The Contemporary Incidence and Sequelae of Rhabdomyolysis Following Extirpative Renal Surgery: A Population Based Analysis

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Purpose: We evaluate the contemporary incidence and consequences of postoperative rhabdomyolysis after extirpative renal surgery.

Materials and Methods: We conducted a population based, retrospective cohort study of patients who underwent extirpative renal surgery with a diagnosis of a renal mass or renal cell carcinoma in the United States between 2004 and 2013. Regression analysis was performed to evaluate 90-day mortality (Clavien grade V), nonfatal major complications (Clavien grade III-IV), hospital readmission rates, direct costs and length of stay.

Results: The final weighted cohort included 310,880 open, 174,283 laparoscopic and 69,880 robotic extirpative renal surgery cases during the 10-year study period, with 745 (0.001%) experiencing postoperative rhabdomyolysis. The presence of postoperative rhabdomyolysis led to a significantly higher incidence of 90-day nonfatal major complications (34.7% vs 7.3%, $p < 0.05$) and higher 90-day mortality (4.4% vs 1.02%, $p < 0.05$). Length of stay was twice as long for patients with postoperative rhabdomyolysis (incidence risk ratio 1.83, 95% CI 1.56–2.15, $p < 0.001$). The robotic approach was associated with a higher likelihood of postoperative rhabdomyolysis (vs laparoscopic approach, OR 2.43, $p < 0.05$). Adjusted 90-day median direct hospital costs were USD 7,515 higher for patients with postoperative rhabdomyolysis ($p < 0.001$). Our model revealed that the combination of obesity and prolonged surgery (more than 5 hours) was associated with a higher likelihood of postoperative rhabdomyolysis developing.

Conclusions: Our study confirms that postoperative rhabdomyolysis is an uncommon complication among patients undergoing extirpative renal surgery, but has a potentially detrimental impact on surgical morbidity, mortality and costs. Male gender, comorbidities, obesity, prolonged surgery (more than 5 hours) and a robotic approach appear to place patients at higher risk for postoperative rhabdomyolysis.

Key Words: rhabdomyolysis; kidney; surgical procedures, operative; population groups

Abbreviations and Acronyms

ARF = acute renal failure
BMI = body mass index
CCI = Charlson comorbidity index
CG = Clavien grade
ERS = extirpative renal surgery
LOS = length of stay
OT = operating room time
PRM = postoperative rhabdomyolysis
RS = renal surgery
USD = US dollars

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RHABDOMYOLYSIS is the dissolution or disintegration of muscle, which is caused by cellular membrane lysis and leakage of muscle constituents, resulting in the excretion of myoglobin in the urine and subsequent

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ARF.[1] While rhabdomyolysis has been observed after traumatic injury, particularly in the setting of a crush injury, it has also been noted in patients undergoing elective surgery.[2] Postoperative rhabdomyolysis has been reported in a number of surgical disciplines, including bariatric, cardiovascular and urological surgery.[3–5] Surgical risk factors for PRM include an exaggerated lithotomy or flank position, significant muscular mass, obesity, hypovolemia, longer operative times, renal dysfunction, diabetes and hypertension.[6]

While previously described, the development of PRM is a rare and poorly characterized complication associated with renal surgery, with an incidence after RS reported at 0% to 5%.[7–9] These incidence rates are derived from limited case series, which may be biased due to case mix and practice patterns. Definitive information about PRM after RS and an understanding of risk factors for this potentially devastating complication are lacking. Thus, we performed a population based study to evaluate the contemporary incidence and consequences of PRM after extirpative renal surgery in the United States.

PATIENTS AND METHODS

Data Source

The Premier Hospital Database (Premier, Inc., Charlotte, North Carolina) is an all-payer hospital discharge database including more than 45 million inpatient discharges (about 20% of annual discharges in the United States) annually from approximately 600 hospitals. This database captures all hospital costs and charges. Each patient has a unique identifier permitting longitudinal analysis. All data are de-identified and we received institutional review board exemption for this study.

Study Cohort and Covariates

Using ICD-9 codes we captured all adult patients who underwent RS (55.4, 55.5x) between January 1, 2004 and September 30, 2013. We restricted the cohort to patients with an associated diagnosis of a renal mass (189.0, 189.1, 189.8, 189.9, 198.0, 198.1, 223.0, 223.1, 233.9, 236.91, 239.5, 593.2, 593.89, 593.9, 753.1x) and excluded any patient with a diagnosis of renal trauma (866.x).

We examined relevant patient and hospital characteristics. Patient characteristics included age (less than 50, 50 to 59, 60 to 69, 70 or greater), gender, race (white, nonwhite), marital status (single, married, unknown) and insurance status (Medicare, Medicaid, private, other/unknown). For each patient in the study cohort we calculated the Charlson comorbidity index, a validated measure predicting 10-year mortality[10] based on available ICD-9 codes for the 12-month period preceding and including the admission for RS.[11] CCI was assessed as a categorical variable (0, 1, 2 or more). Hospital characteristics included teaching status, hospital size (less than 400, 400 to 599, 600 or more beds), location (urban or rural) and geographic region (Northeast, Midwest, West, South). Surgical characteristics included approach (open, laparoscopic, robotic).

To characterize the potential risk factors for PRM we calculated OT for the index procedure based on data from the charge description master. In addition, anthropomorphic data on BMI were obtained with ICD-9 codes for overweight (278.02) and obesity (278.00, 278.01), as well as specific BMI categories (V85.0-V85.54). Patient position could not be determined with the available data.

Outcomes

We characterized the development of PRM (728.88), including its incidence and risk factors. In addition, we determined the morbidity associated with PRM. We identified 90-day postoperative complications as defined by the Clavien classification system,[12,13] assigning the highest Clavien grade of complication to each patient. We used ICD-9 codes to identify complications as previously described.[14] We only included events not present at the time of the admission for RS but occurring during the index hospital stay and/or on hospital readmission within 90 days after the procedure. Our analysis focused only on major complications (CG III to V) because all patients with PRM are considered to have at least a minor complication (CG II). Mortality (CG V) was evaluated separately and identified through disposition codes. According to the European Association of Urology guidelines we assessed that our methodology met 8 of the 10 Martin criteria.[15] In addition, we evaluated LOS for the index admission and summed the 90-day direct hospital costs to estimate resource use. Of note, the capital costs and maintenance fees for the robotic platform were not included in this analysis. These sunk costs are a function of frequency and duration of use as well as amortization, none of which is reliably available in the database. All costs were adjusted to 2013 USD with the consumer price index to facilitate comparison.

Statistical Analyses

We summarized patient, hospital and surgical characteristics with descriptive statistics. Categorical variables were compared using chi-square tests while continuous variables were compared using the Mann-Whitney U test given the nonnormal distribution of data. Main and interaction effects were assessed with multivariable logistic regression to determine predictors of categorical outcomes. OT was assessed as a dichotomized variable after sensitivity analysis was performed to identify an appropriate threshold. Given the nonnormal distribution of data we assessed LOS with a negative binomial regression model and 90-day direct hospital costs with a generalized linear model using a gamma distribution. Our multivariable models were tested with tenfold cross-validation to avoid overfitting.

Sampling weights in the Premier Hospital Database are derived from the 1998 American Hospital Association Annual Survey and validated by the 1998 National Hospital Discharge Survey. Using these sampling weights and adjusting for hospital clustering, we were able to determine nationally representative estimates for these reported analyses. All tests were 2-sided and $p < 0.05$ was