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Correlation of Volume Loss with Functional Change in Robot Assisted Nephron Sparing Surgery: A Short Term Prospective Study

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Abstract: ***Introduction and Objective: Function loss following Robot assisted nephron sparing surgery (RANSS) also termed as Robot partial nephrectomy occurs due to ischemia during vessel clamping, normal parenchyma loss with the specimen and loss due to ischemia during suturing. We tried to put an insight into the function loss due to warm ischemia and excised parenchyma using simple mathematical formulae. Material and Method: Eighty-five patients underwent RANSS during January 2016 to March 2017. Pre-operative and 3 months post-operative glomerular filtration rate (GFR) by DTPA scan and CT volume by cylinder formula were compared. Normal renal parenchyma volume excised with specimen was calculated using ellipsoid formula. Results: pT1b tumor was 56.4% and pT2a was 4.7%. Warm ischemia time (WIT) was high (> 30 minutes) in 16 patients. RENAL nephrometry score was > 10 in 11 patients. Mean split GFR of the affected kidney was 40.8 ± 12.9 ml/min/1.73 m^2, which fell to 32.2 ± 12.4 ml/min/1.73 m^2. Mean loss of normal parenchyma excised was 20.70 ± 22.4 cc, while mean loss of kidney volume on CT was 22.69 ± 11.3 cc. CKD upstaging was seen in 16 patients. Age (p = 0.002), baseline serum creatinine (p = 0.003), tumor size (p = 0.039) and volume of normal kidney tissue excised with specimen (p = <0.001) were found to be significant in decreasing split GFR of affected kidney. Upstaging of CKD status was dependent on age (p = 0.015) and WIT (p = 0.018). Conclusion: RANSS is associated with loss of normal renal parenchyma, causing significant reduction in split GFR of affected kidney. Advanced age and WIT were found to be the risk factors causing decreased total GFR. Function loss resulting from pressure ischemia due to suturing needs further study.***

Keywords: Robot assisted, Robot partial nephrectomy, Nephron, Partial nephrectomy, Glomerular filtration rate

1. Introduction

In last two decades, there has been an increment of 2% in the incidence of renal cell carcinoma (RCC) in North America and Europe (1,2). This rise in incidence is mainly the result of increased finding of incidental small renal masses (SRM) on radiological imaging (3,4). Robotics has led to advancement in terms of easier suturing of remnant parenchyma, better tumor handling due to three dimensional vision and seven degrees of freedom of movement (5-7). It has also led to the expansion of indication for partial nephrectomy in difficult hilar tumors and larger T1b tumors (8-12).The whole idea behind RANSS is preservation of renal tissue and to minimize overall renal function deterioration(13).

The aim of this study was to define renal function assessment on objective basis using GFR (based on renal scan) in patients undergoing RANSS, and also to predict volume of normal parenchyma loss during RANSS causing GFR change. Modifiable and non-modifiable factors leading to change in GFR were also determined. Function loss following RANSS occurs due to ischemia during vessel clamping, normal parenchyma loss with specimen and ischemia during suturing. We tried to put an insight into function loss due to warm ischemia and excised parenchyma using simple mathematical formulae.

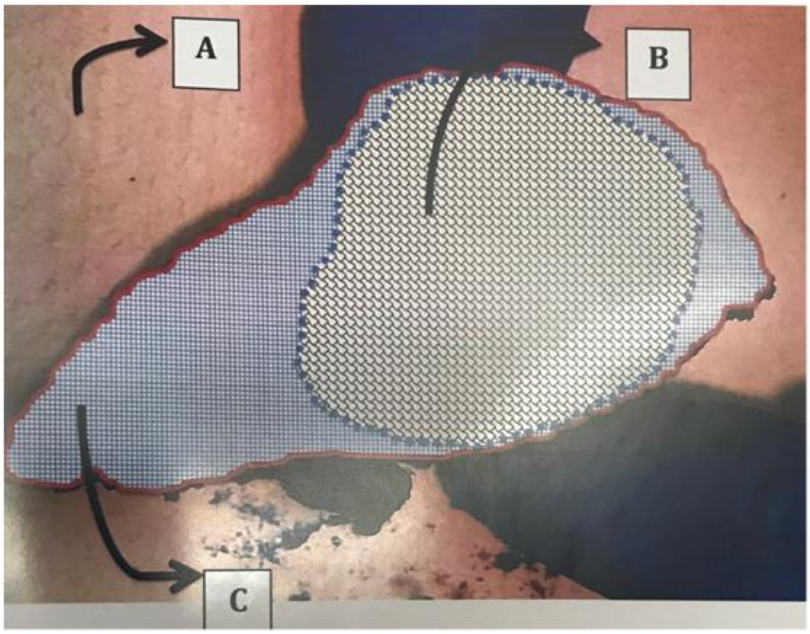
2. Material and Method

Prospective observational study of 85 patients undergoing RANSSwas conducted from January 2016 to March 2017.

Pre-operative and 3 months post-operative GFR by DTPA scan and CT volume by cylinder formula [‘3.14 x r x r x h’, where r = radius and h = height] were compared.

R.E.N.A.L. nephrometry score was calculated pre-operatively on CT scan and categorized as low (46), moderate (7-9) and high (10-12). Intra-operatively WIT was calculated and categorized into low (< 20 minutes), medium (20-30 minutes) and high (> 30 minutes).

Normal renal parenchyma volume excised with specimen was calculated using ellipsoid formula [(0.5xyz)-(.5x’y’z’), where x, y and z are 3 dimensions of surgical specimen and x’, y’ and z’ are of tumor measured on pathological assessment].



Cross-section of RANSS pathology specimen: A- Tumour, B- Rim of healthy renal parenchyma, C- Volume of specimen and tumour obtained by ellipsoid formula

3. Observations

WIT > 30 minutes was seen in 16 patients. RENAL score > 10 was present in 11 patients. Mean split GFR of affected kidney decreased from 40.8 ± 12.9 ml/min/1.73m^2 to 32.2 ± 12.4ml/min/1.73m^2. Mean loss of normal parenchyma excised was 20.70 ± 22.4cc. Mean loss of kidney volume on CT scan was 22.69 ± 11.3cc. CKD upstaging was seen in 16 patients. Age (p = 0.002), tumor size (p = 0.039) &volume of normal kidney parenchyma excised with specimen (p = <0.001) were significant to decrease split GFR of affected kidney. Upstaging of CKD status was age (p=0.015) and WIT (p=0.018) dependent.

4. Tables

1) Volumetric & Functional data

Parameters	Pre-op (Mean±SD)	Post-op (Mean±SD)	P value
Kidney volume (ml)	85.67 ± 17.8	62.96 ± 13.7	< 0.001
Overall GFR (ml/min/m2)	81.52 ± 24.03	75.15 ± 23.53	< 0.001
Split GFR (involved kidney)	40.8 ± 12.9	32.2 ± 12.4	< 0.001

2) Linear regression analysis for % reduction in Split/Total GFR after NSS

Variable	Univariate			Multivariate		
	Beta	T	p value	Beta	T	p value
Pre-op DTPA (involved kidney)	-0.155/ -0.047	-1.426/-0.431	0.158/0.668	-	-	-
Pre-op DTPA (overall)	-0.181/-0.061	-1.677/-0.560	0.097/0.577	-	-	-
Tumor size	0.224/0.156	2.096/1.435	0.039/0.155	0.071/-	0.680/-	0.498/-
Tumor volume	0.182/0.175	1.698/1.623	0.095/0.108	-	-	-
Normal parenchyma volume	0.384/0.276	3.791/2.619	< 0.001/0.010	0.312/0.215	2.914/2.064	0.005/0.042
Post-op kidney volume	0.043/-0.067	0.394/-0.613	0.694/0.541	-	-	-
WIT	0.149/-0.010	1.375/-0.093	0.173/0.926	-	-	-
RENAL score	0.183/0.008	1.694/0.069	0.094/0.945	-	-	-
% Kidney change	-0.099/-0.126	-0.905/-1.157	0.368/0.251	-	-	-

3) Predictive factors for CKD stage progression after 3 months of NSS

Variable	No progression (n = 69)		Progression (n = 16)		p value
	Mean ± SD/ Frequency	Range/%	Mean ± SD/ Frequency	Range/%	
Age	49.3 ± 15.3	15 – 81	59.7 ± 12.8	27 - 77	0.015
Tumor size	4.7 ± 1.6	1.7 – 10	4.6 ± 1.3	2 – 7	0.830
Tumor volume	47.2 ± 46.3	1.91 - 300	42.9 ± 33.8	3.42 – 131	0.729
% kidney change	25.62 ± 9.74	4.9 - 56.3	26.5 ± 9.56	13.04 - 45.09	0.744
Normal parenchyma volume	20.4 ± 19.8	0.625 - 90	21.6 ± 32	1.74 - 122.4	0.852
Pre-op Split GFR	40.8 ± 13.2	17.3 - 82	40.9 ± 12	0.29 - 26.16	0.972
Pre-op Overall GFR	81.8 ± 25.8	32.4 - 164	80.3 ± 14.3	60 - 105	0.827
R.E.N.A.L. score (low/moderate/high)	26/33/10	37.7/47.8/14.5	7/8/1	43.8/50/6.3	0.664
WIT (low/medium/high)	5/55/9	7.2/79.7/13	1/8/7	6.3/50/43.8	0.018

5. Discussion

Partial nephrectomy provides oncological control equivalent to radical nephrectomy, and is also beneficial for preserving renal function. Zargar et al.(14) in his study stated that eGFR (estimated GFR) calculation overestimates renal function reserve after NSS. He reported 72% GFR preservation of operated kidney and 83.83% total GFR preservation vs. 78.2% and 92% respectively in our study indicating the usefulness of split GFR in estimating functional outcome after RANSS.

Although displacement of water method was found to be most accurate by Kurta JM et al.(15) for change in volume (normal parenchyma loss) assessment, we found no significant correlation of tumor volume with GFR after RANSS on measuring tumor and specimen dimensions using ellipsoid formula(14). Zargar et al.(14) showed that R.E.N.A.L nephrometry score & tumor size correlated with normal excised parenchyma volume, contradictory to our observation. Although Zargar et al.(14) showed that pre-operative eGFR of operated kidney predicts renal function preservation after RANSS, our observation was inconsistent. Thompson et al.(12) showed correlation between WIT (≥25 min) and degree of renal function loss after RANSS, contradictory to study by Zargar et al.(14) and present study.

6. Conclusion

RANSS is associated with normal parenchyma loss, significantly reducing split GFR of affected kidney. Risk factors causing decreased total GFR are age and WIT. Functional loss resulting from pressure ischemia due to suturing needs study.

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