Differential Use of Partial Nephrectomy for Intermediate and High Complexity Tumors May Explain Variability in Reported Utilization Rates

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Purpose: Partial nephrectomy has become a reference standard for tumors amenable to a kidney sparing approach but reported utilization rates vary widely. The R.E.N.A.L. (radius, exophytic/endophytic, nearness of tumor to collecting system or sinus, anterior/posterior, location relative to polar lines and hilar tumor touching main renal artery or vein) nephrometry score was developed to standardize the reporting of tumor complexity with applicability in academic and community based settings. We hypothesized that tumor and surgeon factors account for variable use of partial nephrectomy.

Materials and Methods: Clinical and R.E.N.A.L. nephrometry score data were analyzed on 1,433 cases performed between 2004 and 2011 by a total of 19 surgeons with varying partial nephrectomy utilization rates (0% to 100%) who practiced at a total of 2 academic centers and 1 community based health system.

Results: Partial nephrectomy use increased during the study period from 36% before 2007 to 73% for 2010 to 2012 ($p < 0.0001$). Increasing proportions of intermediate and high R.E.N.A.L. nephrometry score tumors were treated with partial nephrectomy during this time (35% to 86% and 11% to 36%, respectively, $p < 0.0001$). Partial nephrectomy use was stable for low complexity tumors at 91% overall. Individual surgeons performed partial nephrectomy for 0% to 100% of intermediate complexity and 0% to 45% of high complexity tumors. On multivariable analysis surgery year, tumor size, each R.E.N.A.L. nephrometry score component, surgeon and annual surgeon volume predicted partial vs radical nephrectomy (each $p < 0.05$). On multivariable analysis several surgeon factors, including surgeon volume, setting, fellowship training, and proportional use of minimally invasive and robotic partial nephrectomy, were associated with higher partial nephrectomy use (each $p < 0.002$).

Conclusions: Surgeon and tumor factors contribute significantly to the choice of partial nephrectomy. The significant variation in partial nephrectomy use by individual surgeons appears to be caused by differential treatment for intermediate and high complexity tumors. This may be due to surgical volume, training, setting and the use of minimally invasive techniques.

Key Words: kidney; kidney neoplasms; nephrectomy; physician's practice patterns; renal insufficiency, chronic

Abbreviations and Acronyms

GFR = glomerular filtration rate
MIPN = minimally invasive PN
PN = partial nephrectomy
RN = radical nephrectomy
RNS = R.E.N.A.L. nephrometry score

Accepted for publication January 3, 2013.
Study received institutional review board approval.

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0022-5347/13/1896-2047/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2013.01.007
Vol. 189, 2047-2053, June 2013
Printed in U.S.A.

Partial nephrectomy is the current reference standard of treatment for renal cortical tumors amenable to such an approach.[1–4] It was initially pioneered for patients who would require renal replacement after RN but nephron sparing surgery is being performed using various techniques to extend its associated renal functional benefits to all eligible patients. Comparisons of data available from population based databases and single institution series indicate wide variability in PN use. In patients with small renal masses (less than 4 cm) groups at individual centers reported an 80% to 90% PN rate, while contemporary data from national databases, such as the SEER (Surveillance, Epidemiology and End Results)-Medicare linked database and National Inpatient Sample, indicate that PN is performed in fewer than 45% of patients.[5–8] Identifiable factors leading to the disparate use of PN have been difficult to evaluate in these types of studies, in large part due to the lack of details on tumors and surgeons.

The RNS, which was established to help quantify renal mass complexity,[9] can be measured with low interobserver variability and it correlates with multiple surgical outcomes.[10–13] Prior studies confirmed its usefulness for predicting surgery type, and renal function outcomes and pathology.[9–11,14,15] Based on our previous analysis of the contribution of individual surgeon factors to PN use, we hypothesized that variability in the approach to tumors of intermediate complexity might explain this heterogeneity.[16] We performed a multi-institutional analysis of factors predicting PN use for 1,433 tumors evaluated by a total of 19 surgeons at 2 academic centers and 1 community based health system.

METHODS

All patients treated with surgery for a suspected renal cortical tumor (solid enhancing lesion or Bosniak III–IV cyst) at 3 American centers between 2004 and 2012 who had preoperative imaging available for retrospective review were included in analysis (936 at Fox Chase Cancer Center, 343 at Spectrum Health Hospital System and 154 at University of Chicago). The cohort included 1,433 patients, of whom 83% underwent surgery in 2008 or later. Patients younger than 18 years, those with metastatic renal cell carcinoma or renal cell carcinoma with tumor thrombus at presentation, and those treated with nephrectomy for upper tract urothelial carcinoma, multiple tumors or a tumor in a single functioning kidney were excluded from analysis. Institutional review board approval was received to use data maintained in 3 institutional kidney tumor registries.

Surgical treatment included RN in 527 patients (37%) and PN in 906 (63%) with open PN in 410, robotic PN in 444 and laparoscopic PN in 52. Surgeon specific data were recorded, such as fellowship training, practice setting, and total and annual renal surgical volume (included cases only). Surgeons were grouped by annual volume terciles, including low—fewer than 5, intermediate—5 to 20 and high—greater than 20 cases per year.

The RNS was assigned based on retrospective review of cross-sectional imaging (computerized tomography or magnetic resonance) in all available cases, in accordance with published guidelines.[9,11] The RNS was assigned while blinded to details on patient, surgeon and surgery type. The RNS on a scale of 4 to 12 is calculated from 4 unique quantitative scores and subsequent classification of each tumor as anterior or posterior and hilar or nonhilar.[8] A score of 1 to 3 points is assigned for 4 tumor properties, including tumor diameter, endophytic/exophytic component, nearness to collecting system and location of the mass relative to the polar lines, as previously described.[8] The RNS was used to categorize tumor complexity as low—4 to 6, intermediate—7 to 9 and high—10 to 12.

Logistic regression analysis was done to examine associations between various predictors and the choice of PN vs RN with $p < 0.05$ considered statistically significant.

RESULTS

Table 1 lists clinical and radiographic data on the cohort of 1,433 patients. Overall, 63% of patients underwent PN with an increase seen during the study years ($p < 0.0001$, fig. 1). From 2004 to 2011 the proportion of high complexity tumors treated with PN increased from 0% to 40% ($p < 0.0001$). Similarly, the proportion of intermediate complexity tumors increased from 35% in the first 3 years to 86% in the last 3 study years ($p < 0.001$). In contrast, 73% to 95% of low complexity tumors were treated with PN annually without a significant change during the study period (p not significant). A total of 19 surgeons were included with an individual volume of between 7 and 530 evaluable cases (table 2). Overall, PN was performed for 85% of tumors 4 cm or less, 54% of tumors 4.1 to 7.0 cm and 15% of tumors greater than 7.0 cm.

Surgical details and outcomes were analyzed according to tumor complexity (table 3). PN was performed less frequently with increasing tumor complexity, that is for 91%, 71% and 27% of low, intermediate and high complexity tumors, respectively ($p < 0.0001$). A minimally invasive approach was used for 55% of PNs with proportionately lesser rates of 74%, 49% and 24% for low, intermediate and high complexity tumors, respectively ($p < 0.0001$). Median warm ischemia time was 21, 29 and 33 minutes for low, intermediate and high complexity tumors, respectively ($p < 0.0001$). Estimated blood loss was greater for higher complexity tumors, that is greater than 500 ml in 4.7%, 6.8% and 18.8% of low, intermediate and high complexity tumors, respectively ($p < 0.001$).

Overall PN use ranged from 0% to 100% among the 19 surgeons (fig. 2). Some intersurgeon variability appeared to be related to case mix. For example, surgeon F with the highest PN use (100%) operated