Hepatic Artery Reconstruction in Living Donor Liver Transplantation From the Microsurgeon’s Point of View

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Microvascular surgery for the reconstruction of the hepatic artery in living donor liver transplantation is discussed from the microsurgeon's point of view. A refined operative procedure to improve the safety of the anastomosis is described. In living donor liver transplantation, the hepatic artery of the graft is short and small, the operative site is deep and mobile, and the anatomic arrangement of the graft left hepatic artery may differ from that of the recipient's dilated hepatic artery. To create a safe anastomosis under these conditions, recipient arteries that were slightly smaller than the graft artery were dissected. Without the size discrepancy, an end-to-end anastomosis could be created. Some refinements to create a good operative field made the anastomosis easy. The apparatus and techniques used in free-flap transfer facilitated a clean anastomosis. We anastomosed 44 arteries in 40 patients undergoing living donor liver transplantation using microsurgical techniques. Neither a decrease in the arterial blood flow nor hepatic artery thrombosis was noted. The refined operative procedure we describe in this report can be used to overcome the problems associated with the hepatic artery anastomosis in living donor liver transplantation.

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In living donor liver transplant surgery (LDLTx), reconstruction of the hepatic artery is difficult because the graft hepatic artery is too fine to anastomose even using surgical loupes. Thus the incidence of hepatic arterial thrombosis (HAT) was high before the introduction of microsurgical techniques.1,2 The results have improved dramatically,2 and microsurgical techniques have become essential in LDLTx.2-4 Anastomosis of the hepatic artery is usually performed by the transplant surgeon. At the Shinshu University Hospital, a microsurgeon performs or supervises this procedure. In this article, we describe our microsurgical techniques for anastomosis of the hepatic artery in LDLTx and discuss them from the microsurgeon's point of view.

Materials and Methods

Between June 1990 and November 1995, 50 patients with end-stage liver disease underwent LDLTx at the Shinshu University Hospital. In the first 10 cases, the transplant surgeon anastomosed the hepatic artery using surgical loupes. In the next 40 cases, the hepatic artery was anastomosed using an operating microscope (Olympus OME 5000, Tokyo, Japan). In the 11th to 18th cases, a microsurgeon (S.F.) performed the anastomosis. In the 19th to 50th cases, a transplant surgeon (T.I.) anastomosed the hepatic artery under the supervision of the microsurgeon.

Angiography of the hepatic artery was performed in each donor, and the diameters of the left and middle hepatic arteries were measured. The recipient hepatic arteries were generally enlarged because of liver disease, except in patients with fulminant hepatic failure or familial amyloid polyneuropathy. Based on these findings, various recipient arteries slightly smaller than the donor artery were dissected to avoid extreme size discrepancies between the arteries to be reconstructed by end-to-end anastomosis, even if it was necessary to reconstruct two graft arteries. The dissection of the recipient artery was often extended to the subsegmental branches. The harvesting and implantation techniques used for the living donor liver grafts have been described elsewhere.5

The arteries were anastomosed after venous and portal reconstruction. The operating table was tilted...
slightly head-down, the operating microscope was inclined toward the caudal surface of the graft, and the first assistant retracted the graft while paying special attention to the blood flow in the portal and hepatic veins. The right costal arch was retracted gently, and a folded surgical towel was placed in the right upper quadrant to prevent the graft from falling back. The direction of the vessels was controlled by the first and second assistants by retraction of the liver and the intestines so that they were parallel to the operator in a horizontal plane (Fig. 1A and B). The flow in each recipient artery was assessed by releasing the vascular clamp temporarily. Arteries without strong pulsatile blood flow were excluded. If there were two arteries in the graft, the recipient’s left hepatic artery was anastomosed to the left-side artery of the graft, and the recipient right hepatic artery was anastomosed to the other graft artery. When there was only one artery in the graft, the recipient artery with the diameter closest to that of the graft artery was selected.

The arteries were held with a disposable double clamp (Bear TKL-W, 120 g; Kyowa Precision Medical Instruments, Ichikawa, Japan). The excess adventitia at the end of the vessel was trimmed, and the artery was irrigated gently with a solution of heparinized saline (100 unit/mL) to wash away any loose clots in the lumen. A solid-colored background with stay suture slits made from a sterilized yellow vinyl sheet was placed under the arteries (Fig. 2A). Interrupted suturing with 8-0 or 9-0 monofilament nylon (Ethilon; Ethicon, Somerville, NJ) was used for the anastomosis. Eight sutures were necessary to complete the anastomosis. During this procedure, the patient was ventilated manually, and respirations were stopped when the needle was passed through the artery.

The first suture was inserted at the 150° position with regard to the horizontal plane because it is technically difficult to place it at 180°. After tying the suture, one end was fixed to the background. Fine forceps were then inserted in the lumen, and the vessel wall was pulled gently to identify the exact 180° position from the first stitch (− 30° position; Fig. 2B). The second suture was placed at the − 30° position, and the suture was fixed to the background. After two stay sutures were placed 180° apart and fixed to the background (Fig. 2C), a third suture was placed at the center of the anterior wall, cut long, and left untied (untied suture technique, Fig. 3A). The fourth and fifth sutures were placed halfway between the third suture and each stay suture. The untied suture technique allows the surgeon to place the fourth and fifth sutures without piercing the back wall (Fig. 3B and C). After the fifth suture was tied, the untied suture was tied (Fig. 3D). The vascular clamp was then flipped over, and the posterior wall was anastomosed in the same manner used on the anterior wall. These are the same techniques used in free-flap transfer.

If there were two arteries in the graft, the larger artery

Figure 1. Schematic drawings of how to create the proper conditions for a good anastomosis. (A) The first assistant retracts the graft while paying special attention to the blood flow in the portal and hepatic veins. The right costal arch is retracted gently, and a folded surgical towel is placed in the right upper quadrant to prevent the graft from falling back. The direction of the vessels is controlled by the first and second assistants by retraction of the liver and the intestines to set the arteries parallel to the operator in the horizontal plane. 1, First assistant’s hand; 2, second assistant’s hand; Op, operator. (B) Close-up view. ST, surgical towel; G, hepatic artery of the graft; HA, recipient’s hepatic artery; P, portal vein.
was anastomosed first. The clamp on the smaller artery of the graft was then released. When pulsatile back-bleeding was obtained, the artery was ligated. If back-bleeding was poor, the smaller artery was anastomosed with another recipient hepatic artery. Blood flow was assessed both intraoperatively and postoperatively by color Doppler ultrasonography with a 5- or 7.5-MHz convex probe (Aloka SSD 680, Tokyo).  

Anticoagulant therapy during and after surgery in pediatric recipients has been described elsewhere. The anticoagulant therapy used in adult recipients was the same as that used in pediatric recipients.

Figure 2. Schematic drawings of how to place the two stay sutures. (A) The arteries are held with a disposable double clamp, and a solid-colored background with stay suture slits made from a sterilized yellow vinyl sheet is placed under the arteries. The first suture is placed at the 150° position. (B) One tail of the suture is fixed to the background. Fine forceps are then inserted into the lumen to pull the vessel wall gently to locate the exact 180° position from the first stitch (−30° position). (C) The two stay sutures 180° apart are fixed to the background.

Figure 3. Schematic drawings of the untied suture technique. (A) The third suture (3) is placed at the center of the anterior wall, cut long, and left untied. (B and C) The fourth (4) and fifth (5) sutures are placed halfway between the third suture and each stay suture. The untied suture technique allows the surgeon to place the fourth and fifth stitches without piercing the back wall. (D) After the fifth suture is tied, the untied suture is tied. The vascular clamp is then flipped over, and the posterior wall is anastomosed in the same manner used on the anterior wall.
Ethical Approval
These operations were performed after informed consent was obtained from the patients and approval was obtained from the Ethics Committee of Shinshu University.

Results
The primary diseases in the last 40 recipients included biliary atresia (n = 25), fulminant hepatic failure (n = 4), familial amyloid polyneuropathy (n = 5), primary biliary cirrhosis (n = 3), and other diseases (n = 3). The ages of the patients ranged from 6 months to 54 years. There were 29 patients under 15 years of age. Their body weights ranged from 6.0 to 54.0 kg (mean, 21.7 kg), with 16 patients weighing less than 10 kg. The liver grafts were left lateral segment (n = 14), extended left lateral segment (n = 10) or whole left liver (n = 16). Forty-four arteries in 40 patients were anastomosed using the operating microscope. Two arteries were reconstructed in 4 patients. The diameters of the hepatic arteries of the grafts and the recipients were recorded (Tables 1 and 2). Intraoperative reanastomosis because of proximal stenosis of the hepatic artery caused by spasm was necessary in only 1 patient. After reconstruction of the hepatic artery, sufficient pulsatile arterial blood flow signals were obtained in all patients intraoperatively and postoperatively. There was neither HAT nor a decrease in the arterial flow intraoperatively or postoperatively.

Discussion
In orthotopic liver transplantation, risk factors for HAT have been reported to be recipient weight <10 kg,11 or 15 kg12 and graft hepatic artery diameter <3 mm.13 Thus anastomoses involving smaller arteries are associated with increased occurrence of HAT. In LDLTx, the hepatic artery must be anastomosed at a peripheral location. The incidence of HAT in LDLTx has been reported as high as 14%2 to 25%1 when microsurgical techniques are not used.

The introduction of microsurgical techniques for hepatic artery anastomosis in LDLTx has improved the outcome of surgery dramatically, with a decrease in the incidence of HAT to 1.7%. These techniques have become essential in LDLTx.2-4 However, several difficulties associated with microsurgical anastomosis of the hepatic artery in LDLTx have recently been reported.14 These include creation of the operative field, size discrepancies between the recipient and graft hepatic arteries, and uselessness of the recipient hepatic artery. We have described our approach to the anastomosis of the hepatic artery in LDLTx from the microsurgeon’s point of view.

In clinical microsurgery, surgeons pay more attention to the creation of proper conditions than to the performance of the microvascular anastomosis itself.7,8 In LDLTx, the hepatic artery of the graft liver is short and small, and the operative site is deep and moves with respirations and heartbeat. These factors make the procedure difficult. Inomoto et al14 have reported that it is difficult to obtain a good operative field and a sufficient view through the microscope when there is a marked discrepancy between the size of the graft and the recipient’s abdominal cavity. This is particularly true when the ratio of graft weight to recipient body weight is >5%. In this situation, the graft overlaps the recipient hepatic artery, and the anastomosis is usually with incomplete visibility.14 We incorporated some modifications to facilitate the procedure and avoid these difficulties. By tilting the operating table, placing a surgical towel in the right upper quadrant, retracting the right costal arch, and retracting the graft and the intestines, we were able to reduce the depth of the operative site. The parallel direction of the vessels in relation to the surgeon in the horizontal plane facilitated the

<p>| Table 1. Diameter of Recipient Hepatic Artery |</p>
<table>
<thead>
<tr>
<th>Diameter</th>
<th>No. of Arteries</th>
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<td>&lt;2 mm</td>
<td>13</td>
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<tr>
<td>2 to 3 mm</td>
<td>23</td>
</tr>
<tr>
<td>&gt;3 mm</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
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<p>| Table 2. Recipient Arteries Used for Anastomosis |</p>
<table>
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<th>Artery</th>
<th>N</th>
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</thead>
<tbody>
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<td>Anterior branch of right hepatic artery</td>
<td>11</td>
</tr>
<tr>
<td>Posterior branch of right hepatic artery</td>
<td>3</td>
</tr>
<tr>
<td>Right hepatic artery</td>
<td>19</td>
</tr>
<tr>
<td>Middle hepatic artery</td>
<td>3</td>
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<td>Left hepatic artery</td>
<td>8</td>
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<td>Total</td>
<td>44</td>
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anastomosis because it is difficult for a right-handed surgeon to anastomose vessels that run obliquely toward him or her from left to right. These maneuvers and dissection of a greater length of the recipient artery enabled us to anastomose the arteries beyond the costal margin with uninhibited visibility.

Anatomic variations of the graft left hepatic artery may often result in a discrepancy with the recipient's dilated hepatic artery. Inomoto et al. have reported 30 instances of size discrepancy between the graft and recipient hepatic arteries in 120 cases of LDLTx. They used several procedures, including oblique cutting, the fish mouth method, the funnelization method, and end-to-side anastomosis to match the size of the arteries. There were no episodes of HAT in their 30 reconstructions. However, size-matching procedures are difficult. In addition, a size discrepancy will create a gap at the anastomosis, resulting in flow turbulence that may contribute to thrombus formation. Another solution for size discrepancy is interposition vascular grafting. However, this procedure requires two anastomoses, is technically complicated, and increases the risk of thrombosis. In contrast, an even end-to-end anastomosis does not result in turbulent blood flow near the anastomotic site, and the procedure is simple and easy. Thus, we prefer end-to-end anastomosis without size discrepancy, reconstructing the hepatic artery using segmental branches if necessary. Because smaller arteries have lower blood flows and are more likely to thrombose, it is important to select vessels with strong pulsations and to perform a clean end-to-end anastomosis. This also provides longer vascular pedicles and allows several chances for end-to-end anastomosis without size discrepancies if the first anastomosis fails.

In the microvascular anastomosis, the apparatus and techniques used by microsurgeons are helpful. A double clamp provides a stable platform for anastomosis and prevents distortion between the two arteries during the procedure. A solid-colored background with stay suture slits facilitates a well-balanced anastomosis, and the untied suture technique prevents violation of the back wall of the vessels. These factors contribute to a decreased occurrence of technical errors, ensuring the safety of the procedure.

In our series, there were no recipients whose hepatic arteries could not be used for anastomosis. However, if that had been the case, we could have used the splenic artery or a vascular graft.

Our basic concept is to create the best possible conditions for anastomosis and to perform a simple end-to-end anastomosis. Because this contributes to the safety of the procedure, we believe a microsurgeon with vast experience in microvascular anastomosis should participate in the LDLTx operation.

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References


