A single United Kingdom center experience of open partial nephrectomy using regional ischemia

Zubair Cheema, MRCS, Mazen Alsinnawi, FRCS (Urol), Rowan G. Casey, FRCS (Urol), John Corr, FRCS

Department of Urological Oncology, Colchester University NHS Foundation Trust, Colchester, Essex, United Kingdom

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Introduction: *Different techniques are used in open partial nephrectomy (OPN) for localized renal cancer, with variable impact on renal function. Regional renal ischemia technique by using different clamps and without the need to occlude renal vessels is gaining popularity. In our study, we present the largest international series; and the first in the United Kingdom; describing OPN using soft bowel clamp. We study the impact of this regional ischemia innovative technique on renal function, postoperative complications and oncological outcomes.*

Materials and methods: *We retrospectively analyzed the first 100 OPN cases done between 2001 and 2011. All available data on the hospital databases were analyzed; recording patient demographics, tumor characteristics, operative procedure details, histopathology results and long term follow up.*

Results: *A direct comparison with other studies that have used different clamps to achieve regional ischemia was performed. Our technique has the advantage of being used for interpolar and hilar/central tumors. Our mean tumor size was higher at 4.1 cm. Our positive margin rate for malignant tumors was comparable with other studies, same for mean operative time and hospital stay. None had significant deterioration in renal function that required renal replacement therapy. Median blood loss was 400 mL. Our series has the advantage of showing the long term follow up data.*

Conclusion: *We believe the technique we have developed using soft bowel clamp to produce regional renal ischemia is practical and successful. It can be applied safely in all OPN cases, with excellent oncological outcome and clinically acceptable renal function preservation.*

Key Words: partial nephrectomy, regional ischemia, renal cancer, bowel clamp

Introduction

The current evidence suggests that localized renal cancers are best managed with partial nephrectomy (PN), when technically feasible, rather than radical nephrectomy (RN).[1] A number of studies suggested increase overall survival with PN in comparison to RN for both open and laparoscopic approaches.[2] Cancer-specific survival rates for both PN and RN are comparable even for larger renal lesions (4 cm-7cm).[3,4] In a critical literature review comparing open and laparoscopic approaches, laparoscopic was found to be challenging. Although the oncologic and functional outcomes for both techniques were found to be similar in experienced centers, ischemia time and learning curve in laparoscopy were longer. A recommendation for careful case selection based on the tumor growth pattern is required for early experiences in laparoscopy.[5]

Robot assisted laparoscopic PN is an alternative to laparoscopic and open nephron sparing surgery[1] but is not available in every cancer center and therefore innovative techniques for open PN have been developed.

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Address correspondence to Mr. Mazen Alsinnawi, Urology Department, Colchester Hospital, Colchester, CO4 5JL, United Kingdom

Different techniques are used in open partial nephrectomy (OPN) with variable impact on renal function.[6] Occluding the hilar renal vessels; to produce relatively bloodless surgical field; for better resection and to minimize blood loss is a commonly used technique. This warm ischemia limits resection time to preferably less than 20-30 minutes.[7] Cold ischemia increases target ischemia time to less than 40-50 minutes by adding ice slush into the operative field.[8,9] Clampless partial nephrectomy without hilar control or renal cooling has also been described, but with higher risk of bleeding which may theoretically obscure the view for resection and further compromise the renal function by blood volume loss. In a recent cohort study using clampless technique, they concluded that although blood loss was slightly higher, blood transfusion rates, renal function and oncologic outcomes were comparable to other historical series that had vascular control and renal cooling.[10]

Manual compression to renal parenchyma has also been practiced without knowing the possible effect on renal function or outcomes.[6,11] Other techniques using different clamps to produce regional renal ischemia and without the need to occlude the renal artery have been described in literature including the Reni-clamp, DeBakey aortic clamp, Satinsky vascular clamps and Nussbaum clamp.[12-16] Endoscopic parenchymal clamps have also been described to achieve regional ischemia during laparoscopic partial nephrectomy.[17,18]

In our study, we present the largest international series; and the first in the United Kingdom; describing OPN using soft bowel clamp to achieve regional ischemia. We study the impact of this regional ischemia innovative technique on renal function, postoperative complications and oncological outcomes.

Materials and methods

We retrospectively analyzed the first 100 OPN cases done between 2001 and 2011. The case notes and all available data on the hospital databases (PACS, tPath, transfusion records) were analyzed; recording patient demographics and presentation, tumor characteristics, renal profile, operative procedure details and estimate blood loss, complications, histopathology results, the details of oncological outcome and long term follow up. Estimated glomerular filtration rate (eGFR) was calculated using the four-variable modification of diet in renal disease equation (using patient's age, sex and serum creatinine).[19] Statistical analysis was done by using Paired T Test (SPSS v16).

All procedures were performed using a supra eleventh or twelfth rib flank incision. Staying in the extraperitoneal space, the kidney was mobilized within the perinephric fat. The renal hilum was dissected to expose the renal vessels and rubber slings were placed around the main renal artery, Figure 1. The tumor was further circumscribed whilst leaving the fat overlying it. O-vicryl Stay sutures were placed about 5 mm away from the edge of the tumor and deeply into the renal parenchyma. For polar lesions a soft bowel clamp was applied leaving more than 5 mm margin around the tumor. For interpolar lesions two soft clamps were used and placed so their tips met underneath the tumor, Figure 1. For medial or hilar tumors, two clamps were used; one above and one below the tumor; coming from the lateral aspect of kidney and meeting medially without including hilar vessels (which has already been identified).

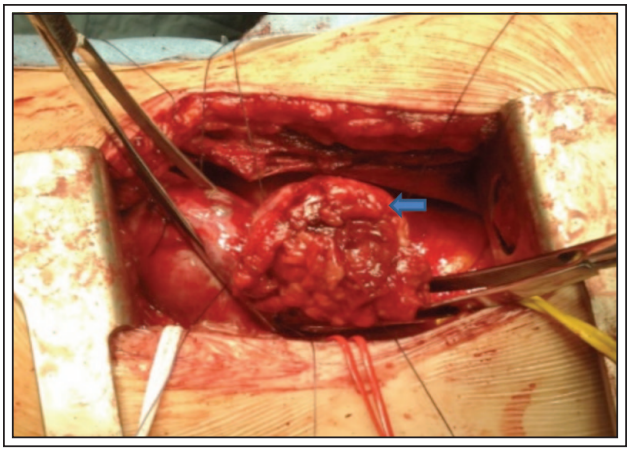

Figure 1. Soft bowel clamps around exophytic renal lesion (arrow), with loops around ureter (yellow), renal artery (red) and renal vein (white).

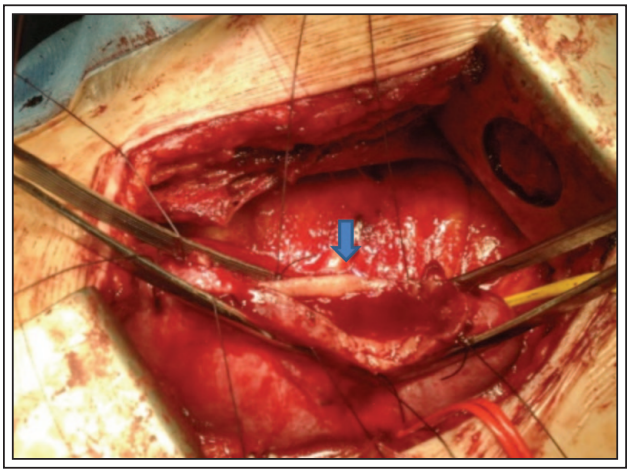

Figure 2. Renal bed after resection of tumor (arrow) with two clamps in-situ.

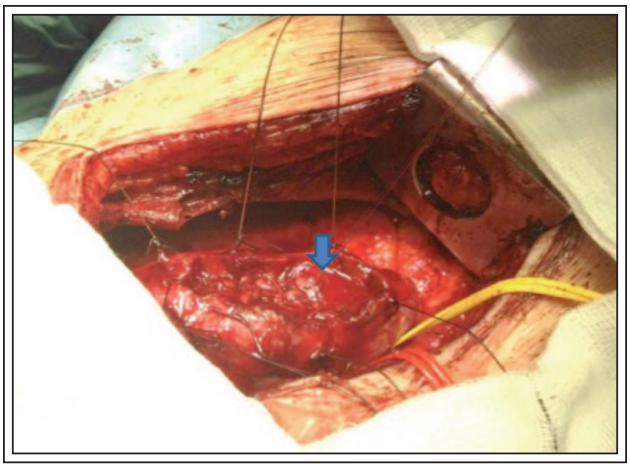

Figure 3. Renal bed after hemostasis and closure of the collecting system (arrow), the two clamps have been removed.

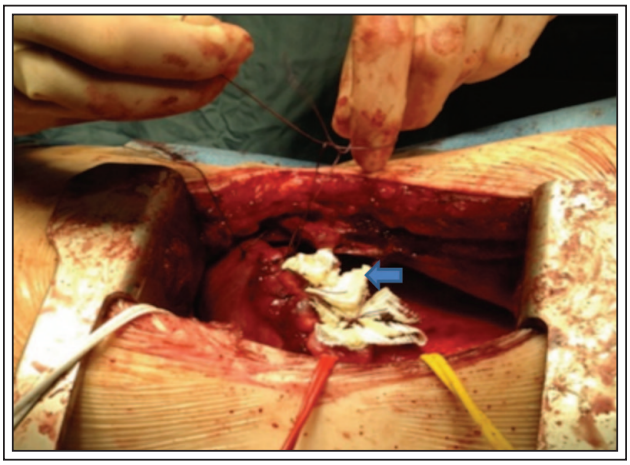

Figure 4. Closure of resection bed with surgicel (arrow).

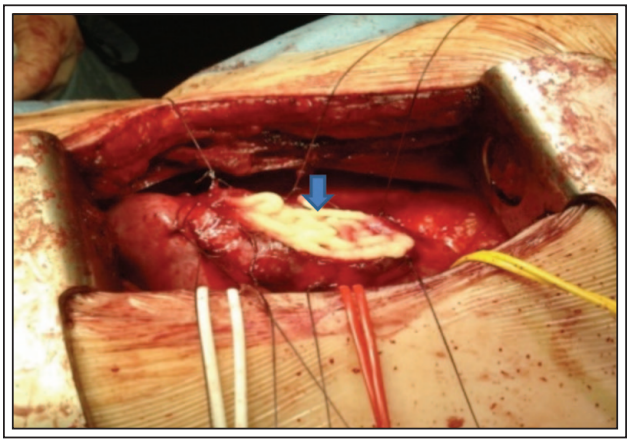

Figure 5. Application of Floseal.

After resecting the tumor in a relatively bloodless field, Figure 2, the underlying renal bed was examined to close any defects in the collecting system using 4/0 monocryl, Figure 3. The parenchymal defect was then closed using surgicel and interrupted 0 vicryl in the manner of parachute closure, Figure 4. Floseal material, Figure 5, was used in selected cases when the defect could not be approximated sufficiently or in solitary kidneys in order to reduce the potential risk of postoperative bleeding. Gentle pressure on the vessel loops intermittently for up to 5 minutes was rarely required to reduce blood loss but was occasionally helpful in renal tumors where the soft bowel clamps could not be positioned to occlude all segmental arteries (such midpolar tumors); to minimize time needed for resection. A 20Fr Roberts drain was employed in all cases.

Results

We are reporting our first 100 OPN procedures that were performed in 97 patients. Seventy-nine percent of these lesions were polar (upper pole to lower pole ratio is 1:1.3). Median estimated blood loss was 400 mL for the full studied period and 230 mL for the second half (2007-2011). Patient demographics, tumor characteristics and operative outcome are all mentioned in Table 1.

TABLE 1. **Patient demographics, tumor characteristics and operative outcome**

Total patients	n = 97
Total procedures	n = 100
Gender	
Male	n = 49
Female	n = 51
Median age (range)	65 (16-85) years
Elective	n = 91
Imperative	n = 9
ASA physical status classification system	
ASA 1	28%
ASA 2	54%
ASA 3	18%
Mean tumor size (range)	4.1 (1.8-18) cm
Tumor location	
Upper pole	n = 34
Lower pole	n = 45
Interpolar	n = 21
Mean operative time	175 minutes

TABLE 2. **Histological outcome, staging and grading of tumor (if any)**

Malignant (total n = 70)		**Benign (total n = 30)**	
Clear cell	54	Oncocytoma	16
Chromophobe	11	Spindle cell angiomyolipoma	11
Papillary	5	Metanephric adenoma	1
		Abscess	1
		Multicystic nephroma	1
Stage			
T1a	(n = 45)		
T1b	(n = 16)		
T2	(n = 2)		
T3	(n = 6)		
T4	(n = 1)		
Grade			
G1	(n = 29)		
G2	(n = 33)		
G3	(n = 8)		
G4	(n = 0)		

For histopathological outcome, staging and grading of diagnosed tumors, see Table 2. Only one patient had a positive margin on final histology with focal involvement with renal cell carcinoma (RCC) tumor (Furnham grade 2, Chromophobe). This patient has no radiological evidence of cancer recurrence at 3 years of follow up. None of the patients in our series suffered with acute kidney injury requiring renal replacement therapy. Three patients had grade 3 complication (Clavien-Dindo classification system) requiring invasive intervention.[20] The first patient previously had pyelonephritis in the past and following OPN developed a peri-renal collection 13 days postop and required pigtail drainage of an infected hematoma. The second patient developed a urinary calyceal leak at day 3 postoperatively which resolved with ureteric stent placement. His procedure was complicated with intraoperative bleeding which may have led to this complication (1 liter blood loss). The third patient developed a small colonic perforation (unrecognized intraoperatively) which required laparoscopic splenic flexure colectomy at later stage with defunctioning ileostomy for a short period of time and full recovery afterwards.

One 30 day mortality was recorded in a 84 year old male who underwent OPN for a 4 cm lesion and developed bowel obstruction and pneumonia then passed away on day 16 postoperative.

We directly compared the preoperative creatinine levels and eGFR with the long term postoperative levels. With the long term being defined as last results available in our pathology system (range 6 mo to 7 yrs, median 2 yrs). Although there was statistically significant difference between preoperative and long term creatinine and the eGFR levels, we found that this did not translate clinically, as none had significant deterioration in renal function to require renal replacement therapy.

Long term follow up of our patients (range 6 mo to 9 yrs, median 2 yrs) revealed one cancer-related mortality. A 73-year-old (ASA III) patient with a pT1b (Furnham grade 2, necrosis present) clear cell RCC lesion that was resected with negative margins. He developed distant tumor recurrence with metastasis in ipsilateral adrenal, liver and acetabulum 6 months postsurgery. He received palliative radiotherapy to his bony lesion and a trial of interferon therapy in the pre sunitinib era.[21]

Up-to-date we have two cases with tumor recurrence at the ipsilateral kidney (at the site of resection). Both had pT1 clear cell RCC disease with negative margins. First was in 81-year-old who developed local tumor recurrence (3.4 cm lesion) 3 years after surgery. He was treated conservatively considering his age and comorbidities. After 6 years of follow up there was only slight increase in tumor size (4.5 cm). The second case was in a 85-year-old who developed local recurrence (2 cm lesion) 4 years after her surgery and again was treated under watchful waiting policy.

TABLE 3. **A comparison between studies that used different types of clamps for open partial nephrectomy (OPN)**

	No. of OPN cases	Mean age	Polar/ interpolar ratio	Mean tumor size (cm)	Mean operative time (min)	Intraoperative blood loss mL
Current study	100	65	79/21 (8/21) hilar/central	4.1	175	400 (median) 230 (median) (2007-2011)
Satinsky vascular clamps[15] (curved)	17	49	11/6	3.6	190	300 (mean) (200-1000)
DeBakey aortic clamps[16] (curved)	10	58	3 polar 7 peripheral	3.2	81	Insignificant
Reni clamp[12] curved/ double	30	63	17 polar 13 midrenal external none central or hilar	2.9	150	150 (mean) (50-450)
DeBakey[13] (curved)	7	47	7 polars all	2.9	236	485 (mean) (250-600)
Nussbaum clamp[14] (straight)	12	66	10 polar 2 middle portion	4	157	300 (mean) (100-500)

Discussion

In our study we present a technique of regional ischemia using one or two soft bowel clamps, allowing for a longer resection time and minimal blood loss. Our technique allows better visualization of anatomical planes between tumor and normal parenchyma and in the same time preserving renal perfusion and function.

We are reporting the largest series describing OPN with a regional ischemia technique. Table 3 shows a direct comparison between published studies that have used different type of clamps to achieve regional ischemia during OPN. Our technique can be used for polar, interpolar and hilar/central tumors. Unlike most of other clamps used that were only suitable for polar or peripheral tumors.[12-14,16] Mean tumor size was found to be higher at 4.1 cm, mean operative time and hospital stay were similar to other studies. Our median intraoperative blood loss was 400 mL which was slightly on the higher side when compared with other studies that had similar technique. However, the median amount of blood loss in the past 5 years was 230 mL which is comparable. We believe the initial high blood loss is related to the learning curve needed to master the technique and to find the best way in engaging the clamps. Our positive margin rate for malignant tumors (1%) was comparable with other studies,[22,23] and the only patient with a focal positive margin had no recurrence during the follow up period. Almost all other studies had frozen section analysis to ensure negative margins. After an initial period of performing frozen section, we are no longer routinely practicing that as we found no oncological advantage or margin benefit. This is supported by a recent publication proven that frozen section during OPN is unnecessary.[24]

Our series has the advantage of showing the long term follow up data. Two studies didn't include any follow up data and only one study, Dufour et al[16] had a comparable mean follow up period with ours (2 years). If we key in the fact that other studies had smaller number of patients with limited follow up, then this may explain why we have two ipsilateral tumor recurrences (at 3 and 4 years postoperatively). Same for Dufour et al[16] who had one case of ipsilateral tumor recurrence (had 17 patients in their series and comparable follow up

period). None of our recurrences had a positive margin postoperatively. Our two percent local recurrence rate is comparable to other international series and to the published EUA guidelines data.[1,23]

Our complication rate and grade is comparable to other studies.[12-16] Plante et al, reported one case of renal failure requiring dialysis after using Reni-clamp for regional ischemia.[12] None of our patients had significant deterioration in eGFR that required renal dialysis.

In terms of the technique, placing vessel loops around the hilar vessels gives the urologist vascular control in case of bleeding and allows quick location and control of the hilar vessels if required (however, rarely required in our series). Using soft bowel clamps on the renal parenchyma is gentle on tissue compared to aortic or Satinsky clamp with no reported incidence of renal loss or capsular rupture. They do tend to slip slightly if placed too close to the tumor and so a good margin around the tumor is necessary. The clamp also acts to stabilize the kidney and allows it to be maneuvered.

We believe the technique we have developed using soft bowel clamp to produce regional renal ischemia is practical and successful. It can be applied safely in all OPN cases, with excellent oncological outcome and clinically acceptable renal function preservation. □

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