ABO incompatible living donor liver transplantation using dual grafts and pure laparoscopic donor right hepatectomy
A case report
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Abstract
Rationale: Because of the shortage of deceased donors, living donor liver transplantation (LDLT) has become the main procedure to treat patients with end-stage liver disease in Asian countries. However, many potential donors are excluded because of donor safety and graft volume issues. In addition, large abdominal wounds after open surgery for hepatectomy could be a reason for hesitating to agree to liver donation, particularly when attempting to recruit young female donors.

Patient concerns: On volumetric computed tomography (CT) examination, remnant liver volume was too small to guarantee the safety of the male donor, and the right hemiliver volume of the female donor was not sufficient to meet the recipient’s metabolic demand. The young female donor also worried about a large abdominal wound following open surgery.

Interventions: We performed ABO-incompatible LDLT using dual grafts and right-sided graft was obtained by pure laparoscopic donor right hepatectomy in a young female donor.

Outcomes: The postoperative course was uneventful in both donors and the recipient is presently doing well in satisfactory condition 7 months after liver transplantation.

Lessons: We overcame these volumetric and cosmetic issues through dual living donor liver grafts using a combination of conventional surgery for 1 donor and laparoscopic right hepatectomy for a second ABO-incompatible donor. We think this procedure can be a good option for the expansion of donor pools.

Abbreviations: GRWR = graft-to-recipient ratio, HCC = hepatocellular carcinoma, LDLT = living donor liver transplantation.

Keywords: hepatectomy, liver transplantation, living donor, minimally invasive surgical procedures

1. Introduction
Recent technical advances in living donor liver transplantation (LDLT) have focused on the cosmetic aspects of donors and expansion of the donor pool. Regarding cosmetic issues, since pure laparoscopic right donor hepatectomy was first introduced by Soubrane et al in 2013,[1] several centers with expertise have adopted this as an attractive alternative to conventional donor hepatectomy via open surgery.[2–4] In addition, to expand donor pools, the exclusion rate of potential donors should be minimized. ABO incompatibility is no longer a reason to avoid live liver donation following the introduction of the anti-CD 20 monoclonal antibodies and a total plasma exchange program, and short-term weight reduction programs have shown effective outcomes for potential donors with severe fatty liver.[5] In addition, small remnant liver portions and a low graft-to-recipient ratio (GRWR) can be overcome through dual graft transplantation.[6]

In the present case, we applied all possible aspects of recent technical refinements on a patient with cirrhosis and hepatocellular carcinoma (HCC) to proceed to successful liver transplantation. We performed dual-graft LDLT with an ABO-incompatible graft obtained successfully using a purely laparoscopic right hepatectomy.

2. Case report
A 51-year-old man (height 166 cm, weight 68.5 kg) was diagnosed with hepatitis B-related liver cirrhosis and HCC in 2011. Thereafter, he received various treatments such as radiofrequency ablation, transarterial chemoembolization, and cryotherapy for recurrent HCC. In August 2017, he complained of a distended abdomen, and new large amounts of ascites and a 13 mm-sized hepatic nodule compatible with HCC at segment 3 was observed on an abdominal computed tomography (CT) scans. His ABO blood type was O+ and the candidate donor (Donor 1) was his 58-year-old brother (height 166 cm, weight 63 kg), with blood type O+.

The volume of the donor’s right hemiliver was calculated as 659 cm³ and the projected GRWR
was 1.04. However, the remnant liver volume was 280 cm$^3$ (29.8% of total liver volume), which was too small to guarantee the donor’s safety. Therefore, we asked for other candidates and his 42-year-old sister with ABO type A$^+$ blood group volunteered to be evaluated for a donor work-up. On volumetric CT examinations, the remnant liver volume was adequate for the donor’s safety, but the right hemiliver volume was not sufficient to meet the recipient’s metabolic demand: the expected right liver volume.

**Figure 1.** Intraoperative cholangiograms. A radiopaque rubber band was anchored at an adequate cutting point as a marker (arrow). (A) Cholangiogram of Donor 1 who underwent conventional open surgery for a left lateral sectionectomy. (B) Cholangiogram of Donor 2 who underwent laparoscopic right heptectomy.

**Figure 2.** Pre and postoperative laboratory results of the 2 donors and recipient. (A) Donor 1. (B) Donor 2. (C) Recipient.
rituximab (300mg/m² per body surface area) and then twofold before surgery, the recipient was administered a single dose of 2) agreed to undergo laparoscopic hepatectomy. Three weeks candidates gave their consent to our plan and the sister (Donor transplantation and laparoscopic donor hepatectomy, both potential risks of dual graft LDLT using ABO-incompatible liver ABO isoagglutinin (IA) titer was 1:64. When we explained the done as reported previously.7 In brief, she was placed in a left intermittent hepatic flow occlusion or a hanging maneuver.3

3. Discussion

LDLT has become the main procedure for liver transplantation in Asian countries because of the scarcity of deceased donor organs. In South Korea, 942 cases of LDLT was performed in 2015, and donors under the age of 35 and lineal descendants comprised two-thirds of all live donors, respectively. In addition, there were 320 cases of donation from female donors.[7] Such a composition of young female donors and lineal descendants gives surgeons concern about cosmetic and recovery problems after conventional open hepatectomy in the donors. In addition, the large abdominal wound following open surgery could be a reason for withdrawing operative consent. Accordingly, a few transplant centers have adopted laparoscopic hepatectomy as a first line procedure for donors in LDLT procedures, and with refinements in surgical techniques and equipment, a recent study showed similar complication rates between laparoscopic and open surgery hepatectomy for the donors.[2]

Regarding the exclusion rate during the live donor evaluation, Nugroho et al reported that 219 of 726 potential donors were excluded initially because of medical problem, withdrawal of consent and a small remnant liver volume/low GRWR.[5] If the
team expects a small remnant liver volume after graft donation, the potential donor should be excluded because their safety is of paramount importance. Also, small grafts that are not sufficient to meet the recipient’s metabolic demands can result in poor outcomes. To overcome these problems, LDLT with dual grafts could be a good option by obtaining sufficient graft volume and leaving large remnant liver portions, but this procedure needs technical expertise, multiple anastomoses, equivalent equipment, long operation time and, above all, 2 donors having to face surgical risks. However, we must consider the risk–benefit ratios for both donors and recipients. A recent multicenter study also has shown favorable results after live liver donation with a major complication rate of only 1.9%.[8]

4. Conclusions
In the present case, we overcame the problems of ABO blood type incompatibility, a small graft, and potential risks to donors, through dual graft LDLT using an ABO-incompatible graft. In addition, we performed a pure laparoscopic donor right hepatectomy to meet the cosmetic needs of the donor. It is mandatory to verify the safety and reproducibility of our procedure through further studies, but we believe our case can be a good model for advancing surgical techniques in LDLT.

Author contributions
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References
[1] Soubrane O, Perdigao Cotta F, Scatton O. Pure laparoscopic right hepatectomy in a living donor. Am J Transplant 2013;13:2467–71.
[2] Suh KS, Hong SK, Lee KW, et al. Pure laparoscopic living donor hepatectomy: focus on 55 donors undergoing right hepatectomy. Am J Transplant 2018;18:434–43.
[3] Kim KH, Kang SH, Jung DH, et al. Initial outcomes of pure laparoscopic living donor right hepatectomy in an experienced adult living donor liver transplant center. Transplantation 2017;101:1106–10.
[4] Cho JY, Han HS, Kaneko H, et al. Survey results of the expert meeting on laparoscopic living donor hepatectomy and literature review. Dig Surg 2018;35:289–93.
[5] Nugroho A, Kim OK, Lee KW, et al. Evaluation of donor workups and exclusions in a single center experience of living donor liver transplantation. Liver Transpl 2017;23:614–24.
[6] Song GW, Lee SG, Moon DB, et al. Dual-graft adult living donor liver transplantation: an innovative surgical procedure for live liver donor pool expansion. Ann Surg 2017;266:10–8.
[7] Han YS, Ha H, Kwon HJ, et al. Pure laparoscopic donor right hepatectomy in a living donor with type 3a biliary variation: a case report. Medicine (Baltimore) 2017;96:e8076.
[8] Lee JG, Lee KW, Kwon CHD, et al. Donor safety in living donor liver transplantation: the Korean Organ Transplantation Registry (KOTRY) study. Liver Transpl 2017;23:999–1006.