Technical and Logistical Considerations of In Situ Split-Liver Transplantation for Two Adults: Part II. Creation of Left Segment I-IV and Right Segment V-VIII Grafts

Hasan Yersiz, John F. Renz,* Garrett Hisatake,* Paulo R. Reichert,† Nicholas J. Feduska Jr,* Susan Lerner,* Douglas G. Farmer,* R. Mark Ghobrial,* Sunil Geevarghese,* Angeles Baquerizo,* Pauline Chen,* and Ronald W. Busuttil**

The success of split-liver transplantation (SLT) applied to pediatric recipients has fueled attempts to expand these surgical techniques to include two adult recipients from one adult cadaveric donor.[1-3] In the December 2001 issue of *Liver Transplantation*, a technique used by our donor recovery teams to procure left segment II, III, and IV and right segment I and V through VIII grafts was described. In this issue, we detail a technique for the creation of a larger left segment I through IV graft and right segment V through VIII graft. Each of the described techniques has been applied by our donor recovery teams at outside facilities during routine donor procurement without specialized equipment and simultaneous with additional organ (heart, kidney, pancreas) procurement.

Creation of Left Segment I Through IV and Right Segment V Through VIII Grafts

As previously stated, SLT should be initiated only after standard techniques of abdominal organ procurement have been performed, including supraceliac and infrarenal aortic dissection, as well as cannulation of the inferior mesenteric vein. Thus, if a donor were to become unstable, SLT could be aborted, with rapid progression to aortic cannulation, cross-clamp, and organ cold perfusion.

Dissection is initiated with division of the falciform ligament and carried to the level of the diaphragm with identification of the hepatic veins. The left, middle, and right hepatic veins are identified, and the right hepatic vein is encircled with a vessel loop. The right lobe is freed from its diaphragmatic attachments, and dissection is continued to the inferior vena cava. Accessory hepatic veins larger than 5 mm in diameter (Fig. 1) are individually preserved with a caval patch for implantation into the recipient vena cava. The left border of the inferior vena cava remains undissected.

Hilar dissection is initiated with a retrograde cholecystectomy. The hepatoduodenal ligament is opened to expose the extrahepatic biliary system, and dissection is continued cephalad. The path of the right hepatic artery can be verified and exposed lateral to the common hepatic duct. We prefer lateral exposure of the right hepatic artery to avoid skeletonization of the proper hepatic bifurcation, thereby preserving the arterial supply of segment IV from the right hepatic artery (see Fig. 4, December 2001 *Liver Transplantation*). The right portal vein is approached from the right side of the hilum (lateral) and dissected to the level of the bifurcation, where it is encircled with a vessel loop (Fig. 2). An isolated Pringle maneuver of the left hilar structures is performed to create a line of demarcation that is marked by electrocautery. Before parenchymal transection, the left bile duct is sharply transected at the hilar plate, with bleeding points secured with 6:0 nonabsorbable monofilament suture. Parenchymal transection is performed along the main portal fissure using hot electrocautery while the surgeon's left fingertips are positioned behind the right lobe and in front of

*From the *Dumont-UCLA Transplant Center, Department of Surgery, University of California, Los Angeles, CA; and the †Department of Anatomy, Universidade de Passo Fundo, Passo Fundo, Brazil.*

"Images in Liver Transplantation" is sponsored by Fujisawa Healthcare, Inc. through an unrestricted educational grant.

Address reprint requests to Ronald W. Busuttil, MD, PhD, Rm 77-120 CHS, 10833 Le Conte Ave, Los Angeles, CA 90095-7054.

1527-6465/02/0801-0018$35.00/0
doi:10.1053/jlts.2002.31036

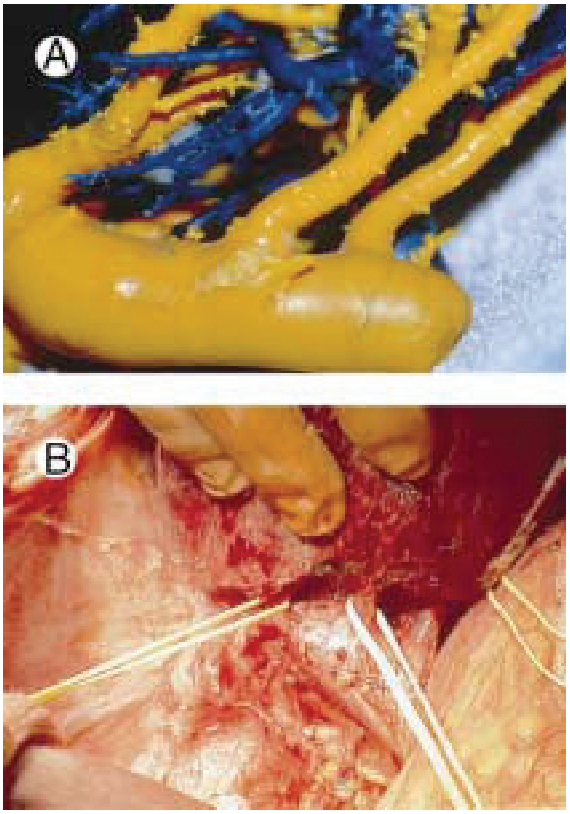

Figure 1. Accessory right hepatic veins (also referred to as inferior right hepatic veins) greater than 5 mm in diameter are shown (A) schematically in a liver corrosion cast and (B) in situ during surgical dissection.

the inferior vena cava. As the major venous branches servicing segments V and VIII are encountered, they are left transected for later perfusion and revascularization through venous conduits. Parenchymal transection is completed at the level of the inferior vena cava, with preservation of the right hepatic vein, right portal vein, and right hepatic artery (Fig. 3). At this point, 30,000 U of heparin is administered, and aortic cannulation is achieved. After aortic cross-clamp and organ perfusion with University of Wisconsin (UW) solution (Viaspan; DuPont Pharmaceuticals, Wilmington, DE), the dissection is continued by sharp transection of the right portal vein just distal to the bifurcation and transection of the right hepatic artery just distal to its takeoff from the proper hepatic artery. The right hepatic vein is divided from the suprahepatic vena cava with a caval patch, and the right segment V through VIII graft is removed (Fig. 4). The bile duct is flushed, and the right graft is stored in cold UW solution. Backtable

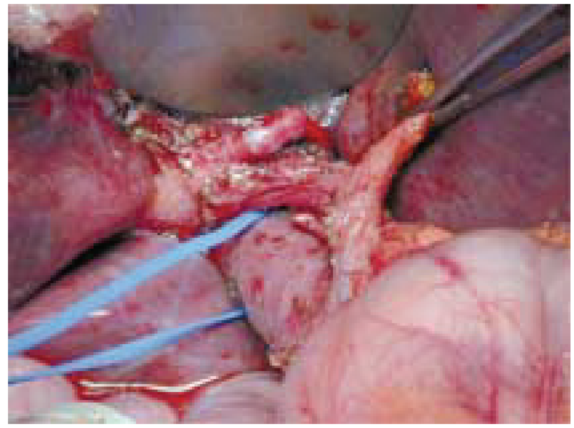

Figure 2. Hilar dissection: the right portal vein is dissected and encircled with a vessel loop (blue). The cystic duct is retracted by the forceps, and the right hepatic artery lies above the common hepatic duct.

preparation of right segment V through VIII grafts includes suture ligature of small biliary radicles and may mandate restoration of segment V and VIII venous outflow through the use of venous conduit (see Fig. 8, December 2001 *Liver Transplantation*). Implantation of right segment V through VIII grafts requires recipient caval preservation.

The left segment I through IV graft (Fig. 5) is removed using standard techniques of donor organ recovery, followed by irrigation of the common bile duct and storage in cold UW solution. Backtable preparation of the left segment I through IV graft includes flushing the left bile duct with UW solution and closure

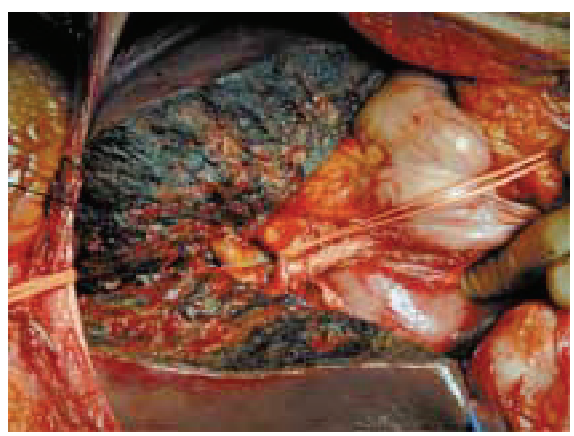

Figure 3. Parenchymal dissection has been completed and the grafts are ready for aortic cannulation and cold perfusion. The left bile duct has been separated; however, the hepatic arterial (left hepatic artery encircled by red vessel loop) and portal venous systems are intact.

Figure 4. Right segment V through VIII graft: the right hepatic vein is being retracted with forceps in the top left. The single right portal vein, right hepatic artery, and right hepatic duct are present in the top center of the photograph. Graft mass was 1,200 g.

Figure 6. Left segment I to IV graft: the celiac is retained with the left segment I through IV graft to optimize blood supply to segment IV. Also shown are the left hepatic duct, main portal vein, and repaired stumps of the right hepatic artery and right portal vein.

of the right portal vein stump, right hepatic vein stump, and right hepatic artery stump, as well as suture ligation of biliary radicles.

Our practice is to preserve the common portal vein and celiac axis with the left graft (Fig. 6). The authors' rationale for preserving the celiac with the left graft is to maximize arterial supply to segment IV because the segment IV arterial supply is routinely derived from branches of the left and right hepatic arteries (Fig. 4, December *Liver Transplantation*). Preservation of the celiac with the left graft thus minimizes posttransplantation segment IV ischemia and/or necrosis.

Figure 5. The left segment I through IV graft is shown. Graft mass was 780 g.

Case Presentation

SLT was performed on a 47-year-old 92-kg male donor and the graft was offered to a United Network for Organ Sharing (UNOS) status 1, 18-year-old, 48-kg female recipient with fulminant hepatic failure of unknown cause. Left-lobe segment I through IV graft mass was 780 g. The recipient of the right segment V through VIII graft was a UNOS status IIB, 52-year-old, 60-kg woman with end-stage liver disease secondary to hepatitis C. Right segment V through VIII graft mass was 1,200 g. Parenchymal division time was 90 minutes, whereas total time required for completion of the donor split procedure was 120 minutes. The procedure was performed concomitantly with a heart, lung, kidney, and pancreas procurement.

Conclusion

Split-liver techniques generate grafts that can support two adult recipients from one cadaveric donor. We have used SLT as an attractive alternative to living donation and to truncate waiting for cadaveric organ donation. Paramount to the success of SLT is accurate donor and recipient selection. We have restricted split-liver techniques to ideal donors who are young and stable and with a relatively short period of hospitalization. Recipient selection is principally limited by available left-lobe mass. Although we have used split-liver grafts for the treatment of UNOS status I fulminant hepatic failure, we have avoided the use of split-liver grafts in patients with advanced chronic liver disease requiring intensive care unit hospitalization (UNOS status IIA).

The techniques described require only standard surgical facilities with no specialized equipment and have been performed concomitantly with other organ procurements. Additional time is required for the procedure, but this has not been an excessive burden provided adequate communication has occurred between donor teams. Furthermore, split-liver grafts have been successfully exported and shared between centers.

References

1. Rogiers X, Malago M, Gawad K, Jauch KW, Olavsson M, Knoefzi WT, et al. In situ splitting of cadaveric livers. The ultimate expansion of a limited donor pool. Ann Surg 1996;224:331-339; discussion, 339-341.
2. Goss JA, Yersiz H, Shackleton CR, Seu P, Smith CV, Markowitz JS, et al. In situ splitting of the cadaveric liver for transplantation. Transplantation 1997;64:871-877.
3. Ghobrial RM, Yersiz H, Farmer DG, Amersi F, Goss J, Chen P, et al. Predictors of survival after in vivo split liver transplantation: Analysis of 110 consecutive patients. Ann Surg 2000;232:312-323.