

Invasive Renal Cell Carcinoma with Inferior Vena Cava Tumor Thrombus: Cardiac Anesthesia in Liver Transplant Settings

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Objectives: Resection of renal cell carcinomas (RCC) with tumor thrombus invasion into the inferior vena cava (IVC) is associated with significant perioperative morbidity and mortality. This study examined the intra- and inter-departmental collaboration among cardiac, liver transplantation, and urologic surgeons and anesthesiologists in caring for these patients.

Design: After IRB approval, medical records of patients who underwent resection of RCC tumor thrombus level III and IV, from 1997 to 2010 in this institution, were reviewed. Data were collected and analyzed by one way-ANOVA and chi-square test.

Setting: Major academic institution, tertiary referral center.

Participants: This was a retrospective study based on the medical records of patients who underwent resection of RCC tumor thrombus level III and IV, from 1997 to 2010.

Interventions: None.

Measurements and Main Results: Fifty-eight patients (82.9%) with level III thrombus and 12 patients (17.1%) with level IV thrombus were analyzed. Sixty-five (92.9%) did not require any extracorporeal circulatory support; 5 (2 with level III and 3 with level IV; 7.1%) required cardiopulmonary bypass. No patients required veno-venous bypass. Compared to patients with level III thrombus extension,

patients with level IV had higher estimated blood loss (6978 ± 2968 mL v 1540 ± 206 , $p < 0.001$) and hospital stays (18.8 ± 1.6 days v 8.1 ± 0.7 , $p < 0.001$). Intraoperative transesophageal echocardiography (TEE) was utilized in 77.6% of patients with level III thrombus extension and in 100% of patients with level IV thrombus extension. Intraoperative TEE guidance resulted in a significant surgical plan modification in 3 cases (5.2%). Short-term mortality was low ($n = 3$, 4.3%).

Conclusions: Utilization of specialized liver transplantation and cardiac surgical techniques in the resection of RCC with extension into the IVC calls for a close intra- and interdepartmental collaboration between surgeons and anesthesiologists. The transabdominal approach to suprahepatic segments of the IVC allowed avoidance of extracorporeal circulatory support in most of these patients. Perioperative management of these patients reflected the critical importance of TEE-proficient practitioners experienced in liver transplantation and cardiac anesthesia.

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KEY WORDS: renal cell carcinoma, invasion of inferior vena cava, cardiac anesthesia, liver transplant, transesophageal echocardiography

RENAL CELL CARCINOMA (RCC) with tumor thrombus extension into the inferior vena cava (IVC) is a medical condition that, if left untreated, invariably results in death. Surgical resection is the only curative option, with five-year survival rates approaching 50% with complete local resection.¹⁻³ Intraoperative management may require cardiopulmonary bypass (CPB), or even deep hypothermic circulatory arrest (DHCA), to obtain controlled access to the retrohepatic IVC. However, the use of CPB may be associated with increased morbidity and risk of tumor thrombus embolization.⁴

Incorporation of surgical techniques, used in liver transplantation, to gain access to the intrahepatic, suprahepatic IVC

and right atrium (RA) may avoid CPB or veno-venous bypass (VVB)⁵⁻⁸ in some patients.^{6,8} Transabdominal access to the intrathoracic segment of the IVC and RA may afford access and control of the supradiaphragmatic IVC in some patients, obviating the need for extracorporeal circulatory support and avoiding its potentially deleterious complications and the need for anticoagulation.⁸

Since first reported by Ciancio et al in 2005, the transabdominal approach to the suprahepatic IVC has gained in popularity as a viable surgical option in some patients with high-level IVC tumor thrombus.⁷ However, its execution requires close collaboration between cardiac and liver transplantation services, both surgical and anesthesiology divisions. This study aimed to quantify the need for specialized techniques used in patients with advanced RCC tumor thrombus expansion (levels III and IV) who underwent surgical resection in this institution during the period between 1997 and 2010 and to describe the rationale behind the pivotal importance of close collaboration among urologic, liver transplant, and cardiac surgeons and anesthesiologists to the successful outcomes.

METHODS

After institutional review board approval, the records of 70 consecutive patients who underwent resection of RCC level III and level IV from August 1997 to August 2010 were reviewed retrospectively. Analyzed data included demographics, level and extent of the tumor, preexisting comorbidities, laboratory results, perioperative anesthetic management, surgical techniques, use of extracorporeal circulatory support, estimated blood loss (EBL), and fluid and blood transfusion requirements, as well as perioperative mortality and ICU and hospital length of stay. Statistical analysis was

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Table 1. Classification of IVC Thrombus Based on Anatomic Landmarks

Level	Description
I	Thrombus is limited to renal vein
II	Superior extent of thrombus is below the level of the intrahepatic IVC
III	<ul style="list-style-type: none"> a Intrahepatic thrombus extending into the retrohepatic IVC but below the major hepatic veins b Hepatic thrombus extending into the retrohepatic IVC reaching the ostia of the major hepatic veins c Thrombus extending into suprahepatic, infradiaphragmatic IVC d Suprahepatic, supradiaphragmatic, infra-atrial thrombus
IV	Thrombus extending into right atrium

Abbreviation: IVC, inferior vena cava.

performed using one-way ANOVA for continuous variables and chi-square test for binominal variables. A p value of less than 0.05 was considered to be statistically significant. Intercooled STATA statistics version 11.0 (Stata Corp., College Station, TX) was used for statistical analysis.

RESULTS

In all patients, the level and size of tumor thrombus were established preoperatively with magnetic resonance imaging (MRI) and/or computed tomography (CT) with three-dimensional (3D) reconstructions. RCC staging and management were performed according to the 2010 TNM American Joint

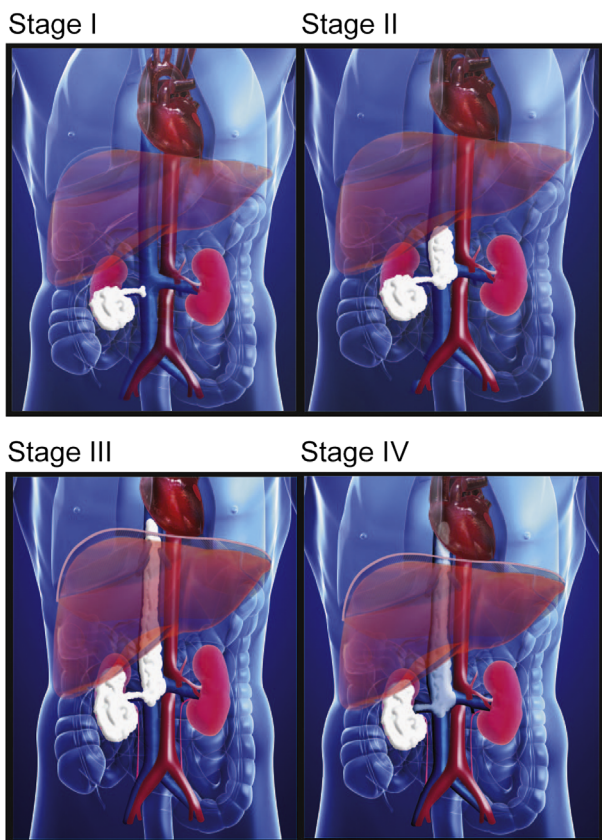


Fig 1. Artist's illustration of the IVC tumor thrombus spread gradation. (Color version of figure is available online.)

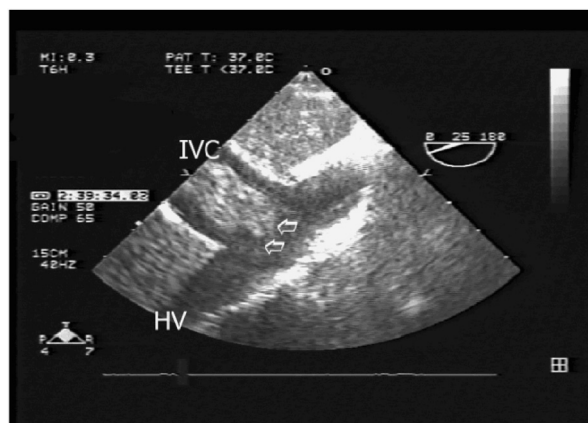


Fig 2. TEE image of the Level III tumor thrombus extension. Arrows point to the most proximal end of the tumor thrombus. HV, hepatic vein. IVC, inferior vena cava.

Committee on Cancer (AJCC) guidelines,⁹ based on 3D extension of tumor, lymph node involvement and metastasis, and anatomic landmarks.¹⁰ The relationship of the tumor thrombus to the liver, hepatic veins, diaphragm, and right atrium determined its staging,¹¹ as described in [Table 1](#) and [Figures 1-3](#).

Intraoperatively, transesophageal echocardiography (TEE) provided the real-time surveillance of the proximal extension of the thrombus and guided both the intra-abdominal and supra-diaphragmatic resection of level III and IV tumors.

Demographic data of patients with level III and IV tumor thrombus are presented in [Table 2](#). Mean age was 55; 35.7% were female. There were no statistical differences in demographic data, comorbidities (hypertension, chronic renal failure, and diabetes) and preoperative laboratory values (hemoglobin, creatinine, and prothrombin time) between the 2 groups. Preoperatively, 2 patients (1 with level III and 1 with level IV tumor thrombus extension) required hemodialysis; this was continued intraoperatively (continuous veno-venous hemodialysis [CVVHD]).

Seventy patients underwent radical nephrectomy with resection of tumor thrombus from suprahepatic and/or retrohepatic IVC using the University of Miami approach. Clinical staging revealed 58 patients (83%) with level III tumor thrombus and 12 patients (17%) with level IV tumor thrombus. Of all cases, 82.8% of stage

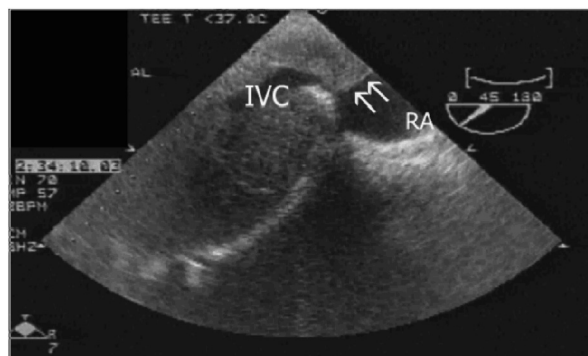


Fig 3. TEE image of the Level IV tumor thrombus extension. Arrows point to the right atrial portion of the tumor thrombus. RA, right atrium. IVC, inferior vena cava.

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