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The efficacy evaluation of partial nephrectomy with selective renal artery branch occlusion by laparoscopy

Chun-Hui Wang, MM[a], Chun-Sheng Li, MM[a], Ying Jiang, MB[b], Hao Zhang, MM[a], Ha-Da Mu, MB[a], Guo-Chang Bao, MM[a,*]

Abstract

Background: To investigate the clinical application and effect of laparoscopic partial nephrectomy with renal artery branch occlusion in the treatment of early renal tumors.

Methods: A retrospective analysis was conducted on the clinical data of 15 cases of renal tumor patients who underwent partial nephrectomy by laparoscopic selective renal artery branch occlusion in our department from January 2017 to January 2018. Nine male patients and 6 female patients were aged 46 to 65 years, with an average age of 54.3 ± 7.2 years. The diameters of tumors were 2.2 to 4.0 cm, with an average of 3.3 ± 0.7 cm. There are 10 tumors locating on the left side and 5 on the right side. Preoperative renal glomerular filtration rate (GFR) were 77.3 to 61.9 mL/min with an average of 47.6 ± 7.5 mL/min. All patients' diseased kidneys underwent renal computer tomography angiography examination before surgery. And the diseased kidney underwent reexamination of renal GFR. The operation time, renal artery branch occlusion time, intraoperative blood loss, postoperative hospital stay, changes of renal function, and complications were evaluated.

Results: All surgery were completed successfully, the surgery time was 136.7 ± 15.2 min, intraoperative renal artery branch occlusion time was 21.3 ± 4.5 min, the intraoperative blood loss was 223.3 ± 69.5 mL, the postoperative hospital stay was 6.5 ± 1.7 days, and the postoperative 1-month GFR was 49.5 ± 6.6 mL/min. There was no significant difference between the renal GFR before and after surgery ($P > .05$). There was no blood transfusion and transfer open surgery cases. The patients were followed up for 3 to 15 months without complications.

Conclusions: Partial nephrectomy with selective renal artery branch occlusion by laparoscopy is a safe, feasible, and effective method for the treatment of early renal cancer. It makes good use of the technical advantages of clear operation field and fine operation of laparoscopic surgery, avoids the heat ischemia process of the whole kidney, and can better protect the renal function.

Abbreviations: CTA = computer tomography angiography, GFR = glomerular filtration rate, WIT = warm ischemia time.

Keywords: partial nephrectomy, renal artery branch occlusion, renal tumor

1. Introduction

With the continuous development of the medical level, the rate that small renal carcinoma can be detected increased significantly. Partial nephrectomy with laparoscopy has the same control effect as radical nephrectomy, which retains renal function and has the characteristics of small trauma and rapid recovery. Currently, it has become the "standard treatment scheme" for renal tumors with a diameter <4 cm.[1] Partial nephrectomy with selective renal artery branch occlusion by laparoscopy is a new technique combining minimally invasive and accurate. It exerts the technical advantages of clear operation field and fine operation of laparoscopic surgery, avoids the warm ischemia process of the whole kidney, and can better protect renal function. Fifteen patients with stage T1 renal tumor in our hospital from January 2017 to January 2018 underwent partial nephrectomy with selective renal artery branch occlusion by laparoscopy, and operations achieved good clinical efficacy. This study was approved by the Ethics Committee of the Affiliated Hospital of Chifeng University and obtained the informed consent of all patients. The results of the study are reported as follows.

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CHW and CSL contributed equally to this work.

The authors have no conflicts of interest to disclose.

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

[a] Department of Urology, Affiliated Hospital of Chifeng University, No. 42 Wangfu Street, Chifeng, Inner Mongolia, China, [b] Department of Reproductive Center, Affiliated Hospital of Chifeng University, No. 42 Wangfu Street, Chifeng, Inner Mongolia, China.

[*] Correspondence: Guo-Chang Bao, Department of Urology, Affiliated Hospital of Chifeng University, No. 42 Wangfu Street, Chifeng, Inner Mongolia 024005, China (e-mail: Baoguochang1968@163.com).

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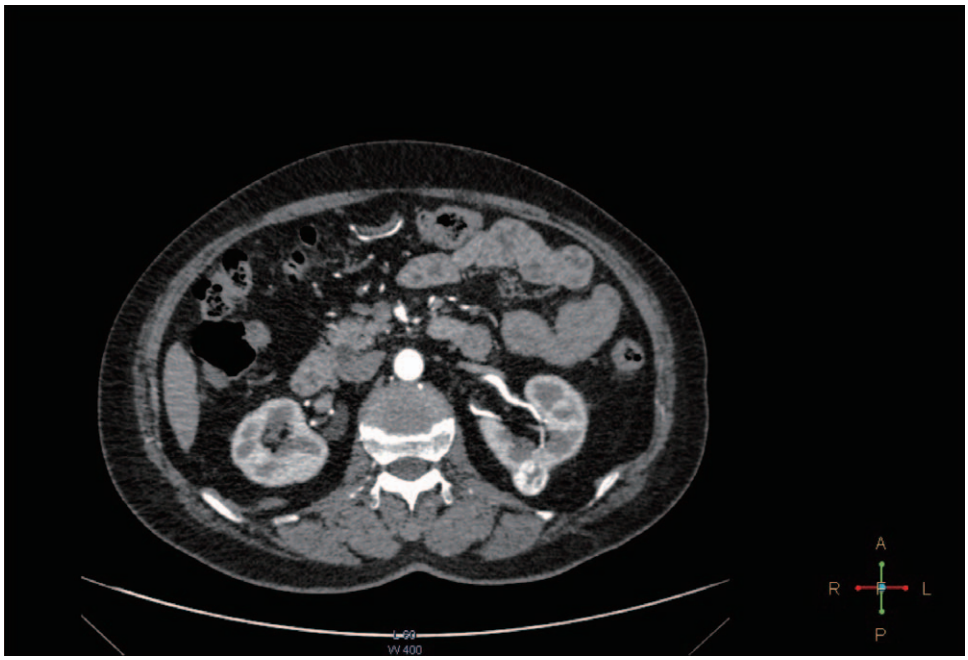

Figure 1. Renal artery CTA arterial stage. CTA = computer tomography angiography.

2. Data and method

2.1. Clinical data

There were 15 patients in this group, including 9 males and 6 females, with an average age of 54.3 ± 7.2 years and a tumor diameter of 3.3 ± 0.7 cm. There were 10 cases of left renal tumor, including 1 case in the middle ventral side, 2 cases in the middle dorsal side, 3 cases in the upper pole, and 4 cases in the lower pole. There were 5 cases of right renal tumor, including 2 cases in the middle ventral side, 1 case in the upper pole, and 2 cases in the lower pole. Preoperative routine renal computer tomography angiography (CTA) was performed to evaluate the size, location, depth, and arterial branching of renal tumors. CTA of renal artery 3-dimensional imaging is performed to identify the branches of the renal artery, which is helpful for the intraoperative search of the branches of the renal artery (Figs. 1 and 2). Emission computed tomography was performed preoperatively and 1 month postoperatively to detect the glomerular filtration rate (GFR) and evaluate the changes in renal function. There were 3 cases of tumors locating in the middle ventral side, and the transabdominal laparoscopic approach was taken, while the remaining 12 cases were treated with a posterior abdominal approach.

2.2. Surgical method

Through the abdominal approach, the patient was placed in a 75° recumbent position on the healthy side with the waist pad height. A 1 cm incision was made at the lateral margin of the rectus abdominis 2 cm above the umbilicus. After the successful puncture, the patient was observed with a mirror. The remaining 3 cannulas were flexibly arranged according to the location of the kidney and tumor. Open the paracolic sulcus along the Toldt line, fully free the colon, pull from the medial side, expose the surgical field, open the perirenal fascia to completely free the kidneys, especially the kidneys in the tumor area, separate the renal hilum structure, and combine the preoperative CTA image to find the target branch. The arteries and vascular slings are lifted up for use. After the branch artery was blocked (Fig. 3), ischemia in the target area can be seen. If there is no ischemia, it means that the artery occlusion is wrong and needs to be repositioned. The capsule is cut along the edge of the tumor, and performs blunt dissection with the aspirator. The cord that cannot be separated by the aspirator is a blood vessel or a collection system, which is cut with an ultrasonic knife and is carefully retained in the collection system. To prevent injury, if it must be removed, use the absorbable line to be strictly continuous, and use 80 to 100 watts of electrocoagulation to stop bleeding in the bleeding site, which can significantly reduce bleeding and keep the surgical field clear. After the tumor was completely resected, the system was sutured continuously with a 4–0 absorbable line, and the bottom was sutured continuously with a 3–0 barb line or a slip line, and the wound was continuously sutured with a 2–0 barb line. For the purpose of hemostasis and to prevent the loss of kidney function caused by the main blood vessel ischemia, the bottom suture should not be too deep. The depth of the outer layer should reach the bottom and the thickness of the edge should not exceed 1 cm. Minimize the loss of kidney function caused by the suture. Finally, the drainage tube was placed, the incision was closed, and the operation was completed. Through the retroperitoneal approach, the healthy side was placed in a 90° decumbent position and the waist was raised. The classic "three-hole method" was used for surgery. The fourth cannula was inserted when necessary to separate the renal artery and the target branch artery.

Kidney and tumor were fully dissociated, and the rest underwent abdominal surgery.

2.3. Statistical software

SPSS19.0 statistical software was used to analyze the data. The normal distribution data were expressed as mean ± standard

Figure 2. Renal artery CTA 3D reconstruction. CTA = computer tomography angiography.

deviation ($\overline{x} \pm s$), and the measurement data were analyzed by t test. $P < .05$ was considered statistically significant.

3. Result

All operations were successfully completed without transfusion and intraoperative open cases. The time of operation was from the establishment of pneumoperitoneum to the completion of drainage tube placement. The operation time of this group was 136.7 ± 15.2 min. The intraoperative renal artery branching-time was 21.3 ± 4.5 min, the intraoperative blood loss was 223.3 ± 69.5 mL, and the postoperative hospital stay was 6.5 ± 1.7 days. There was no significant change in renal GFR before and after surgery, which is 47.6 ± 7.5 mL/min before operation and 49.5 ± 6.6 mL/min 1 month after the operation. The difference was not statistically significant ($P > .05$). The patients were followed up for 3 to 15 months without bleeding, urine leakage, and other complications. The pathological results were all clear cell carcinoma of the kidney with a negative incisional margin.

4. Discussion

In 2011, Gill et al[2] reported for the first time 15 cases of partial nephrectomy using "zero ischemia" technology to block renal tumor-related renal artery branches and achieved good results. Shao et al[3] formally proposed the concept of selective renal artery branch occlusion, whose technical key lies in the separation and selective occlusion of the blood supply artery of the renal segment where the tumor is located. This concept makes renal artery occlusion more accurate and renal function protection more ideal. With the advent of the era of minimally invasive surgery, laparoscopic partial nephrectomy has gradually been popularized and applied, and has gradually become the recommended surgical method for the treatment of stage T1a and some stage T1b and T2 renal tumors.[4] Traditional partial nephrectomy requires blocking the renal artery, which inevitably leads to heat ischemia injury. At present, there is no safe range of thermal ischemia time.[5] Partial nephrectomy only blocks the arterial branch that supplies the tumor area, and the blood supply to the rest of the renal artery is not affected, thus minimizing the impact of heat ischemia on the kidney. In a control study of 665 patients with robot-assisted partial nephrectomy conducted by Desai et al.[6] Two hundred sixty six patients underwent partial nephrectomy with renal artery branch occlusion (zero ischemia group), which had the highest renal function survival rate (92.9%), and the effect was superior to warm ischemia time (WIT) >30 minutes group (83.2%) and WIT ≤ 30 minutes group (89.2%). After preoperative and postoperative GFR measurements, the preoperative GFR was 47.6 ± 7.5 mL/min, and the postoperative GFR was 49.5 ± 6.6 mL/min 1 month after surgery.

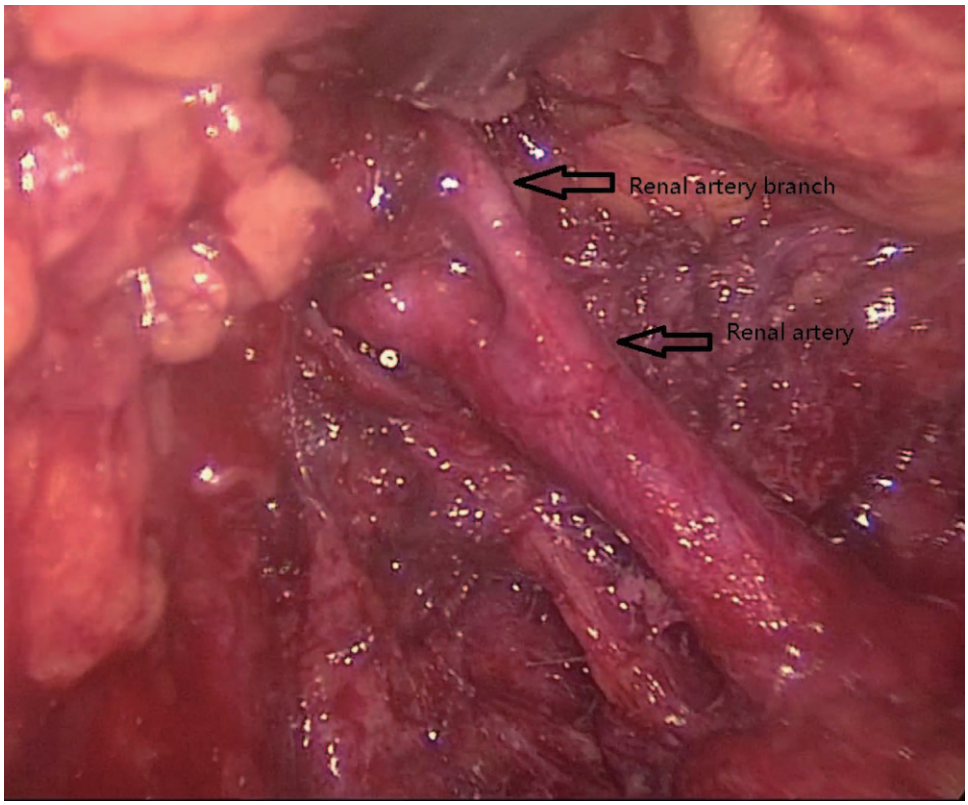

Figure 3. Branches of the renal artery were separated.

The difference was not statistically significant, which was consistent with the above conclusions, suggesting that partial nephrectomy with blocked renal artery branches has a good protective effect on renal function.

In terms of safety, a large number of studies have confirmed that laparoscopic partial nephrectomy with renal artery branch occlusion is safe and feasible. Avitan et al[7] and Shao et al[8] reported the incidence of complications of postoperative urine leakage and massive hemorrhage. The rate of urine leakage and bleeding in partial nephrectomy with total renal pedicle vascular occlusion was higher than that of partial nephrectomy with renal artery branch occlusion, but there was no significant statistical significance. Simone et al[9] compared the amount of hemorrhage in partial nephrectomy with that in conventional vascular occlusion, and found the estimated blood loss in the renal artery branch block partial nephrectomy is higher than that in conventional partial nephrectomy (500 vs 200 mL, $P = .001$), and the former has a higher rate of blood transfusion (42% vs 21%, $P = .001$), but the author thinks that patients can decrease retained nephron of the kidney damage, and advantages overweigh disadvantages. In a retrospective control study of 466 patients with partial nephrectomy conducted by Pu et al.[10] Three hundred fourteen patients underwent partial nephrectomy with renal artery branch occlusion, and 152 underwent standard partial nephrectomy. Studies have shown that although the partial nephrectomy group with renal artery branch occlusion experienced a slight increase in operative time, thermal ischemia time, and blood loss ($P < .01$) as compared with the standard partial nephrectomy group, it provided better early postoperative renal function ($P < .01$). A retrospective analysis of the reported study of Ng et al[11] and Abreau et al[12] showed that a total of 100 people underwent partial nephrectomy with blocked renal artery branches and postoperative pathological returns showed that all the incised margins were negative and no tumor tissue residues were found. In this group, 15 patients who underwent partial nephrectomy with renal artery branch occlusion had no complications related to bleeding and urine leakage. The amount of bleeding was similar to that reported in the literature above, and the pathological return margin was all negative.

Partial nephrectomy with selective renal artery branch occlusion by laparoscopy can treat more technically challenging tumors, such as those located in the deep parenchyma, center, or hilum of the kidney, which are often accompanied by advanced arteries that can be specifically occluded. However, for tumors located in the lateral position of the kidney, the increased distance of parenchyma between the main renal artery and the tumor makes it impossible to determine the branch supplying the tumor artery. In addition, if the lateral tumor is large, there are usually multiple arterial branches supplying the tumor, so these peripheral tumors are not suitable for this technique. Yu et al[13] applied laparoscopic partial nephrectomy of blocked renal artery branch in a patient with renal pelvis cancer. During the follow-up period of more than 42 months after surgery, there was no evidence of recurrence, providing a feasible treatment method for tumors limited to the calyx. Because partial nephrectomy with blocked renal artery branches has good protection to renal function, more and more scholars have applied it to patients with isolated renal tumors and achieved good surgical results. In terms of improvement in surgical techniques, on the basis of partial nephrectomy with selective

renal artery branch occlusion, laparoscopic renal surgery of "leapfrog" way,[14] laparoscopic renal artery branches sequential treatments blocking renal resection of multiple renal tumor,[15] and single-pore laparoscopic robot zero ischemic renal resections have achieved good clinical results.[16]

At present, the treatment of early renal cancer, radical, or partial nephrectomy is still the standard treatment. However, innovative ablation techniques, including radiofrequency ablation, microwave ablation, cryoablation, and so on, may be another treatment option for small kidney disease in patients who are not suitable for surgery.[17]

In conclusion, partial nephrectomy with renal artery branch occlusion is safe, effective, and has better efficacy in the treatment of early renal cancer. Undeniably, on the basis of traditional renal artery occlusion, various cooling methods, such as retrograde intubation hypothermia, ice chip hypothermia, and perfusion hypothermia via renal artery[18] are also effective methods to protect renal function. Although partial nephrectomy without interruption or suture is more promising and advantageous in recent years, the risk and complications are also increased.[19] The surgeon should choose the operative plan reasonably according to his own experience and the patient's condition, and maximally protect the kidney function while avoiding risks. Of course, partial nephrectomy with blocked branches of the renal artery also has many shortcomings. Firstly, the area after blocked branches of the renal artery is usually larger than the area of the tumor. Secondly, the secondary or even tertiary branches of the artery were separated during the operation, and the operation time was significantly prolonged. Finally, excessive intraoperative stimulation of the renal artery may cause spasms of the renal artery and collateral damage caused by excessive intraoperative dissociation. With the development of digital imaging, intraoperative suture and hemostasis, partial nephrectomy with renal artery branch occlusion will be more mature and perfect.

However, there are many shortcomings in our study. For the sake of our patients, we did not have a control group. And we have only done 15 surgeries. In the following work, with the maturity of surgical techniques, the blocking time of renal artery branches will be further shortened, and the amount of surgery will also be greatly increased, so as to verify our results.

Author contributions

All authors have made a significant contribution to the findings and methods in the paper.
All authors have read and approved the final draft.
The work has not already been published and has not been submitted simultaneously to any other journal.
The corresponding author takes on the above responsibilities with his signature.
Conceptualization: Chun-Hui Wang, Guo-Chang Bao.
Data curation: Chun-Hui Wang, Chun-Sheng Li, Ying Jiang, Hao Zhang, Ha-Da Mu, Guo-Chang Bao.
Formal analysis: Chun-Hui Wang, Chun-Sheng Li, Ying Jiang, Guo-Chang Bao.
Investigation: Chun-Sheng Li, Guo-Chang Bao.
Resources: Guo-Chang Bao.
Software: Chun-Hui Wang, Ying Jiang.
Writing – original draft: Chun-Hui Wang, Chun-Sheng Li.
Writing – review & editing: Chun-Hui Wang, Chun-Sheng Li.

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