Ex Vivo Reduction of Thickness in the Left Lateral Section to Tailor the Graft Size in Infantile Split Deceased Donor Liver Transplantation

TO THE EDITOR:

Liver transplantation (LT) in infants and small children is still a challenging operation. One obstacle facing this type of operation is the issue of large-for-size grafts because too-large grafts can result in graft compression, splinting of the diaphragm, and abdominal closure with synthetic mesh, which may lead to other complications.[1] Reduction procedures for adult left lateral section (LLS), including hyper-reduced grafts and monosegmental grafts (MSGs), have recently been developed to eliminate size mismatch in living donor liver transplantation (LDLT) for small children.[1,2] However, although both of those grafts are created by removing excess parts of the LLS to achieve a target graft weight, the graft thickness of hyper-reduced grafts cannot be reduced because this strategy employs a simple nonanatomical reduction of the lateral and/or caudal parts of the LLS. Therefore, MSGs of segment 2 are considered more suitable grafts for small children. Recently, MSGs of segment 2 with the preservation of the main Glisson's pedicle of segment 3 have been increasingly frequently adopted because of the ready accessibility of radiological interventional treatment in the event of biliary and vascular complications. Furthermore, reduction procedures to create MSGs may require precise assessments of anatomical variations of vasculatures and bile ducts inside the LLS, which can lead to safe reduction procedures and eventually reduce the likelihood of surgical complications.[3] However, when procuring a deceased donor liver, oftentimes there is insufficient information available to evaluate the anatomy for creating MSGs.

We herein report the ex vivo reduction of an adult deceased LLS to create a MSG in a case of infantile split LT.

Case Presentation

A 6-month-old girl, who presented with hyperammonemia immediately after birth and was consequently diagnosed with citrullinemia type 1 (CTLN1), was referred to our hospital for LT. At the time of the referral, the patient required intensive care, including continuous hemodiafiltration for an attack of hyperammonemia. Her height was 63.0 cm, and her body weight was 6.3 kg. An appropriate living donor (LD) could not be found among her family members, so she was placed on the waiting list as a candidate for deceased donor LT.

A liver was donated from a brain-dead 47-year-old female. Her height was 157.0 cm, and her body weight was 58.5 kg. Liver procurement was performed at a local hospital, and the LLS and right trisegments were divided by an ex vivo splitting procedure, which took approximately 40 minutes. The actual weight of the

Abbreviations: CTLN1, citrullinemia type 1; CUSA, Cavitron ultrasonic surgical aspirator; GRWR, graft-to-recipient weight ratio; LD, living donor; LDLT, living donor liver transplantation; LHV, left hepatic vein; LLS, left lateral section; LT, liver transplantation; MSG, monosegmental graft.

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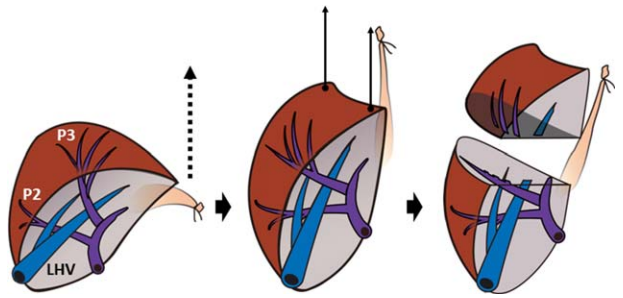

FIG. 1. The concept of ex vivo reduction procedure of LLS. Diagrams illustrate ex vivo reduction procedure of an adult deceased LLS to create a MSG. The parenchymal transection to remove the ventral part of segment 3 while preserving the main Glisson's pedicle of segment 3 on the graft side could be properly configured to create a horizontal plane by upward traction of the round ligament (dotted arrow) and stay sutures (solid arrows). Notably, the main LHVs always run between the main Glisson's pedicle of segment 2 (P2) and 3 (P3).

LLS was 375 g, which was an extremely large-for-size graft for the target patient, with a graft-to-recipient weight ratio (GRWR) of 6.0%. In addition, the LLS was rather thick, and therefore, further reduction to a thickness-reduced LLS graft was required.

The procedure was performed using a Cavitron ultrasonic surgical aspirator (CUSA) for parenchymal transection in cold organ preservation solution (Fig. 1). The estimated cutting lines were scored on the surface of the liver to indicate the boundary between the ventral and dorsal parts of segment 3 while preserving the main Glisson's pedicle of segment 3 on the graft side (Fig. 2A). Parenchymal transection was started from the peripheral edge toward the root of the round ligament, which was pulled upward (Fig. 2B). The main portal venous branch of segment 3 was confirmed by inserting a surgical probe, and the clearly exposed hepatic vein tributaries and Glisson's capsules were meticulously ligated or sutured. Extra care was taken by immersing the graft side in the cold preservation solution during parenchymal transection (Fig. 2C). The main portal venous branch perfusing the dorsal part of segment 3 and the drainage hepatic veins were able to be preserved. The weight of the MSG was reduced to 262 g, with a new GRWR of 4.2%, and the thickness of the graft was reduced to 4.0 cm.

The graft was successfully implanted with a cold ischemia time of 7 hours 25 minutes, and primary abdominal closure was achieved (Fig. 2D). The recipient operation time was 7 hours 24 minutes, and the estimated blood loss was 262 mL. Her postoperative course was uneventful, and she was discharged on postoperative day 35. She is doing well with a good graft function at 6 months after her LT.

Discussion

Adult LLS grafts can usually be assigned to pediatric recipients in reduced-size, split liver, and LDLT. However, the adult LLS may be too large for infants and small children, and a further reduction of the LLS may be needed to overcome a weight discrepancy of more than 10:1 from donor to recipient.[4] This kind of reduction procedure has been used with deceased donor organs since the 1990s and expanded to LDs. The graft types include a nonanatomically reduced LLS graft, mainly consisting of segment 3 (ie, hyper-reduced graft), and an anatomically reduced LLS graft of segment 2 (ie, MSG). When creating a hyper-reduced graft, the reduction plane is relatively far from the left main Glisson's pedicles at the hilum and the trunk of the left hepatic veins (LHVs), and therefore, the reduction procedure is not technically complicated. In contrast, it is necessary to identify and avoid injuring the Glisson's pedicle close to the base of the umbilical fissure during the reduction procedure to create a MSG. As such, nonanatomically reduced LLS grafts are selected more often in the setting of deceased donor LT.[4] Monosegmental LT using segment 2 grafts from LDs has been reported more recently[2,3] because the reduction procedure is more complicated than that of nonanatomically reduced LLS grafts, and it requires precise information concerning the anatomical patterns of the intrahepatic vasculature. Furthermore, recent advances in the preoperative analysis using a 3-dimensional computer-generated model of the donor's liver may encourage more frequent application of MSGs in LDLT for infants and small children.[2] The technical knowledge related to the creation of MSGs in LD operations has accumulated, and then the concept of the ex vivo reduction of an adult deceased LLS to create a MSG was introduced in the present case. In addition, it is better to use contrast-enhanced computed tomography to gain a clearer understanding of the anatomical patterns of the liver, which can provide information that is helpful for decision making related to the

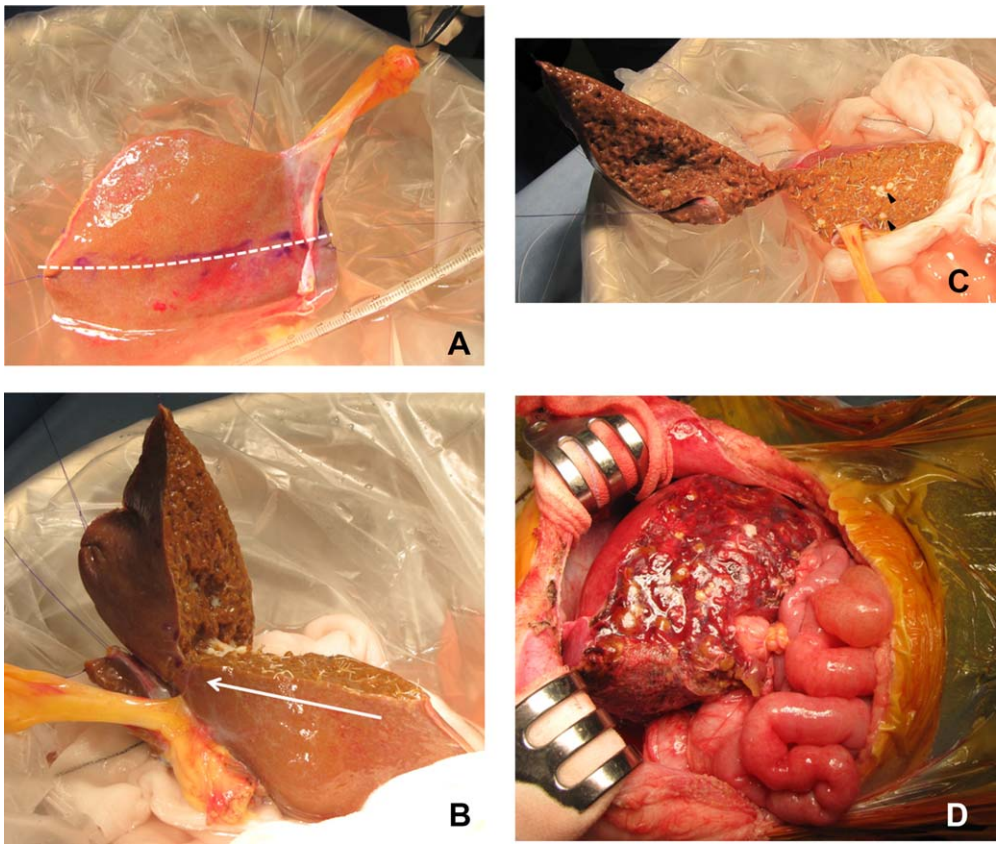

FIG. 2. The details in ex vivo reduction procedure of LLS. (A) The estimated cutting lines (white dotted line) were scored on the surface of the liver to indicate the boundary between the ventral and dorsal parts of segment 3. (B) Parenchymal transection was started from the peripheral edge toward the root of the round ligament (arrow indicating the direction), while preserving the main Glisson's pedicle of segment 3 on the graft side. (C) The ventral branches of Glisson's pedicle of segment 3 (arrowheads) were properly ligated in the periphery on the cutting surface. (D) The graft, weighing 262 g with a new GRWR of 4.2%, was successfully implanted. The graft thickness was reduced to 4.0 cm.

type of graft, even when procuring a deceased donor liver.

Despite the technical difficulty in performing a further reduction to create a MSG, this procedure may have advantages with regard to reducing not only the graft volume but also the graft thickness. In the present case, the LLS was an extremely large-for-size graft for the patient, with a GRWR of 6.0%. Furthermore, the LLS was too thick not to allow for primary closure. Some studies have shown that delayed abdominal closure can be used safely without increasing the risk of complications that compromise the graft and patient survival.[5] However, delayed closure may increase the risk of wound infection, dehiscence, and incisional hernia. Patients with CTLN1 are often malnourished due to protein restriction and vulnerable to infection. Therefore, abdominal closure with synthetic mesh was not suitable for the present case, and we decided to perform further reduction to create a MSG.

Whether a further reduction procedure is performed before or after implanting the graft is the next issue to address because both approaches have advantages and disadvantages. Advantages of performing this procedure after implantation include better recognition of the anatomy of intrahepatic vasculature and bile ducts. However, liver resection of an immediately revascularized graft is technically complicated in patients with hemostasis disorders.[4] Disadvantages of performing this procedure before implantation include the prolongation of ischemia time with back-table warming. It is important to minimize the ischemia time as much as possible in the setting of split LT. We decided to

perform further reduction before implantation after careful consideration of the advantages and disadvantages described above.

Regarding the technical aspects of the back-table procedure to create a MSG, it is crucial to avoid injuring the portal pedicle close to the base of the umbilical fissure. It might be dangerous to approach the main Glisson's pedicle of segment 3 without understanding the anatomical patterns of the intrahepatic vasculature. The injection of methylene blue in the portal branch of segment 3 may aid in the accurate transection between segments 2 and 3. In the present case, we removed the ventral part of segment 3 while preserving the main Glisson's pedicle of segment 3, which was confirmed to be included in the graft side using the surgical probe. Parenchymal transection was then properly configured to create a horizontal plane by upward traction of the round ligament and water surface of the cold preservation solution. Extra care must be taken by immersing the graft side in cold preservation solution in order to prevent back-table warming. This reduction procedure took approximately half an hour, which was facilitated using CUSA.

In conclusion, we reported the technical aspects of ex vivo reduction of an adult deceased LLS to create a MSG consisting of segment 2 and partial segment 3. This procedure was shown to be safe and technically feasible, and it is also applicable to cases of split deceased donor LT for infants and small children.

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