

Retroperitoneal Robot-Assisted Single-Port Laparoscopic Partial Nephrectomy: Initial Experience With the Da Vinci Si Robotic System

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Abstract

(1) Background: To present the initial experience in retroperitoneal robot-assisted single-port laparoscopic partial nephrectomy for renal cell carcinoma and evaluate its efficiency and safety.

(2) Methods: Retrospectively analyzed four patients underwent retroperitoneal robot-assisted single-port laparoscopic partial nephrectomy in our hospital during September 2020 to December 2020. Patients who with renal cell carcinoma (T1b or T1c) were selected into our study. A multichannel port was inserted retroperitoneally through a 4-5cm incision. Preoperative, intraoperative and postoperative outcomes were finally recorded and analyzed.

(3) Results: The median patient age was 62.0(range 49-68) year, the median body mass index was 23.0(range 21.3-24.2) kg/m². No one had abdominal surgery history. All surgeries were successfully completed and none of them was changed to open surgery or added additional auxiliary channels. The median docking time was 16.5(range 15-25) minutes, the median operation time was 177.5(range 145-230) minutes, the median warm ischemia time was 19.0(range 15-25) minutes, the median estimated blood loss was 50.0(range 40-60) mL. No patient needed blood transfusion. The median postoperative fasting time was 3.5(range 1-5) days, the median catheter removal time was 5.5(range 5-7) days, and the median hospital stay was 7.0(6-8) days. None of the patients had intraoperative or postoperative complications. After 3 months of follow-up, there was no tumor recurrence in all four patients.

(4) Conclusions: Retroperitoneal robot-assisted single-port laparoscopic partial nephrectomy is a feasible surgical method, but additional investigations are still needed to evaluate its safety and oncologic adequacy.

Background

For patients with localized renal cell carcinoma (RCC), surgery can be considered the only curable treatment(1). The latest EAU guideline recommends that partial nephrectomy, instead of radical nephrectomy, is more suitable for patients with T1a-T1b RCC(2).

Partial nephrectomy has gone from open surgery to laparoscopic surgery. In 1991, Clayman et al. successfully performed the first laparoscopic partial nephrectomy (LPN)(3), and the following series of studies concluded that LPN is favorable than the open partial nephrectomy(OPN) in terms of oncology and surgical principles(4–6). During the last decades, the advent of Da Vinci robotic system provided the doctors more alternatives to operate the urological surgery. Robot-assisted laparoscopic partial nephrectomy (RA-LPN) has become a hot spot because of its minimal invasiveness and improvement in quality of life for patients(7).

As a trend to pursue smaller and more concealed incision, single port surgery is now getting more and more attention. Laparoscopic single-site (LESS) has been applied to nephrectomy in 2007 by Raman et al.(8) and then, Kaouk et al.(9) drew support from the a Vinci system to perform the partial nephrectomy

(PN), confirmed that robot-assisted single-port laparoscopic partial nephrectomy (RASP-LPN) was feasible. Constrained by the difficulty of learning-curve, there are relatively few researches on RASP-LPN in the whole world.

The aim of this retrospective investigational study was to present the initial experience in RASP-LPN for RCC and evaluate its efficiency and safety.

Methods

Patients

We retrospectively analyzed the data from four patients who underwent the RASP-LPN during September 2020 to December 2020 in Sir Run Run Shaw Hospital. All the surgeries were performed by a single skilled surgeon. Patients who were diagnosed with T1a or T1b RCC according to their CT scan (Fig. 1), with no metastasis and could endure the robotic surgery were collected into this study. Those who had other cancers or severe cardiopulmonary diseases were excluded. This study was approved by the local ethics committee and written informed consent was taken from all patients. All the patients were told the cons and pros of the alternative treatment methods, and were informed in detail about the possible complications during the perioperative period.

Table 1
The demographic characteristics of four patients.

Characteristic	Case 1	Case 2	Case 3	Case 4
Age, y	60	49	64	68
Sex	Male	Male	Male	Female
Body mass index, kg/m ²	23.0	24.2	21.3	22.9
Charlson comorbidity index	0	0	0	0
ASA score	2	2	2	1
Previous surgery	No	No	No	No
Laterality	Right	Right	Right	Right
Location	Low	Low	Low	Upper
Tumor size, mm	26.0	31.0	66.6	26.5
R.E.N.A.L. score	1+1+1+P+1	1+2+2+P+1	2+1+3+P+1	1+1+1+P+1
ASA = American Society of Anesthesiologists; R.E.N.A.L. score = radius, exophytic/endophytic, nearness to collecting system or sinus, anterior/posterior, location relative to polar lines				

Surgical procedures

The da Vinci Si surgical system (Intuitive Surgical Inc., Sunnyvale, CA, USA) was used to perform all the surgeries.

The patient was in a full flank position with waist raising. An incision, approximately 4-5cm in length, was produced below the tip of 12th rib. The obliques and transversalis were split directly to expose the thoracolumbar fascia. Once the retroperitoneal approach was established, a balloon-dilating device was placed to maintain the pneumoretroperitoneum at 15mmHg. And then the specific disposable multichannel laparoscopic surgical approach system FreePort (Senscure Biotechnology Co., Ltd, Ningbo, Zhejiang, PRC) was installed. This multichannel port consisted of an 8.5mm endoscope channel, two 7.0mm trocars and a 12.0mm assistant port (Fig. 2.a). The robot was docked and the robotic arms were connected to the instrument introduced into the port early (Fig. 2.b). The incision was showed as Fig. 2.c.

Identified the salient landmark with the help of laparoscope, then manipulated the kidney and exposed the renal mass by laparoscopic grasper. Carefully silt the Gerota fascia (Fig. 3.a), found the kidney and determined the position of the tumor, then dissected the renal artery and renal vein clearly at the renal hilum. Dissected the tissue around the tumor to expose the tumor. After blocking the renal artery with bulldog clamps (Fig. 3.b), the kidney parenchyma was excised 0.5 cm from the edge of the tumor (Fig. 3.c). Renorrhaphy was performed continuedly using absorbable sutures and hem-o-lok was used to reinforce after every suture (Fig. 3.d). Loosen the bulldog clamp if there was no obvious active bleeding. Removed the tumor. Fibrinogen coagulation enhancers were applied on the defect and a drain is placed in the pelvis.

Data analysis

Patient demographics, perioperative outcomes and short-term follow-up were retrospectively extracted from the electronic medical record system. Demographics date included age, sex, body mass index (BMI), Charlson comorbidity index, ASA score, preoperative diagnosis, R.E.N.A.L. index. Intraoperative data included operation time, docking time, warm ischemia time (WIT) and estimated blood loss (EBL). Postoperative data included postoperative fasting day, catheter removal day, hospital stay and complications. Clinical and pathological staging were carried out as per the 2017 TNM classification(10). Operation time was defined as the total time from the robot docking to the end of stitching. The comorbidity of the disease was predicted according to the Charlson comorbidity index(11). The ASA score was evaluated according to the 2014 American Society of Anesthesiologists (ASA) Physical Status Classification System(12).

Statistical analysis

Statistical analysis was performed by Package for Social Sciences (IBM SPSS Statistics; New York, NY, USA) version 22.0. Descriptive statistics were used for evaluation of the study data.

Ethics

This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). All procedures performed in this study were approved by the Ethics Committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine (No.20210421-30) and individual consent for this retrospective analysis was waived.

Results

From September 2020 and December 2020, four patients underwent RASP-LPN in our hospital and their demographic characteristics were summarized in Table 1. The median patient age was 62.0(range 49–68) year, the median BMI was 23.0(range 21.3–24.2) kg/m². All the patients had a Charlson comorbidity index of 0 and had no abdominal surgery history. The median ASA score was 2(range,1–2). Three patients had a tumor located at lower pole of the right kidney, and one at upper pole of the right kidney. The median tumor size was 28.8(range 26–67) cm. Table 2 shows the perioperative outcomes and follow-up parameters of those patients. All the surgeries were successfully completed, and none of them was changed to open surgery or added additional auxiliary channels. The median operation time was 177.5(range 144–230) minutes, the median docking time was 16.5(range 15–25) minutes, the median WIT was 19.0(range 15–25) minutes, the median blood loss was 50.0(range 40–60) mL and no patient needed blood transfusion. The mean postoperative fasting time was 3.5(range 1–5) days, the mean catheter removal time was 5.5(range 5–7) days, and the hospital stay was 7.0(6–8) days. None of the patients had any intraoperative or postoperative complications. According to the postoperative pathological results, three were clear cell carcinoma, including two Grade I and one Grade II, and another was papillary renal cell carcinoma. No positive surgical margins were detected in any of the cases. There was no tumor recurrence in all four patients after 3-months follow-up.

Table 2
The perioperative outcomes and follow-up parameters.

Characteristic	Case 1	Case 2	Case 3	Case 4
Docking time, min	15	15	25	18
Operation time, min	170	185	230	145
WIT, min	18	20	25	15
EBL, ml	45	60	55	40
Transfusion, ml	0	0	0	0
Postoperative pathology	Clear cell carcinoma (Grade I)	Clear cell carcinoma (Grade I)	Clear cell carcinoma (Grade II)	Papillary renal cell carcinoma
Margin	Negative	Negative	Negative	Negative
Postoperative fasting, d	3	4	1	5
Postoperative hospital stay, d	8	6	7	7
Catheter removal, d	7	5	6	5
Intraoperative complications	0	0	0	0
postoperative complications	0	0	0	0
Tumor recurrence	No	No	No	No

WIT = warm ischemia time; EBL = estimated blood loss.

Discussion

This study evaluated the efficiency and safety of RSAP-LPN. Considering the advantages of renal function perseveration, PN has become the new standard surgical treatment for T1a(13) and selected T1b tumors(14, 15). Along as the popularity of da Vinci system using in urological surgery worldwide, RA-LPN has be applied in the treatment of small renal tumor(1). A meta-analysis involving 3418 patients showed that though RA-LPN had a longer operation time than OPN, it had the superiority of shorter hospital stay, less perioperative complications, and less blood loss, and it appeared an efficient alternative to open surgery(16).

In order to minimize the length of the scar and to reduce the morbidity associated with conventional laparoscopic surgery, LESS techniques have raised significant interest in the whole world(17). Raman et al.(8) and Kaouk et al.(18) successively performed single-incision nephrectomies, preliminary confirmed that LESS technology used in nephrectomy was feasible. A comparative study showed that LESS nephrectomy had cosmetic advantages and offered the similar perioperative outcomes and short-term measures compared to conventional laparoscopic nephrectomy(19). A multi-center clinical trial involving 190 patients with RCC showed that, because of the less risk of postoperative complications, it was feasible for experienced surgeons to safely and effectively perform LESS-PN, especially for those who with low PADUA scores(20).

In 2008, Kaouk et al. firstly reported compared single-port laparoscopic PN(N = 5) and RASP-LPN(N = 2). For RASP-LPN, neither of them changed to open or traditional laparoscopic surgery, proving the feasibility of robot-assisted LESS surgery(9). In 2014, Kaouk et al. carried out a prospective trial, which included 8 patients with kidney cancer, using the Da Vinci SP system to carry out RN and PN respectively(21). No additional incisions were added and none of the patients who received PN had postoperative complications. After 3 years follow-up, all patients had good renal function, and no one had tumor recurrence. This clinical trial also proved once again that the Da Vinci system will not bring additional surgical risks to patients.

For PN, transperitoneal and retroperitoneal are the common approaches to perform the surgery. For patients with a history of abdominal surgery, retroperitoneal surgery was a better choice. Abdominal surgery could affect the relative position of the various organs of the abdomen, making it difficult to find the location of the kidney by transperitoneal approach. By contrast, the retroperitoneal approach could help finding the renal hilum more directly and quickly. Especially for posterior tumor, the shorter surgery path made the renal artery blocking more efficiently, reducing the probability of blood transfusion. Besides, there were less interferences for abdominal organs intraoperatively and less complications of nearby organs for the retroperitoneal approach(22). A meta-analysis including 6 clinical trials presented that, for those patients with dorsal RCC, retroperitoneal PN could avoid peristalsis effectively by finding the renal hilum to enter the kidney to achieve the purpose of reducing the operation time and ensuring the safety of the operation(23). In 2019, Malki et al. compared the outcomes of retroperitoneal RALPN (N = 110) and transperitoneal RALPN (N = 17) in obese patients (BMI \geq 30), the results showed that retroperitoneal RALPN was associated with less blood loss, shorter surgical time and shorter WIT compared with transperitoneal RALPN(24), being considered reducing the restrictions of patients and benefiting more patients with obesity. None of the patients in our study was obesity (BMI \leq 25.0) or had a history of diabetes or cardiovascular diseases. A research showed that obese patients had a trend toward higher EBL, longer operative time and WIT(25). Considering the accumulation of body fat, it was harder to prepare operative space in retroperitoneum for obese patients than normally sized patients. And we must admit that the BMI and fundamental diseases could influence the outcomes of the surgery, so there might be a discrepancy with the research results between western institutions' and ours.

In 2009, Petal et al. firstly compared results of RALPN for patients with tumors > 4 cm (N = 15) and ≤ 4 cm (N = 56)(26). No significant differences were found between groups for EBL, total operative time, hospital stay, complication rates, and change in estimated glomerular filtration rate(eGFR). But it could be seen that patients with larger tumors had longer median WIT (25 vs 20 min; p = 0.011). In 2012, Tiu et al. obtained the similar results on RASP-LPN with patient whose tumors > 4cm (N = 47) and ≤ 4cm (N = 20)(27). Above-mentioned results both confirmed the feasibility and safety of RALPN, especially RASP-LPN for huge renal tumors. In our study, the tumor size of case 3 was 66.6mm, the successfully completed operation haven't produced additional complications but gained similar prognosis with other 3 cases. Thus, some guidance for our institution to carry out RASP-LPN for renal tumor > 4cm could be offered in the future.

In this study, we used the existing Si platform and adopted a multi-channel laparoscopic surgical approach system. Different from the more common GelPOINT advanced access platform (Applied Medical, Rancho Santa Margarita, CA), the platform FreePort we used was interchangeable for all laparoscopic surgery. The characteristic that not limited to the robotic surgery use made it more economical to patients.

The main disadvantage of RASP-LPN was the collision of robotic arms. Different from the traditional multi-site surgery, single-port surgery meant the robotic arms were concentrated in a narrower space. Especially when dissecting the kidney, the collisions would happen frequently. Besides, the traditional laparoscopic instruments we used were not as flexible as the double-jointed instruments, increasing the difficulty of the surgery. To reduce external collisions and provide extra space for the movement of the robotic arm, we tried keeping the endoscope away from the surgical field and abducting the proximal robotic arms. In our study, a 30° upwards endoscope was used to provide a clearer vision, with the cooperation of manual adjustment to change the distance between the lens and the robotic arms. According to our results, the tumors located in the upper or lower pole of the kidney, especially those exogenous tumors, were more suitable to accepted the RASP-LPN. For those selected tumors, it was easier to determine the position when entering the posterior peritoneum, and would reduce the difficulty of the surgery objectively. Our study was lack of cases with endogenous or anterior tumors, needed further exploration was needed to evaluate the indications of retroperitoneal RASP-LPN.

Our study was limited by its retrospective analysis of a single institution and single surgeon experience. Nevertheless, the inclusion of multiple institutions or surgeons would inevitably expand the sample size and improve the credibility of the results, it simultaneously increased the heterogeneity because of the differences in personal skills. And the 3-months follow-up period restricted the prediction of the long-term complications and prognosis, which was necessary access the oncological and functional outcomes. Besides, selection biases were inevitable due to the retrospective design and small sample size. Despite the learning curve, we still planned to continue using the technique in more patients to help other surgeons overcome the barriers of RASP-LPN.

Conclusions

In conclusion, retroperitoneal RASP-LPN can be an alternative for selected RCC patients with the help of Da Vinci Si system. Our initial experience showed that it could be a safe approach, because there was no need to transform to open surgery or added additional auxiliary channels, and there were no uncontrolled complications happened. According to our study, strict evaluation of the size and location of the tumor before the operation was necessary and the principle of precision medicine and personalized treatment was needed to formulate to benefit the patients.

Our initial experience preliminarily proofed that retroperitoneal RASP-LPN is a feasible and safe approach for those selected patients with RCC, but further studies are required to clearly evaluate the potential benefits and perfect its limitations.

Abbreviations

RCC

renal cell carcinoma

LPN

laparoscopic partial nephrectomy

OPN

open partial nephrectomy

RA-LPN

robot-assisted laparoscopic partial nephrectomy

LESS

laparoscopic single-site

PN

partial nephrectomy

RASP-LPN

robot-assisted single-port laparoscopic partial nephrectomy

BMI

body mass index

WIT

warm ischemia time

EBL

estimated blood loss

ASA

American Society of Anesthesiologists

Declarations

Ethics approval and consent to participate

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). All procedures performed in this study were approved by the Ethics Committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine (No.20210421-30) and individual consent for this retrospective analysis was waived.

Consent for publication

Written informed consent for publication was obtained from all participants.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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This research had no funding support.

Authors' contributions

CY and LY proposed the research design, collected and analyzed the data. CY was a major contributor in writing the manuscript. SY and GL provided the administrative support. ZW, SZ, SY and GL provided the study materials or patients. All authors read and approved the final manuscript.

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Figures

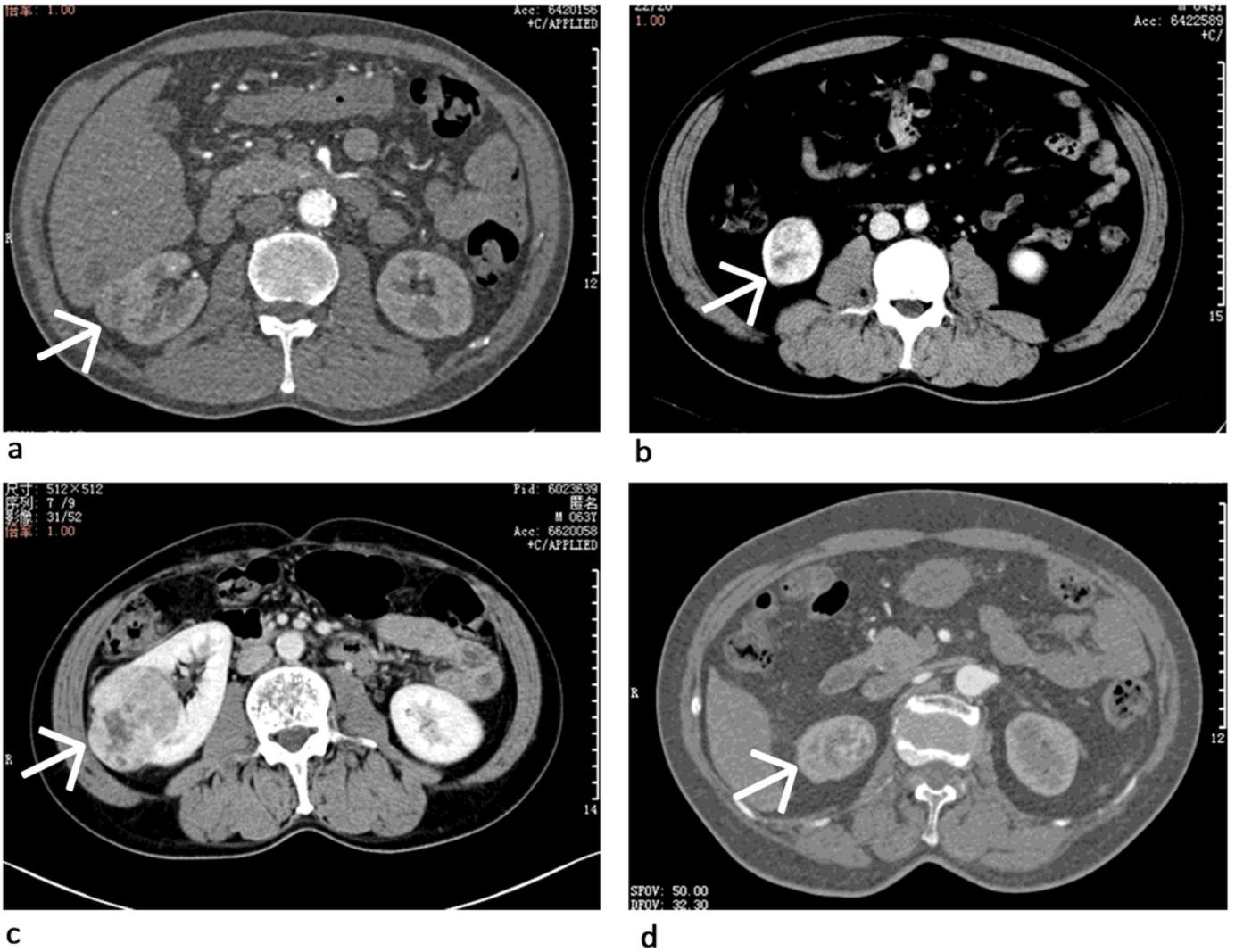


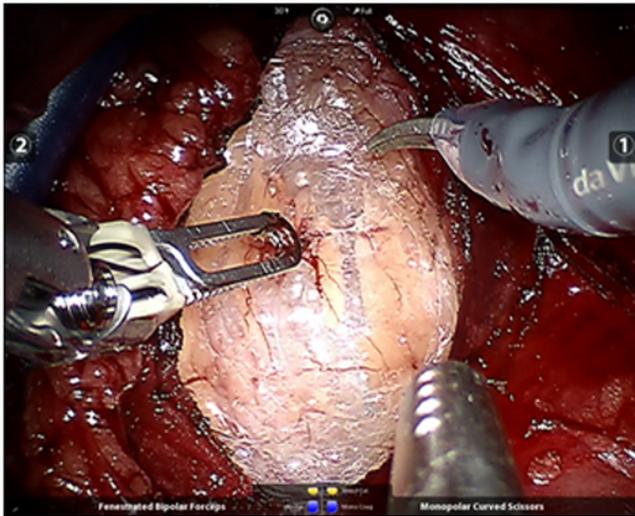
Figure 1

The CT scan of four patients. a. case 1. b. case 2. c. case 3. d. case 4. The arrow→shows the tumor.

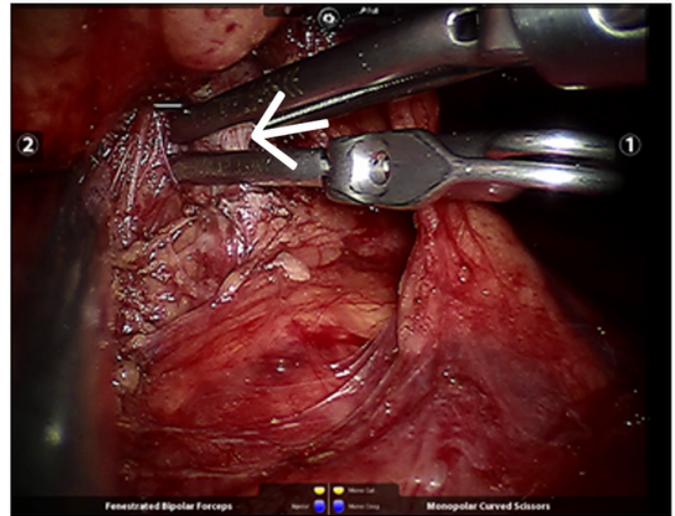


Figure 2

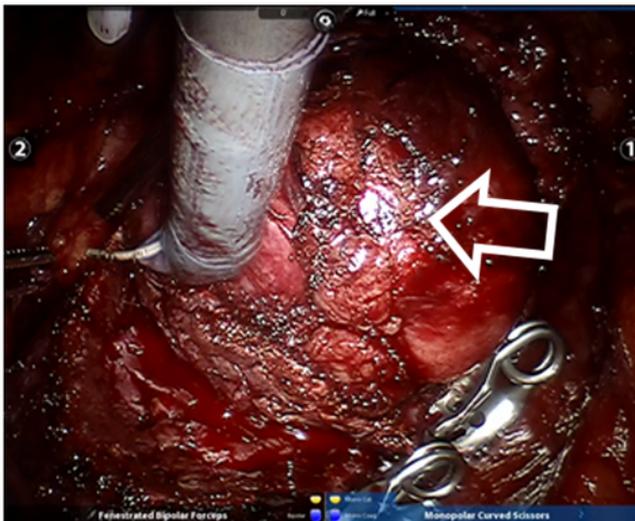
The photograph of the robot system and the incision. a. The position of the patient and the multichannel-port. b. The relative position of every robotic arms. c. The final incision.



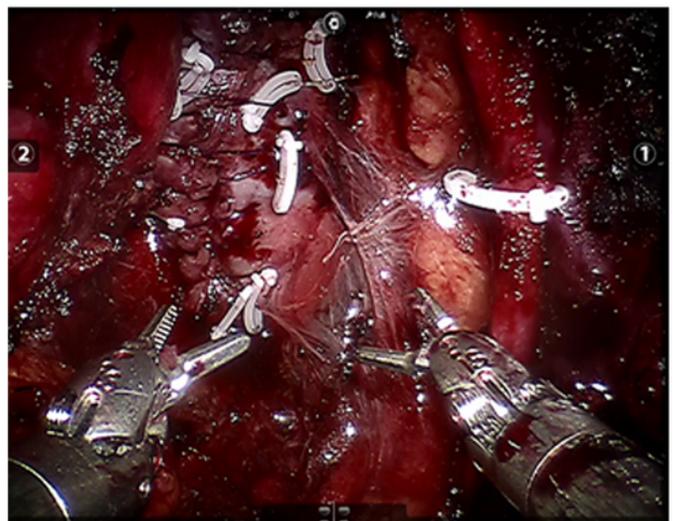
a



b



c



d

Figure 3

The procedure of the surgery. a. Slit the Gerota fascia. b. Block the renal artery with bulldog clamp. The arrow→shows the renal artery. c. Remove the tumor. The arrow→shows the tumor. d. Renorrhaphy