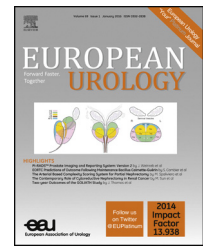


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Case Series of the Month

Advances in Robotic Vena Cava Tumor Thrombectomy: Intracaval Balloon Occlusion, Patch Grafting, and Vena Cavoscopy

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Abstract

Robotic level III inferior vena cava (IVC) tumor thrombectomy was described recently. We present ongoing robotic advances in this arena in a case series of six patients with Mayo level II–III thrombi who underwent robotic caval thrombectomy, radical nephrectomy, and retroperitoneal lymphadenectomy. In four patients, proximal intra- or retrohepatic IVC control was obtained solely with an intracaval Fogarty balloon catheter; in one patient, robot-guided flexible cystoscopy of the IVC lumen was performed to rule out any residual or secondary skip thrombi. In one patient, the caval wall defect after thrombus excision was reconstructed robotically using a bovine pericardial patch. Finally, a patient with concomitant renal and adrenal tumors had two distinct thrombi of levels I and III; a robotic double thrombectomy was performed. Mean renal tumor size was 8.4 cm (± 1.6). Four thrombi (66%) were level III. Mean operative time was 6.4 h (± 1.7); IVC clamp time, 53.5 min (± 29.8); blood loss, 668 ml (± 692); and hospital stay, 5.5 d (± 3.8). Two patients required blood transfusions. Complications included Clavien grade 1 ($n = 2$), grade 3a ($n = 1$), and grade 5 ($n = 1$). Mean follow-up was 5.8 mo (± 4.3). Robotic IVC thrombectomy is a viable alternative to open surgery for appropriately selected cases by experienced teams.

Patient summary: We present ongoing robotic surgical advances in a case series of six patients with blood clots in the inferior vena cava. These innovations will help further advance the field.

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1. Case report

Approximately 4–10% of renal cancers are associated with inferior vena cava (IVC) tumor thrombus [1,2]. Experience with robotic and laparoscopic IVC thrombectomy is increasing [3–8]. We recently described the initial series of exclusively robotic level III IVC thrombectomy [5]. In

this paper, we present ongoing technological innovations that may further extend this field by describing a case series of six patients. We report on robotic control of the intra- or retrohepatic IVC with an intracaval occlusion balloon, robotic excision of the infiltrated caval wall with biologic patch cavoplasty, robotic vena cavoscopy, and a robotic double thrombectomy in a patient with two

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distinct IVC thrombi. Patient selection was reported previously [5].

1.1. Intracaval balloon occlusion

Four consecutive patients underwent proximal control of the intra- or retrohepatic IVC using an intracaval Fogarty balloon catheter (Edwards Life Sciences, Irvine, CA, USA). Our preoperative preparation, port placement, and developed midline-first, kidney-last approach was used [5]. The infrarenal IVC (Fig. 1a and 1b) and left renal vein (Fig. 1c and 1d) were secured with an intra-abdominally controlled Rummel tourniquet; the lumbar veins and right renal artery were clipped and transected. The suprarenal IVC was dissected and encircled with a safety vessel loop, as was the thrombus-bearing right renal vein (Fig. 1e and 1f). Intraoperative ultrasound confirmed the cephalad extent of the partially occluding caval thrombus, with excellent caval flow.

A 9F Fogarty balloon catheter (Fig. 1g–i) was inserted into the abdomen through a 5-mm laparoscopic port. The infrarenal IVC and left renal vein Rummel tourniquets were cinched. At the proposed infrarenal site of balloon catheter entry into the IVC, a purse-string stitch was preplaced in the caval wall just caudal to the right renal vein, cephalad to the infrarenal IVC Rummel tourniquet; a small cavotomy was created, and the Fogarty catheter was carefully inserted over a soft-tip guidewire (Fig. 2a and 2b) and easily

advanced past the thrombus into an intrahepatic location (Fig. 2c and 2d). Adequate inflation of the intracaval balloon was confirmed by injecting the predetermined volume of saline into the balloon (Fig. 1h and 1i) and laparoscopic ultrasonography and/or transesophageal echocardiography (Fig. 2e–2g). Once the intrahepatic IVC was occluded with the balloon, the thrombus-bearing right renal vein was transected with an Endo-GIA stapler (Covidien, Minneapolis, MN, USA) with a 45-mm vascular load; the excluded IVC segment was rotated and inspected 360° to ensure all feeding lumbar veins were occluded.

The thrombus, along with the stapled right renal vein ostium, was excised en bloc with visually negative margins (Fig. 3a) and immediately entrapped in an Endo Catch bag (Covidien, Norwalk, CT, USA). Caval lumen was irrigated with heparinized water and suture repaired (4-0 Gore-Tex, W.L. Gore & Associates, Inc., Newark, DE, USA). The Fogarty balloon was deflated, removed, and the catheter-site purse-string suture tied after evacuating any intraluminal carbon dioxide bubbles. Rummel tourniquets were removed, fully restoring caval flow (Fig. 3b). Right radical nephrectomy and ipsilateral retroperitoneal lymph node dissection (RPLND) were then completed.

In all four patients, throughout the entire duration of the cavotomy, thrombus delivery, renal vein ostium excision, and caval repair, the intracaval balloon provided excellent proximal hemostatic control. No case required liver mobilization or short hepatic vein control. During balloon

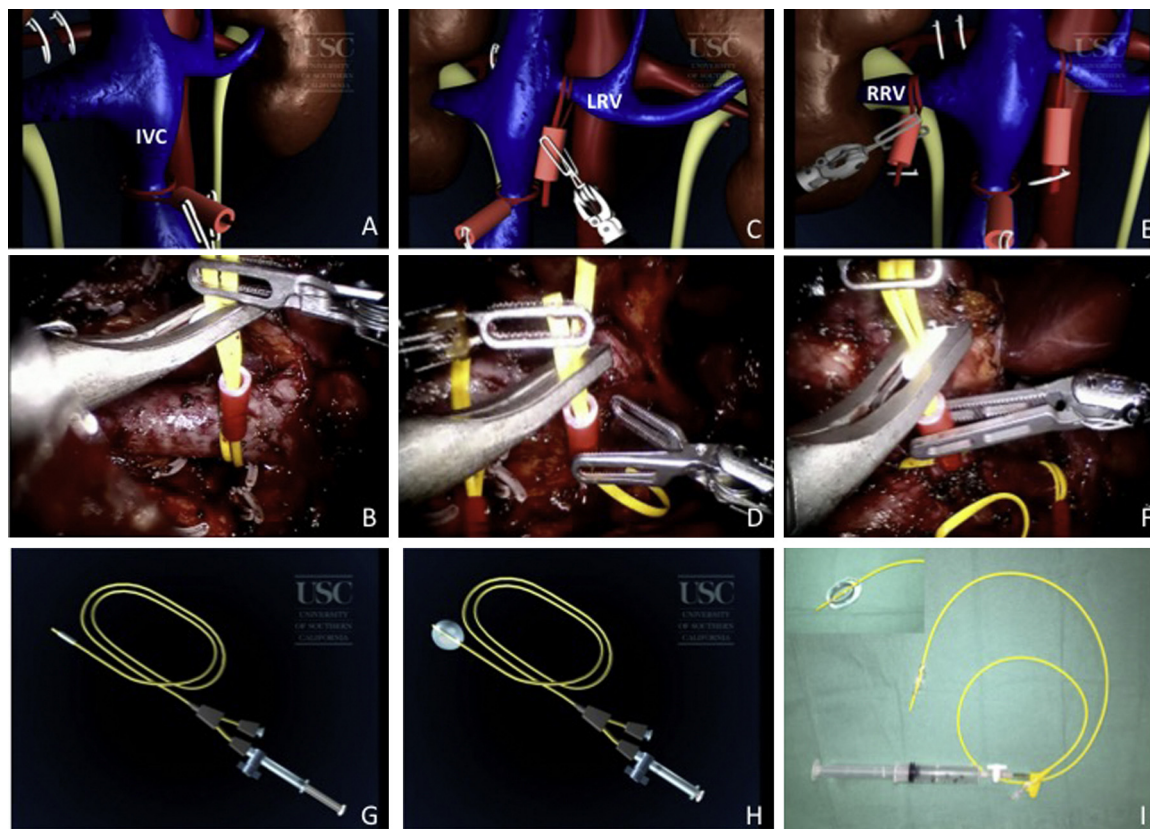


Fig. 1 – Schematics with corresponding intraoperative photos of Rummel tourniquet placement (a, b) at the infrarenal inferior vena cava, (c, d) at the left renal vein, and (e, f) at the right renal vein. Schematics and photos of (g) the Fogarty balloon catheter (9F; Coda LP, Cook Medical, Bloomington, IN, USA); (h, i) Fogarty balloon catheter with balloon inflated with a predetermined volume of saline.

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