A novel technique for proximal inferior vena cava control during tumor thrombectomy using the COBRA-OS balloon

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INTRODUCTION

One of the distinctive characteristics of renal cell carcinoma (RCC) is inferior vena cava (IVC) tumor thrombus, which can occur in 4–10% of patients.[1] With cephalad migration, the IVC tumor thrombus may extend adjacent to the entry of the renal vein (stage I) into the level of more than 2 cm above the renal vein but below the hepatic veins (stage II), then to the intrahepatic portion of the IVC above the hepatic veins but below the diaphragm (stage III), and finally to the level above the diaphragm (stage IV) as far as the right atrium or beyond.[2] An intensive surgical strategy, involving radical nephrectomy and IVC thrombectomy, can cure 45–70% of patients with RCC with IVC thrombus.[2,3]

We performed radical nephrectomy with IVC thrombectomy in a RCC patient with level III IVC thrombus using the vascular balloon system technology of COBRA-OS® (Control Of Bleeding, Resuscitation, Arterial Occlusion System) to gain proximal control of the IVC and obviate the need for extensive hepatic mobilization.

CASE REPORT

A 60-year-old male presented with a history of worsening fatigue, significant weight loss, and right-sided flank pain. Abdominal magnetic resonance imaging (MRI) demonstrated a heterogenous mass measuring 7.9 x 8.5 x 8.8 cm in the upper mid-pole of the right kidney. There was exophytic component of the mass extending into the right renal vein and into IVC. The most proximal portion of the IVC thrombus was seen within the superior aspect of the intrahepatic IVC (Figure 1). There was no evidence of lymphadenopathy or visceral organ metastasis. Bone scan was negative. His bloodwork demonstrated hemoglobin of 88 g/L and creatinine of 72 µmol/L.

Technique

A chevron incision was made in the supine position. Early arterial control was achieved by identifying and tying off the right renal artery in the inter-aortocaval region. With careful dissection along the lateral aspect of the IVC, the kidney was completely mobilized on the renal vein. The tumour thrombus was found to be outside of reach in the retrohepatic IVC higher than what appeared on the MRI. Intraoperative transesophageal echocardiogram (TEE) showed no evidence of any thrombus in the atrium or the proximal IVC. Rather than extensive hepatic mobilization, we decided to gain proximal control of the IVC using the COBRA-OS (Figure 2).

First, we introduced the 4 Fr custom sheath into the IVC at the level superior to the right renal vein besides the tumor thrombus. Then the COBRA-OS was inserted through the sheath up into the IVC along

Figure 1. Coronal T1 magnetic resonance imaging showing a heterogenous mass with exophytic component extending into the right renal vein into inferior vena cava (IVC). The most superior portion of the IVC thrombus was seen within the superior aspect of the intrahepatic IVC.

the side of the thrombus until it reached the level above the thrombus. This was confirmed on TEE. Finally, the balloon was inflated for complete proximal control (Figure 3).

Vascular control of the left renal vein and infrarenal IVC was obtained. The lateral aspect of the IVC was opened and the thrombus was completely removed along with the right renal vein and kidney. A large Satinsky clamp was placed for proximal control of the IVC after the balloon was deflated. The balloon hole was stitched with 5-0 Prolene. The IVC was reconstructed with 4-0 Prolene.

The operative time was six hours and five minutes. The estimated blood loss was 2 L, mostly occurring during reconstruction. Pathologic analysis revealed a 7.8 cm G3 clear-cell RCC extending into renal sinus and major vein with no sarcomatoid or rhabdoid features. Ten lymph nodes were negative; pT3c N0. At his three-month followup, he had a repeat computed tomography scan that showed no evidence of disease. He declined adjuvant immunotherapy.

DISCUSSION

Studies have shown that tumor thrombus level is a significant predictor of survival and recurrence.[3,4] The five-year overall survival rates across all tumor thrombus stages are 30–60%.[1] Radical nephrectomy with IVC thrombectomy might increase the five-year disease-free survival up to 64%; however, perioperative complication rate increases with higher level of tumor thrombus, ranging from 12–47%.[5] The mortality rate following radical nephrectomy and thrombus removal ranges from 5–12.5%, depending on the concurrent conditions and tumor thrombus features.[1] According to the rarity and complexity of the disease, better surgical results are likely to be achieved in high-volume hospitals.[6]

For level I and II IVC thrombus, the tumors can be removed by dissociating and occluding the contralateral renal vein, lumbar veins, and IVC to create a bloodless surgical field; however, in some cases, it is challenging for level III and IV tumor thrombus removal where extensive hepatic mobilization and hepatic vascular control, or vascular bypass techniques such as cardiopulmonary bypass (CPB), venovenous bypass (VVB), deep hypothermic circulatory arrest (DHCA), are required.[7]

A liver transplantation technique, in which the liver is mobilized in a "piggy-back" fashion, has also been used in level III and IV tumor thrombus patients to avoid CPB.[8] Multiple operative techniques, including isolation of the retrohepatic IVC from the central diaphragmatic

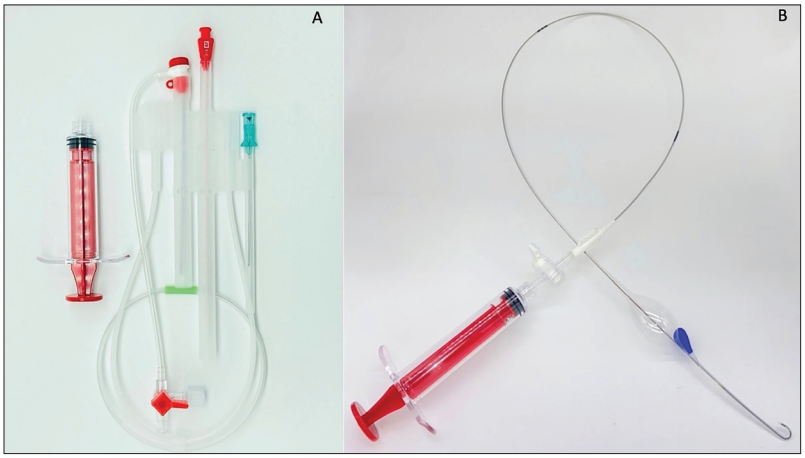

Figure 2. (A) Image of the 4 Fr Custom Sheath Introducer Kit in holster and a 10 cc sword-handled syringe. (B) Image of the COBRA-OS with atraumatic flexible J-tip and a 0.018 inch guidewire with syringe attached. COBRA-OS: Control Of Bleeding, Resuscitation, Arterial Occlusion System.

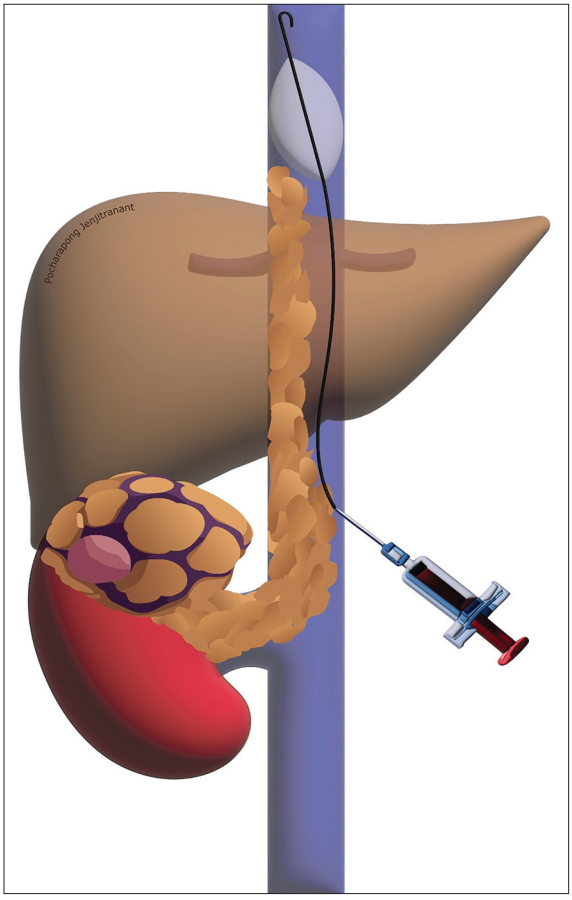

Figure 3. The COBRA-OS was inserted through the 4 Fr sheath up into the inferior vena cava (IVC) along the side of the thrombus until it reached the level above the thrombus. The balloon was inflated for complete proximal control. COBRA-OS: Control Of Bleeding, Resuscitation, Arterial Occlusion System.

tendon, tumor thrombus milking-down, hepatic vein clamping, Pringle maneuver, and sequential IVC clamping technique, may also be necessary for high-level thrombectomy to avoid CPB.[9]

COBRA-OS is an ultra-low-profile, large diameter, compliant balloon designed to temporarily occlude large blood vessels. This device is primarily used for resuscitative endovascular balloon occlusion of the aorta (REBOA); however, the same technology from this device can be applied for proximal vena caval control in tumor thrombectomies.[10] We successfully used COBRA-OS for proximal control of the IVC for a level III tumor thrombectomy, thus eliminating the need to perform additional complex and challenging procedures, such as retrohepatic IVC isolation, Pringle maneuver, CPB, or DHCA.

The small sheath size of only 4 Fr helps to decrease the access site complications. A better quality of hemostasis was achieved using the device compared to the conventional technique of liver mobilization and retrohepatic clamping. Moreover, the device has a flexible atraumatic tip that is safe for blind insertion into the vessels. Care must be taken when choosing the balloon introduction site to avoid embolizing the thrombus. We used TEE to confirm placement and carefully avoid manipulating the intracaval thrombus.

CONCLUSIONS

Radical nephrectomy with IVC thrombectomy in RCC patients with high-level IVC thrombus is a challenging surgical procedure that may require many complicated steps to obtain the proximal control of the IVC. We successfully applied COBRA-OS in a RCC patient with level III IVC thrombus, which can help to bypass those steps.

COMPETING INTERESTS: Dr. A. Power is co-founder and major shareholder of company manufacturing and selling device discussed in manuscript. The remaining authors do not report any competing personal or financial interests related to this work.

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