Are Patients with Cardiovascular Disease at Higher Risk for Postoperative Complications following Total Hip or Total Knee Replacements? A Retrospective Cohort Study

Mark Orland (✉ morlan5@uic.edu)

University of Illinois at Chicago College of Medicine <https://orcid.org/0000-0002-1842-6187>

Nandini Rajaram Siva

University of Illinois at Chicago College of Medicine

Diego Barragan

University of Illinois at Chicago College of Medicine

Anshum Sood

University of Illinois at Chicago College of Medicine

Mark H Gonzalez

University of Illinois at Chicago College of Medicine

Research

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Abstract

Background: Cardiovascular disease affects 121.5 million Americans, or 48% of the adult US population and is the leading cause of death in the United States. The demand for total joint replacement is expected to increase due to an aging population and advances in technology. Given the prevalence of cardiovascular disease and the expected increase in total joint replacement procedures, we sought to examine whether cardiovascular disease was associated with increased postoperative complications in patients undergoing total hip and knee replacements.

Methods:

CPT codes were used to investigate the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database for patients who underwent total hip or knee replacements from 2010 to 2017. Patients were classified as having cardiovascular disease as per the American Heart Association guidelines. Patient samples with all possible covariates were included in a multivariate logistic regression analysis. A patient sample size of 119,076 for total hip and 189,297 for total knee replacement was analyzed.

Results: Patients with cardiovascular disease were found to have a statistically significant increased risk for the following postoperative complications: sepsis, wound complications, pneumonia, urinary tract infection, myocardial infarction, unplanned intubation, and cardiac arrest.

Conclusions: Patients with cardiovascular disease undergoing a total hip or knee replacement have increased risk for wound, infectious and cardiovascular-associated postoperative complications. This finding necessitates the need for more frequent and sooner postoperative visits, a stringent cardiovascular preoperative evaluation, and patient education on the increased postoperative risks of joint replacements to lower the incidence of complications.

Introduction

Currently more than 7 million Americans live with a hip or knee replacement (1). The prevalence of total hip arthroplasty (THA) and total knee arthroplasty (TKA) is expected to increase. Prediction models estimate that the number of THA and TKA in the United States will increase by 85% and 71% respectively, by the year 2050 (2). The decreasing mean age at which patients are undergoing total joint replacements can partially explain this rise in volume. Additionally a recent report from the CDC indicates that the number of hip replacements from 2000 to 2010 more than tripled in adults aged from 45 to 54 (3). Given this trend, it is important to practice judicious patient selection with preoperative optimization and standardization for total joint replacements to minimize patient complications and hospital costs.

While the number of total joint replacements increases, cardiovascular disease continues to be the leading cause of death in both men and women in the United States (4). The American Heart Association

(AHA) reports that cardiovascular disease affects 121.5 million Americans, or 48% of the adult US population (5).

Although cardiovascular disease has been extensively studied as a prognostic indicator for surgical outcomes, previous studies have not assessed its prevalence and corresponding complications following total joint replacement (6–11). Moreover, total blood loss in surgery is generally associated with postoperative complications, and THA and TKA are known to have some of the highest with an estimated average of 1500 mL and 1472 mL of blood respectively (12, 13). Therefore, we sought to examine whether patients with cardiovascular disease undergoing total joint replacement were more at risk for major postoperative complications when compared to those without cardiovascular disease.

Materials And Methods

Data Collection

This was a retrospective analysis of data collected from the American College of Surgery National Quality Improvement Database (ACS-NSQIP), a national database of clinical information collected from over 500 participating hospitals across the United States (14).

Based on the data in the ACS-NSQIP, patients undergoing THA or TKA from 2010 to 2017 were identified. Current Procedural Terminology (CPT) codes were used to identify both surgeries, specifically 27130 for THA and 27447 for TKA (15, 16). To account for potential confounding variable in subsequent analyses, data were filtered to only include samples that accounted for the following variables: sex, race, smoking status, abnormal renal function (as indicated by dialysis use), thrombocytopenia (platelet count < 150,000 cells/mm³), anemia (hematocrit level < 36% for women and <39% for men per the World Health Organization), age, obesity (body mass index > 30 kg/m²), diabetic history, COPD history, bleeding disorder, steroid or immunosuppressant use, dyspnea present at rest, and preoperative blood transfusions within 72 hours of the procedure (17).

Data Stratification

Based on criteria from the World Health Organization, preoperative cardiovascular disease was defined as a patient with a history of coronary artery disease, cerebrovascular disease, peripheral artery disease, rheumatic and congenital heart disease, and history of venous thromboembolisms (18). Patients with documented history of ischemic heart disease from atherosclerosis, history of prior myocardial infarctions, congestive heart failure, prior venous thromboembolisms, and congenital heart disease were stratified as those with existing cardiovascular disease pre-operatively. Cardiovascular disease in the TKA and THA cohorts were analyzed with respect to postoperative complications that occurred within thirty days of the surgery.

Thirty-Day Postoperative Complications

The postoperative variables analyzed consisted of wound complications which included periprosthetic complications (wound infection, surgical site infection, organ space infection, and wound dehiscence), clotting complications (deep vein thrombosis, pulmonary embolism, myocardial infarction, stroke), blood transfusions, unplanned intubations, urinary tract infections (UTIs), and major systemic complications including sepsis and cardiac arrest.

Statistical Analysis

All analyses were done with the R software, version 3.6.1 (19). Univariate analysis utilizing Pearson's χ^2 test was performed to compare patient preoperative clinical data and operative time to determine any confounding variates in both procedures separately. The length of operation and patient age for THA and TKA were separately stratified into four quartiles based on the mean in each, to be analyzed as categorical rather than continuous variables for statistical analysis in the logistic regression. Patient demographics and comorbidities that were significantly associated with cardiovascular disease were included as covariate variables and thus accounted for in the multivariate logistic regression (MLR). MLR analysis was used to test the relationship between pre-operative cardiovascular disease and postoperative complications in each procedure separately. Odds ratios (OR) and 95% confidence intervals (CI) were reported. Statistical significance for all analyses was set as $p < 0.05$.

Results

Total Hip Replacement

The following covariates from the χ^2 test were found to be significant for THA via univariate analysis: sex, race, smoking status, abnormal renal function, thrombocytopenia, anemia, age, obesity, diabetes, COPD, bleeding disorders, steroid or immunosuppressant use, dyspnea at rest, and preoperative blood transfusions. The full results can be found in Table 1.

Table 1

Univariate analysis of all potential preoperative and perioperative covariates in patients undergoing THA.

Preoperative and Perioperative Variables	Cardiovascular Disease (n=68,306)		No Disease (n=50,730)		p-value
	Count	Percent (%)	Count	Percent (%)	
Operative Time					0.17
<i>1st Quartile</i>	17,572	25.7	12,794	25.2	
<i>2nd Quartile</i>	16,682	24.4	12,507	24.6	
<i>3rd Quartile</i>	17,062	25.0	12,850	25.3	
<i>4th Quartile</i>	16,990	24.9	12,619	24.9	
Sex					<0.001
<i>Female</i>	36,521	53.5	28,882	56.9	
<i>Male</i>	31,785	46.5	21,888	43.1	
Race					<0.001
<i>American Indian or Alaska Native</i>	264	0.4	293	0.6	
<i>White</i>	59,461	87.1	46,381	91.4	
<i>Native Hawaiian or Pacific Islander</i>	227	0.3	144	0.3	
<i>Asian</i>	1,093	1.6	799	1.6	
<i>Black or African American</i>	7,261	10.6	3,153	6.2	
Smoking Status	8,407	12.3	7,388	14.6	<0.001
Abnormal Renal Function	198	0.3	65	0.1	<0.001
Thrombocytopenia	3,401	5.0	1,791	3.5	<0.001
Anemia	11,778	17.2	5,061	10.0	<0.001
Age					<0.001
<i>0-58</i>	13,635	20.0	19,736	38.9	
<i>59-65</i>	15,424	22.6	12,574	24.8	
<i>66-72</i>	17,228	25.2	10,286	20.3	
<i>73+</i>	22,019	32.2	8,174	16.1	
Obesity	36,825	53.9	18,816	37.1	<0.001

Preoperative and Perioperative Variables	Cardiovascular Disease (n=68,306)		No Disease (n=50,730)		p-value
	Count	Percent (%)	Count	Percent (%)	
Diabetes	12,370	18.1	2,015	4.0	<0.001
COPD	3,470	5.1	1,290	2.5	<0.001
Bleeding Disorder	2,016	3.0	639	1.3	<0.001
Steroid or Immunosuppressant Use	2,756	4.0	1,678	3.3	<0.001
Dyspnea at Rest	4,042	5.9	1,273	2.5	<0.001
Preoperative Transfusion	94	0.1	44	0.1	0.01

119,076 patients had data recorded for all of the above covariates. 68,306 (57.4%) had a history of cardiovascular disease, while 50,730 (42.6%) did not. The results of the MLR analysis examining the association between cardiovascular disease and postoperative complications while accounting for all covariates can be found in Table 2. There was a statistically significantly increased incidence of the following complications in patients with cardiovascular disease: sepsis, postoperative transfusions, wound complications (surgical site infections, deep wound infection, organ space infection, wound dehiscence, and wound infection), pneumonia, urinary tract infections (UTIs), myocardial infarction, unplanned intubation, stroke, deep vein thrombosis (DVT), and cardiac arrest ($p < 0.05$, $OR > 1$). Full results can be found in Table 2.

Table 2

MLR analysis of postoperative complications in patients with cardiovascular disease undergoing THA compared to those without.

Postoperative Complications	Odds Ratio	95% CI	p-value
Sepsis	2.64	1.44-4.85	0.002
Surgical Site Infection	1.44	1.22-1.71	<0.001
Deep Wound Infection	1.69	1.3-2.2	<0.001
Organ Space Infection	1.83	1.41-2.38	<0.001
Wound Dehiscence	1.52	1.06-2.19	0.02
Wound Infection	1.62	1.44-1.83	<0.001
Pneumonia	1.62	1.29-2.03	<0.001
Urinary Tract Infection	1.56	1.36-1.79	<0.001
Myocardial Infarction	3.35	2.39-4.7	<0.001
Unplanned Intubation	2.34	1.65-3.32	<0.001
Postoperative Stroke	1.87	1.21-2.87	0.005
Postoperative Transfusion	1.16	1.1-1.21	<0.001
Deep Vein Thrombosis	1.37	1.13-1.67	0.001
Cardiac Arrest	2.28	1.32-3.93	0.003
Pulmonary Embolism	0.88	0.7-1.12	0.29

Total Knee Replacement

Univariate analysis of the preoperative and perioperative variables of patients undergoing TKA showed the same covariates as THA. The full results can be found in Table 3.

Table 3

Univariate analysis of all potential demographic and preoperative covariates in patients undergoing TKA.

Preoperative and Perioperative Variables	Cardiovascular Disease (n=126,086)		No Disease (n=63,211)		p-value
	Count	Percent (%)	Count	Percent (%)	
Operative Time					0.18
<i>1st Quartile</i>	33,286	26.4	16,789	26.6	
<i>2nd Quartile</i>	30,197	23.9	15,296	24.2	
<i>3rd Quartile</i>	31,101	24.7	15,617	24.7	
<i>4th Quartile</i>	31,502	25.0	15,509	24.5	
Sex					<0.001
<i>Female</i>	77,423	61.4	40,362	63.9	
<i>Male</i>	48,663	38.6	22,849	36.1	
Race					<0.001
<i>American Indian or Alaska Native</i>	730	0.6	444	0.7	
<i>White</i>	108,229	85.8	57,542	91.0	
<i>Native Hawaiian or Pacific Islander</i>	577	0.5	268	0.4	
<i>Asian</i>	3,298	2.6	1,358	2.1	
<i>Black or African American</i>	13,252	10.5	3,599	5.7	
Smoking Status	9,929	7.9	6,201	9.8	<0.001
Abnormal Renal Function	197	0.2	99	0.2	<0.001
Thrombocytopenia	6,432	5.1	2,448	3.9	<0.001
Anemia	18,850	15.0	5,488	8.7	<0.001
Age					<0.001
<i>0-58</i>	19,491	15.5	18,011	28.5	
<i>59-65</i>	29,721	23.6	17,130	27.1	
<i>66-72</i>	36,787	29.2	15,424	24.4	
<i>73+</i>	40,087	31.8	12,646	20.0	
Obesity	86,013	68.2	34,505	54.6	<0.001

Preoperative and Perioperative Variables	Cardiovascular Disease (n=126,086)		No Disease (n=63,211)		p-value
	Count	Percent (%)	Count	Percent (%)	
Diabetes	30,013	23.8	4,295	6.8	<0.001
COPD	5,349	4.2	1,540	2.4	<0.001
Bleeding Disorder	3,473	2.8	891	1.4	<0.001
Steroid or Immunosuppressant Use	4,554	3.6	2,240	3.5	0.46
Dyspnea at Rest	8,437	6.7	2,060	3.3	<0.001
Preoperative Transfusion	45	0.0	19	0.0	0.62

189,297 patients had data recorded for all covariates. 126,086 (66.6%) had a history of cardiovascular disease, while 63,211 (33.4%) did not. The results of the MLR analysis can be found in Table 4. The following postoperative complications demonstrated an increased incidence in patients with a cardiovascular disease: sepsis, postoperative transfusions, wound complications (surgical site infections, deep surgical infection, wound dehiscence, and wound infection), pneumonia, UTIs, myocardial infarction, unplanned intubation, stroke, and cardiac arrest ($p < 0.05$, $OR > 1$).

Table 4
Multivariate analysis of all postoperative complications in patients with cardiovascular disease undergoing TKA compared to those without.

Postoperative Complications	Odds Ratio	95% CI	p-value
Sepsis	2.80	1.59-4.94	<0.001
Surgical Site Infection	1.25	1.07-1.46	0.005
Deep Wound Infection	1.58	1.14-2.18	0.006
Organ Space Infection	1.29	1-1.66	0.047
Wound Dehiscence	1.61	1.26-2.05	<0.001
Wound Infection	1.34	1.2-1.5	<0.001
Pneumonia	1.55	1.29-1.88	<0.001
Urinary Tract Infection	1.39	1.24-1.56	<0.001
Myocardial Infarction	2.73	2.03-3.67	<0.001
Unplanned Intubation	2.14	1.56-2.94	<0.001
Postoperative Stroke	1.87	1.26-2.76	0.002
Postoperative Transfusion	1.27	1.21-1.34	<0.001
Deep Vein Thrombosis	0.92	0.82-1.02	0.12
Cardiac Arrest	2.03	1.32-3.14	0.001
Pulmonary Embolism	1.01	0.88-1.16	0.86

Discussion

Although it is generally accepted by clinicians that cardiovascular disease is associated with certain postoperative complications, specifics regarding which complications following total joint replacements has not been examined. Our results showed that cardiovascular disease is associated with a higher risk of every potential post-operative complication documented barring venous thromboembolisms in the thirty-day period following THA or TKA. These complications were not limited to those typically associated with, and accounted for, in pre-operative cardiac risk indices such as postoperative cardiac arrest, myocardial infarctions or strokes, but also included wound care complications, systemic infections and several other complications. Reasons for this may include the association of delayed wound healing with cardiovascular disease, potentially due to its complex impact on the hemostatic and remodeling stage of healing (20, 21). While the delay in wound healing itself can lead to a nidus for infection in the post-operative immunocompromised state, cardiovascular disease and its impact on the immune system is still being explored as a potential immunosuppressed state (22, 23). Findings such as these point to

the necessity of further research examining the pathway of healing and infection and how cardiovascular disease can impact. Prior to further advancements in optimal wound care and cardioimmunology, patients with cardiovascular disease and planned total joint replacements

should have more frequent postoperative follow-ups with their surgical care team, be flagged preoperatively for increased medical clearance and optimization prior to surgery and be well-informed of the increased risk of complications postoperatively.

Bohl et. al found that the median day of diagnosis of UTIs and surgical site infections following total joint replacements occurred on postoperative day 8 and 17, respectively (24). However, given that follow-ups after surgery for wound care are recommended to be by 2 weeks, surgical infections may go undiagnosed for longer if the follow-up is at 14 days progressing to more serious infections and potential sepsis (25, 26). Due to the significantly higher rate of infection in those with cardiovascular disease, the patient's care team should educate the patient on the need for frequent and sooner postoperative visits to with the surgical care team to minimize this chance, as well as have a lower threshold for follow-up if infectious symptoms arise. These frequent follow-ups can also tailor antithrombotic management for patients undergoing total joint replacements to minimize the risk of post-operative myocardial infarctions and strokes, as well as the risk of bleeding.

To minimize the complications associated with cardiovascular disease, we recommend a thorough preoperative evaluation of cardiovascular disease during the preoperative medical clearance process including collaboration with patients' primary care team. This planning can help improve patient outcomes, reduce length of hospital stay, and lower the cost of care (27, 28). Currently, orthopaedic surgeries are considered intermediate risk for cardiac death or nonfatal myocardial infarctions post-operatively which does not necessitate stress testing, echocardiograms, or cardiology consults in patients with cardiovascular disease (29). However, as patients with cardiovascular disease are suffering more postoperative strokes and myocardial infarctions after total joint replacements, the benefit of treating these as a higher risk surgeries with more stringent preoperative evaluations should be examined in future research.

When preoperative screening identifies patients with cardiovascular disease, shared decision making between the patient and the care team can help the patient understand and balance the risks and benefits of the surgery and postoperative care. It also gives the team more opportunity to stress the importance of mitigating modifiable risk factors contributing to cardiovascular disease including uncontrolled hypertension, diabetes, smoking, diet, and physical activity (30–32). In addition to patients' primary care team being aware of a patient's choice for an elective joint replacement, orthopaedic surgeons must be aware of the importance of working closely with the patient and rest of the care team to optimize patients' cardiovascular health prior to surgery.

The main limitations of this study result from the multicentered nature of the database. We cannot measure how surgical experience may have acted as a confounder, are limited to analyzing only the variables in the dataset as potential confounders, and cannot comment on if patients with cardiovascular

disease received any form of pre-operative optimization or not. Additionally, our study found that patients with cardiovascular disease undergoing TKA were not at higher risk for deep vein thrombosis (DVT) despite the literature suggesting an association between TKA and DVTs (33–36). Potential reasons for this include residual effects of aspirin or an underpowered analysis due to the low incidence of DVTs following total knee replacements.

Conclusions

Patients with cardiovascular disease undergoing a total hip or knee replacement have increased risk for wound, infectious and cardiovascular-associated postoperative complications. This finding necessitates the need for more frequent and sooner postoperative visits, a stringent cardiovascular preoperative evaluation, and patient education on the increased postoperative risks of joint replacements to lower the incidence of complications.

Declarations

Ethics Approval and Consent to Participate: Not applicable.

Consent for Publication: Not applicable.

Availability of Data and Materials: The datasets analyzed during the current study are available in the American College of Surgeons National Surgical Quality Improvement Program repository, available by request: <https://www.facs.org/quality-programs/acs-nsqip/participant-use>

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