BRIEF ARTICLES

Sonographic evaluation of vessel grafts in living donor liver transplantation recipients of the right lobe

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Author contributions: Lu Q and Luo Y designed the study and performed the ultrasound examinations; Wu H, Fan YT and Zhang ZW collected the sonographic and clinical data; Lu Q wrote the manuscript; Wu H and Luo Y were involved in editing the manuscript.

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Received: April 11, 2009 Revised: June 19, 2009

Accepted: June 26, 2009

Published online: July 28, 2009

occluded VG was 30.1 ± 5.6 cm/s, 16.5 ± 5.8 cm/s, respectively, in chronic patents. The difference between two groups was statistically significant ($P < 0.001$).

CONCLUSION: Our results indicate that most VG are patent in the first postoperative week while only a small portion with a higher velocity remains patent after 3 mo. Intrahepatic venous collaterals can be observed in some patients after occlusion of VG.

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Key words: Living donor liver transplantation; Ultrasound; Vessel graft; Venous collateral; Middle hepatic vein

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Lu Q, Wu H, Fan YT, Luo Y, Zhang ZW. Sonographic evaluation of vessel grafts in living donor liver transplantation recipients of the right lobe. *World J Gastroenterol* 2009; 15(28): 3550-3554 Available from: URL: <http://www.wjgnet.com/1007-9327/15/3550.asp> DOI: <http://dx.doi.org/10.3748/wjg.15.3550>

Abstract

AIM: To evaluate the vessel grafts (VG) used to reconstruct the middle hepatic vein (MHV) tributaries with ultrasonography.

METHODS: Twenty-four patients undergone living donor liver transplantation were enrolled in our study. MHV tributaries larger than 5 mm in diameter were reconstructed with interposition VG. Blood flow of the graft and interposition VG was checked by Doppler ultrasonography daily in the first 2 postoperative weeks and monthly followed up after discharge. The sensitivity of VG detected by ultrasonography was assessed using surgical records as references. Student's *t* test was used to compare the velocity of VG and occluded VG in chronic patents (> 3 mo).

RESULTS: Thirty-one VG were used to reconstruct the MHV tributaries. Ultrasonography identified 96.7% (30/31) of large MHV tributaries and 90.3% (28/31) of VG. The diameter of VG was 5.6 ± 0.8 mm and the velocity of VG was 19.7 ± 8.1 cm/s. Two VG (2/31, 6.5%) were occluded on the first postoperative day in one patient who suffered from persistent ascites and had a prolonged recovery of liver function. Twenty-six VG (26/31, 83.9%) were patent 2 wk after operation. Six (6/31, 19.4%) VG were patent over 3 mo after operation. Intrahepatic venous collaterals were detected in 29.2% (7/24) patients. The velocity of VG and

INTRODUCTION

Adult-to-adult living donor liver transplantation (AALDLT) is emerging as an alternative to cadaveric liver transplantation due to shortage of graft organs^[1,2]. A right lobe liver graft is now commonly used in this procedure, and the middle hepatic vein (MHV) trunk is usually preserved for the donor for his or her safety^[3,4]. Because hepatic venous blood of the anterior segment usually drains to the inferior vena cava through the V5 and V8 MHV tributaries, this type of grafts is inherently prone to cause congestion of the right paramedian sector (segments V and VIII), leading to tissue atrophy or necrosis^[5,6]. Because establishment of optimal hepatic venous outflow is essential to a successful outcome of AALDLT, there has been emerging interest in hepatic venous congestion in the paramedian sector of the right lobe graft after AALDLT. Recently, surgical reconstruction of the major MHV tributaries using an interposition VG has been advocated to achieve optimal hepatic venous outflow

of the paramedian sector in AALDLT recipients using a modified right lobe graft. Although the indication for reconstruction of MHV is still controversial^[3,7,8], MHV tributaries in the anterior segment of the modified right lobe graft are routinely reconstructed in our institution if they are larger than 5 mm in diameter. However, compared with the recent surgical interest and investigations designed to prevent hepatic venous congestion in the right paramedian sector of the right lobe grafts after AALDLT, little attention has been given to postoperative radiological surveillance for thick MHV tributaries, VG and intrahepatic venous collaterals.

Therefore, this study was to assess the value of ultrasound in the evaluation of interposition VG and intrahepatic venous collateral formation after occlusion of the VG in AALDLT.

MATERIALS AND METHODS

Patients

From January 2006 to August 2007, 51 consecutive adult patients underwent AALDLT using the right lobe grafts at West China Hospital. The indications for liver transplantation included hepatitis-B virus cirrhosis in 26 patients, acute hepatic failure in 8 patients, hepatitis-B cirrhosis associated with hepatocellular carcinoma in 16 patients, retransplant for diffused ischemic intrahepatic biliary stenosis of cadaveric graft with liver failure in 1 patient. Twenty-four (47.1%) patients (21 males and 3 females) who underwent MHV reconstruction were enrolled in our study. Their median age was 38 years (range, 22–54 years). The donors (14 males and 10 females) with a median age of 36 years (range, 22–53 years) included 6 wives, 7 brothers, 2 sisters, 4 sons, 2 daughters, 2 fathers and 1 husband. All cases were approved by the ethics committee of local authority and informed consent was obtained from each patient.

Preoperative assessment

Right liver volume was estimated by multi-slice computed tomography (CT). Candidates in whom the right liver represented more than 70% of the whole liver were excluded from prospective donors. An estimated graft volume to recipient standard liver volume ratio of 40% was the lower limit for right lobe liver transplantation. The number and diameter of thick MHV tributaries draining the right paramedian sector were evaluated by CT.

Intraoperative evaluation

Donor hepatectomy was performed through a J-shaped incision. Intraoperative ultrasound was performed to confirm the hepatic vein anatomy and verify the transection plane. Major MHV tributaries were isolated and preserved if present and greater than 5 mm in diameter. Hepatic venous congestion in the right paramedian sector was investigated intraoperatively after parenchyma transaction by clamping test^[9]. Liver surface discoloration in the right paramedian sector was observed 5 min after simultaneous clamping of MHV tributaries and the right hepatic artery. If the congested

area was dominant as determined by the clamping test or the diameter of MHV tributaries was larger than 5 mm, reconstruction of MHV tributaries was preceded. The autogenous great saphenous and cryopreserved cadaveric external iliac veins are most commonly used as interposition vessel grafts.

Postoperative ultrasound examination

To prevent thrombosis of hepatic artery and vessel grafts, prophylactic anticoagulation therapy was routinely used after surgery. Blood flow in the graft or interposition vessel was checked by Doppler sonography using a HDI 5000 scanner (Philips Medical Systems, Bothell, WA) or a LOGIQ 9 scanner (GE Medical Systems, Milwaukee, Wis). Contrast enhanced ultrasound examinations were done with a Sequoia 512 ultrasound scanner (Acuson Siemens, Erlangen, Germany). The contrast agent was SonoVue (Bracco Imaging, Milan, Italy) consisting of sulphur hexafluoride microbubbles stabilized by a phospholipid shell, 2.4 mL of SonoVue per exploration was injected through a peripheral vein. A low mechanical index mode was used. Scans were performed by an ultrasound doctor with more than 5-year experience in liver transplantation ultrasound. Patients received ultrasound examination daily until postoperative day 14 and once a week thereafter until hospital discharge. Intercostal views of the right upper quadrant of abdomen were obtained to examine the full extension of the hepatic parenchyma. Thick tributaries of the MHV, identified at the left margin of the graft, were used as extrahepatic interposition VG. Fundamental gray scale, color flow images, and Doppler spectra were obtained. Angle-corrected velocities were obtained with the Doppler angle less than 60°. Contrast enhanced ultrasound study was conducted in 5 patients and late parenchymal phase (60 s after injection of SonoVue) was used to observe the patency of VG. All images were acquired when the patients did not hold their breath.

VG were divided into long term patent group and occluded group according to the vessel patency 3 mo after surgery. Student's *t* test was used to compare the velocity in two groups.

RESULTS

Thirty-one vessel grafts were used to reconstruct the MHV tributaries, including V5 (*n* = 13), V8 (*n* = 4), both V5 and V8 (*n* = 7) (Figure 1). Ultrasonography identified 96.7% (30/31) of large MHV tributaries and 90.3% (28/31) of vessel grafts (Figure 2). The diameter of VG was 5.6 ± 0.8 mm and the velocity of VG was 19.7 ± 8.1 cm/s. Two VG (6.5%) were occluded on the first day after surgery in one patient (Figure 3) who had a prolonged recovery of graft function and persistent ascites for 2 mo. Twenty-six VG (83.9%) were patent 2 wk after operation. Six VG (19.4%) were patent over 3 mo after after operation. Intrahepatic venous communications between the MHV tributaries and the right hepatic vein were detected in 7 (29.2%) patients (Figure 4). The velocity in long term patent VG group and occluded VG group was 30.1 ± 5.6 cm/s and 16.5 ± 5.8 cm/s, respectively. The

Figure 1 Intraoperative photograph showing an interposition vessel graft (white arrow) draining venous flow from MHV tributaries in segments V-IVC (black arrow) (A) and interposition vessel grafts V5 (white arrow) and V8 (black arrow) (B) used to reconstruct MHV tributaries in segments V and VIII. MHV: Middle hepatic vein, IVC: Inferior vena cava.

Figure 2 Color Doppler ultrasonography showing large MHV tributaries (arrow) in segment V containing hepatofugal venous flow (A), vessel grafts (arrow) draining the IVC along the surgical margin of liver graft (B), and vessel graft (arrow) filled with contrast agent on contrast enhanced ultrasound indicating the vessel graft patency (C).

Figure 3 Color Doppler sonography showing MHV tributaries filled with hypoechoic substances representing thrombus (arrow) with no color signal in vessel grafts (A), contrast enhanced sonography showing no contrast agent in vessel grafts (arrow) and MHV tributaries (red arrow) indicating vessel occlusion (B), and contrast enhanced CT scan on postoperative day 2 showing an area of low attenuation in segment V corresponding to the draining territory of MHV (arrow) (C) in a 42-years old male who received a modified right lobe graft from his brother.

Figure 4 Color Doppler ultrasonography (A) and its sketch (B) showing MHV tributaries draining into the RHV via collaterals after thrombosis of vessel grafts on postoperative day 7 in a 32 years old male who received a right lobe graft from his wife.

difference between two groups was statistically significant ($P < 0.001$).

DISCUSSION

The major limitation of AALDLT is the inadequacy of graft size. To guarantee the safety of the donor, many institutes perform AALDLT using a right liver graft without the MHV trunk^[1,10,11]. However, this procedure might be complicated by severe congestion of the right paramedian sector, leading to tissue atrophy or necrosis. Therefore, the MHV tributaries larger than 5 mm in diameter should be preserved to achieve optimal outflow of the right paramedian sector.

Doppler sonography is generally regarded as a primary technique for vascular surveillance after LDLT and is, sometimes, the only available bedside imaging modality in the early postoperative period^[12,13]. Good spatial resolution and high sensitivity to slow flow make ultrasound useful in depicting the MHV tributaries and interposition VD. In our study, Doppler sonography demonstrated 90.3% of the VG and 96.7% of the large MHV tributaries. However, ultrasound scan was interfered by bowel and lung gas, thus failing to identify the rest three VG and one MHV tributary.

Early occlusion of VG may result in an eventful recovery of liver function. One patient in whom the VG were occluded on the first postoperative day had a prolonged recovery of graft function and persistent ascites for 2 mo. Occlusion of the VG caused venous congestion of the right paramedian sector, thus delaying the recovery of liver function. Persistent ascites can be caused by an inadequate hepatic mass^[14,15]. The regenerated liver cannot reach its adequate size in the early postoperative period and venous congestion of the right paramedian sector can further decrease the functional hepatic mass size.

Unlike the hepatic vein, since VG do not support the surrounding hepatic parenchyma, these VG are under a greater pressure from the neighboring structures due to liver regeneration. Moreover, because the diminished flow also attributes to the occlusion of VG, VG have a tendency to occlude with time. In our study, only 6 VG (19.4%) remained patent 3 mo after operation and had a higher velocity than the occluded VG.

Identification of intrahepatic collaterals between MHV tributaries and right hepatic vein is important, because the presence of intrahepatic collaterals indicates the outflow of the right paramedian sector is not occluded. Whether all patients have intrahepatic venous collaterals still remains controversial. De Cecchis *et al*^[16] reported that intrahepatic communicating veins are sometimes observed. Kaneko *et al*^[17] demonstrated that the right branch of MHV drains into the right hepatic vein via the collaterals between them. However, Cescon *et al*^[18] described that the venous flow in MHV was eliminated without intrahepatic venous communication in 24 grafts of 30 living donor liver transplantations when the MHV was clamped, Doppler ultrasound is sensitive to slow flow and provides information about the direction of blood flow. In our study, extensive subcapsular venous

communications were demonstrated in 7 patients (29.2%) after the occlusion of VG at follow-up ultrasound examination with no salient echogenicity change.

Contrast enhanced ultrasound is a newly emerged technique and can greatly improve the visualization of low velocity flow^[19,20]. We did not routinely use it to evaluate VG due to the high price of contrast agent. In our series, 5 patients underwent contrast enhanced ultrasound study to exclude hepatic artery thrombosis and evaluate the patency of VG. The results show that it can greatly enhance the confidence of ultrasound doctors. However, further study is needed to evaluate the diagnostic value of this new technique.

In conclusion, Doppler sonography is useful in depicting thick MHV tributaries and VG. Most interposition VG are patent in the first week after surgery and trend to occlude with time with only a small portion remains patent 3 mo after operation. Intrahepatic venous collaterals can be observed after occlusion of VG.

ACKNOWLEDGMENTS

The authors thank Shan-Xia Luo for her editorial assistance in preparing the manuscript.

COMMENTS

Background

Surgical reconstruction of major middle hepatic vein tributaries using interposition vessel grafts (VG) has been advocated to achieve optimal hepatic venous outflow of the paramedian sector in adult-to-adult living donor liver transplantation recipients using a modified right lobe graft. However, little attention has been given to postoperative radiological surveillance for thick MHV tributaries, VG and intrahepatic venous collaterals.

Research frontiers

Doppler sonography and contrast enhanced ultrasound were used to investigate the patency and velocity of VG in study. The relation between VG velocity and long term patency was discussed. The issue of intrahepatic venous collaterals was also addressed.

Innovations and breakthroughs

Although some studies have already discussed the issue of reconstructed vessels, our study focused on the patency of reconstructed vessels, which has received little attention.

Applications

By displaying the relation between the velocity and patency of VG and the formation of intrahepatic venous collaterals, sonographic surveillance may represent a strategy for prediction of the VG patency and even the paramedian sector congestion of transplanted liver.

Terminology

VG used to reconstruct middle hepatic vein (MHV) tributaries are vascular conduit between MHV tributaries and inferior vena cava. Autogenous great saphenous and cryopreserved cadaveric external iliac veins are the most frequently used VG.

Peer review

The authors investigated the patency of vascular conduits (vessel graft) for MHV reconstruction with right liver graft in living donor liver transplantation. They used autogenous great saphenous and cryopreserved cadaveric external iliac veins as vascular conduit. Their data and experience are valuable because little evidence of the patency of reconstructed vessels is available, although similar studies are available.

REFERENCES

- 1 Trotter JF, Wachs M, Everson GT, Kam I. Adult-to-adult transplantation of the right hepatic lobe from a living donor. *N Engl J Med* 2002; **346**: 1074-1082

- 2 **Inomata Y**, Uemoto S, Asonuma K, Egawa H. Right lobe graft in living donor liver transplantation. *Transplantation* 2000; **69**: 258-264
- 3 **Kim BW**, Park YK, Paik OJ, Lee BM, Wang HJ, Kim MW. Effective anatomic reconstruction of the middle hepatic vein in modified right lobe graft living donor liver transplantation. *Transplant Proc* 2007; **39**: 3228-3233
- 4 **Sugawara Y**, Makuuchi M, Sano K, Imamura H, Kaneko J, Ohkubo T, Matsui Y, Kokudo N. Vein reconstruction in modified right liver graft for living donor liver transplantation. *Ann Surg* 2003; **237**: 180-185
- 5 **Fan ST**, Lo CM, Liu CL. Technical refinement in adult-to-adult living donor liver transplantation using right lobe graft. *Ann Surg* 2000; **231**: 126-131
- 6 **Lee S**, Park K, Hwang S, Kim K, Ahn C, Moon D, Joo J, Cho S, Oh K, Ha T, Yang H, Choi K, Hwang K, Lee E, Lee Y, Lee H, Chung Y, Kim M, Lee S, Suh D, Sung K. Anterior segment congestion of a right liver lobe graft in living-donor liver transplantation and strategy to prevent congestion. *J Hepatobiliary Pancreat Surg* 2003; **10**: 16-25
- 7 **Kubota T**, Togo S, Sekido H, Shizawa R, Takeda K, Morioka D, Tanaka K, Endo I, Tanaka K, Shimada H. Indications for hepatic vein reconstruction in living donor liver transplantation of right liver grafts. *Transplant Proc* 2004; **36**: 2263-2266
- 8 **Wu J**, Wang W, Zhang M, Shen Y, Liang T, Yu P, Xu X, Yan S, Zheng S. Reconstruction of middle hepatic vein in living donor liver transplantation with modified right lobe graft: a single center experience. *Transpl Int* 2008; **21**: 843-849
- 9 **Sano K**, Makuuchi M, Miki K, Maema A, Sugawara Y, Imamura H, Matsunami H, Takayama T. Evaluation of hepatic venous congestion: proposed indication criteria for hepatic vein reconstruction. *Ann Surg* 2002; **236**: 241-247
- 10 **Gyu Lee S**, Min Park K, Hwang S, Hun Kim K, Nak Choi D, Hyung Joo S, Soo Anh C, Won Nah Y, Yeong Jeon J, Hoon Park S, Suck Koh K, Hoon Han S, Taek Choi K, Sam Hwang K, Sugawara Y, Makuuchi M, Chul Min P. Modified right liver graft from a living donor to prevent congestion. *Transplantation* 2002; **74**: 54-59
- 11 **Hayashi PH**, Trotter JF. Review article: adult-to-adult right hepatic lobe living donor liver transplantation. *Aliment Pharmacol Ther* 2002; **16**: 1833-1841
- 12 **Kim SY**, Kim KW, Lee SS, Song GW, Hwang S, Kim PN, Lee SG. Doppler sonography to diagnose venous congestion in a modified right lobe graft after living donor liver transplantation. *AJR Am J Roentgenol* 2008; **190**: 1010-1017
- 13 **Kim KW**, Kim TK, Kim SY, Kim MJ, Park MS, Lee MG, Lee SG. Doppler sonographic abnormalities suggestive of venous congestion in the right lobe graft of living donor liver transplant recipients. *AJR Am J Roentgenol* 2007; **188**: W239-W245
- 14 **Imura S**, Shimada M, Ikegami T, Morine Y, Kanemura H. Strategies for improving the outcomes of small-for-size grafts in adult-to-adult living-donor liver transplantation. *J Hepatobiliary Pancreat Surg* 2008; **15**: 102-110
- 15 **Abbasoglu O**. Liver transplantation: yesterday, today and tomorrow. *World J Gastroenterol* 2008; **14**: 3117-3122
- 16 **De Cecchis L**, Hribernik M, Ravnik D, Gadzijev EM. Anatomical variations in the pattern of the right hepatic veins: possibilities for type classification. *J Anat* 2000; **197** Pt 3: 487-493
- 17 **Kaneko T**, Kaneko K, Sugimoto H, Inoue S, Hatsuno T, Sawada K, Ando H, Nakao A. Intrahepatic anastomosis formation between the hepatic veins in the graft liver of the living related liver transplantation: observation by Doppler ultrasonography. *Transplantation* 2000; **70**: 982-985
- 18 **Cescon M**, Sugawara Y, Sano K, Ohkubo T, Kaneko J, Makuuchi M. Right liver graft without middle hepatic vein reconstruction from a living donor. *Transplantation* 2002; **73**: 1164-1166
- 19 **Nielsen MB**, Bang N. Contrast enhanced ultrasound in liver imaging. *Eur J Radiol* 2004; **51** Suppl: S3-S8
- 20 **Marshall MM**, Beese RC, Muiesan P, Sarma DI, O'Grady J, Sidhu PS. Assessment of portal venous system patency in the liver transplant candidate: a prospective study comparing ultrasound, microbubble-enhanced colour Doppler ultrasound, with arteriography and surgery. *Clin Radiol* 2002; **57**: 377-383

S- Editor Li LF L- Editor Wang XL E- Editor Ma WH