External Validation of Contact Surface Area as a Predictor of Postoperative Renal Function in Patients Undergoing Partial Nephrectomy

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Purpose: We sought to externally validate a mathematical formula for tumor contact surface area as a predictor of postoperative renal function in patients undergoing partial nephrectomy for renal cell carcinoma.

Materials and Methods: We queried a prospectively maintained kidney cancer database for patients who underwent partial nephrectomy between 2014 and 2016. Contact surface area was calculated using data obtained from preoperative cross-sectional imaging. The correlation between contact surface area and perioperative variables was examined. The correlation between postoperative renal functional outcomes, contact surface area and the R.E.N.A.L. (radius, exophytic/endophytic properties, nearness of tumor to collecting system or sinus, anterior/posterior, location relative to polar lines and tumor touches main renal artery or vein) nephrometry score was also assessed.

Results: A total of 257 patients who underwent partial nephrectomy had sufficient data to enter the study. Median contact surface area was 14.5 cm^2 (IQR 6.2–36) and the median nephrometry score was 9 (IQR 7–10). Spearman correlation analysis showed that contact surface area correlated with estimated blood loss ($r_s = 0.42$, $p < 0.001$), length of stay ($r_s = 0.18$, $p = 0.005$), and percent and absolute change in the estimated glomerular filtration rate ($r_s = -0.77$ and -0.78, respectively, each $p < 0.001$). On multivariable analysis contact surface area and nephrometry score were independent predictors of the absolute change in the estimated glomerular filtration rate (each $p < 0.001$). ROC curve analysis revealed that contact surface area was a better predictor of a greater than 20% postoperative decline in the estimated glomerular filtration rate compared with the nephrometry score (AUC 0.94 vs 0.80).

Conclusions: Contact surface area correlated with the change in postoperative renal function after partial nephrectomy. It can be used in conjunction with the nephrometry score to counsel patients about the risk of renal functional decline after partial nephrectomy.

Abbreviations and Acronyms

ACE = absolute eGFR change
AUA = American Urological Association
CKD = chronic kidney disease
CSA = contact surface area
EBL = estimated blood loss
eGFR = estimated glomerular filtration rate
LOS = length of stay
MVA = multivariable analysis
NNPV = nonneoplastic parenchymal volume
PCE = percent eGFR change
PN = partial nephrectomy
RN = radical nephrectomy
RNS = R.E.N.A.L. (radius, exophytic/endophytic properties, nearness of tumor to collecting system or sinus, anterior/posterior, location relative to polar lines and tumor touches main renal artery or vein) nephrometry score

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PARTIAL nephrectomy provides oncologic outcomes similar to those of RN. Therefore, the decision to proceed with PN vs RN is predicated on the risk trade-off between the increased perioperative complications associated with PN and the inferior renal functional outcomes associated with RN.[1]

Whether the improvement in renal function associated with PN translates into a survival benefit remains controversial. Despite being criticized for methodological reasons[2,3] the only randomized trial to date, EORTC (European Organisation for Research and Treatment of Cancer) 30904, failed to demonstrate a survival benefit in the PN arm, although de novo CKD was more likely to develop in patients in the RN arm.[4] A growing body of retrospective and population based evidence suggests a potential survival benefit for PN, probably stemming from a lower incidence of complications of CKD.[5–8] Based on these data EAU (European Association of Urology) and AUA guidelines recommend that PN should be prioritized over RN in cases of a cT1 mass with some exceptions, such as high surgical complexity.[9,10]

Postoperative renal function is further confounded by tumor complexity. RNS has been used to characterize tumor complexity and it has correlated with postoperative renal function.[11,12] Yoo et al recently reported that the renoprotective advantage of PN for T1b tumors is limited to patients with RNS less than 9.[13] However, there was no difference in the CKD rate in patients with RNS greater than 9 regardless of whether they underwent RN or PN. Other nephrometry systems, such as the PADUA (Preoperative aspects and dimensions used for an anatomical) Score and the C-Index, have also been developed and correlated with postoperative renal function.[14,15]

The CSA concept was first described by Leslie et al.[16] CSA is the area of contact of a tumor with the surrounding uninvolved renal parenchyma. CSA calculations are based on imaging software, which has precluded its widespread use as a quantitative measure. In contrast, Hsieh et al developed a mathematical model to calculate CSA.[17] They reported that CSA predicted renal function loss more accurately than RNS but the cohort was small and followup was short. In this study we externally validated the CSA model in a large, well-defined cohort of patients treated with PN.

MATERIALS AND METHODS

We reviewed our institutionally maintained, prospective, institutional review board approved kidney cancer database for all patients who underwent PN for localized kidney cancer between January 2014 and December 2016. The choice between an open or a minimally invasive approach was determined by a frank discussion between the performing surgeon and the patient, and depended mainly on the surgical complexity of the tumor and the surgical history of the patient. Study exclusion criteria included multiple or bilateral tumors, a solitary kidney and a lack of imaging or renal functional data.

Demographic data (gender, age, body mass index and RNS), perioperative data (operative time, ischemia time, EBL and LOS) and pathological data were evaluated. eGFR was based on serum creatinine and calculated using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula.[18] Renal function was assessed using the most recent eGFR prior to surgery and the first eGFR after the perioperative period with the latter defined as the first 30 days postoperatively. Renal function dynamics were represented by ACE and PCE in eGFR, which were calculated by the formulas, $ACE = eGFR_{postoperative} - eGFR_{preoperative}$ and $PCE = (eGFR_{postoperative} - eGFR_{preoperative})/eGFR_{preoperative}$, respectively. CSA was calculated by the formula, $CSA = 2 \times p \times r \times d$, where r represents the maximal tumor radius and d represents the depth of tumor invasion into the renal parenchyma (fig. 1).[17]

Continuous variables are presented as the median and IQR, and categorical variables are presented as proportions. The correlation of CSA with RNS and with other perioperative outcomes was assessed by r_s (the Spearman

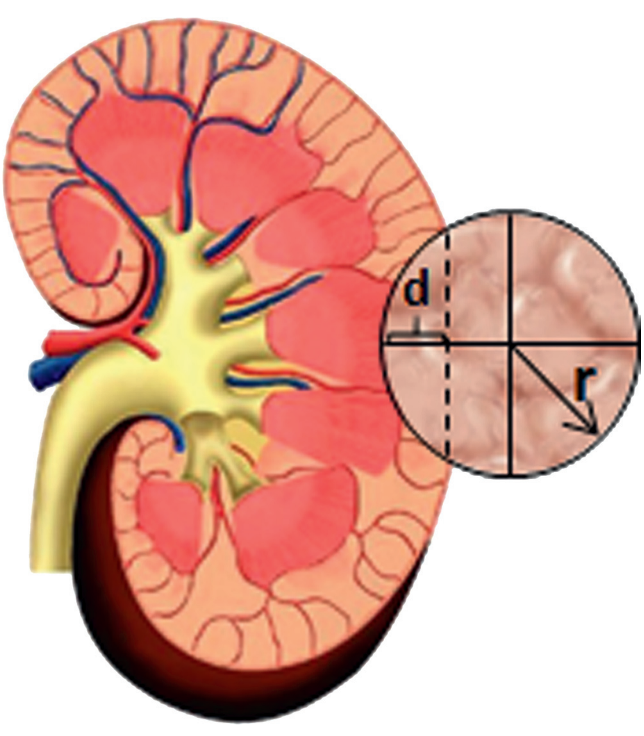

Figure 1. CSA model shows tumor modeled as sphere. *d*, depth of intraparenchymal part of tumor. *r*, tumor radius.