Sonographic Evaluation of Post-transplantation Portal Vein Stenosis in Pediatric Living-donor Liver Transplant Recipients With Left-liver Grafts

H.-W. Hsu[a], T.-L. Huang[a], Y.-F. Cheng[a,*], T.-Y. Chen[a], L.L. Tsang[a], H.-Y. Ou[a], C.-Y. Yu[a], A.M. Concejero[b], and C.-L. Chen[b]

Departments of [a]Diagnostic Radiology, and [b]Surgery, Kaohsiung Chang Gung Memorial Hospital, Chang Gung University College of Medicine, Kaohsiung, Taiwan

ABSTRACT

Introduction. Portal vein (PV) stenosis is not uncommon in post-transplantation pediatric living-donor liver transplant (PLDLT) recipients. The purpose of this study was to identify specific ultrasound criteria that may be used to detect PV stenosis in PLDLT with left-liver grafts.

Patients and Methods. From January 2010 to October 2014, 87 pediatric recipients underwent PLDLT with left lobes or left lateral segments at our hospital. All patients underwent routine liver Doppler ultrasound (DUS) as follow-up protocol. The morphologic narrowing and mean time averaged velocity (TAV) at the PV anastomotic site, change in anastomotic/pre-anastomotic TAV (ΔTAV), and the umbilical portal width were evaluated and analyzed. Ultrasound findings were correlated with computed tomography angiography where PV stenosis was suspected.

Results. In the liver graft follow-up study, 80.4% (70 of 87 patients) of PV anastomosis was well visualized and measured by Doppler ultrasound. The optimal threshold values for TAV and ΔTAV were 49.6 cm/s and 30 cm/s, respectively, for significant PV anastomosis stenosis. In the other 19.5% (17/87), the PV anastomosis could not be identified properly. The PV anastomosis was not always visible with ultrasound; however, the optimal dilated umbilical portion of the PV indicating possible PV anastomosis narrowing threshold was umbilical portal width >1.5 cm.

Conclusions. Increased anastomotic TAV and ΔTAV are useful features for diagnosing PV stenosis. The identification of a dilated umbilical portion of the left PV helps in detection of PV stenosis in PLDLT recipients especially when the anastomotic narrowed region cannot be visualized.

LIVING-DONOR liver transplant (LDLT) is the optimal solution due to a shortage of deceased-donor liver grafts in Asian countries. The combination of improvements in surgical technique, immunosuppression therapy, anesthesia, intensive care, and organ utilization has resulted in better post-transplantation outcomes [1]. Vascular complications after transplantation remain the major cause of morbidity, especially in pediatric cases. Portal vein (PV) complications are less frequent than hepatic artery complications but may also cause graft failure [2–5]. Portal vein stenosis (PVS) in pediatric recipients is a vascular complication that requires interventional or surgical procedure in 3% to 19% [6–8] of cases. A stenting procedure might fail in PV occlusion recipients with longer periods of PV obstruction before being referred for interventional procedure [9].

Doppler ultrasound (DUS) provides swift anatomical and dynamic data on the patency of major vascular anastomoses. It is extensively performed as a routine screening study to

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*Address correspondence to Yu-Fan Cheng, MD, Department of Diagnostic Radiology, Kaohsiung Chang Gung Memorial Hospital, 123 Ta-Pei Road, Niao-Sung, Kaohsiung 83305, Taiwan. E-mail: cheng.yufan@msa.hinet.net

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demonstrate vascular complications in liver transplantation patients before they become clinically symptomatic, especially in the early post-transplantation period. It has been noted that time-averaged velocity (TAV) at PV anastomosis, change in anastomotic–to–pre-anastomotic velocity (ΔTAV), anastomotic–to–pre-anastomotic velocity ratio, and venous pulsatility index are useful features to diagnose PVS after liver transplantation [10–12].

Although PV anastomotic sites can be adequately demonstrated by DUS when evaluating right-lobe grafts and whole liver grafts, a significant number of PV anastomoses could not be adequately identified by DUS when a left lobe is used. The prior criteria to diagnose PVS, such as increased anastomotic TAV and ΔTAV, is often inexact. Thus, evaluation of possible PVS by other indirect sign(s) to avoid delay in the diagnosis of PVS after pediatric LDLT (PLDLT) is necessary. Increased umbilical portal vein width (UPW) can be visualized by ultrasound in left-lobe grafts with PVS at the anastomosis. The aim of this study was to identify specific ultrasound criteria that may be used to detect PVS in PLDLT with left-lobe graft grafts and to identify whether the UPW has a role in detection of PVS after PLDLT.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Chang Gung Memorial Hospital (IRB104-6115B). The Institutional Review Board allowed us to retrospectively analyze clinical data. From January 2010 to October 2014, 87 pediatric recipients (51 boys and 36 girls; mean age: 2.3 years [range: 0.4 years to 11.2 years]) underwent primary LDLT using a left-lobe liver graft. Routine liver graft DUS was performed in the immediate postoperative period and during regular long-term out-patient follow-up. The morphologic narrowing at the portal anastomotic site, TAV, ΔTAV, and the UPW were analyzed. From May 2013 to December 2014, 182 right-lobe liver donors who underwent DUS for pretransplantation evaluation and post-hepatectomy follow-up were chosen as a control group to evaluate the UPW of the left portal vein (LPV) 6 months after right hepatectomy.

Liver Graft Ultrasound

DUS examinations were performed using the ultrasound machine (Acuson S2000TM ultrasound system, Siemens AG, Erlangen, Bavaria, Germany) with gates, pulse repetition frequency, and angle of insonation optimized for each patient. Ultrasound study included gray-scale assessment of portal anastomosis diameter, native PV diameter, and UPW. Spectral DUS included angle-corrected TAV at the portal anastomosis and pre-anastomotic site if the LPV anastomosis could be identified. All ultrasound studies were reviewed by well-trained radiologists, each with extensive experience in liver transplantation ultrasound.

Width of LPV Umbilical Portion (UPW)

UPW refers to the maximal width of LPV umbilical portion. It can usually be approached by ultrasound with transverse view or subcostal view in a supine position.

PV Complications

PV complications such as stenosis and thrombosis that occurred immediately after the surgery or during the follow-up period and required either percutaneous or surgical interventions were reviewed. Main PV narrowing with portal hypertension symptoms more than 50% was the diagnostic criteria for PVS. PVS shown by DUS were all confirmed by computed tomographic angiography (CTA) or magnetic resonance angiography before being referred for intervention procedures. The minimum follow-up period among surviving patients was 6 months.

Statistical Analysis

All values were expressed as mean ± standard deviation. The Student *t* test was used for the difference of groups to confirm the validity of receiver operating characteristic (ROC) analysis. ROC curves were then constructed for TAV, ΔTAV, and UPW. The sensitivity and specificity for TAV, ΔTAV threshold values, and UPW were calculated from the ROC. The data from our study were entered into SPSS 18 (Statistical Package for the Social Sciences, IBM, Chicago, Ill, USA) package program. A $P < .05$ was accepted as statistically significant.

RESULTS

Eighty-seven pediatric recipients were studied in our series; however, in 19.5% (17 of 87 patients), the PVS could not be studied. In this left-lobe liver graft follow-up study, 80.4% (70 of 87 patients) of the PV anastomosis could be visualized and measured by DUS. Where PV anastomosis could not be visualized during post-transplantation liver ultrasound because of positional changes of the graft or for other reasons such as angulation and obscuration by bowel gas, indirect signs on DUS may give clues as to the condition of LPV anastomosis. We noted that the umbilical portion of the LPV could always be visualized during postoperative ultrasound whether the PV anastomosis was visible or not.

TAV of Visible PV Anastomosis

Of 87 pediatric recipients, post-transplantation PVS occurred in 8 cases in our series (9.2%). Of the 17 liver grafts with nonvisible portal anastomosis, 3 had portal anastomosis narrowing which was confirmed by CTA. In the other accessible 70 left-lobe grafts evaluated, the TAV traversing the portal anastomosis was 36 ± 19.7 cm/s. For portal vein anastomotic TAV, comparison of the PVS group with the normal group showed $P = .007$ using the Student *t* test for difference of means, assuming unequal variances. An ROC curve was constructed and analyzed. The area under the ROC curve was 0.938 (SE, 0.034; 95% confidence interval [CI], 0.863–1.0). The optimal TAV cutoff value for PVS was >49.6 cm/s with a sensitivity of 83.3%, specificity of 81.2%, positive predictive value (PPV) of 29.4%, and negative predictive value (NPV) of 98.1%. However, the PV anastomosis could not be visualized in 37.5% (3 of 8) of the left lobe graft patients with PVS. Hence, the total diagnostic ability of TAV to detect PV anastomosis narrowing was only 50% if the 3 missed PVS cases with nonvisualized PV anastomosis were included in the statistical analysis.

Change in Anastomotic–to-pre-anastomotic TAV

The ΔTAV between anastomotic and pre-anastomotic patients was unknown in 17 patients whose PV anastomosis