TECHNIQUE

"Heparinless" Venovenous Bypass for Renal Cell Carcinoma Involving the Inferior Vena Cava: A Case Report

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Abstract

This presentation offers a simple yet effective method of venovenous bypass without systemic heparinization to assist in the surgical intervention of renal cell carcinoma involving the inferior vena cava. This system is comprised of a closed Bio-Medicus (a) centrifugal pump system and cannulation sites of femoral vein and axillary vein. No direct cardiac cannulation is made.

Renal cell carcinomas involving the inferior vena cava have been surgically treated by means of cavotomy, often with major loss of blood (1). Risks also include embolization to the right heart and lungs, poor visualization with less than desirable results, uncertainty as to retrieval of tumor thrombus, and the possibility of decreased return of venous blood to the right heart and those sequelae.

Other surgical measures have included cardiopulmonary bypass with or without circulatory arrest. Also, a venovenous bypass from femoral vein to right atrium has been conducted (2, 3). Some complications associated with these uses will be discussed in the following text.

The degree of inferior vena caval involvement in this case report extended to the diaphragm and was handled surgically with the assist of this venovenous bypass system, but cases involving thrombus above the level of the diaphragm might also be considered depending on the extent and surgeon discretion.

The bypass described herein affords a simple, convenient method to offer hemodynamic stability in the surgical procedure without cannulation of the heart and systemic heparinization. This bypass will be utilized in future cases based on individual situations.

Introduction

Renal cell carcinoma, (RCC), the most common primary malignant renal tumor, consists of pure or partially epithelial character. It is also known as hypernephroma, Grawitz's tumor, renal adenocarcinoma, malignant nephroma, and metaphroma (4).

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Renal cell carcinoma is 1% (5) to 5% (6) of all malignancies. The annual incidence in the United States is 9.4/100,000 for white men, 8.7/100,000 for black men, and 4.4/100,000 for black and white females (5). This cancer is exceedingly rare under the age of 20 years, and 60% of these tumors occur in people 50 to 70 years of age (3). The cause may be linked to chemical, physical, viral, or hormonal agents, radiation or cigar smoking (5).

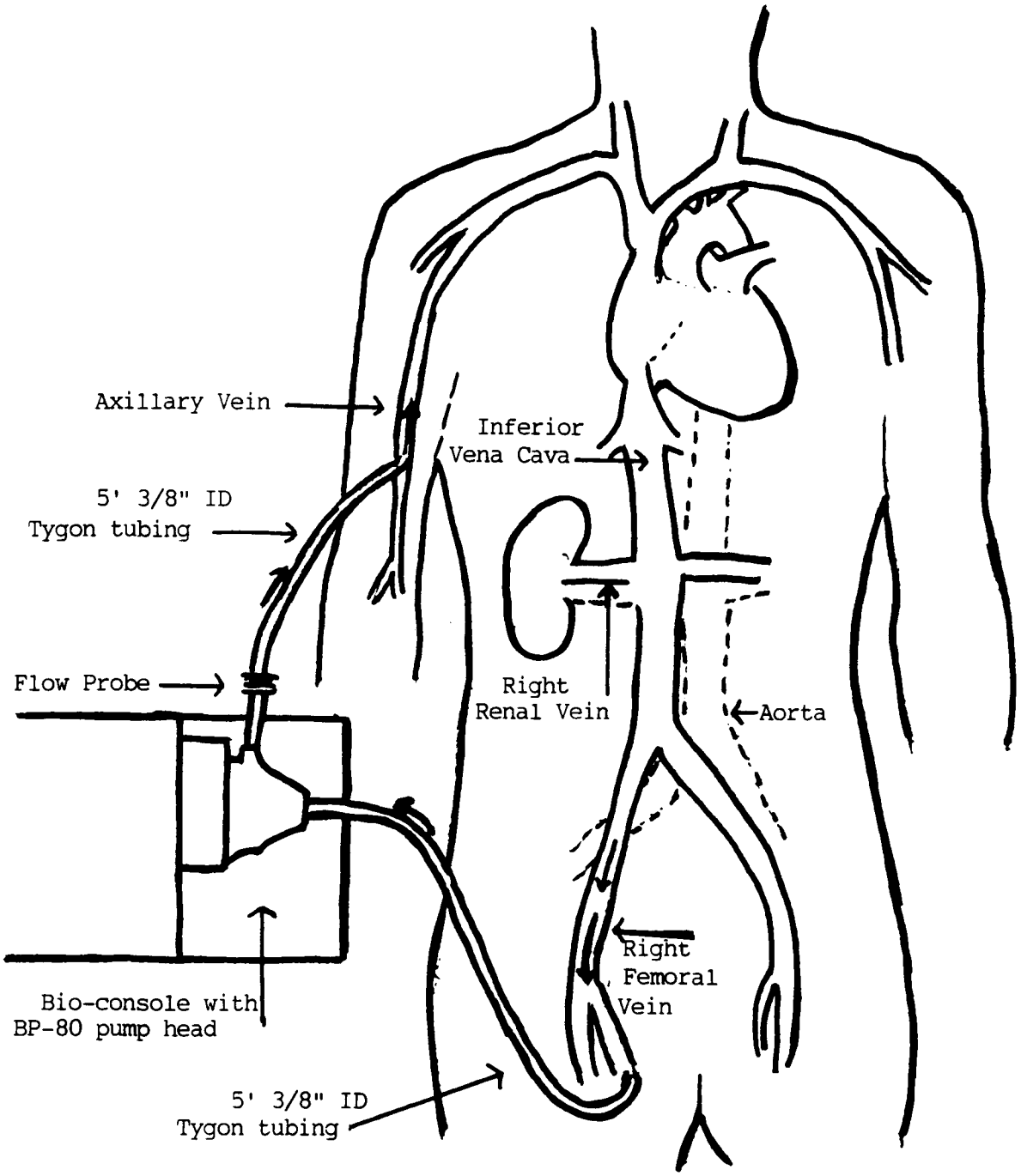
The right and left kidneys are involved with equal frequency. Renal cell carcinoma originates from the renal tubular epithelial cells and spreads by direct, local extension, or via the venous or lymphatic channels. It is a silent, slow growing malignancy which may remain undetected because of lack of symptoms until early metastasis. Spread of the disease to lungs, bone, brain, contralateral kidney, and other visceral organs is common. At the time of admission, 30% show metastasis (5). It is not exceptional that the diagnosis is made by microscopy of an excised skin tumor (3). Also, the diagnosis is made in some instances at autopsy.

Growth inside vascular channels is characteristic of renal cell carcinoma. The larger veins and main renal vein may hold a long "tumor thrombus." Extensive intravenous growth may be found in more than half of all renal cancers at time of nephrectomy. It appears more frequently (85%) with the right kidney than the left, perhaps because of the short length of the right renal vein (7). Venous growth of the tumor thrombus may continue along the vena cava (4-10% of all RCC) (8), and less commonly to the right atrium (occurring in less than 20% of those with inferior caval involvement) (2). One case, however, reported a tumor thrombus projecting through the tricuspid valve into the right ventricle (8). Unfortunately, death has occurred from massive pulmonary embolism with tumor found only in the renal vein (8).

The tumor thrombus rarely is fixed or invading the caval wall except at the site of the renal vein, but it usually behaves as a free-floating thrombus. Even if it is adherent, it is usually not invasive. If the inferior vena cava (IVC) becomes occluded with tumor thrombus, the lumbar and azygos systems will gradually assume the load and carry the venous return to the heart.

a. Bio-Medicus, Minneapolis, MN, 55334

Figure One - Circuitry utilized in venovenous bypass for nephrectomy and extraction of caval tumor thrombus.



Extension to the vena cava alone has a limited impact on prognosis with a full five year survival rate of 50% (7). Caval involvement may not be as serious as lymph node involvement.

Several factors influence survival. Most authors state that large size, multiple tumors, and involvement in perirenal fat and lymphatics offer poorer prognosis. Survival seems to be more related to these factors than to venous growth of the tumor (9).

Solitary metastasis may occur years after nephrectomy. Follow-up care of 15 years is deemed critical. Survival rates of 67% for two years, 50% for five years, and 34% for 10 years appear frequently in the literatures (5). Robson, et al., exhibited a 10-year survival rate of 66% (5).

Earlier diagnosis and decisions concerning appropriate treatment are made possible by the diagnostic tools of excretory urograms, ultrasound, renal angiograms, bone scanning, and computer tomography.

Currently, surgical resection ot the primary renal cell carcinoma with en bloc removal of tumor from the IVC may be the procedure of choice. The role of lymphadenectomy is controversial as is the role of infarction of the affected kidney, irradiation, definitive chemotherapy, and immunotherapy. If all demonstrable tumors can be excised, the patient is provided the greatest choice of cure (8).

If the tumor thrombus is confined to the renal vein and a small portion of the vena cava, no bypass may be indicated. Cavotomies to retrieve tumor thrombus, above or below the hepatic veins, have been attempted with the use of clamps, forceps, Fogarty, or Foley catheters. Trendelenburg position and positive pressure respirations are included to help prevent the possibility of pulmonary embolism.

Intraoperative hazards include: tumor embolization to the right heart and lungs; inadequate venous return and subsequent sequelae; massive bleeding; and incomplete clearance of tumor thrombus. After involvement above the hepatic veins, technical surgical problems are much greater.

The rich vascularity of the RCC, as well as the enhanced collateral circulation, gives rise to the increased possibility of difficulty in maintaining control of the situation. Drainage from the hepatic veins, lumbar veins, and the contralateral kidney can be a major problem. Hemorrhage and poor visualization can compromise surgical management (10).

As stated earlier, some have utilized cardiopulmonary bypass with or without circulatory arrest. This management can provide its own set of problems such as coagulation and hemolytic disorders related to thrombocyte and reticulocyte fractionation (11), renal impairment (12), pulmonary complications (13), and psychosis (14). There can be a great loss of blood due to the systemic heparinization and a reluctance to aspirate (by pump suction) blood and possibly tumor cells into the bypass system. Heterologous blood transfusion has been shown to be detrimental to the five year survival rate in RCC (15). Thus, a significant advantage is gained when blood loss is minimized.

The venovenous bypass system utilizing the Bio-Medicus centrifugal pump and cannulation of the femoral vein (via the saphenous vein) to the axillary vein offers a less complex procedure which allows access to the inferior vena cava while providing protection from pulmonary embolism and tumor dissemination. This assist reduces operating time, cost, and, hopefully, morbidity when compared to the cardiopulmonary bypass.

The surgical approach described here is particularly convenient because of the overwhelming majority of the right kidney tumors extending into the cava. It avoids cardiac arrest, systemic heparinization, allows normal perfusion of the heart, lungs, brain, spinal cord, and the remaining kidney. It is simpler, contains less priming volume (300 ml), and blood loss may not be as serious a problem. It also allows the surgeon a more relaxed atmosphere in which to perform the tumor extraction.

Case Study

The patient was a 48-year old white male who presented with a several month history of anorexia with a 22 pound weight loss in three months. He exhibited the classic triad of symptoms for RCC: hematuria, flank pain, and palpable abdominal mass. Other symptoms linked to RCC may be fever, generalized weakness, erythrocytosis, anemia, hypercalcemia, cardiac enlargement, or hepatic dysfunction without evidence of metastasis (exact cause unknown). Findings such as increased sedimentation rate, increased prothrombin time, hypoalbuminemia, hyperglobulinemia, increased serum alkaline phosphatase, and increased renal renin may also be seen.

He experienced occasional right flank pain with nausea and one episode of hematuria seven months prior to diagnostic work-up. He denied any other urinary symptoms or change in bowel habits. He had a positive history for peptic ulcer disease.

The patient had undergone an inguinal herniorrhaphy just three months prior to work-up. His only medication was Zantac. He was a cigarette smoker, one pack a day for 10 years, and had occasional alcohol use. He had no known allergies. He had a negative history pertaining to exposure to toxic chemicals or fumes. One daughter, 25, had died of a brain tumor, and his mother had died of lung cancer.

On admission, his weight was 76 kilograms. All gross physical systems reviewed were normal with the exception of a right upper quadrant mass. A CT scan and abdominal ultrasound both indicated a large right renal cell carcinoma and invasion of the inferior vena cava with tumor or thrombus. The tumor thrombus was said to be from the level of the right kidney to the level of the diaphragm at the exact location where the hepatic veins enter. The report showed good flow in all three hepatic veins. There was no definite hepatic vein involvement, but was in close proximity.

The patient was brought to the operating room and placed in a right side up at 45 degrees, with access to the right axilla and right groin. A thoracoabdominal incision was made. On opening of the chest, no abnormality of the lung was found. Also, no metastatic disease was noted to either the liver or other abdominal contents.

The kidney was described as "huge." There were markedly enlarged collaterals on its anterior surface. These were dissected and ligated. The mass occluded or almost completely occluded the inferior vena cava. The caval tumor extended from 2 cm

below the right renal vein to the level of major right and left hepatic veins at the level of the diaphragm.

The diaphragm was opened. Palpation and ballotment revealed the tumor did not extend above diaphragm. The right renal vein was markedly dilated and solid with tumor.

Next, cannulation for the venovenous bypass was initiated. A #7 Gott (b) shunt was placed into the femoral vein via the right saphenous vein, and a #7 Gott shunt was placed in the right axillary vein.

The perfusion system consisted of a pre-primed (approximately 300 ml of Plasmalyte 7.4 (c) with approximately 700 units beef lung heparin) Bio-head BP-8O (a) and a flow probe. At each of the inflow and outflow of the Bio-head, there was a 5-feet length of 3/8 inch I.D. Tygon tubing (d). The inflow to the Bio-head was connected to the femoral vein cannula, and the outflow of the Bio-head was connected to the axillary vein cannula with appropriate size connectors. This particular system has been utilized extensively in the liver transplant program at this medical center.

Bypass was started and flows of 1.2 to 1.8 liters per minute (LPM) were achieved. Cardiac outputs were maintained at 6.3, 5.5, and 7.8 LPM range much as the pre-bypass levels of 6.1, 6.2, and 6.3 LPM. Arterial pressures pre-bypass at 110/60 mm Hg rose slightly to 120/80 mm Hg. Mixed venous saturation levels remained at 81% to 83%. Pulmonary artery pressures on bypass ranged from 29/16 to 20/12 mm Hg, much the same as pre-bypass values of 30/16 to 20/10 mm Hg. Central venous pressures pre-bypass were in the range of 3 to 7 mm Hg. On initiation of bypass, the value rose to 10 mm Hg, but then returned to 7 mm Hg. Urinary output remained at 1-3 ml per kilogram per hour.

Control of the cava and the left renal vein was gained by use of Rommel tourniquets. A #18 Foley catheter with a 30 cc balloon was passed between the cava and thrombus. The balloon was inflated and drawn back with tumor. A venotomy was performed. Tumor was extracted and a visual inspection showed evidence of a tongue of tumor into one of the lumbar veins. Then the right renal vein was transected and the entire tumor specimen was removed.

The specimen was 24 x 15 x 8 cm and weighed 2100 grams. An average kidney weighs 150 grams. About 95% of the kidney was obliterated by tumor. One of the four lymph nodes removed proved to be positive for metastasis.

The cava was closed without a patch. The Foley catheter was withdrawn and the venotomy was closed. The total bypass time was 46 minutes. The entire surgery took 11 hours. The patient required 14 units of packed cells, 16 units of fresh frozen plasma, and 5600 ml of crystalloid. A Rapid Infusion System (e) was employed. Blood loss was significant pre-bypass, but it had to be accepted to prevent dislodging tumor thrombus.

A cell-saver was not utilized due to speculation about the possibility of dissemination of tumor. However, in future cases, a cell-saver might possibly be used depending on availability of donor cells. A study, performed by Hart in 50 patients with RCC, noted "no observed complications directly attributable to autotransfusion. None developed diffuse metastatic disease compatible with intravascular dissemination of tumor during autotransfusion (16)."

According to his physicians, the patient did impressively well despite the magnitude of the surgery during his immediate post-operative course. He was maintained on a low dose intravenous heparin drip (100 units an hour) for the first several post-operation days, and then switched to subcutaneous heparin (5,000 units every 12 hours). On the third post-op day, the chest tube was removed; he was ambulatory shortly after the naso-gastric tube was removed. A liquid diet was initiated on post-op day four with progression to a full diet on post-op day six. The lungs remained clear.

An ultrasound six days post-op revealed a patent IVC with normal flow from below infrahepatic portion to the right atrium. The left renal vein and three of three hepatic veins were patent with normal flow. No thrombus was detected. On the seventh post-op day, the liver function tests rose in regard to bilirubin, SGTP, alkaline phosphatase, and SGOT values. The possibility of resorption of hematoma was considered. On post-op day eight, a CT scan and ultrasound indicated echogenic material noted in the infrahepatic IVC. The hepatic veins were patent. It was considered to be a partial thrombus since flow could be demonstrated throughout the IVC and the left renal vein. A heparin drip was started and was later changed to a combination of heparin and Coumadin.

The patient was discharged with visiting nurse association (VNA) support and on a therapeutic regimen of Coumadin. The VNA would also monitor the anticoagulation levels. The patient did well at home and was started on immunotherapy Alpha Gamma interferon.

Summary

The use of the virtually "heparinless" venovenous bypass with cannulation of femoral vein to axillary vein yielded excellent results and would undoubtedly be utilized by this group of surgeons again for patients with renal cell carcinoma tumor thrombus invading the inferior vena cava.

According to Dr. Thomas Hakala, Professor and Chief of Urologic Surgery, the situation for use would be determined by size and location of the tumor thrombus as well as adherence to caval wall with the possibility of caval graft. Cardiopulmonary bypass would also be a consideration for more extensive disease.

Future considerations for this bypass approach might also include any massive tumor (i.e., Wilm's tumor) involving the great vessels and requiring control of circulation.

a. Bio-Medicus, Minneapolis, MN , 55344
b. Argyle Division of Sherwood Medical, St. Louis, MO 63103
c. Travenol Labs, Inc., Deerfield, IL, 60015
d. Norton Industrial Plastics, Akron, OH, 44309
e. Haemonetics, Inc., Braintree, MA, 02184

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Addendum

Subsequent to this procedure, an elderly female presented with a large left renal cell carcinoma with tumor thrombus which had invaded the inferior vena cava and the right atrium. With the assistance of the cardiac surgical team, the venovenous bypass was instituted. The Bio-head and tubing configuration which was used for this procedure was seen in Figure 1 with the addition of two more drainage cannulae with appropriate 3/8" Y connectors. The pump inflow cannulation sites were the superior vena cava and the right femoral vein. (The attempted right renal vein cannulation was not successful, but the decompression of this area was deemed adequate.) The flow from the centrifugal pump was directed to the pulmonary artery. This was considered to be a right heart bypass. Number 7 Gott shunts were used in all of the cannulation sites. The left renal mass was removed as was the tumor thrombus.

This heparinless venovenous bypass was considered to be a success and would be used again for extensive tumor thrombus caval involvement.