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## Laparoscopic Partial Nephrectomy Using a Microwave Tissue Coagulator for Treating Small Peripheral Renal Tumors

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### Abstract

**Background:** Laparoscopic partial nephrectomy has been recently applied as a minimally invasive procedure. Several non-ischemic operation devices in partial nephrectomy have been developed. However, the problem related to maintenance of renal homeostasis remains. We investigated the efficacy and safety of a microwave tissue coagulator in laparoscopic partial nephrectomy.

**Methods:** Between April 2001 and February 2003, eleven patients with small renal tumors underwent laparoscopic partial nephrectomy using a microwave tissue coagulator. Seven patients underwent hand-assisted laparoscopic procedure and 4 pure laparoscopic procedure.

**Results:** The mean tumor size on preoperative CT scan was 2.5 cm (range: 2.0 to 4.0 cm), the mean operative time was 307 minutes (range: 160 to 580 minutes), and the mean estimated blood loss was 154.4 ml (range: 50 to 1,140 ml). The microwave tissue coagulator well controlled the renal bleeding and maintained renal function. All patients safely underwent partial nephrectomy without inducing renal ischemia. A complication of urine leakage was recognized in only one patient with hypoproteinemia caused by nephrotic syndrome.

**Conclusions:** Laparoscopic partial nephrectomy using a microwave tissue coagulator was a useful method for achieving homeostasis, and was less invasive for treating small renal tumors. (J Nippon Med Sch 2004; 71: 392–398)

**Key words:** renal cell carcinoma, partial nephrectomy, laparoscopic surgery, microwave tissue coagulator

### Introduction

Recently, partial nephrectomy has become a generally accepted option for treating localized renal cell carcinoma (RCC) of below 4 cm in size<sup>1,2</sup>. Recent advances in laparoscopic surgery and new developments of laparoscopic tools have made it possible to transform many open urologic operations into safe, rapid, and minimally invasive laparoscopic

operations. Radical nephrectomy is generally performed through a laparoscopic approach with or without hand assistance. Furthermore, the operative procedure of partial nephrectomy has recently been changed from an open to a laparoscopic procedure. However, a major problem of partial nephrectomy is the control of bleeding. A surgery under renal ischemia is performed with the aim of controlling bleeding. It is difficult to perform cold ischemia on the kidney using laparoscopic procedures. Several

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Table 1 Preoperative data of 11 patients who underwent laparoscopic partial nephrectomy

Patient No.	Age (years)	Gender	Tumor location	Tumor side	Tumor size (cm)	Complication
1	58	F	Lower, posterior	R	2.3	Nephrotic syndrome
2	75	M	Mid, lateral	L	2.3	CGN
3	65	M	Mid, posterior	L	4.0	
4	73	M	Mid, anterior	R	2.2	
5	73	M	Lower, posterior	L	2.8	
6	65	M	Lower, anterior	L	3.3	
7	53	M	Mid, lateral	L	2.0	
8	64	M	Lower, lateral	L	2.0	Hypertensive kidney
9	67	M	Mid, posterior	L	3.0	
10	71	F	Mid, anterior	R	2.0	
11	58	M	Lower, anterior	L	2.0	Horseshoe kidney
Mean	66.8				2.5	

CGN: Chronic glomerular nephritis

non-ischemic operation devices that are utilized in partial nephrectomy such as radio frequency ablation<sup>3</sup>, ultrasound dissection<sup>4,5</sup>, hydro-jet dissection<sup>6</sup>, microwave tissue coagulation<sup>7-9</sup>, argon-beam coagulation<sup>10</sup> and holmium (YAG laser)<sup>11</sup> have been developed. However, the problem related to maintenance of renal homeostasis remains.

A microwave tissue coagulator developed by Tabuse in 1979 is useful for controlling bleeding<sup>12</sup>. Kagebayashi et al.<sup>7</sup> report its usefulness in open partial nephrectomy. We had employed open partial nephrectomy using a microwave tissue coagulator since 1999 at our institution. Based on our previous results of open partial nephrectomy, we had attempted to use it in laparoscopic surgery from 2000. It is reported that a laparoscopic procedure using a microwave tissue coagulator results in more rapid recovery than an open procedure<sup>13</sup>. In this study, we presented the efficacy and safety of the microwave tissue coagulator in laparoscopic partial nephrectomy.

### Patients and Methods

Since April 2001, laparoscopic partial nephrectomy was performed in 11 patients at our hospital. All patients underwent spiral computerized tomography (CT) to precisely delineate the renal mass. The clinical stage of the renal tumors in all the patients was T1N0M0. Mean tumor size seen on preoperative CT scan was 2.5 cm (range: 2.0 to 4.0 cm) (Table 1).

The precise anatomical locations of the tumor in kidney are listed in Table 1. A case of over 4 cm tumor locating on the upper pole of kidney declined these laparoscopic procedures. We received written informed consent for the operation from all patients before they underwent retroperitoneal partial nephrectomy. Seven patients were operated according to a hand-assisted laparoscopic method, and four according to a pure laparoscopic method. Renal function was evaluated using the parameters of BUN and serum creatinine.

### Techniques

#### *Hand-assisted laparoscopic method*

Under general anesthesia, each patient was placed in a 45 to 60-degree lateral decubitus position. A pararectal incision was made, and the care was taken not to disrupt the peritoneum. A Lap-disk (Hakko Medical, Japan) was placed and a hand was inserted in the retroperitoneal space. Subsequently, two 12-mm laparoscopic ports and one 5-mm port were inserted with hand assistance. Gerota's fascia was dissected off the renal surface to preserve perirenal fat in contact with the tumor. The renal vessels were isolated or covered by the vessel tape only in three patients (Patients 1, 2 and 3).

#### *Pure laparoscopic method*

The patients' positions used were as noted above. A skin incision 1.5 cm in length was made inferior to the 12th rib along the axially line. After incision of the muscular and fascial layers, a PDB S2 balloon

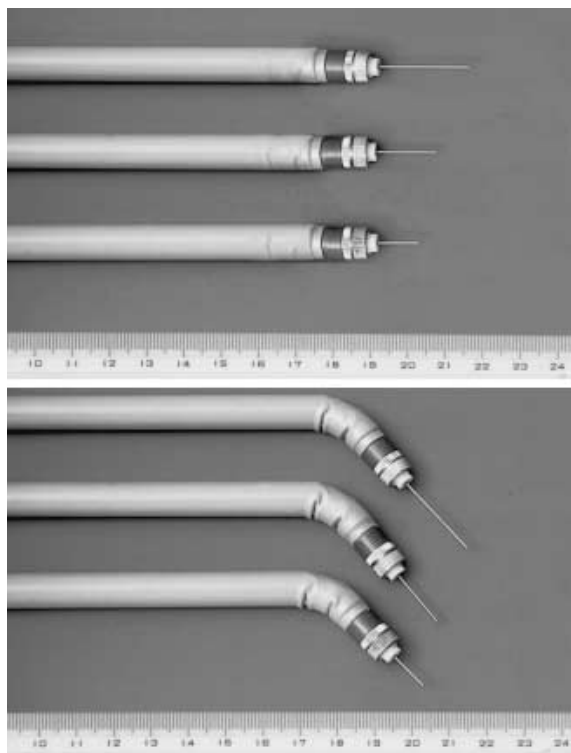


Fig. 1 Pictures of the microwave tissue coagulators used for laparoscopic surgery. Antenna needle angle is flexible.

(Tyco Health Care, USA) was inserted into the retroperitoneal space and was distended with 700 ml of air. After leaving the balloon being inflated for 5 minutes, it was deflated and removed. A 12-mm laparoscopic port was inserted, and carbon dioxide in the pneumoretroperitoneum was increased to be 10 mmHg. After laparoscopy confirmed proper entry of the initial port into the retroperitoneum, two additional ports (i.e., a 12-mm port along the posterior axially line and a 5-mm port along the anterior axially line) were placed under direct vision. After all ports were set, carbon dioxide was decreased to be 8 mmHg. Gerota's fascia was dissected off the renal surface to preserve perirenal fat in contact with the tumor to stab the antenna needle.

#### *Microwave tissue coagulator method*

We selected three different lengths of an antenna needle for microwave tissue coagulators (Fig. 1). The regions 6 to 7 mm distant from the tumor margin were the sites of puncture, and the puncture was performed every 6~7 mm along the demarcation line to make the coagulated surfaces

overlap each other. The lengths of inserted antenna needle were changed depending on the depth of coagulation. We usually used 2-cm antenna needle. Each session consisted of 45 seconds of coagulation at 65 Watts and 15 seconds of dissociation. After withdrawing the needle, additional coagulation next to the hole was applied if bleeding was observed. When the bleeding vessel was observed, we used bipolar forceps. After coagulation, the tumor rose from the kidney and became easy to be enucleated with scissors. The specimen was removed using an endoscopy bag through the 12-mm port or Lap-disk. After confirming renal hemostasis, indigotindisulfonate sodium was intravenously injected to investigate the presence of significant urine leakage. If major urine leakage was detected, a double pig-tail ureteral catheter was indwelled. After suturing the kidney using 3-0 polyglycolic acid thread, fibrin glue was sprinkled on the kidney covered with Gerotas fascia. A drainage tube was then placed in the retroperitoneum near the tumor bed, and the port incision was closed with 2-0 polyglycolic acid thread.

## Results

Laparoscopic partial nephrectomy was successfully completed in all patients. Patient characteristics and surgical results are presented in **Tables 1 and 2**. The mean operative time was 307 minutes (range: 160 to 580 minutes), and the mean estimated blood loss was 154.4 ml (range: 50 to 1,140 ml). In Patients 1, 2 and 3 whose renal vessels were isolated or controlled, the lumbar vessels and small arteries were injured, which resulted in much blood loss. However, we prepared 800 g of autologous blood for transfusion, and no patient required an allogenic blood transfusion. Compared with the bleeding from vessels, that from the tumor bed was controllable after microwave tissue coagulation. Therefore, we did not peel off the hilum in patients except Patients 1, 2 and 3. The operation time was longer and more blood loss occurred in Patient 11 because this patient exhibited horseshoe kidney malformation. The mean operative time was 278.6 minutes (range: 160 to 397 minutes) and the mean

Table 2 Pathological results of 11 patients who underwent partial laparoscopic nephrectomy

Patient No.	Operation Method	Operation Time (min)	Blood loss (ml)	Pathological Stage	Feeding day	Walking day
1	HALS	480	1,140	G1, pT1a	4	4
2	HALS	580	750	G1, pT1a	2	3
3	HALS	540	400	G1, pT1a	2	7
4	HALS	290	50	AML	1	2
5	HALS	397	100	G2, pT1a	2	4
6	HALS	232	115	G1, pT1a	2	7
7	HALS	160	100	G1, pT1a	1	2
8	Pure laparo	290	50	G1, pT1a	1	2
9	Pure laparo	300	220	G1, pT1a	1	2
10	Pure laparo	225	50	AML	1	3
11	Pure laparo	335	305	G1, pT1a	1	2
Mean		307	154.4			

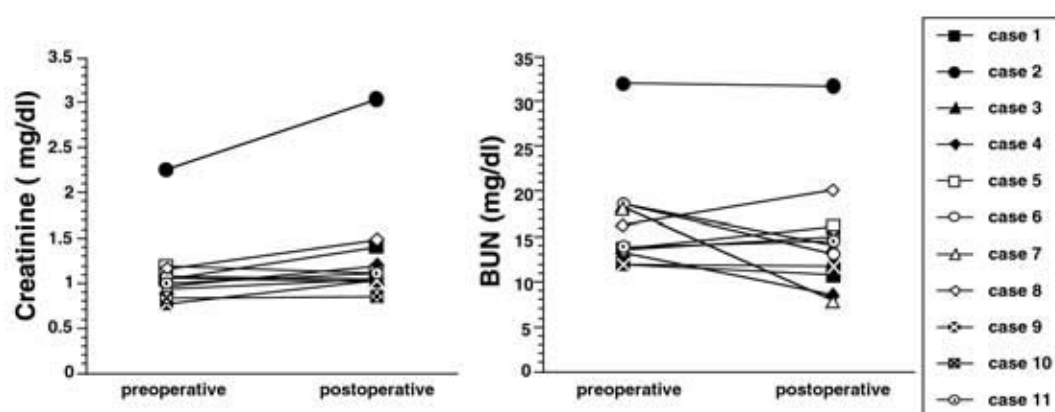


Fig. 2 Comparison of renal function between preoperative and postoperative stages.

blood loss was 121.2 ml (range: 50 to 305 ml) in cases excluding Patients 1, 2 and 3. As the operation time was shortened along with the increased skillfulness, pure laparoscopic procedures were employed in Patients 8 to 11.

The mean post-operative days required to start walking and oral intake were 3.4 and 1.6, respectively. Patients usually started to walk and eat within two days and one day after surgery, respectively; while Patients 1, 2, 3, 4 and 5 needed 5 to 7 days after surgery. In these initial patients, we needed more days to observe the presence of postoperative bleeding.

Pathological examinations of the specimens revealed that 9 patients had renal cell carcinoma and 2 angiomyolipoma (AML). All patients with renal cell carcinoma had grade 1 pT1a tumors. The surgical margins were tumor-free in all patients. During a mean follow-up of 28.9 months (range: 14 to

36 months), no cases of tumor recurrence or port site seeding were observed.

No vascular, nervous or ureteral complications were found. We observed the leakage of urine in one case of nephrotic syndrome that was not confirmed during surgery. The indwelled ureteral stent and Forley catheter were removed 20 days after operation, and the follow-up radiogram taken 1 month after operation showed no abnormalities. No patients showed delayed hemorrhage or urinoma formation.

Fig. 2 shows the post-operative renal functions. Three patients exhibited a mild and transient postoperative increase in blood creatinine above the upper limit of the normal range. These patients were diagnosed as having nephrotic syndrome, chronic glomerular nephritis, and hypertensive nephropathy, respectively. No recurrent tumor was recognized for at least one year after operation.

## Discussion

Small RCC is usually a silent disease. Currently, smaller tumors are incidentally diagnosed more frequently as a result of the wide spread use of ultrasound and computerized tomography for evaluating other abdominal processes such as gall bladder diseases. Based on the evidence that asymptomatic small RCC has good prognosis and low local recurrence rates<sup>14-16</sup>, partial nephrectomy is a treatment option for localized diseases. According to our institutional experience<sup>17</sup>, a 4-cm cut-off size for the lesion was an important selection criterion for a nephron-sparing surgery. In recent years, RCC laparoscopic procedures have been reported<sup>18</sup>, because they offer patients immediate benefits (e.g., shorter hospital stay, more rapid convalescence, decreased pain, and less disfigurement). However, the lack of a consistent method for obtaining hemostasis remains a major barrier against routine laparoscopic partial nephrectomy. Our experiences in open partial nephrectomy using a microwave tissue coagulator made it easy to practice laparoscopic operation using the microwave tissue coagulator without inducing renal ischemia. We believed that a microwave tissue coagulator was one of the best instruments available for obtaining homeostasis in open partial nephrectomy.

Tissue coagulation using a microwave coagulator results from the convergence of energy from microwaves (2,459 MHz) transmitted from a microwave generator to a monopolar antenna needle inserted into the tissue. The rapid oscillation of water particles caused by microwave results in a high temperature, and thereby induces cone-shaped tissue coagulation around the needle 7 to 10 mm in width without carbonization. In addition, coagulation is followed by dissociation of the needle from the coagulated tissue with galvanization to avoid injuries to the surrounding normal tissues. Removal of the needle rarely results in postoperative hemorrhage<sup>19</sup>. These properties prevent renal dysfunction and make pathological diagnosis possible.

A few cases of laparoscopic partial nephrectomy using a microwave tissue coagulator have been

reported<sup>13,20-22</sup>. Using only the limited number of patients, they describe that the microwave tissue coagulator is useful and less invasive. However, some complications such as urinoma, hematoma and renal arteriovenous fistula are also reported<sup>23</sup>. To avoid these complications, tumor size, location, and proper coagulator devices should be selected. Moreover, excessive coagulation should be avoided. Based on these findings, indications for laparoscopic partial nephrectomy using a microwave tissue coagulator were "tumors whose size was 4 cm or less and peripherally located" and "tumors that were not present at the hilar or upper pole regions". Tumors attaching the renal calyx should not be treated with this method, because of its possibility to open the renal calyx by the heat degradation. The main renal artery usually sites in the upper zone, and it is better to exclude the case whose tumor locates in the upper central kidney from the indication for laparoscopic partial nephrectomy. A major complication was recognized only in one case based on these indices. Urine leakage was recognized four days after the operation in Patient 1, but the leakage was not observed during surgery. It might occur after renal tissue degradation by microwave tissue coagulation in patients with hypoproteinemia. The patient suffered nephrotic syndrome, and therefore hypoproteinemia was present. After the ureteral stent and Forley catheter were indwelled, the urine leakage stopped. The care was required when treating hypoproteinemia patients with partial nephrectomy.

A microwave coagulator was useful for the following reasons. 1) A microwave coagulator could induce coagulation, and made the control of bleeding easy if there was bleeding from the needle puncture site after removing the probe when coagulation was insufficient. In other words, bleeding could be easily assessed after excision. 2) Since it was not necessary to expose the hilum, the operating time was shortened. 3) There was no ischemia, which resulted in preventing renal dysfunction. It was difficult in laparoscopic procedures to use cold ischemia. Since most coagulators such as a microwave coagulator and ultrasound scissors emitted energy, they require the cold ischemic conditions to prevent tissue

injuries. 4) After coagulation, the tumor appeared to protrude more with of the shrinkage coagulated zone, and thus excision was performed more easily.

The operation time and the amount of blood losses were acceptable in most cases, but not in Patients 1, 2 and 3 because of our inexperienced hand skill for the laparoscopic procedure and renal vessel control. Operation time gradually became shorter as we gained much experience. Hand-assisted laparoscopy was used in the first 7 patients because we were not familiar with pure laparoscopic procedures, but the pure laparoscopic approach was selected in the residual patients. Patient 11 had the horseshoe kidney with RCC. It was the first anomalous case, and the operation time was longer and the amount of blood loss was greater than in patients with the normal kidney. It was possible to perform partial nephrectomy to the horseshoe kidney without ischemia.

It is important to ensure complete resection in a malignant tumor operation. The microwave coagulator induces a large heat change in tissues. Usually, the microwave coagulator needle is inserted 5~7 mm outside of the tumor edge. Although a laparoscopic ultrasound probe was not used to determine the margin in the present series, there were no positive surgical tumor margins because of patients' selection and precise computer tomography. A pathological examination was used to evaluate the grades, histological types, and stages of all tumors. These results suggested that a microwave coagulator was helpful for the pathological diagnosis of RCC in partial nephrectomy.

The major concern of performing partial nephrectomy was potential impairment of renal function. Postoperative renal function was normal in the subjects except 3 cases of nephrotic syndrome, chronic glomerulonephritis, and the hypertensive kidney. This method was useful for maintaining homeostasis of the normal kidney. It was possible to maintain residual renal function according to our protocol of partial nephrectomy using a microwave tissue coagulator within a single kidney. It was important to perform partial nephrectomy without inducing renal ischemia and the microwave tissue

coagulator could make blood loss in the tumor bed little. In addition, a microwave tissue coagulator made laparoscopic partial nephrectomy easy even for surgeons who were inexperienced in laparoscopic operations, as long as they were familiar with open surgery. Further survival studies with long-term follow-up should be necessary to investigate the duration of protection of renal function and presence of recurrence of renal tumors after laparoscopic partial nephrectomy using a microwave tissue coagulator.

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(Received, July 2, 2004)

(Accepted, September 13, 2004)

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