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The effect of renal dysfunction on short-term outcomes after lumbar fusion☆

Taylor E. Purvis, Remi A. Kessler, Christine Boone, Benjamin D. Elder, C. Rory Goodwin, Daniel M. Sciubba*

Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA

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ABSTRACT

Objective: To compare post-lumbar decompression and fusion complication rates and mortality for patients without preoperative hemodialysis (HD) use with and without renal dysfunction as estimated by glomerular filtration rate (GFR) and creatinine levels.

Patients and methods: Baseline and outcome data were obtained from the 2005–2014 American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database for patients over the age of 18 who underwent non-emergent lumbar fusion surgery. Preoperative HD status and GFR and creatinine levels were extracted. Variables analyzed included development of at least one complication, development of a major complication, in-hospital mortality, and length of stay.

Results: A total of 29,081 patients were identified. Those with severe preoperative kidney dysfunction as estimated by GFR were more likely to develop a complication (GFR = 15–30 ml/min/1.73 m^2; OR, 3.82; 95% CI, 2.061–7.082; $P = < 0.0001$ and GFR = 30–45 ml/min/1.73 m^2; OR, 2.124; 95% CI, 1.506–2.996; $P < 0.0001$). Compared to patients with normal preoperative creatinine levels (0.75–1.0 mg/dL), patients with elevated creatinine were more likely to develop at least one complication.

Conclusion: Patients with low estimated GFR and elevated creatinine levels were associated with higher perioperative morbidity. This increased risk should be taken into consideration when counselling this patient population.

1. Introduction

Chronic kidney disease (CKD) remains a worldwide public health problem, with a rising incidence and prevalence of kidney failure [1,2]. Over 660,000 individuals in the USA currently suffer from end-stage renal disease (ESRD) and 88% of these patients are being treated with hemodialysis (HD) [2] CKD's clinical progression is correlated with a multitude of major complications, including an increased risk of anemia, hyperlipidemia, metabolic bone disease, and cardiovascular disease. [3]. CKD patients have poorer quality of life, greater overall health care services utilization, and higher rates of morbidity and mortality [4–7].

CKD is of significant importance to spine surgeons due to the osseous manifestations distinctive of severely decreased renal function, as well as other systemic manifestations dependent on disease severity [8,9]. Among patients undergoing lumbar fusion, the presence of CKD has been shown to be associated with significantly worse clinical outcomes following 1–2 level posterolateral lumbar interbody fusion [10,11]. Because atherosclerosis often ensues following CKD onset, impaired blood flow due to the narrowing of arteries can exacerbate degeneration of the spine and neural tissue [12,13]. Therefore, CKD and subsequent systemic atherosclerosis may affect clinical outcomes and complications after decompressive surgery for lumbar pathology [14]. Because of the sheer volume of spinal lumbar procedures performed, a reasonable estimation and evaluation of risks is essential for clinical decision-making and patient counselling.[9]

With the emergence of databases such as the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, it is now possible to investigate clinical outcomes correlated with CKD among lumbar fusion patients within a large, nationally representative sample. Existing research on CKD

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* Corresponding author at: 600 North Wolfe Street, Meyer 5-185, Baltimore, MD 21287, USA.
E-mail address: Dsciubb1@jhmi.edu (D.M. Sciubba).

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and lumbar surgery using NSQIP has been limited to single years of data, non-specific lumbar procedures, and sole use of glomerular filtration rate (GFR) as an indicator of renal dysfunction [9]. To our knowledge, no studies have been performed examining the risks of CKD in lumbar fusion patients using multi-year NSQIP data, limited to lumbar fusion specifically and including creatinine as a marker of renal impairment among lumbar fusion patients. The objective of this study is to compare post-lumbar decompression and fusion complication rates for non-preoperative HD patients with and without renal dysfunction as estimated by GFR and creatinine levels. We hypothesized that patients with insufficient preoperative kidney function would have a higher risk of experiencing a major medical complication within one month of surgery than patients with normal kidney function, even after controlling for potential confounders.

2. Materials and methods

ACS-NSQIP is a database commonly used to assess data on inpatient and outpatient surgical procedures in U.S. hospitals. ACS-NSQIP collects information from participating hospitals that is based on the patient's medical chart, as opposed to billing or insurance claims data. This information is then risk-adjusted to allow for equitable comparison among hospitals nationwide [15]. Patients in the ACS-NSQIP database are representative of all insurance statuses, including those uninsured and those covered by private insurance, Medicare, and Medicaid. Since its inception in 2004, ACS-NSQIP has expanded to include 445 participating hospitals [16]. As of 2014, the database collects more than 150 variables for each surgical procedure entered, including demographic information, preoperative comorbidities, intraoperative variables, and 30-day postoperative mortality and morbidity data [17]. Procedures are reported using Current Procedural Terminology (CPT) codes. This study was deemed exempt from review by our Institutional Review Board (IRB00096323).

2.1. Inclusion criteria

Patients over the age of 18 undergoing lumbar fusion, excluding emergency cases, were identified using the CPT codes listed in Table 1. Patients who undwerwent these procedures between 2005 and 2014 were included for analysis. Multilevel lumbar fusion was indicated by CPT codes (Table 1; CPT codes 22614, 22585, 22632, 22634, 22842, 22843, 22844, 22845, 22846, and 22847). Patients who did not undergo treatment were excluded from analysis.

2.2. Collected data

The following baseline admission data were collected: age, gender, race, American Society of Anesthesiologists (ASA) status, osteotomy count, height, weight, revision status, and whether the procedure involved multiple levels. The Charlson Comorbidity Index (CCI) score was calculated from comorbidity information provided in the ACS-NSQIP database. These comorbidities included cancer, ascites or esophageal varices, end-stage renal disease, diabetes, chronic obstructive pulmonary disease, cerebrovascular accident or transient ischemic attack, rest pain or peripheral vascular disease, congestive heart failures, and myocardial infarction. For each decade above 40 years of age, one point was added to the overall estimated CCI score [18,19]. To estimate preoperative kidney function in patients without HD, the most recent lab values for creatinine collected within 90 days prior the operation were evaluated. Glomerular filtration rate (GFR) was then estimated using the CKD-Epi formula that accounts for race, gender, and age [20].

The primary outcome measure was the development of at least one perioperative complication during the 30 days following surgery. These complications included mortality, intraoperative events (myocardial infarction or cardiac arrest requiring resuscitation), acute renal failure, progressive renal insufficiency, nerve injury, deep vein thrombosis, ventilator use over 48 h, pneumonia, pulmonary embolism, cerebrovascular accident or stroke, myocardial infarction, cardiac arrest, wound dehiscence, urinary tract infection, sepsis, septic shock, superficial surgical site infection (SSI), deep SSI, organ space SSI, coma over 24 h, and unplanned re-intubation. Major complications were defined as 30-day mortality, intraoperative events, acute renal failure, ventilator use for over 48 h, pulmonary embolism, cerebrovascular accident or stroke, myocardial infarction, cardiac arrest, sepsis, septic shock, coma for over 24 h, and unplanned re-intubation. Other outcome data collected included length of stay (LOS), operative time, and blood transfusion status.

Table 1
List of surgical procedure groups included and corresponding subgroups identified by Current Procedural Terminology (CPT) codes.

Procedure Name	CPT code
Single Level Fusion	
Posterolateral Fusion, Lumbar (first level)	22612
Anterior Interbody Fusion, Lumbar (first interspace)	22558
Posterior Interbody Fusion, Lumbar (first interspace)	22630
Combined fusion, posterolateral fusion, with posterior interbody fusion (first interspace and segment)	22633
Multilevel Fusion	
Posterior Interbody Fusion, Lumbar (each additional interspace)	22632
Combined fusion, posterolateral fusion, with posterior interbody fusion (each additional interspace/segment)	22634
Posterior Instrumentation (segmental, 3–6 vertebral segments)	22842
Posterior Instrumentation (segmental, 7–12 vertebral segments)	22843
Posterior Instrumentation (segmental, 13+ vertebral segments)	22844
Anterior Instrumentation (3 vertebral segments)	22845
Anterior Instrumentation (4–7 vertebral segments)	22846
Anterior Instrumentation (8 or more vertebral segments)	22847
Posterolateral Fusion, Lumbar (each additional segment)	22614
Anterior Interbody Fusion, Lumbar (each additional interspace)	22585

CPT: Current Procedural Terminology.

2.3. Statistical analyses

Logistic regression models were used to test the effect of GFR and creatinine levels in non-HD patients on morbidity. Here, age was divided in to 18–45 years (reference group) and every 10 years of age thereafter. GFR was described in intervals of 15 ml/min/1.73 m^2 with a GFR of 75–90 ml/min/1.73 m^2 serving as the reference group. A creatinine level of 0.75–1.0 mg/dL was the reference level for creatinine analysis. Variables with a *P*-value less than 0.1 in univariate analyses were included in the multivariate logistic regression model. Results of logistic regression analysis are presented as odds ratios (OR) with 95% confidence intervals (CI). All data were analyzed using SPSS 24 (IBM, SPSS Inc., Chicago, Illinois, USA). A *P*-value of less than 0.05 was considered to be statistically significant.

3. Results

3.1. Patient characteristics

A total of 29,081 patients undergoing lumbar fusion with no preoperative HD were identified (Table 2). Overall, there were 2134