Compensatory Hypertrophy after Partial and Radical Nephrectomy in Adults

Toshio Takagi, Maria C. Mir, Nidhi Sharma, Erick M. Remer, Jianbo Li, Sevag Demirjian, Jihad H. Kaouk and Steven C. Campbell*

From the Glickman Urological Kidney Institute (TT, MCM, EMR, SD, JHK, SCC), Imaging Institute (NS, EMR) and Quantitative Health Service (JL), Cleveland Clinic, Cleveland, Ohio

Abbreviations and Acronyms

BMI = body mass index

CCI = Charlson comorbidity index

CKD = chronic kidney disease

GFR = glomerular filtration rate

PN = partial nephrectomy

R.E.N.A.L. = radius, exophytic/endophytic tumor properties, nearness of tumor deepest portion to collecting system or sinus, anterior/posterior and location relative to polar line

RN = radical nephrectomy

Accepted for publication June 5, 2014.

Study received institutional review board approval.

* Correspondence: Center for Urologic Oncology, Room Q10-120, 9500 Euclid Ave., Glickman Urological Kidney Institute, Cleveland Clinic, Cleveland, Ohio 44195 (telephone: 216-444-5595; FAX: 216-636-0770; e-mail: campbes3@ccf.org).

Purpose: We assessed compensatory hypertrophy in the contralateral kidney after partial and radical nephrectomy in adults. We also examined predictive factors to facilitate more accurate estimation of global renal function after surgery.

Materials and Methods: We analyzed the records of 172 patients who underwent partial or radical nephrectomy with appropriate studies to determine function and parenchymal mass specifically in the operated and contralateral kidneys. All patients required renal scans to provide split renal function preoperatively and postoperatively. Parenchymal volume was measured by computerized tomography. All studies were done less than 2 months preoperatively and 4 to 12 months postoperatively.

Results: A total of 113 and 59 patients underwent partial and radical nephrectomy, and median tumor size was 3.5 and 7.0 cm, respectively ($p < 0.0001$). Of patients treated with partial nephrectomy 19% had high complexity tumor compared to 80% of those treated with radical nephrectomy ($p < 0.0001$). Median ipsilateral parenchymal volume was reduced 18% after partial nephrectomy and the median glomerular filtration rate in this kidney decreased 24.4%. The median contralateral kidney function increase after partial nephrectomy was 2.3% vs 21.1% after radical nephrectomy ($p < 0.0001$). Median global function decreased 9.6% after partial nephrectomy vs 32.2% after radical nephrectomy ($p < 0.0001$). A larger percent parenchymal volume loss ($p = 0.0001$) and fewer comorbidities ($p = 0.0072$) significantly correlated with greater compensatory hypertrophy in the contralateral kidney on multivariable analysis.

Conclusions: Compensatory hypertrophy in adults was limited after partial nephrectomy and it correlated significantly with the amount of parenchymal volume excised. Healthier patients also appeared to respond better. These results may allow for more accurate estimation of global renal function after partial and radical nephrectomy.

Key Words: kidney, nephrectomy, kidney function tests, hypertrophy, comorbidity

Renal function is now recognized as an important consideration for cancer survivorship after management of localized renal tumors. CKD can be associated with increased morbid cardiovascular events and decreased survival during long-term surveillance,[1] particularly if other comorbidities are present. Based on this PN has been prioritized for small renal

0022-5347/14/1926-1612/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2014.06.018
Vol. 192, 1612-1619, December 2014
Printed in U.S.A.

masses and it is imperatively indicated when the contralateral kidney is anatomically or functionally abnormal.[2] However, counseling patients with tumors that are larger or with a hilar location can be more challenging since the functional advantages of PN must be weighed against oncologic risks and the potential for perioperative morbidity.[3] Tools to more accurately estimate global renal function after surgery for localized renal tumors would be of great use in such circumstances. Contralateral hypertrophy is an important aspect of this situation, although the biological mechanisms that underlie this phenomenon are not well understood.[4,5] Contralateral hypertrophy is impressive in neonates and children, in whom the volume and function of the remaining kidney was documented to almost double.[6,7]

In contrast, information on contralateral hypertrophy in adults is much more limited, particularly after PN. For RN most studies suggest a 10% to 20% increase in parenchymal mass in the contralateral kidney[8,9] and functional increases in the 20% to 40% range.[8–12] Corresponding data on PN suggest approximately 5% to 10% increases in contralateral kidney parenchymal mass and function.[9,13,14] Patient age, comorbidities and total or contralateral parenchymal volume have been proposed as predictive factors for the degree of compensatory hypertrophy,[8,9] although data are limited on compensatory hypertrophy after PN. In addition, previous studies of compensatory hypertrophy after PN in adults have been limited to few patients[14] or focused only on global renal function.[9]

In this study we provide a more granular analysis of parenchymal volume and function specific to the ipsilateral and contralateral kidneys before and after PN and RN. We also provide a comprehensive analysis of correlative factors for compensatory hypertrophy after each type of surgery.

MATERIALS AND METHODS

Patient Population

A total of 2,946 PNs and RNs were performed at our institution between 2007 and 2013. Upon receiving institutional review board approval we identified 172 patients who underwent either surgery for whom GFR and parenchymal volume specifically in the operated kidney could be rigorously established preoperatively and postoperatively. Patients with a solitary kidney were excluded from study. The PN techniques used at our institution were described previously.[13]

Intravenous mannitol was routinely administered as a renal protective maneuver. Surgical approach and cold vs warm ischemia were applied according to surgeon preference. Tumor complexity was defined by the R.E.N.A.L. nephrometry score.[15] Comorbidities were converted to a CCI score.

Renal Function Evaluation

All serum creatinine measurements were made at a single clinical reference laboratory and GFR was estimated using the MDRD2 (Modification of Diet in Renal Disease 2) equation.[16] GFR specifically in each kidney was estimated by preoperative and postoperative mercaptoacetyltriglycine nuclear renal scans based on split renal function. All measurements were made less than 2 months preoperatively, and between 4 and 12 months postoperatively. In a similar manner computerized tomography for volumetric analysis was performed within 2 months preoperatively and 4 to 12 months postoperatively.[13] Previous studies demonstrated a minimal 1% to 2% change in parenchymal mass or function during the first several months after initial recovery from surgery.[9]

Analysis

Volumetric. A standard renal mass protocol and abdominal computerized tomography protocols using a Sensation 16 or 64 multidetector scanner (Siemens, Forchheim, Germany) were done for preoperative and postoperative imaging, respectively. The totality of volume estimates were obtained from axial scans in the venous phase reconstructed at 3 mm intervals as previously described.[13] The IMPAX Xero (AGFA Healthcare, Mortsel, Belgium) was used to evaluate images. To estimate preoperative parenchymal volume in the operated kidney we measured the total volume of parenchyma and tumor on that side and subtracted tumor volume. Additional variables evaluated in each patient included age, gender, BMI, CCI, tumor complexity (R.E.N.A.L. score), surgical approach and preoperative GFR.

Statistical. All statistical analysis was done with JMP®, version 10.0. Univariable comparisons were made using the chi-square or Kruskal-Wallis test as appropriate. Multivariable linear regression models were used to determine variables that independently correlated with compensatory hypertrophy. Linear regression assumptions were tested and met. A standard least squares model was used with $p < 0.05$ considered statistically significant.

RESULTS

Table 1 shows patient characteristics for the total cohort. The PN and RN groups included 113 and 59 patients, respectively. Age ($p = 0.61$), gender ($p = 0.90$) and BMI ($p = 0.23$) did not significantly differ between the groups. More than 10% of patients in each group had a CCI score of 5 or more. There were fundamental differences in tumor characteristics between the 2 groups, as expected. Median tumor diameter was 3.5 vs 7.0 cm in the PN vs RN groups ($p < 0.0001$). Of patients treated with PN 19% had a high complexity tumor (R.E.N.A.L. score 10–12) compared with 85% in the RN cohort ($p < 0.0001$). Minimally invasive surgery was done for 64% of PNs and 75% of RNs ($p = 0.15$). Global preoperative GFR ($p = 0.049$) and total parenchymal volume ($p = 0.042$) were significantly higher