Preoperative hepatic hemodynamics in the prediction of early portal vein thrombosis after liver transplantation in pediatric patients with biliary atresia

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BACKGROUND: Portal vein thrombosis (PVT) is one of the main vascular complications after liver transplantation (LT), especially in pediatric patients with biliary atresia (BA). This study aimed to assess the preoperative hepatic hemodynamics in pediatric patients with BA using Doppler ultrasound and determine whether ultrasonographic parameters may predict early PVT after LT.

METHODS: One hundred and twenty-eight pediatric patients with BA younger than 3 years of age underwent Doppler ultrasound within seven days before LT, between October 2006 and June 2013. The preoperative hepatic hemodynamic parameters were then compared between patients with early PVT (within 1 month following LT) and those without PVT. Receiver operating characteristic analysis was performed to determine the optimal cutoff value for predicting early PVT.

RESULTS: Of the 128 transplant recipients, 41 (32.03%) had a hypoplastic portal vein (PV), 52 (40.63%) had hepatofugal PV flow and 40 (31.25%) had a high hepatic artery resistance index (HARI) of ≥1. Nine cases (7.03%) experienced early PVT. A PV diameter ≤4 mm (sensitivity 88.89%, specificity 72.27%), and a hepatofugal PV flow (sensitivity 77.78%, specificity 62.18%) with a high HARI ≥1 (sensitivity 77.78%, specificity 72.27%) were hepatic hemodynamic risk factors for early PVT.

CONCLUSIONS: Hepatic hemodynamic disturbances in pediatric recipients with BA were more common. Small PV diameter (≤4 mm) and hepatofugal PV flow combined with high HARI (≥1) are strong warning signs of early PVT after LT in pediatric patients with BA. Intense monitoring of vascular patency and prophylactic thrombolytic therapy should be considered in pediatric patients undergoing LT for BA.

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KEY WORDS: liver transplantation; Doppler ultrasound; hemodynamics; portal vein thrombosis; biliary atresia

Introduction

Biliary atresia (BA) is a destructive inflammatory obliterative cholangiopathy of neonates that affects both intrahepatic and extrahepatic bile ducts. The prevalence of BA in the United Kingdom and France ranges from 1 in 17000 to 1 in 19000 live births. It is most common in east Asian, with a reported frequency of 1 in 5000.[1] A study[1] reported that the overall long-term survival rate of children with BA varied from 20% to 45%, with a Kasai portoenterostomy regarded as a palliative procedure in most cases. Unfortunately, early liver failure occurs before 4 years of age in most cases, requiring liver transplantation (LT) to prolong life.[1]

As the surgical and medical care of transplant patients has improved, so has long-term survival. Indeed, in pediatric populations the expected 5-year survival rate is greater than 80%. Portal vein thrombosis (PVT) is one of the main vascular complications after LT, especially in pediatric patients with BA.[2] The reported incidence of PVT varies from 8% to 27%[3-7] in pediatric cases of BA, which is 5 to 9 times higher than that in adults

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(1.8%-3%).[8-10] PVT is a serious complication and needs immidiate managements which includes the restoration of portal vein (PV) blood flow. Unfortunately, clinical symptoms and signs are usually absent during the early phase of PVT, making a timely intervention challenging. Accordingly, the present study was to assess the preoperative hepatic hemodynamic parameters in pediatric patients with BA using Doppler ultrasound, and determine whether any of these parameters predicts the development of early PVT after LT.

Methods

Patients

Of the 151 consecutive pediatric recipients of LT performed between October 2006 and June 2013 at the Department of Liver Surgery in our hospital, 128 pediatric patients with BA younger than 3 years old, without preoperative and intraoperative PVT were selected for this study. Patient age ranged from 5 to 36 months at the time of LT. There were 66 boys (51.56%) and 62 girls (48.44%). Among the 128 recipients, 51 had a Kasai portoenterostomy before LT, 31 had a laparotomy and 46 had no surgical history. This retrospective study was approved by an institutional review board, and informed consent was waived.

Operative technique

Living donor LTs were performed in 128 pediatric patients according to standard procedures. The portion of the liver that was transplanted included the left lateral segment (segments II and III). The recipient's right, middle and left hepatic veins were reshaped as a single orifice, which was then anastomosed end-to-side to the graft's left hepatic vein with 5-0 polydioxanone continuous sutures. The PV was reconstructed end-to-end with 6-0 polydioxanone continuous sutures between the recipient's right and left PV bifurcation point and the graft's left PV. Hepatic artery (HA) reconstruction was performed end-to-end under a surgical microscope with 8-0 prolene interrupted sutures.

Doppler ultrasound protocol

Doppler ultrasound was performed by experienced radiologists using an Acuson Sequoia 512 scanner (Acuson, Mountain View, CA, USA) with a 3.5 MHz transducer available for color Doppler imaging. All the pediatric transplant recipients included in this study underwent the Doppler ultrasound examination within 7 days before LT. All patients were sedated with oral chloral hydrate (0.5-1.0 mg/kg body weight) before examination. Patients were placed in the supine position with the right arm abducted. Standard Doppler ultrasound parameters were adjusted to maximal gain without background noise and lowest pulse repetition frequency without aliasing artifacts. The angle between the Doppler beam and long axis of the vessel was held at less than 60 degrees. All PV measurements were obtained at the extrahepatic portion of the main PV near its bifurcation. PV diameter, maximum PV velocity (PVVmax) and the direction of the PV flow were recorded. The ultrasound system's "zoom" function was used to amplify the ultrasound image, and multiple measurements were taken, with the mean value calculated for further analysis. Measurements of the HA, which included the HA diameter, HA peak systolic velocity (HAPSV) and HA resistance index (HARI) were obtained along the hepatic hilum. PV hypoplasia was defined as a PV diameter ≤4 mm.[11] Hepatopetal flow in the PV was considered normal, and hepatofugal flow in the PV (directed away from the liver) was regarded as anomalous. HARI was considered abnormal when it was ≥1.

Statistical analysis

Statistical analyses were performed using SPSS, version 13 for Window (SPSS, Chicago, IL, USA). The demographic characteristics of the patients were summarized with frequency counts, mean±standard deviation (SD) and/or median with a range. Differences in age, body weight, pediatric end-stage liver disease (PELD) score, PV diameter, PVVmax, HA diameter, HAPSV and HARI between the early PVT group and non-PVT group were evaluated by using an independent *t* test. The PV flow direction in the two groups were compared using a Chi-square test. Logistic regression analyses were used to determine the possible relationship between early PVT and individual variables. The optimal cutoff value was determined by using receiver operating characteristic analysis to identify which parameters that could act as an independent risk factor for early PVT. A $P<0.05$ was considered statistically significant.

Results

Among the 128 pediatric patients, PV diameter and PVVmax were 4.48±0.84 mm (range 2.80-7.70) and 22.93±8.16 cm/sec (range 7.60-47.30), respectively (Table 1). There were 32.03% (41/128) of patients with a hypoplastic PV (diameter ≤4 mm), and 40.63% (52/128) of patients with hepatofugal PV flow. HA diameter, HAPSV and HARI were 2.71±0.47 mm (range 1.50-4.40),127.81±46.76 cm/sec (range 22.60-300.00) and 0.92±0.11 (range 0.64-1.26), respectively. Finally, 31.25% (40/128) of patients had an HARI of ≥1.