Temporal Study of Renal Volume Losses in Patients with Robotic Partial Nephrectomies

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Abstract

Purpose: Partial nephrectomies by their nature are associated with renal volume loss. Our goal from this study is to examine renal volume loss over time post partial nephrectomy.

Material and Methods: Fifty patients were followed for 1-year post partial robotic nephrectomy with two-layer renorrhaphy and the sliding clip technique. This was done with an initial preoperative computed tomography (CT) scan to assess renal mass and location. Post partial nephrectomy patients were imaged at time points 3-days, 6-months, and 12-months.

Results: Patient demographics were 82% male with a median (IQR) age of 57 (45-67) and all were of Japanese descent. The medians (IQR) for warm ischemia time: 18 minutes (14-22), total operative time: 181.5 minutes (169.3-218.5), and estimated blood loss: 20 mL (10-50). The tumor characteristics had a median (IQR) diameter of 2.8 cm (2.5-3.4) with a RENAL score of 7 (6-8). The renal CT volumes showed median (IQR) volume losses at 3-days: -1% (-7.1, 1.8), 6-months: -15.3% (-20.6, -11.2), and 12-months: -16.3% (-19.0, -12.8). Significance was seen at the 3-days to 6-months comparison for volume loss ($p<0.0001$). Mean (SD) eGFR losses were as follows: at discharge 0.5% (12.9), 1-month -6.4% (11.8), 6-months -4.6% (9.8), and 12-months -3.6% (11.9). Statistical analysis showed significance for GFR loss at the comparison between discharge to 1-month and 6-months ($p=0.01$, $p=0.04$).

Conclusion: The initial volume loss seen post-surgery from resected healthy tissue was not significant and only became relevant at longer time points suggesting that loss could be from atrophy. Volume loss over time supports the hypothesis that suture renorrhaphy is a primary cause of volume loss when warm ischemia time is <25minutes.

Background

- Small renal masses are increasingly being treated with partial nephrectomy as availability of robotic assistance increases.
- Emphasis is placed on sparing renal function which includes minimizing resected healthy kidney and ischemic injury from suture renorrhaphy and hilar clamping.
- The degree to which resection of healthy parenchyma or renorrhaphy contributes to renal volume loss not well characterized.
- Our hypothesis is that postoperative day 3-4 CT scans demonstrate resection loss and delayed scans at 4-6months demonstrate ischemia/renorrhaphy injury and that by comparing the two we can better understand volume and functional loss after partial nephrectomy.

Materials & Methods

- A total of 50 patients undergoing robotic-assisted partial nephrectomy by a single surgeon between 4/2013 and 3/2015 had available CT scans for volume calculation preoperatively, postoperative day 3, 6 months, and 12 months.
- Those with tumors <2cm, multiple tumors, or requiring postoperative embolization were excluded.
- Intraoperative US was used in all the cases and vascular bull dogs were used for clamping. A sliding clip cortical renorrhaphy was used in all cases. There were no transfusions or intraoperative complications.
- The post-operative day 3 or 4 scan was obtained prospectively to assess for asymptomatic pseudoaneurysms. A base-layer and cortical renorrhaphy were used.
- Philips Intellispace Portal was used to construct three-dimensional models of the operated kidneys using slice-by-slice semi-automatic segmentation. The vol. of the tumor was subtracted from the preoperative vol.
- GraphPad Prism was used to perform descriptive statistics and the Mann-Whitney U-test to compare volume losses.

Table 1. Demographics

	Median (IQR)
n	50
Age, years	57 (45-67)
Male, %	82%
Japanese Descent, %	100%
Right side, %	54%
BMI, kg/m²	24.7 (23-26)
Hemoglobin, g/dL	14.6 (13.98-15.40)
Tumor diameter, cm	2.8 (2.5-3.4)
Nephrometry, RENAL	7 (6-8)
Low (4-6), %	19 (38%)
Intermediate (7-9), %	27 (54%)
High (10-12), %	4 (8%)
Positive surgical margins, %	0%
Pathology	n (%)
Renal cell carcinoma	50 (100)
Clear Cell	44 (88)
Papillary	3 (6)
Chromophobe	2 (4)
Mucinous, tubular, and spindle cell	1 (2)
Tumor Stage	
pT1a (%)	45 (90)
pT1b (%)	5 (10)
Nodal Metastasis	
No	50 (100)
Distant Metastasis	
Mo	50 (100)
Fuhrman Grade	
One	6 (12)
Two	40 (80)
Three	3 (6)
Four	1 (2)

Table 2. Surgical Intervention Results for Robotic Partial Nephrectomies

	Median (IQR)
Total operating time (from incision to finished closing), min.	181.5 (169.3-218.5)
EBL, mL	20 (10-50)
eGFR pre-op, mL/min/1.72m²	65.8 (56.7-75.1)
Warm ischemia time, min.	18 (14-22)
Urine leaks, %	2%
Drains placed, %	52%

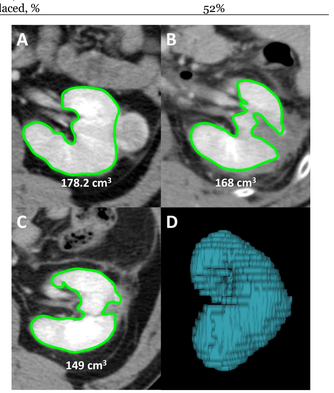

Figure 1: CT imaging of the abdomen. The selected sections indicate the renal parenchyma during contrast infusion at 3 time points with estimated renal volumes. (A) Pre-Operative. (B) Immediately post-surgery. (C) 6 months post-surgery. (D) 3D reconstruction of kidney pre-surgery used for volume estimation.

Results

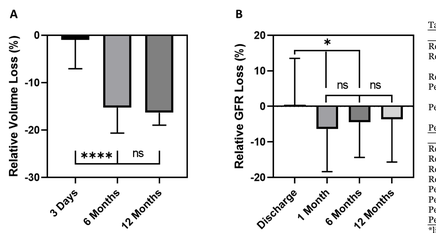

Figure 2: (A) Volumetric loss post partial nephrectomy showing significant volume loss at 6-months and volume loss stabilization at 12-months time point. (B) GFR loss post partial nephrectomy showing significant loss after 6-months and insignificant changes in 6-to-12-month comparison.

Table 3. Volumetric and Functional Losses

	Median (IQR)
Relative Volume loss at 3-4 days, cm³	-1.9 (-11.2, 2.8)
Relative Volume loss at 6 months, cm³	-23.5 (-34.3, -17)
Relative Volume loss at 12 months, cm³*	-23.3 (-30.6, -19.3)
Percent Volume loss at 3-4 days, %	-1.0 (-7.1, 1.8)
Percent Volume loss at 6 months, %	-15.3 (-20.6, -11.2)
Percent Volume loss at 12 months, %*	-16.3 (-19.0, -12.8)
	Mean (STD)
Relative GFR loss at discharge, mL/min/1.72m²	-0.5 (11.8)
Relative GFR loss at 1 month, mL/min/1.72m²	-6.4 (11.7)
Relative GFR loss at 6 months, mL/min/1.72m²	-4.8 (9.3)
Relative GFR loss at 12 months, mL/min/1.72m²	-3.7 (10.6)
Percent GFR loss at discharge, %	0.5 (12.9)
Percent GFR loss at 1 month, %	-6.4 (11.8)
Percent GFR loss at 6 months, %	-4.5 (9.8)
Percent GFR loss at 12 months, %	-3.6 (11.9)

*limited to 20 with available CT scan

Discussion

Conclusion

- The majority of volume loss after partial nephrectomy was not detected in the immediate postoperative period but was seen at 6months.
- This supports the hypothesis that volume and functional loss after partial nephrectomy are not due to resected healthy kidney alone but also ischemia and reconstruction injury.
- Further studies are warranted evaluating renal function loss after partial nephrectomy looking at reconstructive injury in addition to resection related loss.

Limitations

- A single partial nephrectomy technique is evaluated in a small series.
- Postoperative renal hyperemia or edema could have artificially elevated the 3-4day volume results although this appears to be minimal.
- The resected healthy margin was not available for evaluation although the attempted margin was ~5mm.

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