Original Article

Chronic Kidney Disease Is an Independent Risk Factor for Transfusion, Cardiovascular Complication, and Thirty-Day Readmission in Minimally Invasive Total Knee Arthroplasty

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A B S T R A C T

Background: Little is known about the relationship between chronic kidney disease (CKD) and minimally invasive total knee arthroplasty (MIS-TKA). We hypothesized that CKD was an independent risk factor for postoperative complications and increased blood transfusion in patients following MIS-TKA.
Methods: A retrospective review of a prospective database was conducted on patients who underwent MIS-TKAs at an academic medical center between 2009 and 2012. Glomerular filtration rates (GFRs) were calculated for each patient at the time of surgery and a CKD group of 205 patients (GFR < 60 mL/min) were matched at a ratio of 1:2 with 410 patients showing a GFR $\geq$ 60 mL/min (control group). There were no differences between the 2 groups regarding age, gender, body mass index, and American Society of Anesthesiologists grade. Patient characteristics, comorbidities, preoperative hemoglobin, calculated total blood loss, transfusion rate, length of stay, and postoperative complications were compared between the 2 groups.
Results: The CKD group had lower preoperative hemoglobin levels; higher preoperative comorbidities with cardiovascular disease, diabetes mellitus, and gout; longer length of stay; and higher total blood loss than the control group. Multivariate logistic regression showed that CKD was an independent risk factor for transfusions (odds ratio [OR] 7.6, 95% confidence interval [CI] 4.79-12.21, $P < .001$), cardiovascular complication (OR 5.5, 95% CI 1.68-9.39, $P = .002$), and 30-day readmission (OR 6.2, 95% CI 1.98-12.18, $P = .005$).
Conclusion: Based on our data, CKD is an independent risk factor for blood transfusion, cardiovascular complication, and 30-day readmission in patients undergoing MIS-TKA.

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The prevalence of chronic kidney disease (CKD) has increased significantly over the past decade [1], particularly in the older population. More than 10% of adults have CKD [2] and this figure rises to 40% in those over the age of 60 years [3]. The national prevalence of CKD was 11.9% in Taiwan [4] and 14% in the United States [5]. Reduced kidney function increases incidence of cardiovascular disease and leads to a high mortality rate [6].

CKD patients manifest many abnormalities in their hemostatic response that may account for their increased risk of both atherothrombotic events and bleeding [7]. For early stages of CKD, patients are typically associated with a prothrombotic tendency, whereas in the end-stage of renal disease, patients suffer from both prothrombotic and bleeding tendencies. Therefore, CKD itself has been reported as both a covariate and as an independent risk factor for adverse surgical outcome after total knee arthroplasty (TKA) [8,9]. This includes a higher rate of postoperative cardiovascular complication and infection which lead to a longer hospital stay.

Minimally invasive total knee arthroplasty (MIS-TKA) has been reported to reduce blood loss and length of hospital stay, quicker rehabilitation with an earlier return to work [10,11]. MIS-TKA was also reported as an effective surgery in octogenarian patients with similar postoperative cardiovascular or cerebrovascular complications compared to nonoctogenarian patients [12]. Meanwhile, more

than one-third of the population aged 70 or older in the United States has moderate or severe CKD [13] and patients of this age are predisposed to have TKA in their lifetime. Therefore, MIS technique may be first considered in CKD patients requiring TKA. But it is unclear whether MIS technique is associated with decreased blood loss and subsequent postoperative complications in CKD patients undergoing TKA.

The primary goal of this case-controlled study was to retrospectively review blood loss, transfusion rate, and all postoperative complications for CKD patients undergoing MIS-TKAs.

Materials and Methods

A retrospective analysis of prospectively collected data of primary TKA patients was conducted. This study was approved by our Institutional Review Board. All patients undergoing elective TKAs performed by a single surgeon between January 2009 and December 2012 in our hospital were included in this study. A total of 205 patients with CKD were included in our study. The exclusion criteria included revision surgery, unicompartmental knee arthroplasty, and conventional TKA procedures.

All operations were performed by the same surgeon using the mini-midvastus approach for MIS-TKA according to Haas et al [14]. An intramedullary alignment rod was used for femoral preparation and an extramedullary guide system for tibial preparation. The femoral canal was routinely plugged with bone. All the implants were secured with antibiotic-laden bone cement. The tourniquet was not released until skin closure and the application of a compressive dressing. Two intra-articular drains were used with open drainage (ie, without compression of the bag) during the first 12 h after surgery. The vacuum bag was then fully compressed to create a negative pressure. The volume of blood drained was recorded until the drains were removed on the second postoperative day. Nonsteroidal anti-inflammatory drugs were avoided in CKD patients after surgery. All patients used oral Factor Xa inhibitor or low molecular weight heparin as deep vein thrombosis (DVT) prophylaxis.

We calculated the estimated glomerular filtration rate (eGFR) by the abbreviated Modification of Diet in Renal Disease (MDRD) equation [15]:

$$eGFR\left(\mathrm{mL/min}/1.73m^2\right) = 186$$
$$\times \text{ serum creatinine } (mg/dL)^{-1.154}$$
$$\times age(year)^{-0.203}$$
$$\times (0.742 \text{ if the patient was female})$$

CKD was defined as eGFR < 60 mL/min/1.73 m^2 [16]. Patients with CKD were matched within a 1:2 ratio with the patients whose eGFR was ≥60 mL/min/1.73 m^2, controlling for age, gender, body mass index (BMI), and American Society of Anesthesiologists (ASA) grade. Preoperative data including diagnosis of the knee disease, hemoglobin (Hb) level, prothrombin time/international normalized ratio (PT/INR), platelet count, preoperative severity of knee deformity measured by mechanical axis, preoperative range of motion, and preoperative comorbidities were collected. Postoperative data including operative time, wound length, length of stay, numbers requiring blood transfusion, unit of transfusion, and postoperative days 1, 2, and 4 Hb levels were collected. Postoperative complications including cardiovascular events (hypotension, congestive heart failure, arrhythmic episode, or myocardial infarction requiring acute in-hospital treatment), neurologic (stroke, delirium/confusion), pulmonary complication (pneumonia/atelectasis), acute renal injury (oliguria < 500 mL/d or creatine levels that

are <30% from preoperative level), upper gastrointestinal bleeding, DVT/pulmonary embolism (PE), wound complications (hematoma formation, dehiscence, cellulitis, or superficial infection), deep infection requiring surgical debridement or prosthesis removal, 30-day readmission, and 1-year mortality were all recorded.

The total blood loss (TBL) was calculated from the maximum Hb loss and the amount of blood transfused [17,18]. The formula can be summarized as follows:

$$\text{Total blood loss} = (total\ blood\ volume$$
$$\times [change\ in\ Hb\ level \div preoperative\ Hb\ level])$$
$$+ volume\ transused$$

The trigger for allogenic blood transfusion was set at an Hb level of 8 g/dL in healthy patients or between 8 and 9 g/dL in patients with symptoms of anemia. In patients with cardiovascular disease, the transfusion threshold was adjusted to an Hb level of 9 g/dL [19]. If CKD patients had preoperative Hb <10 mg/dL, early blood transfusion was conducted to prevent deterioration of renal function.

Power Calculation

The sample size required for the study was based on the retrospective analysis of 526 patients undergoing elective total knee and hip arthroplasty, including revision procedures [20]. Because population data suggested that patients with CKD should constitute approximately 20% of our surgical population, a sample size of 84 patients in each group achieved 80% power to detect a difference at an overall significance level of 0.05.

Statistical Analysis

Categorical data were summarized as absolute values (percentage). Continuous data were presented as mean ± standard deviation. The differences among patients with CKD and the control group were analyzed with use of the chi-squares test for categorical variables and the independent t-test for continuous variables. Multivariate logistic regressions were used to determine if CKD was an independent predictor for transfusion, cardiovascular, neurologic, pulmonary, renal, upper gastrointestinal bleeding, DVT, PE, wound/deep infection complications, 30-day readmission, and 1-year mortality. A full regression model was created for each complication, transfusion, 30-day readmission, and 1-year mortality, incorporating all possible factors, including the following demographics: age, gender, BMI, ASA, diagnosis, preoperative Hb, PT/INR and platelet count, preoperative knee deformity by mechanical axis, range of knee motion, and the comorbidities—cardiovascular (coronary artery disease, congestive heart failure), diabetes mellitus, liver disease, lung disease, and gout. The odds ratios (ORs) and 95% confidence intervals (CIs) were based on the multivariate analyses and presented in a forest plot. Statistical analysis was completed by using software (version 14.12.0; MedCalc, Ostend, Belgium). P-values <.05 were considered statistically significant.

Results

Of the 1529 total patients in the study period database, 205 (13.4%) had CKD. Most patients with CKD were in stage 3 (88.8%). The rest were in stage 4 (6.8%) and stage 5 (4.4%). Meanwhile, 410 patients without CKD were matched to the patients with CKD based on age, gender, BMI, and ASA grade. The mean follow-up time was 2.7 years (range 2-4.8 years). Patient characteristics