

VENO-VEIN BYPASS WITHOUT SYSTEMIC ANTICOAGULATION FOR TRANSPLANTATION OF THE HUMAN LIVER

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A CRUCIAL intraoperative period during orthotopic liver transplantation occurs during mobilization of the diseased recipient liver prior to hepatectomy and during the subsequent anhepatic phase of the hepatectomy and implantation of the new liver. During this time, obstruction of the portal vein and inferior vena cava can result in a fall in cardiac output and arterial pressure (1), consequent hypoperfusion of critical organs, damage to the engorged subdiaphragmatic capillary beds and extensive bleeding from high pressure venous collaterals. These nonphysiologic conditions have been responsible for intraoperative or delayed deaths and have contributed to the lack of wide application of replacement of the liver (2).

When orthotopic liver transplantation was developed in dogs, bypass techniques were used to shunt blood from the lower to the upper half of the body without pumps and systemic heparinization (3,4). The clinical application of the passive bypass resulted in the formation of clots in the tubing with the consequent passage of multiple "emboli" to the lungs (5). The use of a pump driven bypass under systemic heparinization was discouraged by major difficulties in reversing the heparin effect in patients with endstage hepatic disease and multiple pre-existing coagulation defects (2, 6, 7). We report herein upon a pump driven nonheparin bypass system that was tested in dogs and was subsequently applied in 23 patients who underwent replacement of the liver.

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TECHNIQUE

The unique components of the circuit include modified heparin bonded Gott aneurysm shunt tubing (Argyle Division, Sherwood Medical) for drainage and return cannulae, plus a centrifugal blood pump (Bio-Medicus, Inc.). The cannula to drain blood from the inferior vena cava is advanced through the saphenofemoral venous junction to near the confluence of the common iliac veins (Fig. 1). The cannula which removes splanchnic blood is placed end-on into the transected portal vein (Fig. 1). The fusiform Gott shunts which are 60 centimeters long with an extra side hole at one end, are ideal for drainage. After intravascular insertion, these cannulae are cut where their diameter is large and joined together with a three-eighths inch polished stainless steel Y type connector (Fig. 1). The blood is drained to a centrifugal pump which returns the effluent to the ipsilateral axillary vein (Fig. 1) through a 7 or 9 millimeter Gott cannula without a side hole. Connections of the cannulae to the blood pump and a flow meter are made with short segments of uncoated three-eighths inch polyvinyl chloride tubing.

The entire circuit may be primed and debubbled on the operative field. After connecting the sterilized components, the drainage cannulae are submerged in a basin of saline solution. A regulated wall suction is then applied to the tip of the return cannula so that priming is completed as the saline solution is drawn through the circuit components. The disposable blood pump head may then be passed off the field and connected to its motor console. Alternatively, the cannulae may be individually primed by a bulb type syringe and connected to the remainder of the circuit which has been primed by the extracorporeal perfusion team in a closed loop manner. While the former method does not require input

from a perfusionist, the latter has caused the least operative interruption and is currently preferred.

The rotation of the centrifugal blood pump is adjusted to deliver the maximum blood return at the minimal revolutions per minute. In adults, total flow has averaged 4 liters per minute and has ranged between 1.5 and 6.0 liters. In many patients, the portal circulation has contributed more than one-half of the total flow. The venovenous bypass has often been initiated prior to extensive retrohepatic resection, and its average duration of 100 minutes (a range of 70 to 158) has, therefore, included the time required for completion of recipient hepatectomy plus implantation of the donor graft.

Venous reservoirs are not needed in this system. All circuit tubing is shortened as much as possible to minimize exposure to foreign surfaces. Except for the rare formation of fine fibrin strands on the rims of the connectors and on the pump cone supports, there has been no evidence of *ex vivo* thrombosis. In one patient, a soft iliac vein thrombosis was removed with the drainage cannula, but there has been no clinical or autopsy evidence in any patient of venous embolism. Component blood replacement during the period of bypass has actually improved the pre-existing coagulopathy during the bypass in spite of a tendency for the platelet counts to fall during this time.

So far, this system has been used only in adults. Children have been found to tolerate the combined portal and venacaval occlusion far better than adults, and it is possible that the system should be used in younger liver recipients only

when indicated by vasomotor instability during test cross clamping. In adults, the advantages of the bypass are so great that it has become a routine part of transplantation of the liver.

SUMMARY

A technique of veno-venous bypass without heparin has been developed for use during the anhepatic phase of transplantation of the liver. With this method, the ability to compress the temporarily obstructed vena caval and portal venous systems has made hepatic transplantation an easier procedure.

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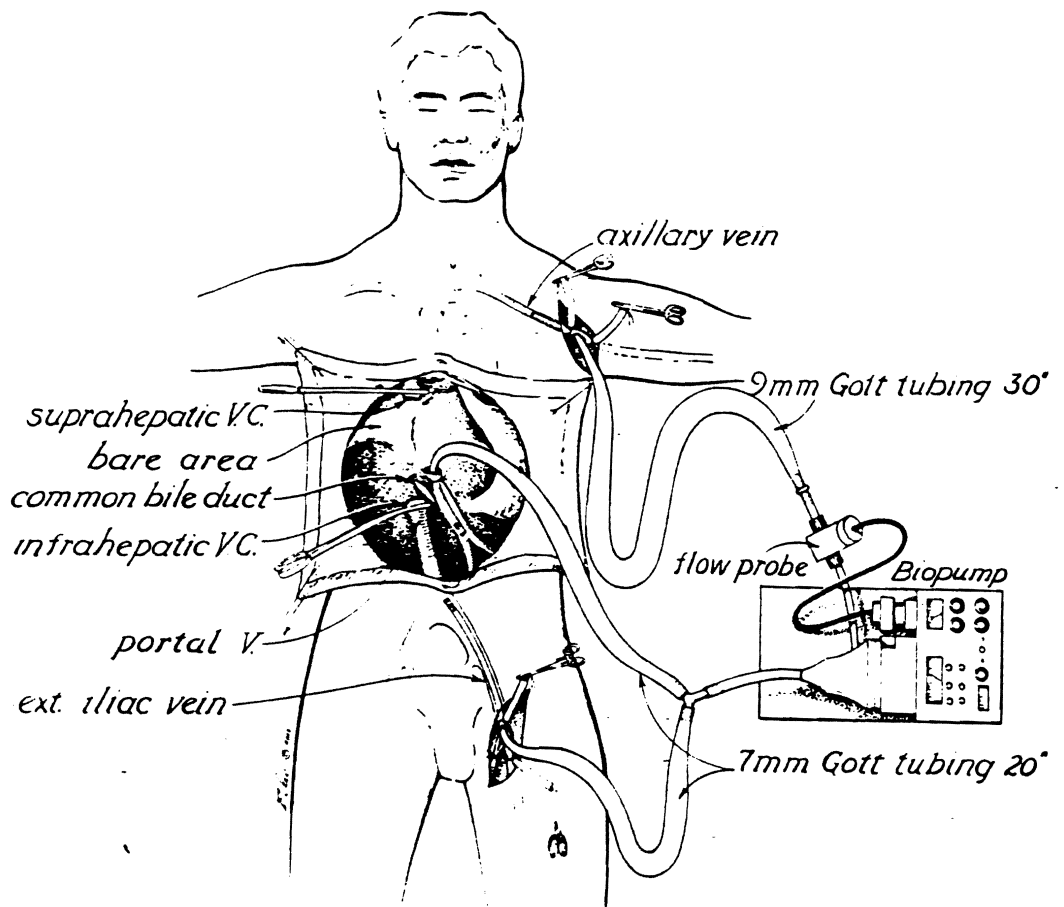


FIG. 1. Anhepatic stage of transplantation of the liver with cavoportal to axillary bypass circuit.

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