Case Reports

Selective Upper-Body Perfusion Technique

for Removal of Renal Cell Carcinoma Extending into the Inferior Vena Cava and Right Atrium

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Invasion of a renal cell carcinoma thrombus into the inferior vena cava and right atrium is infrequent. Reaching and completely excising a tumor from the inferior vena cava is particularly challenging because the liver covers the surgical field. We report the case of a 61-year-old man who underwent surgery for a renal cell carcinoma of the right kidney that extended into the inferior vena cava and right atrium. During dissection of the liver to expose the inferior vena cava, transesophageal echocardiograms revealed right atrial mass migration into the tricuspid valve. On emergency sternotomy, the tumor embolized into the main pulmonary artery. We used a selective upper-body perfusion technique involving moderately hypothermic cardiopulmonary bypass, cardioplegic arrest, and clamping of the descending aorta, which provided a bloodless surgical field for precise removal of the mass and resulted in minimal blood loss. Our technique might be useful in other patients with tumor thrombus extending into the right atrium because it reduces the need for transfusion and avoids the deleterious effects of deep hypothermic circulatory arrest. Our case also illustrates the importance of continuous transesophageal echocardiographic monitoring to detect thrombus embolization. ***(Tex Heart Inst J 2017;44(4):283-6)***

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Renal cell carcinoma (RCC) is the most prevalent malignant kidney tumor. Although extension of the tumor thrombus into the inferior vena cava (IVC) has been reported in 5% to 10% of cases,[1] extension up to the right-sided heart chambers is seen in only 1% of patients with RCC.[2] The mainstay of treatment in these patients is radical nephrectomy with complete surgical removal of the tumor thrombus, including the portions extending into the IVC and right atrium. The usual surgical approach is to combine intra-abdominal and cardiac surgery with cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest (DHCA); this provides a bloodless surgical field, eliminates the need for IVC cannulation, and facilitates complete removal of the cavoatrial mass.[3] However, DHCA has well-known deleterious systemic effects and increases the risk of neurologic complications.[4]

To avoid DHCA, we used a selective upper-body perfusion technique during the operation to remove a tumor thrombus extending into the IVC and right atrium in a patient with RCC. We also used a piggyback liver dissection technique to facilitate en bloc tumor resection and patch closure.

Case Report

In February 2016, a 61-year-old man was referred to our hospital with a diagnosis of RCC in the right kidney and tumor thrombus extending into the IVC and right atrium. The patient, who presented with right flank pain, hematuria, and dysuria, had a history of hypertension, type 2 diabetes mellitus, and hypothyroidism. No abnormalities were found on physical examination, except for a palpable abdominal mass in the right upper quadrant. Routine hematologic and biochemical laboratory tests were conducted, and the results were normal. Computed tomograms revealed a 122 × 98 × 106-mm mass in the right kidney that extended into the IVC and right atrium (Fig. 1). Positron emission tomograms showed no distant metastases. A transthoracic echocardiogram showed a 35 × 27-mm mass in the IVC and right atrium (Fig. 2A). Cardiac and valvular function were normal. Coronary angiography was performed, and no coronary artery disease was detected. Combined abdominal and cardiac surgery was planned for complete removal of the RCC and tumor thrombus.

To avoid DHCA, we planned to use an upper-body perfusion technique during removal of tumor thrombus from the heart. The patient was placed in a supine position, and general anesthesia was induced. Transesophageal echocardiography (TEE) was used to monitor the intracardiac tumor thrombus to detect any mobility or embolism during the abdominal procedure.

The urology team made a chevron incision to gain access to the abdominal cavity. The duodenum and ascending colon were mobilized to expose the tumor in the right kidney and to prepare for the exposure of the infrahepatic IVC. After bleeding was under control, the contralateral renal vein was clamped to protect the left kidney from any emboli. The transplantation team then started to mobilize the liver from the lateral side to expose the infrahepatic IVC, in the manner of a piggyback liver dissection. During dissection, TEE revealed movement of the intra-atrial tumor thrombus into the tricuspid valve (Fig. 2B). The cardiovascular team performed an emergency sternotomy and prepared to initiate CPB. While the ascending aortic cannula was being inserted, TEE indicated that the tumor thrombus had embolized into the main pulmonary artery, causing immediate hemodynamic deterioration (Fig. 2C).

Cardiopulmonary bypass was started with cannulation of the ascending aorta and superior vena cava. An additional cannula was inserted into the right femoral vein and advanced just below the level of the renal veins. The patient was cooled to a temperature of 30 °C. The posterior pericardium was opened, and the descending

Fig. 1 *Computed tomogram shows a large mass (122 × 98 × 106 mm) extending from the right kidney into the inferior vena cava (IVC).*

RRT = right renal tumor; RRV = right renal vein; TT = tumor thrombus

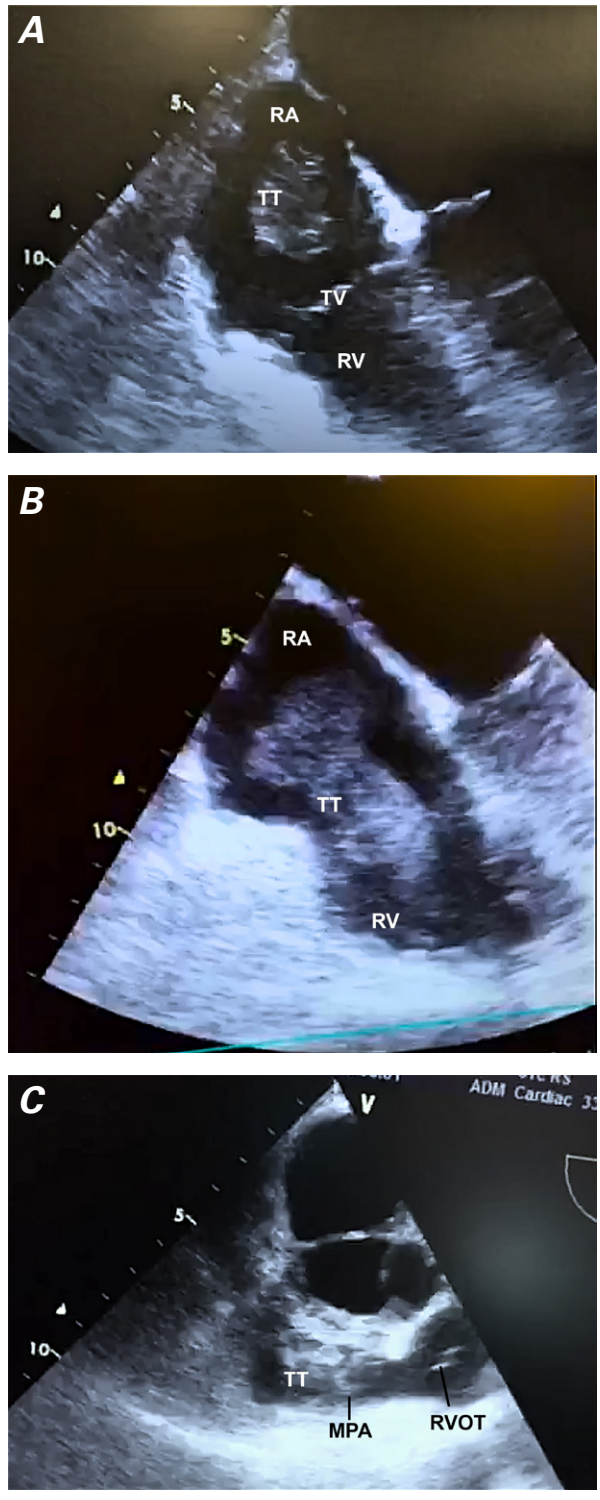

Fig. 2 *Transthoracic echocardiograms show **A**) a 35 × 27-mm mass in the inferior vena cava (IVC) and right atrium (RA), **B**) the cephalad movement of the intra-atrial tumor thrombus (TT) into the tricuspid valve (TV), and **C**) the thrombus embolized in the main pulmonary artery (MPA).*

RV = right ventricle; RVOT = right ventricular outflow tract

aorta was encircled at the diaphragmatic level. After ascending aortic cross-clamping, antegrade, tepid blood cardioplegic solution was administered; the superior vena cava was snared; and the descending aorta and infrarenal IVC were clamped. Selective upper-body perfusion was started, enabling operation in a bloodless surgical field.

The tumor thrombus was excised through a right atriotomy (Fig. 3). An additional pulmonary arteriotomy was made to check the distal pulmonary arteries for any thrombotic residue. At the same time, the urology team resected the RCC with a complete right nephrectomy, and residual thrombus was removed from the IVC through a small longitudinal incision. After ensuring that all the tumor thrombus had been removed, the cardiovascular team closed the incisions, removed the cross-clamps, and stopped upper-body perfusion. The patient was rewarmed, and CPB was terminated without difficulty. The cross-clamp and CPB times were 41 and 95 min, respectively. During surgery, the patient lost 400 mL of blood and received 250 mL of red blood cells. Figure 4 shows the resected tumor and thrombus.

The patient's postoperative course was uneventful, and he was discharged from the hospital on postoperative day 5. In the 16 months since his surgery, he has had no recurrences, metastases, or thromboembolic events.

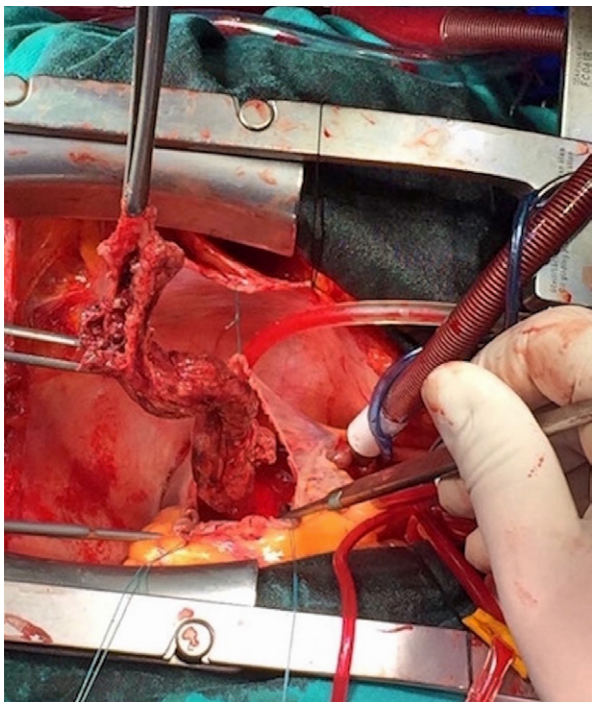

Fig. 3 *Intraoperative photograph shows the bloodless excision of the tumor thrombus from the right atrium.*

Supplemental motion image is available for Figure 3.

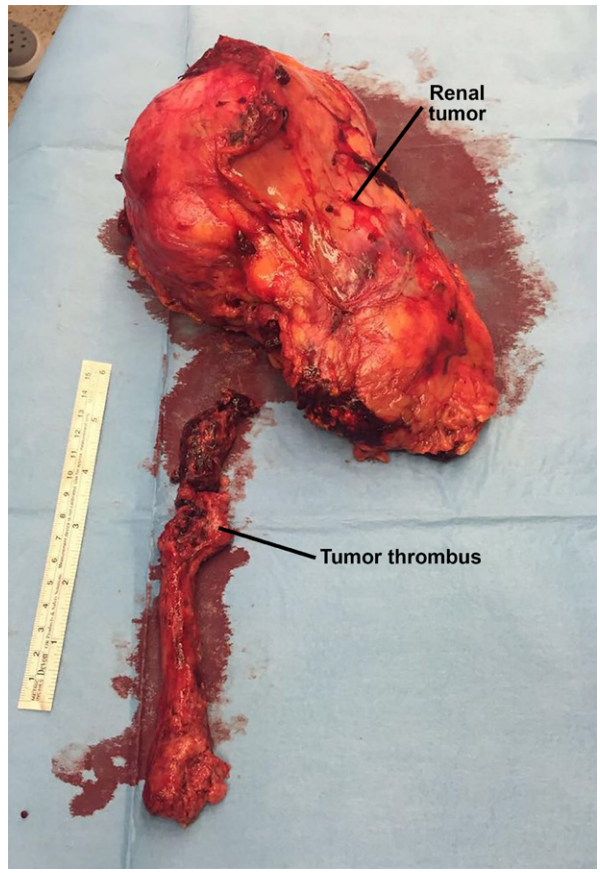

Fig. 4 *Photograph shows the renal tumor and tumor thrombus resected from the inferior vena cava.*

Discussion

Renal cell carcinoma with tumor thrombus extension into the right atrium is a major problem and a surgical challenge.[1-3] Whereas patients with level I to level III RCCs with transluminal IVC invasion are reported to have a 5-year survival rate of 32% to 69% after radical nephrectomy and tumor thrombectomy,[5] patients with level IV tumors, which have suprahepatic or intra-atrial extension, have poorer prognoses because of the risk of pulmonary embolism.[6] Such patients with intracardiac extension need proper cardiovascular evaluation and immediate intervention.

Reaching and completely excising a tumor from the IVC is a surgical challenge because the liver covers the surgical field. Ciancio and colleagues[7] described mobilizing the liver through a modified cruciate incision and using the piggyback liver transplantation technique to gain access to the retrohepatic IVC. Piggyback liver dissection also enables en bloc resection of the tumor and facilitates patch closure.[8]

Intraoperative TEE is one of the best methods for evaluating the location of a thrombus and detecting cardiac or pulmonary embolism.[9] In surgical resection

of tumor thrombi in the IVC or right atrium, intraoperative TEE can reveal tumor adherence to the IVC, mobility, and fragility—factors that greatly increase the risk of pulmonary embolism.[10] In our case, TEE enabled us to detect the cephalad extent of the thrombus and to quickly recognize the tumor's movement into the patient's tricuspid valve and embolization of the tumor thrombus into the main pulmonary artery.

Since Marshall and colleagues[11] first resected a tumor from the vena cava with the use of hypothermia and CPB, adjunct methods have been proposed to improve the outcome and feasibility of the operation. Using DHCA, which is generally safe, is advantageous to the surgeon because it provides a bloodless operative field for optimal viewing during the manipulation of the thrombus in the atrium and IVC; however, prolonged circulatory arrest is associated with increased mortality rates and risk of stroke.[3] To avoid the drawbacks of DHCA, Calcaterra and associates[12] operated on a beating heart, using normothermic CPB, with a snared superior vena cava and femoral venous cannulation. The technique was successful in 3 patients with RCC. They suggested that this technique provides a bloodless operative field, but we think that residual flow in the IVC and coronary sinus can compromise precise tumor removal. In addition, each patient was given autotransfused red blood cells (mean, 6 units), which could have increased the risk of tumor dissemination.

Another technique for RCC patients with involvement of the supradiaphragmatic IVC (level IIId) is transabdominal tumor removal without sternotomy or CPB. In this technique, the thrombus is "milked" from the right atrium and downward through the IVC before a cross-clamp is placed across the supradiaphragmatic IVC.[13] However, in patients with intra-atrial thrombus (level IV)—including our patient—the technique is less suitable because of the considerable risk of embolism.

Antegrade and retrograde selective cerebral perfusion techniques have also been used during cavoatrial tumor thrombectomies. Antegrade techniques provide cerebral protection during surgery with DHCA[14] and retrograde selective cerebral perfusion techniques used in conjunction with DHCA extend the safe period of cerebral ischemia, providing more time for accurate dissection and reconstruction.[15] The most similar technique to ours is that described by Ruel and co-authors,[16] who used moderate hypothermia and CPB and cross-clamping of the descending aorta, without cardioplegic arrest and aortic cross-clamping.

In conclusion, our selective upper-body perfusion technique—involving moderately hypothermic CPB, cardioplegic arrest, and clamping of the descending aorta—offers a new surgical strategy for the resection of RCC extending into the inferior vena cava and right atrium. Our technique is advantageous because it provides a truly bloodless surgical field for precise removal of the mass, minimizes blood loss, and reduces the need for transfusion without the deleterious effects of DHCA. In surgery for the removal of cavoatrial tumor thrombi, we consider continuous TEE monitoring essential for the detection of thrombus embolization.

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