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Enlarging vascular stents after pediatric liver transplantation☆

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ABSTRACT

Background: Endovascular intervention with stent placement to treat portal vein (PV) and hepatic vein (HV) stenosis after pediatric liver transplantation (LT) is still controversial in small children owing to the potential risk of functional stenosis after growth. The aim of this study is to evaluate the safety and efficacy of stent placement in this population.
Methods: Between 2004 and 2016, 6 children (all <3 years) received HV ($n = 2$) and PV ($n = 4$) stents placement among 46 pediatric LT patients at our institution. The clinical outcome and patency rate were followed. Morphologic changes of stents were assessed from plain films by a new index: the stent diameter ratio (SDR).
Results: The median age of the patients at LT was 8.9 months. The patency rate was 100% without functional stenosis during a median follow-up period of 65.5 months. The "stent growth" phenomenon was demonstrated by SDR with significant resolution of hourglass deformity 2 years after stent placement (p for trend <.001).
Conclusion: Vascular stent placement is a safe and effective method for the management of PV and HV stenosis following pediatric LT because these stents will enlarge as children grow.
Type of study: Case Series with no Comparison Group
Level of evidence: Level IV.

Liver transplantation (LT) has been the curative treatment for a variety of disease conditions, including but not limited to end-stage liver disease, acute decompensated hepatitis, hepatic malignancies, metabolic liver disease, and congenital hepatobiliary anomalies [1]. As the indication for LT expands, living-donor liver transplantation (LDLT) has been developed as a solution to circumvent both the shortage of donor organs and the paucity of suitable liver grafts. This issue is especially true in the pediatric population [2]. Despite the marked improvement in outcomes of pediatric LT over the years, however, vascular complications still occur in a significant proportion of pediatric patients receiving partial liver grafts, which could be devastating since they may result in loss of the graft. In the pediatric population, the incidence of portal vein (PV) and hepatic vein (HV) complications is higher, probably owing to the short vascular pedicles, size mismatch between donor and recipient vessels, sclerotic change of the PV, twisting or kinking of the anastomosis, and undue tension on the anastomosis [3].

With the advancement of minimally invasive endovascular treatment, percutaneous transluminal balloon angioplasty (PTA) with stent placement has been adopted widely as an effective method to treat PV or HV anastomotic stenosis or occlusion in both adults and adolescents [4–7]. In contrast, surgical revisions, including the shunt procedure and retransplantation, were regarded as the last resort for patients not salvageable by endovascular intervention [8,9]. Whether the good results in the adult population could be extrapolated to the young pediatric population, especially to growing infants and toddlers, remains unanswered owing to the potential risk of stent migration or functional stenosis with vascular stents placed at such young ages [9–12]. Also, the timing of stent placement (early vs. delayed after trial sessions of PTA) in the pediatric population is another controversial issue [10,11].

Therefore, we conducted a retrospective cohort study to evaluate the long-term outcomes (vascular patency, the need for further treatment, and patient survival) and objective morphological outcome of vascular stents in the management of PV and HV stenosis, focusing on a population of infants and toddlers (<3 years old) receiving LDLT.

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1. Patients and methods

1.1. Study population

This study was approved by the institutional review board of Taipei Veterans General Hospital with permission of a waiver for the need of consent. From October 2004 to December 2016, 46 recipients younger than 18 years old received liver transplantation (LT) at our institute. Of these, seven patients (15.2%) underwent endovascular intervention with stent placement for treating the complications of PV or HV anastomotic stenosis or obstruction. Six among 24 patients less than 3 years of age receiving lateral segment grafts underwent PV ($n = 4$) or HV ($n = 2$) stent placement. The other patient, who was 18 years old at the time of HV stents placement, was excluded. The diagnosis of vascular complications was defined by Doppler ultrasound (DUS) showing no intravascular flow or focal luminal narrowing greater than 50% of the adjacent normal vessel that was also confirmed by dynamic computed tomography. The median age of these six patients at LT was 8.9 months old [interquartile range (IQR), 8.2–9.2 months]. The median interval between LT and stent placement was 1.1 months (IQR, 0–3.4 months). In addition, the mean body weight (BW) and height at the time of vascular stenting were 9.6 kg and 68.6 cm. The demographic characteristics of the study population are summarized in Table 1.

1.2. Endovascular procedures

Written informed consent was obtained from each patient's legal guardian before the endovascular intervention. All procedures were performed under general anesthesia by a single experienced interventional radiologist (HS Tseng).

1.2.1. Percutaneous transhepatic approach

Under sonographic guidance, a Chiba needle (Cook, Bloomington, IN) or a 21-gauge PTC needle (Hakko Medical Co., Osaka, Japan) was used to puncture the peripheral branches of the PV or the HV. Then a 4-Fr or a 7-Fr angiosheath (Terumo, Tokyo, Japan) was advanced over a .018-in. guidewire (Terumo) using the Seldinger technique. A .035-in. stiff guidewire (Terumo) was inserted and negotiated through the obstruction site. Then, a self-expandable stent was deployed after balloon dilatation with a balloon catheter (FoxCross PTA Catheter; Abbott Vascular, Beringen, Switzerland). This approach could be performed in the operating room or the interventional radiology suite.

1.2.2. Percutaneous bidirectional approach

A percutaneous bidirectional approach, as described in our previous article [13], was needed in the patient with total occlusion of the PV since the percutaneous transhepatic approach failed to resolve this complication. First, we inserted a snare wire via the transsplenic route to the end of the obstructed PV and used a 21-gauge PTC needle (Hakko Medical Co.) for the transhepatic puncture, which targeted the snare wire to create a tract between the two blind ends of the PV. Then, a .018-in. guidewire (Terumo) was introduced via the transhepatic route and caught by the snare wire to the splenic vein. The rest of the procedures for stent placement were similar to those for the percutaneous transhepatic approach.

Table 1
Demographics of the study patients.

Characteristics	Values
Sex, male/female, n	1/5
Median age, months (IQR)	
LT	8.9 (8.2–9.2)
Stent placement	10.2 (8.9–11.7)
Median interval between LT and stent placement, months (IQR)	1.1 (0–3.4)
Body weight at transplantation, kg, mean ± SD	9.7 ± 1.7
Height at transplantation, cm, mean ± SD	68.6 ± 5.8
Underlying diseases, n	
Biliary atresia	4
Methylmalonic acidemia	1
Propionic acidemia	1
Preceding causes for stent	
Portal vein anastomotic stenosis	1
Portal vein sclerosis	2
Portal vein compression cause by biliary stenting	1
Hepatic vein anastomotic stenosis	2

LT, liver transplantation; IQR, interquartile range; SD, standard deviation.

1.3. Anticoagulation regimen and follow-up

Oral antiplatelet drugs (BW < 20 kg: acetylsalicylic acid 50 mg/day and dipyridamole 12.5 mg/day; BW > 20 kg: acetylsalicylic acid 100 mg/day and dipyridamole 25 mg/day) were administered when platelet counts were >50,000/mm^3 after stent placement and maintained for one year. However, in the case with total vascular occlusion, additional in-stent thrombolytic infusion with a continuous instillation of urokinase (1000 IU/h) would be given for 3 days and followed with subcutaneous injections of low molecular weight heparin (50 IU/kg) twice daily for 7 days. The stent patency was measured by DUS on postprocedural days 1, 3, and 7, every week for one month, every three months for one year, and then annually thereafter.

1.4. Follow-up parameters

1.4.1. Technical and clinical success

Technical success was defined as successful completion of the percutaneous endovascular stenting with <20% stenosis using postprocedural portography/venography. Clinical success was defined as marked improvement of symptoms of portal hypertension, liver congestion, and continuous patency of the stent without recurrent stenosis. Any technical or delayed complications, such as hemoperitoneum, subcapsular hematoma, or stent migration, and the sessions of endovascular angioplasty before or after the stent placement were also recorded. The endpoint of observation was defined as occlusion of the stent despite subsequent PTA, the patient's death, and the end of the study.

1.4.2. Morphologic changes of the implanted stents

To evaluate the morphologic changes of stents in the growing children further, we checked each patient's subsequent plain films during the study period by the picture archiving and communication system (PACS) and identified two new measurement indexes: the stent diameter ratio (SDR) and the bottleneck ratio (BNR). The SDR is the narrowest diameter of the stent divided by the designed stent diameter provided by the manufacturer. The digital caliper on each plain film was calibrated by the known length of each stent. The trend of the SDR was intended to evaluate the possibility of growing diameters of the stents. The BNR is the narrowest diameter of the stent divided by the widest diameter of the stent. The trend of BNR provided an evaluation of possible resolution of the hourglass deformity of each stent (Fig. 1). All descriptive statistics and linear regression models were analyzed using XLSTAT version 2016 (Addinsoft Inc., Brooklyn, NY). A $p < .05$ was considered statistically significant.

2. Results

2.1. Primary and long-term outcomes

All self-expandable stents were implanted in these six patients, and stent sizes were 9–10 mm in diameter, 20–40 mm in length for HV and 8–9 mm in diameter, 40–60 mm in length for the PV. Technical and clinical successes without stent-edge or functional stenosis were achieved in all patients during the median follow-up period of 65.5 months (IQR, 43.9–75.2 months). In addition, there were no cases with immediate complications or delayed stent migration (Table 2).