Hepato-venous reconstruction in orthotopic liver transplantation with preservation of the recipients’ inferior vena cava and veno-venous bypass

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Abstract Background and aims: The potential advantages of vena cava-preserving recipient hepatectomy in orthotopic liver transplantation are reduced hemorrhage, improved cardiovascular stability and preserved renal perfusion without the requirement of veno-venous bypass as compared with recipient hepatectomy including the vena cava. No detailed information is available on the use of veno-venous bypass during complicated vena cava preserving recipient hepatectomy and liver transplantation. In the present study, the peri- and postoperative courses of adult liver transplant recipients in whom the hepatovenous reconstruction was performed according to three different techniques with and without the use of veno-venous bypass were investigated. Patients/Methods: During primary orthotopic liver transplantation, an end-to-end (ETE) cavo-caval interposition of the donor vena cava to the recipient’s vena cava was performed in 75 patients (group I). In 15 patients, a termino-terminal piggyback (PB) anastomosis was constructed to the remnant of the recipient’s hepatic vein (group II), and in 72 transplantations a latero-lateral cavo-cavostomy (LLC) of donor-to-recipient’s vena cava (group III) was performed. The use of bypass, operative time and cold ischemia time, perioperative blood product requirements, incidence of relaparotomy, the evolution of postoperative renal function, technical complications and the survival were analyzed and compared using multivariate statistics and actuarial techniques for statistical evaluation. Results: No differences could be found in preoperative patient conditions, donor conditions, operating time, anastomosing time or cold ischemia time. In groups I–III, the venovenous bypass was used in 50 (67%), 8 (53%) and 6 (8%) cases respectively ($P=0.02$ for group III). The mean preoperative packed cells requirements were 20.4 vs 29.6 vs 10.8 units ($P=0.01$ for group III), while postoperative blood product requirements (first 24 h) were 2.6 vs 5.0 vs 0.20 units of packed cells ($P=0.02$ for group III). Relaparotomy for diffuse retroperitoneal hemorrhage was performed 14 times (19%) in group I, 3 times (20%) in group II and 7 times (8.3%) in group III ($P=0.002$). The incidence of postoperative early renal dysfunction (increase of $\geq 1.3 \text{ mg\% serum creatinine}$) in group I vs group II vs group III was 24% vs 60% vs 16.7% ($P=0.001$ for group II) for patients without the use of veno-venous bypass. No significant difference was observed concerning early renal dysfunction in patients where a veno-venous bypass was used. The survival at 12 months was 81% for group I, 86% for group II and 93.0% for group III. In group III there were four complications ($P=0.03$) at the hepatovenous anastomosis of which two were eventually fatal. Conclusion: Preservation of the recipient’s vena cava and LLC can reduce, but not avoid, the requirement for veno-venous bypass. In orthotopic liver transplantation, postoperative hemorrhage, as measured by surgical revisions and requirement for blood products, is significantly reduced with LLC with and without bypass. Early renal dysfunction also occurs in the group of LLC as compared with the termino-terminal cavostomy independent of the bypass. A technical failure resulting in patient death can be associated with LLC.

Key words Liver transplantation · Venous complications · Veno-venous bypass
**Introduction**

Liver allograft implantation was originally described with the removal and replacement of the inferior vena cava as part of the recipient heptectomy [1,2]. This cavo-caval end-to-end (ETE) anastomosis in orthotopic liver transplantation is less frequently associated with complications such as stenosis or thrombosis as compared with the arterial or portal-venous anastomosis because of the large size of the anastomosis and the voluminous blood flow. With the increasing use of modified liver grafts, such as reduced livers [3] or partial livers as obtained with split liver transplantation or from living, related donors, modified techniques for the anastomosis of the hepato-venous-caval junction have been recently described [3,4]. These are characterized by the preservation of recipients inferior vena cava (IVC), avoiding difficult dissection of the retrocaval space usually associated with excessive hemorrhage [5,6,7]. As this is a requirement for the use of grafts encompassing only the hepatic veins, broader experience with this technique has allowed the use of the end-to-side (ETS) piggyback (PB) procedure to the IVC or ETE to the recipients’ hepatic veins, even in the case of a present donor IVC [6,7,8]. A further evolution was the introduction of the latero-lateral cavo-cavostomy (LLC) described by Belghiti [5,9], facilitating caval blood flow during the anhepatic phase and avoiding veno-venous bypass. Complications with these anastomoses, however, and their treatment have been exceptionally reported [3,4,10,11]. The need for veno-venous bypass, even in the case of maintained caval blood flow, has only been scarcely reported. In the present paper, the experience with these three techniques to reconstruct the hepato-venous outflow was analyzed regarding the clinical course and the outcome after transplantation, focusing on the evolution of renal function, peri- and postoperative blood loss and operation time with and without the use of veno-venous bypass.

**Patients and methods**

A total of 162 primary consecutive adult liver transplantations were prospectively documented and analyzed. For donor organ preparation, a fast method for removal of multiple organs was used in all cases, as has been described [12]. According to each technique used for transplantation, the graft preparation was performed on the back table after cleaning the hepatic graft. UW (University of Wisconsin) solution (Viaspan, Dupont Pharma, The Netherlands) or HTK (histidine tryptophan ketoglutarate; Custodiol Dr.; Franz Köhler Chemie, Alsbach-Hähnlein, Germany) was used for all organ procurements. Three different techniques were employed to reconstruct the hepato-venous outflow (Fig. 1a-c).

In group I (n=75, 46.3%) an orthotopic replacement of the vena cava was performed, with ETE interposition of the donor vena cava to the recipient vena cava, as this has been thoroughly described [1,2] (Fig. 1a).

In group II (n=15, 9.3%) the so called PB technique [7,8] was performed with an ETE anastomosis to the hepatic veins. After removal of the recipient’s liver by ligature and clipping of the caudate hepatic veins, the recipient’s IVC was cross-clamped below the diaphragm and above the right adrenal vein.

A common orifice was created by joining the two orifices of left/middle and right hepatic veins. An evertting intraluminal (4×0 Prolène) suturing technique was used for the anastomosis between the upper outlet of the IVC and the orifice. The lower outlet of the donor IVC was closed by a running suture (4×0 Prolène) (Fig. 1b).

The decision to perform PB or LLC was made following recipient heptectomy. When the superior orifice of the donor vena cava was insufficiently long to be closed and the remnant of the recipient’s hepatic veins were suitable to be used for anastomosis, the PB technique was performed. Lateral caval clamping encom- passing the remnant of the hepatic veins, i.e., sufficient distance to the diaphragm, was essential for using the PB technique, with ETE anastomosis of the donor caval vein to the hepatic veins of the recipient. Otherwise, the LLC technique was used.

In group III (n=72, 44.4%) a LLC [5,9] was performed. On the back table, the vena cava of the hepatic graft was sutured 1 cm above the confluence of the hepatic veins (4×0 Prolène). In the recipient, a complete retrohepatic dissection of the IVC was performed, transecting and ligating all the short hepatic veins draining the posterior part of the liver. Finally, the hepatic veins were transected and oversewn (4×0 Prolène). A vascular clamp was applied laterally on the anterior part of the IVC, permitting caval blood flow during the anhepatic phase. After a longitudinal 3–4 cm cavotomy on donor and recipient vena cava, a side-to-side (STS) running suture anastomosis (4×0 Prolène) was performed. Arterial, portal venous and biliary reconstructions were performed uniformly as described elsewhere [2]. During reconstruction of the caval anastomosis, the liver was flushed via the portal vein with human albumin solution. Once the portal flow was restored, the caval clamp was released and the infrahepatic vena cava was closed (4×0 Prolène) (Fig. 1c).

For the use of veno-venous bypass, preservation time, anesthesia time and operating time (all in minutes) during transplantation were registered. In our institution, veno-venous bypass is used when mean arterial blood pressure decreases by more than 30% or the cardiac index decreases by more than 50%, or both, during a trial of clamping of the portal vein and IVC [13]. During this 5-min trial, fluids [packed cells (PC), fresh frozen plasma (FFP), colloids, crystalloids] are administered to restore preclamping cen-