Impact of Chronic Kidney Disease Stage on Lower-extremity Arthroplasty

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End-stage renal disease and dialysis is commonly associated with poor outcomes after joint replacement surgery. The goal of this study was to evaluate postoperative complications in patients with less advanced chronic kidney disease undergoing total hip arthroplasty (THA) or total knee arthroplasty (TKA). Patients who underwent THA or TKA between 2004 and 2011 with stage 1, 2, or 3 chronic kidney disease were retrospectively reviewed via an electronic medical record. The authors compared 377 patients who had stage 1 to 2 chronic kidney disease with 402 patients who had stage 3 chronic kidney disease. No significant differences in 90-day readmission or revision rates were found between the stage 1 to 2 and stage 3 patient groups. For patients with stage 3 chronic kidney disease, the overall mortality rate was greater than that in patients with stage 1 to 2 chronic kidney disease. However, when adjusted for comorbid disease, no significant increases were seen in joint infection, readmission, or early revision between patients with stage 1 to 2 chronic kidney disease vs patients with stage 3 chronic kidney disease. The overall incidence of infection was high (3.5%) but far less than reported for patients with end-stage renal disease, dialysis, and kidney transplant. In conclusion, patients with stage 1, 2, or 3 chronic kidney disease may have a higher than expected rate of prosthetic joint infection (3.5%) after total joint arthroplasty. Patients with stage 3 chronic kidney disease are at higher risk for postoperative mortality compared with those with lesser stages of kidney disease.
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corbidities in patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) are known to cause poor outcomes, including increased hospital readmission rates, greater length of stay, and higher mortality rates. Risk factors for poor surgical outcomes include hepatitis C, coronary disease, hypertension, previous deep venous thrombosis, diabetes mellitus, and chronic kidney disease. Because the incidence of THA and TKA is projected to increase by 174% and 673%, respectively, by 2030, it is of increasing importance for surgeons to accurately inform patients of the risk of complications after joint replacement.

The prevalence of chronic kidney disease in the United States increased from approximately 10% in 1994 to 14% in 2010. Classically, it is diagnosed by a chronically low estimated glomerular filtration rate, albuminuria, or both. In patients with chronic kidney disease, the incidence of total joint arthroplasty is increased compared with the general population. Additionally, chronic kidney disease is associated with comorbidities such as obesity, diabetes mellitus, hypertension, and glomerulonephritis, each of which is an independent risk factor in total joint arthroplasty. Consequently, it is important to inform patients with chronic kidney disease of risks associated with THA or TKA. Multiple studies have examined outcomes of total joint arthroplasty in patients with end-stage (stage 4-5) chronic kidney disease and in renal transplant recipients, showing higher risk of increased length of stay, readmission, and mortality in this population. However, to the authors’ knowledge, no previous study has reported the outcomes of patients with intermediate stages of chronic kidney disease undergoing THA and TKA.

The goal of this study was to assess the infection, revision, 90-day readmission, and mortality rates of patients with stage 1, 2, or 3 chronic kidney disease who did not require dialysis or transplantation and were undergoing elective THA or TKA. The hypothesis was that progressive stages of chronic kidney disease lead to increased complication rates in this patient population.

**Materials and Methods**

A retrospective review of the electronic medical record at Geisinger Health System from May 2004 to April 2011 was performed after institutional review board approval was obtained. Patients included in the study were adults (≥18 years) who underwent THA or TKA and were previously diagnosed as having stage 1 to 3 chronic kidney disease, based on the presence of proteinuria, as well as 2 elevated glomerular filtration rates separated by at least 90 days. Follow-up data were collected through May 2012.

Patients were categorized into stages 1 to 2 (n=377) based on estimated glomerular filtration rate of 60 mL/min or greater with proteinuria and stage 3 (n=402) based on estimated glomerular filtration rate of 30 to 59 mL/min. Excluded from the study were patients who were lost to follow-up, had known infection before surgery, had previous hip or knee surgery, underwent THA or TKA because of open fracture, were pregnant within 6 months before surgery, or had an acute kidney injury within 1 month before surgery.

Baseline data collected immediately before surgery included age, sex, body mass index, HgbA1c level, total cholesterol level, albumin level, and history of rheumatic disease, congestive heart failure, diabetes mellitus, or coronary disease. Outcome data collected by manual chart review included mortality, complications (hematoma and infection), reoperation (revision and repeat debridement and irrigation [D&I]), and readmission for any reason within 90 days. Infection after total joint arthroplasty in patients with end-stage renal disease was defined as bacterial growth on solid media, permanent histologic sections with acute inflammation, growth of the same bacteria from at least 2 deep cultures, or the presence of pus around the prosthesis.

Chi-square analysis was used to compare the percentage of patients with 90-day readmission in the stage 1 to 2 and stage 3 groups. For the remaining outcomes, a series of Cox proportional hazards survival models, both unadjusted and adjusted for covariates, were used to compare all-cause mortality, revision, and infection between the stage 1 to 2 and stage 3 groups. Because of differences observed between the patients with THA and those with TKA during preliminary analysis, the authors also repeated the adjusted models stratified by joint replaced. Unless otherwise noted, all results reported here are based on the models adjusted for age, sex, joint replaced, and body mass index at the time of surgery. P<.05 represented a statistically significant difference between any 2 groups.

**Results**

Seven hundred seventy-nine patients met the inclusion criteria. Of these, 377 had stage 1 to 2 chronic kidney disease and 402 had stage 3 chronic kidney disease. Approximately 71% of both groups—patients with stage 1 to 2 chronic kidney disease (n=268) and patients with stage 3 chronic kidney disease (n=286)—underwent TKA. Baseline characteristics of all patients are shown in Table 1.

Table 2 shows the clinical outcomes of the 2 patient groups at final follow-up. Table 3 and the Figure show the results of survival analyses. As expected, the mortality rate was higher in the patients with stage 3 chronic kidney disease than in the patients with stage 1 to 2 chronic kidney disease (P=.02). A marginally significant lower risk of infection was seen in the patients with stage 3 chronic kidney disease (P=.07), and no difference was seen in the risk of revision between the 2 groups (P=.45). The percentages of patients in both groups who required 90-day readmission were similar (10% vs 9%, P=.68).
Table 4 shows the results of secondary analysis, which stratified patients by type of joint replacement (THA or TKA). The significant difference in the mortality rate between the stage 1 to 2 group vs the stage 3 group persisted in patients who had undergone THA ($P=0.02$) but not in patients who had undergone TKA ($P=0.29$). The marginal difference in infection risk that was seen in the overall data set did not persist in either the TKA or the THA group when examined separately ($P=0.10$ and $P=0.43$, respectively).

As in the overall analysis, there continued to be no significant difference in the rate of revisions between patients with stage 1 to 2 chronic kidney disease and those with stage 3 chronic kidney disease in either the TKA or the THA subgroup ($P=0.24$ and $P=0.78$, respectively). The rate of 90-day readmissions was slightly lower in patients with stage 1 to 2 chronic kidney disease than in patients with stage 3 chronic kidney disease in the TKA subgroup (7% vs 8%) and slightly higher in the THA subgroup (18% vs 11%). However, neither of these differences achieved statistical significance ($P=0.55$ and $P=0.17$, respectively).

**Discussion**

The rates of chronic kidney disease and total joint arthroplasty in the United States are of increasing importance, as the incidence of both continue to rise. Previous studies have examined operative treatment of patients with several comorbidities, including hepatitis C, coronary disease, hypertension, previous deep venous thrombosis, and diabetes mellitus, with an emphasis on postoperative complications. These studies found increased rates of postoperative readmission, length of stay, and mortality. Accordingly, it is essential for orthopedic surgeons to recognize the health care burden of this population and to assess the outcomes of elective joint arthroplasty in patients with chronic kidney disease. When examining operatively treated patients with chronic kidney disease.
Table 3

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Cox Proportional Hazards Regression</th>
<th>Hazard Ratio (Stage 3 vs Stage 1-2) (95% CI)</th>
<th>Nonparametric Rank Testing P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>Unadjusted model</td>
<td>2.02 (1.11-3.68)</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>Adjusted for age, sex, BMI, joint replaced</td>
<td>2.09 (1.14-3.80)</td>
<td>.02</td>
</tr>
<tr>
<td>Revision</td>
<td>Unadjusted model</td>
<td>0.78 (0.44-1.36)</td>
<td>.38</td>
</tr>
<tr>
<td></td>
<td>Adjusted for age, sex, BMI, joint replaced</td>
<td>0.80 (0.46-1.41)</td>
<td>.45</td>
</tr>
<tr>
<td>Infection</td>
<td>Unadjusted model</td>
<td>0.46 (0.20-1.01)</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td>Adjusted for age, sex, BMI, joint replaced</td>
<td>0.47 (0.21-1.06)</td>
<td>.07</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index.

Figure: Survival curves for mortality, revision, and infection for patients with stage 1-2 vs stage 3 chronic kidney disease. Mortality rates in both groups (A). Revision rates in both groups (B). Infection rates in both groups (C).
and infection in patients with implanted prostheses. As the severity of chronic kidney disease increases, infection is of increasing concern for patients undergoing surgery. Overall, the current study population had a relatively high infection rate of 3.5%. Within the study, the infection rate was marginally increased in patients with stage 1 to 2 chronic kidney disease compared with those with stage 3 chronic kidney disease ($P = .05$). However, this finding may not be truly significant because a model adjusted for age, sex, body mass index, and joint replaced did not show significance ($P = .07$) (Table 3). When divided further among subgroups of THA vs TKA, no significant difference in infection rate was seen in patients with early-stage chronic kidney disease. Hence, the elevated infection rate may be caused by the burden of comorbid disease in the study population as a whole and is not likely related to worsening severity of chronic kidney disease between the study groups.

Limitations of this study included those inherent to any retrospective review. Additionally, the authors were unable to distinguish between patients with stage 1 and patients with stage 2 chronic kidney disease because the reporting of estimated glomerular filtration rate in the electronic medical record did not allow stratification of patients in this manner. Although the authors found no increased risk between patients with stage 1 to 2 chronic kidney disease and those with stage 3 chronic kidney disease, they were unable to assess the risks between patients with stage 1 and stage 2 chronic kidney disease, which could have proven significant. There was also no matched baseline control group to allow comparison of rates of postoperative mortality, reoperation, and complications. This would have been helpful when addressing infection rates because the overall incidence of infection was rather high in the study population (3.5%). Nevertheless, this may be explained by the high prevalence of comorbidities other than chronic kidney disease in this patient population, including diabetes mellitus (20%) and obesity (average body mass index, 32.4).

### Table 4

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Total Knee Arthroplasty</th>
<th>Total Hip Arthroplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cox Proportional Hazards Regression</td>
<td>Cox Proportional Hazards Regression</td>
</tr>
<tr>
<td></td>
<td>Hazard Ratio (Stage 3 vs Stage 1-2) (95% CI)</td>
<td>Hazard Ratio (Stage 3 vs Stage 1-2) (95% CI)</td>
</tr>
<tr>
<td></td>
<td>$P$</td>
<td>$P$</td>
</tr>
<tr>
<td>Death</td>
<td>Unadjusted model</td>
<td>1.43 (0.66-3.09)</td>
</tr>
<tr>
<td></td>
<td>Adjusted for age, sex, BMI</td>
<td>1.53 (0.72-3.31)</td>
</tr>
<tr>
<td>Revision</td>
<td>Unadjusted model</td>
<td>0.67 (0.33-1.35)</td>
</tr>
<tr>
<td></td>
<td>Adjusted for age, sex, BMI</td>
<td>0.66 (0.33-1.33)</td>
</tr>
<tr>
<td>Infection</td>
<td>Unadjusted model</td>
<td>0.46 (0.19-1.15)</td>
</tr>
<tr>
<td></td>
<td>Adjusted for age, sex, BMI</td>
<td>0.47 (0.19-1.17)</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index.

### Conclusion

The results of the current study showed that the increased risk of perioperative complications seen in patients with end-stage renal disease occurs late in the course of disease. However, the mortality rate was higher in patients with stage 3 chronic kidney disease compared with patients with stage 1 to 2 chronic kidney disease. Additionally, the overall risk of infection in this study (3.5%) was higher than routinely reported for most THA and TKA populations. However, it is unclear whether the higher rate of infection was the result of any degree of chronic kidney disease or other confounding comorbidities within the study population. Based on this study, the surgeon author (T.R.B.) continues to perform total joint arthroplasty in patients with chronic kidney disease who are not receiving dialysis, but preoperatively counsels patients with stage 1, 2, and 3 chronic kidney disease that they may have a higher than expected rate of prosthetic joint infection (3.5%). Also, patients with stage 3 chronic kidney disease are informed that their renal dis-
ease has been associated with a higher risk of postoperative mortality compared with lesser stages of kidney disease.

REFERENCES


