Trends in Renal Surgery: Robotic Technology is Associated with Increased Use of Partial Nephrectomy

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Purpose: Underuse of partial vs radical nephrectomy for renal tumors was noted in recent population based analyses. An explanation is the learning curve associated with laparoscopic partial nephrectomy. We analyzed state trends in renal surgery and their relationship to the introduction of robotic technology.

Materials and Methods: We used the Maryland HSCRC (Health Services Cost Review Commission) database to identify patients who underwent radical or partial nephrectomy, or renal ablation from 2000 to 2011. Utilization trends, and associated patient and hospital factors were analyzed using multivariate logistic regression. ICD-9 robotic modifier codes were established in October 2008.

Results: Of the 14,260 patients included in analysis 11,271 (79.0%), 2,622 (18.4%) and 367 (2.6%) underwent radical and partial nephrectomy, and renal ablation, respectively. Partial nephrectomy increased from 8.6% in 2000 to 27% in 2011. Open radical nephrectomy decreased by 33%, while minimally invasive radical nephrectomy increased by 15%. Robot-assisted laparoscopic partial nephrectomy increased from 2008 to 2011, attaining a 14% rate at university and 10% at nonuniversity hospitals ($p = 0.03$). It was associated with increased partial nephrectomy (OR 9.67, $p < 0.001$). Younger age, male gender and low patient complexity predicted partial nephrectomy on overall analysis, while higher hospital volume and university status were predictors only in earlier years.

Conclusions: Partial nephrectomy use increased in Maryland from 2001 to 2011, which was facilitated by robotic technology. Associations with hospital factors decreased with time. These data suggest that robotic technology may enable surgeons across practice settings to more frequently perform nephron sparing surgery.

Key Words: kidney, nephrectomy, robotics, laparoscopy, trends

Abbreviations and Acronyms

APC = annual percent change
LPN = laparoscopic PN
LRA = laparoscopic renal ablation
LRN = laparoscopic RN
MIS = minimally invasive surgery
OPN = open PN
ORN = open RN
PN = partial nephrectomy
PRA = percutaneous renal ablation
RALPN = robot-assisted LPN
RALRN = robot-assisted LRN
RN = radical nephrectomy

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ACCUMULATING data on surgical management for renal tumors has challenged previously held notions about the safety and oncological efficacy of PN vs RN even for larger lesions.[1–3] In addition to oncological equivalence, PN is associated with a decreased risk of chronic kidney disease[4] and cardiovascular sequelae.[5,6] Population based studies showed improved overall survival and equivalent cancer specific mortality for PN compared to RN.[7–9] A prospective, randomized trial demonstrated an unexplained overall survival benefit in the RN group on intent to treat analysis but no difference in survival for patients with renal cell carcinoma.[10]

PN underuse raised a quality of care concern in the last decade.[11]

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Also, the effect of MIS on PN and RN use has accrued significant attention. LPN proved to be a challenging procedure with a steep learning curve.[12,13] In contrast, the comparative ease of LRN may be competing with and hindering wider dissemination of PN.[14] Although studies show that PN use is increasing,[15–17] this trend may be offset by a parallel increase in LRN.[17] The recent application of robotic technology to renal surgery was validated against LPN and OPN, and it has a potential learning curve of 2 dozen procedures, likely facilitated by previous experience with robotic prostatectomy.[18,19] Short-term oncological and perioperative outcomes of RALPN have been equivalent to those of LPN.[20–22]

Although it was suggested that robotic technology is an enabler of PN,[23] to our knowledge its impact on PN use has not been previously described. We analyzed trends in extirpative and ablative renal procedures in Maryland from 2000 to 2011, specifically looking at associations of PN use with patient and hospital factors, and robotic technology.

METHODS

The HSCRC was established to regulate insurer rates in Maryland. The HSCRC prospectively collects clinical, demographic and billing data on inpatient discharges at 51 nonfederal hospitals in Maryland limited to 30 days after the patient index admission. After obtaining institutional review board approval, we queried the HSCRC database for patients 18 years old or older treated with extirpative (RN or PN) or ablative renal procedures by any surgical approach (open, laparoscopic or robotic) from 2000 through 2011. Patients were identified using ICD-9 codes for RN (55.5–55.54) or PN (55.4) by open, laparoscopic (54.21, 54.51) and robotic (17.41–17.49) approaches as well as for open renal ablation (55.32), PRA (55.33) and LRA (55.34). ICD-9 codes for ablation were added in October 2006. Because ICD-9 robotic modifiers (17.41–17.49) were established in October 2008, robotic procedures performed before this time were coded as laparoscopic. MIS refers to laparoscopy as well as to robotic assistance.

Demographic data included patient age, gender, race, surgery year, payer status and county of residence, categorized as urban (population greater than 200,000 individuals adjacent to Baltimore or Washington, D.C.), rural or excluded due to vague statistics. Patient complexity and mortality risk were abstracted based on the expanded APR-DRG (All Patient Refined Diagnosis Related Groups) structure, which subclassifies comorbid illness severity (patient complexity) and mortality risk on a range of 1 to 4. APR-DRG Software (3M™) assesses the interaction of multiple secondary diagnoses. Hospital data included identification codes and university affiliation with a residency program. Hospitals and operating surgeons were categorized into quartiles by procedure volume based on unique hospital and surgeon identification codes. Volume calculations were based on the total number of extirpative surgeries performed by a surgeon or at a hospital during a period.

Statistical analysis was performed using STATA®, version 11 with significance considered at 2-sided $p \leq 0.05$. The percent use of PN vs RN was analyzed by each variable, as was the percent of PN or RN done by MIS. Continuous variables were compared using the Student t test if normally distributed, or the Wilcoxon rank sum test if not normally distributed. The chi-square test was used to analyze categorical variables. APC was calculated by fitting a least squares regression line to the natural log of the number of operations using year as a regressor variable. Multivariate logistic regression models were developed to identify variables associated with PN vs RN and renal ablation combined, and to quantify ORs. Patient complexity was categorized as low—1 to 2 or high—3 to 4. Regression was performed for the entire period as well as in approximately 3-year periods, including 2000 to 2002, 2003 to 2005, 2006 to the third quarter of 2008 and the fourth quarter of 2008 to 2011. This was adjusted to group the robotic era together after the ICD-9 robotic modifier was established. Robotic technology was included as a variable in the latter period. Hospital and surgeon volume calculations were performed for the entire study period and individually for the 4 periods. While some variability existed among the periods, in any given period high volume surgeons always performed greater than 8 operations and greater than 58 operations were always performed at hospitals.

RESULTS

A total of 14,260 inpatient discharges between 2000 and 2011 met study inclusion criteria, including 11,271 RNs (79.0%), 2,622 PNs (18.4%) and 367 ablations (2.6%). Demographic and hospital factors for extirpative surgery were expressed as the percent of extirpative operations performed using PN and also subdivided by the percent of PN or RN performed using MIS. The table shows the results of multivariate logistic regression performed for PN use during each period.

Trends

Radical nephrectomy. The total and per hospital number of RNs remained stable (APC +0.2%) during the 12-year period (fig. 1). However, the RN rate decreased from 91% (87% ORN and 4% LRN) to 73% (54% ORN, 15% LRN and 4% RALRN) of all extirpative surgeries. There was a trend toward MIS for RN through the study period but it plateaued to an average of 26% of all RNs from 2006 to 2011. LRN peaked at 20% of all nephrectomies in 2006 and the total proportion of LRNs and RALRNs combined subsequently remained at approximately 20%. On univariate analysis patient factors associated with increased MIS use for RN were younger age, female gender, and lower complexity and mortality risk subclasses. Hospital factors associated with MIS for RN were university hospital status, and higher hospital and surgeon volume.