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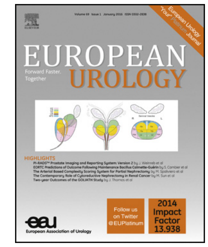

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Surgery in Motion

Robot-assisted Level II–III Inferior Vena Cava Tumor Thrombectomy: Step-by-Step Technique and 1-Year Outcomes

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Abstract

Background: Level II–III inferior vena cava (IVC) tumor thrombectomy for renal cell carcinoma is among the most challenging urologic oncologic surgeries. In 2015, we reported the initial series of robot-assisted level III caval thrombectomy.
Objective: To describe our University of Southern California technique in a step-by-step fashion for robot-assisted IVC level II–III tumor thrombectomy.
Design, setting, and participants: Twenty-five selected patients with renal neoplasm and level II–III IVC tumor thrombus underwent robot-assisted surgery with a minimum 1-yr follow-up (July 2011 to March 2015).
Surgical procedure: Our standardized anatomic-based "IVC-first, kidney-last" technique for robot-assisted IVC thrombectomy focuses on minimizing the chances of an intraoperative tumor thromboembolism and major hemorrhage.
Outcome measurements and statistical analysis: Baseline demographics, pathology data, 90-d and 1-yr complications, and oncologic outcomes at last follow-up were assessed.
Results and limitations: Robot-assisted IVC thrombectomy was successful in 24 patients (96%) (level III: $n = 11$; level II: $n = 13$); one patient was electively converted to open surgery for failure to progress. Median data included operative time of 4.5 h, estimated blood loss was 240 ml, hospital stay 4 d; five patients (21%) received intraoperative blood transfusion. All surgical margins were negative. Complications occurred in four patients (17%): two were Clavien 2, one was Clavien 3a, and one was Clavien 3b. All patients were alive at a 16-mo median follow-up (range: 12–39 mo).
Conclusions: Robotic IVC tumor thrombectomy is feasible for level II–III thrombi. To maximize intraoperative safety and chances of success, a thorough understanding of applied anatomy and altered vascular collateral flow channels, careful patient selection, meticulous cross-sectional imaging, and a highly experienced robotic team are essential.
Patient summary: We present the detailed operative steps of a new minimally invasive robot-assisted surgical approach to treat patients with advanced kidney cancer. This type of surgery can be performed safely with low blood loss and excellent outcomes. Even patients with advanced kidney cancer could now benefit from robotic surgery with a quicker recovery.

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1. Introduction

Surgical management of patients with level II–III inferior vena cava (IVC) tumor thrombus arising from a renal tumor requires IVC thrombectomy, radical nephrectomy (RN), and ipsilateral retroperitoneal lymphadenectomy (RPLND). This complex major open surgical operation requires a large muscle-cutting abdominal or thoracoabdominal incision to achieve the necessary surgical access for vascular control and thrombectomy. In patents without metastatic disease, complete surgical excision is the first-line treatment and provides 5-yr cancer-specific survival of up to 65% [1], a 38% complication rate, and an operative mortality rate of 4–10% [2].

Minimally invasive IVC tumor thrombectomy is a relatively recent advancement. Building on early developmental work in the laboratory [3,4], the initial experience for level 0 (renal vein) and level I–II thrombi were reported in 2003 and 2011, respectively [5,6]. Robot-assisted surgery for level III caval thrombi was first reported in 2015 [1] and 2016 [7], and laparoscopic surgery for level IV caval thrombi in 2015 [8]. Spurred by these initial publications, additional centers have recently reported early experiences attesting to the increasing interest within the field for robot-assisted caval thrombectomy surgery [9–11]. Although the literature just cited is indicative of progress, we believe that for the robotic approach to duplicate open surgery reliably and thus allow more teams to embark safely on robot-assisted caval thrombectomy surgery, a description of a uniform and reproducible technique is of value.

We carefully developed a step-by-step standardized anatomic-based robotic approach for robot-assisted IVC thrombectomy. This approach is primarily targeted towards minimizing the chances of intraoperative tumor thromboembolism and major hemorrhage, the two major complications of IVC thrombectomy surgery. This report describes our University of Southern California technique in a step-by-step fashion.

2. Patients and methods

2.1. Study population

A renal database approved by an institutional review board prospectively accrued data for all level II and III IVC thrombectomy cases. A total of 25 patients have completed a minimum follow-up of 1 yr and form the basis for this two-center series. All cases were performed by a single combined robotic team from July 2013 to March 2015.

Exclusion criteria for this study comprised Mayo level 0–I thrombi (extending <2 cm into the IVC), level IV thrombi (supradiaphragmatic), and widespread metastatic disease (more than one metastatic site). Also, to maintain consistency in the reported technique, we excluded four patients in whom intra- or retro-hepatic IVC control was obtained via an intracaval Fogarty balloon [12]. All patients underwent surgery with curative or cytoreductive intent.

2.2. Preoperative assessment and surgical indication

All patients included in the study presented with a renal mass and a level II or III IVC tumor thrombus and had good performance status (Eastern Cooperative Oncology Group performance status 0 or 1). Five patients (20%) had preexisting small-volume metastasis.

Patients underwent a standard preoperative work-up including cross-sectional abdominal imaging (computed tomography and/or magnetic resonance imaging). Angioembolization of the tumor-bearing kidney was performed in a majority of cases (80%).

2.3. Surgical technique

2.3.1. Robotic instrumentation

The four-arm Si or Xi da Vinci Surgical System (Intuitive Surgical Inc, Sunnyvale, CA, USA) with a six- to seven-port approach was used including two assistant ports. Bariatric-length robotic ports help minimize external robotic arm clashing, and standard robotic instruments were used. A double-fenestrated grasper is used to pass posterior to the vena cava to establish Rummel tourniquet control of the retrohepatic/intrahepatic IVC.

2.3.2. Patient positioning, port placement, and robot docking

The patient is secured in a 75° lateral decubitus position with the table fully flexed. For both right- or left-sided tumors, the patient is initially secured right side up to facilitate IVC exposure and control. For right-sided tumors, the procedure proceeds directly to a right RN following IVC thrombectomy; for left-sided tumors, the patient is repositioned left side up and the robot's redocked following IVC thrombectomy (Fig. 1a–1d).

2.3.3. Vena cava control (for right- or left-sided tumors)

The primary concept we developed in this regard is the "IVC-first, kidney-last" approach in a minimal IVC touch manner, to minimize chances of tumor embolism and major hemorrhage. The right colon and duodenum are reflected medially to expose the vena cava. Retroperitoneal dissection begins infrarenally in the midline to expose the interaortocaval region (Fig. 2a–2b). The laparoscopic fan retractor facilitates the medial retraction of bowel for increased exposure.

Dissection of the infrarenal IVC involves control of all relevant lumbar veins (Fig. 2c) and the gonadal vein (Fig. 2d), which are taken with Hem-o-lok clips (Teleflex, Wayne, PA, USA). The infrarenal IVC is encircled with a double-loop tourniquet (Rummel) using a vessel loop (part no. KDL311456694, Devon Surgical Vessel Loops [Covidien, Dublin, Ireland]; dimensions: 12.5 × 4.9 × 5.8 in; volume: 0.206 ft^3) passed through a half-inch piece of 20F red rubber urethral catheter and secured in place with a Hem-o-lok clip (Fig. 2e). Dissection is carried cephalad within the interaortocaval region. The left renal vein is mobilized and encircled with a Rummel tourniquet (Fig. 2f).

For proximal IVC control, careful interaortocaval dissection is performed towards the liver. For level III thrombi, the

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