathways better predicts primary TKA LOS than patient characteristics [12]. Primary TKA LOS is likely unaffected by complexity of surgical reconstruction. Sodhi et al. observed no increased LOS when primary TKA was performed with a hinged prosthesis compared with when it was performed with a less-constrained implant [13]. As a result, all patients should be considered as potential candidates for rapid recovery after aseptic revision TKA.

Although this study may provide guidance in the management of patients who underwent revision TKA, we understand our work has limitations. First, our study is retrospective, so the quality of our conclusions is limited by the accuracy of available data. Second, our sample size may have resulted in type II error. However, the same factors that reduced our sample size, restrictive inclusion criteria and single-surgeon experience, also reduced data heterogeneity and confounding factors such as variable surgical technique. Third, our findings at an academic medical center may not be generalizable to other practice populations.

Conclusions

A rapid recovery care pathway used for aseptic revision TKA involving both femoral and tibial components allowed home discharge on POD 1 for the majority of patients. POD 1 discharge did not increase the likelihood of readmission or return to the ER. In applying the rapid recovery care pathway nonselectively to patients who underwent aseptic revision TKA at an academic medical center, we found neither patient characteristics nor complexity of surgical reconstruction affected LOS.

Conflict of interests

S. Nandi is a member of the editorial or governing board of the Journal of Arthroplasty and is a board or committee member of the AAHKS and AAOS, and M. Sahiani and J. Pontasch declare no potential conflicts of interest.

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