Original Article

Radiofrequency-assisted, laparoscopic, clampless partial nephrectomy in patients with low-complexity small renal tumors: A retrospective cohort study

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Abstract

Background: This single-center, retrospective study was performed to investigate the safety and efficacy of radiofrequency-assisted (RF), laparoscopic partial nephrectomy (PN) with zero ischemia in patients with low-complexity small renal tumors.

Materials and Methods: Patients with small renal masses (SRMs) who underwent laparoscopic, clampless laparoscopic partial nephrectomy - radiofrequency assisted (LPN-RFA) between January 2016 and June 2020 were studied. Demographics, clinical and pathological characteristics, recurrence-free survival, and overall survival were recorded.

Results: Fifty-two SRMs were excised from corresponding patients using RFA–LPN. The median tumor size was 2.5 cm and all specimens involved low-complexity masses according to the renal nephrometry score. No conversions to radical nephrectomy were recorded. Postoperatively, there were one patient with fever, one with hematuria, and two with urinary leakage treated endoscopically. The majority of tumors (48/52, 86.2%) were clear-cell carcinomas. According to the glomerular filtration rate postoperatively and 12 months' posttreatment, adequate renal function was preserved in all patients. There were no positive surgical margins identified postoperatively and no recurrences during a median follow-up 24 months. All patients were alive at the last follow-up.

Conclusions: This study suggests that RFA laparoscopic clampless PN represents an effective method for managing patients with low-complexity SRMs. It offers adequate intraoperative safety and excellent mid-term oncological control and functional preservation.

Keywords: Laparoscopy, partial nephrectomy, radiofrequency, renal tumor

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INTRODUCTION

The incidence of renal cell carcinoma (RCC) is rising at least partially due to the wide use of modern imaging techniques leading to early diagnosis of kidney tumors particularly small renal masses (SRMs).[1,2] Current

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treatment options for SRMs include radical (RN) or partial nephrectomy (PN), thermal ablative strategies, or surveillance. Oncological outcomes after PN or RN appear to be similar; nevertheless, PN offers preservation of renal function. Nephron-sparing surgery (NSS) is performed either with open or with laparoscopic approach, resulting in similar oncological and renal functional outcomes.[3]

Laparoscopic PN (LPN) has rapidly gained ground as an innovative technique with minimal invasive advantages and lower cost. However, it remains largely underutilized, mainly due to its complexity and especially because it requires excellent surgical skills.[4] Control of bleeding and warm ischemia time are the main challenges in NSS. To avoid intraoperative complications, particularly bleeding, warm ischemia could be prolonged, leading to renal parenchymal damage and functional impairment. Advancing nephron-sparing surgical techniques is the key to minimize and even eliminating warm ischemia time, ensure adequate hemostasis, and minimize complications.

One technique that may achieve rapid coagulation is the radiofrequency ablation (RFA) and is commonly applied for resections of liver lesions without the Pringle maneuver and with no blood loss.[5,6] RFA involves coagulation of a slice surface of parenchyma around the tumor before the resection. Coagulation is achieved with an electrode – needle while a generator produces high-frequency current inducing a thermal effect throughout the tissue.

The purpose of this study was to evaluate the safety and efficacy of RFA-assisted clampless PN in a cohort of patients with low complexity SRMs who underwent this procedure laparoscopically.

MATERIALS AND METHODS

Adult patients with a diagnosis of a solitary renal mass, up to 4 cm in maximum diameter, who underwent RFA-assisted clampless PN at the University Hospital of Larissa, Greece between January 2016 and June 2020 were included in this retrospective cohort study. Written informed consent was obtained by all patients enrolled in this study. Preoperatively, all patients underwent contrast-enhanced computed tomography (CT) scan of the abdomen, chest CT scan, and laboratory screening that included full blood count and coagulation testing.

The surgical approach consisted of a transperitoneal LPN with four ports. In each case, the renal pedicle vessels were identified but not clamped off. The lesion was identified, defatted, and circumscribed with the use of a 17G RF needle electrode on coagulation mode. The active tip of the needle was 1.5 cm creating an avascular rim of normal parenchyma encircling the mass while maintaining ≥0.5 cm distance from the lesion. RF energy was delivered to tissue starting at 60W and the power was increased to a maximum power of 80W. The power setting remained at 80W until impedance had risen to more than 250Ω, at which time the power was decreased to <10W.

Then with a small traction on the mass, the coagulated parenchyma was excised with scissors. Then RF was used repeatedly until complete excision of the mass. The tumor bed was totally coagulated and the adjacent perirenal fat was applied to cover the defect. Surgical specimens were then extracted for pathological evaluation and a drain was used in all cases. RF procedure was performed with impedance-controlled pulsed current from the 3rd generation 200 W RF3004 generator.

Intra-and postoperative complications were recorded using the Clavien–Dindo classification system and renal function preservation was assessed by comparing pre-and post-operative creatinine values and glomerular filtration rate (GFR). The RENAL nephrometry scoring system was retrospectively applied to all lesions. The majority of our patients had low-complexity tumors (score 4–6). CT imaging was studied in detail and scored by two independent reviewers; in the case of disagreement, an additional reviewer was recruited to finally reach a consensus. Patient follow-up consisted, besides physical exam and blood work, of an abdominal CT (or magnetic resonance imaging) scan and a chest X-ray every 6 months following PN for the first 3 years and then yearly up to 5 years. The estimated GFR (eGFR) was calculated for all patients preoperatively and postoperatively according to the modified Modification of Diet in the Renal Disease equation. Recurrence was defined as any new enhancement (10HU) on CT scans after 3 months' postoperatively.

The study was approved by the Ethics Committee of our institution and was conducted according to the World Medical Association Declaration of Helsinki.

RESULTS

A total of 52 patients (41 men, 11 women) with a median age of 60.5 years (29–81), underwent RF-assisted (RFA) clampless LPN from January 2016 to June 2020. Regarding the affected kidney, 28 out of 52 tumors (53.85%) were right-sided and 24 (46.15%) were left-sided. The majority of the lesions (49/52, 94%) were categorized as low complexity (4–6) and 3/52 (6%) as moderate (7–9). With regard to tumor location, 33/52 (63.46%) were located anteriorly, 13/52 (25%) posteriorly and 6/52 (11.54%)

were central. Forty-nine out of 52 tumors (94%) were exophytic, two were endophytic (4%) and one (2%) was mixed. The mean tumor size was 2.45 cm (0.9–4). In 42/52 cases (81%), tumor size was ≤3 cm [Table 1]. The mean operative time was 112.5 min (75–150). The mean cauterization time for each puncture was about 7 s (4–10), while the average excision time was 16 min (6–24). No conversions to radical nephrectomy were recorded. The median hospital stay was 5 days (3–7). There were 48/52 (92%) histologically proven clear cell RCCs, 3/52 (6%) were papillary and 1 (2%) was oncocytoma. Positive surgical margins were recorded in 1 specimen although without recurrence of the corresponding patient during follow-up. There was a clinically insignificant elevation of serum creatinine levels 7 days postoperatively 1.02 mg/dL (0.97–1.07) from 0.95 mg/dL (0.89–1.02) preoperatively. However, at 30 days' postoperatively, no difference was recorded. Median eGFR before surgery was 85.2 mL/min/1.73 m^2 (65.9–118.7) and median eGFR 1 year postoperatively was 69.8 mL/min/1.73 m^2 (54.7–110.5). There was no major bleeding with a mean blood loss of 130 mL (10–250). No other major complications were observed intraoperatively [Table 2]. Two patients (3.84%) were diagnosed with urine leakage postoperatively (surgical complication grade III according to Clavien Dindo classification); one on the 3rd postoperative day and the other one 8 days following the procedure. Both cases were managed with retrograde insertion of a double J ureteric stent. Moreover, two patients in our cohort experienced fever and hematuria (surgical complication Grade I according to Clavien Dindo classification). No other patients experienced any complications. All patients were alive at data collection with no evidence of local recurrence or progression to metastatic disease at the last available follow-up. The median follow-up was 24 months (12–36).

Table 1: Baseline characteristics for patients in the study group

	RFA-LPN
Patients	52
Male/female	41/11
Median age (years)	60.5 (29–81)
Median ASA score	1.5 (1–3)
Kidney left/right	24/28
RENAL nephrometry score: Low (4–6)/ moderate (7–9) complexity	49/3
Tumor location: Anterior/posterior/central	33/13/6
Growth pattern: Exophytic/endophytic/mixed	49/2/1
Mean size (cm)	2.45 (0.9–4)

ASA: American Society of Anesthesiologists, physical status classification system, RENAL: Radius, Exophytic/endophytic, Nearness of tumor deepest portion to the collecting system or sinus, Anterior (a)/ posterior (p) descriptor and the Location relative to the polar line, RFA-LPN: Radiofrequency-assisted laparoscopic partial nephrectomy

Table 2: Patient's perioperative and renal function outcome of the study group

	RFA-LPN
Median OT (min)	112.5 (75–150)
Median WIT (min)	0
Median EBL (mL)	100 (80–140)
Median hospital stay (days)	5 (3–7)
Histopathology: Clear cell/oncocytoma/ papillary, *n* (%)	48/1/3 (86.2/3.4/10.3)
Furhman grade of RCC: I/II, *n* (%)	23/29 (44.8/55.2)
Complications (Clavien-Dindo classification): Grade I (fever/hematuria) - Grade III (urinary leakage), *n* (%)	1/1–2 (0.02/0.02/0.04)
Median eGFR (mL/min/1.73 m^2): Preoperatively/12 months' postoperatively	85.2 (65.9–118.7)/69.8 (54.7–110.5)
Median follow-up (months)	24 (12–36)

OT: Operation time, WIT: Warm ischemia time, EBL: Estimated blood loss, RCC: Renal cell carcinoma, eGFR: Estimated glomerular filtration rate, RFA-LPN: Radiofrequency-assisted laparoscopic partial nephrectomy

DISCUSSION

Increasing rates of SRMs' detection on imaging has favored the use of PN. According to the current urological and oncological guidelines, NSS remains the gold standard for SRMs up to 4 cm (stage T1a) and in selective case up to 7 cm (stage T1b).[7] Regarding active surveillance or/and other local techniques, a surveillance, epidemiology, and end results-medicare-linked population Study showed that cancer-specific survival and overall survival for active surveillance were significantly lower compared to partial or radical nephrectomy or local techniques such as thermal ablation.[8] In addition, local tumor ablation and noninterventional management showed worse 5-year cancer-specific mortality, relative to PN.[9] Particularly, local tumor ablation exhibited worse cancer-specific mortality in elderly patients, whereas active surveillance exhibited higher mortality rates in both younger and older patients.[9] Further, PN preserves renal function and offers comparable results in terms of overall and cancer-specific survival compared to radical nephrectomy.[10] Besides PN, other minimal invasive techniques have been applied for the treatment of SRMs, including RFA, microwave ablation and cryoablation. These techniques have been mostly used in hepatic surgery and much less in renal surgery mostly as ablative strategies via percutaneous approach in frail patients who are unfit to undergo open surgery due to multiple comorbidities.[11] The first RFA-assisted surgical excision of SRM without renal hilum clamping was described by Jacomides *et al*. in 2003.[12] Since then, other studies reported the adequate hemostasis achieved using RFA in NSS.[13,14]

Surgical resection of renal masses has greatly evolved since 1963 when Robson described the classical radical nephrectomy to include PN and particularly the laparoscopic approach.[15] Regardless of laparoscopic or open NSS, clamping of the renal hilum is an inherent part of the procedure, followed by

tumor resection and suturing of the renal bed with the use of hemolocks clips or simple stitches. However, clamping is challenging and in some cases detrimental for renal function when warm ischemia time exceeds 30 min.[16-18] In addition, this is a demanding procedure requiring excellent surgical skills and fast movements from the surgeon that could be difficult during the laparoscopic approach. Therefore, clampless laparoscopic RFA-assisted PN has been proposed as an alternative method, overcoming blood loss and warm ischemia time, which could even be performed by less experienced surgeons.

In this study, we examined the safety and efficacy of this technique exploiting the bipolar energy of RF in our center's cohort of patients. A comparison between PN, active surveillance or/and other local techniques is beyond the scope of this work. We found an excellent hemostasis of tumor bed in all cases, and renal function was preserved postoperatively. In terms of histopathological findings and clinical outcomes, there were no positive margins, but one, and all patients were alive without clinical or radiographic evidence of local recurrence or metastatic progression during follow-up. Our findings are complement prior studies which reported excellent oncological outcomes with recurrence-free and cancer-specific survival rates exceeding 90%.[13,18] The major concern of PN is oncological safety, particularly the rate of positive margins and local recurrence. Several smaller studies compared to ours, for example, Patel *et al*. found no positive margins and no recurrences in a short follow-up period in 15 patients.[19] Zhao *et al*. did report a 3.6% of disease progression in 42 patients without local recurrence at the enucleation bed.[14] while Rimar *et al*. in a larger study with 54 patients described a 2.7% frequency of positive margins and 6.1% recurrence rate.[13] In the present study, with the longest follow-up of 3 years, we found only one positive surgical margin (2%) and no local or distant recurrences suggesting that cancer-specific survival and progression-free survival rates were 100%. In conclusion, RFA LPN is safe in short-term follow-up. However, long-term evaluation is needed to provide a clearer picture of the overall recurrence risk in the future.

Regarding safety, there were two patients in our cohort with fever and hematuria and 2 others who experienced urinary leakage and were treated endoscopically. The latter complication has been previously described and attributed to the poor recovery ability of the collecting system after ablation.[20-22]

We opted to perform LPN by the transperitoneal approach because of its larger working area and superior instrument angles for intracorporeal renal reconstruction. In addition, the limited retroperitoneal space makes retroperitoneal LPN/RLPN technically more challenging.[23] In line with prior studies and meta-analyses,[24,25] we agree that understanding both techniques and adapting the access type to the clinical case is key to maximize clinical benefit and minimize complications.

Although RFA-assisted LPN has several advantages such as a very good level of hemostasis, zero-ischemia resection, and excellent oncological and functional outcomes, it is not applicable to all tumors. In our study, all patients had low-complexity tumors including exophytic location and small size <4 cm. Thus, careful selection of these patients may assist in avoiding postoperative complications including urine leakage which has been reported at much higher rates in previous studies.

Another important caveat in our study compared to previous works is the use of adjacent perirenal fat to fill the defect created by the excision of the tumor. RFA PN may not be ideal for large, deeply penetrating the renal parenchyma or adjacent to the renal hilum lesions, because there is a concern that the thermal effect, created by the RF, may provoke early or delayed injury to the collective system easily missed by the surgeon intraoperatively. By placing a vascularized piece of perirenal fat we were able to improve the healing of the collective system caused by RF's coagulation necrosis.

One limitation of RFA LPN is the clearance of the plane between the tumor and normal parenchyma. In tumors presenting with pseudocapsule, the identification of the correct plane could be difficult, and thus may increase the difficulty of the operation. To overcome this concern, we used scissors to cut until the normal parenchyma appeared and then we coagulated the tumor bed. In this manner, we were able to recognize clearly the border between the tumor and the normal parenchyma.

This study is limited by its retrospective design, the relatively small sample size, the small follow-up period, and the fact that it was conducted at a single, although high-volume center. Larger, prospective, multi-center studies are needed to better elucidate the exact place of this technique within the surgical treatment armamentarium for SRMs, particularly for those with high complexity, which were not included in our study.

CONCLUSIONS

Collectively, RFA LPN is a safe and effective approach

for NSS, serving adequate preservation of renal function without compromising oncological outcomes in selected patients with low-complexity renal tumors. Further, this study's findings open up new avenues for further expanding this technique to other minimally-invasive ways of treating SRMs.

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Conflicts of interest

There are no conflicts of interest.

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