

RAPID COMMUNICATION

Donor safety in adult living donor liver transplantation using the right lobe: Single center experience in China

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Abstract

AIM: To evaluate the safety of donors in adult living donor liver transplantation (LDLT) using the right lobe in a single liver transplantation center in China.

METHODS: We investigated retrospectively 52 living donor liver resections performed from October 2003 to July 2006. All patients were evaluated by blood tests and abdominal CT. The mean donor age was 28.2 ± 7.4 years. Residual liver volume was $42.1\% \pm 4.7\%$. Mean operative time was 420 ± 76.2 min; mean ICU stay, less than 36 h; mean hospital stay, 16.4 ± 8.6 d; and mean follow-up period, 6 mo.

RESULTS: There was no mortality. The overall complication rate was 40% (21 donors). Major complications included biliary leak in two, and pneumonia in 2 donors. Minor complications included mild pleural effusion in 12 donors, transient ascites in 6, mild depression in 4, intra-abdominal collections in 2, and wound infections in 1 donor. Residual liver volume did not affect the complication rate. None required re-operation. Return to pre-donation activity occurred within 5-8 wk.

CONCLUSION: Right hemi-hepatectomy can be performed safely with minimal risk in cases of careful donor selection. Major complications occurred in only 7.7% of our series.

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Key words: Safety; Donor; Liver transplantation; Complication

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INTRODUCTION

Living donor liver transplantation (LDLT) is an acceptable modality to treat end-stage liver disease and offers hope to patients with end-stage liver disease in areas where the waiting mortality is high and the availability of deceased donor organs falls short of the population. Regardless of the potential benefit that LDLT offers to the critically ill patients with end-stage liver disease, donor safety is a prime concern^[1]. Furthermore, the graft mass cannot satisfy the demand in adult patients requiring use of the right lobe^[2]. This donor risk was especially emphasized by discouraging episodes of donor mortality in North America, Europe, South America, and East Asia^[3-7]. A few donors had to undergo liver transplantation due to hepatic failure following liver donation^[3,4]. The advance of LDLT using right lobe grafts has raised special concerns about the safety of living liver donors. In 2003, our team started a new program using the right lobe in living donor transplantation. The aim of this study was to retrospectively review our experience with donor hepatectomy using the right lobe, specifically in the context of preserving donor safety at a single center in China.

MATERIALS AND METHODS

From October 2003 to July 2006, 52 donor operations for adult LDLT using the right lobe were performed at the Department of General Surgery, West China Hospital, Sichuan University of China. We investigated retrospectively the 52 living donor liver resections. All patients were evaluated by blood tests and abdominal CT. Donors' age ranged from 17 to 52 years, the mean age was 28.2 ± 7.4 years, 29 were men and 23 were women. In relation to the recipient, there were 22 sons, 12 spouses, 8 brothers or sisters, and 10 other relatives.

Preoperative donor evaluation included computed tomography with volumetry and magnetic resonance imaging with angiography and cholangiography. The criteria for donor selection included ABO blood type compatibility, acceptable ranges of liver function tests,

reasonable liver volumes, age < 50 years, and fatty change < 30% by liver biopsy. The transection line was demarcated on the liver surface by temporary occlusion of right hepatic artery and portal vein. Inflow vascular occlusion was not used during liver transection. Vascular and biliary stumps were closed using a Prolene or an interrupted suture. Liver volume was evaluated with CT volumetry during the preoperative period and at 3 mo postoperatively. Intraoperative liver biopsy was performed routinely by one hepatic pathologist to check the percent of fatty change. We reviewed the donor characteristics, operative findings, and postoperative results, including the peak value of liver enzymes (AST, ALT and bilirubin). Findings were correlated with donor age (< 30 years and < 40 years), percent of fatty change in donor liver (no change, < 10%, and < 30%) size of remnant left lobe volume (< 35%, < 40%, and > 40%) and regeneration activity, as evaluated by CT volumetry at 3 mo postoperatively.

Operative technique

The donor procedure involved several steps. First, cholecystectomy and intraoperative cholangiography were performed to delineate the biliary anatomy. Next, the right hepatic artery and right portal vein were dissected. Intraoperative ultrasound was then performed to define the hepatic venous drainage of the right liver lobe. In most of our donors, the middle hepatic vein was preserved to avoid outflow obstruction to the remaining donor segment 4. The right hepatic vein was then isolated and the attachments between the right lobe and the diaphragm were divided to expose the inferior right hepatic veins (IRHVs), which drains the right lobe directly into the inferior vena cava. All IRHVs of more than 5 mm diameter were preserved for subsequent anastomosis to the recipient inferior vena cava. The right bile duct was cut sharply. The hepatic parenchyma was divided along Cantlie's line 1 cm to the right of the main stem of the middle hepatic vein using electrocautery and a Cavitron ultra-sonic aspirator. After the right lobe was completely separated, vascular clamps were applied to the right portal vein, right hepatic vein, and IRHVs. The lobe was removed, transferred to a back table, and flushed with a heparinized solution. Abdominal closure was performed in standard fashion.

RESULTS

All donors survived the procedure. Fifty-two right lobectomies required 316-576 (420 ± 76.2) min. The transfusions during operation ranged from 0 to 6 (mean 1.29 ± 1.21) U. The mean length of stay in the intensive care unit was less than 36 h, and the mean hospital stay was 16.4 ± 8.6 (range, 10 to 48) d. The total volume of the donor liver ranged from 976 to 1816 (mean 1106 ± 201) mL, including 382-925 (mean 526 ± 146) mL in the volume of the left lobe, and the ratio of the left lobe to the whole liver ranged from 32.3% to 46.2% (mean $38.6\% \pm 4.8\%$).

In the immediate postoperative period, all donors exhibited transient liver enzyme elevation, hyperbilirubi-

nemia and hypoalbuminemia. The liver profiles normalized after a mean of 12 d. Prothrombin time was prolonged in the early postoperative period, but in most cases this was normalized within 14 d.

The postoperative peak values of liver enzymes increased based on the severity of fatty changes, especially between the groups with < 10% or > 10% fatty change, but the differences were not statistically significant. According to remnant left liver volume, there was statistically significant difference between the group with < 35% and the group > 35% postoperative liver enzymes ($P < 0.05$), but there was no significant difference among the groups with > 35%. The volume of the remnant liver is an important factor that influences the postoperative liver enzymes.

Computed tomography with volumetry was performed preoperatively and at 3 months postoperatively. The regeneration of the remnant liver (percent) was calculated as the liver volume on postoperative mo 3 versus preoperative liver volume $\times 100$. The mean regeneration of the remnant left lobe at 3 mo postoperatively was $208\% \pm 41\%$ (148%-312%) compared with the preoperative liver volume.

The mean follow-up time for the 52 cases was 6 mo. There was no donor mortality, and overall complication rate was 40% ($n = 21$). Four donors (7.7%) developed early postoperative major complications, including biliary leakage (two cases), and pneumonia (two cases). Bile leakage from the stump of the duct in one patient was treated with continuous drainage and healed spontaneously. The other patient with bile leakage was successfully managed with endoscopic retrograde cholangiopancreatography (ERCP) and placement of a biliary stent, which extended the patient's hospital stay to 36 d. The stent was removed 6 wk later and no further interventions were needed. Both cases of pneumonia were successfully treated with antibiotics. The minor complications included mild pleural effusion (12 donors, 23%), transient self-limited ascites (6 donors, 11.5%), mild depression in (4 donors, 7.7%), intra-abdominal collections (2 donors, 3.8%) and wound infection (1 donor, 2%). The pleural effusion was on the right side in most cases. Three donors had to be readmitted 1 mo after the operation for aspiration of a purulent subphrenic collection. The most common problem, especially for young donors who cared about their looks, was scar formation^[8]. At 1-year follow-up, prominent hypertrophic scar was observed in about 5% of donors, but no keloid has ever been detected. No one received wound revision for cosmetic purposes. All donors returned to their predonation daily activities within 5-8 wk, and no liver impairment was noted during follow-up.

DISCUSSION

Selection and evaluation of a living liver donor for adult recipients is a complex process that involves optimizing graft size in relation to the safety of donors and recipients, technical details of liver procurement, and ethical problems of using nonrelated live donors. As in most countries,

including the United States and Japan, no legal restrictions exist for living donation, local ethics committees confirm whether the candidates are appropriate potential donors. Voluntarism is the primary selection criterion and medical evaluation can only be started after confirmation of the voluntary nature of the donation.

Volumetric study using computed tomography scans is mandatory. For patients with advanced liver disease, a graft volume of greater than 40% of the recipient standard liver volume is necessary^[9], while for the living donor the remnant liver mass must be more than 30% of the whole liver^[10]. Selection of right lobe graft should be very prudently considered if the right liver appears to be 65% of the whole liver volume^[11]. The term "standard liver volume" has become a key concept in LDLT^[12]. Estimated liver volume on computed tomography in healthy volunteers is proportional to body surface area and is calculated using the following formula: liver volume (mL) = 706.2 × body surface area (m²) + 2.4.

In living donor liver transplantation using the right lobe, donor safety must always be the primary consideration. We reviewed the peak value of liver enzymes as parameters of donor risk and considered several factors, including donor age, degree of fatty change, and volume of remnant liver as factors that influence the value of liver enzymes. Among the factors, the volume of remnant liver was most important. Several investigators have suggested that individuals with normal liver function tolerate resection of up to 60% or 70% of a nontumorous liver^[13].

Our data indicate that the peak value of liver enzymes in donors with < 35% of the liver as a remnant were significantly higher than the group with > 35%. These values could induce risks to the donor. With regard to the safety margin, a remnant liver volume of 30% of the total is probably the lowest limit.

During screening donor evaluation, many candidates have some degree of fatty liver. We select donors whose livers have < 30% fatty change. Our data suggest that, even in this acceptable limit of fatty change, the postoperative peak value of liver enzymes increased according to the degree of fatty change, especially in cases of > 10% fatty change. Although this factor is not significant itself, it is problematic when combined with other risk factors.

The recovery of the donor liver depends on the regenerative activity of the remnant liver. Regeneration after resection usually starts in the immediate postoperative period, and occurs mainly within 2 wk after operation. The liver mass of small-for-size grafts increased more rapidly to meet the metabolic demands of greater relative body size. We observed liver regeneration at postoperative month 3. Our data indicate that regeneration of liver volume at 3 mo postoperatively is about twofold greater than the preoperative value, and the regenerative activity was increased among the groups with smaller remnants.

The most important complication during donor operation is biliary injury. However, there was no biliary injury in our data. The precise biliary anatomy and meticulous hilar dissection could prevent such injury. Ischemia due to excessive dissection of the right hepatic

artery is probably responsible for biliary stricture. We recommend dissection of the right hepatic artery to a lesser degree, confining the exposure to the right side of common hepatic artery.

In conclusion, our single-center experience showed that life-threatening complications of the right hemihepatectomy donor operation could be avoided or overcome only through the strict selection of living donors, intensive postoperative surveillance, and timely feedback of surgical techniques. In LDLT, the physical and psychologic sacrifice by the donor is significant and is associated with high expectations regarding a good outcome for themselves and the recipient^[14]. There can be significant risks to the donor, including the risk of death and substantial morbidity, that must be taken into account before patients, physicians, and transplant programs embark on LDLT. Universally acceptable criteria for donor selection should be established to prevent immoderate procurement of liver graft. Right hemihepatectomy can be performed safely with minimal risk in cases of careful donor selection such that the remnant liver volume exceeds 30% of the total liver volume while showing minimal fatty change. Major complications occurred in only 7.7% of our series.

REFERENCES

- 1 **Lo CM**. Complications and long-term outcome of living liver donors: a survey of 1,508 cases in five Asian centers. *Transplantation* 2003; **75**: S12-S15
- 2 **Kawasaki S**, Makuuchi M, Matsunami H, Hashikura Y, Ikegami T, Nakazawa Y, Chisuwa H, Terada M, Miyagawa S. Living related liver transplantation in adults. *Ann Surg* 1998; **227**: 269-274
- 3 **Brown RS**, Russo MW, Lai M, Shiffman ML, Richardson MC, Everhart JE, Hoofnagle JH. A survey of liver transplantation from living adult donors in the United States. *N Engl J Med* 2003; **348**: 818-825
- 4 **Akabayashi A**, Slingsby BT, Fujita M. The first donor death after living-related liver transplantation in Japan. *Transplantation* 2004; **77**: 634
- 5 **Settmacher U**, Theruvath T, Pascher A, Neuhaus P. Living-donor liver transplantation--European experiences. *Nephrol Dial Transplant* 2004; **19** Suppl 4: iv16-iv21
- 6 **Wiederkehr JC**, Pereira JC, Ekermann M, Porto F, Kondo W, Nagima I, Amaral W, Camargo CA, Moreira M. Results of 132 hepatectomies for living donor liver transplantation: report of one death. *Transplant Proc* 2005; **37**: 1079-1080
- 7 **Miller C**, Florman S, Kim-Schluger L, Lento P, De La Garza J, Wu J, Xie B, Zhang W, Bottone E, Zhang D, Schwartz M. Fulminant and fatal gas gangrene of the stomach in a healthy live liver donor. *Liver Transpl* 2004; **10**: 1315-1319
- 8 **Chen CH**, Chen Y, Chiang YJ, Wu CT, Chen HW, Chu SH. Risks and quality-of-life changes in living kidney donors. *Transplant Proc* 2004; **36**: 1920-1921
- 9 **Lo CM**, Fan ST, Liu CL, Chan JK, Lam BK, Lau GK, Wei WI, Wong J. Minimum graft size for successful living donor liver transplantation. *Transplantation* 1999; **68**: 1112-1116
- 10 **Fan ST**, Lo CM, Liu CL, Yong BH, Chan JK, Ng IO. Safety of donors in live donor liver transplantation using right lobe grafts. *Arch Surg* 2000; **135**: 336-340
- 11 **Hwang S**, Lee SG, Lee YJ, Sung KB, Park KM, Kim KH, Ahn CS, Moon DB, Hwang GS, Kim KM, Ha TY, Kim DS, Jung JP, Song GW. Lessons learned from 1,000 living donor

- liver transplantations in a single center: how to make living donations safe. *Liver Transpl* 2006; **12**: 920-927
- 12 **Urata K**, Kawasaki S, Matsunami H, Hashikura Y, Ikegami T, Ishizone S, Momose Y, Komiyama A, Makuuchi M. Calculation of child and adult standard liver volume for liver transplantation. *Hepatology* 1995; **21**: 1317-1321
- 13 **Stone HH**, Long WD, Smith RB, Haynes CD. Physiologic considerations in major hepatic resections. *Am J Surg* 1969; **117**: 78-84
- 14 **Sugawara Y**, Makuuchi M. Advances in adult living donor liver transplantation: a review based on reports from the 10th anniversary of the adult-to-adult living donor liver transplantation meeting in Tokyo. *Liver Transpl* 2004; **10**: 715-720

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