Oncology

Comparison of RENAL, PADUA, CSA, and PAVP Nephrometry Scores in Predicting Functional Outcomes After Partial Nephrectomy

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OBJECTIVE   To evaluate the accuracy of radius, exophytic/endophytic, nearness to collecting system/sinus, anterior/posterior, and location relative to polar lines (RENAL), preoperative aspects and dimensions used for anatomical classification (PADUA), contact surface area (CSA), and preoperative assessment of volume preservation (PAVP) nephrometry scores in predicting postoperative renal functional outcomes after partial nephrectomy (PN). Few studies have compared the accuracy of tumor complexity systems directly in the same set of PN patients.

MATERIALS AND METHODS   Patients treated with robotic, laparoscopic, or open PN having available imaging (n = 344) were examined. The ability of 4 systems to predict nadir estimated glomerular filtration rate (eGFR [median postoperative day 1]) and new baseline eGFR (median: 0.95 year) was analyzed using univariable and multivariable models.

RESULTS   Median preoperative, nadir, and new baseline eGFR were 79 (interquartile range [IQR]: 63-97), 65 (IQR: 47-85), and 80 (IQR: 63-99) mL/min/1.73 m^2. Multivariable models incorporating RENAL, PADUA, CSA, or PAVP were similarly predictive of postoperative renal function (nadir eGFR: R^2 = 0.683-0.688, new baseline eGFR: R^2 = 0.775). In univariable analysis, all 4 complexity systems were predictors of nadir GFR (each $P < .05$), with RENAL ($P = .045$), CSA ($P = .027$), and PAVP ($P = .012$) also significantly predicting nadir eGFR in multivariable models. No complexity system was significantly associated with new baseline eGFR in multivariable analysis, with only RENAL ($P = .023$) and PAVP ($P = .049$) having a statistically significant association in univariable analysis.

CONCLUSION   RENAL, PADUA, CSA, and PAVP are all predictors of early postoperative renal function. RENAL and PAVP provided the greatest predictive ability for later renal functional outcomes. UROLOGY 124: 160−167, 2019. © 2018 Elsevier Inc.

Partial nephrectomy (PN) is the gold standard for treating small renal masses amenable to such an approach.[1,2] Despite comparable cancer-specific survival between PN and radical nephrectomy, the preservation of renal parenchyma can confer a lower noncancer mortality rate.[3-7] The decision to undergo PN is based on multiple variables, though it relies heavily on the complexity of the tumor and gestalt of the surgeon.

Multiple scoring systems have been designed and validated as a method to determine the complexity of a renal mass. RENAL (consists of (R)adius, (E)xophytic/endophytic, (N)earness to collecting system/sinus, (A)nterior/posterior, and (L)ocation relative to polar lines) nephrometry, preoperative aspects and dimensions used for an anatomical classification (PADUA), and contact surface area (CSA) are each unique scoring systems to quantify tumor complexity.[8-10] Multiple studies have shown the clinical utility and reproducibility of each of the scoring systems and their association with perioperative outcomes.[11-15] Each of these scoring systems focuses on specific features of the tumor itself. Volume of functional parenchyma preserved strongly correlates with functional outcomes after PN[16-19] and studies have found surgeon assessment of volume preservation before (PAVP) and after (SAVP) PN are reliable estimates of functional renal volume preservation.[20,21]

Since the advent of renal tumor complexity scoring systems, each generation has pushed for a more simplistic and clinically relevant model. One of the primary nononcologic goals of PN is preservation of functional renal parenchyma. The aim of this study is to evaluate the correlation of RENAL, PADUA, CSA, and PAVP with postoperative renal function following PN.

MATERIALS AND METHODS

Patient data were collected on 344 patients that underwent PN at a single institution between January 2001 and February 2016. Renal function was determined by calculating preoperative and postoperative estimated glomerular filtration rate (eGFR) values based on age, sex, ethnicity, and serum creatinine using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation.[22] Preoperative eGFR was calculated using the last measured creatinine level prior to surgery. Nadir eGFR was calculated using the highest creatinine value measured within 1 week after surgery. New baseline eGFR was calculated using the median postoperative creatinine value after stabilization of renal function (347 days, range: 30-805 days). Latest eGFR values obtained 1 year or more after PN were also evaluated for patients in whom these data were available.

RENAL, PADUA, CSA, and PAVP were all determined based on preoperative computerized tomography or magnetic resonance imaging, in accordance with published standards retrospectively by a surgeon blinded to the surgical procedure or outcome (see Appendix).[8-10,21] Clinical tumor size was measured preoperatively using imaging to determine the largest dimension of the tumor. Pathologic tumor size was measured postoperatively as the largest dimension of the excised tissue mass. Surgeons were grouped into the category of other surgeon if they performed fewer than 25 surgeries of the sample. Surgery types were classified as robotic PN, laparoscopic PN, and open PN.

Ability of the scoring systems to predict postoperative functional outcomes was evaluated using a univariable model. The significant factors in the univariable models were used in subsequent multivariable least squares models, each with a different scoring system locked in, which used a backward stepwise multivariable model selection process with a P value threshold of .05 for variables to remain in the model. This method starts with all variables in the model and removes nonsignificant variables as well as those whose loss has negligible effect on the fit of the model. Four models were run for predicting each postoperative eGFR. Each model made use of a different scoring system locked into the model. The variables that were entered in the backward stepwise multivariable model for predicting nadir eGFR and latest eGFR included age, surgery type, coronary artery disease, diabetes, hypertension, pathologic tumor size, clinical tumor size, preoperative eGFR, and surgeon. The R^2 and root-mean-square error values of the multivariable analyses of each postoperative

measure were compared. A P value <.05 was considered statistically significant. Statistical modeling was performed using JMP 13 statistical software.

RESULTS

Table 1 lists the demographic and clinical data of the 344 patients involved in the study. Median radiographic tumor size was 2.7 cm (interquartile range [IQR]: 1.8-3.8) and the most common surgery type was robotic PN (n = 190, 55.2%). Warm ischemia was used in 60.8% of cases with median 19 minutes (range: 6-56 minutes, IQR 15-26.7 minutes). Cold ischemia was used in 29% with median 29 minutes (range: 5-100 min, IQR 18-39 min). Ischemia type and time were missing in 8.7% and 17.2%

Table 1. Demographic and clinical data of the study population

	Median (IQR)/ Percentage (n)
Age, years	60 (51-69)
Male gender	59.6% (205)
African American	8.7% (30)
No smoking history	48% (165)
Charlson comorbidity index	2 (0-2)
Hypertension	59.3% (204)
Diabetes mellitus	57.6% (198)
Coronary artery disease	43.6% (150)
Peripheral vascular disease	6.1% (21)
Clinical tumor size, cm	2.7 (1.8-3.8)
RENAL	6 (5-8)
PADUA	8 (7-9)
CSA, cm²	9 (4.9-17.6)
PAVP, percentage	90 (85-95)
Surgery type	
- RPN	55.2% (190)
- LPN	7.8% (27)
- OPN	36.9% (127)
Ischemia type	
- Warm	60.8% (191)
- Cold	29.0% (91)
- Segmental	1.0% (3)
- None	9.2% (29)
Ischemia time, min	19 (13-28)
Surgeon	
- A	21.5% (74)
- B	49.1% (169)
- C	6.7% (23)
- Others	22.7% (78)
Malignant histology (vs benign)	89.0% (306)
Pathologic tumor size, cm	2.5 (1.8-3.5)
Preoperative eGFR, mL/min/1.73 m²	79.2 (62.8-97.3)
Nadir eGFR, mL/min/1.73 m²	65 (47.3-84.8)
Time to nadir eGFR, days	1 (1-2)
New baseline eGFR, mL/min/1.73 m²	79.6 (63.0-99.3)
Time to new baseline eGFR, years	0.95 (0.48-1.58)
Length of clinical follow-up	4.0 (2.2-6.2)

CSA = contact surface area; eGFR = estimated glomerular filtration rate; IQR = interquartile range; LPN = laparoscopic partial nephrectomy; OPN = open partial nephrectomy; PADUA = preoperative aspects and dimensions used for anatomical classification; PAVP = preoperative surgeon assessed volume preservation; RENAL = radius, exophytic/endophytic, nearness, anterior/posterior, location; RPN = robotic partial nephrectomy.

of surgeries, respectively. Median RENAL score was 6 (IQR: 5-8), median PADUA score was 8 (IQR: 7-9), median CSA was 9 (IQR: 4.9-17.6) cm^2, and median PAVP was 90% (IQR: 85-95). Median preoperative eGFR was 79.2 (IQR: 62.8-97.3) mL/min/1.73 m^2. Median nadir eGFR was 65 (IQR: 47.3-84.8) mL/min/1.73 m^2, occurring 1 day after PN (IQR: 1-2 days) representing a median 14.7% decrease (IQR: 1.71%-31.2%) after surgery. New baseline eGFR was 79.6 (IQR: 63.0-99.3) mL/min/1.73 m^2, was measured at a median of 0.95 years after PN (IQR: 0.48-1.58 years), and indicated a 0.5% (IQR: 11.1%-(+)14.2%) median decrease from preoperative GFR. The median most recent clinical follow-up in this cohort was 4.0 years (IQR: 2.2-6.2). Three hundred thirteen patients (91%) were alive at last follow-up, with at least 15 experiencing cancer recurrence; 31 patients (9%) are deceased with at least 9 attributable to cancer-related causes.

Univariable models were constructed to evaluate for predictors of nadir and new baseline GFR (Table 2). Factors strongly associated with nadir eGFR included age, Charlson comorbidity index, surgery type, ischemia type,

PAVP, pathologic and clinical tumor size, and preoperative eGFR ($P < .0001$ for each). Other associated factors included diabetes ($P = .0001$), RENAL ($P = .0005$), CSA ($P = .0007$), surgeon ($P = .0134$), CAD ($P = .00174$), PADUA ($P = .0086$), ischemia time ($P = .0025$), and hypertension ($P = .0483$). For new baseline eGFR, the significant predictors included age, gender, Charlson comorbidity index, preoperative eGFR (all $P < .0001$), diabetes ($P = .0016$), PAVP ($P = .0493$), clinical tumor size ($P = .005$), and pathologic tumor size ($P = .0046$). Surgery year was not significantly associated with nadir eGFR ($P = .215$) or new baseline eGFR ($P = .58$) (data not shown). Pathologic diagnosis of cancer was also not significantly associated with nadir eGFR ($P = .25$) or new baseline eGFR ($P = .20$).

The significant variables from the backward stepwise multivariable models were entered into standard least squares multivariable models (Table 3). In all 4 models, predicted nadir GFR was lower following cold ischemia (estimates: −4.24 to −3.97, each $P \leq .001$), longer ischemia time (estimates: −0.40 to −0.38 each $P < .001$), for patients with diabetes (estimates: −1.93 to −1.83, each

Table 2. Univariable model of postoperative eGFR

	Nadir eGFR Estimate (95% CI)	P Value	New Baseline eGFR Estimate (95% CI)	P Value
Age, years	−0.96 (−1.14, −0.78)	<.0001	−1.18 (−1.35, −1.00)	<.0001
Gender [male]	−0.75 (−3.50, 2.00)	.59	−8.91 (−11.62, −6.21)	<.0001
African American [yes]	2.92 (−1.85, 7.69)	.23	4.76 (−0.19, 9.72)	.059
No smoking history	6.01 (−6.13, 18.14)	.57	13.13 (0.54, 25.72)	.111
Charlson comorbidity index	−3.95 (−5.67, −2.23)	<.0001	−4.21 (−6.0, −2.42)	<.0001
Hypertension [yes]	−2.75 (−5.48, −0.02)	.0483	−2.38 (−5.23, 0.47)	.101
Diabetes mellitus [yes]	−5.23 (−7.90, −2.56)	.0001	−4.53 (−7.33, −1.72)	.0016
Coronary artery disease [yes]	−3.29 (−5.98, −0.59)	.017	−1.85 (−4.68, 0.98)	.20
Peripheral vascular disease [yes]	−1.85 (−7.48, 3.78)	.52	−3.51 (−9.37, 2.35)	.24
Clinical tumor size, cm	−2.79 (−4.36, −1.21)	.0006	−2.38 (−4.03, −0.72)	.005
RENAL	−2.75 (−4.29, −1.20)	.0005	−1.89 (−3.52, −0.26)	.0231
PADUA	−2.07 (−3.62, −0.53)	.0086	−1.34 (−2.96, 0.28)	.105
CSA, cm^2	−0.33 (−0.53, −0.14)	.0007	−0.17 (−0.38, 0.03)	.095
PAVP, percentage	0.82 (0.50, 1.14)	<.0001	0.35 (0.001, 0.70)	.0493
Surgery type		<.0001		.099
- RPN	7.78 (3.63, 11.92)		4.59 (0.15, 9.03)	
- LPN	−1.77 (−8.24, 4.71)		−3.63 (−10.57, 3.31)	
- OPN	−6.01 (−10.38, −1.63)		−0.96 (−5.66, 3.74)	
Ischemia type		<.0001		.101
- Warm	6.23 (−1.59, 14.04)		1.96 (−6.48, 10.40)	
- Cold	−8.97 (−17.20, −0.74)		−4.30 (−13.18, 4.58)	
- Segmental	2.11 (−18.82, 23.03)		10.11 (−12.47, 32.69)	
- None	0.63 (−9.10, 10.36)		−7.78 (−18.28, 2.73)	
Ischemia time (min)	−0.33 (−0.55, −0.12)	.0025	−0.02 (−0.25, 0.21)	.87
Surgeon		.0134		.46
- A	3.21 (−2.08, 8.51)		0.63 (−4.95, 6.22)	
- B	6.69 (2.36, 11.03)		2.50 (−2.07, 7.07)	
- C	−8.57 (−16.60, −0.53)		−6.27 (−14.74, 2.21)	
- Others	−1.34 (−6.55, 3.87)		3.14 (−2.37, 8.64)	
Malignant histology [yes]	2.50 (−1.80, 6.79)	.25	2.90 (−1.57, 7.38)	.20
Pathologic tumor size, cm	−2.69 (−4.23, −1.15)	.0007	−2.34 (−3.95, −0.72)	.0046
Preoperative eGFR (mL/min/1.73 m^2)	0.81 (0.74, 0.88)	<.0001	0.88 (0.80, 0.95)	<.0001

CI = confidence interval; CSA = contact surface area; eGFR = estimated glomerular filtration rate; LPN = laproscopic partial nephrectomy; OPN = open partial nephrectomy; PADUA = preoperative aspects and dimensions used for an anatomical classification; PAVP = preoperative surgeon assessed volume preservation; RENAL = radius, exophytic/endophytic, nearness, anterior/posterior, location; RPN = robotic partial nephrectomy.

Table 3. Standard least squares multivariable model of nadir eGFR

	Model Including RENAL		Model Including PADUA		Model Including CSA		Model Including PAVP	
	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P
Preoperative eGFR mL/min/1.73 m²	0.79 (0.71, 0.86)	<.0001	0.79 (0.72, 0.86)	<.0001	0.79 (0.72, 0.86)	<.0001	0.79 (0.72, 0.86)	<.0001
Ischemia type (cold)	−4.24 (−6.04, −2.43)	<.0001	−4.21 (−6.02, −2.39)	<.0001	−4.17 (−5.98, −2.36)	<.0001	−3.97 (−5.79, −2.15)	<.0001
Ischemia time	−0.39 (−0.52, −0.26)	<.0001	−0.40 (−0.53, −0.27)	<.0001	−0.40 (−0.53, −0.27)	<.0001	−0.38 (−0.51, −0.24)	<.0001
Diabetes mellitus	−1.88 (−3.63, −0.12)	.0359	−1.90 (−3.69, −0.17)	.0314	−1.93 (−3.68, −0.17)	.0313	−1.83 (−3.57, −0.08)	.0406
RENAL	−1.04 (−2.05, −0.02)	.0455	—	—	—	—	—	—
PADUA	—	—	−0.79 (−1.77, 0.19)	.1132	—	—	—	—
CSA, cm²	—	—	—	—	−0.14 (−0.25, −0.02)	.0267	—	—
PAVP, percentage	—	—	—	—	—	—	0.28 (0.04, 0.48)	.0120
R-square	0.684964		0.683218		0.68603		0.687662	
RMSE	14.18457		14.22383		14.16054		14.12371	

CI = confidence interval; CSA = contact surface area; eGFR = estimated glomerular filtration rate; LPN = laparoscopic partial nephrectomy; OPN = open partial nephrectomy; PADUA = preoperative aspects and dimensions used for an anatomical classification; PAVP = preoperative surgeon assessed volume preservation; RENAL = radius, exophytic/endophytic, nearness, anterior/posterior, location; RMSE = root-mean-square error; RPN = robotic partial nephrectomy.
The variables considered for inclusion were age, surgery type, diabetes, hypertension, pathologic tumor size, clinical tumor size, preoperative eGFR, surgeon, and complexity scores; the backward stepwise multivariable model removed variables that were not significant variables and/or not required for the model to reach the highest possible R² value.

$P < .05$), and in patients with lower preoperative eGFR (estimates: 0.79, each $P < .0001$). All scoring systems were significant in models predicting nadir eGFR with R^2 values within 0.003 of each other.

Multivariable models for new baseline eGFR using the statistically significant variables from the univariable models are seen in Table 4. Age, gender, preoperative eGFR, surgery year, ischemia time, and ischemia type all demonstrated statistically significant associations with new baseline GFR in these models (all $P < .05$). All models for predicting new baseline eGFR were similarly predictive, with R^2 values within 0.0006 of each other.

Spearman correlation (nonparametric correlation) among the 4 evaluated scoring systems was moderate to strong (Supplementary Figure 1). The strongest correlations were between RENAL and PADUA (R = 0.8810), followed by CSA and PAVP (R = −0.7430). Correlation between scoring systems and eGFR values is indicated in Supplementary Table 1. Tumor complexity according to all 4 scoring systems significantly correlated with nadir eGFR ($P \leq .01$); PAVP had the most significant and highest correlation with nadir eGFR (R = 0.2209, $P < .0001$). No scoring system significantly correlated with new baseline eGFR (all $P > .05$).

DISCUSSION

PN is the preferred method for treating small renal tumors compared with radical nephrectomy due to the equivalent oncologic outcomes and superior preservation of functional renal parenchyma.[3-7,23-25] Multiple nonmodifiable factors impact postoperative functional outcomes after PN. Among the factors analyzed in this study, the variables associated with short-term renal dysfunction (nadir eGFR) include surgery type, diabetes, pathologic tumor size, preoperative eGFR, and tumor complexity. Independent variables associated with new baseline eGFR include age, pathologic tumor size, preoperative eGFR, and tumor complexity.

Nephrometry scoring systems provide a quantifiable model shown to strongly correlate with perioperative surgical and functional outcomes.[8-10,15,20] In this study, there was a strong connection between nadir eGFR and each of the 4 scoring systems (Table 2). New baseline eGFR, however, was only significantly correlated with RENAL ($P = .0231$) and PAVP ($P = .0493$) in univariable models (Table 2). It has been well documented that the quality and quantity of nephrons spared remain the key player in long-term renal function,[19] yet some data would suggest that after 1 year, the benefits are less pronounced.[26] In this study, the length of follow-up was moderate (median time was 346.6 days [IQR: 1.176.5-578.5]).

RENAL and PADUA nephrometry scoring systems are commonly used worldwide, at least in research settings.[11,25,27] However, in the context of this study, these 2 scoring systems fail to predict new baseline eGFR. In individual multivariable models (Table 4) of each scoring system with new baseline eGFR, RENAL and PADUA

Table 4. Standard least squares multivariable model of new baseline eGFR

	RENAL		PADUA		CSA		PAVP	
	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P
Preoperative eGFR mL/min/1.73 m²	0.80 (0.71, 0.89)	<.0001	0.80 (0.72, 0.89)	<.0001	0.81 (0.72, 0.89)	<.0001	0.81 (0.72, 0.89)	<.0001
Age, years	−0.42 (−0.57, −0.26)	<.0001	−0.22 (−0.38, −0.06)	.0067	−0.21 (−0.37, −0.05)	.0107	−0.21 (−0.37, −0.04)	.0106
Gender (male)	−8.45 (−10.0, −6.90)	<.0001	−8.46 (−10.02, −6.91)	<.0001	−8.46 (−10.02, −6.90)	<.0001	−8.45 (−10.0, −6.89)	<.0001
Surgery year	−0.80 (−1.45, −0.15)	.0157	−0.80 (−1.45, −0.15)	.0155	−0.87 (−1.53, −0.21)	.0096	−0.85 (−1.50, −0.21)	.010
Ischemia type (cold)	−2.57 (−4.19, −0.94)	.0021	−2.53 (−4.16, −0.90)	.0025	−2.68 (−4.32, −1.05)	.0014	−2.68 (−4.33, −1.03)	.0015
Ischemia time	−0.18 (−0.31, −0.05)	.0057	−0.18 (−0.31, −0.05)	.0056	−0.20 (−0.33, −0.08)	.0017	−0.20 (−0.33, −0.07)	.0021
RENAL	−0.37 (−1.30, 0.55)	.43	—	—	—	—	—	—
PADUA	—	—	−0.39 (−1.28, 0.49)	.38	—	—	—	—
CSA, cm²	—	—	—	—	0.02 (−0.09, 0.13)	.69	—	—
PAVP, percentage	—	—	—	—	—	—	−0.03 (−0.22, 0.17)	.79
R-square	0.775488		0.775616		0.775098		0.775023	
RMSE	12.57774		12.57414		12.58866		12.59074	

CI = confidence interval; CSA = contact surface area; eGFR = estimated glomerular filtration rate; PADUA = preoperative aspects and dimensions used for an anatomical classification; PAVP = preoperative surgeon assessed volume preservation; RENAL = radius, exophytic/endophytic, nearness, anterior/posterior, location; RMSE = root-mean-square error.
The variables considered for inclusion were age, surgery type, coronary artery disease, diabetes, hypertension, pathologic tumor size, clinical tumor size, preoperative eGFR, surgeon, and complexity scores; the backward stepwise multivariable model removed variables that were not significant variables and/or not required for the model to reach the highest possible R^2 value.

showed no more significance than CSA or PAVP, despite the strong association of age, gender, ischemia, and preoperative GFR.

Few studies have critically looked to compare multiple scoring systems, aside from evaluations of RENAL versus PADUA, which have largely demonstrated comparable outcomes. The earlier scoring systems (RENAL and PADUA) were created for academic purposes with the goal of objectively quantifying the complexity of a mass. Newer models, such as CSA and PAVP/SAVP, have looked at the volume of tumor at the interface with the existing renal parenchyma. This study analyzes both first- and second-generation renal tumor complexity models, providing some evidence to support this change. All 4 systems were significantly correlated with one another ($P < .0001$), with RENAL and PADUA (R = 0.881), and CSA and PAVP (R = −0.743) having the strongest correlations. Without a distinctly superior system, simplicity and ease of calculation should help determine the clinical utility of each. Additional benefits of PAVP are its rapid time to calculation (less than 60 seconds on average for practicing surgeons and those in training) and its reliance on the clinical gestalt of the surgeon. The favorable outcomes with PAVP, when compared directly with more time-intensive scoring systems in this cohort lead us to suggest that PAVP should be used routinely during preoperative counseling for patients. Those surgeons and institutions that desire more robust analyses should continue to record CSA, RENAL/PADUA, and 3DVP for research purposes.

This study suffers from the limitations of any retrospective, single-institution study. Generalizability may be limited by the inclusion of only patients from a single community-based training hospital. Additionally, there is some interobserver variability inherent in assessment of tumors using the 4 scoring systems. Validation of the results using larger, multi-institutional cohorts would account for any observed institutional and observational biases.

CONCLUSION

Among the factors that were analyzed in this study, the independent significant predictors for nadir GFR after PN include preoperative GFR, ischemia type, ischemia time, diabetes, and tumor complexity. For new baseline eGFR, the independent significant predictors include preoperative eGFR, gender, age, surgery year, ischemia type, ischemia time, surgery year, and tumor complexity. Multivariable models incorporating the independently significant factors and any of the 4 scoring systems were similarly predictive of postoperative renal function. RENAL, CSA, and PAVP were significant predictors of nadir eGFR, and none were significant predictors of new baseline eGFR.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.urology.2018.03.055.

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Editorial Comment

In this issue of *Urology*, Lane et al. evaluated the ability of tumor complexity scoring systems to predict postoperative renal function (PRF) following partial nephrectomy (PN). The authors found that the assessed scoring systems (RENAL, PADUA, CSA, and PAVP) had similar predictive characteristics for nadir GFR, while RENAL and PAVP scores demonstrated an association with new baseline GFR on univariable analyses. These findings add to our growing knowledge regarding the utility of nephrometry systems, but only paint a partial picture of the landscape of variables that determine PRF.

Evidence has long shown that performing a PN on most localized renal tumors is oncologically safe. This is reflected in recent AUA guidelines promoting the consideration of PN over radical nephrectomy (RN) for certain clinically localized tumors.[1,2] PN, however, carries unique risks, as is reflected by data from the AHRQ[2]; NSQIP estimates that the baseline risk for any complication for PN is 10.8% vs. 7% for a laparoscopic RN.[3] To therefore justify its use, the renal functional benefits of PN must outweigh the perioperative risk; and clinicians must be able to better articulate the functional tradeoffs inherent to these decisions.[4,5]

From a patient's perspective, discussing expected post-PN renal function is an important aspect of preoperative counseling. Whereas we currently have limited tools to make such predictions,

Determinants & Measures of Post-Operative Renal Function
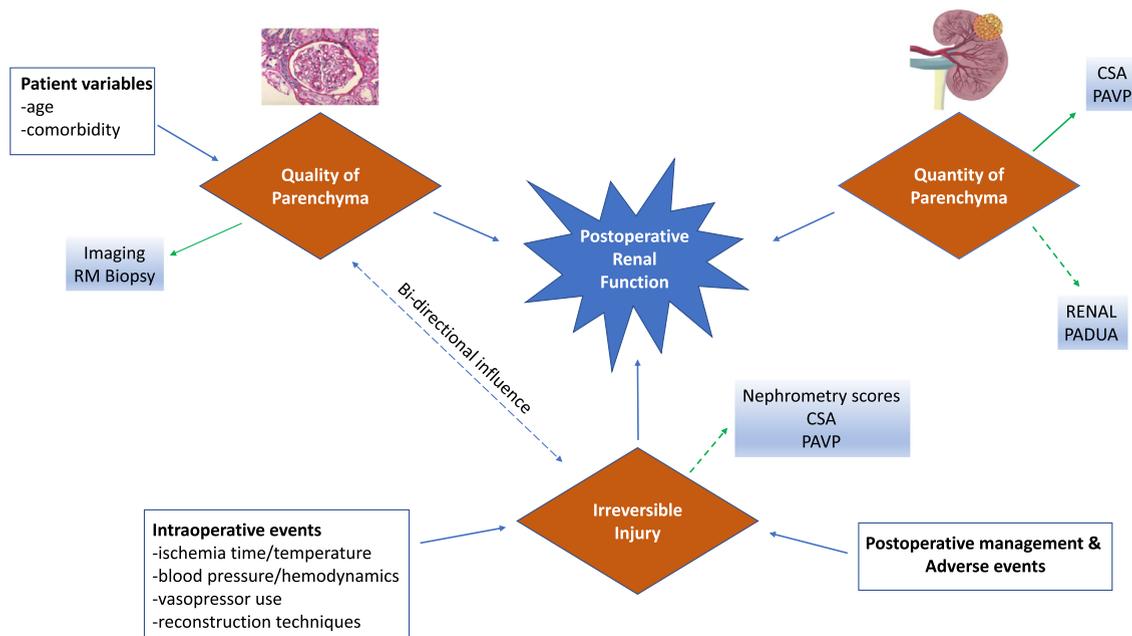

Figure. Postoperative renal function is determined by the quantity of parenchyma, quality of parenchyma, and amount of irreversible parenchymal injury sustained during surgery. Many factors influence each of these variables, examples of which are shown in the figure.

Light blue boxes with green arrows = measurement methods (Solid arrows = direct measurements; Dashed arrows = indirect measurements)

CSA= Contact Surface Area

PAVP= Preoperative Assessment of Volume Preservation

RENAL= Nephrometry score: Radius, Endophytic/exophytic, Nearness to collecting system, Anterior-posterior, location relative to Polar lines

PADUA= Preoperative Aspects and Dimensions Used for Anatomic classification

RM biopsy = Renal mass biopsy

attempts to generate predictive algorithms in this space should be encouraged for the benefit of both patients and physicians.

Nephrometry, at first glance, seems like a natural tool for predicting functional outcomes. But as the name suggests, complexity scores are only intended to communicate tumor complexity. They are powerful tools when used for tumor analysis and risk-communication[6]; but their power to predict functional risks is only a derivate of their primary goal and does not incorporate other important variables that determine postoperative function. Alternatively, calculating parenchymal mass preservation may be a more accurate way of predicting the expected quantity of remaining kidney. However, these calculations are bulky to use at the point of care and may require significant coordination with radiology, all for minimal improvements in predictive ability.[7] More importantly, the quantity of preserved parenchyma is not the only variable that determines postoperative function.

The goal, of course, is to give patients an upfront idea about renal functional risks. The accompanying figure illustrates a conceptual framework for discussing functional risks with patients. Postoperative renal function is determined by the combined effects of parenchymal quality, quantity, and irreversible parenchymal damage that results from surgery. Tumor complexity scores and parenchymal mass calculations can help describe some of these variables. However, none of these scores are able to incorporate _all_ of the important variables that go into determining postoperative renal function.

We should continue to encourage efforts that improve our ability to counsel patients on oncological versus functional risks. Patients with renal tumors fear both cancer progression AND the risk of renal replacement therapy. Moreover, they ascribe different values and tradeoff preferences to each. Though complexity scores are an important tool in our armamentarium, their role in predicting composite outcomes like PRF should not be overestimated.

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