Robotic Level III Inferior Vena Cava Tumor Thrombectomy: Initial Series

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Purpose: Level III inferior vena cava tumor thrombectomy for renal cancer is one of the most challenging open urologic oncology surgeries. We present the initial series of completely intracorporeal robotic level III inferior vena cava tumor thrombectomy.

Materials and Methods: Nine patients underwent robotic level III inferior vena cava thrombectomy and 7 patients underwent level II thrombectomy. The entire operation (high intrahepatic inferior vena cava control, caval exclusion, tumor thrombectomy, inferior vena cava repair, radical nephrectomy, retroperitoneal lymphadenectomy) was performed exclusively robotically. To minimize the chances of intraoperative inferior vena cava thrombus embolization, an "inferior vena cava-first, kidney-last" robotic technique was developed. Data were accrued prospectively.

Results: All 16 robotic procedures were successful, without open conversion or mortality. For level III cases (9), median primary kidney (right 6, left 3) cancer size was 8.5 cm (range 5.3 to 10.8) and inferior vena cava thrombus length was 5.7 cm (range 4 to 7). Median operative time was 4.9 hours (range 4.5 to 6.3), estimated blood loss was 375 cc (range 200 to 7,000) and hospital stay was 4.5 days. All surgical margins were negative. There were no intraoperative complications and 1 postoperative complication (Clavien 3b). At a median 7 months of followup (range 1 to 18) all patients are alive. Compared to level II thrombi the level III cohort trended toward greater inferior vena cava thrombus length (3.3 vs 5.7 cm), operative time (4.5 vs 4.9 hours) and blood loss (290 vs 375 cc).

Conclusions: With appropriate patient selection, surgical planning and robotic experience, completely intracorporeal robotic level III inferior vena cava thrombectomy is feasible and can be performed efficiently. Larger experience, longer followup and comparison with open surgery are needed to confirm these initial outcomes.

Key Words: vena cava, inferior; robotics; thrombectomy

Abbreviations and Acronyms

BMI = body mass index
CSS = cancer specific survival
CT = computerized tomography
IVC = inferior vena cava
Mets = metastasis
NED = no evidence of disease
O.R. = operating room
RCC = renal cell carcinoma
SH = short hepatic

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LOCALLY advanced renal cancer with inferior vena cava tumor thrombus is infrequent, occurring in 4% to 10% of patients.[1] Absent systemic metastases, prognosis is typically good, dictated largely by pathological TNM stage, grade and subtype, but not thrombus extent.[1] Complete surgical excision is the only curative option. Radical nephrectomy with caval thrombectomy,

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with or without (neo)adjuvant therapy, confers an encouraging 5-year CSS of 40% to 65%.[2] The Mayo classification subdivides caval thrombi into 4 categories based on their cephalad extent,[3] which has implications on surgical complexity, blood loss, transfusion rates and perioperative complications but not CSS (table 1, fig. 1).[1] Level III denotes a thrombus whose proximal extent is intrahepatic yet infradiaphragmatic. Open surgical IVC tumor thrombectomy is a major undertaking, associated with prolonged recovery, significant morbidity, a 25% to 40% complication rate and a 5% to 10% perioperative mortality rate.[1,2]

Minimally invasive IVC thrombectomy has evolved during the last 15 years. In the laboratory, laparoscopic level II and level III/IV caval thrombectomy techniques were first developed by our team in the early 2000s.[4,5] Pure laparoscopic renal vein thrombectomy[6] was followed by robotic level I and II caval thrombectomy.[7] Recently the technique and initial clinical case reports of robotic level III thrombectomy were described.[8–10] We present the initial series of robotic level III tumor thrombectomy in 9 patients. Furthermore, we add 7 cases of robotic Mayo level II thrombectomy to the literature.

MATERIALS AND METHODS

Sixteen patients underwent completely intracorporeal robotic tumor thrombectomy for level III (9) and level II (7) IVC thrombus by a single surgeon (June 2013 to February 2015). Exclusion criteria comprised patients with Mayo level 0-I (less than 2 cm into IVC), suprahepatic thrombus, metastatic disease (more than 1 site), unacceptable anesthetic risk or those undergoing venacavectomy. After informed consent, data were collected prospectively in our institutional review board approved databases. Complications were graded according to the Clavien-Dindo system.[11]

Patient Evaluation

Abdominopelvic imaging delineates thrombus anatomy (length/diameter, intrahepatic extent, distance from main hepatic veins, arterialization, bland thrombus extent), IVC anatomy (diameter, presence of flow, wall invasion, bilateral renal vein locations), hepatic anatomy (number/location of short/main hepatic veins, liver size/involvement), renal anatomy (number of renal arteries/veins, venous flow/collaterals, renal tumor size/stage) and retroperitoneal anatomy (adenopathy, venous collaterals) (fig. 2). Additional evaluation included renal/hepatic function testing, metastatic evaluation (CT chest, bone scan, occasionally positron emission tomography-CT) and evaluating for leg deep vein thrombosis, with anesthesia, cardiopulmonary, medical oncology and surgical (cardiovascular, hepatobiliary) consultations obtained as indicated.

Preoperative Preparation

Angioembolization of the tumor bearing kidney is performed, especially for patients with a left side or large renal tumor, significant perirenal collaterals or arterialized thrombus. Intraoperative monitoring (arterial, central venous, Swan Ganz) also included real-time, transesophageal echocardiography to assess cardiac hemodynamics, thrombus extent/tip stability during manipulation and caval flow cessation upon tourniquet occlusion. Followup included biochemical tests, chest x-ray and abdominal-pelvic scanning at 3 to 6 months and per surgeon discretion thereafter.

Robotic Technique

Right Side Thrombus. Complete caval exclusion with cross-clamping is performed routinely. The patient is secured in a right side up, 60-degree lateral position.

Table 1. *Mayo classification of IVC tumor thrombi*[3]

Thrombus Level	Proximal Extent of Thrombus	No. Robotic Cases Reported	Surgical Maneuvers Necessary	Mean Blood Loss (L)*	Mean Units Packed Red Blood Cells Transfused*	Periop Complications (%)*	5-Yr CSS (%)*
0	Renal vein	Many	Milk back thrombus, staple at renal vein-IVC junction	0.6	3	8.6	-
I	Up to 2 cm into IVC	5	Partial circumference Satinsky clamping or limited cross-clamping of IVC	1.0	4	15.2	31.7
II	More than 2 cm into IVC, yet infrahepatic	5	IVC exclusion + cross-clamping: control of lumbar veins, infrarenal IVC, contralat renal vein + suprarenal infrahepatic IVC	1.3	7	14.1	26.3
III	Intrahepatic, yet infradiaphragmatic†,*	9 (current study)	All maneuvers for level II thrombi, + control of short hepatic veins, intrahepatic IVC, occasionally porta hepatis (Pringle), suprahepatic IVC or intrapericardial IVC	2.7	16	17.9	39.4
IV	Supradiaphragmatic	0	Cardiopulmonary bypass	2.5	18	30	37
p Value	Not applicable	Not applicable	Not applicable	<0.001	<0.001	<0.001	0.87

* These data are obtained for the Mayo Clinic open surgical series of IVC thrombectomy.[1]

† Spiros et al subcategorized level III thrombi into 4 subgroups depending on the need for dissection of the hepatic veins and degree of IVC control required to extract the thrombus, as IIIa (intrahepatic) thrombus extending into the retrohepatic IVC but below the main hepatic veins, IIIb (hepatic) thrombus reaching/extending into ostia of major hepatic veins, IIIc (infradiaphragmatic) thrombus extending above major hepatic veins but infradiaphragmatic, and IIId (suprahepatic, supradiaphragmatic) thrombus extending into the intrapericardial IVC but not into the right heart.[17]