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TECHNIQUE OF ORTHOTOPIC LIVER ALLOTRANSPLANTATION IN DOGS

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The technique of orthotopic liver allotransplantation in dogs used by the authors has been described. Some technical modifications have been introduced to simulate the clinical conditions. They are: the donor remains hypotensive for about an hour before the liver is taken out, the liver is taken from the cadaver, warm ischemia is prolonged to 20—30 minutes.

Abundant literature concerning experimental liver allotransplantation in dogs can be found in recent medical journals (1—7). Various techniques and numerous modifications have been described. Nevertheless the Polish medical literature is lacking thoroughful anatomical description of liver transplantation. It seemed necessary to elaborate here a simple method of transplantation which would suit our conditions, and in which materials available in Poland could be used. The anatomical differences of the German shepherd dog, used mostly for experiments in our laboratories, were also taken into account.

Some special modifications aimed at maximal approximation to the clinical conditions were introduced. For example, livers were taken only from cadavers, recipients were not heparinized, livers were continuously cooled with balanced Ringer's solution during the period of implantation.

PROCUREMENT OF THE LIVER FOR TRANSPLANTATION

The donor is being kept for 3 days on a carbohydrate-rich diet and 300,000 u of penicillin per day. At the time of hepatectomy in the recipient the donor is anesthetized with a small dose of ether. Barbiturates are absolutely contraindicated. A 2 mm wide polyethylene cannula is introduced to the femoral vein, and intravenous drip of 500 ml of 5% dextrose in water started. The femoral artery is also dissected, and the dog is bled 500 ml into a plastic bag with the ACD preservative. That blood is transfused later on to the recipient. The next

step is intravenous administration of 3 mg/kg of heparin, and 3 minutes later the dog is sacrificed with an intravenous bolus of 20 ml 10% Kalium chloride.

About 2—3 minutes later a long mid-line incision from the neck down to the pubis is made and abdomen and thorax opened. The infrahepatic segment of the inferior vena cava at the level of the right adrenal vein is ligated. Then the distal

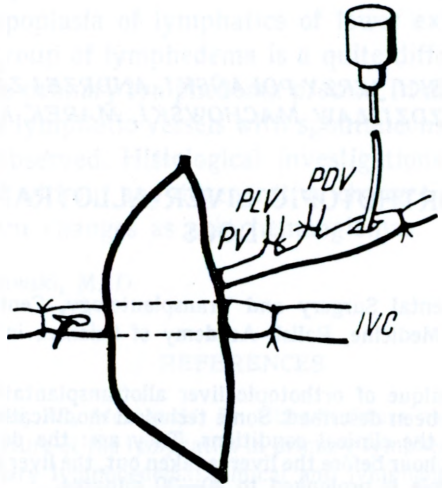

Fig. 1. Cooling of the liver. PV — portal vein, PDV — pancreatoduodenal vein, IVC — inferior vena cava, PV — pyloric vein.

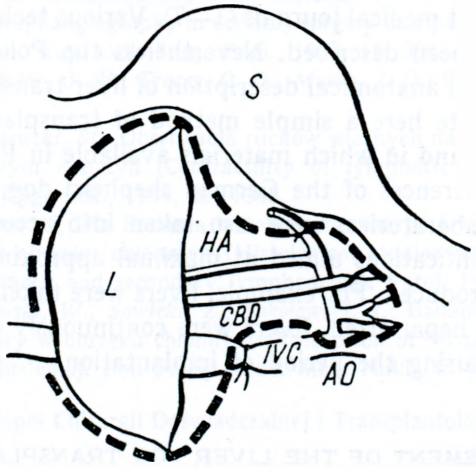

Fig. 2. Dissection and division of hepatic vessels. HA — hepatic artery, RGA — right gastric artery, CBD — common bile duct, AO — aorta, IVC — inferior vena cava, S — stomach, L — liver. Dotted line indicates the site of division of ligaments fixing the liver.

part of the superior mesenteric vein, the pyloric vein, and the pancreatoduodenal vein are ligated. A cannula is introduced to the portal vein, and the liver washed out with 1500 ml of Ringer's solution with 20 ml of 5% sodium bicarbonate and

300,000 u of penicillin, at +4°C. The surface temeprature of the liver goes down to 6—8°C in about 15 minutes. At the end of cooling the left hepato-phrenic ligament is ligated, then cut. Also the peritoneum between the liver and phrenic crura is divided (Fig. 2).

The next step consists in ligation and division in the smaller omentum, then of the hepato-duodenal ligament with the right gastric artery, common bile duct, and small veins. Small tributaries of the portal vein are ligated and divided, the main stem of the vein being cut distally to the cannula. The liver is slightly displaced upwards so that the hepatic artery may be better exposed. All the tributaries of the hepatic artery with the splenic artery are ligated. Then the main trunk of the celiac artery is cut close to its origin from the aorta.

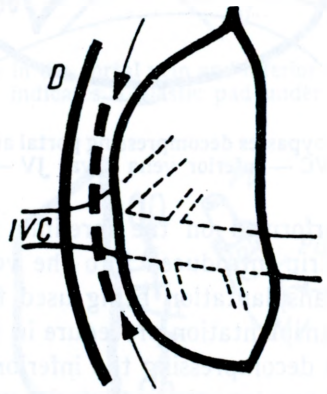

Fig. 3. The level of cutting of the suprahepatic inferior vena cava. D — diaphragm, IVC — inferior vena cava.

The inferior vena cava is divided at the level of the right adrenal vein. Also the peritoneal fold between the liver and the diaphragmatic crura is cut. As the next the suprahepatic infradiaphragmatic vena cava is cut transversely very close to the liver (Fig. 3). If it is cut high above the liver the phrenic veins can be inadvertently cut and remain open when the clamp is removed from the IVC.

The hepatic artery is flushed with 50 ml of cold Ringer's solution. The cannula is left in the portal vein and a cool drip continued until the anastomoses of the IVC with the recipients veins are completed.

PROCUREMENT OF THE RECIPIENT

The weight of the recipient should be about the same as of the donor. This way the size of the transplanted liver will be similar to that of the removed liver. This is very important because of two reasons: one can avoid the disparities between the lumen of donor and recipient vessels, and also the transplanted

liver will not produce too much resistance for the portal flow. The recipient is pretreated for 3 days with parenteral penicillin (300,000 u) and oral Neomycin (2 g).

Dogs are premedicated with 0·3—0·5 mg of atropine sulphate intravenously, then anesthetized with halothane at the concentration of 5 vol%. Following the induction they are intubated and anesthesia is continued with 1·5—2·5 vol% of Halothane.

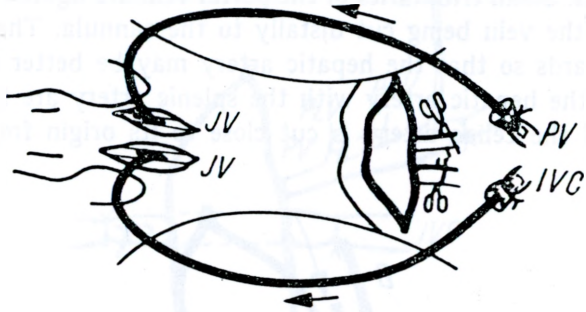

Fig. 4. The diagram of venous bypasses decompressing portal and inferior vena cava circulation. PV — portal vein, IVC — inferior vena cava, JV — jugular vein.

The venesection is performed on the forelimb, a plastic cannula for the continuous intravenous drip introduced into the vein. It remains in the vein for several days after transplantation being used for fluid infusions.

The first step of the transplantation procedure in the recipient is the procurement of venous bypasses decompressing the inferior vena cava and the portal circulation (Fig. 4). Right jugular vein and inferior vena cava will be cannulated on one side, and left jugular vein and portal vein on the other side. A longitudinal 5 cm long incision is made on the neck and the jugular vein exposed. Only its anterior aspect is freed, the other parts being left intact. This technique helps to avoid constriction of the vein. Peripheral part of the vein is ligated and the proximal is intubated with a 8—10 mm wide cannula. The cannula is filled with heparinized saline, and connected to a tubing which will later be introduced into the inferior vena cava or the portal vein.

HEPATECTOMY IN THE RECIPIENT

A midline incision between the xiphoid process and pubis is made. The right adrenal vein is ligated and cut between the ligatures. The inferior vena cava is freed from the adjacent structures below the liver.

The next step of the operation is right nephrectomy. The stump of removed kidney will serve for anastomosis with the hepatic artery. The kidney capsule is cut and renal artery exposed down to its origin from the aorta. As long as

possible segment of that artery is left, what makes the anastomosis with hepatic artery much easier. Left triangular ligament is ligated and cut, then the peritoneal fold between the liver and diaphragmatic crura carefully separated. The gastro-hepatic ligament and the common bile duct are cut. At that time other structures like hepatic artery and portal vein become exposed. The artery is cut close to the liver hilum, the portal vein dissected meticulously down to the liver.

Fig. 5. Fixation of the cannula in the portal vein and inferior vena cava. V — vein, C — cannula. Arrow indicates a plastic pad under the ligature.

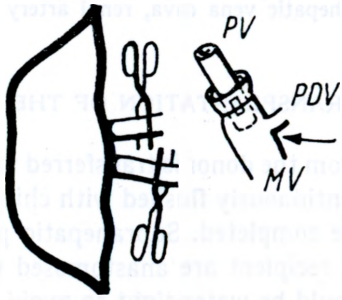

Fig. 6. Occlusion of the pancreato-duodenal vein by inadvertent placement of the ligature close to its origin (arrow). PV — portal vein, PDV — pancreato-duodenal vein, MV — mesenteric vein.

The peritoneal fold between the liver and right diaphragmatic crus is cut, its small arteries being previously ligated. The inferior vena cava and portal vein are ready for cannulation. A clamp is placed on the inferior vena cava above the renal veins, another one on the same vein close to the liver. The vein is cut. Its lumen is intubated with the tubing the other end of which was previously placed in the jugular vein. A ligature is put around the vein with cannula and tied on a plastic pad (Fig. 5). The clamp is taken off of the tubing and blood flows freely from the lower part of the body to the jugular vein. Using the same technique the portal vein is cannulated. Attention should be paid to avoid twisting of the portal vein by 45° and occlusion of the pancreato-duodenal vein (Fig. 6).

With the bypasses decompressing portal and inferior vena cava circulation recipient's own liver is removed. A large curved clamp is placed on the suphra-

hepatic portion of the inferior vena cava. The vein is cut below that clamp close to the liver parenchyma (Fig. 7). Cutting of the vein higher up would lead to damaging of phrenic veins what may cause profuse uncontrollable bleeding after removal of the clamp.

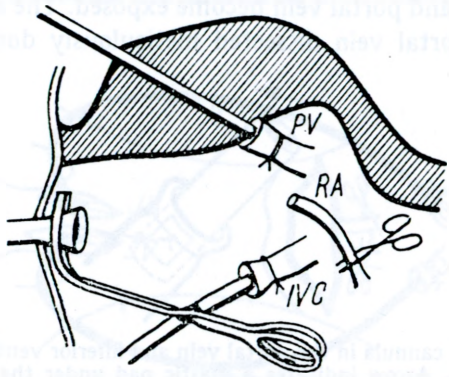

Fig. 7. Abdominal cavity after hepatectomy. Clamps placed on the infradiaphragmatic vena cava, infrahepatic vena cava, renal artery and portal vein.

TRANSPLANTATION OF THE LIVER

The liver taken out from the donor is transferred to the abdominal cavity of the recipient. It is being continuously flushed with chilly Ringer's solution until the venous anastomoses are completed. Suprahepatic portion of the inferior vena cava of the donor and recipient are anastomosed with a continuous 3—0 silk suture. That suture should be water-tight to avoid postoperative bleeding from the suture line. The next step is anastomosis of the renal artery of the recipient with the hepatic artery of the donor liver end-to-end using 5—0 silk. With those two anastomoses completed the clamps are taken off from the suphrahepatic inferior vena cava and renal artery. The liver is filling with recipients blood.

The third anastomosis is made between the inferior vena cava below the liver. With the posterior row of suture ready a clamp is placed on the vein above the renal veins, the cannula removed and anterior row of sutures put on fast. The same holds for the portal anastomosis.

Careful hemostasis is made and then the gallbladder anastomosed to the duodenum. Abdominal cavity is closed. A small plastic drain is left in the abdomen to drain blood which collects in the neighborhood of the transplant, and helps to evaluate the extent of blood loss. Cannulas are removed from the jugular veins.

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