CASE REPORT

Pediatric Liver Resection Using the Pump-Oxygenator and Red Blood Cell Washers

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Keywords: Autotransfusion, Liver resection, Rapid infusion system

Abstract

This case report describes the use of the pump-oxygenator as a rapid infusion system during the resection of a liver tumor in a 12 month old child. All banked blood was washed in a cell washer before addition to the oxygenator to avoid the deleterious effects of hyperkalemia, acidosis and ionic hypocalcemia. The blood was warmed and recirculated in the perfusion circuit to provide volume replacement when necessary during the surgical procedure. The patient made an uneventful recovery after receiving transfusions exceeding 4½ times the patient's estimated blood volume.

Introduction

The perfusionist's role has expanded beyond Open Heart Surgery because expertise with perfusion techniques and devices can be of benefit in other areas of surgery and medicine. Many techniques have been described to manage the blood loss and hemodynamic status during liver resection and transplantation. These include deep hypothermia with circulatory arrest,[1] moderate hypothermia with extreme hemodilution, liver transplant with veno-venous bypass,[2] liver transplantation without bypass,[3] and liver resection with the pump-oxygenator.[4] Using a protocol similar to Estrin's, this report describes the use of a pump-oxygenator and red cell washers to provide large volume blood replacement in a pediatric patient undergoing liver resection.

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Case Report

The patient was a 12 month old male who presented at 7 months with an enlarged liver. Hepatoblastoma was the suspected diagnosis. Exploratory laparotomy at 7 months revealed an infiltrating tumor which involved almost all of the right lobe and both segments of the left lobe including the medial segment. The tumor was noted to be "unresectable" because the mass was considered too large and, in addition, was found to be adherent to the inferior vena cava. Biopsy specimens were obtained and surgery was concluded. Postoperative plans for tumor mass shrinkage by chemotherapy were made prior to another attempt at liver resection.

At the time of the second laparotomy the patient's weight was 5 kg, and his hematocrit was 35%. Chemistries and coagulation profiles were normal prior to surgery. Estimated blood volume was 400 cc.

The transfusion system consisted of a Cobe Stockert pump console, a Cobe VPCML membrane oxygenator,[a] a Pall LPE1440 arterial filter,[b] 3/16 arterial line tubing, a Haemonetics Cell Saver Plus high speed cell washer, and a Cell Saver I[c] (Figure 1).

The perfusion circuit was primed with two units of *washed* homologous red blood cells and two units of fresh frozen plasma. A non-heparinized, non-hyperkalemic transfusate was accomplished by first washing the bank blood in the cell saver and mixing it in the perfusion circuit with the fresh frozen plasma.

The total priming volume was approximately 1000 ml. The prime was buffered with sodium bicarbonate

a Cobe Laboratories, Lakewood CO 80215
b Pall Corporation, East Hills NY 11548
c Haemonetics Corporation, Braintree, MA 02184

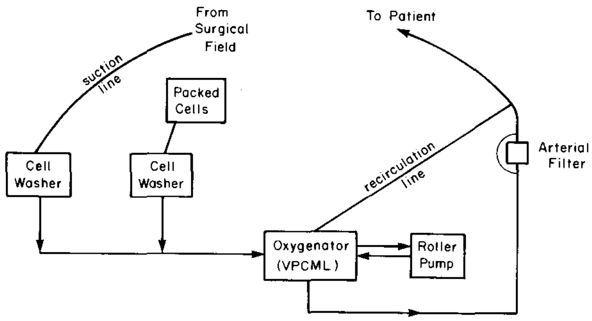

Figure 1. Transfusion System Using the Pump-Oxygenator and Red Blood Cell Washers

(20 MEq) and recirculated through a shunt line distal to the arterial filter. In addition to providing constant movement of the blood through the perfusion circuit, recirculation through the heat exchanger maintained the blood temperature at 37°C. The 3/16" arterial line was connected to a 6.5 Fr. Swan-Ganz catheter introducer inserted percutaneously into the right internal jugular vein.

The operation lasted approximately 10½ hours of which 6 hours actively involved the perfusion team. During the course of the procedure three units of washed homologous banked blood and three units of fresh frozen plasma were added to the system. Blood analyses were performed on the recirculating blood to maintain the hematocrit at 30% and the acid-base balance within normal limits.

The patient remained stable hemodynamically throughout the procedure and transfusions were given whenever the mean central venous pressure dropped below 7 mmHg. During this period the rectal temperature was maintained between 36.5–37 degrees centigrade, PT and PTT were less than 1.25 of control values, and platelet counts remained greater than 200,000. A calcium chloride infusion with additional boluses corrected intraoperative hypocalcemia (2 grams total given). Potassium supplementation (total 26 MEq) was required. A total of approximately 1800 ml. of blood was transfused over a 6 hour period.

When the total resectable tumor was removed and the rapid transfusion system was no longer required, the system was disconnected from the central venous catheter. Additional blood products were administered in a standard fashion through the central line. Postoperatively the patient did well. On arrival in the recovery room his vital signs were stable, his hematocrit was 32%, and his temperature normothermic.

Discussion

The survival rate among patients with resectable liver tumors is about 35%. High operative complications (28%) are attributed to massive blood loss and the hemodynamic, chemical, thermal, and coagulation consequences of massive blood transfusion.[4] This operation is sometimes not attempted or abandoned once started because of the possibility of exsanguinating blood loss.

The surgical approach to liver resection is very difficult primarily due to poor exposure. In transplant surgery, most of the blood loss occurs during the recipient hepatectomy. Many patients with liver disease have coagulation abnormalities. This combined with venous hypertension and collateral circulation sets the stage for massive blood loss during the operative procedure.[5]

Starzl reported that the red cell usage during liver transplant surgery in adults was significantly reduced during veno-venous bypass compared to no bypass.[2] Autotransfusion during liver transplantation has also been shown to be beneficial in reducing homologous blood requirements. Van Voorst et al.[6] demonstrated that the use of a cell washing dèvice during liver transplantation reduced the mean red cell usage from 28 units to 20 units. The chemical consequences of massive transfusion can be dramatic in the presence of end stage hepatic function. Since citrate is normally metabolized by the liver, transfusion of citrated blood products increases the serum citrate levels and often results in ionic hypocalcemia. Calcium levels less than 0.56 mm/L are associated with depressed cardiovascular function.[7] Depending on the age of bank blood, hyperkalemia and acidosis can be additional concerns.

Although the procedure was successful, it was very intensive in terms of personnel and equipment requirements. Since we were following the protocols described by Estrin, there were two perfusionists, two Cell Savers, one pump console, and a membrane oxygenator circuit. The operating room was extremely crowded, and our capacity to do Open Heart procedures was reduced.

In reviewing our case experience, several points became apparent. The use of an oxygenator is probably not necessary for two reasons. First, there is some oxygenation of bank blood in the Cell Saver during processing ($pO2>120$ mm Hg), and second, the blood will be transfused into the patient's venous system. Instead a cardioplegia heat exchanger could be used to heat the blood, reducing the priming volume of the circuit (Figure 2). A

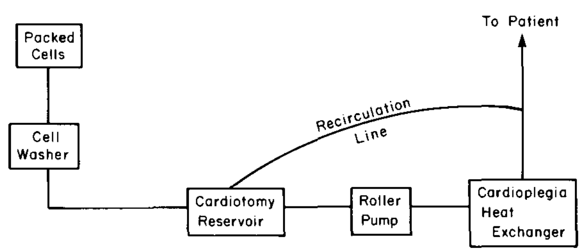

Figure 2. Proposed Transfusion System Using a Cardioplegia Heat Exchanger and One Red Blood Cell Washer

second cell washing system is unnecessary. It is unlikely that blood loss during the actual tumor resection will be saved because of the potential for recirculating malignant cells.[8] A simpler system consisting of one roller pump, one cell washer, and a cardioplegia heat exchanger could be operated by one perfusionist, reducing the cost of manpower and supplies.

As perfusion technology expands into other areas of surgery and medicine, the opportunity for the perfusionist to participate and become a part of these changes is an exciting expansion of the perfusion profession.

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