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CASE REPORT

Living donor liver transplantation using a left liver extended to right anterior sector

Kyung-Suk Suh, Suk-Won Suh, Jeong-Moo Lee, Young Rok Choi, Nam-Joon Yi and Kwang-Woong Lee

Department of Surgery, College of Medicine, Seoul National University, Seoul, Korea

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Correspondence
Kyung-Suk Suh, MD, Department of Surgery, Seoul National University College of Medicine, 101 Daehak-ro, Jongno-gu, Seoul 110-744, Republic of Korea.
Tel.: 82 2 2072 3789;
fax: 82 2 766 3975;
e-mail: kssuh@snu.ac.kr

Kyung-Suk Suh and Suk-Won Suh have contributed equally to this work as co-first author.

Conflicts of interest
The authors have declared no conflicts of interest.

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Summary

In living donor liver transplantations, right liver grafts have been commonly used to meet the metabolic demands of the recipient. However, a small left remnant liver volume sometimes limits its use due to donor safety concerns. Here, we report an innovative living donor hepatectomy using a left liver extended to the right anterior sector (segments 2–5 and 8), which can be considered for donors who are unsuited for right liver donation.

Introduction

Living donor liver transplantation (LDLT) has emerged as a valuable alternative option in countries where the availability of deceased-donor organs is limited [1]. The overall experience with left liver grafts in adult recipients has revealed a higher incidence of small-for-size graft syndrome, with right liver grafts replacing them as routine LDLTs at many centers [2]. Although LDLT using a right liver graft has the advantage of a larger graft volume, its use may be precluded by a small left remnant liver volume (RLV), as a percentage of total liver volume, and a complicated biliary system anatomy [3]. Thus, various alternative approaches for donors with small left RLVs have been attempted, including the use of right posterior sections or dual-donor grafts [4,5]. Here, we report the first case of LDLT performed using a left liver extended to the right anterior sector (segments 2–5 and 8).

Case

The recipient was a 55-year-old man who had hepatitis B-associated liver cirrhosis and hepatocellular carcinoma within Milan criteria; the donor was a 46-year-old man. The donor was evaluated, step-by-step, according to a previously reported evaluation protocol for living liver donors in our hospital. The donor's liver function tests; biochemistry; hematology; coagulation profile; urine analysis;

hepatitis A, B, and C; serology; chest radiography; and electrocardiography were within normal limits. Similarly, the levels of aspartate transaminase (19 IU/l; normal, 1–40 IU/l), alanine transaminase (17 IU/l; normal, 1–40 IU/l), total bilirubin (0.7 mg/dl; normal, 0.2–1.2 mg/dl), and international normalized ratio (1.09, normal, 0.8–1.2) were also within normal limits; the blood types of donor and recipient also matched. Next, the potential donor underwent a complete medical and anatomical evaluation. A volumetric evaluation, using liver dynamic computed tomography (CT), revealed that the total volume of the donor's liver was 1074 ml, with a right liver volume was 767 ml, leaving an RLV of 28.5% and an RLV-to-donor body weight ratio (RLV-BWR) of 0.49, following a hypothetical right liver donation. He also had a segment 2 hemangioma, 3.1–3.5 cm in size, which was not excluded in the preoperative volumetric analysis, indicating that the actual RLV might be <28.5%. According to our center's donor selection policy, the right liver should not be considered for donation if the estimated RLV is <30%, due to donor safety concerns. A left trisection would leave a right posterior RLV of 30.3% and an RLV-BWR of 0.53, with a graft volume/recipient body weight ratio of 1.26 (Fig. 1). Hepatic arterial or portal venous variations were not observed, but magnetic resonance cholangiopancreatography showed a bile duct variation; the right posterior hepatic duct separately drained into the common bile duct, type C1 according to the Couinaud classification [6] (Fig. 2), suggesting that the biliary anatomy favored a left trisection donation, as a common bile opening could be obtained. Magnetic resonance spectroscopy revealed a 1.4% fat fraction ratio. Thus, left trisectionectomy approach was determined to be appropriate for donor hepatectomy.

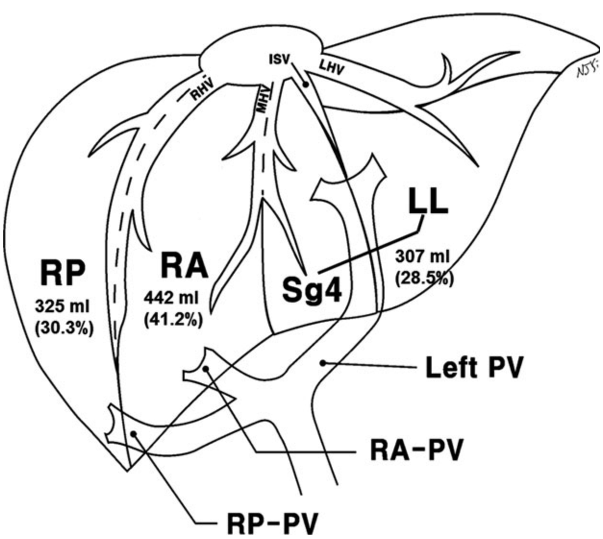

Figure 1 Preoperative volumetric analysis of the liver. A total volume of the liver was 1074 ml. The volume of whole left liver, right anterior section, and right posterior section was 307 ml (28.5%), 442 ml (41.2%), and 325 ml (30.3%), respectively. A remnant liver volume of 28.5% in case of right liver donation, however, if we use a left liver extended to right anterior sector, the remnant liver volume of right posterior section was 30.3%.

The donor laparotomy was performed with an inverted L incision. The left triangular ligament was then divided, and the lesser omentum was incised. The ligamentum venosum was ligated, and dissection around the common trunk of the middle and left hepatic veins was carefully performed. Hilar dissection was performed to isolate the left and right anterior and posterior branches of the hepatic artery and portal vein. Then, the liver was transected in a plane that was demarcated on the liver surface, temporarily occluding the right anterior branch of the hepatic artery and portal vein, using a previously described hanging maneuver [7]; inflow vascular occlusion was not used during the liver transection. The confluence of the right posterior hepatic duct and the common trunk of the right anterior and left hepatic ducts was identified and divided near their confluence. The left, middle, and right anterior hepatic arteries and the left and right anterior portal veins were divided, preserving their right posterior branches (Fig. 3a). The common trunk of the middle and left hepatic veins was divided, allowing the recovery of the left trisection of the liver, with an operative time of 453 min. Transfusions were not required, and intra-operative complications did not occur.

The right anterior portal branch and the left portal vein were reconstructed, *ex vivo*, using a Y-graft from the portal vein of the recipient. The recipient's diseased liver was resected, preserving the inferior vena cava. The common trunk of the donated liver's hepatic vein was then anastomosed to the recipient's middle and left hepatic veins. Then, the common orifice of the graft's reconstructed portal vein was anastomosed to the recipient's main portal vein (Fig. 3b). Finally, the left, middle, and right anterior hepatic arteries of the graft were anastomosed to the recipient's left, right anterior, and right posterior hepatic arteries, and a duct-to-duct biliary anastomosis was performed (Fig. 3c).

The donor's high total bilirubin level was sustained during the early postoperative period, which might be related to a temporary small-for-size syndrome, but the patient was discharged with improved liver function on postoperative day 21. CT examinations of the donor and recipient livers were performed on postoperative day 7, per protocol, and showed patent vascular structures, without any abnormal findings (Fig. 4). The donor and recipient have since completed a 1-year follow-up examination, with the donor remaining healthy and complication-free, having normal liver function, and having returned to his previous

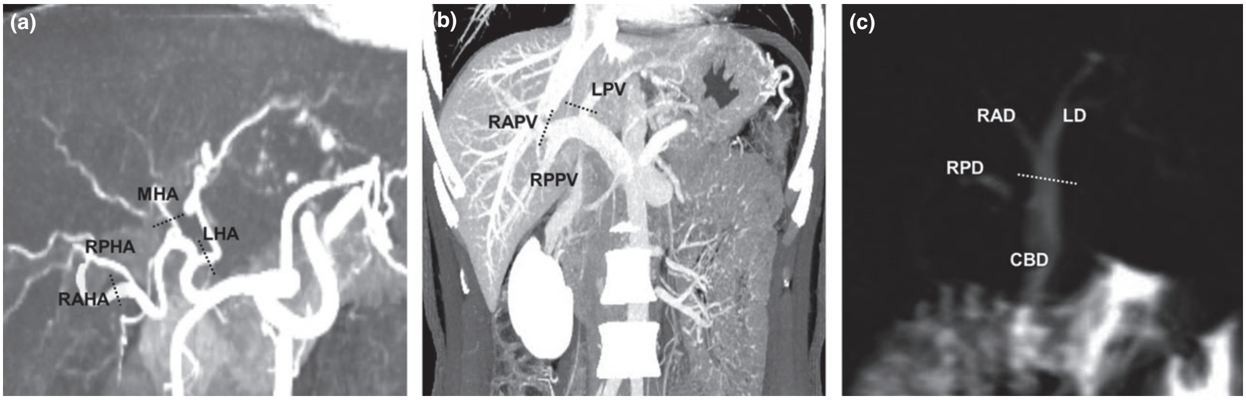

Figure 2 Preoperative computerized tomography and magnetic resonance cholangiopancreatography. Left and right hepatic arteries were separated, middle hepatic artery originates from right hepatic artery, and then right anterior and posterior hepatic artery were separated (a). Left and right portal veins were separated, and then right anterior and posterior portal vein were separated (b). Right posterior hepatic duct separately drained into common bile duct (c). Dotted lines indicate the division points.

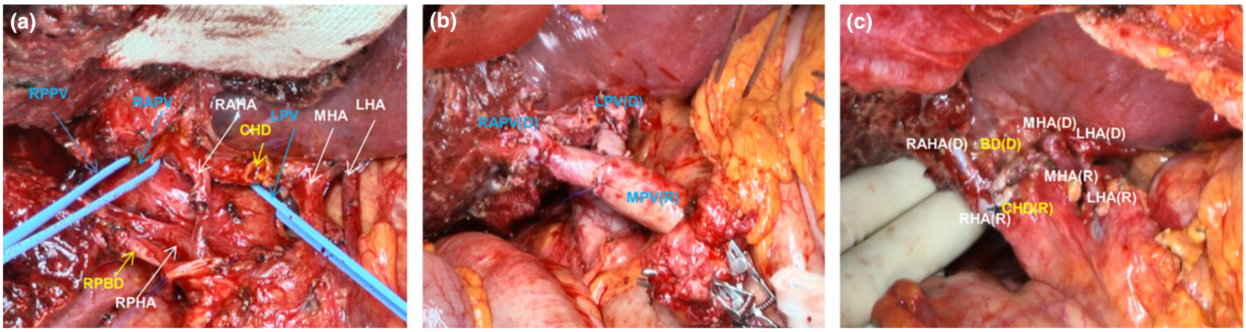

Figure 3 Intra-operative findings. Left, middle, and right anterior hepatic arteries (white arrows) and left and right anterior portal veins (blue arrows) were dissected preserving right posterior branches of them. The confluence of the right posterior hepatic duct and common hepatic duct including right anterior and left hepatic ducts was identified and divided near their confluence (yellow arrows) (a). The common orifice of the reconstructed portal vein using recipient's Y-graft for left and right anterior portal vein of the donor (D) was anastomosed to the main portal vein of recipient (R) (b). The left, middle, and right anterior hepatic arteries of the donor (D) were anastomosed to the left, right anterior, and right posterior hepatic arteries of the recipient (R) (white), and the big common orifice of bile duct of donor including left hepatic duct and right anterior hepatic duct was anastomosed to the common hepatic duct of the recipient (yellow) (c).

occupation. The recipient followed an immediate postoperative course similar to other LDLT recipients; however, a biloma was detected on postoperative day 61 and percutaneous drainage was performed. Further complications were not observed, following resolution of the biloma.

Discussion

Since January 1999, when our LDLT program began, more than 1000 LDLTs have been performed in our hospital without any irreversible disabilities or mortalities reported. Because donor safety remains the utmost priority in LDLT operations, only the minimum required liver volume should be resected, leaving sufficient remaining liver volume to sustain the metabolic demands of the donor [8]. Several studies have reported increased morbidity and the possibility of mortality in donors with small RLVs. Therefore, most centers suggest that a minimum RLV of 30% and RLV-BWR of 0.5 is necessary to maintain donor safety [9–11]. Our donor would have had a small estimated RLV (<28.5%) and an RLV-BWR of 0.49, had we performed a right liver donation. As the donor was not young, this may have had an adverse effect on liver regeneration, indicating the need for more careful attention to donor RLVs. Hence, the selection of a different graft type was necessary, based on the donor's sectional liver volume and the recipient's body size.

Vascular and biliary anatomies are other important factors in decisions regarding the type of graft to be performed. Biliary complications are the most common post-LDLT complications for both the donor and the recipient, but the varied and complicated biliary system

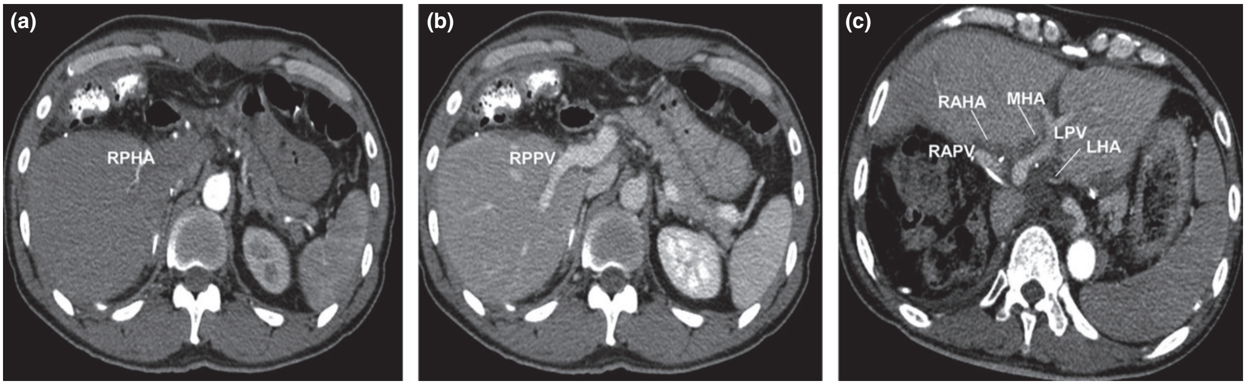

Figure 4 Postoperative computerized tomography of donor and recipient 1 week after transplantation. Right posterior hepatic artery (a) and right posterior portal vein (b) were shown in the remnant right posterior section of the donor. Left, middle, and right anterior hepatic arteries and left and right anterior portal veins were noted in the graft of the recipient (c).

anatomy often makes the operation difficult [12]. Preoperative magnetic resonance cholangiopancreatography has contributed to improved outcomes by permitting an accurate understanding of the bile duct anatomy [13]. In the subject donor, the right posterior duct separately drained into the common bile duct, allowing one opening into the bile duct and facilitating the biliary anastomosis. Had we used a right liver donation, two separate openings to the right anterior and posterior hepatic ducts would have been obtained, potentially causing difficulty in both the donor and recipient operations, and increasing the possibility of biliary complications. The venous systems of the right anterior section and the left liver mainly drained into the middle and left hepatic veins, enabling their simultaneous harvest in conjunction with the common trunk. However, this graft also presented some technical difficulties. For example, the three hepatic arteries (left, middle, and right anterior branches) required three separate anastomoses. Further, the left and right anterior portal vein branches necessitated an *ex vivo* reconstruction to create a common orifice. We had accumulated an institutional experience from over 1000 living donor liver transplantation donor hepatectomies, which enabled us to perform this surgical procedure.

Justification of the complexity and risks of this procedure in the subject donor may be controversial; however, this report provides a valuable introduction of the left trisection as an option for special situations in which the donor is utterly unsuitable for right liver donation.

Conclusion

This is the first report of an LDLT procedure using left trisection of the liver. Although this was a complex operation, it represents a valuable option for special situations involving donors unsuitable for right liver donation.

Authorship

KSS: participated in research design, performance of research, analysis, and writing of manuscript. SWS: participated in research design, performance of research, analysis, and writing of manuscript. JML, YC, NJY and KWL: participated in research design and performance of research.

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References

1. Ghobrial RM, Freise CE, Trotter JF, *et al.* Donor morbidity after living donation for liver transplantation. *Gastroenterology* 2008; **135**: 468.
2. Kiuchi T, Kasahara M, Uryuhara K, *et al.* Impact of graft size mismatching on graft prognosis in liver transplantation from living donors. *Transplantation* 1999; **67**: 321.
3. Ikegami T, Soejima Y, Taketomi A, *et al.* Hilar anatomic variations in living-donor liver transplantation using right-lobe grafts. *Dig Surg* 2008; **25**: 117.
4. Kim SH, Suh KS, Kim SB, Lee HJ, Lee KU. Adult living donor liver transplantation using right posterior segment. *Transpl Int* 2003; **16**: 689.
5. Lee S, Hwang S, Park K, *et al.* An adult-to-adult living donor liver transplant using dual left lobe grafts. *Surgery* 2001; **129**: 647.
6. Couinaud C. *Le Foie: Etudes Anatomiques et Chirurgicales*. Paris: Masson & Cie, 1957: 530.
7. Suh KS, Lee HJ, Kim SH, Kim SB, Lee KU. Hanging maneuver in left hepatectomy. *Hepatogastroenterology* 2004; **51**: 1464.
8. Yi NJ, Suh KS, Cho JY, *et al.* Three-quarters of right liver donors experienced postoperative complications. *Liver Transpl* 2007; **13**: 797.

9. Cho JY, Suh KS, Kwon CH, *et al.* Outcome of donors with a remnant liver volume of less than 35% after right hepatectomy. *Liver Transpl* 2006; **12**: 201.
10. Ibrahim S, Chen CL, Wang CC, *et al.* Small remnant liver volume after right lobe living donor hepatectomy. *Surgery* 2006; **140**: 749.
11. Ste′phanie T, Emmanuel B, Ge′raldine S, *et al.* Liver function following extended hepatectomy can be accurately predicted using remnant liver volume to body weight ratio. *World J Surg* 2015 Jan 6. [Epub ahead of print].
12. Jeon YM, Lee KW, Yi NJ, *et al.* The right posterior bile duct anatomy of the donor is important in biliary complications of the recipients after living-donor liver transplantation. *Ann Surg* 2013; **247**: 702.
13. Hsu HW, Tsang LL, Yap A, *et al.* Magnetic resonance cholangiography in living donor liver transplantation. *Transplantation* 2011; **92**: 94.