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## Surgery in Motion

# Liver Transplantation Techniques for the Surgical Management of Renal Cell Carcinoma with Tumor Thrombus in the Inferior Vena Cava: Step-by-Step Description

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### Abstract

**Background:** Renal cell carcinoma (RCC) with tumor thrombus in the inferior vena cava (IVC) poses a challenge to the surgeon given the operative difficulty, potential for massive hemorrhage, and possibility of tumor thromboemboli.

**Objective:** To determine the applicability of a self-developed technique based on orthotopic liver transplantation procedures for safe resection of these tumors.

**Design, setting, and participants:** From August 1997 to February 2008, 68 consecutive patients underwent resection of RCC with suprahepatic and/or retrohepatic (level 3 and 4) tumor thrombus in a single referral institution.

**Surgical procedure:** A triradiate incision over the upper abdomen permits the placement of a Rochard retractor. Early vascular control of the renal artery is achieved by creating a posterior plane of dissection. Venous collateral decompression permits development of a bloodless anterior plane by mobilizing the liver in a “piggy-back” fashion and the spleen–pancreas en bloc to the midline. Thrombus extraction requires circumferential control at the renal veins, hepatic hilum, and IVC before cavotomy. The central tendon of the diaphragm may be opened for cranial control and gentle traction over the right atrium performed. Repositioning of the proximal clamp and Pringle release avoid veno-venous bypass and cardiopulmonary bypass (CPB) in most cases.

**Measurements:** The extent of the tumor thrombus was retrohepatic in 56 patients and suprahepatic/intra-atrial in 12 patients.

**Results and limitations:** Mean operative time was 5 h 32 min. Mean estimated blood loss (EBL) was  $2112 \pm 3834$  ml (range: 100–25 000), with a mean transfusion being  $4.2 \pm 4.1$  U (range: 0–30). Five patients (7.3%) required CPB. Three patients (4.4%) died in the immediate postoperative period. All had complete tumor resection. No patient developed intraoperative thromboembolism.

**Conclusions:** This surgical approach provides excellent exposure and control of the IVC in cases with level 3 and 4 tumor thrombus, avoiding CPB except in rare circumstances.

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## 1. Introduction

Renal cell carcinoma (RCC) unfortunately remains a common malignancy throughout the world. This cancer is unique in its proclivity for vascular invasion and not infrequently extends into the renal vein and inferior vena cava (IVC) [1]. When it occurs, extirpative surgery offers the only potential cure [2]. The approach varies among surgeons, yet the consensus is that such cases are complex, require an excellent understanding of the anatomy, and benefit from a team approach [3–9]. We describe in detail our techniques and experience managing 68 patients with RCC and suprahepatic/intra-atrial and/or retrohepatic IVC tumor thrombus using a transabdominal approach—without intraoperative bypass maneuvers in most cases.

## 2. Methods

From August 1997 to February 2008, 104 patients with RCC and tumor thrombus were surgically treated. In 68 cases, RCC extended to the retrohepatic IVC or beyond. Sixty-four patients were managed by a transabdominal approach without bypass maneuvers. Diagnosis was made radiographically by computed tomography (CT) scan or ultrasound. Cardiac, renal, and respiratory status was evaluated preoperatively. The level of the thrombus was confirmed with magnetic resonance imaging (MRI) scans. Transesophageal echocardiography (TEE) was occasionally used to monitor tumor thrombi above the infrahepatic vena cava. The cranial extent of the tumor was initially defined per Neves and Zincke [3]; however, for level 3 thrombi, we used our modified definition [8].

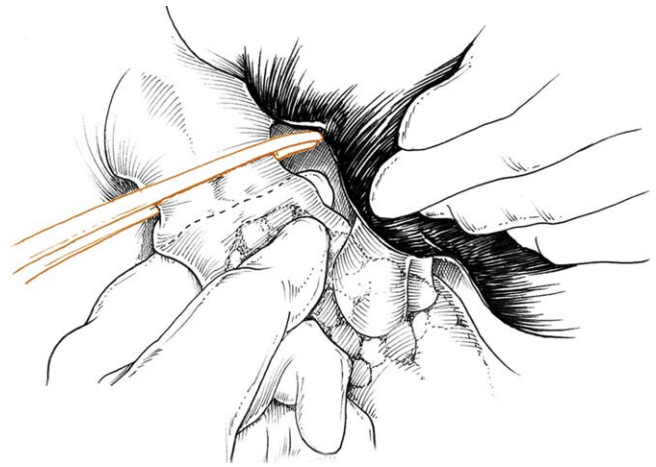
### 2.1. Operative technique

A triradiate incision is made commencing approximately two finger-breadths below the right costal margin and extending laterally to the midaxillary line. This incision is extended below the left costal margin as far as necessary and vertically in the midline to the xiphoid process. A Rochard self-retaining retractor is placed, elevating the costal margins and splaying them laterally toward the axillae.

We pursue early intraoperative ligation of the involved renal artery. The kidney is mobilized medially until the renal artery is identified and ligated [10]. Arterial ligation results in decompression of collateral circulation and decreases blood loss. Exposure of the left kidney begins by mobilization of the descending colon. The spleen is dissected off the diaphragm and mobilized en bloc with the pancreas toward the midline [11], exposing the entire upper retroperitoneal space from the diaphragm to the inferior border of the kidney.

Liver mobilization begins with dissection of the ligamentum teres, which is divided. The falciform ligament is divided with cautery, and this incision is carried around both to the right superior coronary ligament and by passing to the left side, dividing the left triangular ligament. The visceral peritoneum on the right of the hepatic hilum and the infrahepatic vena cava are incised in conjunction with the right inferior coronary and hepato-renal ligaments. The liver is gradually rolled to the left using these techniques, as described for liver transplantation [8–15].

Opening the lesser omentum allows the porta hepatis to be controlled with a Rummel tourniquet; a Pringle maneuver can then be carried out (temporarily occluding the portal venous and arterial inflow to the liver) as required. Then, we proceed with the “piggy-back” liver transplantation technique [15]. Piggy-back liver transplantation is so called, because the recipient’s vena cava is left in situ and the liver mobilized off the vessel [15]. Small hepatic veins passing from the right

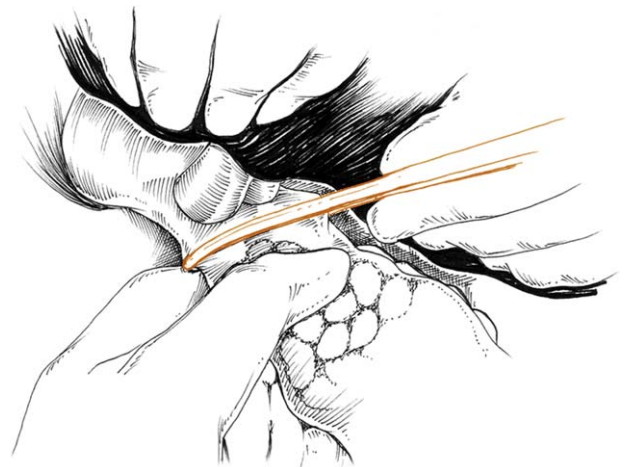


**Fig. 1** – The thrombus reaches a level above the major hepatic veins. A vascular clamp is applied in the suprahepatic vena cava. The surgeon milks the thrombus upper limit downwards to a level below the major hepatic veins.

and caudate lobe are ligated and divided. The liver is dissected off the IVC until it lies in a piggy-back fashion, attached to the IVC only by the major hepatic veins.

In this fashion, the infrahepatic, intrahepatic, and suprahepatic portions of the IVC are completely exposed. In addition to mobilizing the liver off the cava, a plane created between the IVC and the posterior abdominal wall is important, because it permits circumferential vascular control of the cava [8,9,13]. Small tributaries can become engorged to look like lumbar vessels, and they should be identified and ligated.

A useful technique, which we have applied for a thrombus located above the hepatic veins, is to milk the thrombus below the major hepatic veins (Fig. 1), and then apply a vascular clamp below these veins (Fig. 2). This technique is often feasible, because ligation of the renal artery reduces the blood supply to the tumor thrombus. The technique serves a dual function. First, it allows the liver to drain into the IVC, avoiding hypotension from decreased venous return. Second, by not clamping the major hepatic veins or porta hepatis, liver congestion and postoperative hepatic dysfunction are avoided. The surgeon must be careful when touching the thrombus so as to avoid dislodging it. For level 4 [16] and some level 3 thrombi [8], the central tendon of the diaphragm is dissected until the supradiaphragmatic, intrapericardial IVC is identified



**Fig. 2** – When the upper limit of the thrombus is placed properly, the vascular clamp is repositioned just below the major hepatic veins.

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