CARDIOPULMONARY BYPASS IN PATIENTS WITH MALIGNANT RENAL NEOPLASMS

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Cardiopulmonary bypass may be a life-saving procedure in patients with malignant renal tumours. These tumours, which invade the venous system in about 5% of patients (Marshall et al., 1970), are those most commonly associated with thrombus of the inferior vena cava. After penetrating the vessel wall, they usually do not infiltrate the intima but enter a vein as a free-floating, friable, pedunculated mass which may extend to the right heart or embolize to the pulmonary arteries. Since venous extension does not necessarily correlate with anaplastic properties or metastasis elsewhere, aggressive surgery will increase survival (Skinner, Pfister and Colvin, 1972). Massive pulmonary embolism, however, is a major hazard during resection and has resulted in numerous deaths (Judd and Scholl, 1924; Mimpriss and Birt, 1949; Masson and Bromwood, 1955; Yates, 1955; Vincze et al., 1969; Shurin et al., 1982). Only five patients with malignant renal tumours have survived emergency pulmonary embolectomy (table I). In three patients (including our own), embolization occurred during surgery (Akyon and Arslan, 1981; Milne et al., 1981), in a fourth before the diagnosis of the renal tumour (Daughtry et al., 1977) and in a fifth, following nephrectomy and closure of the abdomen (Utley et al., 1973). To date, no anaesthetic texts mention the hazard of massive pulmonary embolism or the need for cardiopulmonary bypass in these patients. The anaesthetic literature contains two reports of intraoperative pulmonary embolism (Akyon and Arslan, 1981; Milne et al., 1981), but no discussion of the prevention of this catastrophe. Therefore, we report our patient, review the literature involving cardiovascular surgery for removal of renal tumours invading the venous system, and suggest guidelines for anaesthetic care and the use of cardiopulmonary bypass.

CASE REPORT

A 54-yr-old, 79-kg white man was admitted for evaluation and treatment following computer axial tomography of the abdomen and selective renal angiography which was consistent with the diagnosis of malignant renal neoplasm with venous extension and tumour thrombus.

Physical examination revealed an apparently healthy man with a swollen left lower leg. Arterial pressure was 124/88 mm Hg, the heart rate regular at 100 beat min⁻¹, and the respiratory rate was 16 b.p.m. Examination of the lungs revealed decreased breath sounds at both bases, more so at the left. The ECG was normal and chest x-ray showed atelectatic changes in the left mid-lung field. Laboratory studies on admission showed a haemoglobin of 12.9 g dl⁻¹, a haematocrit of 35.5%, and a white cell count of 6500 mm³ with a normal differential count. The electrolytes, BUN, creatinine, and SGOT concentrations were normal. The LDH concentration was 846 u. ml⁻¹. Analysis of arterial blood at an FiO₂ of 0.21 showed a pHₒ of 7.50, a PaCO₂ of 4.0 kPa and a PaO₂ of 9.7 kPa. A ventilation and perfusion scan revealed moderately unmatched perfusion defects, but a
TABLE I. Patients with malignant renal neoplasms surviving emergency cardiopulmonary bypass for pulmonary embolism

<table>
<thead>
<tr>
<th>Report</th>
<th>Age (yr)</th>
<th>Tumour</th>
<th>Follow-up</th>
<th>Extent of invasion</th>
<th>Position and/or type of incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>54 M</td>
<td>Renal cell</td>
<td>Dead, 6 months</td>
<td>Total occlusion of inferior vena cava</td>
<td>45° left lateral decubitus; turned to supine</td>
</tr>
<tr>
<td>Milne and others (1981)</td>
<td>15 F</td>
<td>Renal cell</td>
<td>Not reported</td>
<td>Inferior vena cava occluded at T12</td>
<td>Left lateral decubitus; turned to supine</td>
</tr>
<tr>
<td>Akyon and Arslan (1981)</td>
<td>10 F</td>
<td>Nephroblastoma</td>
<td>27 months</td>
<td>Renal vein</td>
<td>Not reported</td>
</tr>
<tr>
<td>Daughtery and others (1977)</td>
<td>68 M</td>
<td>Renal cell</td>
<td>30 months</td>
<td>Right renal vein</td>
<td>Not reported</td>
</tr>
<tr>
<td>Utley and others (1973)</td>
<td>2 M</td>
<td>Nephroblastoma</td>
<td>Dead, 3 months</td>
<td>Inferior vena cava to diaphragm</td>
<td>Left lateral decubitus; turned to supine</td>
</tr>
</tbody>
</table>

Pulmonary arteriogram showed no evidence of emboli. An inferior venogram showed a large intraluminal mass occupying the entire distal inferior vena cava with complete obstruction at L2 and tumour or thrombus extending above the diaphragm 2 cm distal to, but not involving, the right atrium (figs 1 and 2). An M-mode cross-sectional echocardiogram showed no masses, intracardiac thrombi or tumour. The patient was scheduled for a right radical nephrectomy with cardiopulmonary bypass on standby.

After premedication with diazepam 10 mg orally and morphine 8 mg i.m. 1 h before surgery, two 14-gauge i.v. cannulae, a right external jugular catheter, and a radial artery cannula were inserted. After induction with thiopentone 400 mg, suxamethonium 100 mg was administered, and...
anaesthesia maintained with 50% nitrous oxide in oxygen, and enflurane. Pancuronium was administered to provide neuromuscular blockade. The patient was positioned in 45° left lateral decubitus position and a thoracoabdominal incision was made. During surgery the arterial pressure was stable at 110/70-130/80 mm Hg and heart rate at 85-105 beat min⁻¹. After exposure and examination of the inferior vena cava and aorta, the systolic pressure decreased to 60 mm Hg. The heart rate increased to 140 beat min⁻¹ and central venous pressure increased from 8 to 23 cm H₂O. A diagnosis of pulmonary embolization was made and the patient was placed immediately in the supine position in preparation for cardiopulmonary bypass. He required sodium bicarbonate and i.v. infusions of adrenaline, isoprenaline and dopamine to maintain a systolic arterial pressure above 60 mm Hg. Total cardiopulmonary bypass was initiated within 20 min, using a single venous cannula and an ascending aortic cannula. With the heart beating, the pulmonary artery was incised and large tumour emboli were retrieved with a Fogarty catheter. A pulmonary artery catheter was then inserted and the pulmonary pressures were 45/25 mm Hg and pulmonary capillary wedge pressure was 11 mm Hg. An Adam Weese vena cavaclan clip was used to plicate the inferior vena cava above the renal veins and below the hepatic veins. Tumour thrombus was removed from the right renal vein and inferior vena cava. A right radical nephrectomy was performed. The patient received 1.7 litre of packed red cells, 0.8 litre of colloid and 10 litre of crystalloid fluid, excluding the pump prime of 2 litre. During the 10 h procedure, the blood loss was 4 litre and urine output was 1.4 litre. On admission of the patient to the intensive care unit, the Hct was 33%. During the first 24 h, his total output was 3.4 litre including 1.7 litre of chest tube drainage, 1.2 litre of urine, and 0.5 litre of nasogastric drainage. He required 7 litre of blood products, colloid and crystalloid to maintain an average pulmonary diastolic pressure of 10-12 mm Hg, a right atrial pressure between 6 and 8 mm Hg, and an Hct between 25% and 30%. He maintained a high cardiac output (7 litre min⁻¹) and a low systemic vascular resistance (500-600 dyne s⁻¹ cm⁻⁵). Since the patient developed a fever of 100-101°F and had a high cardiac output and a low systemic vascular resistance, a presumptive diagnosis of sepsis was made despite negative cultures. The patient was receiving cefaxolino at the time. He did well and was discharged from the intensive care unit on the 4th day after operation, but required another surgical procedure for intestinal obstruction a month later. He went home after 2 months, but returned 4 months later with nausea, vomiting and abdominal pain. He died after an upper gastrointestinal haemorrhage secondary to gastritis and mucosal erosion at the gastro-oesophageal junction.

The major autopsy findings were multiple metastases to the liver, inferior vena cava, left eye and mesentery. There were also pulmonary emboli containing tumour in inferior branches of right and left pulmonary arteries with infarcts of both lower lobes of the lung.

**DISCUSSION**

If surgery for malignant renal neoplasms with venous extension is to be successful, the anaesthetist must know the extent of tumour growth, the resultant pathophysiological and haemodynamic alterations, and probable complications. In the past, diagnosis of venous extension was made only during the operation or on postmortem examination. Today, however, ultrasonography of kidney and vena cava, computed tomography, echocardiography, selective renal angiography, vena cavaography, and right heart angiography allow accurate preoperative assessment.

In a review of the literature, Schechter and colleagues (1983) reported a total of 187 patients requiring vascular procedures for venous extension other than removal of tumour from the renal vein. In 19% supradiaphragmatic tumour extension had occurred. To date, 27 patients have undergone cardiopulmonary bypass for tumour removal (Akyon and Arslan, 1981; Schechter, 1983; Katz, Spence and Wallace, 1984). Almost half of these patients had emergency bypass procedures because of failure to diagnose the degree of venous extension, or massive pulmonary embolism. A number of children have also had resection of Wilm's tumour with intravascular extension with the use of cardiopulmonary bypass (Vaughan, Crosby and Tegtmeyer, 1977; Theman et al., 1978; Luck et al., 1982). Thus, the elective use of cardiopulmonary bypass may be a critical factor in preventing intraoperative embolization.

Numerous anatomical classifications of venous extension have been reported in the surgical literature (Skinner, Vernillion and Colvin, 1972; McCullough and Gittes, 1974; Freed and Gliedman, 1975; Musiani, 1977; Abdelsayed et al.,
If the tumour extends well into the vena cava (Type II), cardiopulmonary bypass should be available. The patient should be placed in the thoracoabdominal or supine position so that the incision may be extended for sternotomy if necessary.

Supradiaphragmatic tumours (Type III) warrant serious consideration of elective cardiopulmonary bypass. Although these tumours have been removed without bypass (Abdelsayed et al., 1978; Clayman, Gonzales and Fraley, 1979; Kearney et al., 1981; Lieskovsky, Pritchett and Skinner, 1984), Lieskovsky, Pritchett and Skinner (1984) reported an intraoperative embolism and death, when tumour extending into the atrium was resected without elective cardiopulmonary bypass. In our patient and that of Milne and colleagues (1981), although a ‘‘standby pump’’ was available, precious time was lost in positioning the patients for embolectomy. Elective cardiopulmonary bypass, therefore, may avoid pulmonary emboli, ease the resection and control haemorrhage.

If cardiopulmonary bypass is used, the technique should include circulatory arrest and moderate hypothermia to 30 °F because the pulmonary artery and aorta may require cross-clamping to

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**Fig. 3. Anatomical location of tumour extension.**
prevent embolization. Supplementary fine gauge filters to and from the oxygenator will strain out tumour fragments and aspirated fluid from the tumour site should not be returned to the pump (Schechter, 1983). A caval umbrella filter in the orifice of the inferior vena cava during cardiopulmonary bypass has been advocated to trap emboli (Farrel, Bloch and Marshall, 1974). Autotransfusion of washed red blood cells is contraindicated because of the risk of disseminating viable tumour cells.

Aggressive surgical removal of malignant renal neoplasms is the only hope for cure. The anaesthetist must have complete knowledge of venous extension, recognize the need for elective cardiopulmonary bypass and be an active participant in the preparation of these patients for operation.

REFERENCES


