Journal of Clinical Orthopaedics and Trauma 11 (2020) 38–42

Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Risk factors for readmission within thirty days following revision total hip arthroplasty

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ARTICLE INFO

Article history:
Received 22 May 2018
Received in revised form
18 September 2018
Accepted 24 October 2018
Available online 25 October 2018

Keywords:
Revision hip arthroplasty
Readmission

ABSTRACT

Background: The number of total hip arthroplasties (THA) being performed has been steadily increasing for decades. With increased primary THA surgical volume, revision THA numbers are also increasing at a steady pace. With the aging, increasingly comorbid patient populations and newly imposed financial penalties for hospitals with high readmission rates, refining understanding of factors influencing readmission following THA is a research priority. We hypothesize that numerous preoperative medical comorbidities and postoperative medical complications will emerge as significant positive risk factors for 30-day readmission.

Methods: ACS-NSQIP database identified patients who underwent revision THA from 2005 to 2015. The primary outcome assessed was hospital readmission within 30 days. Patient demographics, preoperative comorbidities, laboratory studies, operative characteristics, and postsurgical complications were compared between readmitted and non-readmitted patients. Logistic regression identified significant independent risk factors for 30-day readmission among these variables.

Results: 10,032 patients underwent revision THA in the ACS-NSQIP from 2005 to 2015; 855 (8.5%) were readmitted within 30-days. Increasing age, the presence of preoperative comorbidities, high ASA class, and increased operative time were significant positively associated independent risk factors for 30-day readmission. Several postoperative medical and surgical complications such as myocardial infarction, stroke, pneumonia, and sepsis demonstrated significant positive associations with readmission.

Conclusion: Identifying and understanding risk factors associated with readmission allows for the implementation of evidence-based interventions aimed at minimizing risk and reducing 30-day readmission rates following revision THA.

1. Introduction

The total number of primary and revision total hip arthroplasties (THA) performed in the United States has been steadily increasing for more than three decades.[1–3] Numerous preoperative comorbidities such as diabetes mellitus, coronary artery disease, and chronic heart failure, contribute to increased probability of postoperative complications.[4]

The Medicare Hospital Readmission Reduction Program and the second phase of the Patient Protection and Affordable Care Act, which penalize hospitals for excessive readmission rates, have fueled interest in uncovering and understanding the predictors and causes of readmission.[5] Previous studies have demonstrated that patients who undergo revision THA, when compared to revision TKA, have more medical comorbidities and are more likely to have a higher severity of revision score.[6,7] Revision THA is costly and often can have a complicated post-operative period compared to other joint arthroplasties. It has been shown to have increased length of hospital stay (+1 ± 3.5 days) and increased hospitalization costs (+$1567±$3846) compared to patients undergoing revision TKA.[6] Previous studies have examined factors leading to readmission following total knee arthroplasty (TKA) and joint arthroplasty as a whole, but revision THA has not been individually studied.

With increasing numbers of revision THAs being performed on seemingly higher risk patients compared to other joint

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https://doi.org/10.1016/j.jcot.2018.10.017
0976-5662/

arthroplasties, an investigation into risk factors for hospital readmission is warranted. The objective of this study was to identify significant, independent risk factors for readmission following revision THA using 2005–2015 data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database.

2. Materials and methods

The data used in this study was obtained from public data sets, was de-identified, and was not considered Human Subjects Research. Therefore, this study was exempt from review by the Institutional Review Board. Data was obtained from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP).[8] ACS-NSQIP is an outcome-based program used to measure and improve the quality of surgical care in hospitals.[9] We searched for all patients in the ACS-NSQIP database who underwent THA between 2005 and 2015 and retrospectively selected only revision THA with Current Procedural Terminology (CPT) codes 27134, 27137, or 27138.

The NSQIP User Guide mentions all of the variables used in this study.[10] All readmissions within a thirty-day postoperative period were included. Postoperative complications were classified as either medical or surgical (Table 3) by NSQIP clinical reviewers.

T- and chi-square tests were utilized to compare demographic and clinical variables between patients that were readmitted versus not. Odds ratios (OR) and 95% confidence intervals (CI) for the association between readmission and non-readmission were estimated using logistic regression. Only variables demonstrating significant unadjusted associations and without significant amounts of missing data, defined as less than 80% data completion, were included in the multivariate analysis. The presence or absence of comorbidity was reported as a single dichotomous variable. We considered variables statistically significant if the p-value was less than 0.05.

3. Results

10,032 patients who underwent revision THA between 2005 and 2015 were included in the study. 855 (8.5%) patients were readmitted within 30 days.

The average age of patients in this study was 66.4 years (19–90 years). Other demographic variables are contained in Tables 1 and 2. Age, race, and BMI were the demographic factors found to show significant positive association with readmission (Tables 1 and 2). For preoperative medical comorbidities, hypertension, diabetes, congestive heart failure, smoking status, dyspnea, COPD, bleeding disorders, systemic sepsis, corticosteroid use, preoperative open wound, and wound infection were positively associated with readmission. Laboratory values such as abnormal white blood cell count, low hematocrit, low serum albumin, and elevated INR were also significantly positively associated with readmission. Operative variables, such as increased operation time, ASA class, and use of general anesthesia vs other techniques demonstrated significant positive associations with readmission. Functional health status prior to surgery and elective surgery were significanty negatively associated with readmission.

Black vs white race (OR: 1.35; 95% CI, 1.05–1.74) was a significant risk factor for 30-day readmission. Age was also considered a significant demographic risk factor for readmission. The average ages

Table 1
Preoperative and operative characteristics.

Variable	Not Readmitted[a] (N = 9177)	Readmitted[a] (N = 855)	P Value	Variable	Not Readmitted[a] (N = 9177)	Readmitted[a] (N = 855)	P Value
Age [b]	66.3	67.7	0.0025	COPD	522 (5.7%)	79 (9.24%)	<0.001
Sex [c]			0.819	Bleeding disorder	498 (5.4%)	68 (8.0%)	0.002
Male	4125 (45.0%)	388 (45.4%)		Pre-op blood transfusion	154 (1.7%)	22 (2.6%)	0.018
Female	5047 (55.0%)	467 (54.6%)		Open/infected wound	213 (2.3%)	38 (4.4%)	<0.001
Race [c]			<0.001	Systemic Sepsis			
White	7105 (77.4%)	680(79.5%)		SIRS	82 (0.9%)	21 (2.5%)	<0.001
Black	588 (6.4%)	76 (8.9%)		Septic Shock	5 (0.1%)	0 (0%)	<0.001
Asian	96 (1.1%)	7 (0.8%)		Sepsis	95 (1.0%)	23 (2.7%)	<0.001
Native American	24 (0.3%)	0 (0.0%)		Corticosteroid use	519 (5.7%)	69 (8.1%)	0.004
Hispanic	241 (2.6%)	21 (2.5%)		**Preoperative Labs**			
Unreported	1123 (12.2%)	71 (8.3%)		WBC count ($X10^3/\mu L$)	7.31 (4.76–9.86)	7.66 (4.50–10.82)	<0.001
BMI Category[c]			0.013	Hematocrit (%)	38.93 (33.70–44.16)	37.48 (31.97–42.99)	<0.001
Underweight (<18.5)	156 (1.7%)	18 (2.2%)		Platelets ($X10^3/\mu L$)	248.74 (167.03–330.45)	249.19(155.17 –343.21)	0.882
Normal (18.5–25)	2074 (22.6%)	185 (21.6%)		Creatinine (mg/dL)	0.94 (0.35–1.54)	0.97 (0.44–1.50)	0.082
Overweight (25–30)	3050 (33.2%)	264 (30.9%)		Serum albumin (g/dL)	3.89 (3.31–4.47)	3.71 (3.08–4.34)	<0.001
Obese (30–35)	2185 (23.8%)	185 (21.7%)		INR	1.06 (0.85–1.27)	1.12 (0.67–1.57)	<0.001
Very obese (35–40)	1060 (11.6%)	122 (14.3%)		**Operative Variables**			
Morbid Obese (≥40)	652 (7.1%)	81 (9.4%)		ASA class [c]			<0.001
Comorbid Conditions[c]				1–2	4004 (43.7%)	246 (28.8%)	
Recent weight loss	55 (0.6%)	6 (0.7%)	0.159	3–4	5166 (56.3%)	609 (71.2%)	
Smoking	1355 (14.8%)	151 (17.7%)	0.023	Operation time[d] (min)	145.35 (68.15–222.55)	153.7 (72.67–234.73)	0.0026
Diabetes	1212 (13.2%)	141 (16.5%)	0.007	Anesthesia technique[c]			<0.001
Ascites	9 (0.1%)	2 (0.2%)	0.251	General	6558 (71.5%)	681 (79.7%)	
Renal Failure	11 (0.1%)	1 (0.1%)	0.981	Non-General	2619 (28.5%)	174 (20.4%)	
Dialysis Use	65 (0.7%)	8 (0.9%)	0.454	Functional Health Status			<0.001
Hypertension	5337 (58.2%)	567 (66.3%)	<0.001	Independent	8593 (94.1%)	745 (88.2%)	
CHF	79 (0.9%)	15 (1.8%)		Partial/Total Dependence	537 (5.9%)	100 (11.8%)	
Dyspnea	528 (5.8%)	73 (8.5%)	<0.001	Length of Hospital Stay[d]	4.54 (6.58)	5.07 (4.17)	0.019

[a] Some data points were unrecorded and were therefore unavailable for inclusion in the evaluation.
[b] The values given represent the average age of patients, in years.
[c] The values are given as a number of patients, with the percentage in parentheses.
[d] The values given represent an average, with 1 standard deviation in parentheses.

Table 2
Preoperative characteristics as risk factors for readmission after revision total hip arthroplasty.

Variable	Odds Ratio (95% CI) [a b]	P value [b]
Preoperative Characteristics		
Sex female vs male	0.98 (0.86–1.13)	0.8192
Race		
Black vs White	1.35 (1.050–1.737)	0.0192
Asian vs White	0.76 (0.352–1.648)	0.4895
Hispanic vs White	0.910 (0.579–1.432)	0.6847
Native American vs White	<0.001 (<0.001 - >999.99)	0.9665
Non-reported vs White	0.661 (0.513–0.850)	0.0013
BMI		
Underweight (<18.5) vs Normal (18.5–25)	1.323 (0.793–2.206)	0.2834
Overweight (25–30) vs Normal (18.5–25)	0.973 (0.798–1.186)	0.7885
Obese (30–35) vs Normal (18.5–25)	0.954 (0.770–1.183)	0.6698
Very obese (35–40) vs Normal (18.5–25)	1.297 (1.018–1.654)	0.0353
Morbidly Obese (≥40) vs Normal (18.5–25)	1.388 (1.051–1.835)	0.0210
Smoking status*	1.238 (1.029–1.490)	0.0236
Diabetes*	1.299 (1.073–1.570)	0.0073
COPD*	1.688 (1.318–2.163)	<0.001
Dyspnea*	1.529 (1.184–1.974)	<0.001
Hypertension*	1.416 (1.222–1.642)	<0.001
Bleeding disorder*	1.506 (1.157–1.960)	0.002
Ascites	2.389 (0.516–11.074)	0.2656
CHF	2.057 (1.179–3.588)	0.01
Renal failure	0.976 (0.126–7.567)	0.981
Corticosteroid use*	1.464 (1.127–1.902)	0.004
Dialysis	1.325 (0.634–2.770)	0.455
Preoperative open wound and wound infection	1.958 (1.376–2.785)	<0.001

[a] The values are given as the odds ratio, with the 95% CI in parentheses.
[b] Logistic regression modeling adjusted for age, sex, race, BMI category, and presence of one of more preoperative comorbidities, ASA class, and operative time.

Table 3
Postoperative complications as risk factors for readmission after revision total hip arthroplasty.

	Not Readmitted[a,b] (N = 9177)	Readmitted[a,b] (N = 855)	P Value[c]	Odds Ratio (95% CI)[d,e]	P Value[e]
Overall complications	2989 (32.6%)	619 (72.4%)			
Medical complications	2876 (31.3%)	441 (51.6%)	<0.001	2.334 (2.026–2.688)	<0.001
Pneumonia	57 (0.6%)	16 (1.9%)	<0.001	3.055 (1.747–5.342)	<0.001
Unplanned intubation	31 (0.3%)	11 (1.3%)	<0.001	3.851 (1.929–7.687)	<0.001
Urinary tract infection	109 (1.2%)	44 (5.2%)	<0.001	4.515 (3.159–6.455)	<0.001
Ventilator for more than 48 h	16 (0.2%)	6 (0.7%)	<0.001	4.051 (1.581–10.377)	0.004
Stroke or cerebrovascular accident	10 (0.1%)	7 (0.8%)	<0.001	7.575 (2.876–19.949)	<0.001
Acute renal failure	12 (0.1%)	4 (0.5%)	0.018	3.596 (1.158–11.169)	0.0269
Cardiac arrest	18 (0.2%)	3 (0.4%)	0.344	1.792 (0.527–6.095)	0.3505
Septic Shock	18 (0.2%)	11 (1.3%)	<0.001	6.632 (3.122–14.088)	<0.001
Sepsis	71 (0.8%)	74 (8.7%)	<0.001	12.152 (8.704–16.966)	<0.001
Myocardial infarction (MI)	39 (0.4%)	11 (1.3%)	<0.001	3.058 (1.561–5.991)	<0.001
Blood transfusion	2724 (29.7%)	340 (39.8%)	<0.001		
Progressive Renal Insufficiency	11 (0.1%)	11 (1.3%)	<0.001	10.86 (4.685–25.123)	<0.001
Surgical complications	113 (1.2%)	178 (20.8%)	<0.001	21.090 (16.452–27.035)	<0.001
Superficial surgical site infection	64 (0.7%)	47 (5.5%)	<0.001	8.283 (5.645–12.152)	<0.001
Deep or incisional surgical site infection	45 (0.5%)	108 (12.6%)	<0.001	29.327 (20.550–41.852)	<0.001
Organ or space surgical site infections	74 (0.8%)	106 (12.4%)			
Pulmonary embolism	22 (0.24%)	17 (1.99%)	<0.001	8.456 (4.473–15.985)	<0.001
Deep venous thrombosis	40 (0.44%)	24 (2.81%)	<0.001	6.597 (3.958–10.998)	<0.001
Wound disruption	5 (0.1%)	31 (3.6%)	<0.001	68.896 (26.734–177.556)	<0.001
Venous thromboembolism	58 (0.6%)	37 (4.3%)	<0.001	7.113 (4.680–10.809)	<0.001
Return to OR	148 (1.6%)	473 (55.3%)	<0.001	75.531 (61.158–93.283)	<0.001

[a] Some data points were unrecorded and were therefore unavailable for inclusion in the evaluation.
[b] The value are given as a number of patients, with the percentage in parentheses.
[c] P value from univariate modeling.
[d] The values are given as the odds ratio, with the 95% CI in parentheses.
[e] Logistic regression modeling adjusted for age, sex, race, and presence of one of more preoperative comorbidities, ASA class, and operative time. Not adjusted for concurrent medical or surgical complications.

among readmitted and non-readmitted patients were 67.7 and 66.3, respectively. BMI was also shown to have a significant ($p = 0.013$) correlation with readmission. Compared to patients with a normal BMI, patients who were very obese (OR: 1.297; 95% CI 1.018–1.654) or morbidly obese (OR: 1.388; 95% CI 1.051–1.835) had significantly greater odds of readmission. Preoperative characteristics shown to have increased odds for readmission included COPD (OR: 1.69; 95% CI, 1.32–2.16), dyspnea (OR: 1.53; 95% CI, 1.18–1.97), smoking status (OR: 1.238; 95% CI, 1.029–1.490), diabetes (OR: 1.299, 95% CI, 1.073–1.570), hypertension (OR: 1.416; 95% CI, 1.222–1.642), CHF (OR: 2.057; 95% CI, 0.516–11.074), bleeding disorders (OR: 1.506; 95% CI, 1.157–1.960), corticosteroid

use (OR: 1.464; 95% CI, 1.127–1.902), and preoperative open wound and wound infection (OR: 1.958; 95% CI, 1.376–2.785).

ASA class of 3–4 had a much higher readmission rate compared to those with an ASA class of 1–2 (OR: 1.919; 95% CI, 1.645–2.237). Other operative variables that showed increased risk for readmission were operative time ($p = 0.0026$), general anesthesia ($p < 0.001$), and functional health status ($p < 0.001$).

All surgical complications and numerous medical complications shown in Table 3 were shown to be statistically significant risks for readmission, with the exception of cardiac arrest. 619 (72.4%) of the readmitted patients experienced complications, compared to 2989 (32.6%) of non-readmitted patients. Of readmitted patients, 51.6% had medical complications and 20.8% had surgical complications. Superficial and deep surgical site infections each significantly increased odds of readmission (OR: 8.283, CI 5.645–12.152 and OR: 29.327, CI 20.550–41.852, respectively). Patients who were readmitted had over six-times the odds of stroke, sepsis, or septic shock, as well as a significantly higher rate of postoperative surgical complications (OR: 21.09; 95% CI, 16.45–27.04).

4. Discussion

Our study included 10,032 patients who underwent revision THA, and 855 (8.5%) were readmitted within 30 days. Our study showed that many demographic variables, comorbidities, laboratory abnormalities, and medical and surgical complications were associated with higher rates of 30-day readmission following revision THA. These demographic variables included age, race, and BMI category (Tables 1 and 2). Comorbidities included hypertension, dyspnea, COPD, bleeding disorders, systemic sepsis, corticosteroid use, preoperative open wound and wound infection (Tables 1 and 2). Laboratory values included leukopenia, anemia, low serum albumin, and elevated INR (Table 1). High ASA score, increased operation time and use of general anesthesia vs other techniques also demonstrated positive associations with readmission (Table 1). Functional health status prior to surgery and elective surgery showed negative associations with readmission (Table 1).

Pugely et al. analyzed data from the ACS-NSQIP database to evaluate risks for readmission after all joint arthroplasties. They found that older age, male gender, elevated BUN, presence of a bleeding disorder, and high ASA score were risk factors for readmission.[11] Our study takes advantage of the additional data from 2007 to 2011 and adds specificity by individually evaluating revision THA. Nichols et al. analyzed cost, destination of discharge, and readmission of primary and revision THA and TKA between 2009 and 2013. 17,934 patients received revision THA. Overall 90-day readmission rate after revision THA was 21.7%, and results showed an increase in readmission rates with increased length of hospitalization. Discharge destination to skilled nursing facility was associated with higher risk of readmission than discharge home with self or home health services as well.[12] Our study showed comparable, but relatively low readmission rates (8.5%) compared to the literature (9.5–21.7%). This may be due to our 30-day follow-up period or lack of knowledge as to whether or not patients were admitted to other institutions.[13]

Our study found that comparing Black vs. White race gave the highest odds ratio (1.35) for readmission. This is consistent with other studies that found an increase in readmission rates in the black vs. white race.[11,13] Merkow et al. reported that black vs. white race was associated with an increased 30-day readmission rate following surgery in the United States (OR: 1.11, CI: 95%, 1.07–1.15).[13] This study also agreed with our findings of increasing age as a risk factor for readmission. In their study, ages 65–79 had an odds ratio of 1.05 for readmission, and age >80 had an odds ratio of 1.27.[13]

Surgical complications showed the highest odds ratios for readmission after revision THA. The average odds ratio for all surgical complications was 21.09, and of these complications return to the OR (OR: 75.5), wound disruption (OR: 68.9), and deep or incisional surgical site infection (OR: 29.3) showed the highest odds for readmission. Superficial surgical site infection was also associated with increased odds of readmission (OR: 8.283). Medical complications were associated with a mean odds ratio of 2.334. Of these complications, sepsis (OR 12.152), stroke (OR: 7.575), and septic shock (OR: 6.632) showed the highest odds of readmission.

Readmission has a significant effect on the outcome and cost of a procedure. Bosco et al. studied 2572 total patients receiving either primary or revision THA or TKA. A cost analysis was then performed on the readmissions from these four cohorts. Readmission after revision THA accounted for 8.4% of the cost burden from this patient population, even though only 294 (10.7%) of the patients received a revision THA and of these, 28 (9.5%) patients were readmitted.[14]

Further evaluation of risk factors for readmission following revision THA will allow for potential development of risk-reducing interventions aimed at decreasing readmission rates. Knowledge of these risk factors for readmission will allow high-risk patients to be identified and properly counseled prior to surgery. Research with extended follow-up and expanded risk factors in this area is warranted. This will allow more informed discussion regarding each patient's risks and benefits in undergoing revision THA.

There were limitations to this study. Demographically, our patients were racially non-diverse, with a majority of patients being white (77.6%) and 11.9% unreported. Although we used a widely-studied, validated database, we did not enter the data, and therefore cannot ensure its accuracy. Another limitation of this study is that calculation of p-values was impossible due to sample size for several variables, including congestive heart failure, as well as for subsets of several variables. This missing data made it impossible to determine the statistical significance of these variables of interest. Many of these variables were considered significant in other studies and were significant based either on univariate or multivariate analysis, but not both.[13] Also, the statistical significance of risk factors does not necessarily demonstrate clinical significance. Furthermore, patients who received additional care at non-participating institutions were considered non-readmitted. Because of this, our study potentially underestimates the readmission rate. Finally, our follow-up period was limited to 30 days by the database. A longer post-operative time frame may have shown higher readmission rates as more patients may have been readmitted after thirty days. Nichols et al.'s study utilized a 90-day follow-up and showed a mean readmission time at 29.9 ± 26.5 days. This shows that many of their readmissions would not have been recorded with a 30-day follow-up period.[12]

This study identified several risk factors associated with 30-day readmission in patients undergoing revision THA such as age, race, several preoperative comorbidities, laboratory values, and medical and surgical complications. Further research is warranted and may identify more risk factors and further clarify details of the previously identified risk factors.

Disclosure

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Funding

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

Conflicts of interest

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2018.10.017.

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