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Original Article

The Benefits of Clamping the Renal Artery in Laparoscopic Partial Nephrectomy

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The purpose of this study is to compare the performance of laparoscopic partial nephrectomy (LPN) with and without clamping of the renal artery and to evaluate the impact of clamping on postoperative renal function. A total of 20 patients underwent LPN, 13 without and 7 with clamping of the renal artery. The 2 groups were compared with respect to complications, blood loss, operative time, mean tumor size, and incidence of positive margins. Renal function was evaluated by pre- and postoperative renal scintigraphy using ^{99m}Technetium-mercaptoacetyltriglycine (^{99m}Tc-MAG3). Intraoperative blood loss was significantly higher in the group without clamping than in the group with clamping ($p = 0.04$). In the group with clamping, the median warm ischemic time was 35 min (range 25-40 min). The serum creatinine values and the renal scintigraphy showed no influence on postoperative renal function with or without clamping. In the group without clamping, 2 cases were showed positive surgical margins. The procedure performed with clamping of the renal artery is superior to the procedure performed without clamping as it provides the advantages of controlling hemorrhaging without injury to renal function and prolonging the surgical time and allowing for more accurate resection of renal tumors.

Key words: laparoscopic partial nephrectomy, ^{99m}Tc-MAG3, renal function

In 1993, successful laparoscopic partial nephrectomy (LPN) was first reported in a porcine model [1]. Since then, groups at several research hospitals have developed laparoscopic techniques for partial nephrectomy [2-5]. However, renal cooling is not easily achieved via the laparoscopic approach [6, 7]. We, along with other investigators, have used different types of cutting devices to perform laparoscopic partial nephrectomy without clamping the renal artery [3-5]. To reveal the advantages and disadvantages of the partial nephrectomy procedure, we compared 2 LPN techniques, one with and one without renal artery clamping.

Materials and Methods

Patients. Between January 2001 and December 2005, 20 patients underwent LPN for renal tumors at Okayama University Hospital. Patients considered eligible for LPN were carefully selected to include those with solid renal tumors no larger than 4 cm in diameter that were mostly exophytic and peripherally located. In all cases the contralateral kidney had normal renal function. In the

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Table 1 Demographic data

	Group 1 (non-Clamping) N = 13	Group 2 (Clamping) N = 7	
Sex (Men/women)	10/3	6/1	
Side (R/L)	8/5	1/6	
Mean age Years (± SD)	60.3 (13.5)	51.8 (10.7)	p = 0.14
Mean BMI kg/m^2 (± SD)	23.9 (4.2)	22.7 (3.7)	p = 0.36
Mean tumor size cm (± SD)	2.13 (0.54)	1.84 (0.63)	p = 0.32

initial 13 patients who underwent LPN between 2001 and 2004, LPN was performed without clamping of the artery (group 1). In 7 patients who underwent LPN in 2005, LPN was performed with clamping the artery (group 2). Demographic data for these patients are listed in Table 1.

Surgical procedure. We selected a retroperitoneal laparoscopic approach in all patients. Under general anesthesia, each patient was placed in a lateral decubitus position. A skin incision 1.5 cm in length was made inferior to the 12th rib along the axillary line. After an incision of the muscular and fascial layers, a tissue expanding balloon (PDB S2 balloon Tyco Health Care, Harrisburg, PA, USA) was inserted into the retroperitoneal space and distended with 700 ml of air. After 5 min, the balloon was deflated and removed. A 12-mm laparoscopic port was inserted, and carbon dioxide in the pneumoretroperitoneum was increased to 12 mmHg. After laparoscopy confirmed the proper entry of the initial port into the retroperitoneum, 3 additional ports, a 12-mm port and two 5-mm ports, were placed under direct vision. After all ports were set, carbon dioxide pressure was decreased to 8 mmHg. In group 1, after the Gerota's fascia was opened, the surface of the kidney was exposed by dissecting the perinephric fat. The tumor was identified, and its margins clearly delineated. The fat overlaying the tumor was preserved. We did not expose and dissect the renal artery. An active blade of ultrasonic shears (Harmonic scalpel ETHICON, New Brunswick, NJ, USA) was inserted vertically to the surface along the resection margin and coagulated for 60 sec. In the resection, we attempted to maintain a margin of about 1.5 cm. The tumor was excised using ultrasonic shears while the operating surgeon used suction aspiration to keep a clear field. After the excision was complete, we tried to confirm that there was no residual tumor tissue in the surgical margin. However, we could not confirm the presence of normal renal tissue due to scarring by the ultrasonic scissors. Bleeding was controlled by an argon beam coagulator. Finally, fibrin glue was spread on the resection surface. In group 2, the renal artery was exposed laparoscopically. After the kidney was dissected and the tumor isolated, the renal artery was clamped with laparoscopic bulldog vascular clamps. The tumor was then excised with a good parenchymal margin using cold scissors. After complete excision, the margin was carefully inspected to confirm the presence of normal renal tissue. Bleeding was controlled by an argon beam coagulator and fibrin glue as in group 1. We did not repair the renal parenchyma. The clamp was subsequently removed and the kidney inspected for bleeding. In both groups, LPN was performed without cooling the renal parenchyma.

Evaluation of intraoperative and postoperative parameters. The 2 groups were compared regarding intraoperative and postoperative parameters, including complication rates, blood loss and transfusion rates, conversion rates, operative time, mean tumor size, and incidence of positive margins. The warm ischemic time was also measured. In addition, the postoperative differential renal function was evaluated by renal scintigraphy using ^{99m}Tc-MAG3 before and less than 3 months after the surgery in 10 of the 20 patients (5 from each group). The details of these 10 patients are given in Table 2. To evaluate the functions of each kidney separately, we assessed split renal function by calculating MAG3 clearance. Statistical analysis was done using Student's t test and χ^2 test, with $p < 0.05$ considered significant.

Results

There were no differences between the 2 groups in terms of patient age (mean: 60.3 years, SD: 13.5, in group 1 and 51.8 years, SD: 10.7, in group 2), body mass index (mean 23.9 kg/m^2, SD: 4.2 and 22.7 kg/m^2, SD: 3.7 in groups 1 and 2, respectively), and tumor size (mean 2.13 cm, SD: 0.54 and

Table 2 Data of patients who were evaluated post operative renal function using 99mTc-MAG3

	Group 1 (Non-clamping) n=5	Group 2 (Clamping) n=5
Tumor location	Upper 0 Middle 3 Lower 2	Upper 1 Middle 3 Lower 1
Mean tumor size cm (± SD)	2.42 (0.37)	1.96 (0.71)
Mean invasion depth cm (± SD)	0.97 (0.37)	1.1 (0.26)
Mean operative time min (± SD)	193.2 (35.1)	212.5 (28.5)
Mean Ischemin time min (± SD)	Not applicable	36.2 (4.18)
Collecting system repairing	1 case	2 cases

Table 3 Operative and postoperative data

	Group 1 (Non-Clamping)	Group 2 (Clamping)	
Operative time (± SD) min	184.2 (45.6)	186.4 (55.1)	p=0.7
Blood loss (± SD) min	133.8 (94.6)	63.3 (70.3)	p=0.04
Ischemic time (± SD) min	Not applicable	33.5 (5.56)	
Preop. to postop. Hemoglobin difference (± SD) mg/dl	2.1 (0.2)	2.9 (0.4)	p=0.12
Postoperative creatinine difference (± SD) mg/dl	0.03 (0.11)	0.04 (−0.10)	p=0.75

1.84 cm, SD: 0.63). Tumors were located at the upper pole (0/13 in group 1 and 2/7 in group 2), lower pole (10/13 in group 1 and 3/7 in group 2), or centrally (3/13 in group 1 and 2/7 in group 2). Operative and postoperative data are shown in Table 3. The mean operative time was 184.2 min (SD: 45.6) in group 1 and 186.4 min (SD: 55.1) in group 2, (p = 0.7). Intraoperative blood loss was significantly higher in group 1 than group 2 (mean 133.8 versus 63.3 ml, p = 0.04). In group 2, the mean ischemic time was

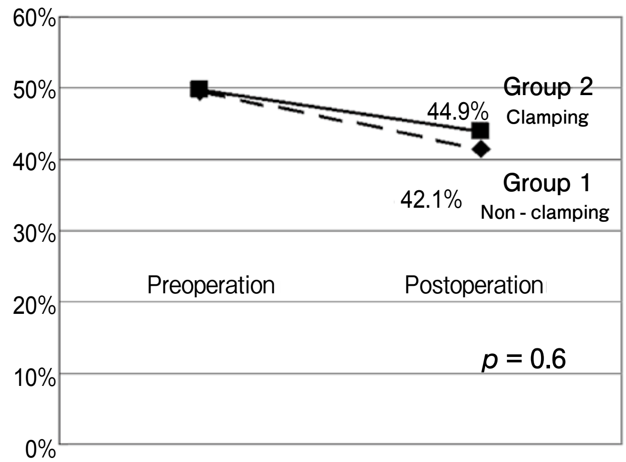

Fig. 1 Changes in split renal function of the affected kidney calculated by ERPF using MAG3. There was no difference between group 1 and group 2 (p = 0.6).

33.5 min (SD: 5.56). The mean change of hemoglobin before and after surgery was similar in group 1 and group 2 (2.1 mg/dl and 2.9 mg/dl, respectively, p = 0.12). There were no cases requiring blood transfusions in either groups. In 3 patients, 1 in group 1 and 2 in group 2, the urinary collecting system was opened and repaired by direct suturing. No postoperative bleeding was observed in any of the patients. In terms of the postoperative increase in serum creatinine, *i.e.*, the median difference between the preoperative level and that at the 1 month follow-up, there was no difference between the groups (p = 0.75). Split renal function before and after surgery is demonstrated in Fig. 1. In terms of the median contribution of the affected kidney after surgery, there was also no difference between group 1 and group 2 (median 44.9% (range: 24.6−49.4) vs median 42.1% (range: 35.0−42.9), p = 0.6). No complications were encountered. The pathologic results indicated renal cell carcinoma in all patients, and a hyperdense cyst in 1 patient in group 2. In group 1, 2 cases showed positive surgical margins; 1 underwent radical nephrectomy and the other is under observation. There have been no recurrences in either group as of this writing.

Discussion

Laparoscopic partial nephrectomy has become a popular surgical procedure for patients with small tumors. In 2002, Gill *et al.* reported LPN with clamping of the renal artery according to the method used for open surgery [2]. However, postoperative loss of renal function of the affected kidney is a problem because of the longer ischemic time needed with LPN than with the open technique [8, 9]. On the other hand, several techniques of vascular control that do not involve clamping the renal artery and that use, for example, ultrasonic scissors and bipolar cautery, have been reported in many cases [3-5]. We carefully selected patients for LPN without clamping, by determining the tumor location and size. A significant percentage of these patients had very small and peripherally located lesions, and tumor excision could be safely performed by ultrasonic scissors without clamping the renal artery, as in open surgery. On the other hand, this technique creates a less clear operative field and can result in uncontrolled bleeding, unidentified injuries to the collecting system, and greater difficulty in identifying the correct excisional plane. However, there are few studies regarding the impact of clamping versus nonclamping of the renal artery on complication rates, kidney function, or the outcome of LPN. In this study, we evaluated the necessity and safety of vascular clamping during LPN. In our study, there was no difference in the postoperative renal function of the affected kidney between the clamping and non-clamping techniques. Shekarriz *et al.* [8] also performed DMSA scans before and after LPN with entire hilar clamping in 17 patients and demonstrated no change in postoperative renal function. Their results were similar to those of our study. Nadu *et al.* [10] also performed DMSA scans after LPN with renal artery clamping in 18 patients and demonstrated that limited warm ischemia does not seem to result in permanent renal damage. They concluded that clamping of the renal artery should be considered during LPN since it seems to be associated with reduced blood loss and a lower incidence of positive margins. Their results are also in concordance with ours. Therefore, the non-clamping technique does not have the advantage of preserving renal function in cases with short ischemic time. The critical renal ischemia time has been reported by several investigators to vary from 20 to 45 min [11, 12]. Although we had regarded one advantage of the non-clamping technique to be the avoidance of this time-limiting factor, no influence on renal function was observed in our LPN procedure with the clamping of the renal artery.

There were 2 cases with positive surgical margins in the non-clamping group. Several studies have reported a higher incidence of positive surgical margins in the non-clamping technique using ultrasonic scissors and extrapolated that poor visualization of the tumor and charring of the tissue can be responsible for inaccurate tumor excision [10, 13]. In addition, they reported that performing LPN without clamping the vascular pedicle is associated with significantly greater blood loss and higher transfusion rates. Our series also showed significantly greater blood loss in group 1 despite the absence of need for transfusion. Bleeding from the excision surface might also cause poor visualization of the tumor.

The advantage of tumor excision with clamping of the renal artery using cold scissors is that it provides us the ability to observe the renal parenchyma, allowing for a clear identification of the mass and the surgical margin.

In our study, as in similar studies, no randomization criteria or definitions were used regarding the indications for clamping of the artery.

Conclusions. In laparascopic partial nephrectomy the procedure that incorporates clamping of the renal artery is superior to the procedure performed without clamping, with the advantages of controlling hemorrhaging without causing injury to renal function or prolonging the surgical time and allowing for more accurate resection of renal tumors.

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