



Kidney Cancer

Laparoscopic Partial Nephrectomy with “On-Demand” Clamping Reduces Warm Ischemia Time

Renaud Bollens*, Alberto Rosenblatt, Baldo P. Espinoza, Alexandre De Groote, Thierry Quackels, Thierry Roumequere, Marc Vanden Bossche, Eric Wespes, Alexandre R. Zlotta, Claude C. Schulman

Department of Urology, Erasme Hospital, University Clinics, Brussels, Belgium

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Abstract

Objectives: To investigate the impact of “on-demand” clamping during laparoscopic partial nephrectomy on warm ischemia time.

Methods: We retrospectively reviewed 39 consecutive patients with renal tumors who had undergone transperitoneal laparoscopic partial nephrectomy from April 2002 to May 2006. Median tumor size was 2.3 cm. In all cases, the hilum was dissected early and extracorporeal clamping performed. The pedicle was clamped only in case of excessive bleeding, and it was released immediately after the closure of the renal defect with knot-tying sutures over Surgicel bolsters.

Results: Median operative time was 120 min. Renal clamping was required in 31 of 39 patients and in this subgroup the median warm ischemia time was 9 min. Median operative blood loss was 150 ml. Eight patients required blood transfusion and among these two were converted to open surgery. Positive surgical margin was observed in one case. Renal cell carcinoma was present in 22 (54.4%) specimens. No recurrence was observed after a median follow-up of 15 mo.

Conclusions: This novel technique using extracorporeal clamping significantly decreases warm ischemia time, avoiding clamping of the pedicle in selected cases. Our study underlines the feasibility of performing laparoscopic partial nephrectomy with extracorporeal hilar clamping, allowing the shortest ischemia time ever published.

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* Corresponding author. Department of Urology, Erasme Hospital, University Clinics, Route de Lennik 808, B1070, Brussels, Belgium. Tel. +32 2 5553614; Fax: +32 2 5553699. E-mail address: renaud.bollens@ulb.ac.be (R. Bollens).

1. Introduction

Since the introduction of cross-sectional imaging for the diagnosis of intra-abdominal pathologies, an

increased number of small renal masses are being incidentally discovered. These lesions are often peripherally located and have a benign histology in only 20–25% of the cases [1]. Nephron-sparing

surgery is now commonly performed and recommended in selected cases, in small peripheral renal lesions (<4 cm) [2], with local recurrence rate of <3% [3]. However, despite potential advantages of nephron-sparing surgery and the minimal invasiveness of laparoscopic approach, laparoscopic partial nephrectomy (LPN) is still not widely used because of technical difficulties inherent to the procedure [4]. Therefore, hemostatic techniques and new surgical devices to help achieve hemostasis during LPN have been introduced [5]. We present our experience of LPN using an extracorporeal clamp to reduce warm ischemia time.

2. Patients and methods

Between April 2002 to May 2006, 39 patients with single sporadic renal masses underwent LPN (Table 1). All patients had complete blood count, electrolytes, serum creatinine, liver function tests, and urinalysis. Preoperative computed tomography (CT) with intravenous contrast and three-dimensional reconstruction were used for clinical staging and to evaluate vascular anatomy. If a main vessel was observed close to the tumor, an open partial nephrectomy was performed. Follow-up consisted of physical examination and serum creatinine measurements 4 wk after surgery. CT scan was performed at 6 mo postoperatively and repeated twice a year subsequently for those patients in whom a malignant lesion was diagnosed.

The tumor was located in the upper pole in 9 (23%), lower pole in 24 (61.5%), and mid-third in 6 (15.5%) patients, respectively. Five (12.8%) patients had solitary kidneys.

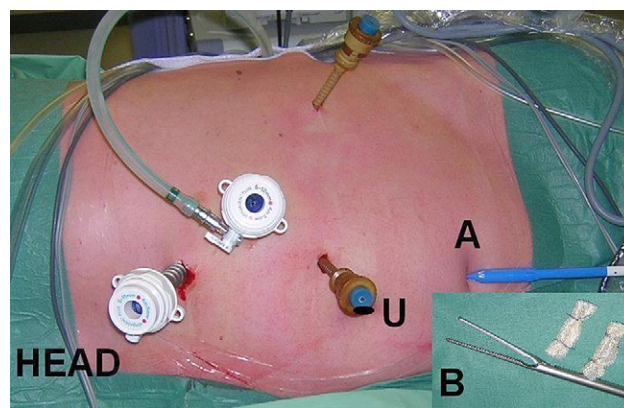


Fig. 1 – placement of abdominal ports. (A) Port site for vascular clamp. (B) insert: Satinsky clamp and surgical bolsters. U = umbilicus.

All surgery was performed by the same surgeon (R.B.), using the transperitoneal approach. A 5-cm jaw Satinsky extracorporeal vascular clamp (Duluc, Microfrance) was used to control the renal pedicle (Fig. 1).

Trocars and laparoscopic instruments used were: 3 × 11-mm (optic 0°, Satinsky clamp, bipolar grasper) and 2 × 5-mm (scissors, suction device). The patient was positioned in a lateral decubitus position with flank hyperextension. Pneumoperitoneum was established via a Veress needle placed two fingerbreaths below the right costal margin arch, at the level of the lateral border of the rectus muscle. The needle was replaced by an 11-mm port and the triangulation rule was used for the placement of the second and third trocars. The fourth port was inserted midline between the umbilical trocar and the anterior iliac crest on the side of the procedure. An 11-mm port was

Table 1 – Patient characteristics and perioperative data

		SD (range)
No. of patients/sex	39 (23 M/16 F)	
Median age, yr	61	14.66 (26–84)
Median tumor size, cm	2.3	1.66 (1.2–9.0)
Localization	Right 22/left 17	
	Upper pole 9 (23%)	
	Mid-pole 6 (15.5%)	
	Lower pole 24 (61.5%)	
	5 solitary kidney	
Median operative time, min	120	34.6 (60–240)*
Median warm ischemia time, min	9	7.96 (6–40)
Median estimated blood loss, ml	150	365 (30–1500)*
No. blood transfusion	6 (15.4%)*	
Complications postoperative	12 (31%)	Hemorrhage 1 Hematoma 6 Urinary leakage 3 Hydronephrosis 1 Chylous lymphocele 1
Median hospital stay, d	7	2.37 (4–13)
Median pre/postoperative serum creatinine, mg/dl	0.9/1.0	0.28 (0.7–2.2)/0.35 (1.0–2.4)
Positive margins (intraoperative frozen analysis)/definitive analysis, no.	4 (10.2%)/1 (2.5%)	
Median follow-up, mo	15	8.34 (1–39)

* Excluding conversions.

introduced caudally and slightly inferior to the umbilicus to place the Satinsky clamp (Fig. 1). For left partial nephrectomy, the plane between the descending colon and Gerota's fascia was developed to allow the colon to fall medially; the splenorenal and lienocolic ligaments were incised allowing the spleen and the tail of the pancreas to be separated from the upper pole of the kidney. On the right, the liver was cranially retracted using a grasper that was fixed to the abdominal wall. The ascending colon was mobilized and dissected from the underlying Gerota's fascia. The mobilization of the colon continued caudally to expose the lower pole of the kidney, ureter, and gonadal vessels. The Gerota at the level of the lower pole was incised and lifted to locate the ureter and psoas muscle, which was followed cranially to expose the pedicle. The Satinsky vascular clamp was introduced and left open around the pedicle. Gerota's fascia overlying the area where the tumor was likely to be found was incised. The fatty tissue overlying the tumor was removed and sent to pathology. The surface of the renal cortex bordering the lesion was stripped of fatty tissue to permit visualization of the tumor's lateral margins. The Gerota was mobilized beyond the margins of the wedge resection to facilitate kidney reconstruction.

The cortex and renal parenchyma around the nodule were incised with cold scissors and the tumor was excised. The pedicle was only clamped when bleeding interfered with safe removal of the tumor.

When a renal calyx was opened, a Vicryl 2-0 running suture was used to close the defect. Interrupted "U-shaped" sutures of Vicryl 0 were placed through the Gerota and the renal parenchyma. Two Surgicel[®] bolsters, 10 × 20 cm, were placed under the loose loops of the suture to fill in the defect, helping with hemostasis. The knot was tied carefully to avoid tearing the parenchyma and after tying the first suture, the clamp was opened. Further bleeding was controlled by placing additional "U-shaped" sutures. An Endo-catch bag (Tyco Autosuture) was used for specimen removal and a 12-mm silicone Penrose drain was positioned adjacent to the repair.

3. Results

The median operative time was 120 min (range: 60–240 min). The renal pedicle was clamped in 31 (79.5%) cases. The artery was clamped alone in 8 patients (20.5%) and vessels were clamped *en bloc* in 23 patients (59%). The median warm ischemia time was 9 min (range: 6–40 min). The median estimated blood loss was 150 ml (range: 30–1500 ml); eight patients (20.5%) required blood transfusion and among these, two were converted to open surgery (Table 1). Renal function returned to baseline in 37 patients (95%). One patient with chronic kidney disease developed worsening of renal function after the procedure and another had a moderate elevation of the serum creatinine level. Postoperative complications developed in 12 patients (30.7%); 6 (15.4%) required surgical management. One patient (2.5%) required open

nephrectomy due to immediate postoperative bleeding. All the other complications were managed endoscopically or laparoscopically. In three patients (7.7%), postoperative urinary leakage was observed and treatment was conservative with double-J stent placement and drainage in two patients and surgical correction in one patient. Retrograde cystography at 1 mo revealed complete closure of the collecting system in all cases. Retroperitoneal hematomas appeared in six patients (15.4%), one of whom required surgical drainage. Hydronephrosis requiring surgical correction occurred in one patient. One patient developed chylous lymphocele and was treated conservatively. Intraoperative frozen section analysis from the margins of resection were positive in four patients (10.2%). In one patient, it was a 3.5-cm centrally located renal cell carcinoma (RCC) in a solitary kidney. We opted to preserve the kidney with close follow-up. In two patients with a normal contralateral kidney, an elective laparoscopic radical nephrectomy was performed due to inconclusive diagnosis. In the other, re-clamping (15-min ischemia time) with secondary resection was necessary to achieve a negative margin status.

The final pathologic results revealed RCC in 22 patients (56.4%), oncocytoma in 4 (10.3%), and benign lesions in 13 (33.3%); 5 angiomyolipoma, 3 atrophic duplicated upper pole, 2 caliceal diverticula, 2 cysts, and 1 lithium pseudotumor).

The median follow-up was 15 mo (range: 1–39 mo), with no local recurrences, including the one with a positive margin (follow-up of 23 mo). One patient with a 1.6-cm RCC pT1a G3 with sarcomatoid dedifferentiation in a solitary kidney developed bone metastases soon after the partial nephrectomy.

4. Discussion

LPN was initially performed in a porcine model by McDougall in 1993 [6]. In the same year, Winfield [7] reported the first case of LPN in a patient for a benign disease. But, despite the well-described advantages of nephron-sparing surgery [8], LPN is not yet widely performed because of its potential complications [9]. Optimal tumor excision can only be achieved with adequate hemostasis and control of the operative field, but the clamping of the renal artery still remains an important debated issue.

Clamping the renal vessels during tumor resection seems to be associated with reduced operative time and blood loss [10], but the drawback is warm ischemia of the kidney and potential damage. Several techniques of achieving complete hemostasis have been described [11]. Renal ischemia can

be achieved globally by clamping only the renal artery or the artery and then the vein separately, with bulldog clamps [12]. In our experience the placement of bulldog clamps requires meticulous dissection of the hilum, and technical difficulties are encountered while manipulating the clamps laparoscopically, increasing surgical time and risk of complications. Finally, the option of *en bloc* clamping of the pedicle using a large Satinsky clamp is faster because less dissection is required, but there is always a risk of parenchymal flow overpressure due to a missed polar artery, which can jeopardize bleeding control. Thus, it is advisable to completely dissect the kidney to exclude an accessory artery when performing the *en bloc* hilar control.

Renal regional ischemia can also be accomplished by clamping the renal parenchyma bordering the tumor [13], but normal renal tissue can be injured due to the excessive clamp compression.

In our technique, only the anterior and lower part of the pedicle is dissected. This minimal dissection ensures less risk of vessel injury and arterial spasm, minimizing operative time.

By placing the clamp parallel to the aorta, inadvertent slippage due to malpositioning of the device and conflict with the surgeon's instruments is avoided. Clamp occlusion is only done when excessive bleeding occurs during tumor resection.

The delayed occlusion of the pedicle together with early clamp release, immediately after the first knot-tying suture of the defect, allows significant reduction of warm ischemia time. The clamp is left in place until the end of the procedure and can be reoccluded in a safe and rapid manner in case of inadvertent bleeding. We now routinely clamp the renal artery only because the functional impairment of the kidney is apparently diminished when the

artery alone is occluded [14]. However, for tumors located close to the hilum, the artery and the vein *en bloc* are clamped to prevent venous backflow bleeding.

Novick [15] reported 30 min to be the maximal tolerable period for arterial occlusion.

Desai and coworkers recently evaluated the impact of warm ischemia on renal function in 179 patients after LPN. The authors concluded that pre-existing azotemia and advanced age increased the risk of postoperative kidney dysfunction if the warm ischemia time exceeded 30 min [16].

In our series, ischemia time was shorter than all the other groups using different techniques of hemostasis (Table 2) and, in selected cases, clamping was avoided with the "last minute" clamping technique.

We observed no significant differences between the preoperative and postoperative serum creatinine values of the patients, including the subset of five patients with solitary kidneys.

Several surgical techniques have been described to induce renal hypothermia during LPN when warm ischemia is expected to be >30 min [17,18], but all of those techniques are time consuming and sometimes associated with complications.

With respect to positive margins, our results compare with the results presented in the literature [19].

We no longer perform routine random biopsies, sending the whole specimen for frozen analysis when the macroscopic margins of the tumor are suspicious.

Many reports have underscored the oncologic efficacy of LPN [20]. In our series, none of the patients with RCC had local recurrences, including

Table 2 – Current series published on laparoscopic partial nephrectomy

References	No.	Mean tumor size, cm	Mean operative time, min	Mean ischemia time, min	Mean blood loss, ml	Positive margins	Complications	Hemostasis
Guilloneau 2002 [10]	28	2	179	27.3	708	0	6 (21%)	Ultrasonic scalpel, bipolar
Kim 2003 [24]	79	2.5	182	26.4	391	2 (2.5%)	4 (5%)	Suture, polyglactin mesh
Ng 2005 [25]	100	3.2	208	31	221	2 (2%)	18 (18%)	Suture, Hem-o-lok
Abukora 2005 [26]	78	2.4	216	39.2	212	1 (1.3%)	5 (6%)	Suture, Hem-o-lok, absorbable clips, cellulose mesh
Ramani 2005 [9]	200	2.9	210	28.7	247	NA	66 (33%)	Suture
Wille 2006 [27]	44	3	210	21	na	0	5 (11%)	FloSeal
Haber 2006 [28]	500	2.9	210	31	150	3 (3%)*	(33%)†	FloSeal, Hem-o-lok, suture
Heinrich 2006 [29]	40	2.6	150	21	270	0	10 (25%)	Suture, cellulose mesh
Brussels series 2006	39	2.3	125	10.2	319	1 (2.5%)	12 (31%)	Bipolar, cellulose mesh

NA = not available.

* Positive margins described in 100 patients.

† Complications described in the first 200 cases.

the one with a positive margin. Nevertheless, a longer follow-up is mandatory.

Ramani [9] analyzed the complications of LPN. The main perioperative complication was acute or delayed hemorrhage, followed by urinary leakage.

In our series, one patient with a solitary kidney and multiple renal arteries had a hemorrhage due to malpositioning of the clamp, and conversion to open partial nephrectomy was performed. After both procedures, despite major blood loss the kidney was preserved. The other bleeding appeared earlier in our series and was due to tearing of the parenchyma while the renal defect was being sutured.

Various techniques of hemostasis have also been studied in laparoscopy, alone or in combination with the use of hemostatic agents. We perform a knot-tying “U-shaped” suture, that includes the Gerota’s fascia bordering the defect and the parenchyma, and two Surgicel bolsters placed into the renal defect.

Some authors describe the use of clips to eliminate knot-tying during warm ischemia [4]. These clips can reduce the possibility of the “cheese-slicing” effect on the renal tissue, which can occur during conventional suture tying, but the length of time required to apply the clips and the cost can be disadvantages.

Different sealant products have been used to control the parenchymal bleeding after tumorectomy [21]. However, there is no consensus on the ideal sealant.

The three postoperative urinary fistulae presented were due to large mattress sutures placed around the parenchyma and the open pelvicaliceal system, used in the beginning of our experience. We do not place a ureteral stent preoperatively. After the cases of urinary leakage, we ensure that the calyces are completely closed. In case of urinary leakage, which usually is observed during the first 2 d, a double-J stent is placed and a bladder catheter is left in place for 7 d. The hydronephrosis presented in one patient was due to upper ureteral adhesions, probably secondary to a retroperitoneal hematoma after the LPN.

Regarding resection of the kidney masses, we routinely use cold scissors for optimal macroscopic evaluation of the margins, but other devices have been used as well [22]. Hand and robot-assisted LPN can also be performed, but the first requires a larger incision, and the latter is associated with longer operative time.

Finally, the choice of the transperitoneal approach used in our laparoscopic technique allows significant advantages over the retroperitoneal approach. Although the latter provides an easier access to the

renal artery and to tumors located posteriorly, the large transperitoneal surgical field permits better visualization and maneuverability during critical steps of the operation [23].

5. Conclusion

In the past, radical nephrectomy was the treatment of choice for renal tumors, but with recent findings clear advantages of nephron-sparing surgery have been established for small masses.

Clamping of renal vessels for laparoscopic nephron-sparing surgery permits excision of renal masses in a controlled hemostatic environment, allowing safe assessment of oncologic margins. Shortening clamping time is useful in reducing warm ischemia time to preserve kidney function.

Although LPN is still considered a challenging procedure demanding advanced laparoscopic skills, the extracorporeal clamping of the renal vessels on demand allowed us to obtain the shortest ischemia time in the literature, and it also permits the safe removal of the tumor without clamping in selected patients.

Conflicts of interest

The authors have nothing to disclose.

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Editorial Comment on: Laparoscopic Partial Nephrectomy with “On-Demand” Clamping Reduces Warm Ischemia Time

Hervé Baumert

Department of Urology,
Paris Saint Joseph Hospital Trust, Paris, France
baumertherve@yahoo.fr

Laparoscopic partial nephrectomy (LPN) is a challenging procedure. Indeed, margin-free excision of the tumour followed by haemostasis and closure of the collecting system must be performed in <30 min to avoid irreversible warm ischaemic renal damage [1]. Although some ingenious authors have described renoprotective cooling techniques [2,3], others have attempted to modify the LPN technique to reduce the warm ischaemia time. Such is the aim of this interesting paper in which Bollens et al report their technique of late clamping of the renal artery before tumour

excision [4]. They achieved an impressive short warm ischaemia time of a median 9 min. However, they also reported a high rate of blood transfusion (20.5%), reoperation (15.4%), and intraoperative positive tumour margins on frozen section histology (10.5%) that were dealt with by either converting to radical nephrectomy or by reclamping the artery and performing a deeper resection to achieve a positive margin rate of 2.5%. With time, the authors will probably improve the results of their interesting “on-demand” clamping technique.

To reduce the warm ischaemia time by improved LPN technique, a compromise must be reached between optimisation of warm ischaemia time and efficient haemostasis. Clamping the renal artery is known to be necessary to reduce blood loss and to provide a bloodless field during excision of the tumour, enabling accurate visualisation of the tumour and its safe resection [5,6]. Contrary to

the late clamping technique of Bollens et al [4], we have recently described a technique involving early unclamping of the renal artery after a safe and bloodless tumour excision and closure of the deep parenchyma. In our preliminary series we reported no blood transfusions and all resection margins were negative [7].

These reports of modified surgical techniques show that experience with LPN technique is growing and that the laparoscopic approach is fast becoming the gold standard for nephron-sparing surgery in high-volume centres. However, it must be remembered that with currently available techniques only the most experienced laparoscopists can expect to achieve a safe and complete tumour excision, without impairing renal function.

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