The Journal of Arthroplasty 39 (2024) 1298–1303

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Revision Arthroplasty

Early Discharge for Revision Total Knee and Hip Arthroplasty: Predictors of Success

Mohamed F. Albana, DO [a,*], Michael F. Yayac, MD, MBA [a], Kelly Sun, BS [b], Zachary D. Post, MD [c], Danielle Y. Ponzio, MD [c], Alvin C. Ong, MD [c]

[a] Department of Orthopaedic Surgery, Inspira Health, Vineland, New Jersey
[b] Sidney Kimmel Medical School, Philadelphia, Pennsylvania
[c] Rothman Orthopaedic Institute, Egg Harbor Township, New Jersey

ARTICLE INFO

Article history:
Received 17 June 2023
Received in revised form
7 November 2023
Accepted 7 November 2023
Available online 14 November 2023

Keywords:
length of stay
revision total knee arthroplasty
revision total hip arthroplasty
bundled payment
surgical time

ABSTRACT

Background: The rate of revision total joint arthroplasties is expected to increase drastically in the near future. Given the recent pandemic, there has been a general push toward early discharge. This study aimed to assess for predictors of early postoperative discharge after revision total knee arthroplasty (rTKA) and revision total hip arthroplasty (rTHA).

Methods: There were 77 rTKA and 129 rTHA collected between January 1, 2019 and December 31, 2021. Demographic data, comorbidities, a comorbidity index, the modified frailty index (mFI-5), and surgical history were collected. The Common Procedural Terminology codes for each case were assessed. Patients were grouped into 2 cohorts, early discharge (length of stay [LOS] <24 hours) and late discharge (LOS >24 hours).

Results: In the rTHA cohort, age >65 years, a history of cardiac or liver disease, an mFI-5 of >1, a comorbidity index of >2.7, a surgical time >122 minutes, and the need for a transfusion were predictors of prolonged LOS. Only the presence of a surgical time of >63 minutes or an mFI-5 >1 increased patient LOS in the rTKA cohort. In both rTHA and rTKA patients, periprosthetic joint infection resulted in a late discharge for all patients, mean 4.8 and 7.1 days, respectively. Dual component revision was performed in 70.5% of rTHA. Only 27.6% of rTKA were 2-component revisions or placements of an antibiotic spacer.

Conclusions: Several patient and surgical factors preclude early discharge candidacy. For rTHA, an mFI-5 of >2/5, comorbidity index of >4, or a surgical time of >122 minutes is predictive of prolonged LOS. For rTKA, an mFI-5 of >2/5, Charlson Comorbidity Index of >5, or a surgical time of >63 minutes predicts prolonged LOS.

Total joint arthroplasty (TJA) is a cost-effective treatment in the management of degenerative joint disease [1,2]. Given the increasingly aging population in the United States, the volume of primary total knee arthroplasty (TKA) is expected to exponentially increase to nearly 3.48 million and the volume of total hip arthroplasty (THA) is expected to reach between 542,000 and 635,000 per annum by the year 2030 [3,4]. With increasing rates of primary procedures, revision THA (rTHA) and revision TKA (rTKA) procedures are expected to increase by 137% and 601% per year, respectively, by 2030 [3].

Length of stay (LOS) has been an area of focus for decreasing TJA costs for the hospital and provider with several studies aiming to identify risk factors for increased lengths of stay or interventions to reduce lengths of stay [5–7]. A recent study showed discharge at 1 to 2 days postoperatively leads to nearly $2,000 in savings per patient for knee osteoarthritis as compared to those staying 3 to 4 days [8]. In addition to cost savings, studies have shown equivalent or higher patient satisfaction scores and decreased complications with shorter hospital stays [8,9]. For these short-stay or early discharge protocols, patient selection has been a focus particularly

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2023.11.008.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

* Address correspondence to: Mohamed F. Albana, DO, 152 Meridian Lane, Sewell, NJ 08080.

https://doi.org/10.1016/j.arth.2023.11.008

in younger patients who have fewer comorbidities dominating these studies as compared to patients who require longer hospital stays [8–11]. The standards for same-day discharge after TJA are even more stringent with some recommending patients aged more than 70 years or those who have an American Society of Anesthesiologists score more than 2 be admitted postoperatively [12–14].

Over the past decade, there has been interest in assessing patient LOS after revision TJA [15–17]. Given the recent COVID-19 pandemic, physicians have advocated for reduced postoperative lengths of stay even more [18]. While a wide range of lengths of stay have been described for rTKA, ranging from 22 hours to 9.3 days, the majority of the literature only addresses aseptic loosening as the surgical indication [19–22]. To our knowledge, there has been only one study in the literature assessing the impact of prosthetic joint infection and one study assessing patient coagulation studies on patient LOS [23,24]. As for rTHA, there are far fewer studies with lengths of stay ranging from 2.1 to 5.4 days [25,26]. With such a gap in the literature, the purpose of this study looked to identify patient factors associated with discharge within 24 hours (same day or postoperative day 1) versus longer hospital stays (postoperative day 2 discharge or later) in revision TJA cases.

Methods

This was a retrospective cohort study that was deemed exempt from Institutional Review Board review after initial protocol review. All patients who underwent an rTKA or rTHA between January 1, 2019 and December 31, 2021 were considered for inclusion. This yielded a total of 205 revision TJAs: 76 patients in the rTKA group and 129 in the rTHA group. Exclusion criteria included patients undergoing nonelective revision arthroplasty procedures, which included 20 patients who sustained periprosthetic fractures indicating them for an rTHA. These 20 patients all stayed more than 24 hours and were excluded from final statistical analyses, yielding 109 rTHA patients. Each cohort was analyzed in 2 ways. Early discharge was defined as LOS less than 24 hours. First, rTKA patients were assessed for late discharge (N = 52) versus early discharge (N = 24). The full cohort was then re-examined based on the year the revision took place with 2019 being considered pre-pandemic (N = 44), as the facility where these procedures took place did not have major restrictions due to the COVID-19 pandemic, and 2020 to 2021 was considered during pandemic (N = 32). The same analyses were performed for the rTHA cohort. The first analysis compared the late discharge (N = 64) and early discharge (N = 45) patients. The second was by year with 52 rTHA taking place in 2019 and the remaining 57 between 2020 and 2021.

Patient demographic data and comorbidities (Table 1) as well as the Charlson Comorbidity Index (CCI) and the modified frailty index (mFI-5) were obtained [27,28]. In addition, pertinent surgical history was recorded, including use of tranexamic acid, intraoperative blood loss, and operative time.

Data Analyses

Prior to running analyses, rTHA and rTKA were separated out and each joint arthroplasty underwent the same analyses. Data were divided descriptively first to understand the distribution of each cohort. Continuous data were presented as means (standard deviations) and categorical data were presented as cell counts and percentages. To assess normality of the continuous data, Shapiro-Wilks tests were run. *T*-tests or Mann-Whitney U tests were run to calculate *P* values for continuous data. *Chi*-square or Fisher's exact tests were used to calculate *P* values for categorical data. Following the descriptive breakdown, a set of receiver operating characteristic curves were run on specific variables and areas under the curve (AUC) calculated to see if an optimal cutoff value could be determined that led to a potential increase in staying longer in the hospital. A set of logistic regressions were then run using the determined cutoff values to see how they would each perform and relate to the dependent outcome: late discharge, defined as hospitalization of more than 24 hours. Independent variables with counts of zero in the late discharge group were not included in the logistic regression analyses. Results were considered significant at *P* value < .05. All statistical analyses were conducted using R Studio (Version 4.1.2, Vienna, Austria).

Table 1
Comorbidities Assessed.

Diabetes Mellitus (DM)
Congestive heart failure (CHF)
COPD/PNA
Hypertension (HTN) on medications
Functional Dependence
Smoker
Alcohol
Frailty Index
Angina or coronary artery disease (CAD)
Myocardial infarction (MI)
Liver Disease
Kidney Disease
Asthma
Obstructive sleep apnea (OSA)
Venous thromboembolism (VTE)
History of Cancer
Peripheral vascular disease (PVD)
Cerebrovascular accident (CVA)
Dementia

Modified frailty index consists of a ratio of the following 5 categories: DM, HTN, CHF, COPD, and functional dependence [28].
COPD, chronic obstructive pulmonary disease; PNA, pneumonia.

Results

For the rTHA cohort, there were no patients in the early discharge cohort with a diagnosis of liver disease or congestive heart failure and descriptive statistics are reported in Table 2. Early discharge (<24 hours) was consistent with a lower mFI-5 ($P = .016$), a lower CCI ($P < .001$), and a shorter surgical time ($P = .023$). For the rTHA cohort, 91 patients had both components revised (Common Procedural Terminology [CPT] 27,134). There were also 19 patients who underwent revision of the acetabular component only (CPT 27137) and 19 patients who underwent revision of only the femoral component (27,138). The AUC values were created to see if certain variables led to an increase in LOS. In rTHA, a mFI-5 of >2, a CCI of >4, or a surgical time of >122 minutes resulted in a 62.6%, 72.8%, and 62.8% chance of remaining hospitalized for more than 24 hours, respectively.

The same analyses were conducted on the 76 rTKA. The same set of comorbidities was assessed. Patients who had chronic obstructive pulmonary disease and obstructive sleep apnea both had a *P* value of < .05 (Table 3). Patients were consistently discharged in less than 24 hours with a lower mFI-5 ($P = .014$), a shorter surgical time ($P < .001$), and with a surgical indication of aseptic loosening as opposed to prosthetic joint infection ($P < .001$). CCI ($P = .53$) did not reach statistical significance in determining LOS after rTKA. The CPTs were assessed for the rTKA cohort as well. It was determined that 55 patients underwent a single component revision (27,486) while 3 underwent both component revision (27,487) and 18 had an antibiotic spacer placed (27,488). The AUC values were created to see if certain variables led to an increase in LOS. In rTKA, a mFI-5 of > 2, a CCI of >5, or a surgical time of >63 minutes resulted in a

Table 2

rTHA Cohort	Late Discharge ($N = 64$)	Early Discharge ($N = 45$)	*P* Value
Women	33 (51.6%)	18 (40%)	.319
Age	71.4 (11.3)	65.4 (9.30)	**.003**
BMI	30.7 (6.97)	29.4 (4.61)	.241
Indication for Revision			.110
Mechanical	46 (71.9%)	39 (86.7%)	
Septic	18 (28.1%)	6 (13.3%)	
DM	15 (23.4%)	7 (15.6%)	.443
CHF	8 (12.5%)	0 (0.00%)	.020[a]
COPD/PNA	8 (12.5%)	1 (2.22%)	.078
HTN on Meds	48 (75.0%)	26 (57.8%)	.091
Functional Dependence	2 (3.12%)	0 (0.00%)	.511
Frailty Index	1.31 (0.99)	0.84 (0.71)	**.016**
Angina/CAD	21 (32.8%)	5 (11.1%)	**.017**
Cirrhosis/Liver Disease	6 (9.38%)	0 (0.00%)	.041[a]
Charlson Comorbidity Index	4.11 (1.84)	2.71 (1.31)	**<.001**
Tranexamic Acid	30 (46.9%)	29 (64.4%)	.106
Surgical Time (min)	127 (81.2)	90.2 (32.6)	**.023**
Transfusion	22 (34.4%)	4 (8.89%)	**.004**

BMI, body mass index; DM, diabetes mellitus; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; PNA, pneumonia; HTN, hypertension; CAD, coronary header disease; rTHA, revision total hip arthroplasty.

[a] Findings: patient age, mFI, CCI, surgical time, need for transfusion, and presence of CAD all significantly impacted patient LOS. Data are presented as mean (standard deviation) or count (%). Bold values indicate $P < .05$.

66.4%, 54.4%, and 78.3% chance of remaining hospitalized for more than 24 hours, respectively.

No significant difference was identified in comparing prepandemic to postpandemic cohorts for any of the assessed variables in either rTHA or rTKA. Finally, a multivariate logistic regression showed that several AUC cutoffs for both the rTHA and rTKA cohorts were significant. Specifically, both a CCI >4 (odds ratio [OR]: 3.02, 95% confidence interval [CI] [1.27, 7.36]) and operative time >122 minutes (OR: 3.21, 95% CI [1.18, 9.73]) emerged as potential risk factors for >24-hour hospitalization among rTHA patients. For rTKA patients, results indicated that operative time >63 minutes (OR: 11.68, 95% CI [3.66, 43.07]) was a potential risk factor for >24-hour hospitalization. Other factors were nonsignificant in the regression models (Table 4).

Table 3

rTKA Cohort	Late Discharge ($N = 52$)	Early Discharge ($N = 24$)	*P* Value
Women	28 (53.8%)	14 (58.3%)	.906
Age	66.8 (10.2)	66.0 (10.2)	.779
BMI	33.3 (7.03)	31.7 (3.68)	.200
Indication for Revision			**<.001**
Mechanical	13 (25.0%)	24 (100%)	
Septic	39 (75.0%)	0 (0.00%)	
DM	13 (25.0%)	5 (20.8%)	.915
CHF	6 (11.5%)	0 (0.00%)	.168
COPD/PNA	9 (17.3%)	0 (0.00%)	.050[a]
HTN on Meds	42 (80.8%)	17 (70.8%)	.503
Functional Dependence	2 (3.85%)	0 (0.00%)	1.000
Frailty Index	1.48 (0.96)	0.92 (0.65)	**.014**
OSA	9 (17.3%)	0 (0.00%)	.050[a]
Charlson Comorbidity Index	3.17 (1.93)	2.67 (1.52)	.530
Tranexamic Acid	21 (40.4%)	12 (50.0%)	.591
Surgical Time (min)	114 (59.9)	63.9 (44.6)	**<.001**
Transfusion	4 (7.69%)	0 (0.00%)	.301

BMI, body mass index; DM, diabetes mellitus; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; PNA, pneumonia; HTN, hypertension; CAD, coronary header disease; rTKA, revision total knee arthroplasty.

[a] Findings: Surgical time, mFI, and indication for revision all significantly impacted LOS. Gender, age, and BMI did not affect LOS. Data are presented as mean (standard deviation) or count (%). Bold value indicates $P < .05$.

Discussion

With this study, the primary goal was to identify factors that significantly affected LOS following rTKA and rTHA, particularly those associated with discharge within 24 hours of procedure. Operative time was a significant predictor of prolonged stay for both rTKA and rTHA, while a CCI more than 4 was a significant predictor for rTHA alone. No other variables analyzed in this study demonstrated a statistically significant correlation with late discharge.

Over the past decade, there has been increasing pressure on arthroplasty surgeons to reduce the cost per episode of care, encouraging a push for same-day discharge after primary TKA and THA procedures. Some have reported a Medicare disbursement of $50,000 per TJA hospitalization [29]. In response to these high costs, the Center for Medicare and Medicaid Services introduced the Bundled Payment for Care Improvement (BPCI) in hopes of decreasing Medicare cost [30]. The Comprehensive Care for Joint Replacement model is a similar retrospective bundled payment model instituted by Medicare to reduce healthcare costs, but unlike BPCI, Comprehensive Care for Joint Replacement only includes lower extremity arthroplasty procedures and is not a voluntary program [31]. While this BPCI program has resulted in reduced LOS after primary TJA at some facilities, this approach to cost-saving is not feasible for all primary cases, as certain high-risk patients require prolonged hospital stays [32,33]. BPCI and similar bundled payment models therefore incentivize providers to preferentially select healthy, low-risk patients, resulting in restricted access for higher risk patients [32–34]. This study identifies several factors associated with early discharge in patients undergoing revision TJA, some of which are nonmodifiable, a potential hurdle for the BPCI program.

As primary TJA cases significantly increase, both rTHA and rTKA cases are expected to follow suit [3]. Given that revision TJA inherently carries a much higher postoperative risk, a greater economic burden on the healthcare system is expected [35]. In recent years, the Center for Medicare and Medicaid Services has been trialing bundled payment models for revision TJA by offering a bundled payment for revision TJA based on diagnosis-related group, which do not allow for risk-adjustment [36]. In anticipation of the potential expansion of the BPCI program, multiple studies have attempted to identify factors that impact postoperative LOS. Understandably, preoperative anemia, preoperative blood transfusions, elevated preoperative international normalized ratio, and the day of the week a revision is performed all lead to significant increases in LOS [21,24,37,38]. The current work builds on these findings by demonstrating the importance of surgical indication, operative time, patient frailty, and comorbidity on both rTHA and rTKA.

Table 4
Logistic Regression Analysis.

Variable	OR (95% CI)	*P* Value
rTHA Cohort		
Frailty >2	1.44 (0.54 to 3.83)	.458
CCI >4	3.02 (1.27 to 7.36)	**.013**
Operative Time >122	3.21 (1.18 to 9.73)	**.028**
rTKA Cohort		
Frailty >2	2.90 (0.71 to 13.77)	.152
CCI >5	7.04 (0.90 to 151.49)	.104
Operative Time >63	11.68 (3.66 to 43.07)	**<.001**

Bold value indicates $P < .05$.
CCI, Charlson comorbidity index; OR, odds ratio; CI, confidence interval; rTHA, revision total hip arthroplasty; rTKA, revision total knee arthroplasty.

Recently, Dai et al used a national database to compare perioperative complications after revision TKA [23]. With a matched cohort of 5,187 patients in each group, they were able to identify an increased risk in multiple complications including the need for blood transfusions, postoperative complications, and a statistically significant increased LOS in periprosthetic joint infection (PJI) revisions when compared to aseptic revisions [23]. Our study showed similar results, with rTKA for PJI (100%) remaining hospitalized for more than 24 hours. Interestingly, this did not hold true for the rTHA cohort as surgical indication for revision was not statistically significant ($P = .110$) when determining postoperative LOS. We found that 6 (13.3%) patients in the rTHA group were revised for PJI and discharged within 24 hours.

Operative time has also been investigated as a cause for increased LOS after revision TJA. Garbarino et al reported on the correlation of increased LOS after rTKA [39]. Their study included 10,604 rTKA between 2008 and 2016. They assessed operative time in 30-minute intervals and found a linear increase in LOS. We determined the same in both the rTKA ($P < .001$) and rTHA ($P = .023$) cohorts. Furthermore, patients whose rTKA took longer than 63 minutes had a 78.3% chance of remaining in the hospital for more than 24 hours. A multivariate logistic regression confirmed the predictive nature of operative time on LOS, although the large CI (95% CI [3.66, 43.07]) indicates these results should be interpreted conservatively. The same conclusion can be made for the rTHA group ($P = .023$) as cases taking longer than 122 minutes had a 62.8% chance of a prolonged hospital stay (95% CI [1.18, 9.73]).

Recently, there has been increased interest in evaluating perioperative complications relative to patient frailty [40–42]. Traven et al assessed 13,948 rTHA patients and 16,304 rTKA patients and found the mFI-5 to be a good predictor of LOS with a mean LOS of 4.61 and 3.72 days, respectively [28]. They were also able to determine progressive increases in LOS with increasing mFI-5 score in both rTHA and rTKA patients [21]. We were able to validate their findings in both the rTHA ($P = .016$) and rTKA ($P = .014$) groups. An increased mFI-5 consistently resulted in a LOS more than 24 hours. Then, using a series of area under the curve values, it was determined that a mFI-5 of 2 or more predicts prolonged LOS in both the rTHA (95% CI [0.54, 3.83]) and the rTKA (95% CI [0.71, 13.7]) groups at 62.6% and 66.4%, respectively.

The CCI has been widely validated as a good predictor of complications in primary THA and TKA, but the literature on its use in the revision setting is sparse [43,44]. Lakomkin et al examined data from 6,121 rTHA patients in the National Surgical Quality Improvement Program database and identified an increased CCI as an independent risk factor for significant postoperative complications including a prolonged LOS [43]. Our findings were consistent with those found in literature for the rTHA ($P < .001$) cohort. This unexpectedly did not hold true for patients who underwent an rTKA ($P = .53$). Predictive models showing >24-hour hospitalization demonstrated a strong predictive capacity for rTHA (CCI >4) and a moderate predictive capacity for rTKA (CCI >5), with area under the curve values of 0.728 and 0.544, respectively.

Given the unique opportunity to assess a highly motivated patient cohort with a desire for rapid discharge in the setting of a global pandemic, we compared patient LOS prior to the cancellation of elective procedures (2019) to procedures taking place amid the pandemic (2020 to 2021). No statistical difference, with regards to patient LOS, was found in surgical indication, surgical time, mFI-5, or CCI in either the rTHA (Table 5) or the rTKA (Table 6) groups. The lack of statistical significance suggests that despite the healthcare system pressure from the COVID-19 pandemic, patients with a high surgical time, high mFI-5, high CCI, or patients revised for septic THA still were not discharged in less than 24 hours.

Table 5

rTHA Cohort	2019 ($N = 52$)	2020-2021 ($N = 57$)	*P* Value
Women	26 (50%)	25 (43.9%)	
Age	69.7 (10.9)	68.1 (10.9)	.454
BMI	30.6 (6.75)	29.8 (5.52)	.535
Indication for Revision			.981
Mechanical	40 (76.9%)	45 (78.9%)	
Septic	12 (23.1%)	12 (21.1%)	
Length of Stay (D)	2.65 (1.85)	4.04 (5.22)	.922
Discharge (Early)	18 (34.6)	27 (47.4)	.248

Data are presented as mean (standard deviation) or count (%).
This indicates that the pandemic had no influence on patient LOS and all significant statistics found between the full cohort length of stay are real.
BMI, body mass index; rTHA, revision total hip arthroplasty.

While primary TJA has made substantial progress in terms of efficiency, predictability cannot reliably be translated to the revision setting. A critical finding of this study is the importance of surgical time on postoperative length of hospitalization. We hypothesize that surgical time is a surrogate for case complexity, with more straightforward cases requiring less surgical dissection and tissue trauma yielding a shorter and more consistent postoperative course. It would be remiss to say the same about 2-component and 3-component revisions. Recently, literature has identified a discrepancy in compensation between septic and aseptic TJA revisions, with aseptic revisions being valued higher in "dollars per minute" than septic revisions [45]. Our study further highlights the potential issue of bundled payment for revision TJA and the likely surgeon aversion from high-risk patients [34].

Our findings should be considered in the context of this study's potential limitations. This investigation is a retrospective review with an inherent risk of selection bias. We tried to mitigate this by including all revision TJA patients in the year immediately preceding the pandemic and the 2 years during the pandemic in which hospital restrictions on elective cases were in place.

Also, in part due to the limited number of surgical procedures that took place during the pandemic, only 185 patients were included. Furthermore, the total number of revisions was further subdivided, giving 2 relatively small cohorts. This was important as rTHA and rTKA procedures inherently carry different risk profiles. The rTHA cohort included 91 of 129 (70.5%) patients who underwent revision of both components. Unfortunately, only 27.6% of rTKA patients underwent 2 component revision or placement of an antibiotic spacer. This difference makes direct comparison of rTHA and rTKA difficult. Future prospective studies with larger samples may be considered to validate the above findings.

Table 6

rTKA Cohort	2019 ($N = 44$)	2020 to 2021 ($N = 32$)	*P* Value
Women	19 (43.2%)	23 (71.9%)	.024
Age	68.2 (9.84)	64.2 (10.2)	.096
BMI	32.8 (6.70)	32.8 (5.52)	.953
Indication for Revision			.152
Mechanical	25 (56.8%)	12 (37.5%)	
Septic	19 (43.2%)	20 (62.5%)	
Length of Stay (D)	4.05 (3.44)	4.97 (7.87)	.859
Discharge (Early)	14 (31.8)	10 (31.2)	1.000

Data are presented as mean (standard deviation) or count (%) and statistical significance is represented by bold print.
No difference between prepandemic and during-pandemic length of stay ($P = 1.00$) for the following comorbidities: functional dependence, alcohol use, liver disease, kidney disease, asthma, history of venous thromboembolism (VTE), PVD, cerebrovascular disease (CVD).
BMI, body mass index; rTKA, revision total knee arthroplasty.

Conclusions

In patients undergoing rTHA, we found that both patient factors, including fragility and overall health, and surgical factors predicted hospitalization for more than 24 hours. Longer operations led to a higher likelihood of prolonged LOS. We also found similar results for patients undergoing rTKA. Longer operative times and increased fragility as well as poor health predicted increased LOS. We did not find that the COVID-19 pandemic affected these results. Further investigation should guide patient management and inform future bundle payment programs.

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