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TRANSDIAPHRAGMATIC-INTRAPERICARDIAC APPROACH TO SUPRADIAPHRAGMATIC VENA CAVA INVASION SECONDARY TO RENAL CELL CARCINOMA: A NOVEL SURGICAL APPROACH

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ABSTRACT

Introduction. A combined abdominal and thoracic surgical approach is the treatment of choice for renal cell carcinoma with secondary thrombus extending to the supradiaphragmatic vena cava and initially into the right atrium. This procedure usually requires a median sternotomy with cardiopulmonary bypass and deep hypothermic circulation arrest or, alternatively, venovenous bypass. In this report, we present a transdiaphragmatic-intrapericardiac approach to supradiaphragmatic thrombus extending to the atrium that avoids the disadvantages, mortality, and morbidity related to cardiopulmonary bypass and deep hypothermic circulatory arrest or venovenous bypass.

Technique. We describe a combined abdominal and transdiaphragmatic-intrapericardiac approach that was performed in 3 patients with renal cell carcinoma with secondary thrombus extending to the atrium. The estimated blood loss of the patients ranged from 1.1 to 2.8 L (mean 1.5). The total operative time ranged from 3 hours, 20 minutes to 4 hours. No postoperative complications were observed in any patient.

Conclusions. This technique allows excellent exposure of the supradiaphragmatic inferior vena cava through a 10-cm incision and optimal control of the distal thrombus edge when it reaches the right atrium. This approach is safer, faster, easier, and minimally invasive and avoids cardiopulmonary bypass with deep hypothermic cardiac arrest or venovenous bypass. UROLOGY **66:** 1101–1105, 2005. © 2005 Elsevier Inc.

Inferior vena cava (IVC) involvement by intraluminal extension of the tumor tissue has been reported in 4% to 10% of renal cell carcinoma (RCC) cases.[1] Radical nephrectomy with thrombectomy is the treatment of choice in patients suitable for surgical treatment; thrombectomy is associated with greater mortality and morbidity directly related to the distal extension.[2] The crucial surgical point is control of the IVC, particularly above the thrombus to prevent pulmonary embolism secondary to sudden thrombus migration. The surgical approach to the thrombus extending above the diaphragm (Stage T3c according to the International Union Against Cancer) is more difficult; a simultaneous thoracic approach with sternotomy, right atriotomy, and cardiopulmonary bypass (CPB) with heparin administration and deep hypothermic circulatory arrest (DHCA) is usually performed.[3] This approach requires the assistance of the cardiovascular surgeon, significantly prolongs the operative time, and further increases the morbidity and mortality.[4] More recently, venovenous bypass has been proposed as an alternative for patients with an infradiaphragmatic tumor and near occlusion of the vena cava who do not tolerate clamping of the vena cava. Venovenous bypass avoids the risks of CPB while ensuring adequate circulation during cavotomy.[5]

As a result, a precise preoperative evaluation of the cranial extension of the tumor thrombus is pivotal to identify better the optimal surgical approach.[6–8] Different cross-sectional imaging techniques, such as computed tomography and magnetic resonance imaging, have been used with this aim.[9] More recently, transesophageal echocardiography (TEE) has been also success-

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fully used.[10–14] Compared with computed tomography and magnetic resonance imaging, TEE can be also used during surgery, providing continuous information about the tumor thrombus position and heart function.[14,15]

We report a safer, easier, and faster surgical approach in patients with tumor thrombus extension above the diaphragm and minimal atrial involvement using a transdiaphragmatic access to intrapericardiac vena cava. This approach does not require CPB and deep hypothermic circulatory arrest or venovenous bypass.

SURGICAL TECHNIQUE

The surgical approach is begun with a vertical midline transperitoneal or Chevron incision, potentially extensible to the thorax. To provide adequate exposure to the upper abdomen, a Bookwalter self-retaining retractor with malleable and Kelly retractor blades is used. In the case of a right kidney tumor, the right colon is reflected medially by dividing the white line of Toldt; the duodenum is then mobilized and reflected medially through Kocher's maneuver to expose the great abdominal vessels. In the case of a left tumor, the entire small bowel is also reflected upward to make the access to the great vessels easier. The IVC is widely exposed, and the real extension of the thrombus is precisely verified with the TEE. Gerota's fascia is carefully and entirely mobilized with sharp and blunt dissection, paying attention to the medial edge, which includes the precaval, laterocaval, and interaortocaval nodes in the case of a right tumor and the preaortic and para-aortic nodes in the case of a left tumor. This maneuver allows the identification of the renal artery, which is ligated and divided. The ureter and gonadal veins are identified and separately ligated and divided near the common iliac vessels. The distal inferior vena cava and contralateral renal vein are encircled with a vessel loop. Specific attention is paid to the control of the inferior vena cava above and at the renal hilum. The accessory hepatic veins and the lumbar veins included in the area of future cavotomy are then ligated and divided to control the inferior vena cava better. At the end, the entire renal fossa is mobilized, with exception of the renal vein.

At this point the table is titled in a reverse Trendelenburg position, improving the caudal displacement of the liver and the surrounding organs. The peritoneum is dissected off the diaphragm. The right triangular ligament is divided at the attachment to the diaphragm, allowing the right lobe of the liver to be deflected medially upward, exposing the hepatic veins and the suprahepatic IVC. The liver is further mobilized by dividing the left triangular, hepatic, and coronary ligaments and lesser omentum. The liver hilum is dissected, and the hepatic vessels and choledochus are identified to allow Pringle's maneuver. It is important to rule out the presence of an accessory left hepatic artery coming off the left gastric artery and coursing transversely in the lesser omentum; if present, this vessel must also be temporarily clamped. The liver hilum was completely and circumferentially mobilized to allow the control of the vena porta, hepatic artery, and choledochus that are also encircled with a single vessel loop.

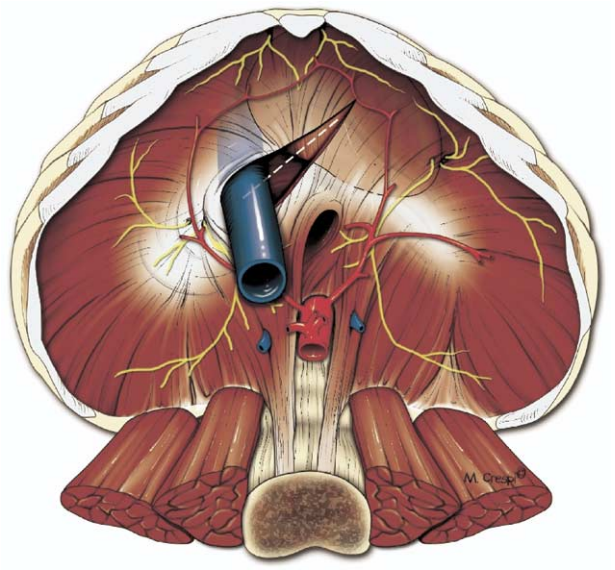

FIGURE 1. *View of abdominal diaphragm surface. Single radial incision of diaphragm performed from diaphgramatic hiatus to expose pericardium, sparing phrenic nerve and vessels.*

A wide view of the abdominal diaphragm surface should now be possible. A careful inspection allows identification of the phrenic vessels and nerve in the area corresponding to the pericardiac cavity. A single 10-cm radial incision of the diaphragm is performed at the central tendon from the diaphragmatic hiatus to expose the pericardium, paying attention to spare the phrenic nerve and vessels (Fig. 1). Pericardiotomy was then performed, to enter the pericardiac cavity (Fig. 2); the IVC is easily accessible.

The superior edge of the tumor thrombus and the anatomic relationships between the thrombus, IVC, and the pulmonary veins and the right atrium, respectively, are again verified with TEE (Fig. 3). The porta hepatis is now occluded (Pringle's maneuver). The contralateral renal vein and infrarenal IVC are sequentially occluded with clamps. A clamp is placed on the intrapericardiac IVC above the thrombus, paying attention to avoid the occlusion

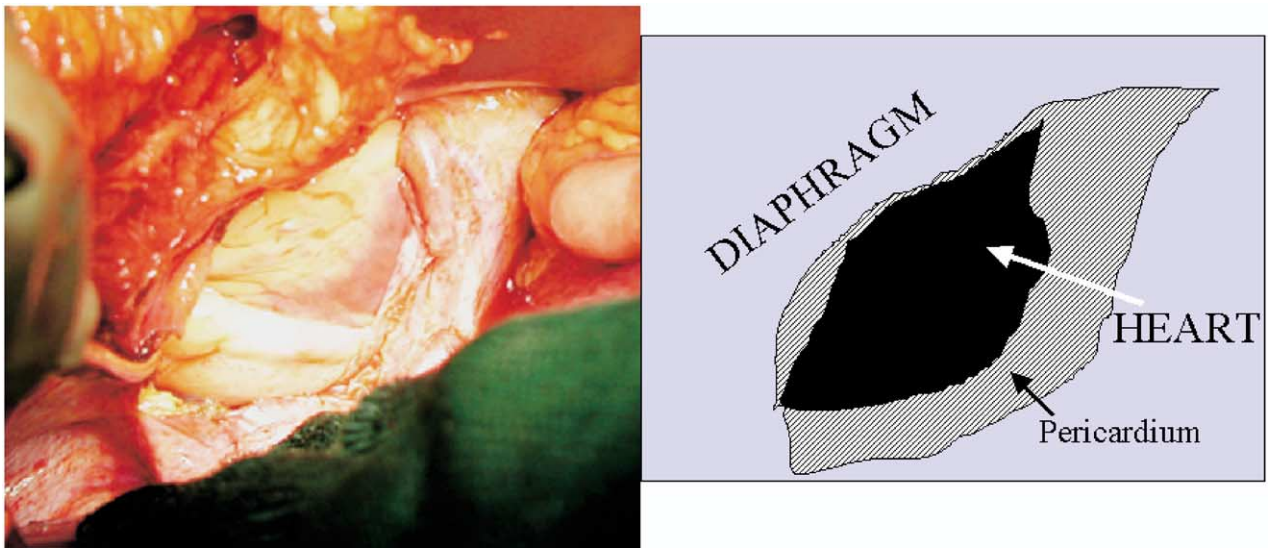

FIGURE 2. *Intraoperative view of diagram. Diaphragm was incised and pericardiotomy performed to expose intrapericardiac tract of IVC.*

FIGURE 3. *Two-dimension transesophageal echocardiogram showing large, round, echogenic tumor. Tumor resides in right atrium.*

of the pulmonary veins and using TEE. A strong Valsalva maneuver induced by the anesthesiologist coupled with a gentle digital maneuver allows one to downstage a thrombus reaching the right atrium and leading it into the IVC.

Longitudinal cavotomy is performed, and the thrombus is carefully and gently removed, allowing removal of the kidney and surrounding tissues. The IVC is then irrigated with heparin solution and sutured with a running monofilament suture. After additional TEE evaluation, all the veins are declamped to restore venous drainage. The diaphragmatic and pericardiac incisions are closed with a single running suture. Abdominal drainage is required.

RESULTS

Clinical Outcome

The procedure was performed in 3 patients: 2 with a right and 1 with a left renal tumor. The masses were 6 × 7 cm, 8 × 5 cm, and 9 × 8 cm. In 2 patients, nodal enlargement (2 to 3 cm in diameter) was present. All the patients were admitted to the intensive care unit for 48 hours and extubated on the first postoperative day in stable hemodynamic condition. The estimated blood loss of the patients ranged from 1.1 to 2.8 L (mean 1.5). The total operative time ranged from 3 hours, 20 minutes to 4 hours. No postoperative complications were observed in any of the 3 patients. Low-molecular-weight heparin was administered preoperatively and for the next 30 days as deep venous thrombosis prophylaxis. Serial chest x-rays were performed, with no signs of intrapericardiac liquid found.

COMMENT

The more usual surgical approach to renal cancer with a supradiaphragmatic tumor thrombus is radical nephrectomy and cavoatrial thrombectomy through a combined abdominal and thoracic approach with CPB and DHCA. However, CPB and DHCA are time-consuming techniques with intraoperative and perioperative complications. Ischemic injury of the brain or other organs has been observed,[16] and secondary coagulopathy, myocardial infarction, and perioperative bleeding have also been reported.[17] The more prolonged operative time necessary for blood rewarming, heparin neutralization, and electrical heart defibrillization is usual. Heparin administration results in greater intraoperative bleeding after protamine neutralization. CPB and

DHCA may facilitate tumor cells spreading into the blood stream owing to the use of the pump[18] and the immunosuppressive effects of CPB.[19]

Recent advances in minimally invasive surgery have prompted investigators to identify alternatives to CPB with DHCA to minimize the risks associated with bypass and circulatory arrest and/or decrease the morbidity of the surgical incision. Venovenous bypass has been proposed as an alternative. This approach spares the sternotomy and the DHCA, but also requires heparin administration. In addition, the operative time is still prolonged.

In this report, we describe a transdiaphragmatic-intrapericardiac approach to supradiaphragmatic thrombus extending to the atrium that avoids the disadvantages, mortality, and morbidity related to CPB and DHCA or venovenous bypass. This approach is also feasible in patients with impaired cardiac or pulmonary function for whom CPB is more dangerous.

This approach is safer, faster, easier, and minimally invasive compared with the above-mentioned alternatives. This technique allows excellent exposure of the supradiaphragmatic IVC throughout a 10-cm incision and optimal control of the distal thrombus edge when it reaches the right atrium. If the patient cannot tolerate vena cava clamping, the known alternatives (CPB with DHCA or venovenous bypass) can be still used during the same surgical session.

The surgical incision is minimally invasive (10 cm) and takes 5 minutes to perform: no cardiosurgeon assistance is necessary. As a consequence, the operative time is significantly decreased.

A precise preoperative clinical and instrumental evaluation of the cardiac function (with electrocardiography, echocardiography, and TEE) is necessary to select the patients. Furthermore, the evaluation of the exact extension of the thrombus and the anatomic relationships with the vena cava wall, pulmonary veins, and the right atrium is mandatory. Real-time TEE fulfills these requirements perfectly and should be used intraoperatively for continuous monitoring, precise placement of the vascular clamp above the thrombus, and to evaluate for complete thrombus removal.

Some critical surgical steps of this technique must be emphasized. First, is the risk of an iatrogenic lesion of the phrenic nerve. This can be easily avoided if the surgeon knows its anatomy perfectly. The left portion of the phrenic nerve pierces the diaphragm in its tendinous portion just laterally to the inferior vena cava foramen.

Secondly, the accidental clamping of the pulmonary veins must be avoided to avoid a dangerous cardiocirculatory situation. Real-time TEE monitoring can perfectly identify the exact position for placement of the clamp and to check for complete thrombus removal.

Nesbitt *et al.*[20] proposed a similar approach to atrial thrombus without CPB and DHCA throughout sternotomy. The tumor thrombus is digitally and gently carried down into the supradiaphragmatic IVC after clamping of the infradiaphragmatic great veins. A vascular clamp is then placed around the IVC immediately below the cavoatrial junction. However, this approach requires sternotomy and real-time TEE is not used.

CONCLUSIONS

The transdiaphragmatic-intrapericardiac approach to supradiaphragmatic thrombus extending to the atrium is a safer, faster, easier, and minimally invasive alternative to CPB with deep hypothermic cardiac arrest or venovenous bypass.

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