

# Modified IVC Clamping Technique in the Left Radical Nephrectomy and Mayo II-III IVC Thrombectomy: A Preliminary Experience

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## Research article

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# Abstract

**Background:** To present our initial experiences on the left radical nephrectomy (RN) and Mayo II-III IVC thrombectomy (IVCTE) using modified inferior vena cava (IVC) clamping technique.

**Methods:** From November 2016 to July 2018, eight left renal cell carcinoma (RCC) patients with inferior vena cava tumor thrombus (IVCTT) underwent retroperitoneal laparoscopic RN and IVCTE using the modified IVC clamping technique. During the IVCTE, the infrarenal IVC, right renal artery, right renal vein were clamped sequentially, then the cephalic IVC of the tumor thrombus was clamped immediately after the thrombus was removed.

**Results:** According to the preoperative plans, all 8 operations were completed successfully without perioperative mortality. Median operative time was 438 min (343-573 min). Median IVC blocking time was 18 min (12-28min), and median warm ischemia time (WIT) for the right kidney was 19min (14-28min). Median estimated intraoperative blood loss was 1107mL (50-6000 ml). Some 50% of patients required an intraoperative blood transfusion. Median length of hospital stay was 12.9 days (6-39). Early postoperative complications occurred in 2 cases, 1 was Clavien class II, another was Clavien class IVa. All 8 patients were followed up continually with a median follow-up period of 16 months (5-25 months). During the mean follow-up period, three patients developed metastatic disease.

**Conclusions:** Modified IVC clamping technique, which is feasible and safe for experienced surgeons in selected patients, can simplify the procedures left RN and Mayo II-III IVCTE.

## Background

Inferior vena cava tumor thrombus (IVCTT) occurs in 4–10% of patients with renal cell carcinoma (RCC) [1]. Due to anatomical differences between the left and right renal veins, left RCC with IVCTT is relatively rare. Surgical treatment of the IVCTT remains challenging, especially for the tumors located on the left renal, not only due to technical difficulties that it involved, but also because of the high associated risks of perioperative mortality (3%–16%) [2–3]. In addition, the surgery complexity increases with the level of tumor thrombus (TT). Thus, among the early reports, the tumors mostly located on the right side, and the level of the TT was mainly Mayo level 0-I.

At present, open surgery is still the standard approach for RCC with IVCTT [4]. Recently, laparoscopy is increasingly being used in RCC patients with IVCTT due to the improvement of the minimally invasive techniques and the accumulation of surgical experiences, and it has been proved to be safe and effective in selected patients [5–12]. Whether open surgery or laparoscopic surgery, it is necessary to clamp the inferior vena cava (IVC) below the inferior margin of TT and above the superior margin of the TT, followed by removing of the TT. However, when the TT is Mayo II that closed to the hepatic vein or Mayo III, this clamping process is complex and time-consuming.

Considering the aforementioned issues, we hereby report our initial experience on the left radical nephrectomy (RN) and Mayo II-III inferior vena cava thrombectomy (IVCTE) using modified IVC clamping technique, which greatly simplified the surgery procedure.

## Methods

### Patient selection

From November 2016 to July 2018, 116 patients diagnosed with RCC with vascular TT were admitted to our hospital, among whom 42 cases had RCC located on the left side and 74 on the right side. Only those with left RCC and Mayo II-III IVCTT, and received retroperitoneal laparoscopic RN and transperitoneal IVCTE by using the modified IVC clamping technique were enrolled in this study. According to this inclusion criteria, 8 patients were at last included and the flow chart of the patient inclusion is shown in Fig. 1. This study was approved by the institutional review board of the hospital involved.

Abdominal color Doppler ultrasound and enhanced computed tomography (CT) were used preoperatively to define the size of the tumor, the tip of the TT, IVC extension and whether the neighboring organs were invaded in all patients. For the patients who were detected with IVCTT, a further IVC magnetic resonance imaging (MRI) examination were performed to define the associations between the TT and the IVC wall. All RCC were classified according to the Union for International Cancer Control (UICC) 2010 TNM staging criteria [13], all IVCTT were classified according to the Mayo Clinic IVC thrombus classification [14], and perioperative complications were graded according to the Clavien system [15].

### Preoperative preparation

General preoperative preparation included skin preparation, fasting, water enema, and placement of an indwelling gastric tube. Second-generation cephalosporins or third-generation quinolones was preventively used 30 min before the operation and 1200-2000ml of suspended red blood cells was routinely prepared.

### Surgical procedure

All 8 patients were first placed in a right lateral decubitus position to receive the retroperitoneal laparoscopic RN, without abscission of the left renal vein at this step. For the 3 patients who received IVCTE by transperitoneal laparoscopic approach, patients were converted to a left lateral decubitus position, and then the right renal artery, right renal vein and IVC were dissected, followed by the resection of IVCTT. While for another 5 patients who received IVCTE by transperitoneal open approach, patients were converted to a supine position, followed by the resection of IVCTT via Chevron incision. Surgical methods and positions of all 8 patients were showed in Table 2.

*Retroperitoneal laparoscopic left RN (RPL-RN)* The detailed steps of RPL-RN for left RCC were described in our previous report [16]. The difference is that after the left nephrectomy, the peritoneum should be incised about 10cm at the left paracolic sulci, preparing for the take of the specimen.

*Transperitoneal laparoscopic IVCTE* The patient was converted to a left lateral decubitus position with the right side pointed upward at 45 degrees. A 1.5cm incision was made on the right of the navel beside the rectus abdominis, then a 11-mm trocar was inserted and CO<sub>2</sub> was insufflated to maintain the pneumoperitoneum pressure at 12 mm Hg, followed by placement of the 30-degree laparoscope. Under the surveillance of the laparoscope, a 13-mm trocar was placed at 4cm below the rib of the right pararectus abdominis, three 5-mm trocars were respectively placed below the xiphoid, in the right anterior axillary line under the rib and inside of the iliac crest. After this, the abdominal cavity was established. The IVC was gently dissected and exposed to the infra-hepatic level, the lumbar veins were transected using ultrasonic scalpel and bipolar, and some short hepatic veins (SHVs) were cut off when necessary. The right renal artery and vein were exposed along the IVC; or the right ureter was firstly identified, then the right renal artery and vein were isolated and exposed between the lower pole of the right kidney and the IVC, along the ureter upwards. Followingly, the vessel loops were wrapped twice around the IVC below the TT, around the infra-hepatic IVC and around the right renal artery and vein, which was secured with a Hem-o-lok clip for surgeon control (Fig.2). Next, the caudal IVC, right renal artery, right renal vein were sequentially clamped and the pneumoperitoneum pressure was elevated to around 20mmHg. Then the left renal vein was incised circumferentially at its junction with the IVC and then the incision was extended between the TT and IVC wall, upwards along the IVC, followed by pulling out of the TT. After the TT was placed into a specimen bag, the infra-hepatic IVC was immediately clamped and the IVC lumen was copiously irrigated and flushed with heparinized saline. Then the IVC was closed with 4-0 prolene suture.

For no.3 patient, three right renal veins were identified and the bottom of the TT located above the right renal vein. When the IVC was incised, the IVC wall was found to be extensively invaded by the TT, so the IVC was segmentally resected. An Endo-GIA stapler was used between the middle and the upwards right renal veins to sever the IVC, and the right renal vein returned to the infra-renal IVC. Another Endo-GIA stapler was used to sever the infra-hepatic IVC after the TT was entirely pulled out (Fig. 3).

Lastly, the 1.5cm incision on the right of the navel was extended longitudinally to about 8cm to ensure that just one hand can enter. Then, the surgeon put one hand into the abdominal cavity and stretched it into the retroperitoneal cavity through the incised peritoneum at the paracolic sulci. Followingly, the TT was firstly moved from the space between the superior mesenteric artery and abdominal aorta to the retroperitoneum, and then it was moved to the abdominal cavity with the left kidney en bloc and be put into the specimen bag. Finally, it was removed through the enlarged incision.

*Transperitoneal open IVCTE* The patient was converted to a supine position and a Chevron incision was made. The right colon, right renal artery and vein were dissected, and the IVC was gently exposed to the infra-hepatic level. After the IVC below the TT, the right renal artery and right renal vein were sequentially clamped, the IVC was longitudinally incised, and a Foley catheter was used to extract the TT under the guidance of Transesophageal echocardiography (TEE). Followingly, the infra-hepatic IVC was immediately clamped and the IVC lumen was copiously irrigated and flushed with heparinized saline, and the incision in the IVC was sutured with 4-0 prolene suture. For the no.4 patient, the IVC below the right

renal vein was extensively invaded by the TT. So, the TT and invaded IVC wall were resected together, during which the IVC was severed using Endo-GIA stapler. The right renal vein returned upwards to the right atrium (Fig.4).

### **Postoperative follow-up**

Regular postoperative follow-up of all patients was performed. CT or MRI scan of the chest, abdomen and pelvis were performed every 3 months within the first postoperative year, then every 6 months.

## **Results**

Baseline characteristics of all the 8 patients are summarized in Table 1. The tumors were all left sided, with a median size of 8.4 cm (rang 5-15.5 cm), the TT were level II and III in 5 and 3 patients, respectively. All the operations were successfully completed without perioperative mortality. The operative data are listed in Table 3.

Retroperitoneal laparoscopic RN was performed for all the 8 patients, then transperitoneal laparoscopic IVCTE was performed for 3 of them, while transperitoneal open IVCTE was performed for the other 5. For all cases, modified IVC clamping technique was performed during the process of IVCTE. And the ipsilateral adrenal resection was performed in 5 cases, the segmental resection of the IVC was performed in 2 cases (the no. 3 and no. 4 patient, respectively). The median operative time was 448 min (range 343–573 min). The median estimated blood loss was 1181 ml (range 50-6000 ml). Four patients (no. 1, 4, 5 and 7 patient, respectively) received transfusion of suspended red cell, with the median volume 775 ml (range 800–3600 ml). One patient (the no. 7 patient) received transfusion of fresh frozen plasma, with the volume of 400 ml. The median IVC clamping time was 18 min (range 12–28 min), while the median warm ischemia time (WIT) of the right kidney was 19 min (range 14–28 min).

Of the 8 patients, one patient (the no. 4) suffered preoperative chronic renal failure (CRF), with the Scr 958  $\mu\text{mol/L}$ , which fell to 130  $\mu\text{mol/L}$  one week after the operation. Early postoperative complications occurred in 2 patients, one (no. 2) was acute tubular necrosis (ATN) (Clavien IVa), with the Scr up to 958  $\mu\text{mol/L}$  one week after the operation. However, the patient`s renal function gradually restored to normal and the patient was discharge 13 days after the operation. Another (no. 3) was incomplete intestinal obstruction, pleural effusion and pulmonary atelectasis (Clavien II). And this patient received conservative therapy, and was discharge 39 days after the operation. The median hospital stay was 12.9 days (6–39 days).

Pathology examination revealed clear cell renal cell carcinoma (ccRCC) in 6 patients and papillary renal cell carcinoma (pRCC) in 2 patients. Of the 6 ccRCC, degeneration and necrosis was found in 4, striated muscle differentiation was found in 1, while the 2 pRCC were both classified into type II. The pathologic stage was T3a in four patients, T3b in 2 patients and T3c in 2 patients too. Lymphatic metastasis was found in 2 patients and the positive lymph nodes were both confirmed to be excised from the renal hilum.

Of the 8 patients, 4 received postoperative targeted therapy, with the sunitinib (SUTENT) and sorafenib were applied in 3 and 1 cases respectively.

All the 8 patients were followed up, with the median follow-up time 31 months (9–40 months). And during the follow-up period, osseous metastasis occurred in one patient 11 months after the operation, and the patients now survives with the tumor; liver metastasis occurred in one patient 3 months after the operation, and the patient died 14 months after the operation due to the tumor progression; brain metastasis occurred in one patient 32 months after the operation, and this patient died 40 months after the operation; abdominal wall implantation metastasis occurred in one patient 4 months after the operation and now no new metastasis is detected after the resection of the metastasis focus. No local recurrence and metastasis was found in the other 5 patients.

## Discussion

Generally, during the procedure of IVCTE for Mayo II IVCTT that closed to the hepatic vein or Mayo III IVCTT, it is necessary to clamp the contralateral renal vascular, subrenal IVC, the first hepatic portal and supra-hepatic IVC. However, this blocking process is complex and time-consuming even for experienced surgeons, and the liver may be damaged during the process of clamping the first porta hepatis. Thus, we modified the IVC clamping technique, that only the IVC below the inferior margin of TT and the contralateral renal vascular were clamped when the TT was resecting; while the cephalic IVC was left to be clamped below the liver margin immediately after the TT was pulled out.

The critical point of this method is how to control the intraoperative bleeding and avoid air embolism. Our experience is that the pneumoperitoneum pressure can be elevated to around 20 mmHg before the incision of IVC to ensure that there is blood flow through the vena cava, but no blood outflow. Though reversal flow of blood in the cephalic IVC at the time of IVC incision is inevitable, this blood flow is so small that the bleeding caused by reversal blood flow can be reduced to a certain extent by increased pneumoperitoneum pressure, which is consistent with K. Eiriksson's results [17]. However, E. Eiriksson also pointed out that high pneumoperitoneum pressure is more likely to cause air embolism. So, the duration of the high pneumoperitoneum pressure should not be too long. In addition, in the process of thrombectomy, the use of aspirator is not recommended unless necessary, because it can easily lead to bleeding. For the 3 patients who received transperitoneal laparoscopic IVCTE using this modified IVC clamping technique in our study, the pneumoperitoneum pressure was elevated to 20 mmHg before the incision of IVC and quickly restored to 12 mmHg after the TT was removed. The surgery were successful with no intraoperative complications, and the intraoperative blood loss was 600 ml, 300 ml and 50 ml, respectively.

For another 5 patients who received transperitoeneal open IVCTE, the Foley catheter-assisted technique was used to remove the TT. It has been reported that some invasive and complicated process such as thoracotomy, median sternotomy and extracorporeal circulation can be avoided by using Foley catheter in patients with Mayo III-IV IVCTT [18]. Conventionally, during the procedure of IVCTE for Mayo II IVCTT that

closed to the hepatic vein or Mayo III IVCTT by using transperitoneal open approach, it is necessary to fully isolate the retro-hepatic IVC and hepatic vein, to incise the ligamentum teres hepatis, the left and right triangular ligament and the sagittal and coronary ligament, and to isolate and retract the liver to the left. These processes are so complicated that it would cause big trauma. In our series, the aforementioned complicated procedures were successfully avoided due to the use of Foley catheter. Therefore, Foley catheter-assisted technique combined with the modified IVC clamping technique can greatly simplify the procedure and reduce the difficulty of operation.

Although it can simplify the operation steps and reduce the surgical trauma, this modified IVC clamping technique cannot be routinely used without caveats—it is not recommended in cases when the friable thrombus is presented, or in cases of intra- or supra-hepatic IVC wall infiltration by TT. At present, there is no standard definition of tumor textures. Roberto Bertini, et al. pointed out that in a friable thrombus, the pseudocapsule is lacking and the tumor cells are intermingled with abundant necrosis and fibrin [19]. This kind of TT is easy to fall off and thus lead to pulmonary embolism during the process that it is pulled out of the IVC lumen. While when the intra- or supra-hepatic IVC was invaded by the TT, it is essential to fully isolate the TT to make it separated from the IVC wall, so that it can be entirely pulled out of the IVC lumen. However, this process is extremely complicated and dangerous. Therefore, in addition to preoperative CT/MRI, intraoperative TEE is recommended in order to determine whether this technique is feasible. Preoperative CT/MRI can preliminarily evaluate the texture of TT and the relationship between TT and IVC wall, while intraoperative TEE is helpful not only to further clarify this, but also to guide the removal of TT in real time. For the 8 patients here, the TT were en bloc extracted under the real-time guidance of the TEE, without shedding and residue.

Complete resection is one of the principles for treatment of malignant tumor. It is reported that for the non-metastatic RCC patients with IVCTT, the 5-year overall survival is 56% if the tumor and thrombus were en bloc resected, versus only 25% if the tumor and thrombus were not entirely resected [20]. Therefore, in order to resect the tumor entirely, segmental IVC resection was performed in 2 patients in whom the IVC wall were extensively invaded by the TT. For these 2 cases, IVC was left in discontinuity without reconstruction, but the circumfluence channel of the right renal vein was ensured (Fig. 3 and Fig. 4). During the follow-up period, no lower extremity edema was found. It is considered that this may be associated with the well-developed collateral circulation due to a long time growth of the tumor.

Perioperative complications is up to 22%-70% for the RN and IVCTE [3, 21]. In our series, early postoperative complications occurred in 2 cases, one is ATN, another is incomplete intestinal obstruction, pleural effusion and pulmonary atelectasis. ATN occurred in a middle-aged man (no. 2), of whom the preoperative SCr was 123  $\mu\text{mol/L}$  [reference range: 53–130  $\mu\text{mol/L}$ ], while one week after the operation it went up to 813  $\mu\text{mol/L}$ , with normal serum potassium. Conservative therapy with no dialysis was performed, and the renal function gradually returned to normal, with the SCr 130  $\mu\text{mol/L}$  one month after the operation. It is analyzed that the ATN may be associated with ischemia-reperfusion injury induced by blocking of the contralateral renal vascular, and renal hypoperfusion caused by the intraoperative blood loss. It is reported that damage of renal function can be reduced if the WIT time is controlled within

30 min. The WIT time is only 21 min for this patient, individual differences may be the reason that lead to ATN, but also may be associated with a relatively high value of preoperative SCr. Incomplete intestinal obstruction, pleural effusion and pulmonary atelectasis occurred in patient no.3, and the long operation time may be the reason. So, improving surgical technique to shorten the operation time is critical to prevent these complications. Interestingly, of the 8 patients, one experienced CRF preoperatively, with SCr 958  $\mu\text{mol /L}$ , which reduced to 130  $\mu\text{mol /L}$  one week after the operation. And this patient received segmental resection of the IVC. It is considered that preoperative high value of SCr may be related with the obstruction of the renal vein return, which caused by too fast growth of the tumor. After the TT was removed, the obstruction of renal venous reflux disappeared, blocked renal vein return was removed, so the postoperative renal function gradually returned to normal.

There are some limitations in our study. First, the cases included are limited, especially the cases with Mayo III IVCTT; second, our study is only a single-center experience summary. Therefore, although it is technically feasible and safe to treat the Mayo II-III IVCTT with the aforementioned technique used in our study, its repeatability should be confirmed by other surgeons before its widespread acceptance.

## Conclusions

By using our modified IVC clamping technique in the left RN and Mayo II-III IVCTE, the supra-hepatic IVC need not to be freed and the first hepatic portal need not to be clamped, which greatly simplified the surgical procedure. However, this feasible but challenging procedure is only recommended to be performed by experienced surgeons.

## Abbreviations

IVC: Inferior vena cava; IVCTT: Inferior vena cava tumor thrombus; RCC: Renal Cell Carcinoma; TT: Tumor thrombus; RN: Radical nephrectomy; IVCTE: Inferior vena cava thrombectomy; CT: Computed tomography; MRI: Magnetic resonance imaging; UICC: Union for international cancer control; RPL-RN: Retroperitoneal laparoscopic left RN; SHVs: Short hepatic veins; TEE: Transesophageal echocardiography; WIT: Warm ischemia time; CRF: Chronic renal failure; ATN: Acute tubular necrosis; ccRCC: Clear cell renal cell carcinoma; pRCC: papillary renal cell carcinoma; BMI: Body mass index; SCr: Serum creatine; TPL-IVCTE: Transperitoneal laparoscopic inferior vena cava thrombectomy; RLD: Right lateral decubitus; LLD: Left lateral decubitus; SP: Supine position

## Declarations

### Ethics approval and consent to participate

This study was approved by the ethics committees of Peking University Third Hospital. Informed consent was obtained from all individual participants included in the study.

### Consent for publication

Written informed consent for publication was obtained from all participants.

### **Availability of data and materials**

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

### **Competing interests**

All authors declare that they have no competing interests.

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No funding was received for this article.

### **Authors' contributions**

CZG and YB contribute equally to this work. CZG and YB analyzed and interpreted data and wrote the article. GLY and ZF contributed to the discussion and final approval of the manuscript. TXJ, HY, WGL, LC, ZSD and MLL provided clinical advice and designed the study. All authors read and approved the final manuscript.

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# Tables

Table 1  
Demographic data of all 8 patients

Number	Sex	Age ranges (yr)	BMI (kg/m <sup>2</sup> )	Max D of tumor (cm)	Thrombus level	Preoperative SCr (μmol/L)	ASA level
1	1	50–60	20.3	9.9	II	98	II
2	1	50–60	21.1	9.1	II	123	I
3	1	70–80	21.6	5.6	III	104	II
4	1	40–50	29.1	15.5	III	958	II
5	1	70–80	23.9	8.9	III	113	II
6	1	70–80	22.8	7.1	II	85	II
7	1	40–50	22.9	5	II	130	II
8	2	60–70	20.5	6.2	II	66	III

BMI = body mass index; Max = maximum; D = diameter; SCr = serum creatine

Table 2  
Different methods and positions for all 8 patients

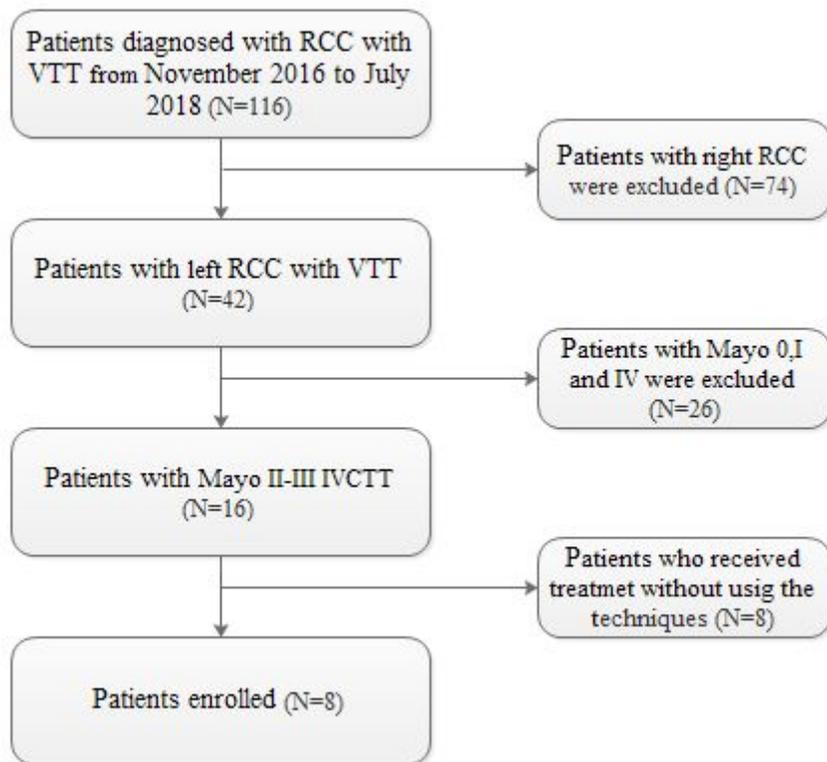
Number	Surgical method	Patient position
1	RPL-RN + Open IVCTE	RLD + SP
2	RPL-RN + Open IVCTE	RLD + SP
3	RPL-RN + TPL-IVCTE	RLD + LLD
4	RPL-RN + Open IVCTE	RLD + SP
5	RPL-RN + Open IVCTE	RLD + SP
6	RPL-RN + TPL-IVCTE	RLD + LLD
7	RPL-RN + Open IVCTE	RLD + SP
8	RPL-RN + TPL-IVCTE	RLD + LLD

RPL-RN = retroperitoneal laparoscopic radical nephrectomy; TPL-IVCTE = transperitoneal laparoscopic inferior vena cava thrombectomy; RLD = right lateral decubitus; LLD = left lateral decubitus; SP = supine position

Table 3  
Perioperative data

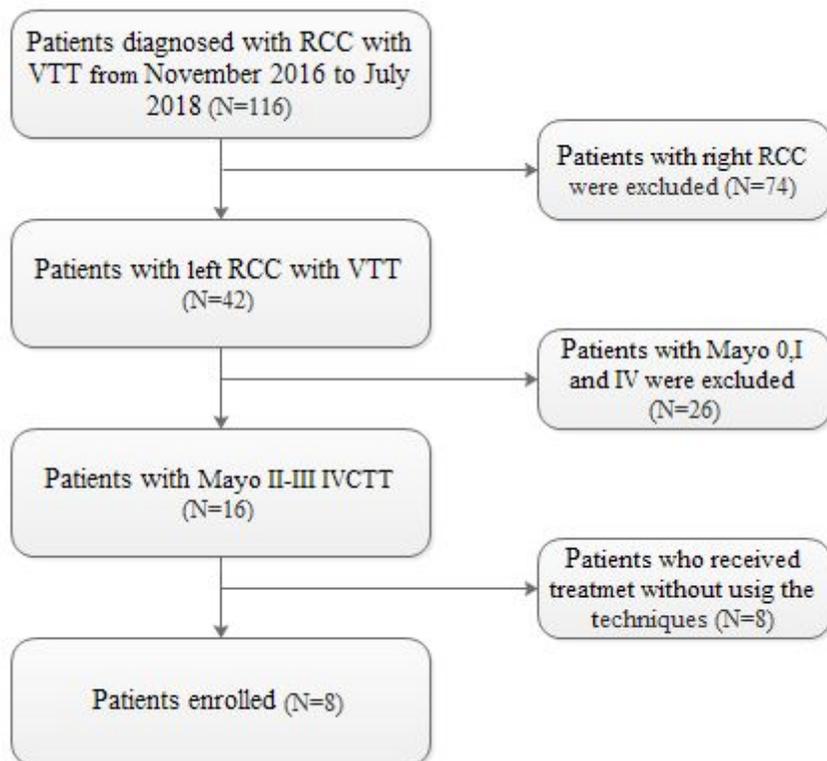
	level II thrombus	level III thrombus	Overall
Segmental IVC wall resection (n)	0	2	2
Ipsilateral adrenalectomy (n)	3	2	5
Operative time(minutes)	431(359–573)	476(343–556)	448(343–573)
IVC clamping time (min)	18(12–24)	19(13–28)	18(12–28)
WIT of the right kidney (min)	19(12–28)	23(14–28)	19(14–28)
Estimated blood loss (ml)	730(50-1300)	3367(600–6000)	1181(50-6000)
Transfusion (n)	480(0-1600)	1267(0-3600)	775(0-3600)
Postoperative SCr (mmol/l)	105(94–114)*	96(74–130)	101(74–130)*
Dissected lymph nodes (n)	3(0–10)	2(0–6)	3(0–10)
Pathological stage (n)			
T3a	3	1	4
T3b	1	1	2
T3c	1	1	2
T4	0	0	0
N0	5	3	8
N1	0	0	0
Complications (n)			
Clavien I–II	1	0	1
Clavien III–V	0	1	1
Postoperative hospital stay(d)	8.8(6–13)	19.7(10–39)	12.9(6–39)
Follow-up (mo)	15(5–25)	17(17–17)	16(5–25)
WIT = warm ischemia time;*except the patient who encountered with postoperative ARF			

## Figures



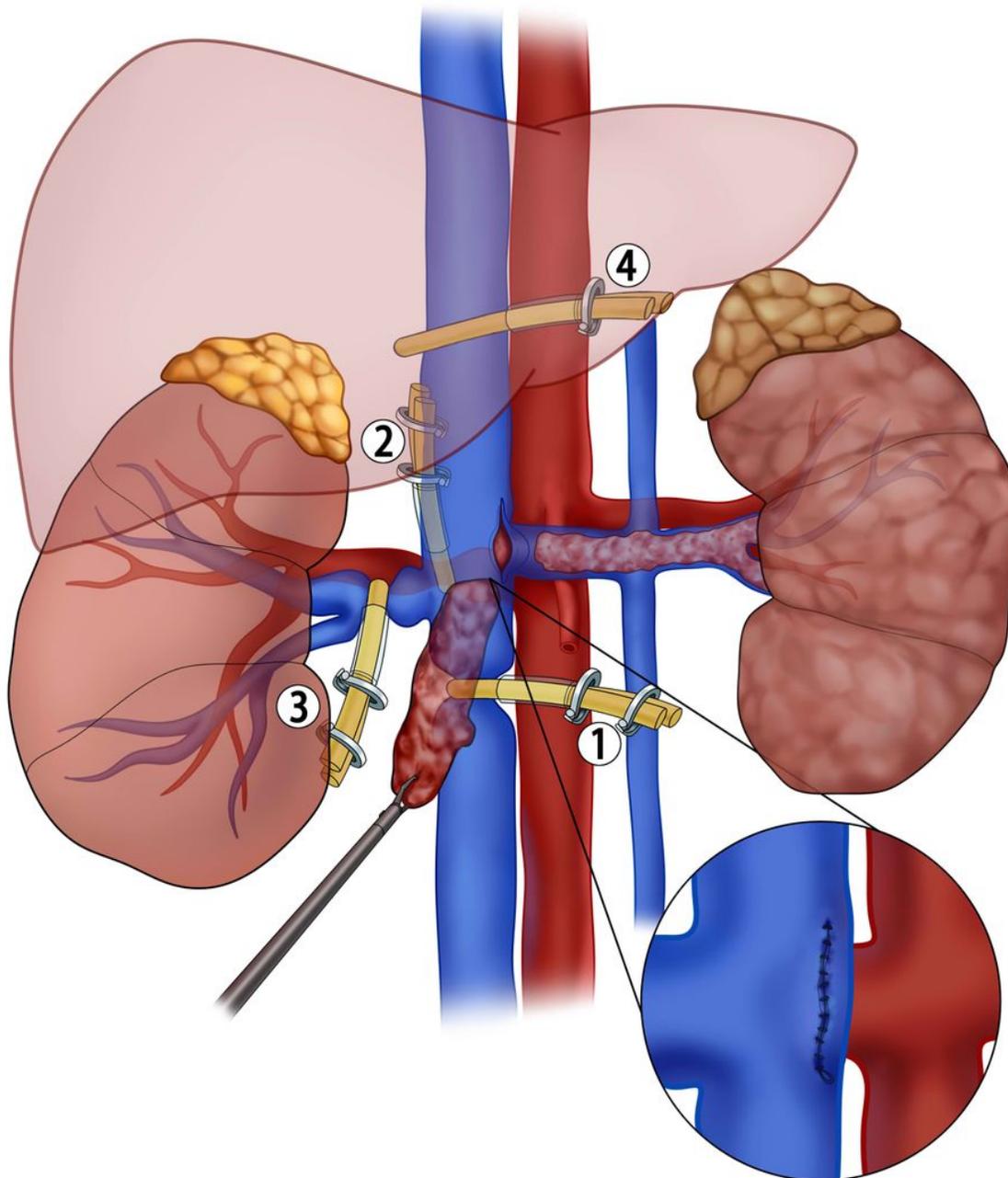
**Figure 1**

The flow chart of the patient inclusion.



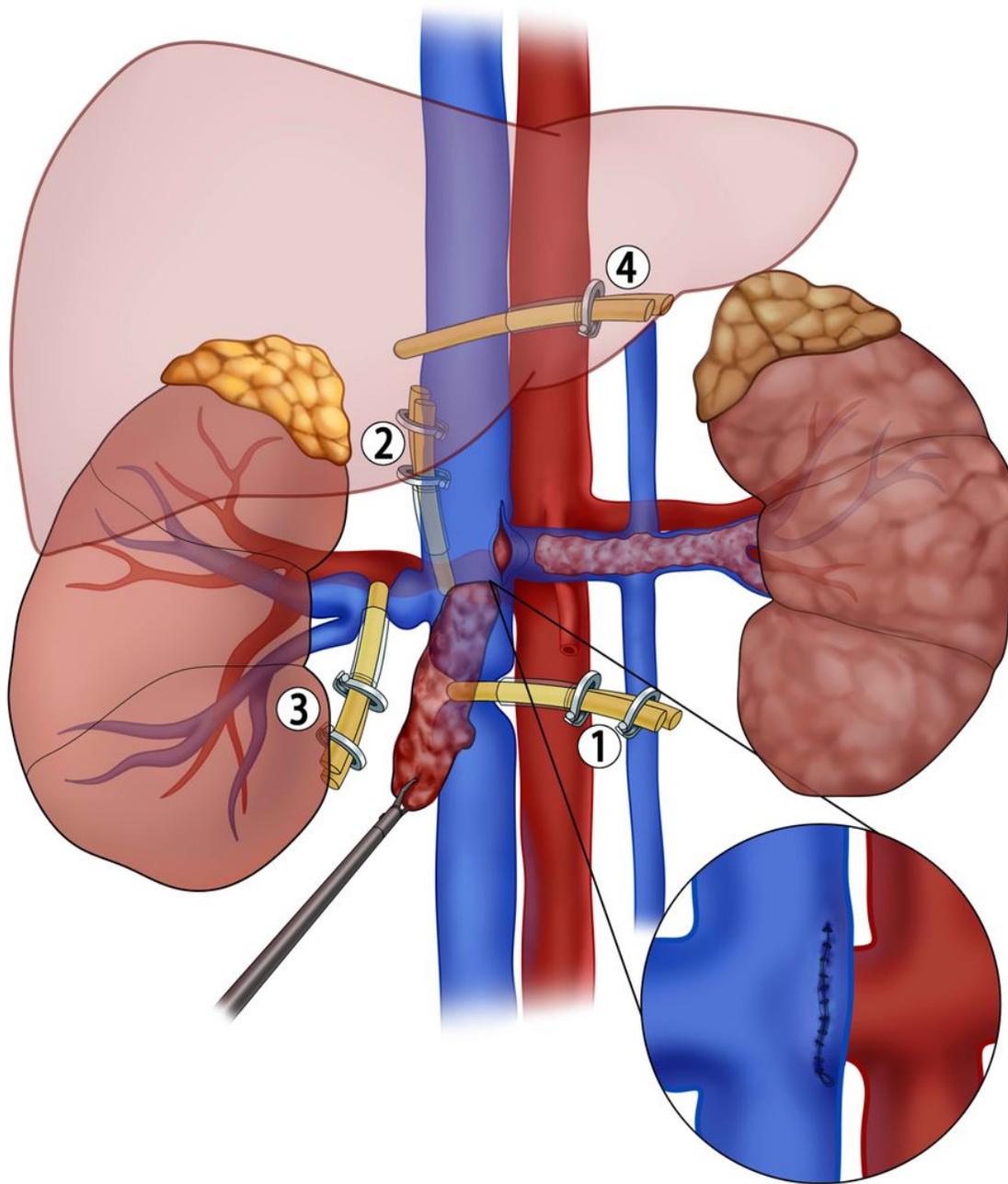
**Figure 1**

The flow chart of the patient inclusion.



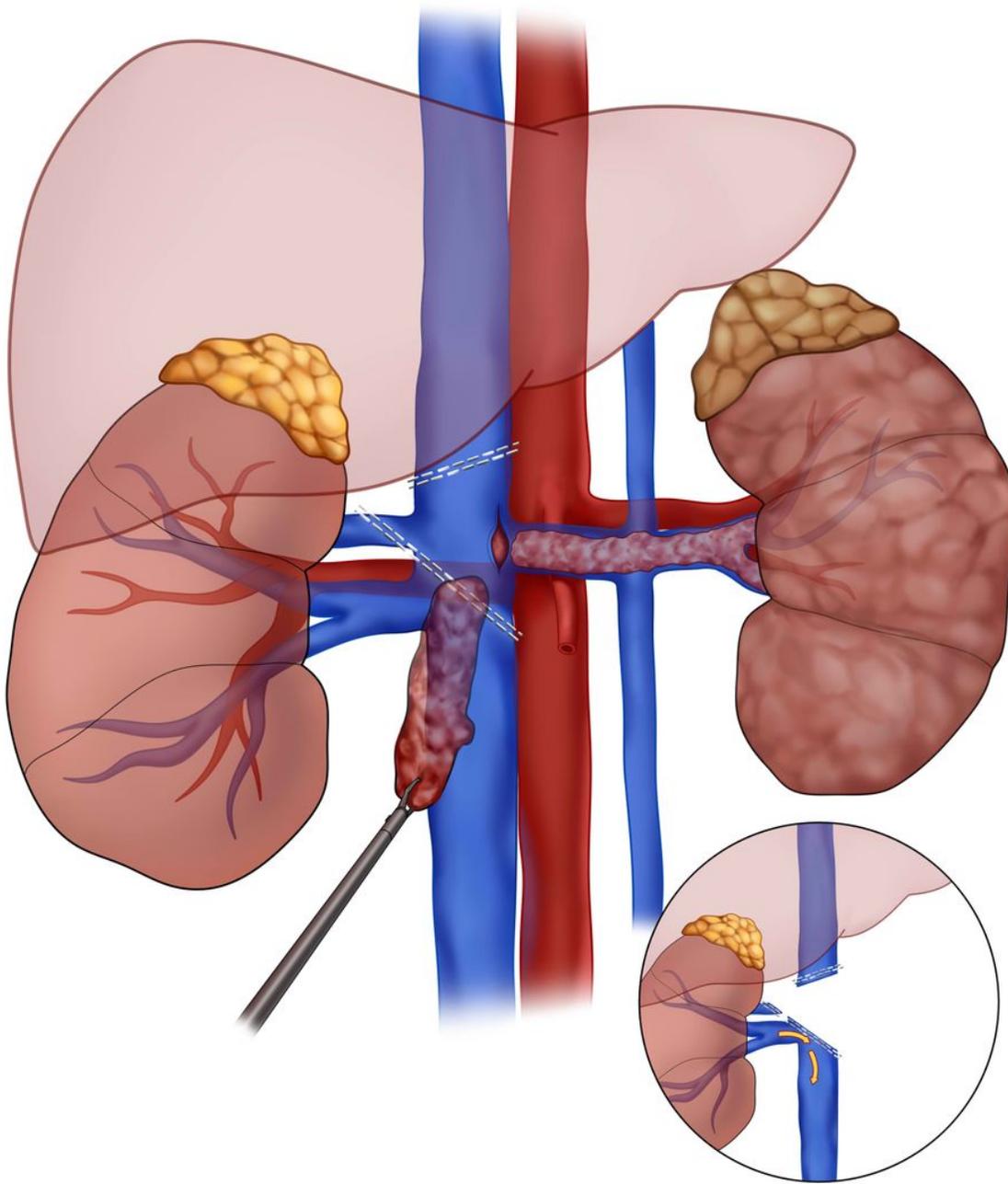
**Figure 2**

Sketch map showing the order for vessel clamping in our modified inferior vena cava (IVC) clamping technique in the left radical nephrectomy and inferior vena thrombectomy. ●1The caudal inferior vena cava (IVC) was clamped with the vessel loop. ●2The right renal artery was clamped with the vessel loop. ●3The right renal vein was clamped with the vessel loop. ●4The cephalic IVC was wrapped with vessel loops, and it was clamped immediately after the tumor thrombus was removed.



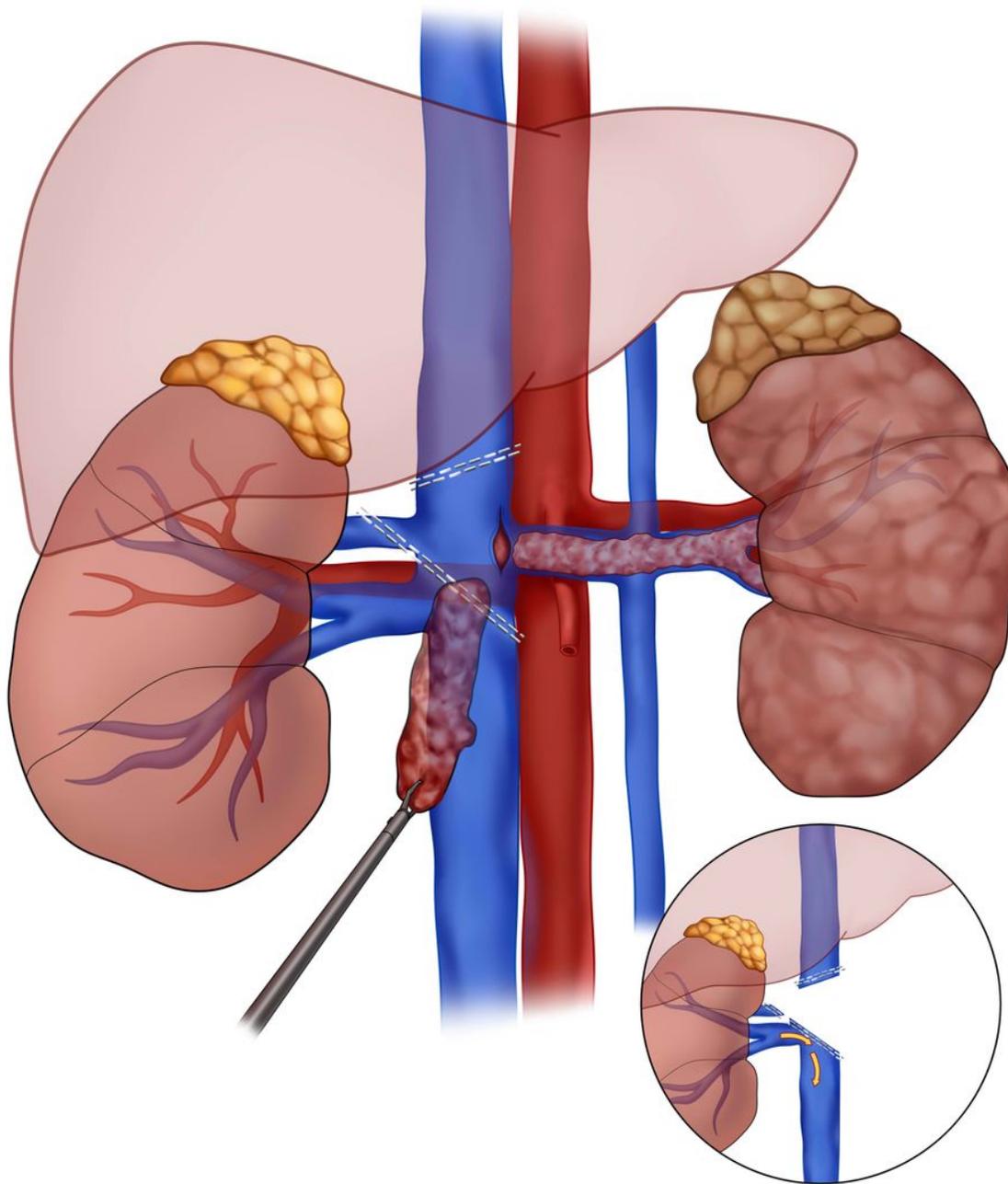
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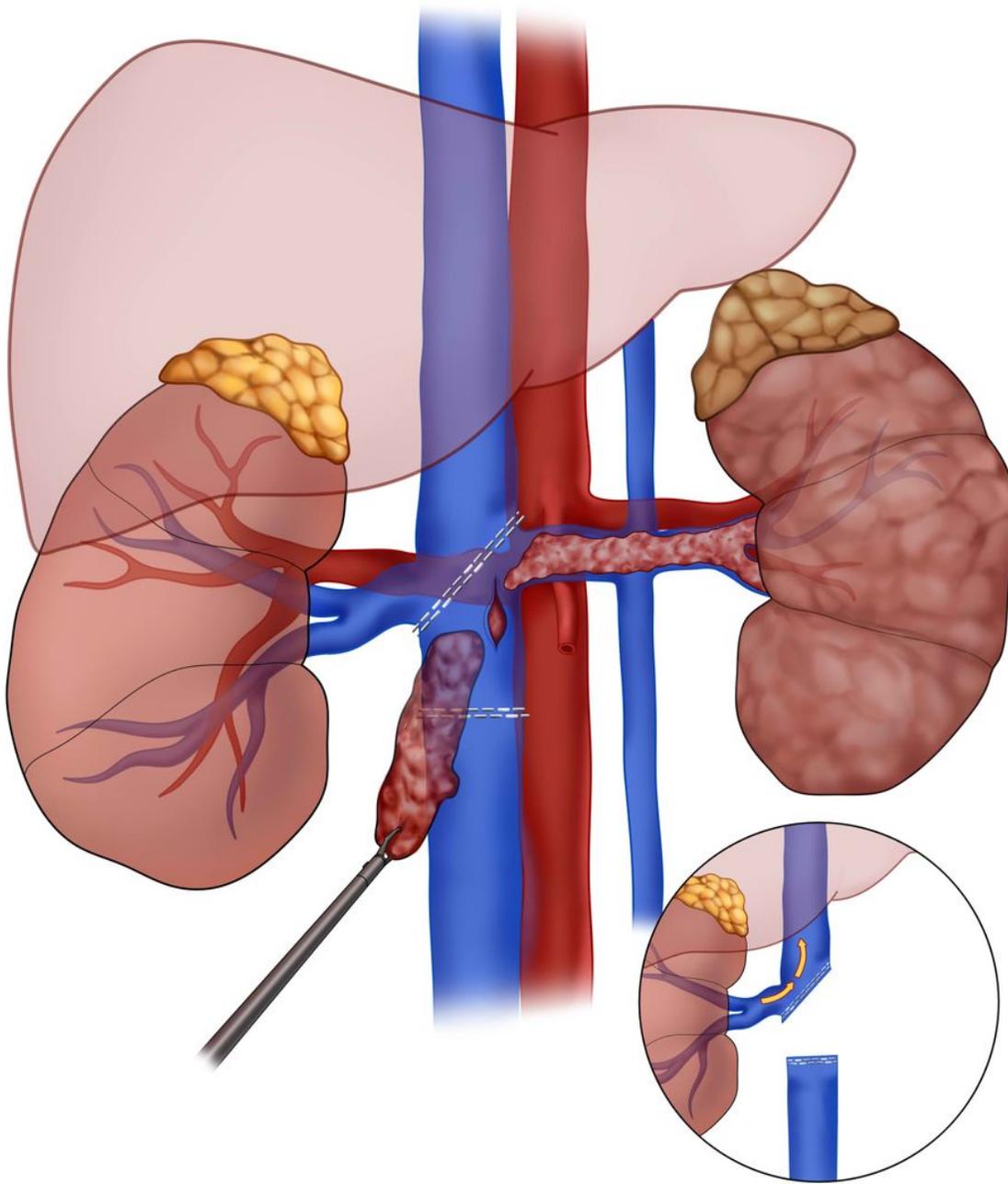
**Figure 3**

Sketch map for the no.3 patient that the inferior vena cava (IVC) was segmentally resected due to the extensively invasion of the IVC wall by the tumor thrombus. Endo-GIA stapler was used to sever the IVC, and the right renal vein returned to the infra-renal IVC (As shown in the local rendering).



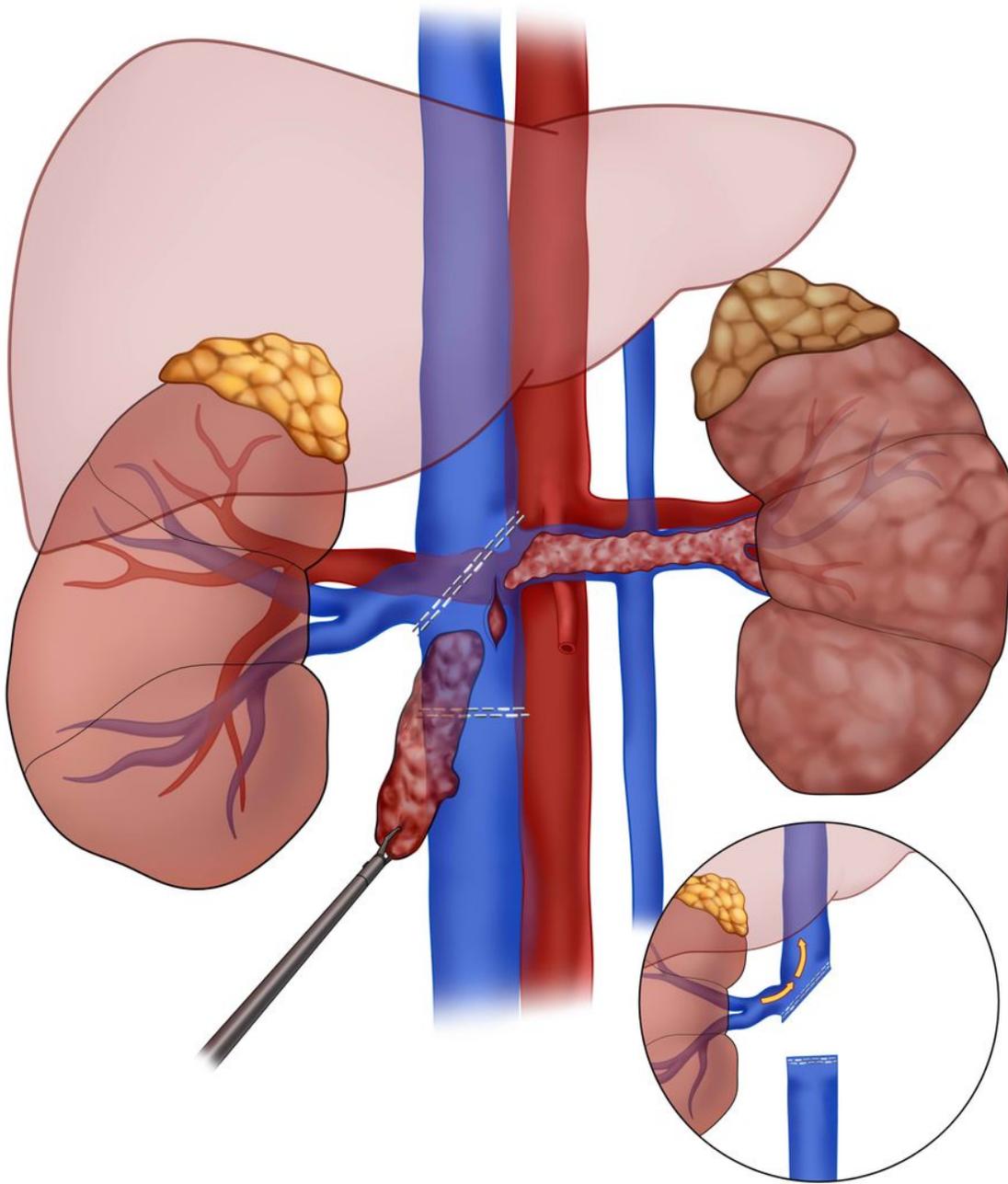
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Sketch map for the no.3 patient that the inferior vena cava (IVC) was segmentally resected due to the extensively invasion of the IVC wall by the tumor thrombus. Endo-GIA stapler was used to sever the IVC, and the right renal vein returned to the infra-renal IVC (As shown in the local rendering).



**Figure 4**

Sketch map for the no.4 patient that the inferior vena cava (IVC) was segmentally resected due to the extensively invasion of the IVC wall by the tumor thrombus. Endo-GIA stapler was used to sever the IVC, and the right renal vein returned upwards to the right atrium (As shown in the local rendering).



**Figure 4**

Sketch map for the no.4 patient that the inferior vena cava (IVC) was segmentally resected due to the extensively invasion of the IVC wall by the tumor thrombus. Endo-GIA stapler was used to sever the IVC, and the right renal vein returned upwards to the right atrium (As shown in the local rendering).