Arthroplasty Today xxx (2018) 1–5

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original research

Cost and determinants of acute kidney injury after elective primary total joint arthroplasty

Orchideh Abar, BA, Nader Toossi, MD, Norman Johanson, MD *

Department of Orthopedic Surgery, Drexel University College of Medicine, Philadelphia, PA, USA

ARTICLE INFO

Article history:
Received 20 February 2018
Received in revised form
4 May 2018
Accepted 7 May 2018
Available online xxx

Keywords:
Total joint arthroplasty
Complications
Acute kidney injury
Outcomes improvement

ABSTRACT

Background: Acute kidney injury (AKI) is a serious complication after major surgery, which may lead to increased morbidity and mortality. The aim of this study was to identify cost and determinants of AKI after total joint arthroplasty.

Methods: A retrospective case-controlled study was conducted with 1719 primary elective total hip or knee replacements performed from January 2004 through September 2015 at an urban teaching hospital. Patients who developed AKI were matched in a 1:3 ratio with those in a control group who did not develop AKI based on age, sex, race, operated joint, and comorbidities including hypertension and diabetes. Increased postoperative serum creatinine was considered indicative of AKI.

Results: Fifty-four patients (3.1%) had AKI that was significantly associated with increased length of hospital stay (8.07 days) compared with that of the control group (4.50 days, $P < .0001$) and incurred significantly higher hospital charges ($224,533) than those of the control group ($142,753, $P < .0001$). We identified high body mass index, undergoing bilateral surgery in one session, high estimated blood loss, and longer duration of surgery as significant risk factors for AKI in univariate analysis. Elevated preoperative creatinine, large postoperative drop in hemoglobin, and high American Society of Anesthesiologists physical status scores were significant independent predictors of AKI in multivariate analysis.

Conclusions: Health-care providers and patients should work together to manage risk factors and to lower the risk of morbidity and mortality, longer in-hospital stay, and high associated costs of AKI.

Introduction

Total joint arthroplasty (TJA) surgery can improve the quality of life for many patients suffering from disabling arthritis of the hip and knee. However, complications after TJA can have a profound impact on patients and health-care systems. Periprosthetic joint infection [1-3], aseptic loosening, implant failure, wound dehiscence, deep vein thrombosis [4-6], dislocation of the prosthesis [7,8], and impaired renal function [9-12] are among the high-impact complications. Renal impairment after TJA is associated with an increased rate of in-hospital stay and long-term mortality [13,14]. A significant number of patients who undergo TJA have comorbid conditions such as hypertension (HTN) and diabetes, and the medications used to manage these conditions may impair renal function [6,15-18]. Risk factors and costs associated with acute kidney injury (AKI) after TJA have not been investigated before using the latest Kidney Disease: Improving Global Outcomes (KDIGO) criteria recommended by the International Society of Nephrology. The aim of this study is to use the latest AKI criteria to identify modifiable risk factors for renal impairment after TJA. Before an elective primary TJA, health-care providers and patients may work together to manage these factors and to lower the risk and associated costs of AKI thereby reducing morbidity and mortality while enhancing quality of life.

Material and methods

A retrospective case-controlled study approved by the institutional review board committee of our institution was performed at a large urban teaching hospital. All patients who underwent primary total hip or knee joint arthroplasty from January 2004 through September 2015 were screened for developing acute

No author associated with this article has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to https://doi.org/10.1016/j.artd.2018.05.002.

* Corresponding author. University Orthopedic Institute at Hahnemann, 216-220 North Broad Street, Feinstein Building, 2nd Floor, Philadelphia, PA 19102, USA. Tel.: +1 215 762 2663.

E-mail address: norman.johanson@tenethealth.com

https://doi.org/10.1016/j.artd.2018.05.002

renal failure using the International Classification of Diseases, Ninth Revision (ICD-9) diagnosis codes (code 5845 for acute kidney failure with lesion of tubular necrosis and code 5849 for acute kidney failure, unspecified). Demographic and perioperative data were obtained from the institution's computerized database and electronic medical record. A total of 1719 patient charts were screened, and all episodes of renal impairment were investigated. Patients who underwent arthroplasty for fracture, patients with missing data, and patients who did not meet the KDIGO criteria for AKI were excluded (Fig. 1).

In the literature, there is no single definition for acute renal impairment. We used the staging guidelines for AKI developed by the KDIGO AKI work group [19]. Recently, this classification has been demonstrated to be a good predictor of AKI in hospitalized patients and cardiac patients [20]. In addition, it was found that the criteria for AKI are independently associated with mortality [20,21]. Stage 1 AKI is defined as a serum creatinine (SCr) increase of 1.5-1.9 times the baseline (preoperative) value within 1 week or a 0.3-mg/dL increase in SCr within 48 hours. Stage 2 AKI is defined as an increase of 2.0-2.9 times the baseline, and stage 3 AKI is 3.0 times the baseline or increase in SCr to greater than or equal to 4.0 mg/dL [22]. All patients who underwent an elective primary TJA and met the criteria for AKI stages 1-3 were included in this study. We then matched the cases that developed AKI to a control group in a 1:3 ratio. The matching criteria were sex, age (within ±3 years), race, operated joint (hip or knee), and comorbidities including HTN and diabetes. We tried to find the closest possible match for each patient from our database.

The perioperative variables investigated for an association with postoperative AKI are listed in Table 1. Preoperative data collected for analysis as potential risk factors for AKI include body mass index (BMI), smoking status, American Society of Anesthesiologists (ASA) physical status score, SCr, hemoglobin (Hb), nonsteroidal anti-inflammatory drug (NSAID) use, angiotensin-converting enzyme inhibitor use, angiotensin receptor blocker use, and diuretic use. We sought to investigate drugs that target kidney function to assess them as potential risk factors for AKI after TJA. We also chose the preoperative variable of SCr as a proxy of kidney function before TJA because it is inversely proportional to kidney glomerular filtration rate. We categorized patients based on low (1,2) and high (3,4) ASA scores. Intraoperative data collected for analysis as potential risk factors for AKI included type of anesthesia, having either unilateral or bilateral surgery in one session, duration of surgery, and estimated blood loss (EBL). Postoperative variables included the lowest Hb value within 1 week and postoperative NSAID use. We used the postoperative SCr value as an outcome measure to determine AKI status. We calculated the difference between preoperative and postoperative Hb levels to analyze the drop in Hb, postoperatively. We also collected data on length of stay and total hospital charges to evaluate the in-hospital and economic burden associated with AKI after TJA.

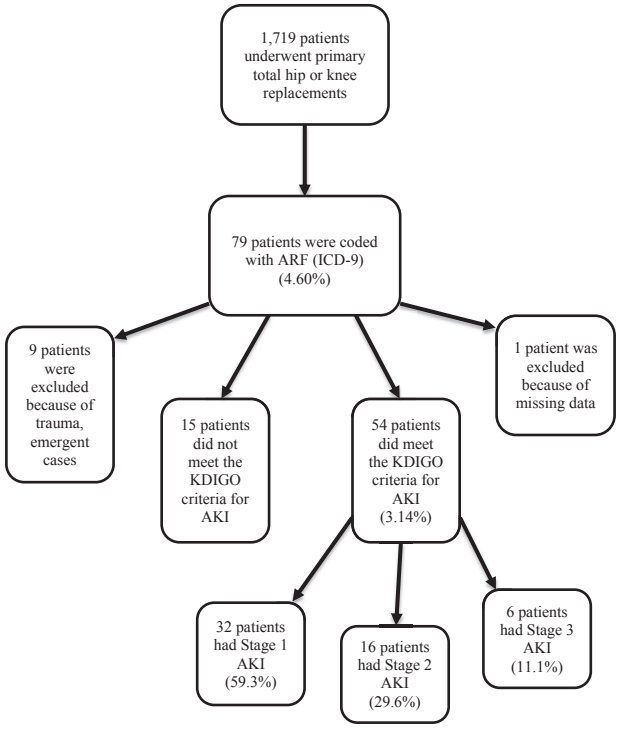

Figure 1. Flow chart showing the process of selecting the patients.

Table 1
Variables examined as potential predictors of AKI after TJA.

Preoperative variables	Intraoperative variables	Postoperative variables
1. BMI	1. Type of anesthesia	1. Postoperative Hb difference
2. SCr	2. Unilateral or bilateral	2. NSAID use
3. Smoking status	3. Duration of surgery	3. LOS
4. ASA score	4. EBL	4. Hospital charges
5. NSAID use		
6. ACE-I use		
7. ARB use		
8. Diuretic use		

ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; LOS, length of stay.

We analyzed the relationship between potential risk factors and their distribution among the case and control groups using univariate analysis. The means for continuous variables and the frequency distribution for categorical variables are reported. To compare continuous variables between cases and controls, the Student's t test was used; to compare frequency distributions, χ^2 analysis was used. Multivariable binary logistic regression analysis was performed, using the enter method to minimize bias, to identify variables that were significant predictors associated with AKI after adjusting for potential confounders. Results were considered statistically significant when the P value was $<.05$. We used SPSS 24 software for the statistical analysis.

Results

During the study period, 54 episodes of AKI occurred in patients who underwent elective primary TJA. In this group, there were 19 (35.2%) total hip arthroplasties and 35 (64.8%) total knee arthroplasties. There were 32 (59.3%) women and 22 (40.7%) men in this group, with a mean age of 61 years (range, 26-89 years). Forty-two (77.8%) patients were identified as black, 10 (18.5%) patients were identified as white, and 2 (3.7%) patients were identified as other. Within this group, 51 (94.4%) patients had HTN and 21 (38.9%) patients had diabetes. The incidence of AKI under the KDIGO criteria in this group was 3.14%. Of these patients, 32 patients (59.3%) developed stage 1 AKI, 16 patients (29.6%) developed stage 2 AKI, and 6 patients (11.1%) developed stage 3 AKI.

The control group consisted of 162 patients who did not develop postoperative renal damage. There were 94 (58.8%) women and 68 (42.0%) men in this group, with a mean age of 60 years (range, 41-89 years). One hundred twenty-eight (79.0%) patients were identified as black, 30 (18.5%) were identified as white, and 4 (2.5%) were identified as other. Within this group, 155 (95.7%) had HTN and 74 (45.7%) had diabetes.

Univariate analysis of individual preoperative and intraoperative risk factors, postoperative variables, and the corresponding P values are summarized in Table 2. Patients who developed postoperative