Unclamped Hand-Assisted Laparoscopic Partial Nephrectomy for Predominantly Endophytic Renal Tumors

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Purpose: To describe our initial experience with unclamped laparoscopic hand-assisted partial nephrectomy for predominantly endophytic renal masses in the setting of relative contraindication to warm ischemia.

Materials and Methods: Unclamped laparoscopic hand-assisted partial nephrectomy was performed on eight consecutive patients from June 2009 to March 2010. All patients had predominantly endophytic renal masses with a preferential enhancing rim noted on the pre-operative computed tomography. The unclamped hand-assisted approach was utilized for no warm ischemia, minimal blood loss, and enhanced visualization of the tumor bed with improved operative exposure.

Results: Mean age of the participants was 55.8 years. All patients underwent unclamped hand-assisted partial nephrectomy (ie, zero ischemia). Mean estimated blood loss was 368.8 cc (range, 100 to 800 cc) and mean operation time was 236.9 minutes (range, 175 to 272 minutes). There were no intra-operative complications and no open conversions. There was one grade II (ileus with small pneumothorax) and one grade IV (pulmonary embolism) in the 90-day peri-operative period. There was one positive surgical margin, which was recognized intra-operatively.

Conclusion: While our results are preliminary, we feel this technique provides superior visualization and adequate hemostasis while preserving oncologic efficacy and renal function in this patient population.

Keywords: kidney neoplasms, hand-assisted laparoscopy, nephrectomy, ischemia

INTRODUCTION

With the increased utilization of cross-sectional imaging, there has been an increased detection of small renal masses with surgical extirpation remaining the gold standard. Prior studies have shown that partial nephrectomy results in improved long-term renal functional outcomes with reduced cardiovascular morbidity as compared to radical nephrectomy. The American Urologic Association (AUA) guidelines for stage 1 small renal masses recommend partial nephrectomy for the management of clinical T1 renal masses suggesting the importance of preservation of renal function.[1] It has been demonstrated that there is a significant decrease in renal function when the warm ischemia time is longer than 30 minutes.[2] Laparoscopic partial nephrectomy may offer sooner return to convalescence compared to open partial nephrectomy; however, laparoscopic partial nephrectomy has been associated with increased risk of urologic complications and longer warm ischemia times. Addressing the difficulty in widespread adoption of laparoscopic partial nephrectomy, several groups have demonstrated the feasibility of robotic partial nephrectomy. The concept of zero ischemia to eliminate any damage to remaining nephrons during partial nephrectomy has been explored.[3-5] Unclamped laparoscopic partial nephrectomy with or without the use of the robot has been attempted by well-experienced laparoscopic surgeons; however, the generalizability of this technique to predominantly endophytic tumors remains to be shown. Hand-assisted laparoscopic partial nephrectomy may lead to an increased utilization of laparoscopic partial nephrectomy. We describe unclamped laparoscopic hand-assisted partial nephrectomy for predominantly endophytic renal masses in the setting of relative contraindication to warm ischemia. This technique offers enhanced mobilization and visualization with acceptable blood loss to completely enucleate and excise not only exophytic, but also predominantly (>50%) endophytic renal masses. Furthermore, this technique preserves renal function due to lack of warm ischemia, and allows for a more comprehensive evaluation of pathologic margins before renal reconstruction.

MATERIALS AND METHODS

All patients were operated on by a single surgeon (J.D.E.) at an academic center between June 2009 and March 2010. Prior to initiation of the study, the surgeon had performed >100 laparoscopic partial nephrectomies, >150 laparoscopic radical nephrectomies with or without hand-assistance, >10 robotic partial nephrectomies, and >800 robotic prostatectomies as an attending surgeon.

Complications were recorded using the Clavien classification system.[6] The Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula was used to estimate glomerular filtration rate (eGFR).[7] Operation time was recorded from cystoscopy with ureteral catheter placement, inclusive of positioning in a full flank position, and ended at placement of the dressing.

Laparoscopic and/or robotic partial nephrectomy is our standard laparoscopic approach to small renal masses. Patients are selected for unclamped hand-assisted laparoscopic partial nephrectomy when tumors are primarily endophytic, multifocal, in a solitary kidney, or when baseline renal insufficiency is present (Figure 1). The presence of a hypodense rim around the tumor on computed tomography (CT) is an important indicator of the feasibility of this approach.

A hand port is placed either via a muscle-splitting Gibson incision (right) or through and above the umbilicus (left), with two additional 12 mm ports placed in their standard locations as for radical nephrectomy. A dissection identical to that of standard hand-assisted laparoscopic radical nephrectomy is performed. The tumor is localized, and the fat overlying the tumor is dissected away and sent as a separate pathologic specimen. A laparoscopic renal ultrasonography is performed to confirm the boundaries of the tumor and to hopefully observe a hyperechoic rim around the tumor, which would indicate encapsulation. The hilum is completely dissected, but clamps are not applied. Mannitol or other diuretics are not given.

The renal capsule around the tumor is then scored circumferentially with a hook electrode. Gentle suction dissection at the base of the tumor will generally delineate an excellent plane at the base of the tumor where it meets the parenchyma. The index finger is then used to bluntly continue this plane as much as would be done with the back of a scalpel handle in open surgery (Figure 2). The plane typically leaves a small amount of normal parenchyma on the tumor, and fol-

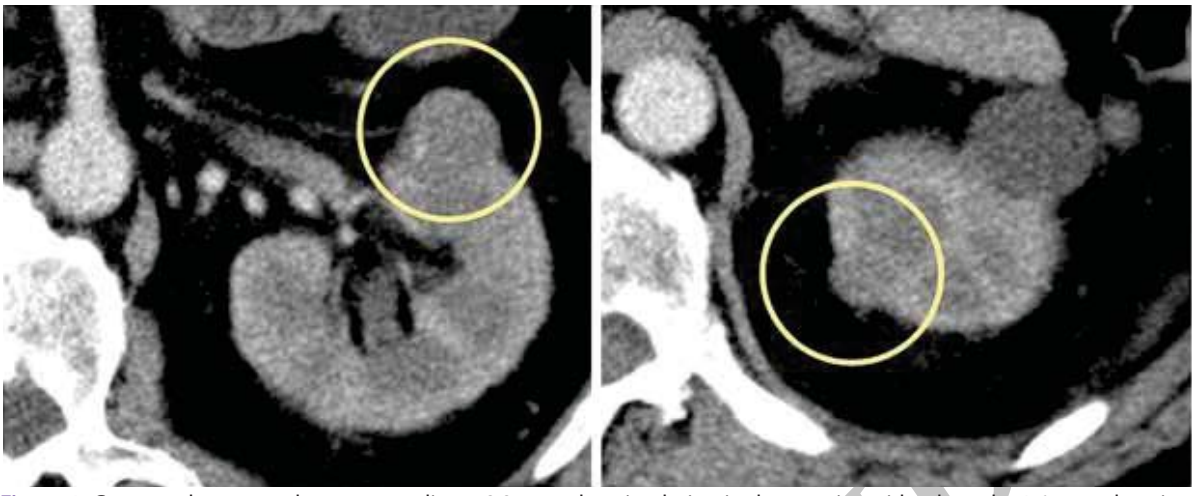

Figure 1. Computed tomography scan revealing a 2.2 cm enhancing lesion in the anterior mid-pole and a 1.6 cm enhancing lesion in the postero-medial lower pole.

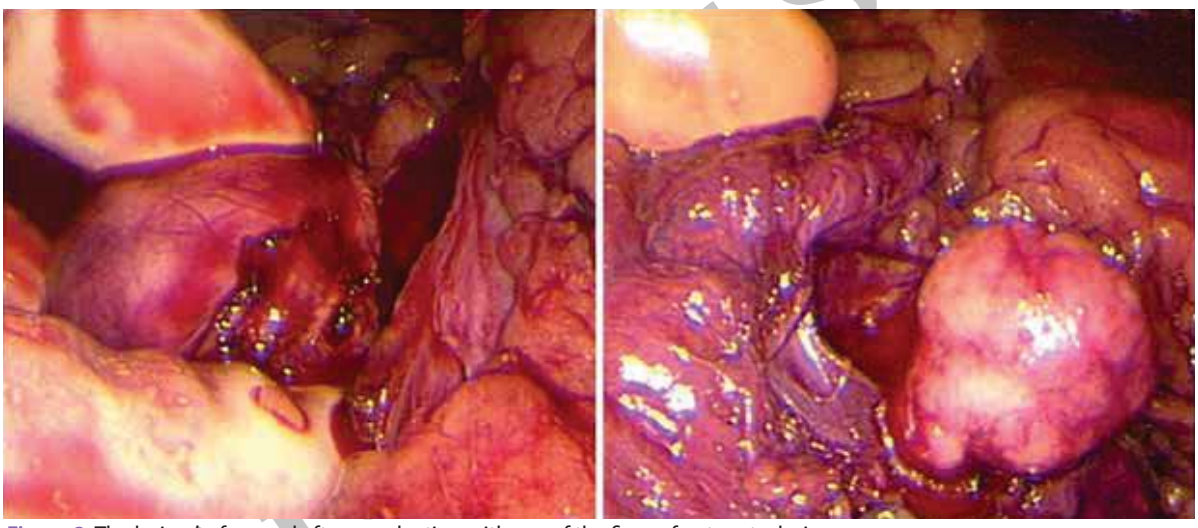

Figure 2. The lesion before and after enucleation with use of the finger fracture technique.

lows the inherent pyramidal anatomy to a single artery at its base. This artery is pinched off between the thumb and index finger, allowing for immediate removal of the tumor for thorough pathologic examination for tumor type and adequacy of margins. As long as the plane has not been forced in any way, hemostasis, even at this point, is generally excellent with only a few points of bleeding at the base of the defect. A single finger can generally be gently placed in the defect to hold pressure. If cortical bleeding occurs as well, this is easily managed by manual compression of the defect. Bleeding is compressed for a full ten minutes, which occurs during pathologic analysis of the specimen.

In the setting of negative margins, no further resection is performed. If there is a positive margin, or if there is clinical suspicion of inadequate resection despite negative margins, careful inspection of the defect can be performed with little blood loss to guide further resection. Nephrectomy is performed where there are multifocal positive margins or where deeper resection is not safe or feasible. Bulldog clamps may be applied at this point if a more aggressive standard laparoscopy or open partial nephrectomy is deemed feasible.

After checking for collecting system leaks with a retrograde

injection of methylene blue and spot suturing of defects or pinpoint bleeding, the renal defect is closed as for all laparoscopic partial nephrectomies at our institution. Argon beam coagulation is routinely used for cautery of the cortex. A standard closure of the renal defect is performed utilizing collagen bolsters, pro-coagulants, and capsular sutures.

RESULTS

Eight consecutive patients with the mean age of 55.8 years were included in this study (Table). All patients underwent unclamped hand-assisted partial nephrectomy (ie, zero ischemia). Median tumor size was 3.7 cm (range, 1.7 to 8.5 cm). Mean estimated blood loss was 368.8 cc (range, 100 to 800 cc). Mean operation time was 236.9 minutes (range, 175 to 272 minutes) and mean hospital stay was 3.3 days. Two cases underwent resection of two separate renal masses and one case underwent concomitant ventral hernia repair and sac excision. There were limited changes in postoperative hematocrit and eGFR.

There were no intra-operative complications and no open conversions. There was one grade II (ileus with small pneumothorax managed by observation alone) and one grade IV (pulmonary embolism) in the 90-day peri-operative period managed solely by anticoagulation for six months. The patient who suffered from the pulmonary embolism also required blood transfusion upon initiation of heparin anticoagulation.

Final pathology revealed 4 (50%) cases of clear cell carcinoma, 3 (37.5%) papillary, and 1 (12.5%) chromophobe. There was one positive surgical margin, which was identified intra-operatively upon frozen section, which led to the intra-operative decision to perform a radical nephrectomy.

DISCUSSION

Partial nephrectomy is emerging as the standard of care for small renal masses.[1] Laparoscopic partial nephrectomy remains a technically challenging procedure[8,9] and may not be readily utilized by urologists with limited laparoscopic experience. Robotic-assisted laparoscopic partial nephrectomy has been recently shown to have at least equivalent oncologic results and peri-operative outcomes.[10] Some drawbacks include lack of tactile feedback in achieving adequate hemostasis are difficulties with the laparoscopic or robotic approach.[4] Furthermore, although the goal of zero ischemia is preferred in order to preserve renal function,[11] few centers have attempted this technique in the laparoscopic setting.[3,4] We describe our technique of unclamped hand-assisted laparoscopic partial nephrectomy in order to further bridge these areas of uncertainty.

Our study has several important findings. First, we were able to enucleate tumors with negative intra-operative frozen section margins in a relatively bloodless field without the need for warm ischemia. Prior studies have demonstrated the feasibility of hand-assisted partial nephrectomy; however, the unclamped technique has only been described using a saline cooled monopolar radiofrequency device on primarily small exophytic tumors.[4] The mean operation time and blood loss in that series were 175 minutes and 186 cc, respectively. There were no open conversions and all margins of resection were negative.[4] We provide similar results without the need for additional hemostatic devices. Upon excision of the tumor and time elapsed for intra-operative frozen section analysis, there appeared to be enough compression time to allow for controlled hemostasis. Any further bleeding was controlled with selective suture ligation. Furthermore, the tactile feedback during enucleation allowed any areas where tissue and/or vessels were adhered to be sharply divided and/or ligated. We feel this tactile feedback was invaluable in performing a complete extirpation along the natural cleavage planes of the renal parenchyma. In patients where an enhancing rim around the tumor on pre-operative CT imaging clearly demarcated a plane for enucleation, the extirpation was particularly uncomplicated and bloodless. We therefore feel that hand-assisted laparoscopy provides unique benefits in these sometimes challenging cases.

Second, we found that the hand-assisted approach obviated the need for vascular clamping in settings where in the past it had been uniformly applied. Although the safe duration of warm ischemia remains controversial,[11] recent studies suggest superiority of no vascular clamping in preserving renal function.[5] The renal cortex is highly sensitive to changes in warm ischemia predominantly because of the aerobic metabolic environment and consequent structural changes in cellular membranes, which may ultimately lead to cell death.[5]

Demographic characteristics and peri-operative outcomes.[£]

Characteristic	Hand-assisted laparoscopic partial nephrectomy (n = 8)
Gender	
Male, n (%)	4 (50)
Female, n(%)	4 (50)
Age, mean (range), y	55.8 (38 to 68)
Body mass index, mean (range), kg/m^2	30.5 (26.5 to 37.4)
ASA score, mean (range)	2.3 (2 to 3)
Side	
Left, n (%)	4 (50)
Right, n (%)	4 (50)
Tumor size, mean (range), cm	3.7(1.7 to 8.5)
Anterior, n (%)	5 (62.5)
Posterior, n (%)	3 (37.5)
Pre-operative eGFR, mean (range)	69.1 (46 to 94)
Operation time, mean (range), min	236.9 (175 to 272)
Estimated blood loss, mean (range), mL	368.8 (100 to 800)
Warm ischemia time, mean (range), min	0
Length of stay, mean (range), day	3.3 (2 to 6)
Intra-operative complications, n	0
Post-op complications, Clavien Grade*	
I	0
II	1
IIIa	0
IIIb	0
IV	1
V	0
Post-op transfusion, n (%)	1 (12.5)
Post-op hematocrit change, n (%)	-3.1 (-7.5)
Post-op eGFR change, n (%)	-1.6 (-2.4)
Pathology	
Clear cell, n (%)	4 (50)
Papillary, n (%)	3 (37.5)
Chromophobe, n (%)	1 (12.5)
Positive surgical margin, n (%)	1 (12.5)**

[£]ASA indicates American Society of Anesthesiology; and eGFR: estimated glomerular filtration rate.
*Based on modified Clavien Classification.[7]
**Positive surgical margin was identified intra-operatively.

Thus, it appears logical that minimizing or eliminating any ischemia to be imperative in preserving maximal renal function during partial nephrectomy. Recent studies have suggested limiting warm ischemia times to less than 20 minutes whenever feasible,[12,13] which is further decreased from the prior 30 minute cut-off.[2] We specifically selected patients with >50% endophytic renal masses because these patients often pose the greatest risk for bleeding and adequacy of tumor resection if partial nephrectomy is attempted. Thus, we feel the ability to perform unclamped partial nephrectomy in this patient population should be thought of as an important tool in the urologic surgeon's armamentarium when the prospect of warm renal ischemia would be best avoided and preservation of renal function is tantamount.

Third, we were able to completely visualize the entire tumor bed, after extirpation, thus verifying adequacy of resection. While efficient mobilization during laparoscopic and robotic approaches is feasible to perform the resection, we feel the added benefit of manually showing the tumor bed in a variety of angles to be unparalleled in comparison. Although no true comparisons have proven this to be an added benefit, we feel that the ability to hold and maneuver the kidney during resection allows the surgeon to take time and meticulously resect the tumor.

During standard laparoscopic or robotic partial nephrectomy utilizing vascular clamping, the tumor is resected often with a small biopsy performed at the tumor base, and the renal defect is immediately closed prior to clamp removal. Recent studies have suggested the role of anatomical vascular microdissection with selective control of tumor specific arterial branches in order to allow complex tumors to be excised without hilar clamping.[14,15] Another innovative technique to avoid hilar clamping was described inducing hypotension in patients who underwent laparoscopic or robotic partial nephrectomy. While the initial results of these novel techniques appear to support the oncologic efficacy and preservation of renal function, the surgeons in these series are highly experienced, which may limit dissemination of their techniques.[3] With the hand-assisted unclamped approach, we are able to fully inspect the tumor base, obtain a margin from the resected specimen, and re-biopsy the tumor bed several times if necessary. We believe the feasibility of this technique may

lead to greater dissemination among urologists, excellent oncologic efficacy, and preserved renal function, which are well worth the additional incision required for a hand port.

Our single instance of positive margin in this series would likely have been missed if we had utilized our standard approach. Initial frozen section analysis of both tumor and tumor bed was negative in this case. However, tactile feedback led the surgeon to have a high index of suspicion for residual tumor, and close inspection of the tumor bed intraoperatively allowed for identification and targeted biopsy of a small nest of carcinoma visualized at the deepest site of resection. Therefore, the inadvertent leaving of tumor behind was avoided, and nephrectomy was performed as further partial resection was not feasible. We feel that the ability to fully inspect the tumor bed without specific time constraints, and to obtain margins from both the resected specimen and the tumor bed prior to renal reconstruction are perhaps the greatest advantages afforded to the patient by the hand-assisted approach.

Our findings must be interpreted in the context of the study design. First, this is a small series of patients and further studies on a larger number of patients are warranted to validate these preliminary findings. Second, we carefully selected patients with >50% endophytic renal masses with radiologic features suggesting that this approach was feasible. The general applicability to all endophytic renal masses in all cases has not been demonstrated here. Third, the larger incision required for the hand port as compared to standard laparoscopy may lead to slightly higher morbidity and should be considered when discussing this procedure as a treatment option. [4] However, we feel the added benefits discussed above of performing an unclamped hand-assisted laparoscopic partial nephrectomy far outweigh any perceived slight increase in morbidity experienced due to additional skin incision length.

CONCLUSION

We describe our technique of unclamped hand-assisted partial nephrectomy for predominantly endophytic renal masses in the setting of relative contraindication to warm ischemia. Although our results are preliminary, we feel this technique provides superior visualization and adequate hemostasis while preserving oncologic efficacy and renal function in this higher-risk patient population.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Campbell SC, Novick AC, Belldegrun A, et al. Guideline for management of the clinical T1 renal mass. J Urol. Vol 182; 2009:1271-9.
2. Gill IS, Kamoi K, Aron M, Desai MM. 800 Laparoscopic partial nephrectomies: a single surgeon series. J Urol. 2010;183:34-41.
3. Gill IS, Eisenberg MS, Aron M, et al. "Zero ischemia" partial nephrectomy: novel laparoscopic and robotic technique. Eur Urol. 2011;59:128-34.
4. Tan YH, Young MD, L'Esperance JO, Preminger GM, Albala DM. Hand-assisted laparoscopic partial nephrectomy without hilar vascular clamping using a saline-cooled, high-density monopolar radiofrequency device. J Endourol. 2004;18:883-7.
5. Thompson RH, Lane BR, Lohse CM, et al. Comparison of warm ischemia versus no ischemia during partial nephrectomy on a solitary kidney. Eur Urol. 2010;58:331-6.
6. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240:205-13.
7. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. Ann Intern Med. 2009;150:604-12.
8. Winfield HN, Donovan JF, Lund GO, et al. Laparoscopic partial nephrectomy: initial experience and comparison to the open surgical approach. J Urol. 1995;153:1409-14.
9. Janetschek G, Daffner P, Peschel R, Bartsch G. Laparoscopic nephron sparing surgery for small renal cell carcinoma. J Urol. 1998;159:1152-5.
10. Rogers C, Sukumar S, Gill IS. Robotic partial nephrectomy: the real benefit. Curr Opin Urol. 2011;21:60-4.
11. Thompson RH, Lane BR, Lohse CM, et al. Every minute counts when the renal hilum is clamped during partial nephrectomy. Eur Urol. 2010;58:340-5.
12. Thompson RH, Leibovich BC, Lohse CM, Zincke H, Blute ML. Complications of contemporary open nephron sparing surgery: a single institution experience. J Urol. 2005;174:855-8.

13. Lane BR, Babineau DC, Poggio ED, et al. Factors predicting renal functional outcome after partial nephrectomy. J Urol. 2008;180:2363-8; discussion 8-9.

14. Gill IS, Patil MB, Abreu AL, et al. Zero ischemia anatomical partial nephrectomy: a novel approach. J Urol. 2012;187:807-14.

15. Ng CK, Gill IS, Patil MB, et al. Anatomic renal artery branch microdissection to facilitate zero-ischemia partial nephrectomy. Eur Urol. 2012;61:67-74.