

The Significance of Hepatic Vein Outflow Volume in Hepatic Outflow Insufficiency of Living Right Liver Graft Evaluated by Doppler Ultrasound

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ABSTRACT

The color Doppler ultrasound has been used to evaluate hepatic vein (HV) outflow insufficiency based on flow velocity and waveforms. In our experience, some cases with flat waveforms are clinically asymptomatic. The parameters of HV flow velocity and waveforms are not always correlated with clinical problems. So, we proposed that total HV flow volume (HVFV) may be a more reliable index. From August 2001 to July 2003, 31 cases among 48 adult-to-adult living related transplants of a right liver graft had one HV anastomosis. HV velocity, waveforms, and HVFV were compared both before and after transplantation. We set the minimal HVFV ratio at 80% based on the original HVFV before graft retrieval. There was no significant difference in HVFV before liver graft retrieval between the 2 groups, but there was a significant change after transplantation. There were no cases of HV insufficiency among group A patients ($>80\%$), whose HVFV ranged from 397 to 1181 mL/min with ratios from 75% to 180% (mean 115%). In group B, there were 4 complicated cases with prolonged severe ascites ($<80\%$) with HVFV ratios from 56% to 76% (mean 66%). Fisher exact test showed a great significance ($P < .001$). Thus the preliminary criteria of 80% minimal HVFV ratio allows detection of HV insufficiency for further interventional management.

HEPATIC OUTFLOW INSUFFICIENCY remains a major complication in living related liver transplantation (LRLT). Hepatic vein (HV) flow average velocity (Va) and waveforms are 2 significant parameters determining outflow insults.¹ Normal waveforms should be biphasic or triphasic; the normal Va is more than 10 cm/s. However, these 2 parameters are not always reliable.^{1,2} In this study, we measured right hepatic vein (RHV) outflow volume (HVFV) instead of HV Va selected adult-adult LRLT before and after transplantation to predict HV outflow insufficiency.

MATERIAL AND METHODS

Among 48 cases of adult-adult LRLT in the past 2 years, only 31 right liver grafts had a single RHV anastomosis (18 men and 13 women of average age 47.3 years old). Color Doppler ultrasound (CDUS) was used to evaluate RHV flow waveforms, Va, and HVFV. All 31 cases with simple RHV monoanastomosis were adjusted to normal waveforms and Va (>10 cm/s) detected by intraoperative CDUS after completion of vascular anastomosis and reperfusion of the liver graft. Therefore, the data before graft

retrieval in the donor and after vascular anastomosis in the recipient were also collected for analysis.

All cases were followed for HVFV by CDUS for months. Normal HV waveforms are biphasic or triphasic; a monophasic pattern is abnormal. The HVFV of RHV were compared before and after the vascular anastomosis. Preliminarily, we set the normal standard ratio of HVFV of RHV before and after graft retrieval to be at least 80%. We divided recipients into groups A and B based on this cut line. Finally, we compared these 2 groups for differences in Va and HVFV ratio for statistical analysis.

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RESULTS

There were 22 cases in group A (HVHV ratio > 80%) and 9 cases in group B (HVHV ratio < 80%). The group A HVHVs ranged from 359 to 1080 mL/min (mean $\pm$ SD = 719 ± 360 mL/min) before graft retrieval in the donor; 397 to 1184 mL/min (mean $\pm$ SD = 790 ± 393 mL/min) after vascular reperfusion in the recipient; and 420 to 1301 mL/min (mean $\pm$ SD = 816 ± 385 mL/min) at 1 month. The corresponding HVHV ratios were 85% to 180% (mean $\pm$ SD = $132 \pm 47\%$) just after liver reperfusion and 92% to 210% (mean $\pm$ SD = $151 \pm 36\%$) after 1 month.

In contrast, group B showed HVHVs that ranged from 370 to 845 mL/min (mean $\pm$ SD = 607 ± 237 mL/min) before graft retrieval in the donor; and 350 to 1105 mL/min after vascular reperfusion in the recipient, which decreased to values from 129 to 511 mL/min upon follow-up. The corresponding HVHV ratios were 83% to 175% (mean $\pm$ SD = $128 \pm 35\%$) just after reperfusion, but the HVHV ratios decreased from 5% to 78% (mean $\pm$ SD = $64 \pm 7\%$). By Fisher exact test of the difference of HVHV ratio was highly significant ($P < .001$).

There were 4 cases with obvious clinically severe ascites (>500 mL/day for 1 month). Interventional angiography in these complicated cases confirmed the diagnosis of HV stenosis. They underwent interventional procedures of balloon dilatation first with 3 cases requiring subsequent metallic stent replacement. CDUS studies performed during the procedures provided confirmation of restoration of normal HV outflow. The Va was restored to 21 to 118 cm/s (mean 54 cm/s) just after the procedures. The complicated ascites disappeared immediately and dramatically during subsequent follow-up.

DISCUSSION

Among the 48 LRLTs in the past 2 years, only 31 cases of single RHV venoplasty were selected for this study because the other 11 cases with multiple venous anastomosis showed a high rate of calculated errors and also no clinical HV complications.

As other authors have reported, the patency of HV outflow tract depended on the flow waveform, because the normal waveform of HV is able to reflect the multiphase change in the right atrium.^{2,3} We analyzed HV waveforms in all 48 cases. There were 14 cases of monophasic waveforms and 34 cases of biphasic or triphasic waveforms; 9 cases of monophasic waveforms belonged to group B and 5 cases belonged to group A. There were no cases with complicated ascites in group A. So, it was not true that cases with monophasic HV waveforms also had HV outflow insufficiency.

Besides, normal Va should be over 10 cm/s, a criterion that has been previously reported.⁴ We had 4 cases with prolonged severe ascites postoperatively due to HH outflow

insufficiency in group B. The flow velocity did not always reflect the amount of HV outflow. We supposed that the problem was due to HV flow tract stenosis and that HVHV was also decreased. HV flow velocity is affected by several parameters including the portal inflow and the HV caliber size change; hepatic arterial inflow has little effect on HV velocity.⁵ Inadequate portal inflow may play a greater role; that is, if the total portal inflow is decreased remarkably, the HV waveform becomes flattened and flow velocity decreased, even though some cases still show Va within normal limits.⁴⁻⁶ In some cases, the HV outflow tract becomes ectatic and HV flow velocity becomes slow; otherwise, the HVHV is not abnormally decreased. The hemodynamics of the velocities and waveforms of HV, PV, and HA reveal corresponding changes for the differential diagnosis of vascular insults.^{7,8}

The total HVHV in the graft is a reasonable percentage of its original amount in the donor, but total hepatic inflow may also be increased after reperfusion due to an hyperkinetic state in the recipient.⁸ We proposed that the minimal HVHV ratio should be 80% because in the 4 cases with clinical symptoms the HVHV ratios were below 80%. Based on this threshold, we divided our cases into 2 groups. The postoperative HVHV ratios just after reperfusion were not significantly different between A and B, but a relatively low Va and HVHV ratios were noted in group B over the following months due to changes in the HV outflow tract. The statistical evaluation of the results showed great significance; however we need a greater number of cases to extend the analysis.

In conclusion, patent HV outflow shows a triphasic or biphasic waveform and a Va over 10 cm/s; but, these parameters are not always reliable due to changes in the HV tract size. In our study, the minimal required HVHV ratio at 80% showed great significance. For the cases with clinical symptoms of suspected HV stenosis but unremarkable changes in Va and HV waveforms, HVHV measurements are recommended for the diagnosis.

REFERENCES

1. Huang TL, Cheng YF, Chen TY, et al: *Transplant Proc* 33:3464, 2001
2. Chen CL, Chen YS, Chiang YC, et al: *J Gastroenterol Hepatol* 2 (suppl): 1, 1996
3. Abu-Yousef MM: *AJR* 156:79, 1991
4. Huang TL, Cheng YF, Chen CL, et al: *Transplant Proc* 32:2097, 2000
5. Someda H, Moriyasu F, Fujimoto, et al: *J Hepatol* 22:623, 1995
6. Cheng YF, Huang TL, Chen CL, et al: *Clin Transplantation* 12:292, 1998
7. Cheng YF, Chen CL, Chen YS, et al: *Transplant Proc* 32:2196, 2000
8. Tzakis AG, Gordon RD, Shaw BW, et al: *Transplantation* 40:667, 1995