ORIGINAL REPORT

Transjugular intrahepatic portosystemic shunting with covered stents in children: A preliminary study of safety and patency

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Abstract

Objective: To retrospectively analyze the safety and efficacy of transjugular intrahepatic portosystemic shunting (TIPS) using covered stents in children.

Material and methods: We present 6 children (mean age, 10.6 years; mean weight, 33.5 kg) who underwent TIPS with 8 mm diameter Viatorr® covered stents for acute (n = 4) or recurrent (n = 2) upper digestive bleeding that could not be controlled by endoscopic measures. Five of the children had cirrhosis and the other had portal vein thrombosis with cavernous transformation. We analyzed the relapse of upper digestive bleeding, the complications that appeared, and the patency of the TIPS shunt on sequential Doppler ultrasonography or until transplantation.

Results: A single stent was implanted in a single session in each child; none of the children died. The mean transhepatic gradient decreased from 16 mmHg (range: 12–21 mmHg) before the procedure to 9 mmHg (range: 1–15 mmHg) after TIPS.

One patient developed mild encephalopathy, and the girl who had portal vein thrombosis with cavernous transformation developed an acute occlusion of the TIPS that resolved after the implantation of a coaxial stent.

Three children received transplants (7, 9, and 10 months after the procedure, respectively), and the patency of the TIPS was confirmed at transplantation. In the three remaining children, patency was confirmed with Doppler ultrasonography 1, 3, and 5 months after implantation. None of the children had new episodes of upper digestive bleeding during follow-up after implantation (mean: 8.1 months).

Conclusion: Our results indicate that TIPS with 8 mm diameter Viatorr® covered stents can be safe and efficacious for the treatment of upper digestive bleeding due to gastroesophageal varices in cirrhotic children; our findings need to be corroborated in larger series.

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PALABRAS CLAVE
Shunt portosistémico intrahepático; Niño; Trombosis vena porta

TIPS recubierto en niños. Estudio preliminar sobre su seguridad y permeabilidad

Resumen
Objetivo: Analizar retrospectivamente la seguridad y eficacia de derivación portosistémica intrahepática por vía transyugular (TIPS) recubierta en niños.

Material y métodos: Presentamos 6 niños con una edad media de 10,6 años y un peso medio de 33,5 kg, a quienes se implantaron endoprótesis recubiertas tipo Viatorr® de 8 mm de diámetro por hemorragia digestiva alta (HDA) aguda (n = 4) o recurrente (n = 2) no controlable por medidas endoscópicas. Cinco niños eran cirróticos y otro un transplantado hepático con trombosis y cavernomatosis portal. Se valoraron la recidiva de la HDA, las complicaciones y la permeabilidad con ecografías-Doppler secuenciales o hasta el trasplante.

Resultados: En todos los niños se implantó una sola endoprótesis en una única sesión, sin mortalidad asociada. El gradiente transhepático medio inicial fue de 16 mmHg (12-21 mmHg) y disminuyó tras la implantación del TIPS a 9 mmHg (1-15 mmHg).

Un paciente presentó encefalopatía leve y la niña con trombosis y cavernomatosis portal presentó una oclusión aguda del TIPS, que se resolvió con la implantación de una endoprótesis coaxial.

Tres niños fueron sometidos a trasplante a los 7,9 y 10 meses, constatándose la permeabilidad del TIPS. En los 3 restantes se comprobó la permeabilidad con ecografía-Doppler a los 1,3 y 5 meses. Ninguno presentó una nueva HDA durante un seguimiento medio de 8,1 meses.

Conclusión: Nuestros resultados indican que la seguridad y permeabilidad de las endoprótesis recubiertas tipo Viatorr® para el tratamiento de la HDA por varices gastroesofágicas en niños cirróticos pueden ser buenas, hecho que deberá ser corroborado con series mayores en un futuro.

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Introduction

Today creating a transjugular intrahepatic portosystemic shunt (TIPS) is an efficient proceeding for the management of complications of portal high blood pressure in adult cirrhotic patients—especially high digestive hemorrhage–HDH and refractory ascites when both medical therapy and conventional endoscopic therapy have failed. However there is no much experience with TIPS among the pediatric population and the greatest series of cases collected in the medical literature are just 12 children. Even though the technique of implantation and the indications are similar in both groups of population children have a series of special considerations.

On the other hand the patency of TIPS in adults with covered endoprostheses is substantially greater than with uncovered endoprostheses. However the majority of series of cases published in children used the latter with a high rate of restenosis.

Our goal is to present our initial experience in 6 children with different etiology-portal hypertension treated with covered TIPS in an effort to analyze security and patency retrospectively as well as the technical considerations of its implantation.

Material and methods

Between May 2009 and April 2011 TIPS were implanted in 6 children with secondary HDH and portal hypertension. The sample consisted of 3 boys and 3 girls with an average age of 10.6 years (6–16 years) and an average weight of 73.8 pounds (44–132 pounds). The etiology of portal hypertension was cirrhotic in 5 children (2 cystic fibrosis, 1 congenital hepatic fibrosis, 1 extrahepatic biliary atresia, 1 Caroli-type complex biliary cystic malformation) and non-cirrhotic in one patient with thrombosis and portal cavernomatosis 6 years after liver transplant from a living donor due to biliary atresia. All children presented with hypersplenism—5 of them with associated plateletenopia and endoscopic evidence of gastroesophageal varices that had caused repeated clinical presentations of HDH unresolved through the standard medical therapy or in 2 of the children with endoscopic variceal ligation. In the remaining 4 such ligation could not be done because the varices were located in the gastric fundus and could not be approached endoscopically (Table 1). Four of the patients showed HDH during the implantation of TIPS and required blood transfusion. None of the children had signs of hepatic encephalopathy or ascites prior to the implantation of TIPS. In all of them the portal axis was studied through Doppler-ultrasound showing patency in 5 children whereas in one girl chronic thrombosis with the aforementioned cavernomatosis could be identified.

All proceedings were done under general anesthesia. The technique of implantation and the equipment used were the same used in adults (Ring TIPS–200 set; Cook Inc., Bjaeverskov, DK). The right internal jugular vein was punctioned with the help of ultrasound control and a 10F introducer kit was inserted. The suprahepatic vein whose approach was more appropriate (right/middle) was used. The needle used for intrahepatic punction and to be able to access the portal system was the Colapinto needle included in the set (16G). As a wire the indirect portography and/or embedded suprahepatic phlebography was used. In all children
Transjugular intrahepatic portosystemic shunting with covered stents in children

Table 1 Demographic characteristics of children and results.

<table>
<thead>
<tr>
<th>Age/sex</th>
<th>Weight (lbs)</th>
<th>Etiology</th>
<th>TIPS indication</th>
<th>Gradient (mmHg)</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pre-TIPS</td>
<td>Post-TIPS</td>
</tr>
<tr>
<td>11/M</td>
<td>59</td>
<td>CF</td>
<td>Recidivant HDH</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>63.9</td>
<td>CF</td>
<td>Acute HDH</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>11/M</td>
<td>77</td>
<td>BV</td>
<td>Plateletpenia</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>16/W</td>
<td>132</td>
<td>CHF</td>
<td>Acute HDH</td>
<td>21</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>66</td>
<td>E. Caroli</td>
<td>Recidivant HDH</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>6/W</td>
<td>44</td>
<td>LT due to BA</td>
<td>Acute HDH</td>
<td>18</td>
<td>8</td>
</tr>
</tbody>
</table>

BA, biliary atresia; CHF, congenital hepatic fibrosis; CF, cystic fibrosis; HDH, high digestive hemorrhage; W, woman; TIPS, transjugular intrahepatic portosystemic shunting; LT, liver transplant; US, Doppler-ultrasound; M, male.

direct portography was done through a conventional calibrated pigtail 5F catheter to select the adequate length of endoprosthesis, visualize portal anatomy, and do one hepatic hemodynamic study to brief on the transhepatic gradient between the portal vein and the right atrium/inferior caval vein before and after the implantation of TIPS. Dilatation of intrahepatic tract between the suprahepatic vein and the portal branch was done through a conventional catheter-balloon of 8 mm diameter. Gastric varices were never embolized whatsoever. The maximum dose of iodinated contrast media during the whole proceeding was 3 ml/2.2 lbs of weight.

In all cases nitinol-prosthesis covered with polytetrafluoroethylene (PTFE) (Viatorr®, W.L. Gore and Associates, Flagstaff, AZ) of 10 mm diameter were used. The length of the prostheses was variable leaving the proximal end in the suprahepatic vein so it would not "show up" in the right atrium—to avoid technical complications during the future transplant. The goal of the proceeding was to achieve a 5–12 mmHg gradient.

No antibiotic drugs or platelet antiagregants were used after TIPS. All children were followed both clinic and analytically and through a Doppler-ultrasound 4–6 days after the implantation of TIPS and from that moment onwards every 3 months until the completion of this study or the transplant.

The correct implantation of TIPS was considered a technical feat and the control of HDH a clinical success.

Results

The technical success was 100% with one covered endoprosthesis and happened in only one session without associated mortality (Fig. 1). The average transhepatic gradient was 16 mmHg (12–21 mmHg) though it grew smaller after the implantation of TIPS to 9 mmHg (1–15 mmHg). In one kid with a post-TIPS transhepatic gradient of 1–15 mmHg the TIPS was previously dilated through a catheter-balloon of 10 mm diameter though portal pressure could not be reduced (Table 1).

Table 2 Reference review of TIPS in children.

<table>
<thead>
<tr>
<th>Author</th>
<th>Number</th>
<th>Model</th>
<th>PP (%)</th>
<th>SP (%)</th>
<th>Major complications (number)</th>
<th>Control HDA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heyman</td>
<td>7</td>
<td>Wallstent</td>
<td>43</td>
<td>0</td>
<td>Rebleeding (1)</td>
<td>80</td>
</tr>
<tr>
<td>Pozler</td>
<td>5</td>
<td>Wallstent</td>
<td>0</td>
<td></td>
<td>Hemoperitoneum (1)</td>
<td>70</td>
</tr>
<tr>
<td>Hackworth</td>
<td>12</td>
<td>Wallstent</td>
<td>92</td>
<td>100</td>
<td>Encephalopathy (1)</td>
<td>100</td>
</tr>
<tr>
<td>Huppert</td>
<td>9</td>
<td>Wallstent (4)</td>
<td>11</td>
<td></td>
<td>Jugular hematoma (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Palmaz (4)</td>
<td></td>
<td></td>
<td>APE (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cragg (1)</td>
<td></td>
<td></td>
<td>Hemoperitoneum (2)</td>
<td>33</td>
</tr>
<tr>
<td>Mermuys</td>
<td>4</td>
<td>Viatorr</td>
<td>75</td>
<td>100</td>
<td>Encephalopathy (1)</td>
<td></td>
</tr>
<tr>
<td>Shivaram</td>
<td>7</td>
<td>Viatorr</td>
<td>100</td>
<td>0</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

APE, acute pulmonary edema; HDH, high digestive hemorrhage; PP, primary patency; SP, secondary patency.
The clinical success was 100%. No patients showed HDH episodes ever again during the clinical follow-up or until the completion of transplant for an average 8.1 months (1–15 months). Among the 5 patients with plateletopenia (1,000–100,000/mm³) only 1 showed an increasing number of platelets—from 1,000 to 82,000/mm³ at 15 months.

Three children were transplanted with no technical complications 7, 9, and 10 months after the implantation of TIPS. The macroscopic piece confirmed its variability (Table 1). In the remaining 3 children (one of them in the transplant waiting list and the other 2 with no indication due to their good hepatic function) the patency of TIPS was confirmed through Doppler-ultrasound at 1, 3, and 15 months.

Discussion

In our study the use of covered TIPS allowed us to control HDH in all children with no further rebleeding episodes during follow-up. Our results relate to those published for this type of covered endoprostheses. However with uncovered endoprostheses rebleeding episodes have been found in as much as 67% of children (Table 2). Plateletopenia does not usually get between with the implantation of TIPS yet this is exactly what happened in one of our children.

Our technical success was 100% and even though there were some sporadic cases of impossibility to implant the TIPS and major mortality and morbidity associated by hemoperitoneum, we can considered it a safe technique. One of our children presented with transient encephalopathy described in 0–11% of cases always associated with final gradients <5 mmHg and always mild. Another transplanted girl with portal thrombosis presented with acute thrombosis of TIPS that eventually resolved by implanting one coaxial endoprosthesis.

Yes despite the complications of portal hypertension in children are similar to those seen in adults the causes are different. Biliary atresia and cystic fibrosis are more common. Given these children are usually cirrhotic they reach their final stage before they are 2 years old—when they are transplanted or treated with surgical shunts. The experience with TIPS in this pediatric population is scarce.

One of the issues derived from this underuse is that we do not have specific TIPS kits for children and we have to use adult kits. Nevertheless in children the liver and veins are smaller which increases risks when thick and rigid introducers are used (10F). Also we do not know basic data like the age and minimum weight of children, data that we would need to use these adult systems—even though they have proven successful in children of 24 pounds of weight. In our series the lowest weight was 44 pounds (Fig. 2). Another important consideration in children is the huge peritoneal fibrosis occurring in the biliary atresia, in the congenital hepatic fibrosis and in cystic fibrosis. All of them can reduce the caliber of portal branches, cause the displacement of suprahepatic veins (which is more serious in cases of hepatic grafts) and harden the hepatic parenchyma which in adults makes the catheterization of suprahepatic veins, the implantation of rigid introducers in its interior and the hepatic puncture to reach the portal system way harder. Some authors have developed smaller introducers (7F) and...
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Figure 2  (A) Six-year-old girl transplanted from living donor. Indirect portography with contrast injection in the splenic artery showing splenomegaly and thrombosis of extrahepatic portal vein with thick varices (arrow) due to cavernomatosis. (B) Direct portography after catheterization of portal vein through one varicose vein. Transhepatic gradient was 18 mmHg. (C) Implantation of recovered patent TIPS with an 8 mmHg-gradient. (D) Direct portography after 72 h showing occluded TIPS. (E) Direct portography showing recanalization of occluded TIPS after implanting one coaxial endoprosthesis. The final transhepatic gradient was 12 mmHg.

thinner needles (18G) that can usually bend during hepatic puncture.5,11

It has been confirmed that in adults with TIPS with covered endoprosthesis of PTFE the patency is better and the rates of rebleeding and encephalopathy are lower than with uncovered endoprostheses.4,13 Most endoprostheses implanted in children have been uncovered endoprostheses showing poor patency in the short term5,11 and a rate
of interventions close to 89%. However the experience of creating TIPS in children with covered endoprostheses with PTFE is minimum. The largest series we know of included 7 children (unpublished data) implanted with Viatorr®-type covered endoprostheses showing no dysfunctions during an average follow-up period of 5.3 months (Table 2). In our series there was only one early occluded TIPS (Fig. 2) even though after recanalization it kept its secondary patency in 100% during the average 8 month-follow-up; 8-and-10-mm-Viatorr® endoprostheses are available today and they cannot be overlidated beyond their nominal diameter. Given that among the pediatric population the creation of TIPS is usually a transient therapy until the completion of liver transplant some authors rather use the 8 mm-Viatorr® due to the small caliber of portal and suprahepatic vessels. However we (Fig. 1) as other authors used the 10 mm-diameter Viatorr® that we initially dilated with 8 mm-diameter balloons to only expand their nominal diameter when the transhepatic gradient is >12 mmHg. We abide by this strategy because – as it happened in 2 of our children not all patients are candidates to liver transplants. In this minority of growing children there might come a time that the 8 mm-endoprosthesys is undersized by the growth of the portal vein that theoretically speaking can cause the relapse of portal hypertension but if this happens we can always overlidate to 10 mm-endoprosthesys.

The minimum experience with the implantation of TIPS in children with liver grafts and portal chronic thrombosis is an added technical difficulty to TIPS. In our series both conditions happened in a girl–even so we managed to complete the implantation very difficult on the technical level but without complications and we could proceed to the recanalization of the occluded portal segment too.

In sum yet despite the great limitation of this study posed by the small number of sample patients this is the largest series with Viatorr®-type covered endoprostheses ever published for the treatment of HDH due to gastrointestinal varices in cirrhotic children. Our results indicate that both the security and patency can be good yet this will need to be confirmed in future studies.

**Ethical responsibilities**

**Protection of people and animals.** Authors confirm that the proceedings followed abide by the ethical regulations of the corresponding human experimentation committee in full compliance with the World Health Organization and the Declaration of Helsinki.

**Data confidentiality.** Authors confirm that the protocols of their centers have been followed on matters concerning the publishing of data from patients. They also confirm that all patients included in this study have been given enough information and handed over their written informed consent for their participation in this study.

**Right to privacy and informed consent.** Authors confirm that in this report there are no personal data from patients.

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**Conflict of interests**

Authors reported no conflicts of interests.

**References**

