

Reducing the Thickness of Left Lateral Segment Grafts in Neonatal Living Donor Liver Transplantation

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Liver transplantation is now an established treatment for children with end-stage liver disease. Left lateral segment (LLS) grafts are most commonly used in split and living donor liver transplantation in children. In very small children, LLS grafts can be too large, and further nonanatomical reduction has recently been introduced to mitigate the problem of large-for-size grafts. However, the implantation of LLS grafts can be a problem in infants and very small children because of the thickness of the grafts, and these techniques do not address problems related to thickness. We herein describe a technique for reducing the thickness of living donor left lateral grafts and successful transplantation in a 2.8-kg infant with acute liver failure. *Liver Transpl* 19:226-228, 2013. © 2012 AASLD.

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The lack of size-matched pediatric liver grafts has led to the development of reduced, split, and living donor liver transplantation. These techniques have expanded the potential donor pool and decreased waiting-list mortality for children.¹ Transplantation in children who weigh less than 5 kg remains a problem because the left lateral segment (LLS) from an adult may be too large when the graft-to-recipient weight ratio is greater than 4.0% and thus may result in a large-for-size graft and its associated morbidity.² Further reduced LLS grafts that can be transplanted safely without compromise to patient survival have been introduced for these children to mitigate the problem of large-for-size grafts.³ In very small children (neonates) who have no portal hypertension, hepatomegaly, or ascites, the abdominal cavity may be small, and the anteroposterior thickness of the graft remains a problem.^{4,5} Abdominal closure may

require a temporary Silastic mesh, and this is associated with complications. We have developed a modified LLS reduction by which the thickness of the graft is addressed and transplantation is allowed in very small infants. The clinical study protocol was approved by the institutional review committee.

CASE PRESENTATION

A 23-day-old Asian girl weighing 2.8 kg who presented with deteriorated liver function was admitted to our hospital. The laboratory study showed a total bilirubin level of 22.7 mg/dL, a prothrombin time/international normalized ratio of 10.0, an alanine aminotransferase level of 500 U/L, and a serum ammonia level of 217 $\mu\text{mol/L}$. The investigations for infectious and inherited metabolic pathogenesis were all negative. The patient was diagnosed with neonatal acute

Abbreviations: LHV, left hepatic vein; LLS, left lateral segment; LPV, left portal vein; MHV, middle hepatic vein; P2, segment II portal vein; P3, segment III portal vein; PV, portal vein; RHV, right hepatic vein; RPV, right portal vein.

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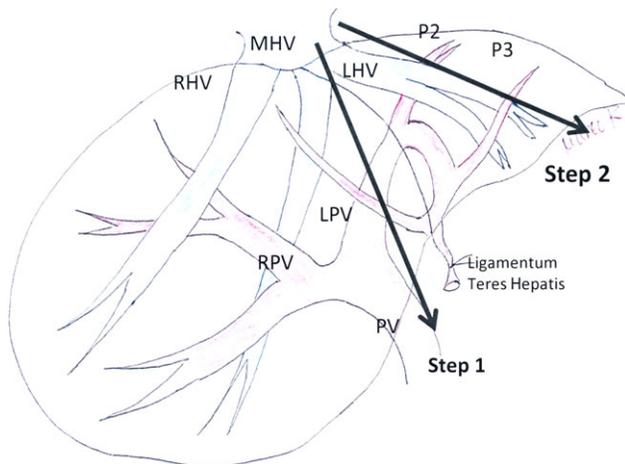


Figure 1. Schema of the cutting lines for left lateral segmentectomy (step 1) and the transection line of the lateral part of the LLS (step 2).

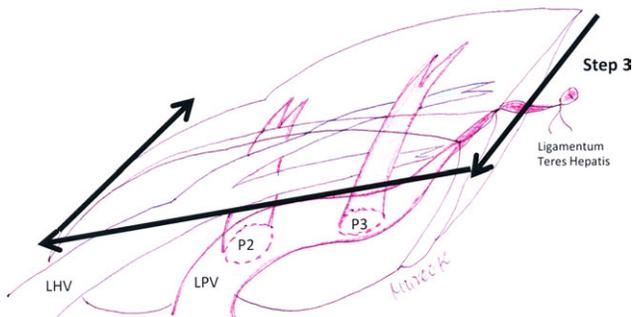


Figure 2. The transection line of the thickness was located horizontally on the level of P3 to thin the graft (step 3).

liver failure of an unknown etiology. The patient, whose liver function had deteriorated despite medical treatment, underwent living donor liver transplantation at the age of 1 month.

The donor was her 31-year-old father, whose blood type was identical. The estimated weight of the LLS according to preoperative computed tomography volumetry was 374 g. This was an extremely large-for-size graft for the child with a graft-to-recipient weight ratio greater than 13%. Hyper-reduction of the LLS graft to remove most of segment II alone seemed inadequate. There was a major anteroposterior size discrepancy between the recipient's abdominal cavity at its maximum (45.6 mm) and the LLS graft of the donor (64.7 mm) according to the preoperative computed tomography evaluation. Therefore, the decision was made to further reduce the anteroposterior thickness of the graft.

In the donor operation, after the isolation of the donor's left hepatic artery and left portal vein (LPV), the hepatic parenchyma was transected 3 mm to the right of the falciform ligament, just as in any standard donor hepatectomy for children (step 1, Fig. 1). The LLS was first reduced by the removal of the lateral aspect of segment II, and care was taken to preserve the segment III branch of the left hepatic vein (LHV;

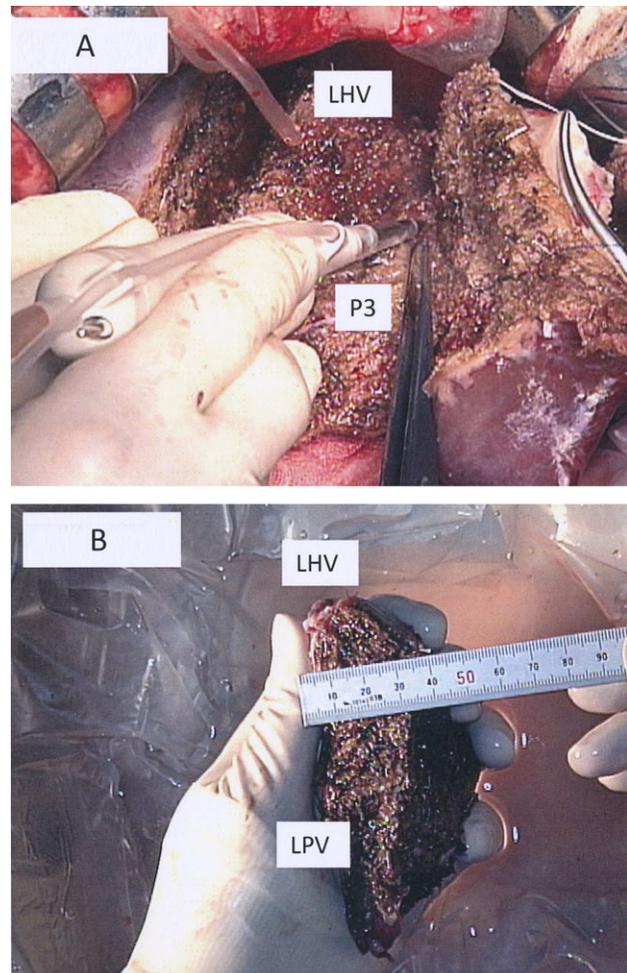


Figure 3. (A) The technique involved the removal of the anterior part of the reduced LLS. This transection line could preserve the drainage vein of the graft, which drained into the inferior vena cava between the segment II and III branches of the PV. This had the potential to reduce the thickness of the LLS graft by more than 40%. (B) The reduced LLS graft weighed 90 g with a thickness of 2.5 cm, so the graft-to-recipient weight ratio was 3.21%.

step 2, Fig. 1).^{2,3,4,6} A further reduction of the LLS to reduce the graft thickness was also performed in situ. This technique involved the removal of the anterior surface of segment III; step 3, Fig. 2). The transection line for this was located horizontally on the level of the segment III branch of the portal vein (PV). This transection line could preserve the drainage vein of the graft, which drained into the inferior vena cava between the segment II and III branches of the PV. This had the potential to reduce the thickness of the LLS graft by more than 40%. The modified-reduced LLS graft weighed 90 g with a thickness of 2.5 cm and with a graft-to-recipient weight ratio of 3.21% (Fig. 3). The graft was successfully implanted with no major bleeding from the cut surfaces, and primary abdominal closure was achieved. The donor operative time and blood loss were 358 minutes and 50 mL, respectively.

The results of the blood tests performed on days 1 and day 7 for the recipient were as follows: 848 and 57 IU/L for aspartate aminotransferase, 418 and 57 IU/L for alanine aminotransferase, 3.16 and 1.81 mg/dL for total bilirubin, and 3.0 and 1.17 for the prothrombin time/international normalized ratio. The baby was discharged on postoperative day 50. The transplant recipient was doing well with good graft function at the outpatient clinic 3 years after transplantation.

DISCUSSION

Over the past 2 decades, long-term survival has improved significantly for pediatric liver transplant recipients.⁵ The disadvantages of using large-for-size grafts include graft compression, the use of Silastic mesh to close the abdomen and associated infections, splinting of the diaphragm, and delayed extubation, all of which contribute to poor outcomes.⁷ These complications are amplified by the small recipient size and often associated malnutrition in a patient population that already presents a technical challenge and postoperative complexity.⁸ To relieve the problem of large-for-size grafts in small babies, reduced LLS grafts have been introduced.^{2,3,4,6} In addition, the size and shape of the LLS of the donor should be taken into consideration. Some LLSs are short and thick, whereas others are thin and long. The second kind poses less of a problem because a further reduction of part of segment II alone may be adequate. However, with short and thick LLSs, the removal of segment II alone is inadequate because the thickness of the graft is the main problem. The technique described herein should be considered for recipients with neonatal/infantile acute liver failure and for children weighing less than 5 kg.

Tailoring the graft size and especially reducing the thickness of the graft might be important for small infants with end-stage liver disease. Although steps 2 and 3 of the procedure presented in this article could be done *ex situ* to protect the donor from the risk of bleeding and possible air embolisms, prolonged cold ischemia times and rewarming of the graft during back-table surgery have been found to be associated with increased susceptibility to ischemic/reperfusion injury in *ex situ* split liver transplantation, and it might be postulated that these factors contribute to a

higher incidence of graft dysfunction.⁹ The procedure is associated with a much higher rate of biliary fistulas, and meticulous surgical technique and pre/intraoperative anatomical evaluations with cholangiography/echography are recommended to prevent compromises to donor and recipient safety. By limiting adhesions in unexpected relaparotomy during follow-up, the use of hemostatic fleeces to protect the cutting edges might be effective.

The modified-reduced LLS has the potential to allow these children to undergo transplantation safely without the associated complications of large-for-size grafts. Although long-term observation should be necessary to establish this technical modification, we hope that increasing experience with the technique and refinements will lead to improved outcomes in liver transplantation for small babies.

REFERENCES

1. Diamond IR, Fecteau A, Millis JM, Losanoff JE, Ng V, Anand R, et al. Impact of graft type on outcome in pediatric liver transplantation: a report from Studies of Pediatric Liver Transplantation (SPLIT). *Ann Surg* 2007;246:301-310.
2. Kasahara M, Kaihara S, Oike F, Ito T, Fujimoto Y, Ogura Y, et al. Living donor liver transplantation with monosegments. *Transplantation* 2003;76:694-696.
3. Srinivasan P, Vilca-Melendez H, Muiesan P, Prachalias A, Heaton ND, Rela M. Liver transplantation with monosegments. *Surgery* 1999;126:10-12.
4. Kasahara M, Fukuda A, Yokoyama S, Sato S, Tanaka H, Kuroda T, Honna T. Living donor liver transplantation with hyperreduced left lateral segments. *J Pediatr Surg* 2008;43:1575-1578.
5. McDiarmid SV, Anand R, Martz K, Millis MJ, Mazariegos G. A multivariate analysis of pre-, peri-, and post-transplant factors affecting outcome after pediatric liver transplantation. *Ann Surg* 2011;254:145-154.
6. Enne M, Pacheco-Moreira L, Balbi E, Cerqueira A, Santalucia G, Martinho JM. Liver transplantation with monosegments. Technical aspects and outcome: a meta-analysis. *Liver Transpl* 2005;11:564-569.
7. Kiuchi T, Kasahara M, Uryuhara K, Inomata Y, Uemoto S, Asonuma K, et al. Impact of graft size mismatching on graft prognosis in liver transplantation from living donors. *Transplantation* 1999;67:321-327.
8. McDiarmid SV. Management of the pediatric liver transplant patient. *Liver Transpl* 2001;7(suppl 1):S77-S86.
9. Busuttil RW, Goss JA. Split liver transplantation. *Ann Surg* 1999;229:313-321.