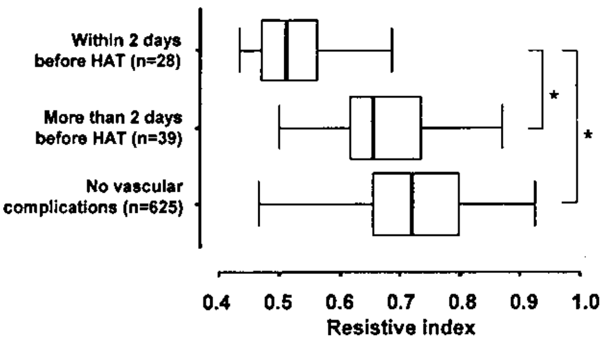

Fig. 3. Distribution of RI values in box-and-whisker plots. In patients with HAT, the RI values 2 days before the onset of HAT were significantly lower than those 2 to 7 days before the onset of HAT or those in patients without HAT. *$p < 0.001$. *n* indicates the number of the US records.

Table 1. Sensitivity and specificity for HAT diagnosis for multiple discriminatory thresholds of RI

Threshold	TN	TP	FN	FP	Sensitivity (%)	Specificity (%)
< 0.4	660	1	29	2	3	100
< 0.5	652	13	17	10	43	99
< 0.6	564	25	5	98	83	85

FN, false negative; FP, false positive; HAT, hepatic artery thrombosis; RI, resistive index; TN, true negative; TP, true positive

10], however, Doppler US was not performed routinely and the indications for Doppler US were not clarified.

Recent studies [58] have indicated that protocol Doppler US is useful for early HAT detection. Urgent thrombectomy and revascularization based on the findings of protocol study significantly reduced the rate of late biliary complications and graft loss subsequently complicated by HAT. The present study differed from previous studies in which RI data were consecutively and prospectively collected. Nolten and colleagues [11] reported a qualitative change in the Doppler waveform over time. Although the waveform was initially normal in appearance, it progressed to an absent diastolic flow, dampening of the systolic peak, and, finally, loss of the hepatic arterial signal. The present study confirmed their findings, indicating that RI values of less than 0.6 predict HAT onset within 2 days with 83% sensitivity and 85% specificity.

In summary, we reviewed 692 Doppler US records in 70 pediatric patients. RI was a sensitive predictor for HAT during the first 2 weeks after LDLT. Thrombectomy and reanastomosis should be considered when RI values are less than 0.6 in protocol Doppler US.

Acknowledgments. This study was supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture; a Grant-in-Aid for Research on the Human Genome; and grants for tissue engineering, food biotechnology, health sciences research from the Ministry of Health, Labor and Welfare of Japan.

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Sharing the Middle Hepatic Vein between Donor and Recipient: Left Liver Graft Procurement Preserving a Large Segment VIII Branch in Donor

Yoji Kishi, Yasuhiko Sugawara, Nobuhisa Akamatsu, Junichi Kaneko, Yuichi Matsui, Norihiro Kokudo, and Masatoshi Makuuchi

There are few reported techniques to minimize the congestion in the donor after left liver graft procuring. If a large tributary of the middle hepatic vein (MHV) draining segment VIII (V8) converges into the root of the MHV in a donor of left liver, this branch should be preserved on the donor side. The volume of congested area when the V8 was ligated was predicted preoperatively by computed tomography (CT) and examined intraoperatively by the clamp test. Postoperative regeneration of the donor liver was evaluated by CT volumetry. This technique was used in 3 cases. The regeneration rate after 3 months of the right paramedian sector was 27, 38, and 8%, and that of the right lateral sector was 31, 63, and 39% in each donor, respectively. No severe complications occurred in the donors. In conclusion, V8 preservation in donors who underwent left liver resection led to satisfactory regeneration both of the right paramedian and lateral sectors and can minimize congestion in remnant liver. (*Liver Transpl 2004;10:1208–1212.*)

A vital issue in living donor liver transplantation (LDLT) is the preservation of a satisfactory blood supply and venous return in both the right and left livers to maximize donor safety and graft function. When splitting the liver along the main portal fissure to procure a hemiliver graft, however, it is practically impossible to maintain complete venous outflow in both, because the middle hepatic vein (MHV) can usually be preserved on only one side. Interruptions of regional venous outflow inevitably cause congestion in the liver. Regional venous outflow disturbances will theoretically disrupt the function of the relevant hepatic parenchyma.[1]

In right liver graft transplantation, various strategies have been reported to reduce the congested area of the right paramedian sector, such as the reconstruction of tributaries of the MHV[2,3] or the use of a right liver graft including the MHV.[4] There are, however, few reported techniques to minimize the congestion in the donor after left liver graft procurement. Here we report a left liver graft without a branch of the MHV tributary that drains the cranial part of the right paramedian sector (V8) to minimize congestion of both the graft and remnant donor liver in left liver graft transplantation.

Patients and Methods

From February 1996 to September 2003, 240 consecutive LDLTs were performed at our institution. Left liver with caudate lobe graft was used in 91 patients. In every donor, sectional computed tomography (CT) volumetry was performed preoperatively and a left liver with caudate lobe graft was indicated when the volume was over 40% of the recipient standard liver volume.[5]

The indication for procurement of the left liver graft was as follows: CT volumetry of donor liver was performed; a 3-dimensional image was reconstructed from CT using Region Growing software (Version 0.5a; Hitachi Medical, Chiba, Japan); if the volume drained by a V8 branch was large (Fig. 1), a left liver graft without a V8 branch was considered; three donors had a large V8 converging into the root of the MHV, and this branch drained a large part of right paramedian sector and a part of right lateral sector; then a left liver graft was procured, preserving this tributary in the cases reported here; case 1 was a 42-year-old female with hepatic failure due to primary biliary cirrhosis and the left liver was donated by her 42-year-old husband; case 2 was a 37-year-old female with primary biliary cirrhosis and the donor was her 66-year-old father; case 3 was a 14-year-old female with biliary atresia and the donor was her 45-year-old mother.

In the donor operation, MHV tributaries were confirmed by intraoperative ultrasonography. After dissection of the coronary ligament, the confluence of the left and middle hepatic veins was sufficiently exposed. The dissecting line of the

Abbreviations: CT, computed tomography; LDLT, living donor liver transplantation; MHV, middle hepatic vein; V8, MHV tributary that drains the cranial part of the right paramedian sector.

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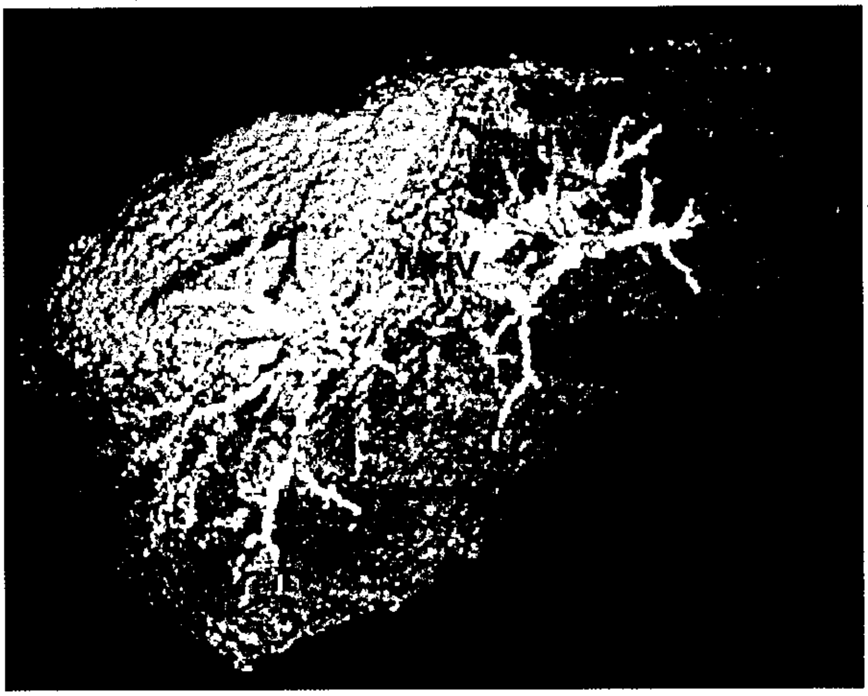

Figure 1. Computer-generated 3-dimensional image of the reconstruction. The red-colored vein indicates a V8 branch that was preserved on the donor side. The area drained by the V8 is shown in light brown. The white line in the left panel shows the dissection line of the hepatic veins. Abbreviations: LHV, left hepatic vein; MHV, middle hepatic vein.

parenchyma was determined according to the demarcation line that appeared by clamping one side of the hepatic artery and portal vein. Dissection of the liver parenchyma was performed using an ultrasonic surgical aspirator (SNP-5000; Aloka, Tokyo, Japan) under Pringle's maneuver.[6,7] During the division of the liver parenchyma, MHV tributaries of more than 5 mm in diameter were preserved using the sling suspension technique.[8] After completion of the parenchymal dissection, the congested area was evaluated as previously described.[9] In brief, after clamping each tributary of the MHV, Doppler ultrasonography was performed to evaluate the portal flow to segment VIII. Subsequently, the right hepatic artery was clamped for a few minutes and the congested area was estimated. When the area of congestion was too large or Doppler ultrasonography indicated reversed portal flow to segment VIII, the MHV was transected proximal to the root of the V8 branch.

The orifice of the hepatic veins of the graft became inevitably separated or became 1 orifice with a septum. Furthermore, the length of the exposed vein was decreased. For easier anastomosis, plasty of the vein orifice on the graft was performed using a cryopreserved deceased donor vein (Fig. 2). To widen the orifice of the superficial branch of the left hepatic vein or that of the MHV, slits were made on the bilateral side of the hepatic vein orifice of the graft. On the recipient side, the venoplasty to make 1 orifice from the left hepatic vein and MHV was performed by the technique described previously.[10] An end-to-end anastomosis was then made between the graft and recipient orifices. The caudate lobe was procured with the left liver and if there were large caudate veins, they were reconstructed.[11]

In recipients, the vascular flow of the graft was checked by Doppler ultrasonography twice a day for the first 14 days and once a week thereafter until hospital discharge. Serum transaminase levels were checked every day for 4 weeks after the operation. In donors, serum transaminase was examined every day for 1 week after the hepatectomy. In both donors and recipients, abdominal CT was performed 3 months after the operation. The regeneration of each sector of the livers was calculated as described elsewhere.[1] The regeneration rates were compared with those of 16 donors who underwent both left hepatectomy with total MHV deprivation and postoperative CT. The Mann-Whitney test was used for the statistical analysis. Measured variables were expressed as range and median. A P value less than .05 was considered significant.

Results

Donors

The operative time and blood loss was 515, 497, and 530 minutes, and 620, 775, and 490 mL, respectively. Postoperatively there were no severe complications to necessitate reoperation. Each donor was discharged on the 12th, 14th, and 16th postoperative day. During the

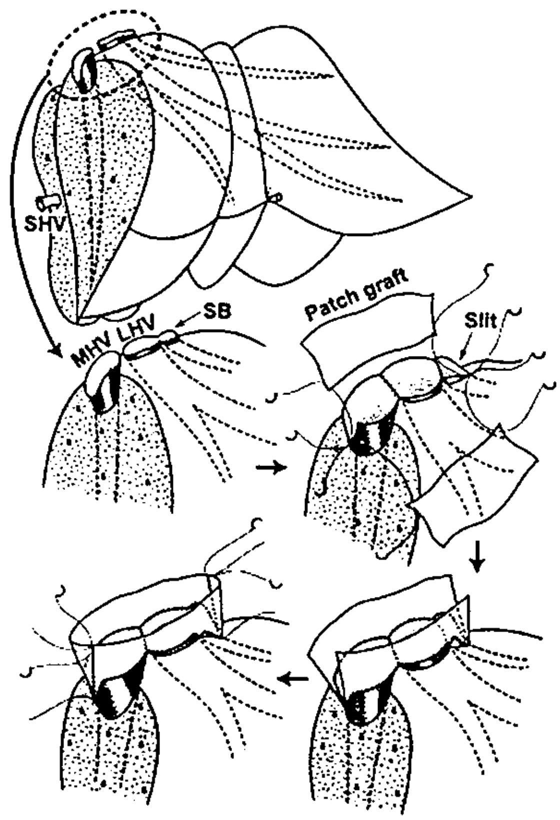

Figure 2. Venoplasty of the stumps using patch grafts. After plasty to make 1 orifice, a slit was made bilaterally to widen the orifice and 2 patches were sutured to the anterior and posterior edges. Each side of the patch was then sutured. The stump was extended and enlarged. Abbreviations: SHV, short hepatic vein; MHV, middle hepatic vein; RHV, right hepatic vein; SB, superficial branch.

3 months after LDLT, comparable regeneration between the right paramedian and lateral sectors was seen in the 3 donors (Table 1).

The regeneration rates of the right paramedian and lateral sector of the 16 donors who underwent left hepatectomy with total MHV deprivation were −20% to 99% (median 3%) and −27% to 118% (median 31%), respectively. There was no significant difference between the 3 cases with V8 preservation and the 16 donors with MHV deprivation in regeneration rate of either the paramedian (P = .12) or lateral (P = .57) sector.

Recipients

The operative time and blood loss of the 3 patients were 880, 955, and 913 minutes, and 4,276, 5,315 and 2,295 mL, respectively. The cold / warm ischemic time of the graft in each case was 106 / 59, 138 / 64, and 150 / 62 minutes, respectively. In Cases 1 and 3, 1 caudate vein was reconstructed. In Case 2, there was no caudate vein with a diameter of more than 5 mm and the reconstruction was not performed. The hospitalization duration after LDLT was 37, 72, and 30 days. During the hospitalization, Doppler ultrasonography revealed a well-maintained triphasic pattern of venous flow and no findings of arterial or portal venous thrombosis in any patient.

Laboratory data indicated that the maximum serum alanine aminotransferase level (376, 314, and 868 IU/L) occurred within the 2nd postoperative day in all cases. In Case 2, a splenectomy was performed simultaneously because of thrombocytopenia. Pancreatic juice leakage occurred postoperatively, but this was treated conservatively by percutaneous drainage, which resulted in a 72-day-long hospitalization. After discharge, no signs of venous stenosis such as persistent abnormal liver function, hypoalbuminemia, ascites, or pleural effusion were observed in either patient.

Discussion

In LDLT, donor safety must be the 1st priority. Preoperative liver volumetry by CT is one of the most important methods for selecting an appropriate donor. Most transplant centers in Western countries choose right liver graft routinely in adult-to-adult LDLT.[12] Right

Table 1. Liver Regeneration in Donors Estimated by Computed Tomography

	RPM			RLS		
Case	Pre (mL)	Post (mL)	RR (%)	Pre (mL)	Post (mL)	RR (%)
1	498	630	27	298	391	31
2	254	351	38	236	386	63
3	462	562	22	243	338	39

Abbreviations: RPM, right paramedian sector; RLS, right lateral sector; Pre, volume on preoperative CT; Post, volume on CT 3 months after LDLT; RR, volume regeneration rate given by (postoperative volume-preoperative volume)/preoperative volume × 100 (%).

liver procuring, however, could impose a higher surgical risk on donors, as reflected by the volume of the residual liver mass.[13] Furthermore, not all donors can provide their right liver.[14] Fan et al.[15] concluded that safe donation was possible only when the estimated residual liver volume was over 30%. Left liver with the caudate lobe can be used as an alternative graft with[12] or without[16] reconstruction of the caudate vein if it is more than 40% of the recipient's standard liver volume.[15]

The MHV usually drains most of the paramedian sector and has a limited role in draining segment IV.[17] For left liver procuring in adult LDLT, the liver parenchyma is usually divided along the right side of the MHV to maintain high graft viability. Although this procedure can cause congestion and atrophy in the paramedian sector of the remnant right liver,[1] congestion is not a significant clinical problem. A compensatory hypertrophy of the right lateral sector may be induced.[18] According to our previous study,[9] in 26% of donors no significant congestion will occur because the regurgitated blood through the right paramedian vein flows into the right lateral vein via intrahepatic venous communication.

There are, however, some anatomic variations of the MHV. A previous report[19] revealed an MHV variation during resection of the right paramedian sector for tumor resection. When a large tributary of the MHV draining segments V and VI was divided, the surface of segment VI became dark purple. To relieve the congestion of segment VI, the MHV tributaries were reconstructed. The MHV sometimes drains a large part of segment VI, in which case, a trunk of the MHV must be preserved on the donor side.[20]

When segment IV is exclusively drained through left hepatic or scissural vein, the present technique will be less relevant. We must note a large interindividual difference in the graft volume regeneration after partial liver transplantation, which might be due to individual anatomical variation in the venous drainage. In the present analysis, we could not clearly show more satisfactory regeneration in the right paramedian sector by V8 preservation. It might be due to the limited number of cases with the present technique.

Another problem with the present technique might include the possible venous graft failure in the long term.[21] Millis et al.[22] reported a 51% complication rate after using cryopreserved vascular graft. Kuang et al.[23] experienced complications including aneurysm, thrombosis, and stricture in 8 of the 9 cryopreserved vein grafts, which were used for portal vein and hepatic arterial interposition. These previous discouraging results indicate that long-term follow-up will be necessary to confirm the feasibility of the technique.

In this report, we propose an option for left liver graft procurement by preserving a large V8. Postoperative CT revealed comparable regeneration of the right paramedian and lateral sectors in donors. Although the indication for the technique is limited by the MHV anatomy, it will minimize liver congestion and can contribute to reducing donor risk.

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Alternatives to the Double Vena Cava Method in Partial Liver Transplantation

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Minimizing graft congestion in partial liver transplantation is important, especially when the graft weight is marginal for the recipient metabolic demand. We prefer the double vena cava technique for reconstructing middle hepatic vein tributaries with thick, short hepatic veins because the technique can reduce the warm ischemic time of the graft and make a wide anastomosis. This technique requires a cryopreserved superior or inferior vena cava. We devised an alternative double vena cava method using iliac or femoral vein grafts and applied it to two right liver transplantation patients. There was no postoperative hepatic venous outflow block in either patient. In conclusion, application of this technique, even in the absence of a suitable vena cava, can help to minimize graft congestion. (*Liver Transpl 2005;11:101–103.*)

Adequate outflow is indispensable for graft function. Hepatic vein reconstruction for adequate outflow, however, is technically demanding in partial liver transplantation because of eventual twisting or compression by the regenerated liver graft.[1] The double vena cava (VC) technique is indicated in a right liver graft if the graft includes major short hepatic veins.[2] Application of this technique, however, depends on the availability of a VC graft. Here we introduce two alternative methods to the double VC technique using venous grafts of smaller diameter.

Patients and Methods

From January 1996 to June 2004, 221 adult patients underwent living donor liver transplantation (LDLT) using a right liver graft at our hospital. The mean follow-up period was 850 days. The indications for LDLT in these patients included hepatitis C virus cirrhosis (n=54), primary biliary cirrhosis (n=50), hepatitis B virus cirrhosis (n=38), fulminant hepatic failure (n=25), cryptogenic cirrhosis (n=17), biliary atresia (n=14), metabolic disorder (n=6), primary sclerosing cholangitis (n=9), and autoimmune hepatitis (n=8). Details regarding the selection criteria and evaluation are described elsewhere.[3,4] All donors and patients provided written informed consent.

Homologous Vein Graft Preparation

Vein grafts were provided by the University of Tokyo Tissue Bank. The preservation and thawing methods have been previously described.[5] In brief, the vein grafts were obtained in a sterile manner from cadavers within 24 hours after cardiac arrest after obtaining informed consent. The specimens were frozen slowly in a programmable freezer at a rate of 1°C/min to -40°C and stored in liquid nitrogen until use. The cryopreservation medium consisted of Rosewell Park Memorial Institute 1640 solution (Whittaker Co., Sydney, Australia), 10% dimethylsulfoxide (Sigma, St. Louis, MO), and .5 g/L cefazolin sodium (Fujisawa, Tokyo, Japan).

For use, the packed vein grafts were placed at room temperature for 7 minutes and immersed gently in 37°C sterile saline for 30 minutes. Thereafter, the vein grafts were picked up from the bag and placed into the Alloflow (Lifenet, Virginia Beach, VA). Finally, they were rinsed with 1 liter of lactated ringer's solution (Lactec G, Ohtsuka Pharmaceutical, Tokyo, Japan).

Right Liver Harvesting

The right liver was harvested as described previously.[4] Briefly, in a basin, the graft was flushed with 1 liter of University of Wisconsin solution through a cannula inserted into the right portal vein. When the graft included major short hepatic veins, including inferior or middle right hepatic veins in the graft, the double VC technique was applied as described previously.[6] Briefly, a cryopreserved VC graft was prepared in a basin. A side hole was made in the wall of the VC, which was anastomosed with the hepatic veins in the graft. With this technique, all hepatic vein trunks of the recipient were sutured at their roots. Then, the inferior VC of the recipient was partially clamped and incised approximately 5 cm longi-

Abbreviations: LDLT, living donor liver transplantation; VC, vena cava.

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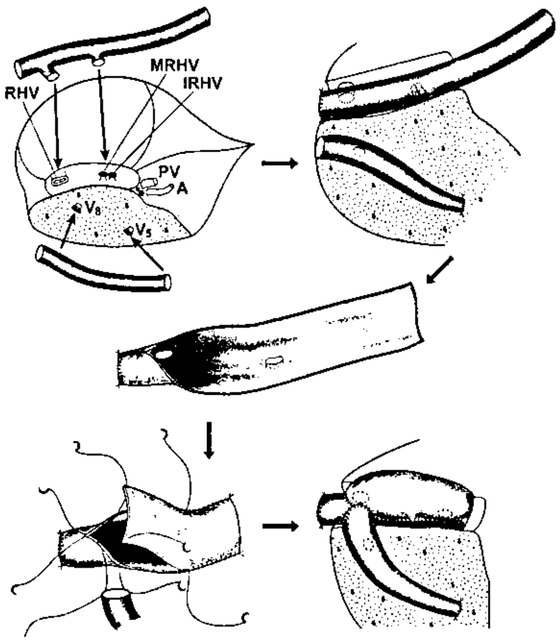

Figure 1. A Method Using Two Iliac Veins. One iliac vein was used to reconstruct a V8 and a V5. The other vein graft was folded at its caudal end. Abbreviations: RHV, right hepatic vein; MRHV, middle right hepatic vein; IRHV, inferior right hepatic vein; V5, drainage vein from segment V; V8, drainage vein from segment VIII; PV, portal vein; A, hepatic artery.

tudinally. The VC graft was similarly incised longitudinally, then anastomosed side-to-side with the inferior VC of the recipient. When a VC graft was not available, iliac or femoral vein grafts were used.

Results

Of 105 right liver grafts, 35 had major short hepatic veins. Of these 35 patients, 2 received two iliac veins and two femoral veins, respectively, as an alternative to VC grafts for the double VC technique.

Patient 1

The patient was a 61-year-old male with hepatitis C virus cirrhosis with a 2 cm diameter nodule of hepatocellular carcinoma. The right liver graft was harvested from his 56-year-old wife. The graft had a middle and inferior right hepatic vein. A VC graft was not available and two iliac veins (76 mm and 55 mm in length, respectively) were used for venous reconstruction at the bench (Figure 1).

One iliac vein was used for reconstruction of the middle hepatic vein tributaries (V5 and V8). The other iliac vein graft was used as an alternative to a VC graft. Its cranial end was closed. Two branches were anastomosed to the orifice of the right hepatic vein and orifices of the middle and inferior right hepatic veins together. The vein graft was 10 mm in diameter, which was too small for direct side-to-side anastomosis with the recipient's inferior VC. The iliac vein was incised longitudinally and the caudal side was folded. The two iliac veins were finally anastomosed side to end.

On the recipient side, all stumps of the hepatic veins were closed at their roots. The recipient inferior VC was semiclamped and incised longitudinally 5 cm in length. The folded iliac vein was incised similarly and sutured side-to-side. Cold and warm ischemic times were 140 minutes and 55 minutes, respectively. The postoperative course was uneventful. There were no vascular complications and Doppler ultrasonography 6 months after transplantation revealed well-maintained flow of all reconstructed veins.

Patient 2

A 44-year-old man underwent LDLT for alcoholic liver cirrhosis. The donor was his 42-year-old wife. A right liver graft with middle hepatic vein trunk was indicated.[7] The weight of the graft was 454 g, which corresponded to 36% of the recipient standard liver volume,[8] leading us to perform venous reconstruction at the bench. Two cryopreserved femoral vein grafts (each 100 mm long) were available.

Five hepatic vein orifices appeared on the inferior VC sulcus of the harvested graft (Figure 2). Two fem-

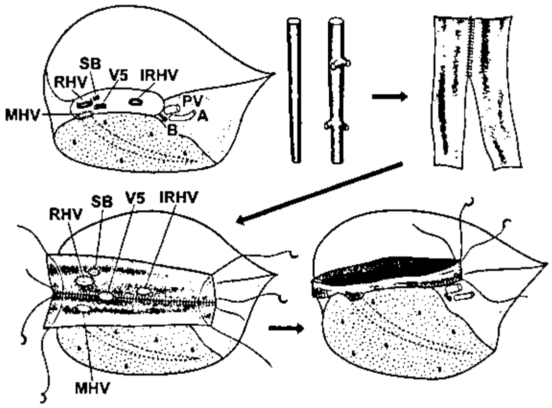

Figure 2. A Method Using Two Femoral Veins. One large rectangular sheet was made, which was sutured to five vein orifices. Abbreviations: MHV, middle hepatic vein; RHV, right hepatic vein; SB, superficial branch; IRHV, inferior right hepatic vein; V5, drainage vein from segment V; B, bile duct; PV, portal vein; A, hepatic artery.

oral veins were cut longitudinally and the two sheets were made into one sheet using interrupted sutures. The V5 orifice was sutured to the medial side of both sheets. Small holes were made on the sheet for anastomosis with the other four stumps of the short hepatic veins. The cranial and caudal ends of the sheet were then sutured to make a new "vena cava." On the recipient side, the inferior VC was cut longitudinally and sutured to the graft-side VC. Cold and warm ischemic times of the graft were 181 minutes and 85 minutes, respectively. Doppler ultrasonography revealed a well-maintained venous flow for 3 months after the operation. The postoperative course was uneventful except for surgical drainage of bile leakage on the fifteenth postoperative day.

Discussion

In adult-to-adult LDLT, right liver is frequently used. When the graft weight is marginal for recipient metabolic demand, the tributaries of the middle hepatic or short hepatic veins must be aggressively reconstructed. When the right liver graft has multiple short hepatic veins, the double VC method should be considered to decrease warm ischemic time. A large anastomosis should be made in a partial liver graft, which will regenerate and might compress the anastomotic site.[2] For this purpose, the double VC method is preferred, which secures a large outflow orifice. We describe two alternative techniques when VC grafts are not available.

The major concern in venous reconstruction using cryopreserved vein grafts is vein graft obstruction or the possibility of narrowing over the long term. We recently reported satisfying short-term results of hepatic vein reconstruction using cryopreserved grafts with a median follow-up of 9 months.[2] Millis et al.,[9] however, reported 51% complication rate after using a cryopreserved vascular graft. Kuang et al.[10] reported complications, including aneurysm, thrombosis, and stricture, in 8 of 9 cryopreserved vein grafts that were used for portal vein and hepatic arterial interposition. To date, we have not experienced any complications using cryopreserved vascular grafts, but the previous discouraging results indicate that long-term follow-up is necessary to confirm the practicality.

In right liver transplantation, the present techniques can be used to expand the chance for performing double VC reconstruction, which will contribute to satisfactory outflow.

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Revolution and Refinement of Surgical Techniques for Living Donor Partial Liver Transplantation

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Living donor liver transplantation (LDLT) was first successfully performed on a child in 1990 and the Shinshu group performed the same procedure on an adult for the first time in 1994. Over the past few years adult LDLT has been increasing worldwide because of the severe shortage of cadaveric organs, especially in locations where the transplantation of organs from brain-dead donors is rarely practiced. The surgical procedures for LDLT are more technically challenging than those for cadaveric whole liver transplantation. LDLT requires a full understanding of hepatobiliary anatomy and continuous technical refinement of the procedure. The development of innovative techniques is a key factor for a successful LDLT. Some of the technical highlights include selective vascular occlusion techniques for donor hepatectomy, hepatic arterial reconstruction under the microscope, the introduction of intraoperative ultrasound, graft volume estimation, hepatic venous reconstruction using cryopreserved vascular grafts, and the use of the right lateral sector of the liver. These techniques have improved the success rate of LDLT over the past few years. This review focuses on the surgical techniques for LDLT on the basis of our experience with adult LDLT at the Tokyo University Hospital.

Key Words: Living donor liver transplantation, middle hepatic vein, right liver graft

INTRODUCTION

The use of live donors for liver transplantation was initiated more than a decade ago as a solution to the cadaveric donor shortage for pediatric recipients.[1] Since the first successful case of LDLT performed on an adult patient in 1994,[2] this procedure is now widely applied to adult recipients, especially in countries where the availability of brain-dead donors is severely restricted.[3] This includes the United States and European countries where there is a critical shortage of cadaveric organs. In attempts to meet the growing needs of recipients, transplant surgeons have had to develop innovative techniques and appropriate algorithms to overcome deteriorating conditions and complications such as outflow and biliary complications.

In this review, several considerations of LDLT, including donor and graft selection criteria, technical highlights, and critical points necessary for successful patient outcome are discussed on the basis of our experience at the Tokyo University Hospital.

DONOR SELECTION CRITERIA

The first priority when performing LDLT is donor safety. Donor characteristics are the primary determinant of the outcome for both patients. Therefore, careful evaluation and selection of the donor are obligatory. In our department, a preoperative donor evaluation consists of three stages. In the first stage, patients and their families are given explanations about LDLT, including the risk of death for LDLT donors. After evaluating the medical and family history, social support system within the family, and psychological fitness, the donor's understanding of the risks involved with a liver resection and accompanying invasive tests must be confirmed for each donor candidate. The age of acceptable donors at our center is between 20 and 65 years with a

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relation to the recipient within the third degree of consanguinity.

The second phase involves performing liver function tests, ABO compatibility testing, lymphocyte cross matching; negative serology for hepatitis B and C, human immunodeficiency and adult T-cell leukemia viruses, cardiopulmonary function tests, the determination of tumor markers of donors over 40 years old, and a pregnancy test for female donors. ABO blood group incompatibility and positive lymphocyte cross matching are not definite exclusion criteria.

If there is no anomaly, the donor candidate can proceed to the third stage; a Doppler ultrasound should be performed for hepatic artery, portal vein, and hepatic vein evaluation. Computed tomography (CT) is used to measure graft volume. Hepatic angiography can be performed to evaluate vessel anatomy. The donor's own blood and plasma are banked preoperatively. Throughout the course of the donor evaluation, the spontaneous willingness of the donor candidate is repeatedly confirmed.[4] Signed informed consent is obtained before the surgery.[5]

Preoperative liver biopsy and steatosis in graft

Preoperative determination of the extent of hepatic steatosis is important to ensure both donor and recipient safety. Donors with significant steatosis may not tolerate surgery as well as those with nonsteatotic livers and they tend to have increased postoperative morbidity, mortality, transfusion requirements, and surgical time.[6] A liver biopsy must be performed for a secure evaluation of the liver. The indications for a liver biopsy, however, must be determined carefully and some patients may require hospitalization after the procedure (5% frequency) or experience serious complications (1%).[7-9]

The degree of steatosis acceptable for LDLT remains controversial. Marcos et al. reported no impairment of function in either the donor or recipient when using grafts containing less than 30% steatosis.[10] Fan et al. do not use a right liver graft with steatosis of 20% or more,[11] whereas other groups use liver grafts with steatosis of less than 50% if the graft volume-to-standard liver volume (SLV) of the recipient ratio is 40% or more.[12] At our center, when hepatic steatosis is suspected by computed tomography and biochemical data (i.e., aspartate aminotransferase < alanine aminotransferase), a liver biopsy for evaluating steatosis is considered. If time permits, the potential donor should undergo a period of prescribed diet and exercise. Livers with less than 10% hepatic macrosteatosis are preferred.[7]

Estimation of the liver graft

A major concern for the application of LDLT to adults is graft size disparity. Small-for-size grafts are defined as functionally insufficient grafts for satisfying the recipient's metabolic demand, which will predispose the recipient to injuries characterized by cholestasis and histologic features of ischemia after implantation.[13] On the other hand, harvesting a larger graft puts the donor at higher risk.[14] The right liver is not indicated as a graft when the estimated volume in donors is over 70%, according to the criteria of Fan et al.[11] We established a method for estimatinggraft volume using CT and the following formula to calculate the SLV (optimal liver mass) in recipients from their body surface area:[15,16]

$$\text{SLV (ml)} = 706.2 \times (\text{body surface area [m}^2\text{]}) + 2.4.$$

The volume of each sector of the donor liver is evaluated by CT. The predicted graft volume/SLV ratio is then calculated.[17]

Principally, grafts with a weight/recipient SLV ratio of 40% are preferred for use in adult patients. In low-risk patients, a right liver graft with or without the middle hepatic vein (MHV) are considered. In other words, grafts with an SLV ratio of 40% or less may suffice only in the ideal situation of a good-risk patient as proposed by Lo and associates.[18] Our data indicate that[19] 96% of patients survive with a graft weight ratio of over 40%, while only 80% of patients survive with a graft weight ratio of 40% or less. High-risk patients include those with primary biliary cirrhosis with a Mayo risk score[20-22] of less than,[10] metabolic disease, and fulminant hepatic failure. For higher risk patients, a left liver with or without a caudate lobe should be evaluated by CT volumetric analysis.[23,24] If the volume of the right lateral sector is greater than that of the left liver, the right lateral sector segments VI and VII, according to Coinaud's nomenclature for liver segmentation, should be considered for the graft.[5,22,23]

Objection against routine use of right liver graft

A right liver graft was first used for a pediatric case by Yamaoka et al.[25] It is now commonly used for adult patients. This procedure was followed by the introduction of an extended right liver graft, which includes the trunk of the MHV. This trend has grown rapidly.[26-28] At the same time, however, important ethical issues were raised regarding the execution of an extended hepatectomy on live donors.[3] Although graft size in living donors may be safely expanded, a multidisciplinary approach and meticulous donor evaluation are always necessary. We do not agree with the recent tendency to use a right liver graft routinely for almost all adult patients.[28] Based on our experience, the number of patients who inevitably need a right liver graft with the MHV is limited; we found that less than 10% of the recipients in our series required an extended right liver graft.

Evaluation of donor hepatic arterial anatomy

When planning a donor resection, a preoperative arteriography is necessary to assess the anatomy and quality of the vasculature of the resulting graft.[29] For example, upon performing a right liver LDLT, it is first necessary to determine which of the varied origins of the artery to segment IV is important for defining the optimal points for transection of the artery.[3] Although an angiography is a relatively invasive study with the potential for complications, the information it provides is essential for surgical planning and donor safety. Unfortunately, non-invasive techniques, such as magnetic resonance angiography or CT, are limited in their ability to demonstrate small vessels such as the accessory hepatic arterial branches.[28,30] The techniques for non-invasive imaging of smaller vascular structures are still under evaluation and are not yet sufficiently reliable for these purposes.

Intermittent inflow occlusion technique

In our department, a donor hepatectomy is routinely performed under Pringle's maneuver without any side effects. We postulate that the intermittent inflow occlusion acts as a preconditioning step and reduces blood loss during the hepatectomy.[31]

RECIPIENTS

During an evaluation of a liver transplant candidate for LDLT, there needs to be a balance between the severity of the liver disease and the adequacy of a partial graft for transplantation. Most of the complications associated with acute hepatic failure are reversible if the transplantation can be performed in the early stage.[32] Stable patients with chronic liver disease also benefit from living donors. Transplantation can be performed electively before decompensatory (i.e. fulminant hepatic failure with irreversible encephalopathy) complications occur.

Recipient surgery

The operative technique for recipients is based on the technique of whole liver resection with preservation of the inferior vena cava used for orthotopic liver transplantation.[33] A J-shape incision is made to open the abdominal space as is done for a right thoracotomy. Electrocautery is effective, time-saving, and useful for sharp dissection. An argon beam coagulator is useful to stop bleeding from the hepatic serosa. Each step of this operation requires meticulous maneuvers and great care to achieve an uneventful resection of the whole liver, while avoiding injury to the other visceral organs. It is important to make a large and long opening along the sides of the hepatic veins, and to maintain satisfactory portal, biliary, and hepatic arterial sources for the reconstruction. The right and left hepatic arteries should be dissected out as distally as possible, the left portal vein should be dissected up to the umbilical portion, which is just distal to the point of origin of the branch to segment,[2] and the right portal vein should be dissected up to its bifurcation into the anterior and posterior branches.

In recipients with little portosystemic collateral circulation (i.e., familial amyloid polyneuropathy, citrullinemia, acute hepatic failure), the prevention of portal congestion is necessary during the anhepatic phase. A temporary shunt between the portal vein and the inferior vena cava should be made.[34] Briefly, the portal vein branch, which will not be used for reconstruction, is anastomosed end-to-side or connected by a tube to the inferior vena cava. Blood flow through this shunt is maintained until portal venous reperfusion to the graft is achieved by portal vein anastomosis.

HEPATIC VENOUS RECONSTRUCTION

The provision of an adequate outflow is indispensable for graft function, thus, it is necessary to obtain a wide ostium and a sufficient length of the hepatic vein for anastomosis.

Left liver

Early cases of LDLT entailed an end-to-side anastomosis for hepatic vein reconstruction. A longitudinal cavatomy was made along the anterior aspect, and the hepatic venous branches, which were joined on the bench, were anastomosed end-to-side to the caval window.[3,35] Takayama et al. cautioned,[36] however, that a direct anastomosis of the hepatic veins to a thin inferior vena cava can cause a bend in the inferior vena cava at the anastomotic side, which can result in outflow occlusion.

Currently, an end-to-end anastomosis[37] is preferred. In such cases, size matching is important. The left hepatic vein (LHV) and MHV in the recipient can be joined into one.[38] If the diameter of the joined veins is smaller than the left liver graft's hepatic vein, a wider orifice can be constructed by venoplasty of three hepatic veins[39] in the recipient (Fig. 1).

In the first method for venoplasty, the neighboring walls were simply sutured together. The second method involves the use of the pantaloon technique. The parenchyma around the venous branches is aspirated using an ultrasonic dissector, resulting in elongation of the venous

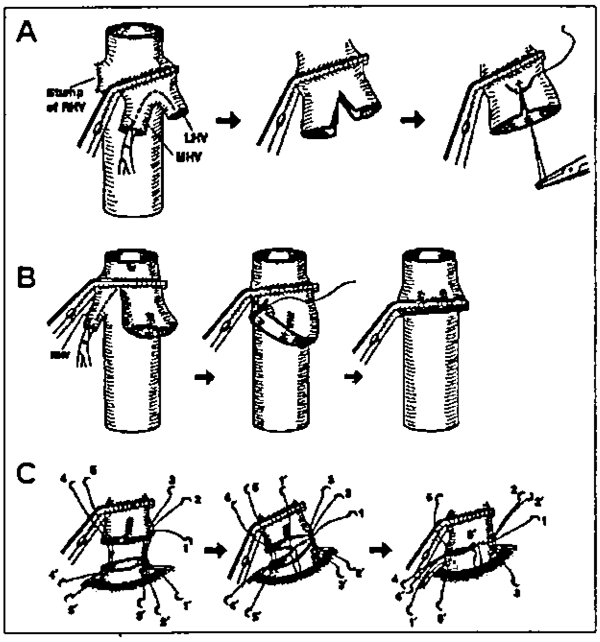

Fig. 1. Recipient venoplasty of the left hepatic vein (LHV) and middle hepatic veins (MHV) (A) or triple hepatic veins (B). (C) The anastomosis was made with continuous sutures (1-5).

branches. The branches are then cut longitudinally and sutured together. In the third method, the hepatic vein of the liver graft is cut in a perpendicular direction, and then a venous patch is anastomosed to the incised graft hepatic veins. De Villa et al.[40] detailed another venoplasty technique. They reported that when two hepatic veins are connected by a longer intervening septum, a venoplasty is made by an incision perpendicular to the septum by first removing the directly underlying liver parenchyma using a Cavitron ultrasonic surgical aspirator (CUSA).

Caudate vein reconstruction

Reconstruction of the caudate vein is technically demanding.[41] In the initial LDLT cases,[23] the drainage vein of the caudate lobe was not reconstructed. Takayama and associates[24] emphasized the importance of short hepatic vein reconstruction. According to the cast study by Couinaud, 91% (115/126) of the caudate veins entered directly to the vena cava,[42] thus indicating that one or two veins of the caudate lobe should be reconstructed to prevent venous congestion of the caudate lobe. The hepatic vein of the caudate lobe

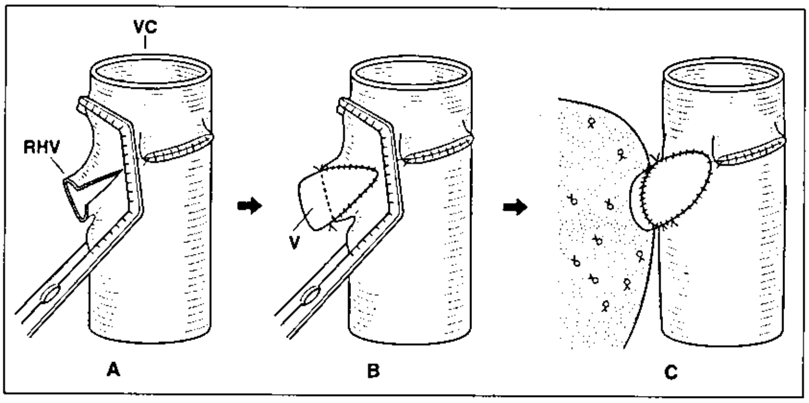

Fig. 2. (A, B) The V-shaped venous patch (V) was anastomosed to the incised anterior wall of the RHV of the recipient. (C) End-to-end anastomosis between the recipient and graft RHVs with continuous sutures.

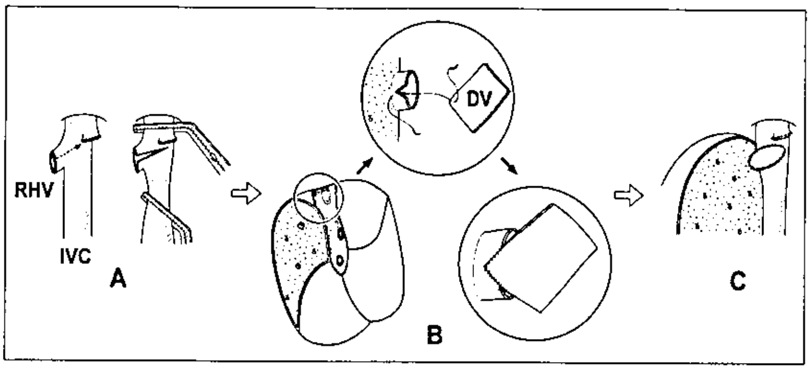

Fig. 3. (A) The anterior wall of the recipient right hepatic vein (RHV) was cut under cross-clamping of the inferior vena cava (IVC) (B) The diamond shaped venous patch (DV) was anastomosed to the incised anterior wall of the recipient's RHV. (C) End-to-end anastomosis was done between the recipient and graft RHV with continuous sutures.

can be resected with a cuff of the vena cava, which resembles a Carrel's patch. In the recipient operation, reconstruction of the caudate hepatic vein is performed and then the trunk of the left and middle hepatic vein of the recipient and the graft are anastomosed. When the orifice of the short hepatic vein is located near those of the LHV and MHV, the caudate vein with a cuff of the inferior vena cava can be sutured to the common orifice of the LHV and MHV (Fig. 4 and 5).[43]

Right liver

To overcome a size discrepancy between the right liver graft and the recipient's hepatic veins, the patch technique can be used. A vascular patch graft can be sutured separately or to both the RHV of the liver graft and the RHV of the recipient (Fig. 2 and 3). Three hepatic veins of the recipient can be joined to create a wide orifice for anastomosis.

The appropriate length for the reconstructed hepatic vein is still controversial and size matching between the liver graft and the recipient's hepatic veins is crucial.[44] Regeneration of the liver graft may compress the venous anastomotic site. Ghobrial et al. suggested that a short hepatic vein places undue tension on the anastomosis[44] and they cautioned that a long vein is predisposed to kinking after reperfusion. In contrast, we believe that it is necessary to obtain a wide ostium and sufficient length of the hepatic vein anastomosis to ensure adequate hepatic venous flow. We usually use a vein graft and make a long and wide anastomosis during the reconstruction.[45]

MHV reconstruction and cryopreserved vascular graft

An extended right liver graft is beneficial with regard to venous drainage of the graft because the MHV is the major draining vein of the right paramedian sector, and its role in the left paramedian sector is limited.[27] On the other hand, a right liver graft without the trunk of the MHV can cause severe congestion of the right paramedian sector (segments V and VIII) without MHV

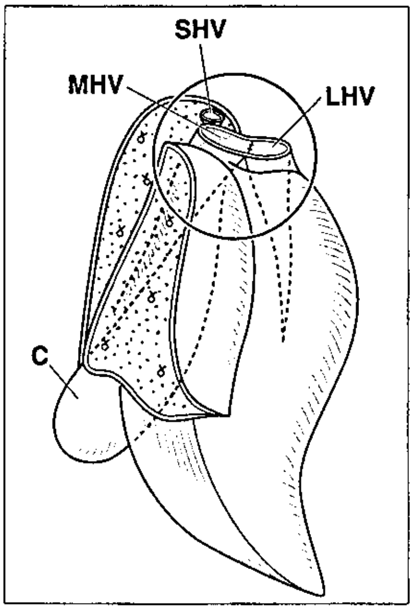

Fig. 4. The thickest hepatic vein (SHV) of the caudate lobe (C) was preserved, which was located near the orifice of the left hepatic vein (LHV) and middle hepatic vein (MHV).

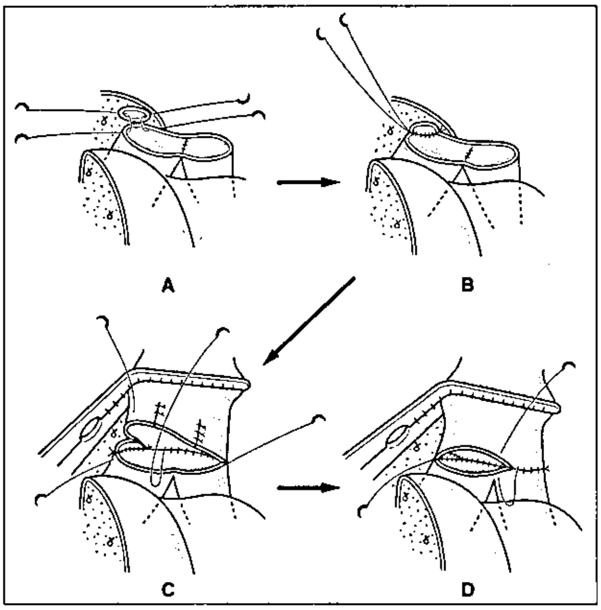

Fig. 5. Short hepatic vein of the caudate lobe sutured to the common orifice of the left and middle hepatic vein of the liver graft from the neighboring wall (A, B) End-to-end anastomosis between the common orifice of the left and middle hepatic vein and newly created hepatic venous orifices of the liver graft (C, D).

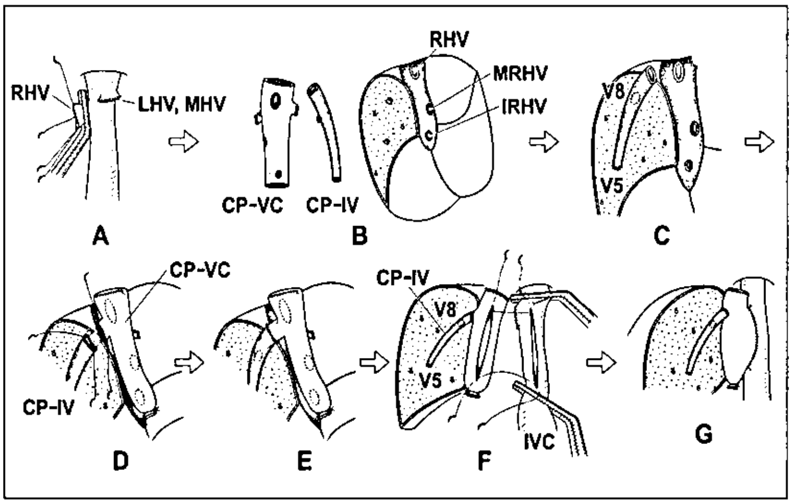

Fig. 6. (A) Left hepatic vein (LHV), middle hepatic vein (MHV) and right hepatic vein (RHV) of the recipient's liver were sutured at their roots. (B) Three side holes were created in the wall of the cryopreserved vena cava graft (CP-VC) for anastomosis with the RHV and the short hepatic veins [inferior right hepatic vein (IRHV) or middle right hepatic vein (MRHV)] of the graft. (C, D) Another cryopreserved vein graft (CP-IV) can be used for middle hepatic vein reconstruction. (E) The stump of the venous branch was anastomosed with a jumping vein graft for middle hepatic vein reconstruction. (F, G) Side-to-side anastomosis between the recipient's inferior vena cava (IVC) and CP-VC with continuous sutures was performed.

reconstruction. To provide a functioning liver mass comparable to an extended right liver, several methods have been devised for MHV reconstruction.[45,46] When a right liver graft has multiple short hepatic veins, use of a cryopreserved vena cava is recommended (Fig. 6).

The major concern in venous reconstruction using cryopreserved vein grafts is vein graft obstruction or the possibility of vein narrowing over the long-term. Mills et al.[47] reported a 51% complication rate after using cryopreserved vascular grafts. Kuang et al.[48] reported complications including an aneurysm, thrombosis, and stricture in 8 of 9 cryopreserved vein grafts that were used for portal vein and hepatic arterial interpositions. To date, we have not experienced any complications using cryopreserved vascular grafts, but previous discouraging results indicate that long-term follow-up is necessary to confirm the feasibility of their use.

Indication for MHV reconstruction

There is no consensus regarding the optimal strategy for MHV reconstruction. Some authors[49] claim that donor liver parenchyma transection without MHV tributary ligation is dangerous and that the reconstruction might increase the warm ischemia time. The development of the collateral circulation that drains the ligated MHV tributaries may occur in approximately 1 week,[50] but there is no evidence that these collaterals always occur or already exist in all patients.[51,52] Nakamura et al. clearly[53] demonstrated that the congestive area, which is due to hepatic vein ligation in the remnant liver, cannot be expected to function with the available parenchyma in the early postoperative period. They established that the congestive area resulted in histologic necrosis of the hepatic parenchyma approximately 24 hours after the ligation, although intrahepatic venous collaterals for draining the congestive area were observed through the sinusoids for 7 days after the ligation.[53]

A careful examination of the preoperative CT scan is useful to detect the number and diameter of the thick MHV tributaries draining the right paramedian sector of the donor liver. Anatomic variations, such as a venous variant type of small RHV with a large MHV might indicate the necessity for MHV reconstruction.[44] The indications for reconstruction of MHV tributaries can be determined based on our objective criteria.[54,55] First, discoloration of the liver surface should be observed after concomitant clamping of the MHV tributary and relevant hepatic artery for 5 minutes. Thereafter, only the hepatic artery is declamped and Doppler ultrasonography is performed. When hepatofugal portal flow is observed, the relevant area of the liver is confirmed to be congested. If the liver volume, excluding the area discolored by occlusion of the artery, is estimated to be insufficient for postoperative metabolic demand, (estimated graft volume less than 40% of the recipient's SLV), the MHV tributaries are reconstructed.

It is not rare to find thick, short hepatic veins during harvesting of a right liver graft (i.e., inferior right hepatic vein, middle right hepatic vein). Reconstruction of these vessels can be determined using the same criteria as for MHV reconstruction.

PORTAL VENOUS ANASTOMOSIS

In the preoperative evaluation of the donor, dynamic CT, visceral angiography, and dynamic CT with three-dimensional reconstruction provide detailed information about portal vein anatomy. Producing an anastomosis that is tension-free with wide enough orifices is a key determinant for successful portal vein anastomosis. Therefore, the portal vein on the recipient side should be dissected at the longest length possible during removal of the liver. On the donor side, a transverse portion of the portal vein has to have a long extrahepatic course to make it easier to obtain a longer portal vein in the left liver grafts than in the right liver grafts.

Portal venous thrombosis, sclerosis, and a size discrepancy between the graft and the recipient's portal vein are other issues that make it difficult or impossible to perform standard end-to-end anastomosis. These problems are usually overcome by use of an interposition vascular graft, vascular patch graft, or portal venoplasty.[56]

Trifurcation of portal vein

A common anomaly that requires attention during the donor operation is trifurcation of the portal vein in which the right lateral and right paramedian sectors are supplied separately. In this anatomic anomaly, the transverse portion of the portal vein is shorter than usual, and this necessitates a complete division of the portal vein tributaries to the caudate lobe when harvesting a left liver graft.

A right liver graft will have two portal branches. Some investigators excise the right paramedian and lateral portal vein with a side wall of the remaining donor portal veins as a patch. Defects in the remaining portal vein on the donor side are repaired with a venous patch, by direct suturing of the defect, or with segmental resection and end-to-end anastomosis. These procedures add to donor risk and result in unsatisfactory portal reconstruction.[57] This anatomic variation can be overcome by one of three ways. First, venoplasty of these portal veins can be performed on the bench and anastomosed as one common orifice to the recipient's portal vein. Second, these branches can be separately anastomosed to the recipient's portal vein. Third, a cryopreserved vascular graft can be used.

ARTERIAL RECONSTRUCTION

The information provided by preoperative angiography is essential for surgical planning and donor safety.[58] Hepatic arteries are subject to many variations.[59,60] Basically, these variations can be summarized as follows: (1) an aberrant left hepatic artery originating from the left gastric artery; (2) an aberrant right hepatic artery originating from the superior mesenteric artery; and (3) aberrant accessory arteries, in addition to the original left (or original middle) hepatic artery, or in addition to the original or replaced right hepatic artery. Division and dissection of the hepatic artery should be planned and meticulously performed according to the preoperative and operative findings.

Hepatic arterial reconstruction in LDLT is technically difficult due to the existence of short and thin hepatic arteries on a liver graft. Marcos et al. reported that anastomosis under a microscope is usually unnecessary in adult recipients, especially with a right liver graft.[28] Hepatic artery thrombosis is a serious complication that occurs after orthotopic liver transplantation, and it might result in hepatic necrosis, biliary leakage, bacteremia, or mortality.[61] Mazzaferro et al.[62] reported a significant association between hepatic arterial thrombosis and the presence of hepatic arteries less than 3 mm in diameter. In LDLT, the median diameter of the arterial branch, especially in a left-sided graft, is less than 3 mm.[60] Thus, microsurgery has an inevitable and indispensable place in LDLT.[63,64]

Is reconstruction of all hepatic arterial branches necessary?

In the early series of LDLT, left liver grafts were mainly used, which had thin, short, and sometimes multiple arterial branches. Broelsch et al.[63] suggested that a double arterial supply to the liver graft is unsuitable for LDLT after two of three of their patients experienced hepatic artery thrombosis. To resolve this problem, Mori et al.[64] reconstructed all hepatic arteries of a liver graft. The Shinshu group,[65] however, demonstrated that reconstruction of all hepatic arterial branches was not necessary in their left liver graft series. Furthermore, Sakamoto revealed that the existence of aberrant hepatic arteries, especially in left liver grafts, allows the physician to obtain a thicker and larger hepatic artery for reconstruction.[60] An additional important note regarding the left liver is that dissection of the perivascular connective tissue around the umbilical portion of the portal vein must be avoided to maintain the collateral circulation among the segmental arteries.[65]

In our previous series, the frequency of multiple arterial orifices was 1% for right-sided liver grafts and 9% for left-sided liver grafts.[59] Whereas recent data from Marcos et al.[66] revealed that 12% (11/95) of consecutive right liver grafts have double arteries. Marcos et al. proposed that reconstruction of all arterial branches of right lobe liver grafts is necessary, claiming that no portion of right liver grafts is supplied by secondary arterial perfusion.[67] In their recent series, they anastomosed double arterial orifices with auto Y-shaped arterial grafts on the bench.[66] It is still controversial, however, whether all arterial stumps must be anastomosed in LDLT. We reported successful results with only one hepatic arterial reconstruction in both a left and right liver graft with multiple arterial stumps.[59,60,65] Redman[68] demonstrated that accessory hepatic arteries usually communicate with the original lobar arteries in the hepatic hilum, but they are not visualized on angiograms unless they actually function as collaterals.

Checking arterial communication in grafts

When multiple hepatic arteries exist, the largest one should be used for reconstruction, and an adequate arterial flow to the nonanastomosed arterial branches should be confirmed using the following criteria. First, during the completion of a donor hepatectomy, when smaller branches of the hepatic artery are cut, pulsatile back-bleeding is observed. Second, on the bench, when perfusion fluid is flushed though the largest artery, it should be observed to flow out from the smaller arterial branches[69] Third, arterial flow can be confirmed during the recipient's operation following the reconstruction of the largest hepatic artery by the presence of pulsatile back-bleeding from the stump of the other graft's arteries. Finally, the hepatic arterial signal can be checked by Doppler ultrasonography of each segment of the liver graft.

BILIARY RECONSTRUCTION

The current standard for biliary reconstruction in whole cadaveric liver transplantation is a duct-to-duct choledochocholedochostomy. The preferred technique in adult LDLT is currently shifting from a hepaticojejunostomy to duct-to-duct anastomosis.

Duct-to-duct biliary reconstruction

Duct-to-duct biliary reconstruction has been presented in some institutions.[70-72] These reports advocate the advantages of duct-to-duct biliary reconstruction over a hepaticojejunostomy, i.e., the procedure might preserve physiologic bilioenteric and bowel continuity, thus preventing a delayed bowel movement. Duct-to-duct reconstruction allows for easy endoscopic access to the biliary tree for diagnostic and therapeutic instrumentation and management, and it prevents ascending cholangitis.

The rationale for using a hepaticojejunostomy in LDLT is based on the small size of the recipient's bile duct and the inadequate length of the donor's bile duct. Although size and length are not restriction factors for adult patients, as they are for pediatric patients, an underlying liver disease (e.g., biliary atresia) often mandates the use of a hepaticojejunostomy. Since 2000, we have used duct-to-duct anastomosis in patients without diseases involving the bile duct, such as biliary atresia or primary sclerosing cholangitis. However, long-term postoperative observations and technical modification are still necessary,[70,73] to determine the success rate.

Devices used during the operation

The rate of biliary complications after LDLT is approximately 40%, suggesting that biliary reconstruction remains a technically demanding and challenging problem in LDLT.[70,74,75] An intraoperative cholangiography is essential for visualizing biliary anatomy and anomalies (i.e., a right lateral sector bile duct originating from the left bile duct), and identifying the precise site of division.[29,76] To avoid narrowing of the common bile duct of the donor, there should be no attempt to obtain a single duct orifice in the graft. It is very important to maintain an adequate blood supply from the hepatic arteries and gastroduodenal artery to the bile duct.[77] Thus, meticulous and sharp dissection of the recipient's bile duct, preserving as much surrounding tissue as possible,[70] is indispensable for the safety of duct-to-duct reconstruction.

The existence of multiple bile duct orifices on the graft side is common. Intermittent suturing or tying them off during the donor operation, or on the bench, may be performed.[78] To identify the orifice of the bile duct to each hepatic segment, a surgical probe can be inserted individually into each bile duct under the guidance of ultrasonography.[79]

Postoperative complications

A surgical revision of bile duct stenosis is technically demanding if the endoscopic approach is not possible or unsuccessful. In repairs using a T-tube, an intraoperative cholangiography should be used for appropriate localization, which allows for sufficient bile juice drainage. Converting duct-to-duct anastomosis to a hepaticojejunostomy is another option.[70]

The raw surface of the liver graft or biliary anastomosis is a common site of bile leakage, which can result in fluid collection or an abscess. Careful ligation of all bile ducts on the raw surface and placing a closed suction drain along the cut surface of the liver graft is important.

Scatton[80] reported an increase in the biliary complication rate in a T-tube group. In LDLT, a T-tube helps to decompress the bile duct, but it will not prevent stenosis at the anastomotic site. Additionally, there are often multiple duct orifices in the graft and a size difference between the common bile duct and the duct orifice in the graft, so it is difficult to put the tip of a T-tube across the anastomotic site. A transanastomotic external tube can theoretically help decrease the intrahepatic biliary pressure caused by edema and the consequent partial obstruction of the anastomosis.[81] The transanastomotic external tube will also facilitate a postoperative imaging study. The advantage over not stenting, however, has not been established.[70]

UNIVERSITY OF TOKYO EXPERIENCE

Between 1996 and September 2003, 167 adult patients underwent LDLT at the Tokyo University Hospital. Donor candidates consisted of 71 children, 34 siblings, 23 parents, 23 spouses, 11 who composed of aunts, uncles, nieces and nephews and 5 others. Their ages ranged from 20 to 65. The LDLT donors underwent a left hepatectomy (n=16), a left liver with caudate lobectomy (n=59), and a right hepatectomy (n=76), a right lateral sector (n=16). The actual graft weight ranged from 289g to 924g (median 534g), and its ratio to the recipient's SLV ranged from 31% to 88% at the time of the transplantation. All the LDLT donors recovered well and returned to normal lives with a mean hospital stay of 15 days (11-56 days). Only minor donor complications occurred. Seven donors (3%) underwent a reoperation with good results. The indications for the reoperation were bile leakage in six donors and peritonitis in one. None of the donors required a banked-blood transfusion.

As for the recipients, three patients required re-transplantation and there were nine early deaths. Primary biliary cirrhosis, primary sclerosing cholangitis, and autoimmune hepatitis were the most common indications (33%), followed by hepatocelluar carcinoma with hepatitis (24%). The most common complication was acute rejection (45%), followed by biliary complications (25%). Patient and graft survival were 91% and 90%, respectively. Several considerations and techniques for performing LDLT and the experiences at Tokyo University were reviewed. The results confirmed that LDLT was satisfactory in adult patients with 3-year accumulated survival rates of 90%, and it can be performed with a low incidence of complications.

CONCLUSION

Taking into account the worldwide shortage of cadaveric organ donations, LDLT offers hope to patients with end-stage liver disease and its use will become increasingly more important. This procedure should be performed by an expert surgical team only after careful consideration of donor safety and recipient outcome. The long-term success of LDLT requires careful, thoughtful application of this procedure, as well as accumulated technical improvements in the field of hepatobiliary surgery.

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