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Hara, Takuto ; Suzuki, Kotaro ; Watanabe, Hiromitsu ; Motoyama, Daisuke ; Otsuka, Atsushi ; Miyake, Hideaki

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A Case Series of Six Patients with Renal Cell Carcinoma with Inferior Vena Cava Tumor
Thrombus who Underwent Robotic-assisted Radical Nephrectomy

Takuto Hara¹, Kotaro Suzuki¹, Hiromitsu Watanabe², Daisuke Motoyama², Atsushi Otsuka²,
Hideaki Miyake¹

1. Department of Urology, Kobe University Graduate School of Medicine, Kobe, Japan
2. Department of Urology, Hamamatsu University School of Medicine

*Correspondence to: Takuto Hara, M.D., Ph.D.

Department of Urology, Kobe University Graduate School of Medicine

7-5-1, Kusunoki-cho, Kobe, 650-0017, Japan

Tel: +81-78-382-6155

Fax: +81-78-382-6169

E-mail: supermarimo85@gmail.com

Abstract

Introduction: Inferior vena cava (IVC) tumor thrombus occurs in 4–10% of renal cell carcinoma (RCC) cases. Robotic-assisted radical nephrectomy (RARN) with IVC tumor thrombectomy offers a minimally invasive alternative to open surgery.

Materials and Methods: We retrospectively reviewed six cases of RARN for RCC with IVC thrombus at two institutions between April 2022 and August 2024. For left-sided RCC, the left renal vein was transected using a vascular stapler before IVC thrombectomy, ensuring adequate access for thrombus removal.

Results: Four patients had right-sided RCC, and two had left-sided RCC. The median operative time was 256 minutes, with median blood loss of 175 mL. No conversions to open surgery, positive surgical margins, or major complications (Clavien-Dindo grade ≥ 3) were reported. No blood transfusions were required.

Conclusion: RARN with IVC thrombectomy resulted in minimal blood loss and no serious complications. Our findings suggest that it is a feasible and safe procedure, even when performed with technical modifications for left-sided RCC.

Introduction

Renal cell carcinoma (RCC) affects around 400,000 people globally each year, with 4–10% presenting with inferior vena cava (IVC) tumor thrombus¹. Nephrectomy with IVC tumor thrombectomy is the standard treatment; however, the procedure is complex, with risks of significant blood loss and high perioperative mortality². Robotic-assisted radical nephrectomy (RARN) was first reported by Abaza et al. in 2011³. Since then, various institutions have refined the technique, aided by advancements in robotic technology⁴. In Japan, RARN was approved for insurance coverage in 2022; however, there are still few large-scale reports. This study presents six cases of robotic-assisted nephrectomies from two facilities.

Materials and Surgical Techniques

We retrospectively collected data on patients who underwent RARN for RCC with IVC tumor thrombus at Kobe University and Hamamatsu University between April 2022 and August 2024. All patients underwent contrast-enhanced CT scans within four weeks prior to surgery to assess tumor extent and classify IVC thrombus height using the MAYO classification⁵. Both the da Vinci Xi® Surgical System (Intuitive Surgical, Sunnyvale, USA) and the hinotori™ Surgical Robot System (Medicaroid, Kobe, Japan) were used in this study, as summarized in Table 1.

The surgical technique for right-sided RCC followed previous reports⁶. For left nephrectomy, trocars were placed according to the method described by Motoyama et al.⁷, with port positions illustrated in Figure 1A, based on case No. 5 (figure 2). After docking the robotic system, the descending colon, spleen, and pancreas were mobilized, and the renal artery was ligated. The renal vein was dissected circumferentially until the IVC wall was visible, then transected using the ENDO-GIA™ TRI-STAPLE™ (Medtronic, Minneapolis, USA). Depending on the thickness of the tumor within the vessel, vascular-specific cartridges, such as Gray for thinner tissues and Camel for thicker tissues, were selected to ensure adequate closure and hemostasis. After kidney mobilization, it was placed into a retrieval bag. The system was temporarily undocked, and the patient's position and trocars were repositioned. The robotic system was redocked, and the thrombus and IVC dissection were performed as in the right-sided approach with port positions illustrated in Figure 1B. The right renal vein and the IVC, both caudal to the renal hilum and cranial to the tumor thrombus, were secured with twice-wrapped vessel loops. The right renal vein and the IVC, both caudal to the renal hilum and cranial to the tumor thrombus, were clamped sequentially with the vessel loops closely by clipping in addition to the use of bulldogs. After this, the IVC wall near the renal hilum was incised, and the thrombus was extracted and placed into a retrieval bag. Caval reconstruction was then performed using a 4-0 polypropylene suture. To prevent tumor spillage, both the kidney and the thrombus were carefully placed into individual retrieval bags (Figures 3).

Results

The patient backgrounds for the six cases are shown in Table 1. Four patients had right-sided renal cancer, and two had left-sided renal cancer. One patient received presurgical therapy with pembrolizumab and lenvatinib. Four patients had level I tumor thrombus and two had level II thrombus, according to the MAYO classification.

The median operative time was 256 minutes (range: 211–474), with a median blood loss of 175 mL (range: 65–1400). No conversions to open surgery, positive margins, Clavien-Dindo grade ≥ 3 complications, or blood transfusions were reported.

Discussion

This study reports surgical outcomes and techniques for six cases of RARN with IVC tumor thrombectomy for RCC, representing the largest case series in Japan and the first for left-sided RCC with IVC thrombus. Our findings suggest that RARN for RCC with IVC thrombus is feasible and safe. Median blood loss was 175 mL, and there were no conversions to open surgery, no Clavien-Dindo grade ≥ 3 complications, and no blood transfusions, which support the findings of previous studies⁸. Although our institution had limited experience with this procedure, the surgeries were performed by a surgeon with extensive expertise in robotic surgery and kidney cancer.

For left-sided renal cancer with IVC thrombus, technical modifications were required due to the challenge of managing the left renal artery, perirenal dissection, and IVC resection in the same view, making it more complex than right-sided tumors. Gill et al.⁹ first reported a left-sided case in 2015, for which they performed preoperative angioembolization of the left renal artery branches. They performed IVC tumor thrombectomy in the right lateral position, then repositioned the patient for left nephrectomy. Aghazadeh and Goh¹⁰ described a technique using the Da Vinci Xi system for left nephrectomy in the supine position without repositioning the patient. Trocars were placed in an arc below the umbilicus, allowing access to both retroperitoneal spaces and circumferential dissection of the IVC and renal vessels without redocking. However, this approach was technically challenging due to the difficulty in mobilizing intra-abdominal organs.

Renal artery embolization before nephrectomy can reduce blood loss^{11,12}. Gill et al.⁹ utilized this technique to reduce bleeding and facilitate IVC thrombus removal. Immediate embolization helped prevent post-infarction syndrome, tissue edema, and necrosis¹¹; however, it does not achieve full infarction, which typically requires 24–48 hours¹². It can also be challenging in cases with multiple renal arteries^{13,14} or collateral circulation, increasing the risk of bleeding if the embolization is incomplete.

In our approach, the left renal vein was transected using Endo GIA before IVC thrombectomy, similar to the procedure used in standard nephrectomy without IVC thrombus. This differs slightly from that of Psutka and Leibovich¹⁵, who emphasized early proximal control of the thrombus to prevent pulmonary embolization; however, we found no increased risk of embolism with our method. Both laparoscopic¹⁶ and robotic¹⁷ nephrectomy for left-sided RCC

with IVC thrombus have demonstrated intraoperative safety, supporting the use of this approach. Moreover, as stapler costs range from \$300 to \$1,000 USD, this technique may be more cost-effective than preoperative embolization. There have been no reports suggesting an increase in tumor recurrence, dissemination, or pulmonary embolism associated with renal vein stapling, but this remains an important area that warrants further investigation.

Our study is limited by its small sample size, which restricts the generalizability of the findings. Although this is the largest series in Japan, larger multicenter studies and longer follow-up periods are needed to confirm the safety, efficacy, and long-term oncological outcomes of RARN for RCC with IVC thrombus.

In conclusion, our findings suggest that RARN for RCC with IVC thrombus is a safe and feasible option, particularly for cases where careful preoperative planning and technical modifications are applied. Our study demonstrated minimal blood loss, no serious complications, and successful outcomes in both right- and left-sided RCC with IVC thrombus.

Conflict of interest

The authors declare that they have no conflicts of interest.

Approval of the research protocol by an Institutional Review Board

This study was approved by the Ethics Committee of Kobe University (Approval No. B240116).

Informed consent

Written informed consent was obtained from all patients.

Registry and the registration No. of the study/trial

N/A.

Animal studies

N/A.

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Figure Legends

Figure 1. (A) shows trocar placement and port positioning for the left-sided approach, based on case No. 5. The figure illustrates the arrangement of ports used during left nephrectomy and for transection of the left renal vein. ① indicates the camera port, ② indicates the left-hand robotic port, ③ indicates the right-hand robotic port, ④ indicates the 12 mm assistant port, and ⑤ indicates the 12 mm AirSeal assistant port.

(B) shows trocar placement and port positioning for the right-sided approach used for thrombectomy and IVC reconstruction. Ⓐ indicates the camera port, Ⓑ indicates the left-hand robotic port, Ⓒ indicates the right-hand robotic port, Ⓓ indicates the 12 mm assistant port, which is reused from ④ in the left-sided approach, and Ⓔ indicates the 12 mm AirSeal assistant port.

Figure 2. The CT coronal section shows the leading edge of the IVC thrombus (arrow) in case No. 5.

Figure 3. Intraoperative findings from case No. 6. A shows the left renal vein being stapled with an Endo GIA, including the tumor thrombus inside. B shows the IVC wall exposed after changing to the right lateral decubitus position, with the arrow indicating the stapled renal vein being pulled from the contralateral side. C shows the renal vein and the cranial and caudal sides of the IVC being secured with twice-wrapped vessel loops. D shows the right renal vein and the IVC being clamped sequentially with the vessel loops closely by clipping in addition to the use of bulldogs. E shows the incision of the IVC wall starting from the caudal corner of the renal vein. F and G show the tumor thrombus being removed while confirming the IVC lumen. H shows IVC reconstruction being performed using 4-0 Polysorb from the

cranial side of the opened IVC.

Table1. Patients characteristics

No	Age	Sex	Tumor side	TNM classification at initial diagnosis	Presurgical therapy	Thrombus level at surgery	Thrombus length from renal vein at surgery (mm)	Robotic Device	Operative time (min)	Robot system usage time (min)	Estimated blood loss (ml)	Major complication (Clavie-Dingo≥3)	Length of stay	Histology	Follow-up term (monthes)	Prognosis
1	76	Female	R	cT3bN0M0	No	Level I	13	da Vinci Xi	211	167	150	No	5	Clear cell	40	Alive, NED
2	67	Male	R	cT3bN0M1	No	Level II	28	da Vinci Xi	311	233	65	No	8	Clear cell	25	Deceased
3	67	Male	R	cT3bN0M0	No	Level II	25	hinotori	228	158	535	No	8	Clear cell	26	Alive with disease progression
4	79	Male	R	cT3bN0M0	No	Level I	6	hinotori	214	156	200	No	10	Clear cell	21	Alive, NED
5	75	Male	L	cT3bN0M0	Pembrolizumab + Lenvatinib	Level I	8	da Vinci Xi	474	165+159*	125	No	8	Clear cell	15	Alive, NED
6	70	Male	L	cT3bN0M0	No	Level I	0	da Vinci Xi	283	98+119*	1400	No	15	Clear cell	4	Alive, NED

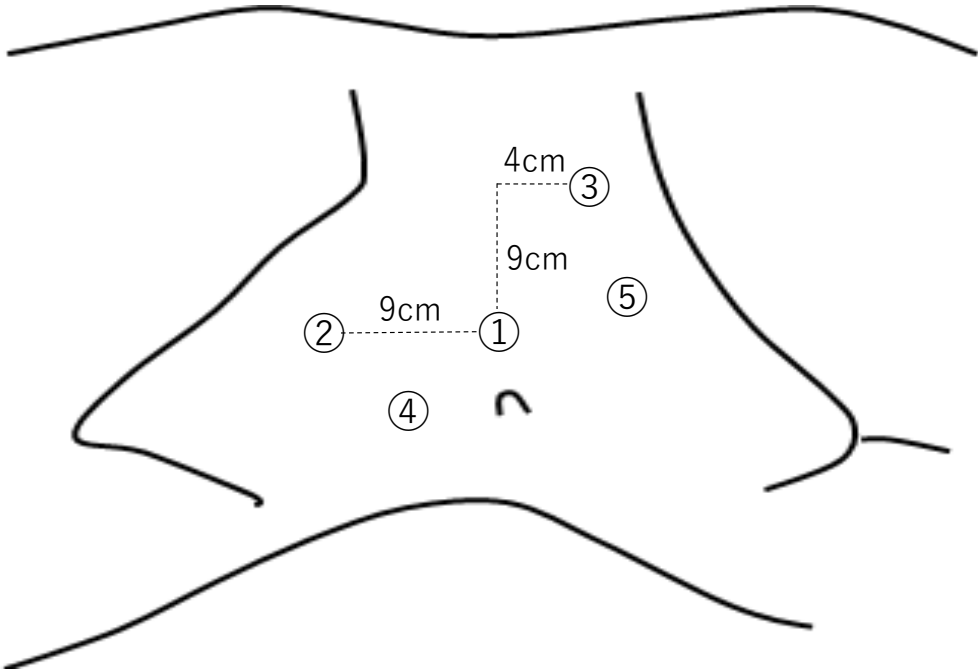
* The first addend represents the time spent on the nephrectomy, while the second addend refers to the time taken for the removal of the IVC thrombus.

NED, no evidence of disease; TNM, tumor-node-metastasis.

Left side (nephrectomy part)

Cranial

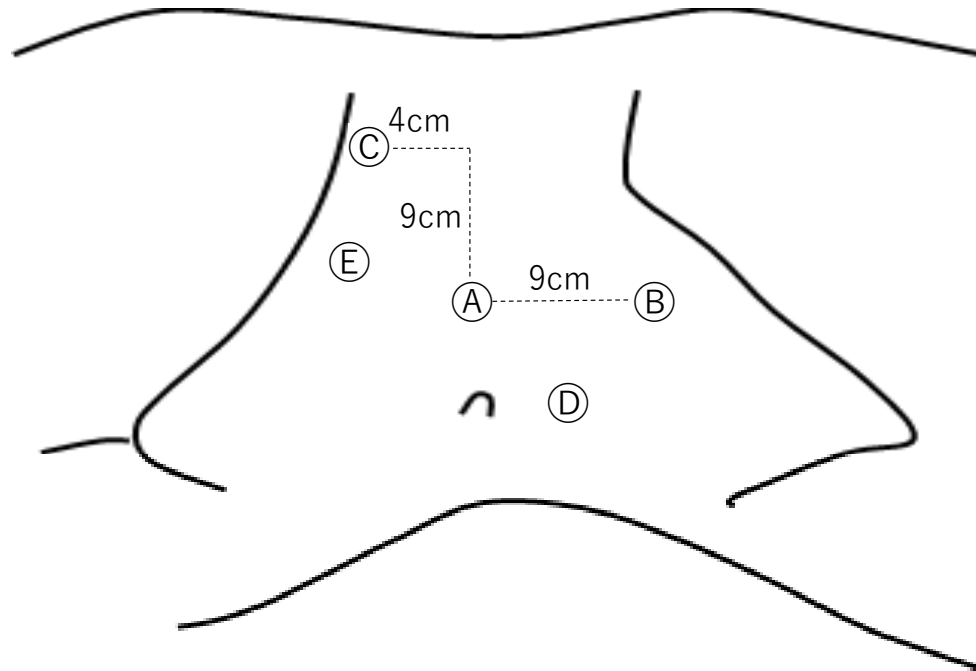
Caudal

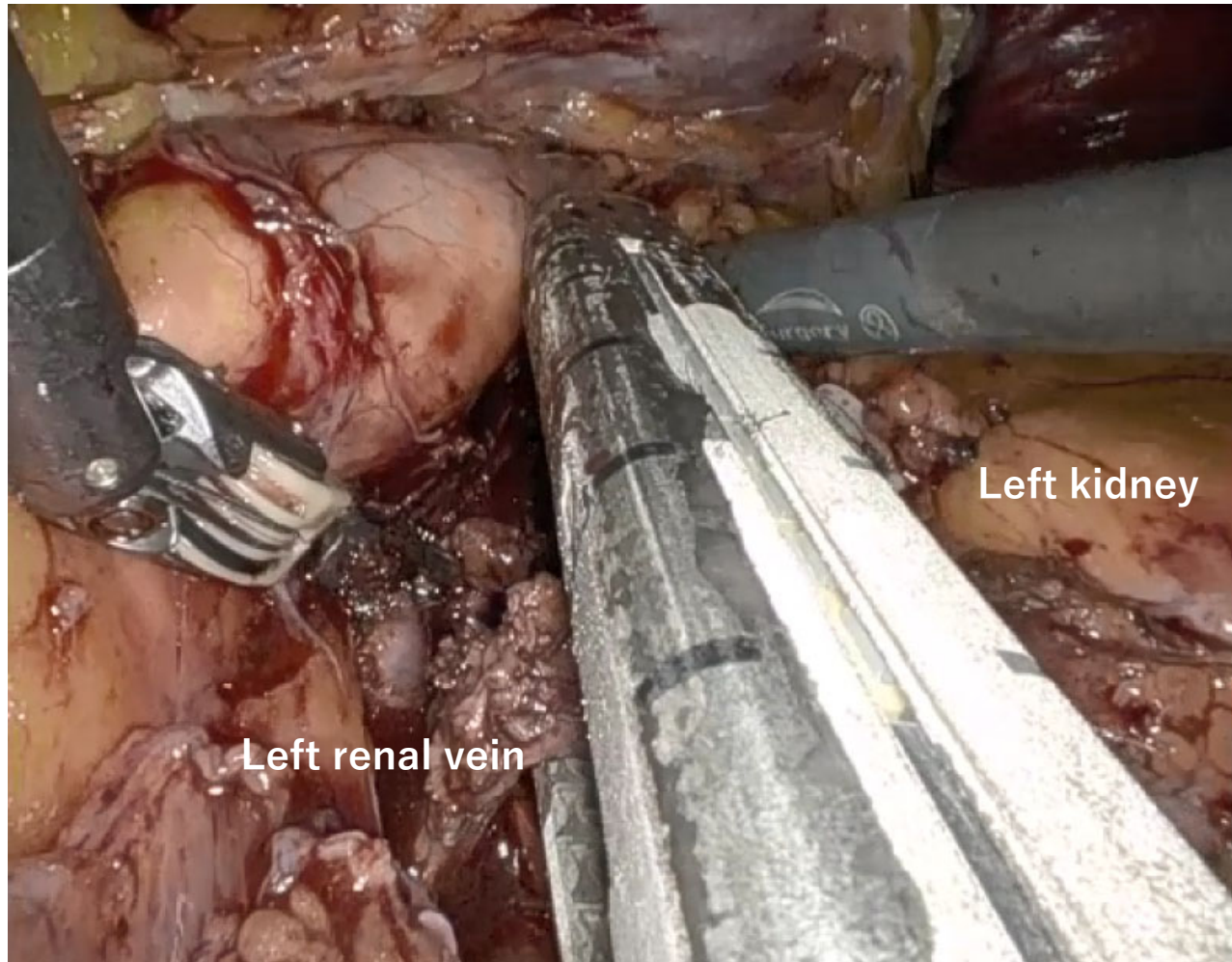


Right side (thromboectomy part)

Caudal

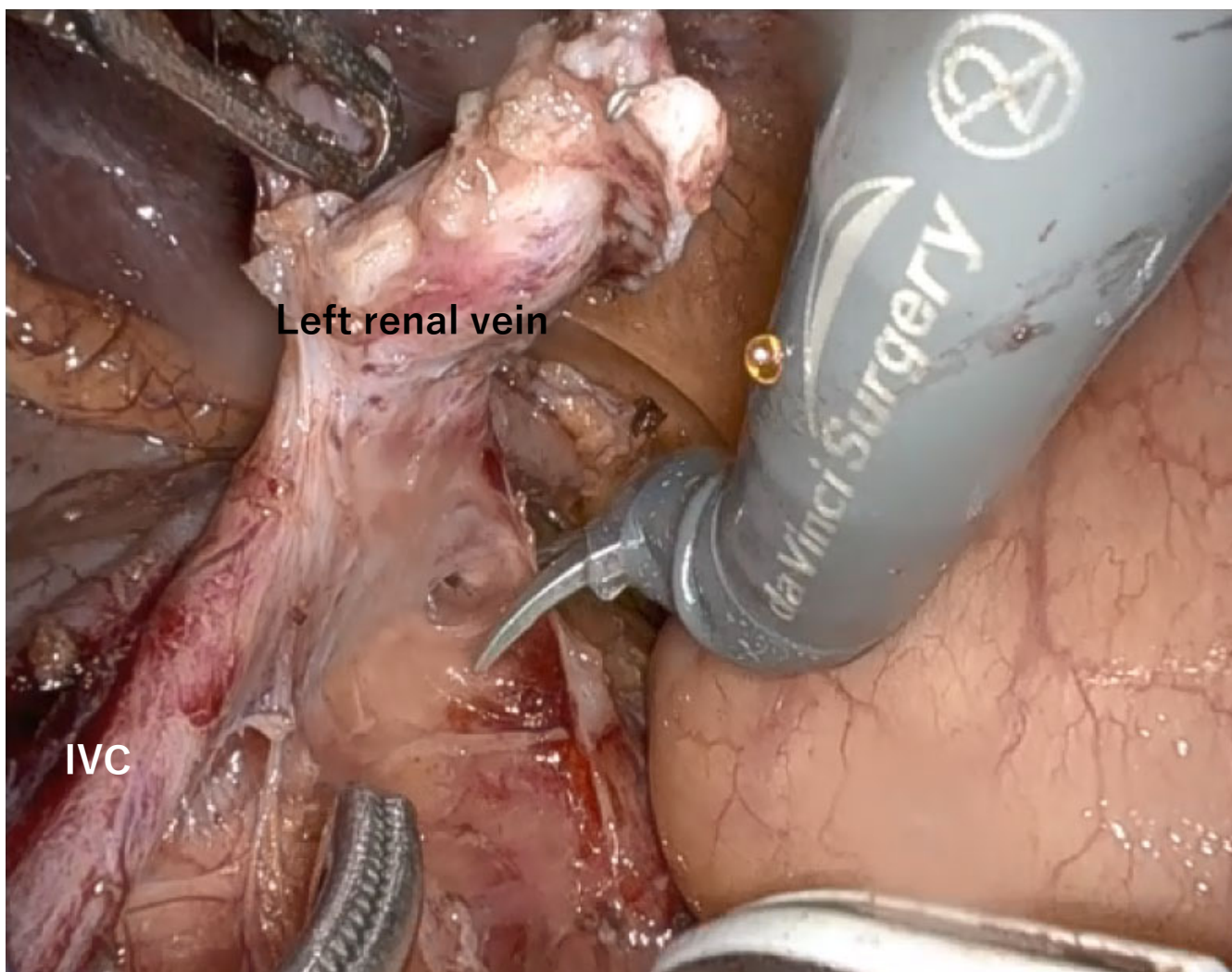
Cranial

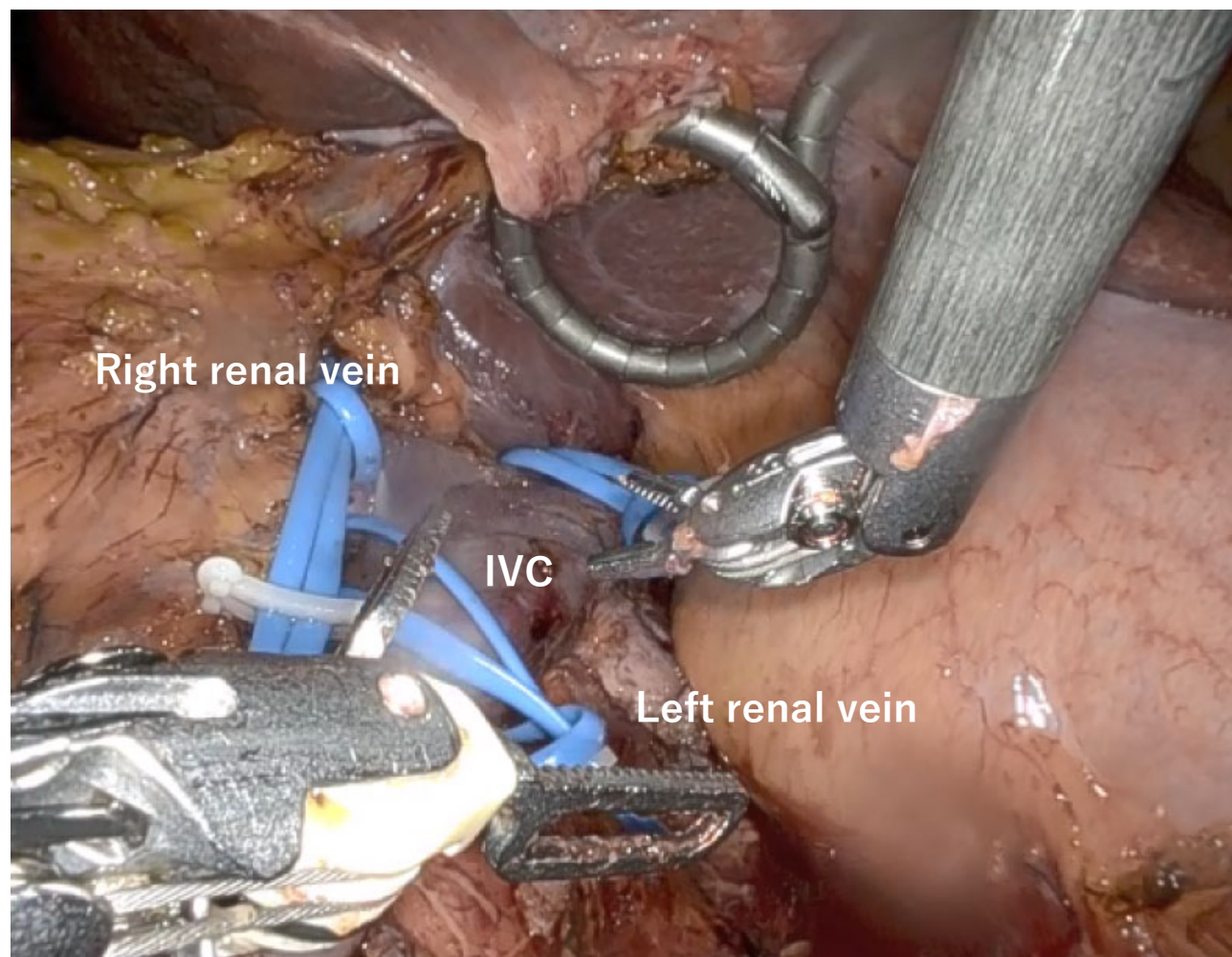




Left kidney

Left renal vein

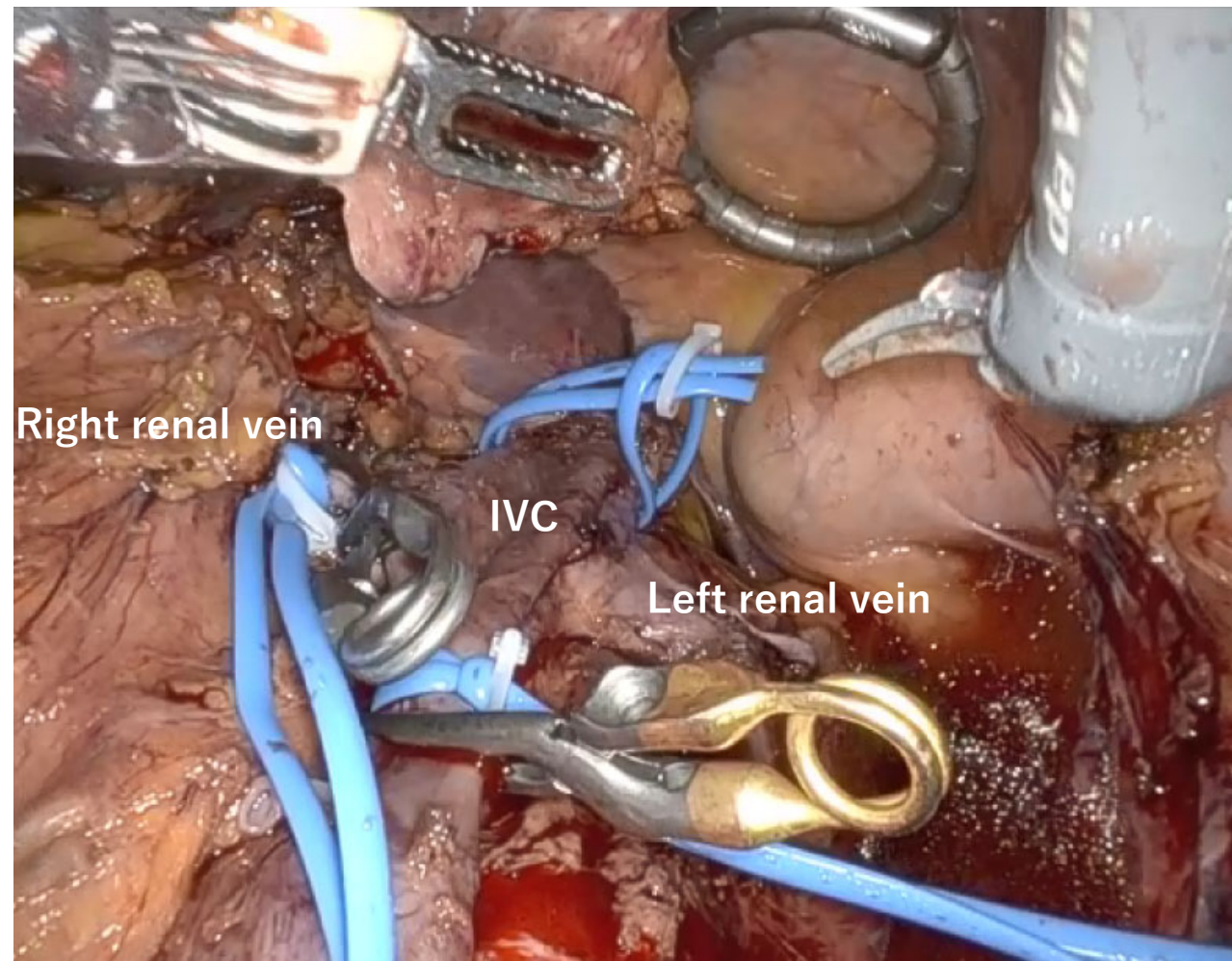




Right renal vein

IVC

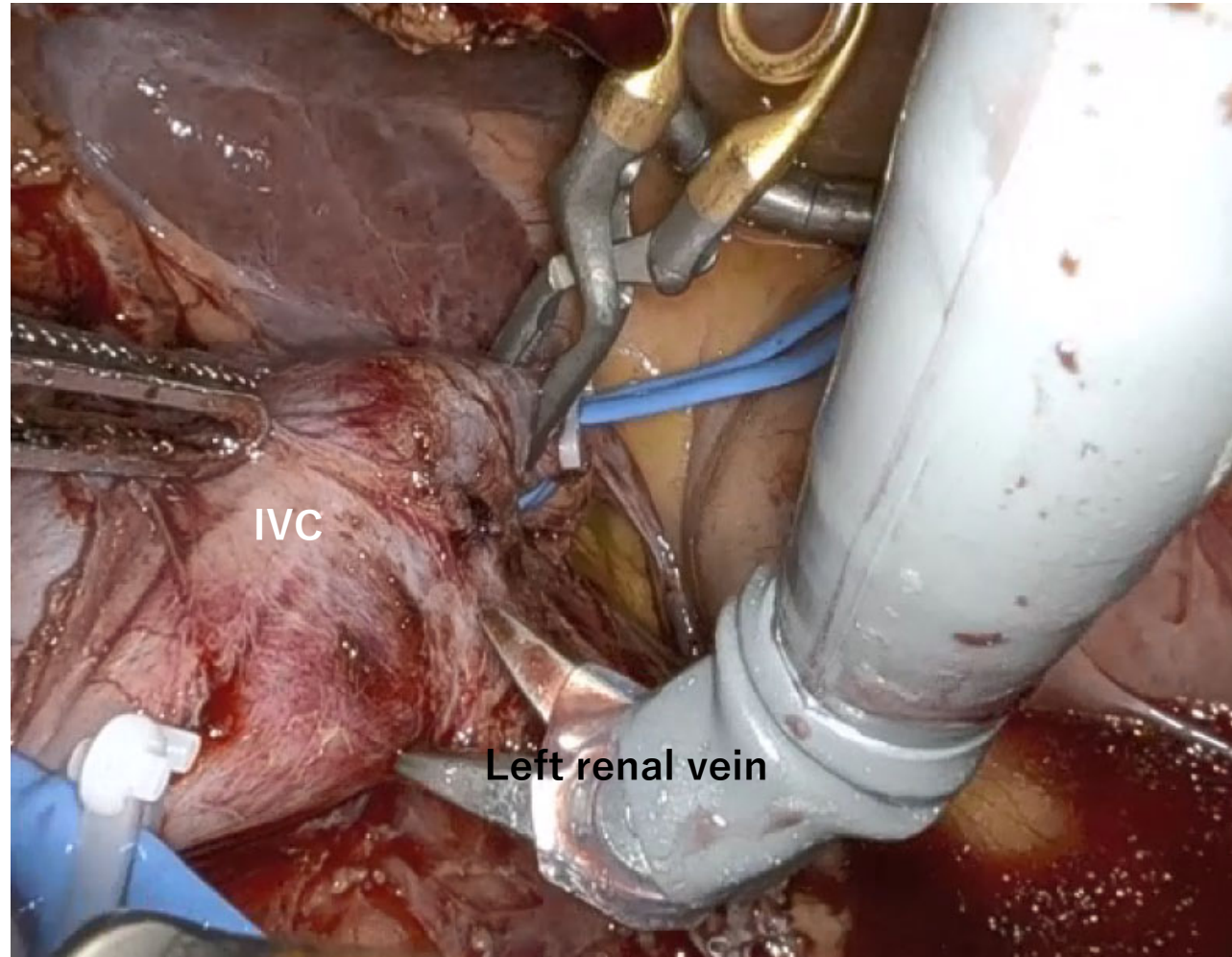
Left renal vein



Right renal vein

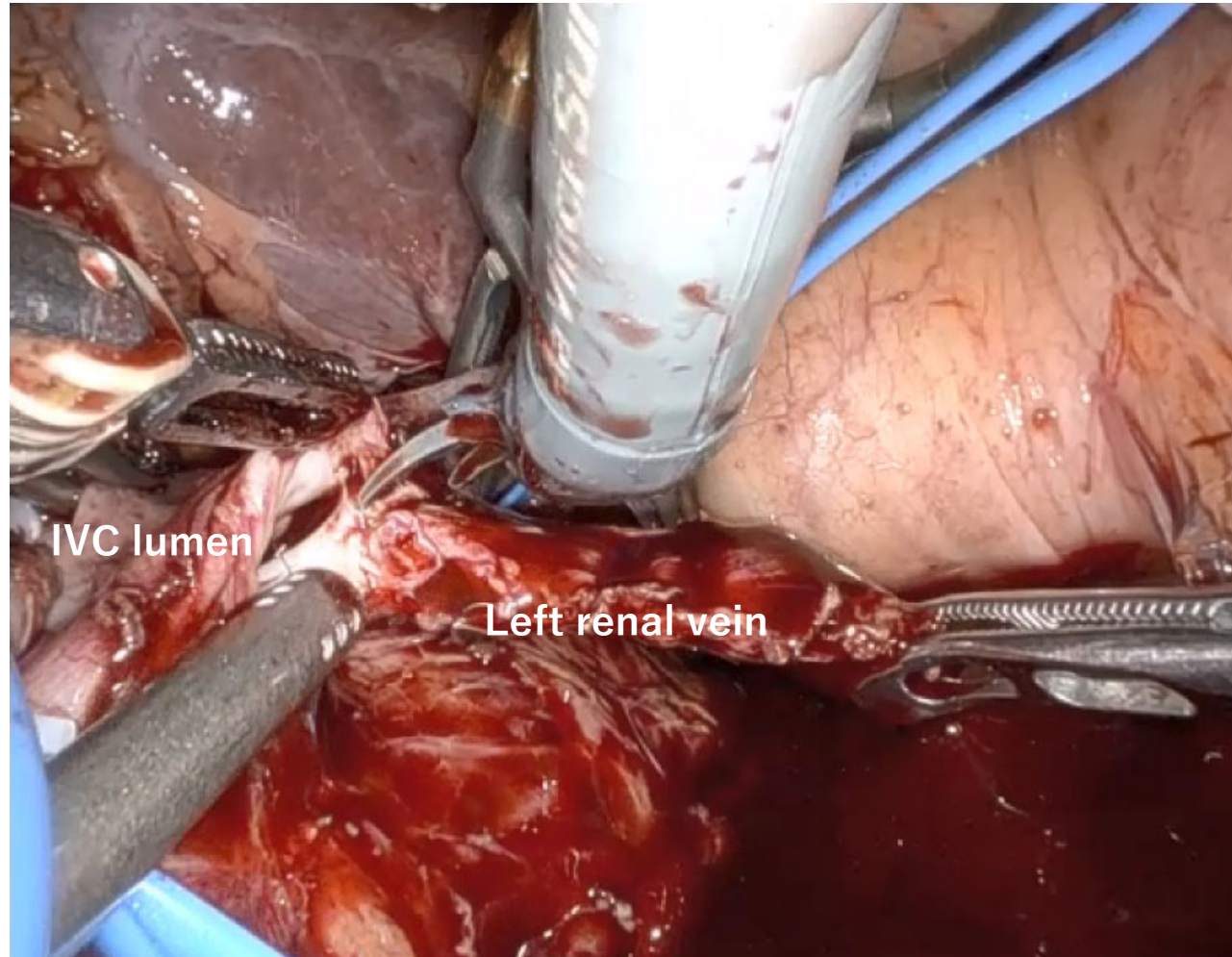
IVC

Left renal vein



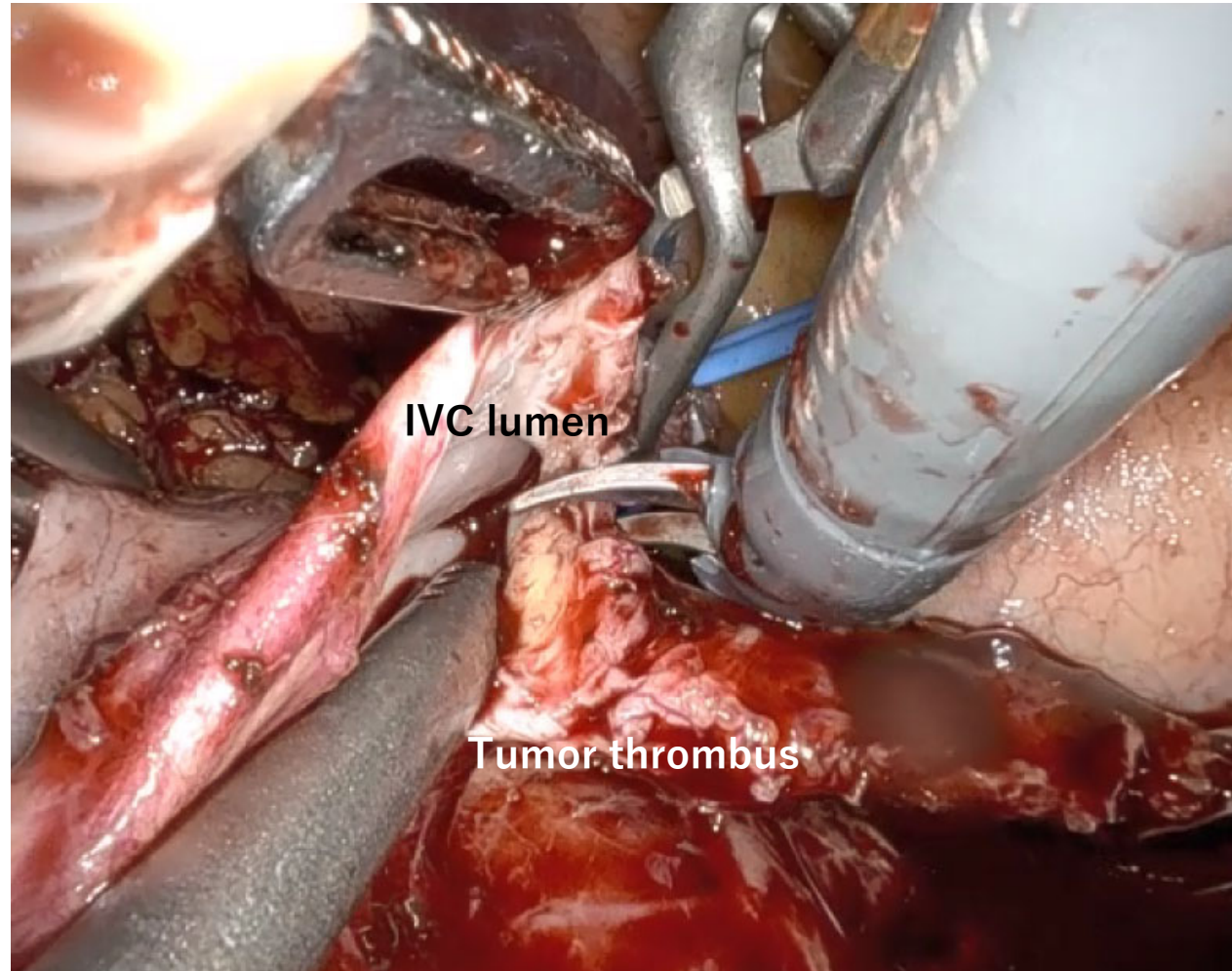
IVC

Left renal vein



IVC lumen

Left renal vein



IVC lumen

Tumor thrombus

