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Normothermic Machine Perfusion Before Backtable Ex Situ Split Procedure in Liver Transplantation

Qimeng Gao, MD, MHS,[1] Isaac Alderete, BS,[1] Isabel DeLaura, BA,[1] Riley Kahan, MBS,[1] Christopher L. Nauser, MD,[1] Kannan P. Samy, MD,[1] Kadiyala Ravindra, MD,[1] Aparna Rege, MD,[1] Deepak Vikraman, MD,[1] Debra L. Sudan, MD,[1] and Andrew S. Barbas, MD[1]

Split-liver transplant (SLT) was first introduced in 1988 to increase the number of available organs for patients with end-stage liver disease (ESLD). Although conceptually attractive, this technique was not widely adopted because early studies demonstrated increased risks of biliary and vascular complications associated with SLT.[1] Liver grafts can be split using either in situ or ex situ techniques. In situ splitting is associated with a shorter cold ischemia time (CIT) and less blood loss after reperfusion. However, it is a technically demanding procedure and adds an extra 2–3 h to the donor procedure. Ex situ splitting is performed at the recipient hospital, and while less logistically and technically challenging, this technique adds significant CIT.

Here, we describe a novel approach to minimize CIT in SLT by utilizing normothermic machine perfusion (NMP) technology. We present 2 cases in which NMP was initiated at the donor hospital before ex situ splitting of the donor grafts on ice at our institution. This study was approved by the Duke Institutional Review Board.

CASE DESCRIPTION

Case 1

A 7-mo-old male developed ESLD secondary to biliary atresia and a failed Kasai procedure at 2 mo old. At the time of transplant, he had a pediatric end-stage liver disease score of 40. Two days following activation on the LT waiting list, a suitable DBD donor was identified. Donor details include an age of 15, body mass index of 20.9, Donor Risk Index of 1.65, and absence of macro and microsteatosis on histologic examination. The liver was attached to the TransMedics Organ Care System (OCS) Liver device at the donor hospital and transported back to our institution on device. The liver graft underwent NMP for 462 min. Total CIT was 335 min. During perfusion, the liver exhibited the customary indicators that meet the criteria for proceeding with transplantation. This included clearance of lactate in the perfusate and the generation of bile throughout the perfusion.

In brief, the ex situ split was performed in the following manner: the donor liver allograft was flushed per protocol as it was removed from the OCS device. The whole liver graft was then flushed with cold University of Wisconsin solution. The right trisegment (RTS) of this graft was not able to be placed. As a result, the entire junction of the left and middle hepatic veins was used for outflow for the left lateral segment (LLS) graft. Parenchyma split was performed using Cavitron ultrasonic surgical aspirator separation with vessel branches controlled with bipolar cautery and ties. The resulting left lateral graft weighed 205 g. Before implant, the graft was flushed again with albumin. The graft implant was performed in standard piggyback fashion and the duct anastomosis was performed to the jejunum roux limb from the previous Kasai procedure. The postoperative course was notable for chylous ascites that was managed with dietary optimization. He spent 3 d in the pediatric intensive care unit and was discharged home on posttransplant day 18. He was last seen in the clinic at 3 mo with stable liver function.

Case 2

Left Lateral Segment Recipient

An 8-mo-old female developed ESLD due to biliary atresia and a failed Kasai procedure. She has a pediatric end-stage liver disease score of 31 and was admitted when a DBD donor was identified.

Right Trisegment Recipient

A 68-y-old female with decompensated alcoholic liver cirrhosis. She was 56.2 kg with a body mass index of 24.2 and her MELD score was 21 at the time of the organ offer.

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[1] *Department of Surgery, Duke University Medical Center, Durham, NC.*
Correspondence: Andrew S. Barbas, MD, Department of Surgery, Duke University Medical Center, Box 3512, Durham, NC 27710. (andrew.barbas@duke.edu).

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The liver was procured by our team and transported back to our institution on the OCS Liver device. Initial CIT was 68 min, followed by 462 min on NMP. The backtable split was performed at Duke as described in the first case. A cholangiogram was then performed to guide the line of transection. The liver was then split into 2 partial liver grafts including a 250 g LLS and a RTS allograft. The RTS graft underwent further backtable modifications, including a vein patch to cover the left hepatic vein orifice defect and further resection of segment 4 with Cavitron ultrasonic surgical aspirator and Harmonic Scalpel to prevent postreperfusion necrosis. Implantations were performed simultaneously by 2 teams. The CIT after NMP is 316 min for the LLS and 312 min for the RTS.

The LLS recipient required a reoperation on posttransplant day 4 to ligate a large collateral vessel to shunt more flow through the portal vein. She spent 5 d in the intensive care unit and was discharged on posttransplant day 16 with no further events. The RTS recipient recovered without complications. Both recipients were last seen in the clinic at 1 mo with stable liver function.

DISCUSSION

These cases demonstrate a novel application of NMP technology to aid in ex situ SLT. A split-liver graft is associated with prolonged CIT, smaller graft volume, difficult arterial reconstruction, and biliary complications. NMP is one technology that could balance some of the those associated risks. By keeping the organs at physiological temperatures, NMP minimizes cold ischemia and permits functional assessment of grafts. There are several practical implications of this: NMP can be used at the donor hospital before ex situ split to facilitate donor procedure logistics while keeping the CIT short. As reported in our cases, CITs were around 6 h—much lower than CITs reported in the literature using the ex situ splitting technique and comparable to those reported with in situ splitting.[1] Although not done in these cases, conceptually, an ex situ split can be performed while the organ is perfused and oxygenated, mimicking physiologic conditions achieved with in situ splitting and allowing for a functional "in situ split" to be performed at the recipient hospital. As the liver graft is perfused, surgeons have direct visualization of the perfused segments and cut surface so that optimal hemostasis can be achieved. Two groups have successfully performed liver splitting during NMP in discarded human livers.[2,3] Last, NMP may be utilized after the split, regardless of technical approach, to prolong preservation time and to facilitate organ placement without extending CIT.[4] Ultimately, the long-term NMP in the range of days, may provide a platform to induce liver regeneration after splitting, allowing 2 adult patients to be transplanted safely.[5]

In conclusion, we report 2 cases of SLT in which the backtable split was performed ex situ following NMP. The use of NMP helps minimize CIT for split-liver grafts and potentially facilitates SLT placement to optimize donor-recipient pairing.

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