Original Article

Application of Mathematically Calculated Tumor Contact Surface Area (CSA) as a Predictive Factor of Renal Function after Partial Nephrectomy for Solitary Renal Mass

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Objective: The aim of the present study was to explore the utility of mathematically calculated tumor contact surface area (CSA), which has been introduced as a predictor of postoperative renal function, in patients who underwent partial nephrectomy (PN) for solitary renal mass at Siriraj Hospital – Thailand's largest national tertiary referral center.

Materials and Methods: The authors retrospectively reviewed all patients who underwent PN as the management of solitary renal mass from 2012 to 2017 at Siriraj Hospital, Bangkok, Thailand. Only patients who had available pre-operative imaging and serum creatinine before and after PN were included. CSA was calculated using the formula $2\pi rd$, where r = tumor radius, and d = intraparenchymal depth of tumor from preoperative computed tomography or magnetic resonance imaging. Estimated glomerular filtration rate (eGFR) was estimated by Chronic Kidney Disease Epidemiology formula. Postoperative eGFR was based on the best serum creatinine level within a year after surgery. Spearman's correlation coefficient, univariate, and multivariate linear regression analyses were utilized to identify factors associated with percent eGFR change (PCE) after PN.

Results: Of 67 patients, the mean age was 58.3±12.5 years and 43 (64.2%) were male. Median tumor size, R.E.N.A.L. score, and CSA was 2.8 cm (interquartile range [IQR]: 2.2 to 3.5), 7 (IQR: 6 to 9), and 16.1 cm^2 (IQR: 9.8 to 23.8), respectively. Open PN was performed in 32 patients (47.8%), and minimally invasive PN was performed in 35 patients (52.2%). Median preoperative and postoperative eGFR was 77 (IQR: 53 to 89) and 70 (IQR: 53 to 87) ml/min/1.73 m^2, respectively. Median absolute eGFR change (ACE) was 4.6 ml/min/1.73 m^2 (IQR: 0.0 to 12.1), and the median PCE was 4.6% (IQR: 0.0 to 4.6). CSA was found to be significantly correlated with R.E.N.A.L. score ($r = 0.55$, $p<0.001$); however, neither CSA nor R.E.N.A.L. score was significantly associated with ACE or PCE. Multivariate analysis showed that male gender ($p = 0.02$) and cardiovascular disease ($p = 0.03$) were significantly associated with PCE.

Conclusion: Although calculated CSA from pre-operative imaging was feasible to predict postoperative renal function after PN, it failed to be associated with postoperative renal function in our study. Further study is needed to validate the utility of this technique.

Keywords: Partial nephrectomy, Renal mass, Contact surface area, Tumor contact surface area

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Partial nephrectomy (PN) has become the standard treatment for small renal masses (SRMs). Retrospective studies and population-based studies have shown survival benefits from PN in patients with SRMs[1,2]. The oncologic outcome of the procedure was favorable with minimal effect on postoperative renal function. Previous studies reported that global glomerular filtration rate (GFR) generally decreased about 10% from its pre-operative value or 20% when focused on the operated kidney. However, no pre-operative parameter was found to predict accurately postoperative renal function or patients at risk of developing end-stage renal disease after the operation[3]. R.E.N.A.L. nephrometry score (RNS), evaluating SRMs characteristics and their locations, has been found to be associated with perioperative outcome during PN; however, it has not been validated to predict postoperative renal outcome[4,5].

In 2014, Leslie, et al introduced tumor contact surface area (CSA) as a novel pre-operative parameter to predict postoperative renal function after PN. Pre-operative kidney imaging is processed with computer software to obtain its total surface area before manually calculated CSA based on intraparenchymal tumor depth[6]. This rendered area represents the volume of renal parenchyma that will be lost during tumor excision, and the ischemic area caused by renorrhaphy. Regarding to the complexity of software-based calculation, CSA has not yet been widely accepted. Since the

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introduction of the mathematically calculated CSA by Hsieh, et al in 2016, CSA has been gaining popularity as a practical predictive factor for post PN renal function. SRMs were assumed to be spherical and the intraparenchymal depth (d) was no greater than the tumor diameter (2r), not totally endophytic tumor (0>d>2r)[7,8].

The objective of the present study was to explore the utility of mathematically calculated tumor CSA, which has been introduced as a predictor of postoperative renal function, in patients who underwent PN for SRMs at Siriraj Hospital Thailand's largest national tertiary referral center.

Materials and Methods

The present study retrospectively reviewed patients with unifocal renal masses who underwent PN during 2012 to 2017 at Siriraj Hospital, Bangkok, Thailand. Only patients who had available pre-operative imaging and serum creatinine before and after PN were included. The protocol for this study was reviewed and approved by the Siriraj Institutional Review Board [COA No. 168/2561 (EC1)].

Patients demographic, tumor characteristic, surgical approaches, and perioperative data (types of renal artery clamping, and ischemia time) were retrospectively collected. Ischemic time was considered prolonged when the warm ischemia time (WIT) was longer than 25 minutes or the cold ischemia time (CIT) was longer than 58 minutes.

CSA was calculated using the formula $2\pi rd$, where r = tumor radius, and d = intraparenchymal depth of tumor from preoperative computed tomography (CT) or magnetic resonance imaging (MRI). Postoperative renal function was chosen by the best estimated glomerular filtration rate (eGFR) within 12 months after PN, as calculated by CKD-EPI (Chronic Kidney Disease Epidemiology 2009) formula. Absolute and percent changes in eGFR were evaluated. Percent eGFR change greater than 10% and 20% were recorded and reviewed.

Statistical analysis

Continuous data are presented as median and interquartile range (IQR) or mean $\pm$ standard deviation (SD). Categorical data are presented as number and percentage (%). Correlation between CSA and RNS, absolute eGFR change (ACE), percentage eGFR change (PCE), and other perioperative outcomes were analyzed using Spearman's correlation. Univariate and multivariate linear regression were utilized to identify factors associated with greater than 20% change in eGFR (PCE20). The accuracy of CSA and RNS to predict postoperative renal function change was assessed by receiver operating characteristic (ROC) curve analysis. All analyses were performed using SPSS Statistics version 22 (SPSS, Inc., Chicago, IL, USA). A *p*-value <0.05 was considered statistically significant.

Results

A total of 67 patients were included in this study. The mean age of patients was 58.3$\pm$12.5 years, and 43 (64.2%) were male. The average estimated BMI was 25.2$\pm$4.4 kg/m^2. Diabetes, hypertension, dyslipidemia, and cardiovascular disease were found in 32.8%, 61.2%, 28.4%, and 7.5% of patients, respectively. An average tumor size was 2.8 cm (IQR: 2.2 to 3.5). Median CSA and RNS were 16.1 cm^2 (IQR: 9.8 to 23.8) and 7 (IQR: 6 to 9), respectively. The preoperative eGFR was 76.3$\pm$32.0 ml/min/1.73 m^2 (Table 1).

Open PN (OPN) was performed in 32 patients (47.8%), and the remaining patients underwent minimally invasive surgery (MIS; laparoscopic or robotic-assisted surgery). The average operative time was slightly shorter in OPN cohort (160.8$\pm$67.4 minutes) compared to MIS (214.9$\pm$75.4 minutes) (p = 0.646). Prolonged WIT (>25 minutes) occurred in 17 patients (25.4%). Postoperative complications, including anemia, fever, and hematuria, were recorded in 16 patients (23.9%); however, no high-grade

Table 1. Patient demographic and tumor characteristics

	Overall	OPN	MIS	*p*-value
Number of patients	67	32	35	
Male gender	43 (64.2%)	19 (28.4%)	24 (35.8%)	0.43
Age (years)	58.35$\pm$12.49	57.08$\pm$12.46	59.51$\pm$12.59	0.43
Body mass index (kg/m^2)	25.19$\pm$4.41	24.56$\pm$4.33	25.77$\pm$4.47	0.26
Preoperative eGFR (ml/min/1.73 m^2)	76.31$\pm$32.01	73.25$\pm$29.96	79.10$\pm$29.96	0.46
Tumor size (cm)	3.12$\pm$1.72	3.66$\pm$2.23	2.63$\pm$0.83	0.02
Contact surface area (cm^2)	16.08 (9.81 to 23.76)	19.11 (11.62 to 36.60)	12.26 (6.41 to 21.12)	0.02
R.E.N.A.L score	7 (6 to 9)	8 (6 to 9)	7 (6 to 8)	0.07
Diabetes	22 (32.8%)	11 (16.4%)	11 (16.4%)	0.80
Hypertension	41 (61.2%)	18 (26.9%)	23 (34.3%)	0.43
Cardiovascular disease	5 (7.5%)	4 (6.0%)	1 (1.5%)	0.13

Data presented as number, number and percentage, mean $\pm$ standard deviation, or median and interquartile range. A *p*-value <0.05 indicates statistical significance.
OPN = open surgery; MIS = minimally invasive surgery; eGFR = estimated glomerular filtration rate; R.E.N.A.L. score = Radius (cm), Exophytic/endophytic, Nearness to collecting system or sinus (mm), Anterior/posterior, Location relative to polar lines

complication (Clavien-Dindo grade 3 to 5) was observed in the present study. The median estimated blood loss (EBL) was 200 ml (IQR: 100 to 350), and the average length of hospital stay (LOS) was 7.6±2.3 days (8.2±2.5 for OPN versus 7.1±1.8 for MIS, p = 0.093) (Table 2).

The average postoperative eGFR was 71.4±29.7 ml/min/1.73 m^2. Median absolute and percentage eGFR change was 4.6 ml/min/1.73 m^2 (IQR: 0.0 to 12.1) and 6.7% (IQR: 0.0 to 14.6), respectively. Greater than 10% change in postoperative eGFR was found in 43.3% of patients, while 13.4% of patients experienced greater than 20% eGFR change. There were 3 patients (4.5%) whose postoperative eGFR declined below 60 ml/min/1.73 m^2 and they were newly diagnosed as chronic kidney disease (CKD) stage 3. Interestingly, 15 patients (22.4%) had improved eGFR, and 5 patients (7.5%) had eGFR level equivalent to their pre-operative one (Table 2).

Spearman's correlation did not show any correlations between CSA or RNS and postoperative renal function outcome (absolute or percentage eGFR change) or other postoperative outcomes. Nevertheless, CSA was found to be strongly significantly associated with RNS (r_s = 0.548, p<0.001). EBL was found to be correlated with LOS, operative time, and postoperative complications (r_s = 0.277, r_s = 0.332, r_s = 0.276; and, p = 0.023, p = 0.006, p = 0.024, respectively) (Table 3).

Univariate linear regression analysis did not show the association between percentage eGFR change (PCE) and other factors, including underlying disease, tumor size, pre-operative CSA/RNS, open surgery, renal artery clamping, or EBL (Table 4). On multivariate analysis, male gender and cardiovascular disease were associated with PCE (p = 0.02).

Table 2. Perioperative outcomes

	Overall	OPN	MIS	*p*-value
Operative time (min)	189.04±76.17	160.78±67.43	214.89±75.36	<0.001
Estimated blood loss (ml)	200 (100 to 450)	200 (100 to 500)	200 (75 to 450)	0.43
Renal artery clamping (%)	59 (88.1%)	26 (38.8%)	33 (49.3%)	0.10
Extended WIT (%)	17 (25.4%)	2 (3.0%)	15 (21.4%)	<0.001
Complication (%)	16 (23.9%)	7 (10.4%)	9 (13.5%)	0.71
Postoperative eGFR (ml/min/1.73m^2)	76.31±32.01	66.91±27.03	75.50±31.72	0.24
ACE (ml/min/1.73m^2)	4.59 (0.00 to 12.15)	6.22 (0.25 to 15.20)	3.39 (-0.80 to 10.07)	0.22
PCE (%)	6.66 (0.00 to 14.64)	11.42 (0.45 to 18.33)	5.08(-1.07 to 12.23)	0.12
LOS (days)	7.61±2.26	8.22±2.52	7.06±1.85	0.03

Data presented as mean ± standard deviation, median and interquartile range, or number and percentage. A *p*-value <0.05 indicates statistical significance.
OPN = open surgery; MIS = minimally invasive surgery; WIT = warm ischemia time; eGFR = estimated glomerular filtration rate; ACE = absolute eGFR change; PCE = percentage eGFR change; LOS = length of stay

Table 3. Spearman's correlation coefficient analysis

	CSA		R.E.N.A.L score	
	Coefficient		Coefficient	
	t	*p*-value	t	*p*-value
CSA	1.00		0.57	<0.001
R.E.N.A.L score	0.57	<0.001	1.00	
Operative time	-0.10	0.49	-0.14	0.33
EBL	0.05	0.74	0.03	0.84
Renal artery clamping	0.15	0.30	0.20	0.16
Extended WIT	-0.04	0.78	-0.13	0.34
Perioperative complication	0.02	0.89	0.15	0.28
LOS	-0.02	0.89	0.02	0.87
ACE	0.13	0.36	0.11	0.43
PCE	0.12	0.41	0.14	0.33

A *p*-value <0.05 indicates statistical significance.
CSA = contact surface area; R.E.N.A.L. score = Radius (cm), Exophytic/endophytic, Nearness to collecting system or sinus (mm), Anterior/posterior, Location relative to polar lines; EBL = estimated blood loss; WIT = warm ischemia time; LOS = length of stay; ACE = absolute eGFR change; PCE = percentage eGFR change

Preoperative eGFR was independently associated with absolute eGFR change, but not percentage change (Table 5).

The accuracy of CSA and RNS for predicting significant renal function change (PCE20) was evaluated using ROC curve analysis. Neither parameter was found to be a good predictor of PCE20, with areas under the curve (AUCs) of 0.678 and 0.601, respectively (Figure 1).

Discussion

Partial nephrectomy (PN) has been now accepted as the standard treatment of small renal masses (SRMs) over radical nephrectomy (RN) due to its benefits to preserve renal parenchyma and thus postoperative renal function. Even though PN patients had better postoperative renal function, the overall survival in this cohort was not improved compared

Table 4. Univariate and multivariate analyses for factors associated with postoperative PCE in patients who underwent PN

	Univariate analysis			Multivariate analysis		
	Coefficient	95% CI	*p*-value	Coefficient	95% CI	*p*-value
CSA	0.08	-0.08, 0.23	0.33	0.01	-0.17, 0.18	0.93
R.E.N.A.L score	1.11	-0.84, 3.06	0.26	-0.01	-2.26, 2.24	0.99
Age	-0.02	-0.30, 0.26	0.90			
Male gender	5.06	-2.11, 12.23	0.16	9.09	1.51, 16.70	0.02
Diabetes	-3.40	-10.8, 3.98	0.36			
Hypertension	2.79	-4.33, 9.92	0.44			
Cardiovascular disease	-11.10	-24.1, 1.87	0.09	-14.50	-27.9, -1.17	0.03
BMI	0.03	-0.76, 0.83	0.93			
Preoperative eGFR	0.08	-0.03, 0.19	0.16	0.10	-0.01, 0.21	0.08
Open surgery	3.78	-3.14, 10.7	0.28	6.50	-0.17, 0.18	0.08
Extended WIT	3.44	-4.95, 11.83	0.41			
Renal artery clamping	-0.91	-11.7, 9.85	0.87			
Estimated blood loss	0.01	-0.01, 0.02	0.35			

A *p*-value <0.05 indicates statistical significance.
PCE = percent eGFR change; CI = confidence interval; CSA = contact surface area; R.E.N.A.L. score = Radius (cm), Exophytic/endophytic, Nearness to collecting system or sinus (mm), Anterior/posterior, Location relative to polar lines; BMI = body mass index; eGFR = estimated glomerular filtration rate; WIT = warm ischemia time; PN = partial nephrectomy

Table 5. Univariate and multivariate analyses for factors associated with postoperative ACE in patients who underwent PN

	Univariate analysis			Multivariate analysis		
	Coefficient	95% CI	*p*-value	Coefficient	95% CI	*p*-value
CSA	0.06	-0.58, 0.17	0.33	0.01	-0.12, 0.14	0.91
R.E.N.A.L score	0.52	-0.98, 2.01	0.49	-0.35	-2.00, 1.31	0.68
Age	-0.08	-0.29, 0.14	0.47			
Male gender	2.06	-3.47, 7.58	0.46	6.04	0.47, 11.62	0.03
Diabetes	-2.58	-8.21, 3.04	0.36			
Hypertension	-0.31	-5.77, 5.14	0.91			
Cardiovascular disease	-5.39	-15.42	4.64	-5.96	-15.78, 3.86	0.23
BMI	0.35	-0.26, 0.95	0.25			
Preoperative eGFR	0.13	0.05, 0.21	<0.001	0.15	0.07, 0.23	<0.001
Open surgery	2.73	-2.54, 8.01	0.31	4.92	-0.42, 10.26	0.07
Extended WIT	2.55	-4.17, 9.27	0.45			
Renal artery clamping	0.34	-7.86, 8.54	0.93			
Estimated blood loss	0.00	-0.01, 0.01	0.73			

A *p*-value <0.05 indicates statistical significance
ACE = absolute eGFR change; CI = confidence interval; CSA = contact surface area; R.E.N.A.L. score = Radius (cm), Exophytic/endophytic, Nearness to collecting system or sinus (mm), Anterior/posterior, Location relative to polar lines; BMI = body mass index; eGFR = estimated glomerular filtration rate; WIT = warm ischemia time; PN = partial nephrectomy

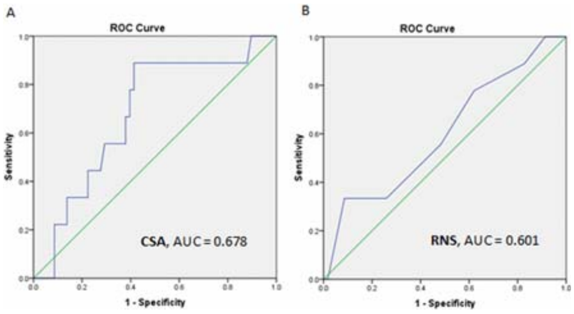

Figure 1. Receiver operating characteristic (ROC) curve analysis demonstrating the ability of calculated tumor contact surface area (CSA) and RENAL nephrometry score (RNS) to predict greater than 20% change in eGFR (PCE20).

to RN patients[9].

There have been many attempts to predict precisely postoperative renal function after renal cancer surgery. Sobrellini, et al proposed a nomogram to predict the 7-year probability of renal failure (83.5% in accuracy). However, postoperative imaging was incorporated into the nomogram and thus made it not helpful to predict the chance of postoperative renal failure[10]. Since kidney imaging is required prior to every operative case, many nephrometry systems have been evaluated, including R.E.N.A.L, PADUA and C-index. All of these systems demonstrated some correlation with renal outcome after PN. Tumor contact surface area (CSA) emerged as an independent factor for predicting postoperative renal function, and has been considered to be a relatively accurate method for estimating the volume of excised renal parenchyma and ischemic parenchyma during renorrhaphy. However, CSA utility was limited due to the complicated software-based calculation. In contrast, mathematically calculated CSA, which assumes that the tumor has a sphere shape and evaluates the surface by integrated calculus, is more appealing. Validated by Haifler, et al in 2017, mathematically calculated CSA was shown to be independently associated with absolute eGFR change, and to be a better predictor of greater than 20% postoperative eGFR decline compared to RNS[8].

Some may argue that this mathematically calculated CSA is not accurate since some renal tumors are not spherical, but rather oval. Some previous studies also proposed more complexed formula to estimate CSA precisely and the true renal parenchyma ischemic volume[11]. Hsieh, et al, the group that proposed this calculus integrated formula, suggested that CSA value calculated by this formula will be equal to the software-based value only when the intraparenchymal tumor depth was not greater than tumor diameter (2r). Since the purpose of mathematical CSA is to predict significant eGFR decline pre-operatively after partial nephrectomy rather than to measure of true contact surface area; this formula is still considered feasible and useful.

Previous studies have introduced the models to predict the possibility of CKD after PN. Liss, et al recently proposed a preoperative assessment model that could identify patients susceptible to postoperative CKD stage 3 or higher. This model utilized the software to measure the size of the tumor and the volume of both kidneys. This information was then combined with preoperative data, including pre-operative GFR, age, gender, race, and underlying disease of diabetes or hypertension. They found that this model was able to be applied in both PN and RN patients, and the strongest predictive factor was pre-operative eGFR[12].

Currently, there are 2 validated cutoff CSA values which accurately predict PCE20 (i.e., 26.1 cm^2 and 76 cm^2)[7,8]. The median CSA in our study was more similar to the latter report (16.1 cm^2 and 14.5 cm^2); however, our patients had lower median RNS compared to their patients (7 versus 9). In addition, patient demographics and tumor characteristic in our study were different from their cohort. Our study had more male patients (64% versus. 32%), patients with diabetes (32.8% versus 15.6%) and hypertension (61.2% versus 59.1%), and slightly lower pre-operative median eGFR (76.3 versus 84.2 ml/min/1.73 m^2). Postoperative eGFR was more dramatically affected in the present study compared to previous study. More specifically, the absolute decline was 4.6 versus 2.5 ml/min/1.73 m^2, and the percentage decline was 6.7% versus 3.1% - both, respectively. In this study, neither CSA nor RNS was found to be correlated with postoperative renal function. Pre-operative eGFR was associated with absolute eGFR change, but not with percentage eGFR change. We also evaluated patients who experienced stable or increased eGFR after PN with univariate linear regression analysis model. The analysis revealed no association between postoperative renal function and pre-operative imaging parameters (CSA, RNS), patient demographic (age, gender, DM, HTN, cardiovascular disease, BMI), or operative technique (open/minimally invasive approach, renal artery clamping).

The present study has some mentionable limitations. First and consistent with the retrospective nature of the present study, some patients had missing or incomplete data and thus were excluded from the study. This might bring the concern of selection bias. Second, the size of the study population was relatively small. As a result, the present study may have insufficient power to identify all significant differences and associations. Third, the patients enrolled in the present study were from the single tertiary center in Thailand which could imply that the patients were complexed with serious underlying disease. This would affect the generalizability of the results. However, the results from our study could reflect to feasibility and accuracy of simple formula CSA in predicting post-PN renal function in the real world.

Conclusion

Although calculated CSA from pre-operative imaging was found to be a practical method, it failed to correlate with postoperative renal function in the present study. Further study is needed to validate the utility of this formula.

What is already known on this topic?

Volume of excised ad residual renal parenchyma is the determinant of functional outcome after partial nephrectomy.

Tumor contact surface area (CSA) is a representative of volume that will be excised during partial nephrectomy then associate with functional outcomes after standard PN.

Mathematical calculated CSA is a better predictor for post partial nephrectomy renal function outcome compare to R.E.N.A.L score.

What this study adds?

CSA was correlated with the R.E.N.A.L score; however, neither was associated with absolute or significant percentage change of glomerular filtration rate.

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This was an unfunded study.

Potential conflicts of interest

The authors declare no conflicts of interest.

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การใช้ขนาดพื้นที่ผิวสัมผัสของเนื้องอกไตเพื่อทำนายการทำงานของไตหลังผ่าตัดไตชนิดตัดออกบางส่วนในโรงพยาบาลศิริราช

ฐิติภัท หาญสมวงศ์, ชลัยรัชฎ์ สุขอวยชัย, วรัชญ์ วรนิสรากุล, ศิรส จิตประไพ, เอกรินทร์ โชติกวณิชย์, ธีระพล อมรเวชสุกิจ, ธวัชชัย ทวีมั่นคงทรัพย์, ไชยยงค์ นวลยง

วัตถุประสงค์: เพื่อศึกษาการใช้ ขนาดพื้นที่ผิวสัมผัสของเนื้องอกไต (CSA) ในการทำนายประสิทธิภาพการทำงานของไต ในผู้ป่วยที่ได้รับการผ่าตัดเนื้องอกไตชนิดตัดออกบางส่วน

วัสดุและวิธีการ: เป็นการศึกษาแบบเก็บข้อมูลย้อนหลัง ของผู้ป่วยที่ได้รับการผ่าตัดเนื้องอกไตชนิดตัดออกบางส่วน ตั้งแต่ปี พ.ศ. 2555 ถึง พ.ศ. 2560 ภาพรังสีวินิจฉัยก่อนผ่าตัดของผู้ป่วยจะถูกนำมาทบทวนและคำนวณหาค่า CSA โดยใช้สูตรคำนวณทางคณิตศาสตร์ (2 x 3.14 x รัศมีของก้อน x ความลึกของก้อนจากผิวไต) ค่าการทำงานของไตทั้งก่อนและหลังการผ่าตัดของผู้ป่วยจะถูกประเมินโดยใช้สูตรคำนวณ chronic kidney disease epidemiology formula ค่าการทำงานของไตหลังผ่าตัดจะพิจารณาจากค่า creatinine ต่ำสุดไม่เกิน 12 เดือนหลังการผ่าตัด

ผลการศึกษา: ผู้ป่วย 67 ราย ที่ได้รับการผ่าตัดไตชนิดตัดออกบางส่วนถูกรวบรวมเข้าในการศึกษานี้ โดยอายุเฉลี่ยของกลุ่มตัวอย่างอยู่ที่ 58.3 ปี เป็นผู้ป่วยชาย 43 ราย ขนาดเนื้องอกโดยเฉลี่ยของกลุ่มตัวอย่างเท่ากับ 2.8 ซม CSA 16 ตร.ซม. ผู้ป่วยจำนวน 38 รายได้รับการผ่าตัดโดยวิธีผ่าตัดเปิด ในขณะที่ผู้ป่วย 29 ราย ได้รับการผ่าตัดโดยการส่องกล้องผ่านช่องท้อง ค่าการทำงานของไตเฉลี่ยก่อนและหลังผ่าตัด เท่ากับ 77 และ 70 มล./นาที/1.73 ตร.ม. คิดเป็นการทำงานที่ลดลงสมบูรณ์ 4.6 มล/นาที/1.73 ตร.ม. และการทำงานที่ลดลงเฉลี่ย ร้อยละ 4.6 จากการศึกษาพบว่าพื้นที่ผิวสัมผัสของเนื้องอกไตมีความสอดคล้องกับค่า R.E.N.A.L score อย่างไรก็ตามทั้ง CSA และ R.E.N.A.L score ไม่มีความสอดคล้องกับค่าการทำงานของไตที่ลดลง ทั้งแบบสมบูรณ์และแบบร้อยละ จากการศึกษาแบบหลายตัวแปรพบว่า เพศชาย และ โรคประจำตัวหลอดเลือดหัวใจ มีความสัมพันธ์กับค่าการทำงานของไตที่ลดลงแบบร้อยละ

สรุป: ถึงแม้การคำนวณหาพื้นที่ผิวสัมผัสของเนื้องอกไตเป็นวิธีที่สะดวก เหมาะกับการใช้ในการวางแผนการรักษาก่อนผ่าตัด แต่ผลการศึกษานี้ยังไม่สามารถยืนยันความสัมพันธ์ของขนาดพื้นผิวสัมผัสนี้กับการเปลี่ยนแปลงการทำงานของไตหลังการผ่าตัดได้