Early Detection of a Cavo-pulmonary Tumor Embolus

with the Use of Transesophageal Echocardiography

Magdy M. El-Sayed
Ahmed, MD, MSc
Raed M. Al-Najjar, MD
Muhammad Aftab, MD
James M. Anton, MD
John S. Colen, MD
Ross M. Reul, MD

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From: Departments of Cardiovascular Surgery (Drs. Aftab, Al-Najjar, El-Sayed Ahmed, and Reul) and Cardiovascular Anesthesiology (Dr. Anton), Texas Heart Institute; Scott Department of Urology (Dr. Colen) and Division of Cardiothoracic Surgery, Michael E. DeBakey Department of Surgery (Drs. Aftab and Al-Najjar), Baylor College of Medicine; Houston, Texas 77030; and Department of Surgery (Dr. El-Sayed Ahmed), Zagazig University Faculty of Medicine, 44519 Zagazig, Egypt

Dr. Al-Najjar is now at The Heart and Vascular Institute, Pikeville Medical Center, Pikeville, Kentucky.

Address for reprints:
Magdy M. El-Sayed Ahmed, MD, MSc, Department of Cardiovascular Surgery, WW3 Suite 400, Children's National Medical Center, 111 Michigan Ave. NW, Washington, DC 20010

E-mail:
elgoharymagdy@yahoo.com

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Pulmonary tumor embolization from renal cell carcinoma is associated with severe cardiopulmonary morbidity and high perioperative mortality rates. We report the case of a 71-year-old woman who presented with right-sided abdominal pain. Magnetic resonance images revealed a mass originating from the upper pole of the right kidney and extending into the infrahepatic portion of the inferior vena cava. Transesophageal echocardiography was continuously used to monitor the mass during intended radical nephrectomy and tumor resection. When the right kidney was mobilized, intracaval thrombus detached and migrated to the patient's right atrium, causing severe hemodynamic instability. After emergent sternotomy and during the initiation of cardiopulmonary bypass, the mass was no longer echocardiographically detectable in the heart; it was soon removed completely from the left pulmonary artery. The mass was a renal cell carcinoma.

We recommend the use of transesophageal echocardiography as an efficient diagnostic tool in the early detection of pulmonary tumor embolization during the resection of renal cell carcinoma that involves the inferior vena cava. (Tex Heart Inst J 2015;42(1):66-9)

Pulmonary tumor embolization from renal cell carcinoma (RCC) is associated with severe cardiopulmonary morbidity and high perioperative mortality rates. In one study,¹ the direct extension of RCC into the inferior vena cava (IVC) was observed in 22 of 295 patients (7%). Massive pulmonary embolism (PE) can occur during surgical treatment for RCC, especially when the tumor extends into the IVC.²⁻⁶ Advantages of using transesophageal echocardiography (TEE) during RCC excision include evaluating the cephalic extension of tumor into the IVC, monitoring the tumor during surgical mobilization, and evaluating cardiac function.^{7,8} We report a case in which continuous TEE monitoring prevented a patient's death from PE, when RCC extended into the IVC.

Case Report

In January 2012, a 71-year-old woman presented with severe right-sided abdominal pain. The patient's medical history included hypertension, chronic obstructive pulmonary disease, osteoarthritis, peptic ulcer disease, glaucoma, aortic insufficiency, mitral regurgitation, and hyperlipidemia. Her surgical history was notable for a C-section and treatment of a perforated peptic ulcer. Her medications included amlodipine, digoxin, hydrochlorothiazide, lisinopril, omeprazole, pravastatin, spironolactone, and zolpidem. She had no known drug allergies. Until recently, she had smoked one pack of cigarettes per day for approximately 15 years. Magnetic resonance images of the patient's abdomen revealed a 9.5 × 6-cm mass in the right kidney with a 2- to 3-cm extension into the infrahepatic portion of the IVC (Figs. 1 and 2). Contrast computed tomograms (CT) of the chest revealed substantial mediastinal lymphadenopathy and multiple small lung nodules. Results of a bone scan were negative. We decided to perform radical nephrectomy and resection of the intracaval mass. The urology team informed the patient that, at worst, surgery would be palliative rather than curative and might extend her life only for months.

The patient's preoperative blood pressure (BP) was 120/65 mmHg, and her heart rate was 80 beats/min. She was given 2 mg of midazolam, and general anesthesia was induced. The patient was monitored by means of electrocardiography (ECG), pulse oximetry, a radial arterial line, a central venous pressure line, end-tidal carbon dioxide measurement, and a rectal temperature probe. An iE33 xMATRIX Echocardiography System probe (Koninklijke Philips N.V.; Best, The Netherlands) was placed. Initially,

Fig. 1 Magnetic resonance image of the abdomen shows a mass extending from the right kidney (Rt K) into the inferior vena cava (IVC).

Fig. 2 Magnetic resonance image of the abdomen shows the intracaval part of the tumor mass (arrow).

TEE showed mild aortic insufficiency, mild mitral regurgitation, a left ventricular ejection fraction of 0.50 to 0.60, and an infrahepatic IVC tumor (Fig. 3A).

The surgical procedure was initiated by the urology team's making a subcostal incision. The liver and right side of the colon were mobilized to the left to expose the right kidney and an approximately 7 × 7-cm right renal mass with intracaval extension for 2 to 3 cm. Of note, during this step, the anesthesia team used TEE to monitor the intracaval tumor thrombus. During further mobilization of the kidney to expose the renal hilum and IVC, thrombus from the IVC tumor detached and migrated to the heart (Fig. 3B). Using TEE, the anesthesia team identified an approximately 1.5 × 2.8-cm

freely mobile mass in the right atrium, so the cardiovascular (CV) surgical team was called. The patient's BP fell to 65/30 mmHg, and the fraction of inspired oxygen was increased from 0.9% to 1.1% to maintain PaO₂ at 99%. There was no significant change in the patient's central venous pressure (10 cm water), heart rate (80 beats/min), ECG patterns, or end-tidal carbon dioxide level (26 mmHg). Arterial blood gas analysis yielded a pH of 7.46, PaO₂ of 412 mmHg, PaCO₂ of 32 mmHg, a bicarbonate level of 22 mmol/L, and a -1.5 base excess. A 10-μg bolus of adrenaline maintained the patient's systolic BP above 90 mmHg. About 15 minutes later, the patient's BP fell to 40/10 mmHg, which necessitated 40-μg boli of norepinephrine to keep the systolic BP above 90 mmHg until cardiopulmonary bypass (CPB) could be initiated. At this time, TEE no longer showed any mass in the right side of the heart. An emergent sternotomy was performed, and the pa-

Fig. 3 Transesophageal echocardiograms show **A**) a relatively mobile echodense structure in the inferior vena cava (IVC) and **B**) a freely mobile echodense structure in the right side of the heart.

RV = right ventricle

Supplemental motion images are available for Figures 3A and 3B.

tient was given enough heparin to keep the activated clotting time above 500 s. After standard aortic cannulation, the bicaval cannulation technique was used to isolate the right atrium. Of note, the procedure was accomplished on a beating heart. The right atrium was opened, and no thrombus was identified there or in the right ventricle. The mass was then felt in and removed from the left pulmonary artery (Fig. 4). The main and right pulmonary arteries were examined for thrombi and masses.

The patient was successfully weaned from CPB, and decannulation was achieved. The urology and CV surgical teams were involved in the next stage, wherein the kidney and IVC were visible through the right subcostal incision. The right renal vein and artery were carefully dissected. The renal artery was ligated and divided; however, the IVC was partially clamped at the junction of the right renal vein with the IVC. The IVC was opened, the remaining tumor was extracted, and the IVC was primarily repaired with use of 5-0 Prolene suture in running fashion. The kidney was completely dissected and sent for histopathologic examination. After the 2 incisions were closed, the patient was admitted to the CV intensive care unit. She was discharged from the hospital on postoperative day 9 after an uneventful course. Upon histopathologic evaluation, the tumor was an RCC, papillary type, with extensive sarcomatoid differentiation. It was Fuhrman nuclear grade 4, invasive into the renal sinus and perinephric adipose tissue, and grossly invasive into the renal vein with tumor thrombus formation. Metastatic carcinoma in 2 of 5 perihilar

lymph nodes was found. The thrombus was predominantly composed of necrotic tumor.

Discussion

Renal cell carcinoma typically invades the vascular system and forms tumor thrombus.⁹ Up to 10% of patients with RCC present with a tumor thrombus in the venous system. In one review,¹⁰ venous embolization had an overall incidence of 1.5% and a 75% mortality rate.

In 1913, Berg¹¹ first described nephrectomy and vena cavotomy for RCC extending into the IVC. Later, a few reports described discouraging surgical results and no survival advantage.¹² However, in 1972, it was recognized that venous extension was potentially curable when surgical resection was complete (5-year survival rate, 55%).¹³ Other similarly favorable outcomes were subsequently reported.¹⁴⁻¹⁶

Investigators have found TEE to be accurate in monitoring intraoperative embolic phenomena during tumor manipulation,¹⁷ evaluating IVC tumor extension,¹⁸ recognizing residual tumor after attempted resection,¹⁹ and evaluating preload and cardiac function during IVC clamping. Oikawa and colleagues²⁰ described the additional use of intraoperative TEE to position an intracaval balloon above the tumor thrombus, thus enabling resection without the need to mobilize the liver.

Several investigators have described TEE as a primary diagnostic tool in hemodynamically significant PE. Pruszczyk and colleagues²¹ found that the diagnostic power of TEE compared well with that of spiral CT (TEE, 80% sensitivity; spiral CT, 90% sensitivity; and both, 100% specificity). In another study,²² TEE was found to have a diagnostic sensitivity of 80.5% and specificity of 97.2%. This contrasts with a study in which TEE, performed intraoperatively during emergency pulmonary embolectomy, identified evidence of PE in only 46% of patients.²³

Our patient had 2 episodes of profound hypotension. The first episode occurred immediately after the tumor thrombus detached and migrated to the heart. An epinephrine bolus resuscitated the patient. The 2nd episode occurred while the CV surgical team was performing sternotomy and initiating CPB. We think that this episode of hypotension occurred when the tumor thrombus migrated from the right side of the heart and lodged in the left pulmonary artery. The patient was resuscitated by 40- μ g boli of norepinephrine. The migration of the mass to the lung with the development of hypoxia might also explain the need to increase the fraction of inspired oxygen from 0.9 to 1.1 to maintain PaO₂ at 99%.

In our opinion, the continuous TEE monitoring of the IVC tumor during mobilization of the right kidney was of tremendous help in rapidly initiating CPB before the patient's hemodynamic instability was aggravated.

Fig. 4 Photograph shows the tumor after its removal from the left pulmonary artery.

Moreover, the excellent communication among the multidisciplinary teams facilitated timely intercession by the CV surgical team.

In summary, TEE has been investigated and efficiently used as a diagnostic tool in cardiac procedures. Its role has expanded into the resection of tumors that extend into the IVC. On the basis of our experience, we recommend that TEE be routinely used during the resection of RCC that has involved the IVC.

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