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Case study

Does chronic kidney disease affect the mortality rate in patients undergoing spine surgery?

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ABSTRACT

The number of patients with chronic kidney disease (CKD) and their life expectancy has been increasing. With time number of patients undergoing spine surgery has also been on a rise. This study we did a retrospective review of registry data to investigate the mortality rate of chronic kidney disease patients following spine surgery using a large, multi-center spine registry. 12,276 consecutive spine-fusion patients from January 2009 to December 2012 were included and mortality rates in patients with CKD compared to those with normal kidney function following spine surgery. Logistic regression was usedto evaluate risk of mortality following spine surgery. The average age of the cohort was 59 (SD = 13.4). 53% were female. Patients who had stage 3, 4 or 5 CKD were older than non-CKD patients (mean = 71,SD = 9.2 vs. 59, SD = 13.3). After adjusting for confounding variables, patients with stage 3 or 4 CKD had higher mortality rates than patients with normal kidney function (OR 1.78, 95% CI 1.3-2.45) Hemodialysis-dependent patients (stage 5 CKD) had even higher rates of mortality compared to patients with normal function (OR 4.18, 95% CI1.87-9.34). our findings suggest that spine surgery is associated with significantly higher mortality rates in patients with CKD compared to patients with normal kidney function. Understanding the additional morbidity and mortality of spine surgery in this medically complicated group of patients is imperative for accurate preoperative risk assessment.

1. Introduction

Globally, the number of patients with chronic kidney disease (CKD) has been on the rise [1,4,5]. In 2001, there were an estimated 1 million people undergoing hemodialysis worldwide and this number was expected to grow by 7% annually [6,7]. Chronic renal diseases is prevalent in 13% of the population in united states [8]. In 2004, with 320,000 patients undergoing dialysis the United States had the highest number of Chronic dialysis patients in the world [4]. This increasing number of patients with CKD is associated with the rise in incidence of diabetes mellitus, advances in the medical management of CKD, kidney transplant technology, and hemodialysis treatments [1–3,9]. The number of CKD patients requiring spine surgery is also expected to increase, which presents a challenge to spine surgeons caring for these patients with multiple medical comorbidities. These comorbid conditions—including Hypertension, Diabetes mellitus, cardiac diseases like congestive heart failure, arrhythmias and coronary artery diseases, osteoporosis, destructive spondyloarthropathy, laboratory abnormalities, and poor overall health, create unique perioperative and surgical challenges [1,10,11]. Patients suffering from chronic renal failure have an altered protein and carbohydrate metabolism as well as an altered electrolyte and acid base balance [12]. These patients also have an increased susceptibility to post op infections due to their decreased cell mediated immunity, altered macrophage and neutrophil function and serum iron overload [13]. All these factors together account for higher mortality and morbidity in these patients undergoing spine surgery.

Data on CKD's effect on morbidity, mortality, and overall clinical outcomes following spinal surgery is sparse. Only large studies has looked closely at in-house mortality rates in a large series of spine surgery patients requiring hemodialysis [14]. However, the mortality rate in CKD patients following spine surgery after the hospitalization period is unknown. In addition, how the presence of CKD affects mortality rates following spine surgery in the

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non-hemodialysis-dependent patient is unclear. The purpose of this study was to evaluate the mortality rate following spine surgery in a large, multi-center series of chronic kidney disease patient, including both those on hemodialysis and those not hemodialysis-dependent.

2. Materials and methods

Beginning in January of 2009, our integrated health system began compiling clinical data on all patients undergoing instrumented spine fusion surgery. These clinical data were collected for all patients who underwent a spine fusion procedure performed in the cervical, thoracic, or lumbosacral spine for any operative indication. Patients who underwent instrumented spine fusion were identified through Electronic Medical Record (EMR) data, procedural codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM codes), manufacturers' implant catalogs reference numbers, as well as manual chart review. Electronic screening algorithms were used to detect reoperations and revisions subsequent to the index spinal procedure. Adjudication via chart review was performed following the CDC (Centers for Disease Control and Prevention) guidelines to identify postoperative infections. The patient characteristics and variables included in our database are shown in Table 1.

For this study, pediatric patients (<18 years old), patients who had liver transplants, and patients who underwent fusion procedures involving multiple regions (such as cervical-lumbar or cervical-thoracic-lumbar fusions) were excluded. eGFR for each patient was calculated using the Modified Diet in Renal Disease [15] equation: $\text{eGFR} = 186.3 \times \text{serum creatinine}^{-1.154} \times \text{age}^{-0.203} \times 1.212$ (if patient race is black) $\times$ 0.742 (if female). For analysis purposes, we grouped patients into one of three groups based on ICD-9 codes according to the Elixhauser comorbidity index [16] those without CKD, those with CKD but not dialysis-dependent (CKD stage 3 & 4) and, finally, those CKD patients who required hemodialysis (CKD stage 5). The primary outcome measure for this study was overall mortality rate. Frequencies, proportions, means, standard deviations (STD), medians, and interquartile ranges (IQR) were reported for the study sample. When comparing patients with CKD to those without CKD, Chi-square tests were used for categorical variables, while a student's t-test was used for continuous variables. Logistic regression was used to estimate the association of mortality in the CKD group compared to that of the non-CKD group. Patient characteristics, surgical characteristics, spine regions fused, American Society of Anesthesiologists (ASA) status, and comorbidities were evaluated as potential confounders. Variables that had no significant effect on the association and were not clinically relevant were excluded from the model. The final model was adjusted for age, gender, body mass index (BMI), diagnosis for the index fusion procedure, bone morphogenetic protein (BMP) usage, smoking status, diabetes and several other comorbidities. All data analysis was performed using SAS (Version 9.2, SAS Institute, Cary, NC, USA) and $p < 0.05$ was considered statistically significant.

3. Results

With our integrated health system's spine implant registry, 12,276 patients undergoing instrumented spine fusion procedures between January 2009 and December 2012 were identified. The average follow-up period was 1.86 years (IQR 0.93–2.91 years). 914 (7.4%) of the procedures were performed on patients with CKD (stage 3, 4 or 5), while 11,362 (93%) of the procedures were performed on patients with normal renal function. Table 1 shows a comparison of patient and surgical characteristics for patients with CKD and patients without CKD. The average age for patients with CKD was 70.8 years old (STD = 9.24), while the average age for patients without CKD was 58.6 (STD = 13.3). When compared to patients without CKD, the CKD patient had more females (53.6% vs. 52.4%), blacks (14.4% vs. 8.5%), and patients with ASA (scores $\geq$ 3 (6.2% vs. 1.3%). Patients over 70 years of age were also much more common in the CKD group compared to the non-CKD group (42.9% vs. 16.8%, respectively), as were patients with ASA scores of 4 or 5 (6.2% vs. 1.3%, respectively). As shown in Table 1, a wide range of operative diagnoses and surgical approaches involving a variety of operative spine regions characterized both groups of patients.

Table 2 shows a comparison of comorbidities for patients with CKD vs. those patients without CKD. Compared to the non-CKD control group, the CKD patients were more likely to suffer from diabetes (51.3% vs. 19%), anemia (31.4% vs. 11.2%), rheumatoid arthritis (7.7% vs. 3.6%), congestive heart failure (12.1% vs. 1.8%), coagulopathy (5.3% vs. 2.1%), hypertension (84.9% vs. 47.3%), hypothyroidism (17.5% vs. 9.5%), fluid and electrolyte disorders (17.9% vs. 8.1%), metastatic cancer (3% vs. 1.8%), other neurological disorders (6.3% vs. 4.5%), obesity (27.5% vs. 21.1%), paralysis (5.7% vs. 2.7%), peripheral vascular disease (19.5% vs. 5%), renal failure (90.7% vs. 0%), malignancy (2.2% vs. 1.2%), and cardiac valve disease (6.2% vs. 1.9%).

Table 3 compares mortality rates following spine surgery between patients with and without CKD, grouping stage 3 & 4 in one group and stage 5 separately. After adjusting for age, gender, BMI, diagnosis at index fusion surgery, BMP usage and comorbidities–including smoking, diabetes, deficiency anemia, congestive heart failure, chronic pulmonary disease, lymphoma, fluid and electrolyte disorders, metastatic cancer, other neurological disorders, paralysis, malignancy, and weight loss–patients with CKD not on hemodialysis (stage 3 or 4 CKD) had 1.78 (95% CI 1.3–2.45) times the risk of death following a spine fusion procedure compared to patients without CKD. Patients with CKD who were dialysis-dependent (CKD stage 5) had 3.98 (95% CI 1.79–8.9) times the risk of mortality when compared to patients without CKD. Other than kidney function, other risk factors for mortality include male gender, age, and operative indication of pathologic fracture/-trauma, smoking status, and all the comorbidities summarized in Table 3. The Kaplan Meir survival plot (Fig. 1) shows that the survival probability for stage 5 renal disease at end of 2 years after surgery is approximately 60%. At the end of 3 years the survivorship for stage 5 is down to approximately 45%. As opposed to that, patients with CKD stage 3 and 4, the 2-year survivorship is approximately 85% and at end 3 years is still over 80%.

4. Discussion

Prior studies have compared the index hospital mortality rate (with an average in–house period of 38.8 days), following spine surgery for dialysis-dependent CKD patients [14]. To our knowledge, our study is the first large-scale evaluation of mortality rates in CKD patients beyond the hospitalization period with an average follow-up was 1.86 years. This was made possible by the use of a comprehensive multi-center spine registry that compiles data from multiple facilities within our health system to assess clinical outcomes. Our study sample of 12,276 patients allowed us to identify statistical differences in mortality rates, to make meaningful comparisons, and to account for confounding variables between our three groups of patients. In addition, prior studies looked at surgical outcomes and mortality rates only in CKD patients who were hemodialysis-dependent [14,17,18]. However, CKD spans a spectrum of severity and may or may not require hemodialysis. One of the most widely recognized CKD staging systems was described