Donor Graft Outflow Venoplasty in Living Donor Liver Transplantation

Allan Concejero,1 Chao-Long Chen,1 Chih-Chi Wang,1 Shih-Ho Wang,1 Chih-Che Lin,1 Yeuh-Wei Liu,1 Chin-Hsiang Yang,1 Chee-Chien Yong,1 Tsan-Shiu Lin,1 Salleh Ibrahim,1 Bruno Jawan,2 Yu-Fan Cheng,3 and Tung-Liang Huang3

1Department of Surgery, 2Department of Anesthesiology, 3Department of Diagnostic Radiology, Liver Transplantation Program, Chang Gung Memorial Hospital, Kaohsiung Medical Center, Kaohsiung, Taiwan

Hepatic venous outflow reconstruction is a key to successful living donor liver transplantation (LDLT) because its obstruction leads to graft dysfunction and eventual loss. Inclusion or reconstruction of most draining veins is ideal to ensure graft venous drainage and avoids acute congestion in the donor graft. We developed donor graft hepatic venoplasty techniques for multiple hepatic veins that can be used in either right- or left-lobe liver transplantation. In left-lobe grafts, venoplasty consisting of the left hepatic vein and adjacent veins such as the left superior vein, middle hepatic vein, or segment 3 vein is performed to create a single, wide orifice without compromising outflow for anastomosis with the recipient’s vena cava. In right lobe graft where a right hepatic vein (RHV) is adjacent with a significantly-sized segment 8 vein, accessory RHV, and/or inferior RHV, venoplasty of the RHV with the accessory RHV, inferior RHV, and/or segment 8 vein is performed to create a single orifice for single outflow reconstruction with the recipient’s RHV or vena cava. Of 35 venoplasties, 2 developed hepatic venous stenoses which were promptly managed with percutaneous interventional radiologic procedures. No graft was lost due to hepatic venous stenosis. In conclusion, these techniques avoid interposition grafts, are easily performed at the back table, simplify graft-to-recipient cava anastomosis, and avoid venous outflow narrowing. Liver Transpl 12:264-268, 2006. © 2006 AASLD.

Received May 24, 2005; accepted August 29, 2005.

Variable venous anatomy increases the risk of outflow complications in living donor liver transplantation (LDLT). Preoperative mapping of the hepatic venous system is indispensable to provide information for decision making as to cutting plane during graft retrieval and the method of venoplasty and anastomosis.1 However, no consensus has emerged to guide optimal venous outflow reconstruction in LDLT.2 It is recognized that the venous drainage of the graft depends largely on the tributaries of the hepatic veins. Failure to effectively reestablish this venous drainage may result in congestion, dysfunction, and eventual graft failure.3,4 Techniques to overcome acute graft congestion by reconstruction of all significantly-sized tributaries of hepatic veins have been the rule for most surgeons utilizing either the right or left liver lobe.

We describe our techniques for donor graft hepatic vein venoplasty, devised to ensure a single, wide orifice in the hepatic veins, for a single outflow anastomosis with the recipient’s hepatic veins or vena cava.

PATIENTS AND METHODS

Between June 1994 and December 2004, we performed 203 consecutive LDLT including 1 dual graft transplantation. A total of 115 left and 89 right donor grafts were used. In the 115 left donor grafts, 29 underwent venoplasty. In the 89 right donor grafts, 6 underwent venoplasty. Table 1 summarized the disease indication for transplantation in the recipients and the grafts used. The operative records, outcome, and follow-up of all recipients and donors whose graft underwent veno-
plasty were reviewed. The minimum recipient follow-up was 6 months.

**Technique of Graft Venoplasty**

Donors underwent detailed hepatic vascular imaging. Two-dimensional Doppler ultrasonography and magnetic resonance venography with angular reconstruction were used to evaluate the hepatic venous anatomy.\(^1\) Computed tomography was used for liver volumetry and to assess fatty content of the donor liver.\(^5\) The number and configuration of the hepatic veins to be taken with the graft were determined preoperatively. Multiple veins may be detected as separate on preoperative imaging studies, but were often harvested with an attached intervening septum.

Our technique of donor hepatectomy has previously been described in detail.\(^6,7\) The graft consisted of either the left lateral segment (segments 2 and 3), extended left lateral segment (segments 2, 3, part of 4), or right lobe (segments 5, 6, 7, and 8). Donor hepatectomy was performed without vascular occlusion. The graft was flushed with University of Wisconsin solution through the portal vein on the back table, where venoplasty was also performed. After graft procurement, the hepatic veins were carefully inspected at the back table. In the left lateral segment or extended left lateral grafts, if 2 or more orifices, i.e., left hepatic vein, left superior hepatic vein, middle hepatic vein, or segment 3 or 4 veins, were found, a venoplasty was performed to fashion a single, wide outflow orifice. Three techniques of venoplasty were employed depending on the presentation of the vessels. First, if 2 veins were connected by a long intervening septum (>1 cm), a plasty of this septum (septoplasty) was performed in order to make the outflow circumference uniform and to depress the septum. This was done by making an incision perpendicular to the septum and removing the underlying liver parenchyma using a cavitron ultrasonic surgical aspirator (CUSA). This incision was then stretched along the axis of the septum. The vessel edges were approximated by interrupted polyglyconate (Maxon) 7-0 suture with the knots on the extraluminal side.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>N</th>
<th>%</th>
<th>Graft used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biliary atresia</td>
<td>20</td>
<td>57</td>
<td>LL-2, LLS-12, ELLS-6</td>
</tr>
<tr>
<td>GSD</td>
<td>6</td>
<td>17</td>
<td>LL-3, LLS-1, ELLS-2</td>
</tr>
<tr>
<td>Neonatal hepatitis</td>
<td>3</td>
<td>8</td>
<td>LLS-3</td>
</tr>
<tr>
<td>HBV-related cirrhosis without HCC</td>
<td>3</td>
<td>8</td>
<td>RL-3</td>
</tr>
<tr>
<td>HCV-related cirrhosis without HCC</td>
<td>1</td>
<td>3</td>
<td>RL</td>
</tr>
<tr>
<td>HBV-related cirrhosis with HCC</td>
<td>1</td>
<td>3</td>
<td>RL</td>
</tr>
<tr>
<td>Alcoholic cirrhosis</td>
<td>1</td>
<td>3</td>
<td>RL</td>
</tr>
</tbody>
</table>

Abbreviations: GSD, glycogen storage disease; HBV, hepatitis B virus; HCV, hepatitis C virus; HCC, hepatocellular carcinoma; LL, left lobe; LLS, left lateral segment; ELLS, extended left lateral segment; RL, right lobe.

![Figure 1.](image1) Clockwise from left top. (A) Septum with intervening tissue separates segments 2 and 3 veins. (B) Septoplasty of this septum is performed in order to make the outflow circumference uniform and to depress the septum. This is done by making an incision perpendicular to the septum and removing the underlying liver parenchyma using a cavitron ultrasonic surgical aspirator (CUSA). (C) This incision is then stretched along the axis of the septum. (D) The vessel edges are approximated using interrupted polyglyconate (Maxon) 7-0 suture with the knots on the extraluminal side.

![Figure 2.](image2) (A) CT angiography showing the middle hepatic vein (MHV), left hepatic vein (LHV), and left superior hepatic vein (LSV). (B) LSV and LHV with short bridging septum in between. (C) Venoplasty is done by interrupted suture approximating the cut edges of the veins on either side of the septum to lengthen the attachment between the 2 vessels.
A caliper was used to measure the diameter of the hepatic vein before and after venoplasty. If more than one orifice was found, i.e., right hepatic vein (RHV), accessory RHV, inferior RHV, or segment 8 vein, venoplasty was performed to create a single, wide outflow orifice. These techniques were as described above. The objective was to make a single orifice out of several orifices (Figs. 3 and 4). If there was tension between veins during approximation, it was prudent not to incorporate all the veins into one orifice in favor of creating two orifices out of the four openings or incorporating three vein openings to form a single orifice and the remaining vein was reconstructed with an interposition graft (Fig. 5).

The segment 8 vein was usually thin and fragile. Refinements in technique must be exercised to avoid lacerating this vein during venoplasty.

Our technique of recipient total hepatectomy has also been described previously in detail.6 In a recipient requiring a left lobe graft, a triple recipient hepatic venoplasty was performed to create a wide outflow orifice. The lumina of the three main hepatic veins were made confluent by cutting across the vessel walls between them, thus creating a big opening. Redundant, irregular tissues were trimmed when necessary. This recipient outflow orifice was tailored to be wider than the measured graft hepatic vein venoplasty. In a recipient requiring a right lobe, the recipient longitudinal RHV orifice was enlarged by trimming it longitudinally along the anterior wall of the vena cava and enlarging the same to a wider-size opening compared to the graft venoplasty.

This single, newly-created graft venoplasty opening was then anastomosed to the wider-size opening created in the recipient's inferior vena cava or hepatic veins using polypropylene 5-0 suture, assuring the correct orientation of the graft and recipient vessels. These techniques avoid interposition grafts, were easily performed at the back table, simplify graft-to-recipient cava anastomosis, and avoid venous outflow narrowing by creating a wide donor graft outflow orifice. Intraoperative Doppler ultrasonography was routinely performed to assess vascular patency and flow velocities upon completion of vascular anastomoses, and before and after closure of the abdomen.

**RESULTS**

A total of 29 left and 6 right graft venoplasties were performed. Tables 2 and 3 summarize the graft vessels that underwent venoplasty. Veno-venous bypass was not used in any recipient. Table 4 summarizes the recipient operative outcomes. Outflow patency and velocity determinations using 2-dimensional Doppler ultrasonography were done after reconstruction. All anastomoses were patent, with flow velocities between 30 and 40 cm/second, and either biphasic or triphasic waveforms. Graft congestion was not observed and there was no complication related to hepatic vein anastomosis immediately after venoplasty surgery. All grafts functioned well.

There were 2 outflow stenoses in which donor graft venoplasty was used, both using left donor grafts (2/29: 7%). Both occurred in pediatric patients and beyond 3 months after transplant. In the above hepatic venous
DISCUSSION

The manner of hepatic vein outflow reconstruction is a major issue in LDLT, in which partial liver transplantation is performed with preservation of the inferior vena cava.\(^5\)\(^,\)\(^9\) Several techniques of outflow reconstruction have been developed, most dealing with recipient vessels and left lobe grafts. A triangulation method to create a wide outflow orifice is advocated by Emond et al.\(^10\) Tanaka et al.\(^8\) widens the outflow by venoplasty of the recipient middle hepatic vein and left hepatic vein with a right caudal extension in the inferior vena cava, whereas Matsunami et al.\(^11\) used triple recipient hepatic vein reconstruction with creation of a long venous trunk. Graft septoplasty and recipient vena cava orifice widening by cutting across intervening septa among the 3 recipient hepatic veins and trimming of irregular edges were developed by De Ville et al.\(^6\) in LDLT. Recently, Sugawara et al.\(^12\) recommends using a V-shaped patch vein graft on the anterior wall of the recipient hepatic vein to widen and elongate the orifice in right lobe outflow reconstruction, whereas Hwang et al.\(^13\) developed a quilt venoplasty technique using autologous greater saphenous vein graft to reconstruct multiple or variant short hepatic veins in right liver grafts.

Congestion should be avoided in the graft during reperfusion as this leads to graft dysfunction and even early graft failure, especially in marginally-sized donor grafts, as venous outflow disturbance adversely affects the regenerative capacity of a partial liver graft.\(^14\) Some authors advocate reconstruction of most sizeable hepatic veins to inclusion of the middle hepatic vein to guarantee uniform venous drainage and optimum graft function. But reconstruction of multiple hepatic veins may be technically difficult, time consuming, and prolong ischemia time.

Liu et al.\(^15\) and Lo et al.\(^16\) have developed a hepatic venoplasty technique in which the RHV and middle hepatic vein are joined together to form a triangular cuff for single anastomosis to a matched triangular opening in the recipient’s inferior vena cava to ensure excellent drainage in the right lobe graft. In addition, Kinkhabwala et al.\(^2\) in a review of 48 right lobe LDLT stressed that outflow obstruction can be avoided if close attention is given to creating a wide RHV anastomosis.

As much as possible, multiple hepatic veins are reconstructed by direct end-to-end anastomosis. Vein graft either from cryopreserved or recipient native veins is also used in reconstruction of multiple hepatic veins for adequate graft drainage. Extra anastomoses are made unnecessary. The adjustments in the exact length, diameter, and orientation of the vessels may be difficult, time consuming, and may lead to graft dysfunction or failure as result of obstruction. The present techniques minimize these technical difficulties and offer the distinct advantage of avoiding the possibility of obstruction due to kinking or malalignment of graft-cava vessels because the direct anastomosis of the graft hepatic vein venoplasty orifice to a wider opening in the vena cava is short.

The good results of the venoplasties described in this series are evident in the excellent biphasic or triphasic waveforms and >30 cm/second velocities demonstrated by Doppler ultrasound, and in the low complication rate. There have been no technical problems encountered during the procedure. All recipients toler-

---

**TABLE 2. Vessels Which Underwent Venoplasty in Left Grafts (N = 29)**

<table>
<thead>
<tr>
<th>Vessels included in venoplasty</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHV + LSV</td>
<td>23</td>
<td>79</td>
</tr>
<tr>
<td>LHV + segment 3 vein</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>LHV + MHV</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>LHV + LSV + segment 4 vein</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

**Abbreviations:** LHV, left hepatic vein; LSV, left superior vein; MHV, middle hepatic vein.

**TABLE 3. Vessels that Underwent Venoplasty in Right Grafts (N = 6)**

<table>
<thead>
<tr>
<th>Vessels included in venoplasty</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHV + aRHV</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>RHV + IRHV</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>IRHV + IRHV</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>RHV + aRHV + segment 8 vein</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Segment 8 vein + MHV + IRHV</td>
<td>1</td>
<td>17</td>
</tr>
</tbody>
</table>

**Abbreviations:** RHV, right hepatic vein; aRHV, accessory right hepatic vein; IRHV, inferior right hepatic vein; MHV, middle hepatic vein.
ated shortened inferior vena cava clamping time, thus avoiding veno-venous bypass.

In summary, we have developed these donor graft hepatic vein venoplasty techniques for multiple hepatic veins that can be used in either right- or left-lobe liver transplantation. They are devised to ensure a single, wide orifice in the hepatic veins for a single-outflow anastomosis with the recipient's hepatic veins or vena cava. The techniques described are simple, are easily performed at the back table, obviate the need for interposition grafts, simplify graft-to-recipient cava anastomosis, and avoid graft venous outflow narrowing by creating a large orifice, thus ensuring adequate venous drainage.

REFERENCES


