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Complications, length of stay, and cost of cholecystectomy in kidney transplant recipients

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ABSTRACT

We hypothesized that cholecystectomy may be riskier for kidney transplant recipients (KTR) given their lifelong immunosuppression, physiologic impact of renal failure, and increased risk of gallstone and biliary disease. Using NIS, we compared mortality, morbidity, length of stay and cost in KTR vs non-KTR following cholecystectomy in the US from 2000 to 2011, adjusting for patient and hospital level factors, including transplant center status. Mortality was higher (OR 2.4), morbidity was higher (OR 1.3), LOS was longer (ratio 1.2), and costs were greater (ratio 1.1) for KTR compared to non-KTR following cholecystectomy. While it is clear that KTR are a high risk group following cholecystectomy, the cause of this increased risk requires further investigation.

Introduction

Cholecystectomy is one of the most common general surgery procedures performed in the United States, with more than 400,000 cases performed every year.[1,2] One unique patient population at increased risk for need of cholecystectomy are kidney transplant recipients (KTR). KTR are at higher risk of developing gallstones and biliary disease than the general population due to their history of renal failure and immunosuppressive medications such as calcineurin inhibitors.[3,4] This risk, combined with improved post-transplant survival, translates to a higher incidence of cholecystectomy in the kidney transplant population.[1,3] While post-cholecystectomy morbidity and mortality are low and the average hospital length of stay (LOS) is two days in the general population, it is unclear if the risks are elevated for KTR.[5–7] An improved understanding of morbidity, LOS, and associated cost in this population is important for peri-operative planning and risk stratification.

Previous single-center studies have reported that post-operative outcomes for solid organ transplant recipients following general surgical procedures are worse than the non-transplant recipients, with a recent review citing up to 32.7% morbidity and 17.5% mortality for emergency abdominal surgery, in comparison to 9% morbidity and less than 0.5% mortality in non-transplant recipients.[1,8] For post-transplant cholecystectomy specifically, a national study of solid organ transplants, including heart, lung, and heart-lung recipients, found a complication rate of 13.6% following cholecystectomy, compared to 4.9% for non-transplant recipients.[1,5] Additionally, these heterogeneous solid-organ transplant recipients had a LOS of 4–8 days, compared to a median 1 day reported for non-transplant recipients.[5,9] Specifically regarding kidney transplant recipients, the largest case-series of cholecystectomies to date reported outcomes of 17 procedures performed in a cohort of 1608 KTR at a single transplant center, with a mortality rate of 5.9%.[3] Given concerns of increased operative risks, many transplant providers feel that morbidity, LOS and cost might be mitigated if transplant recipients receive their surgical care at transplant centers.[10–12]

To explore post-cholecystectomy outcomes in a more generalizable fashion, we used the National Inpatient Sample (NIS) to investigate the differences in mortality, morbidity, LOS and cost between KTR and non-KTR undergoing cholecystectomy in a large population of patients undergoing cholecystectomy in the United States. We also investigated outcomes based on the location of surgical care at transplant centers compared to non-transplant centers.

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Material and methods

Data source

Patients were drawn from the NIS. Available through the Healthcare Cost and Utilization Project, the NIS contains data from approximately 7 million hospital stays yearly, and is made up of a stratified sample of 20% of the non-federal hospitals in the United States. The stratified sample is self-weighted to allow for population based estimates.[13] The NIS captures inpatient data for individual hospital visits. It does not capture follow-up data or outpatient information, allowing for inferences to be drawn related to the index admission only. Information provided in the NIS includes patient level hospital discharge data such as patient demographics, as well as diagnostic and procedural ICD-9 codes for the index hospital admission. All study methods were approved by the Johns Hopkins Hospital Institutional Review Board.

Study population

We studied 7318 adult KTR and 5,341,427 non-KTR undergoing cholecystectomy from January 1, 2000–December 31, 2011. We included all patients who had International Classification of Disease, Ninth Revision (ICD-9) procedure codes for laparoscopic or open cholecystectomy KTR were distinguished from non-KTR by the presence of ICD-9 diagnosis codes consistent with prior KT. We excluded patients with ICD-9 codes indicating a history of other solid or non-solid organ transplants (Appendix A).

Patient and hospital level characteristics

In addition to examining basic demographic characteristics and surgical approach (laparoscopic vs. open), the Charlson Comorbidity Index score was calculated for each patient.[14,15] Hospital characteristics examined were standard NIS categories of location (rural or urban), size (small, medium, large), teaching status, and region (Northeast, Midwest, South, or West). We categorized hospitals as transplant centers (a hospital where at least one kidney transplant was performed during the study period) or non-transplant centers.

Clinical outcomes

We defined mortality as death during the primary surgical hospital admission. Morbidities, defined as intraoperative or postoperative complications during the index hospital admission, were identified by ICD-9 code and categorized into system-based groups as established in previous studies (Appendix B).[16] The NIS does not capture follow-up or long term outcomes. Incidences of mortality and morbidity were modeled using hierarchical multivariable logistic regression.

Length of stay was examined using hierarchical multivariable negative binomial regression. Multivariable mixed linear regression was used to examine log-transformed costs. The NIS contains data on total charges for hospital admission, representing the amount that hospitals bill for the admission. The Healthcare Cost and Utilization Project Cost-to-Charge Ratio Files, designed to be used with certain databases including NIS, enable the conversion from charges to cost, on a hospital-specific basis, for all hospitals represented in the database.

Multivariable models for each outcome included random intercepts for each hospital and were adjusted for surgical approach (laparoscopic or open), patient characteristics (sex, age, African American race, Charlson Comorbidity Index, primary insurance status), and hospital factors (location, size, region, teaching status, and transplant center status).

Effect modification by transplant center

We investigated whether the association of KTR status with mortality, morbidity, LOS and cost varied by treatment at transplant centers compared to non-transplant centers. To evaluate this, we created an interaction term for KTR status with transplant center status in the regression models described above.

Statistical analysis

We used $\chi 2$ tests to evaluate categorical variables and Student's *t*-test for continuous variables to compare KTR with non-KTR. We used multivariable regression models described above to evaluate control for a variety of patient and hospital characteristics, in addition to surgical approach. For all analyses, a two-tailed p-value of <0.05 was considered statistically significant. Confidence intervals are reported as per the method of Louis and Zeger.[17] Statistical analysis was performed using Stata 14.0 (StataCorp, College Station, Texas).

Results

Study population

A total of 7318 KTR and 5,341,427 non-KTR underwent cholecystectomy during the study period. KTR were a similar age (median 54 [IQR 44-63] years vs. median 56 years [IQR 40-72]; $p = 0.051$), more likely to be male (55.3 vs 34.3%, $p < 0.001$), African American (13.8 vs 9.3%, $p < 0.001$), have public insurance (66.8% vs 46.3%, $p < 0.001$) and have a higher Charlson Comorbidity Index scores (36.4% vs 16.9% with score ≥ 2) compared to non-KTR. KTR were less likely to have a laparoscopic cholecystectomy than non-KTR (68.2% vs 77.7%, $p < 0.001$) (Table 1), and KTR were less likely to have a laparoscopic cholecystectomy when treated at transplant centers compared to non-transplant centers (60.7% vs 71.9%).

Mortality and morbidity

Mortality was higher following cholecystectomy during the index admission for KTR compared to non-KTR (2.7% vs 1.2%, $p < 0.001$, Table 2). After adjusting for patient and hospital characteristics, the odds of in-hospital mortality following cholecystectomy in KTR was 2.39-fold higher than non-KTR (aOR $_{1.66}2.39_{3.44}$). KTR were more likely than non-KTR to have postoperative complications during their index surgical hospitalization (18.8% vs 13.9%, $p < 0.001$). KTR had more in-hospital wound complications (2.0% vs 0.8%, $p < 0.001$), infectious complications (4.4% vs 2.1%, $p < 0.001$), genitourinary complications (1.4% vs 0.8%, $p = 0.01$) and intraoperative complications (3.7% vs 2.4%, $p = 0.001$) than non-KTR. After adjustment, the odds of any in-hospital morbidity were 1.3-fold higher in KTR than non-KTR (aOR $_{1.12}1.30_{1.51}$). Specifically, KTR had higher wound (aOR $_{1.27}1.90_{2.84}$), infectious (aOR $_{1.44}1.89_{2.48}$), and intraoperative (aOR $_{1.03}1.39_{1.86}$) complications when compared to non-KTR (Table 2).

Length of stay and cost

Median LOS was longer in KTR compared to non-KTR (5 days vs 3 days, $p < 0.001$, Table 2). After adjusting for patient and hospital level characteristics including operative approach, LOS was 1.23-fold longer for KTR (ratio $_{1.17}1.23_{1.28}$) compared to non-KTR. The median cost for cholecystectomy was $12,077 for KTR and $9002 for non-KTR ($p < 0.001$). After adjustment, cost was 1.13-fold higher for KTR than non-KTR (ratio $_{1.08}1.13_{1.17}$, Table 2).

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