Does Robotic Assistance Confer an Economic Benefit during Laparoscopic Radical Nephrectomy?

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Purpose: While robotic assisted radical nephrectomy is safe with outcomes and complication rates comparable to those of the pure laparoscopic approach, there is little evidence of an economic or clinical benefit.

Materials and Methods: From the 2009 to 2011 Nationwide Inpatient Sample database we identified patients 18 years old or older who underwent radical nephrectomy for primary renal malignancy. Robotic assisted and laparoscopic techniques were noted. Patients treated with the open technique and those with evidence of metastatic disease were excluded from analysis. Descriptive statistics were performed using the chi-square and Mann-Whitney tests, and the Student t-test. Multiple linear regression was done to examine factors associated with increased hospital costs and charges.

Results: We identified 24,312 radical nephrectomy cases for study inclusion, of which 7,787 (32%) were performed robotically. There was no demographic difference between robotic assisted and pure laparoscopic radical nephrectomy cases. Median total charges were $47,036 vs $38,068 for robotic assisted vs laparoscopic surgery ($p < 0.001$). Median total hospital costs for robotic assisted surgery were $15,149 compared to $11,735 for laparoscopic surgery ($p < 0.001$). There was no difference in perioperative complications or the incidence of death. Compared to the laparoscopic approach robotic assistance conferred an estimated $4,565 and $11,267 increase in hospital costs and charges, respectively, when adjusted for adapted Charlson comorbidity index score, perioperative complications and length of stay ($p < 0.001$).

Conclusions: Robotic assisted radical nephrectomy results in increased medical expense without improving patient morbidity. Assuming surgeon proficiency with pure laparoscopy, robotic technology should be reserved primarily for complex surgeries requiring reconstruction. Traditional laparoscopic techniques should continue to be used for routine radical nephrectomy.

Key Words: kidney, nephrectomy, robotics, laparoscopy, cost-benefit analysis

Abbreviations and Acronyms

CCI = Charlson comorbidity index
EBL = estimated blood loss
LARN = laparoscopic RN
LOS = length of stay
MIS = minimally invasive surgery
NIS = Nationwide Inpatient Sample
PN = partial nephrectomy
RARN = robotic assisted RN
RN = radical nephrectomy

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RADICAL nephrectomy is the gold standard treatment for large renal tumors. Since the first documented pure LARN in the 1990s, there has been a well documented increase in MIS use.[1,2] MIS results in decreased EBL, shorter LOS and quicker recovery.[3] Nevertheless, laparoscopic surgery has limited dexterity and maneuverability along with a significant learning curve.[4]

By adopting robotic assisted surgery urologists have achieved increased

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instrument dexterity, a shorter learning curve and advanced intraoperative imaging.[4–6] Robotic assistance is used increasingly for pyeloplasty, PN and prostatectomy, which involve significant reconstruction with intracorporeal suturing.[7–9] In procedures without reconstruction the robot may be less advantageous. Reports have demonstrated the safety and efficacy of RARN but only show clinical equivalence to LARN.[5,10–14] We evaluated differences in charges and hospital costs for RARN vs LARN.

METHODS

After obtaining institutional review board exemption we performed a retrospective study of patients using the NIS database, which is made available by HCUP (Healthcare Cost and Utilization Project).[8] NIS has 20% capture of annual inpatient hospitalizations at community and academic hospitals throughout the United States. Using provided hospital discharge weights NIS data can generate national level estimates of the procedures performed.[8] ICD-9 codes are used to determine procedures and diagnoses. NIS provides total charges along with a cost-to-charge ratio, enabling calculation of total costs associated with hospitalization, excluding physician fees.[15]

We used patients from 2009 to 2011 as our cohort because ICD-9 coding for robotic assisted procedures began in the final quarter of 2008. We identified all patients treated with RN for renal malignancy. All variables were assessed for completeness, and only cost and race were missing more than 10% of data. Race is known to be missing at a high rate in NIS because certain states do not report it. In our study it was missing in 11.5% of cases. Cost data were missing in 15% of cases. To address this situation race was included in the descriptive analysis but excluded from regression analysis. Because cost was missing for all patients, nondifferentially from certain locations and institutions due to nonreporting, we kept it as the primary outcome of multivariable regression.

Population

Patients 18 years old or older treated with RN were identified by ICD-9 code 55.51, which includes RN and nephroureterectomy. Only patients with primary renal malignancy (ICD-9 189.0) were included in study. Those with a history of metastatic disease (197.0, 197.7 or 198.x), solitary kidney, transplantation or bilateral nephrectomy were excluded from analysis. Robotic assistance was identified by the code 17.4x while laparoscopic procedures were identified by 54.21 and 54.51. Procedures not identified as robotic assisted or laparoscopic were considered open and, thus, also excluded. Cases converted from MIS to open surgery were assumed to be coded as open.

Outcomes and Variables

Primary outcomes were total hospital costs and inpatient charges. Included variables were categorized as patient based, hospital based and hospitalization characteristics. Patient variables were age, gender, race (white, black or other), median ZIP Code income quartile and adapted CCI score. Hospital variables were region (Northeast, Midwest, South or West) and location (rural, urban nonteaching or urban teaching). Hospitalization characteristics were primary payer (Medicare, Medicaid, private insurance or other), LOS, postoperative complication including death, total charges and hospital cost. The adapted CCI with a range of 0 to 8 was calculated using the previously established method of Deyo et al.[16] Inpatient complications were determined by previously described methods.[17,18] By organ system the complications included cardiac, vascular, respiratory, digestive, urinary, shock, hematoma/seroma, accidental puncture, postoperative infection and wound complication.[17] Total charges were defined as the amount that the hospital billed for the case and hospitalization while cost was considered as the estimated cost to the hospital to provide the services. Notably neither charges nor costs include physician fees. Additionally, fixed costs associated with acquisition and maintenance of the robot are applied variably throughout the country. At some institutions a fee is applied to all inpatients, only to surgical patients or only to patients undergoing a robotic procedure. Since this is not reported, we could not assess how robotic fixed costs were applied for the study patients.

Analysis

Patient hospital discharge weights were applied using HCUP methodology to estimate the national incidence of cases.[8] Using weighted data we performed descriptive analysis using the Pearson chi-square test for categorical data, Student t-test for continuous data, and Mann-Whitney test for charge and cost comparisons. Univariate logistic regression was done to assess regional trends in robotic assistance with time. Multiple linear regression was used to assess hospital costs and charges associated with RN. Primary variables of interest in the regression model were determined a priori using clinical judgment of factors influencing hospital cost and charges. Variables included in the model were robotic assisted vs laparoscopic procedure, CCI, any postoperative complication and LOS. We limited this model to cases in which LOS was 10 days or less since this represented the 90th percentile. Further protracted hospitalization durations were deemed outliers. A priori significance was considered at $p < 0.05$ for 2-sided statistical tests. Statistical analysis was done with STATA® 12.1.

RESULTS

Of the 24,312 RN cases that met study inclusion criteria 7,787 (32%) were performed with robotic assistance and the remaining 16,525 (68%) were pure LARN. Another 93,665 open RNs were done during the same period but excluded from the study. There was no demographic difference between patients treated with RARN and LARN (table 1). From 2009 to 2011 there was an overall 22% increase in the proportion of cases done with robotic assistance with regional increases in the Midwest, South and West ($p < 0.001$, see figure). While the majority of RNs were performed in the South, the largest