

Evaluation of transjugular intrahepatic portosystemic shunt (TIPS) as a previous step to liver transplantation in pediatric patients

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ABSTRACT

Introduction. Transjugular intrahepatic portosystemic shunt (TIPS) was designed to treat complications of portal hypertension (PH). The objective of this study was to analyze the results of the TIPS performed in pediatric patients in our institution as a previous step to liver transplantation (LT).

Materials and methods. A retrospective, descriptive study of pediatric patients with liver cirrhosis undergoing TIPS prior to LT from 2015 to 2020 was carried out.

Results. TIPS was performed in 10 patients. The reason for TIPS was hard-to-control ascites in 7 patients (70%), upper gastrointestinal bleeding due to esophageal varices in 1 patient (10%), and portal hypoplasia in 2 cases (20%). No intraoperative complications were recorded. Stent patency was achieved in all cases.

TIPS patency until LT was observed in 6 patients (60%). Indirect signs of patency were noted in 1 patient (10%). 2 patients (20%) required re-intervention, with patency being achieved in the second attempt. And finally, no patency was observed after 3 attempts in 1 patient (10%).

A decrease in portocaval gradient ($p = 0.001$) and an increase in portal velocity ($p = 0.006$) were observed. No platelet count changes were found. A slight, non-significant increase in ammonia was noted.

Conclusion. TIPS is a safe and effective procedure to reduce complications of hard-to-control PH in pediatric patients. It allows general condition to be optimized, deterioration to be avoided, and portal vein narrowing to be alleviated in cirrhosis patients as a previous step to LT.

KEY WORDS: TIPS; Portosystemic shunt; Pediatric liver cirrhosis; Portal hypertension; Portal hypoplasia.

EVALUACIÓN DEL SHUNT PORTOSISTÉMICO INTRAHEPÁTICO TRANSYUGULAR (TIPS) COMO PUENTE TERAPÉUTICO AL TRASPLANTE HEPÁTICO EN PACIENTES PEDIÁTRICOS

RESUMEN

Introducción. El *shunt* portosistémico intrahepático transyugular (TIPS) es un procedimiento para tratar las complicaciones de la hipertensión portal. El objetivo del estudio es analizar los resultados de los TIPS realizados en nuestro centro, a pacientes pediátricos como puente al trasplante hepático (TH).

Material y métodos. Estudio retrospectivo y descriptivo de pacientes pediátricos con cirrosis hepática a los cuales se les ha realizado un TIPS previo al trasplante hepático entre los años 2015 y 2020.

Resultados. Se realizó el TIPS a 10 pacientes. El motivo fue en 7 por ascitis de difícil control (70%), un caso por hemorragia digestiva alta por varices esofágicas (10%) y en 2 por hipoplasia portal (20%). No hubo complicaciones intraoperatorias y en todos los casos se logró permeabilidad de la endoprótesis.

En 6 pacientes (60%) se observó permeabilidad del TIPS hasta el TH, en un paciente se observaron signos indirectos de permeabilidad (10%), 2 casos requirieron reintervención, lográndose permeabilidad en el segundo intento (20%) y en otra paciente (10%) no se observó permeabilidad tras 3 intentos.

Se apreció una disminución del gradiente portocava ($p = 0,001$) y un aumento en la velocidad portal ($p = 0,006$). No se evidenció cambios en la cifras de plaquetas y se produjo un ligero aumento del amonio, sin ser significativos.

Conclusión. El TIPS es un procedimiento seguro y eficaz para paliar las complicaciones de la hipertensión portal de difícil control en pacientes pediátricos. Nos permite optimizar el estado general, evitar el deterioro y paliar el estrechamiento de la vena porta de los pacientes cirróticos como puente al TH.

PALABRAS CLAVE: TIPS; *Shunt* portosistémico; Cirrosis hepática pediátrica; Hipertensión portal; Hipoplasia portal.

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INTRODUCTION

Portal hypertension (PH) and PH complications are rare in pediatric patients as compared to adult cirrhosis

patients. PH treatment schemes in children are usually based on adult schemes, since experience with adults is more extensive⁽¹⁾. Medical treatment of PH complications in pediatric patients does not differ much and primarily consists of diuretics for ascites and beta blockers for esophageal varices⁽²⁾.

Transjugular intrahepatic portosystemic shunt (TIPS) involves the creation of a by-pass, with blood flowing from the portal to the central venous system in order to reduce portal system pressure and diminish hypertension complications – namely ascites and esophageal varices^(1,3-5). Shunt dysfunction as a result of obstruction or thrombosis is the main complication associated with this technique. Therefore, patients usually remain under antiplatelet and anticoagulant treatment for a certain period of time^(1,3-5).

This technique is frequent in adult cirrhosis patients with PH – both as an acute and as a chronic treatment – in order to reduce complications, and as a previous step to liver transplantation (LT) or a palliative treatment in patients non-eligible for LT^(1,3). Although there are recent series of pediatric patients with TIPS⁽⁴⁻¹²⁾, experience in this age group is limited as a result of PH being less common.

The objective of this study was to describe our experience with the first pediatric patients with PH undergoing TIPS prior to LT in our institution – a third-level reference hospital in terms of liver pathologies.

MATERIALS AND METHODS

A descriptive and retrospective study of pediatric patients with liver cirrhosis and PH undergoing TIPS as a previous step to LT from 2015 to 2020 was carried out.

Inclusion criteria for TIPS were: patients with portal hypertension of hepatic origin, hard-to-control ascites in spite of medical treatment, esophageal varices with bleeding or high risk of bleeding, and progressive hypoplasia of the portal vein.

Qualitative variables were expressed as an absolute number and a percentage, while quantitative variables were expressed as a mean and a range. Statistical analysis was carried out using the *SPSS STATISTICS V.21* software (Armonk, NY, USA). A statistical analysis of platelets, ammonia, portocaval gradient, and portal velocity (as measured by ultrasonography) pre- and post-TIPS was conducted using Student's t-test and Fisher's exact test for coupled data. Statistical signification was established at $p < 0.05$.

TECHNIQUE DESCRIPTION

TIPS was carried out by the Pediatric Radiology department from our institution at the hemodynamics room. The technique used was classic TIPS⁽¹³⁾. Paracentesis had

been previously performed for fluid evacuation purposes in patients with ascites (70%). The procedure consisted of the following:

With the patient under general and local anesthesia – at the site to be punctured –, ultrasound-guided puncture of the right jugular vein is conducted, and the guide is introduced along with the manometer to measure central venous pressure and suprahepatic wedge pressure. If portocaval gradient is over 12 mmHg, the shunt is performed⁽¹¹⁾. The portal vein is assessed through ultrasonography, and the trajectory to be punctured is decided upon. If feasible, communication between the right suprahepatic vein and the right portal vein is created. Following puncture, an uncovered self-expanding stent (*PRECISE PRO-Cordis*[®] carotid stent) is placed, with its size varying according to the patient. An angiography is carried out while observing the presence of flow, according to which dilatation with an angioplasty balloon is considered. Finally, portosystemic gradient is measured again, and TIPS effectiveness (< 12 mmHg) is verified (Fig. 1).

In our case, antibiotic prophylaxis consisted of a single 25 mg/kg dose of intravenous cefazolin.

Ultrasonographies were conducted on the first three postoperative days in order to confirm shunt patency. Follow-up ultrasonographies were subsequently performed at external consultations. To avoid shunt thrombosis, patients should remain under antiplatelet – since uncovered stents are used – and anticoagulant treatment. Acetylsalicylic acid (5 mg/kg/day) is administered for a minimum of 1 month, and subcutaneous low-molecular-weight heparin (LMWH) for a minimum of 3 months (1-2 months of age: one 0.75 mg/kg dose every 12 hours; over 2 months of age: one 0.5 mg/kg dose every 12 hours). For an adequate control of anticoagulation, anti-Xa factor is used, with prophylactic levels ranging from 0.35 to 0.5. In those cases where no flow was observed through the shunt, a new patency attempt was carried out according to the patient, up to three times.

RESULTS

10 patients – 7 girls and 3 boys – (Table I) underwent TIPS. Mean age was 23.8 months (R: 4-182). 8 patients were under 1 year old, 1 patient was 17 months old, and 1 patient was 15 years old.

Baseline condition was biliary atresia in 7 cases (70%), familial intrahepatic cholestasis in 1 patient (10%), and idiopathic cirrhosis in 2 patients (20%). The reason for TIPS was hard-to-control ascites in 7 cases (70%), esophageal varices with upper digestive bleeding in 1 case (10%), and portal hypoplasia with a tendency to progressive portal vein narrowing in 2 cases (20%).

No complications were recorded, and stent patency was observed in all cases immediately after placement.

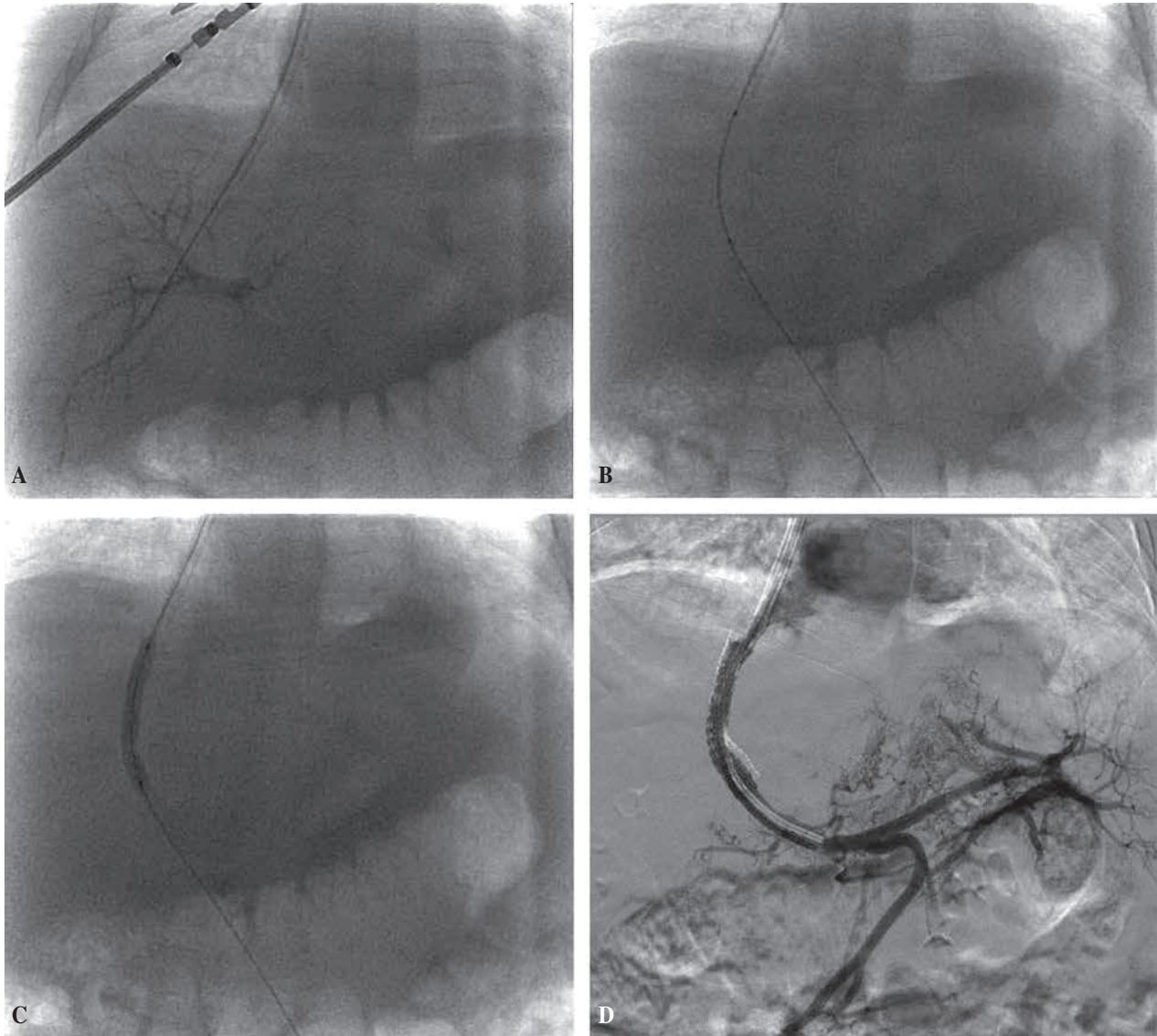


Figure 1. Transjugular intrahepatic portosystemic shunt (TIPS) technique. A) Right portal vein portography following puncture from the right suprahepatic vein. B) Placement of the guide with a non-expanded stent. Two black spots – the extremities of the stent – can be noted on the guide, which allows the stent to be placed in the position desired. C) Expansion of the stent with the balloon between the right suprahepatic vein and the right portal vein. D) Portography following stent expansion to confirm flow through the TIPS. Contrast passage from the portal to the central vein system can be observed.

Only in 1 case (10%), puncture proved uneasy as a result of significant liver fibrosis, but the stent remained patent until LT.

Adequate patency until LT was achieved in 6 patients (60%). Doppler ultrasound examination revealed no flow through the shunt in 1 patient (10%), but indirect signs of patency, such as increased portal velocity, increased flow in the suprahepatic veins, and reduced portal resistance, were detected. This patient underwent transplantation 23 days following TIPS as a result of having an ideal cadaveric donor, so no further patency attempts were made. Re-intervention was required in 2 cases (20%) as a result of shunt

thrombosis, with patency being achieved in the second attempt. No patency following 3 shunt patency attempts was observed in 1 patient (10%).

8 patients (80%) had grade 3 ascites – thus requiring evacuation paracentesis –, 1 patient (10%) had grade 2 ascites – well controlled with diuretics –, and 1 patient (10%) had no ascites. Spontaneous bacterial peritonitis (SBP) was observed in 4 patients (40%), who required admission and antibiotic treatment. Only 1 patient (10%) had esophageal varices with bleeding.

On average, uncovered stents were 5.1 mm thick x 2.89 cm long (R: 3.5-10 mm x 2-5 cm). The most common stent

Table I. Demographic characteristics of the sample and results.

Variable	Result
Sex	7 F 3 M
Age (months)	23.8 (4-182)
Baseline condition	Biliary atresia: 7 (70%) Familial cholestasis: 1 (10%) Idiopathic cirrhosis: 2 (20%)
Indication for TIPS	Hard-to-control ascites: 7 (70%) Portal hypoplasia: 2 (20%) UDB: (10%)
Ascites	Grade 3: 8 (80%) Grade 2: 1 (10%) No: 1 (10%)
Esophagogastric varices	Yes: 1 (10%) No upper GI endoscopy: 9 (90%)
SBP	Yes: 4 (40%) No: 6 (60%)
Stent size	5.1 mm (3.5-10) x 2.89 cm (2-5)
Intraoperative patency	Yes: 10 (100%) No: 0 (0%)
Long-term patency of TIPS	Yes: 6 (60%) Indirect signs: 1 (10%) Yes (following new patency attempts): 2 (20%) No: 1 (10%)
Time from TIPS to LT (months)	1.86 (1-5)

F: female; M: male; LT: liver transplantation; SBP: spontaneous bacterial peritonitis; Grade 3: ascites requiring surgical treatment; Grade 2: ascites requiring medical treatment.

was the 5 mm x 3 cm one. A 10 mm x 5 cm covered stent was placed in the 15-year-old patient.

A reduction in portocaval gradient following TIPS was observed, with pre-TIPS gradient being 16.38 mmHg (R: 11-29), and post-TIPS gradient being 5.6250 mmHg (R: 4-11) – the difference being statistically significant ($p = 0.001$). Although the official indication for pre-TIPS gradient was 12 mmHg, 1 patient underwent TIPS with 11 mmHg – the interventional radiologist decided so due

to the presence of ascites. Regarding portal velocity, an increase was noted, with pre-TIPS velocity being 10.5 cm/s (R: 4.00-21) and post-TIPS velocity being 28.64 cm/s (R: 8-45) – the difference being statistically significant ($p = 0.006$). No remarkable changes were found in platelet count, with pre-TIPS levels being 237,800 p/mm³ (R: 63,000-558,000) and post-TIPS levels being 244,200 p/mm³ (R: 88,000-416,000) – the difference not being statistically significant ($p = 0.878$). A small increase in ammonia levels was noted, from 116 µg/dl (R: 55-209) pre-TIPS to 122 µg/dl (R: 51-270) post-TIPS – the difference not being statistically significant ($p = 0.788$). None of the patients developed encephalopathy as a result of ammonia (Table II).

Abdominal drainage was removed in 5 out of the 7 patients (71%) diagnosed with ascites, with no evacuation paracentesis until LT required. It was left in place with occasional paracenteses in the remaining 2 patients (29%), with flow and frequency of ascitic fluid decreasing, which facilitated pre-transplantation management. The patient (10%) who had previously suffered from UDB had no further episodes until LT following TIPS.

LT was carried out in 8 patients (80%) 2.29 months (R: 1-5) following TIPS. 2 patients (20%) are currently waiting for LT 3 and 5 months following TIPS, respectively. LT was performed without intraoperative complications in all cases. Only 1 patient (10%) had intraoperative portal hypoplasia and multiple abdominal adhesions – this is the same patient where no TIPS patency had been achieved following three attempts. Except for that girl, the remaining patients had no portal hypoplasia or cavernomatosis, which facilitated portal anastomosis and made grafts unnecessary.

After a mean follow-up of 16 months (R: 3-60) following transplantation, of the 8 patients undergoing LT, 1 patient (10%) had hepatic artery thrombosis, required two re-transplantations, and eventually died. In the remaining patients (70%), the transplanted liver is working fine.

DISCUSSION

TIPS has demonstrated to be a safe and effective technique to alleviate PH in adult patients^(1,13,14). In pediatric patients, experience is more limited as a result of PH being

Table II. Variables pre-TIPS vs. post-TIPS.

Variable	Pre-TIPS	Post-TIPS	p value
Ammonia (µg/dl)	116 (55-209)	122 (51-270)	$p = 0.788$
Platelet count (platelets/mm ³)	237,800 (63,000-558,000)	244,200 (88,000-416,000)	$p = 0.878$
Portocaval gradient (mmHg)	16.38 (6-29)	5.6250 (4-11)	$p = 0.001$
Portal velocity (cm/s)	10.5 (4.00-21)	28.64 (8.00-45)	$p = 0.006$

less frequent^(7,12). However, in the last years, various series of children undergoing TIPS⁽⁴⁻¹²⁾ have been published. One of the longest series, which was published in 2019, is Bertino F et al.⁽⁴⁾, with 59 cases, as well as Johansen LC's⁽¹¹⁾, which was published in 2018, with 40 patients. Other series include 29⁽⁶⁾, 21⁽⁸⁾, and 12⁽⁷⁾ cases. Previous series are smaller and do not exceed 15 patients. The growing number of cases included in the last publications shows this technique is being increasingly used to alleviate PH complications in children. The objective of our study was to describe our experience with the first ten patients undergoing TIPS as a previous step to LT in our institution, and to demonstrate its efficacy in our limited series.

In adults, TIPS has been clearly demonstrated to alleviate PH effects and increase survival of patients subsequently undergoing LT⁽¹⁵⁾. This study randomized patients in a TIPS group vs. a paracentesis and albumin replacement group, concluding that the group undergoing TIPS had longer graft and patient survival. There are no pediatric studies randomizing patients according to whether TIPS has been performed or not, and assessing TIPS effectiveness prior to transplantation. Nevertheless, our series and all pediatric series analyzed⁽⁴⁻¹²⁾ describe an improvement in PH complications. Therefore, if patient baseline condition improves, LT and patient survival should improve, too.

The main reason for TIPS in our patients was the presence of hard-to-control ascites (70%), with esophageal variceal bleeding (EVB) being less prevalent (10%). These data significantly differ from the main indications in the series of pediatric patients undergoing TIPS published⁽⁴⁻¹²⁾, with EVB being the reason for TIPS in more than 80% of cases. It is worth noting that mean age in the various series published^(6-8,11,12) is 11-12 years old, which means patients were remarkably older than ours, who were just 2 years old approximately. This explains why hard-to-control ascites was our main indication. EVB only represented 10% of the sample, and it corresponded precisely with an older 15-year-old patient. However, in another study with biliary atresia patients of a mean age similar to ours⁽⁵⁾, EVB was the main indication for TIPS.

Liver fibrosis implies a progressive decrease or inversion in portal flow direction, thus reducing the caliber of the portal vein (PV) and making subsequent anastomosis between patient and graft PV more difficult. 20% of indications in our series were hypoplasia and portal narrowing. In the remaining patients, the main indication was hard-to-control ascites, but they all had narrowing, too, so it was also considered when indicating TIPS. Such indication is not well defined in the pediatric literature. However, in our experience, patients undergoing TIPS have a thicker PV at LT, which facilitates anastomosis. In our series, TIPS has demonstrated to increase portal velocity and preserve hepatopetal flow, as well as to reduce portocaval gradient. We believe that early TIPS in pediatric patients with PH facilitates LT, thus achieving better long-term results.

Nevertheless, contrarily to adult patients⁽¹⁵⁾, there are no studies supporting this. In our opinion, indication should be established prior to clinical deterioration, before ascites is poorly controlled or requires frequent evacuation paracenteses, or when ultrasonography shows signs of reduced portal flow prior to portal hypoplasia or cavernomatosis, or to an episode of UDB. Bleeding and hemoperitoneum are the main and most dreaded complications described in the literature^(6-8,11,12). However, in our series, no complications associated with the technique were recorded. In the hands of expert pediatric interventional radiologists, the benefits are greater than the risks associated with the procedure. Nevertheless, the risk of potentially severe complications should not be underestimated.

For it to be successful, TIPS should remain patent over time. In our series, primary or intraoperative patency was 100%. This is greater than the percentage described in the literature, which ranges from 70% to 100%. In our study, secondary or long-term patency until LT was 70%, similar to other series⁽⁴⁻¹²⁾.

In our study, no complications associated with the technique, such as hemoperitoneum, ammonia-induced encephalopathy, hepatic vein thrombosis, or biliary leak – which have been described as rare in other studies⁽⁴⁻¹²⁾ –, were found. Consistent with other series, PH clinical signs improved in all patients who maintained TIPS patency. Therefore, it can be stated that TIPS is a safe technique, with a low percentage of complications and proven efficacy in pediatric patients.

Currently, in adult patients, covered stents are preferred, since they have demonstrated greater effectiveness^(15,16). In pediatrics, a 12-case study⁽⁷⁾ claimed that covered stents were superior and more effective than uncovered stents, but patients were older than ours. In our sample, all patients, except for a 15-year-old girl, received an uncovered stent, since there are no small covered stents available in the market for such a young age. A young patient with a covered stent in place was referred from another hospital and underwent LT in our institution. During transplantation, the stent turned out to be strongly adhered to the PV, which impaired PV division and made it necessary to resect a segment of the patient's PV, thus making portal anastomosis more difficult. Placing an excessively long stent may result in iatrogenic lesions of the PV and make LT anastomosis uneasy. Consequently, in our hospital, as long as there are no shorter covered stents available in the market, we will keep using uncovered ones.

In order to avoid shunt thrombosis, patients should remain under antiplatelet – since uncovered stents are used – and anticoagulant treatment. Given that pediatric literature does not describe the experience of anticoagulation following TIPS, we analyzed data from studies in adults. A study by CJ. Steib⁽¹⁷⁾ demonstrates the variability and lack of consensus in the use of anticoagulant and antiplatelet treatment following TIPS in various adult institu-

tions. However, anticoagulant and antiplatelet treatment is strongly recommended in order to avoid TIPS thrombosis, especially when using uncovered stents. Regarding the use of the anti-Xa factor as an anticoagulation monitoring element, it has demonstrated to be a reliable indicator to measure anticoagulant action in deep venous thrombosis⁽¹⁸⁾. Nevertheless, post-TIPS experience in pediatric patients is limited. In our experience, the anti-Xa factor allows the effect of heparin to be measured, and the dosage regimen to be adjusted to each patient.

The main limitation of our study lies in the fact it has a small sample size. This is because PH is rare in the pediatric population as compared to adults. In addition, this technique has been used for less than 30 years, which means experience is limited. Furthermore, the fact it is a retrospective sample implies there was no patient randomization. However, given the high efficacy of this technique⁽⁴⁻¹²⁾, it would be unethical to conduct a study with a non-TIPS arm.

Our study adds a limited number of patients to the literature currently available. However, contrarily to other studies, it was carried out in younger patients, and ascites was the main indication. It also includes portal hypoplasia as an indication, which was not the case in previous studies, and demonstrates the usefulness of TIPS in this group of patients and the advantages of early TIPS.

CONCLUSION

TIPS is a safe and effective technique which has demonstrated to decrease portocaval gradient and increase portal velocity, thus reducing PH complications in pediatric cirrhosis patients and avoiding deterioration prior to LT.

Early TIPS allows portal hypoplasia to be reduced, thus making the portal vein thicker at LT and facilitating anastomosis.

REFERENCES

- Bajaj JS, Sanyal AJ, Collares FB. Overview of transjugular intrahepatic portosystemic shunts (TIPS). [Internet]. UpToDate; 2022.
- Squires RH. Acute liver failure in children: Management, complications, and outcomes. [Internet]. UpToDate; 2022.
- Garcia-Tsao G, Abraldes JG, Berzigotti A, Bosch J. Portal hypertensive bleeding in cirrhosis: Risk stratification, diagnosis, and management: 2016 practice guidance by the American Association for the study of liver diseases. *Hepatology*. 2017; 65(1): 310-35.
- Bertino F, Hawkins CM, Shivaram G, Gill AE, Lungren MP, Reposar A, et al. Technical Feasibility and Clinical Effectiveness of Transjugular Intrahepatic Portosystemic Shunt Creation in Pediatric and Adolescent Patients. *J Vasc Interv Radiol*. 2019; 30(2): 178-86.e5.
- Huppert PE, Goffette P, Astfalk W, Sokal EM, Brambs H-J, Schott U, et al. Transjugular intrahepatic portosystemic shunts in children with biliary atresia. *Cardiovasc Intervent Radiol*. 2002; 25(6): 484-93.
- Di Giorgio A, Nicastro E, Agazzi R, Colusso M, D'Antiga L. Long-term Outcome of Transjugular Intrahepatic Portosystemic Shunt in children with Portal Hypertension. *J Pediatr Gastroenterol Nutr*. 2019; 70(5): 615-22.
- Zurera LJ, Espejo JJ, Lombardo S, Gilbert JJ, Canis M, Ruiz C. Safety and efficacy of expanded polytetrafluoroethylene-covered transjugular intrahepatic portosystemic shunts in children with acute or recurring upper gastrointestinal bleeding. *Pediatr Radiol*. 2015; 45(3): 422-9.
- Ghannam JS, Cline MR, Hage AN, Chick JFB, Srinivasa RN, Dasika NL, et al. Technical success and outcomes in pediatric patients undergoing transjugular intrahepatic portosystemic shunt placement: a 20-year experience. *Pediatr Radiol*. 2019; 49(1): 128-35.
- Lv Y, He C, Guo W, Yin Z, Wang J, Zhang B, et al. Transjugular Intrahepatic Portosystemic Shunt for Extrahepatic Portal Venous Obstruction in Children. *J Pediatr Gastroenterol Nutr*. 2016; 62(2): 233-41.
- Schweizer P, Brambs HJ, Schweizer M, Astfalk W. TIPS: a new therapy for esophageal variceal bleeding caused by EHBA. *Eur J Pediatr Surg*. 1995; 5(4): 211-5.
- Johansen LC, McKiernan PJ, Sharif K, McGuirk SP. Transjugular Intrahepatic Portosystemic Shunt Insertion for the Management of Portal Hypertension in Children. *J Pediatr Gastroenterol Nutr*. 2018; 67(2): 173-9.
- Zurera LJ, Espejo JJ, Canis M, Bueno A, Vicente J, Gilbert JJ. [Transjugular intrahepatic portosystemic shunting with covered stents in children: a preliminary study of safety and patency]. *Radiologia*. 2014; 56(4): 339-45.
- Amesur NB, Novelli P. Transjugular Intrahepatic Portosystemic Shunt. En: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020.
- Strunk H, Marinova M. Transjugular Intrahepatic Portosystemic Shunt (TIPS): Pathophysiologic Basics, Actual Indications and Results with Review of the Literature. *Rofo*. 2018; 190(8): 701-11.
- Bureau C, Thabut D, Oberti F, Dharancy S, Carbonell N, Bouvier A, et al. Transjugular Intrahepatic Portosystemic Shunts With Covered Stents Increase Transplant-Free Survival of Patients With Cirrhosis and Recurrent Ascites. *Gastroenterology*. 2017; 152(1): 157-63.
- Maleux G, Perez-Gutierrez NA, Evrard S, Mroue A, Le Moine O, Laleman W, et al. Covered stents are better than uncovered stents for transjugular intrahepatic portosystemic shunts in cirrhotic patients with refractory ascites: a retrospective cohort study. *Acta Gastroenterol Belg*. 2010; 73(3): 336-41.
- Steib CJ, Li H, Zhang J, Mayerle J, Ricke J, Gerbes AL, et al. Transjugular intrahepatic portosystemic shunt for patients with liver cirrhosis: survey evaluating indications, standardization of procedures and anticoagulation in 43 German hospitals. *Eur J Gastroenterol Hepatol*. 2020; 32: 1179-85.
- Mahé I, Drouet L, Chassany O, Grenard A-S, Caulin C, Bergmann J-F. Low molecular weight heparin for the prevention of deep venous thrombosis: a suitable monitoring in elderly patients? *Pathophysiol Haemost Thromb*. 2002; 32: 134-6.