Diagn Interv Radiol 2019; 25:346–352

INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Long-term follow-up of transjugular intrahepatic portosystemic shunt (TIPS) with stent-graft

Margalida Pons Perelló
Javier Pueyo Mur
Magdalena Sastre Vives
Juan Manuel Martinez Riutort
Asunción Pastor Artigues
Carolina Nieto García
Maria Lucia Bonet Vidal
Ana Escarda Gelabert
Margalida Vanrell Garau

PURPOSE
We aimed to retrospectively evaluate the long-term clinical and patency results after the placement of transjugular intrahepatic portosystemic shunts (TIPS) using stent-graft. Many studies show the clinical results and the patency follow-up of TIPS with stent-graft in the short and medium term. However, few studies show long-term results.

METHODS
Between 2002 and 2016, TIPS with stent-grafts were placed in 132 patients. The median age was 59.5 years. The median Model for End-stage Liver Disease (MELD) score was 13, and 71% were Child-Pugh B. Indications for TIPS were bleeding (83%) and ascites or hydrothorax (17%). The technical and clinical success rates were calculated, as were the rates of patency, survival and complications. The median follow-up period was 43 months.

RESULTS
The technical success rate was 98%, and the clinical success rates were 85% in patients with indication for bleeding and 95% in patients with indication for ascites or hydrothorax. Primary patency did not decrease from 66% after 6 years (95% confidence interval [CI], 56.2%–75.8%) primary assisted patency remained stable at 87% after 6 years (95% CI, 77.2%–96.8%) and secondary patency did not decrease from 98% after 4 years (95% CI, 95.1%–100%). The median overall survival was 42.8 months (95% CI, 33.8–51.8 months). A total of 54 patients suffered some type of complication, minor (28 patients) or major (26 patients), during the follow-up.

CONCLUSION
The clinical success rate was high. The choice of the maximum initial limit of portosystemic gradient and the diameter of the post-TIPS shunt, together with the number of shunt reductions, are important to be able to compare results between publications. In our study, the patency rates did not decrease after 6 years; hence, long-term follow-up of these patients may not be necessary.

Portal hypertension is a syndrome characterized by an increase in hydrostatic pressure in the portal venous system; therefore, it can be caused by any disease that increases resistance to blood flow at this level. In our environment, the most common cause of portal hypertension is liver cirrhosis, which is primarily caused by hepatitis B and C, alcoholic liver disease, or a combination of these disorders. Complications due to portal hypertension include acute hemorrhage caused by varicose veins, ascites, and encephalopathy.

Transjugular intrahepatic portosystemic shunt (TIPS) is an effective intervention to decompress the portal venous system (1). The classic indications for TIPS are the secondary prevention of the bleeding of the esophageal varices, second-line treatment for acute refractory bleeding, and treatment for refractory ascites. Other indications include Budd-Chiari syndrome, portal thrombosis, and hepatorenal syndrome (1, 2). Patients with cirrhosis and a TIPS on the liver transplant waiting list have a lower mortality rate than those without a TIPS (3).

The first report of a TIPS procedure performed on a human using a bare-metal stent was published in 1989 (4). However, this type of stent shows high levels of dysfunction attributed to acute thrombosis, pseudointimal hyperplasia secondary to the leakage of the bile

From the Departments of Radiology (M.P.P. ✉ *margaponsp@gmail.com*, J.P.M., M.S.V., J.M.M.R., A.P.A., C.N.G.) and Gastroenterology (M.L.B.V., A.E.G., M.V.G.), Hospital Universitari Son Espases, Palma de Mallorca, Spain.

Received 28 September 2018; revision requested 03 November 2018; last revision received 17 December 2018; accepted 29 December 2018.

Published online 18 July 2019.

DOI 10.5152/dir.2019.18416

You may cite this article as: Pons Perelló M, Pueyo Mur J, Sastre Vives M, et al. Long-term follow-up of transjugular intrahepatic portosystemic shunt (TIPS) with stent-graft. Diagn Interv Radiol 2019; 25:346–352.

ducts transected in the shunt lumen, and intimal hyperplasia in the hepatic vein. To avoid these problems, the stent-graft was introduced in the early 2000s, representing a major turning point that led to significant improvements in patency rates (5–7).

Numerous publications have reported the short- and medium-term results after the placement of a TIPS with a stent-graft (5, 6, 8–13), showing patency and survival rates at 6, 12, and even 24 months. The objective of this study was to evaluate the long-term results of TIPS in daily clinical practice.

Methods

Study design and definitions

A total of 217 TIPSs were conducted in our tertiary hospital between June 1992 and October 2016. A total of 132 TIPSs with stent-graft performed between April 2002 and October 2016 were reviewed.

The study was approved by the Investigation Board (approval number: CI-261-18).

Using electronic medical records, follow-up data were recorded to determine clinical success (i.e., the absence of re-bleeding or refractory ascites) as well as the overall survival and primary, primary assisted, and secondary patency rates.

The definitions of the Quality Improvement Guidelines for Transjugular Intrahepatic Portosystemic Shunts, 2016 (14) were followed. "Elective TIPS" denoted recurrent varicose bleeding despite pharmacological and endoscopic therapy as the indication for TIPS, whereas "emergent TIPS" denoted patients with uncontrollable bleeding despite drugs and endoscopic treatment. We noted whether emergent patients were in hemorrhagic shock.

Technical success was defined as the successful creation of a shunt between the hepatic and portal venous system, and hemodynamic success was defined when a post-TIPS portosystemic gradient (PSG) ≤12 mmHg was achieved.

For patients with indications of bleeding (e.g., hematemesis, rectal bleeding, and bleeding from ostomies), clinical success was defined as the absence of new episodes of bleeding as evidenced by clinical signs during the follow-up period. For patients with indication for ascites, clinical success was defined as the lack of the need to use evacuating paracentesis (or thoracocentesis in the case of hepatic hydrothorax) during the follow-up period.

Primary patency was defined as continuous shunt patency with a PSG ≤12 mmHg without any further intervention. The primary patency period ended with any intervention to maintain the PSG ≤12 mmHg or with shunt occlusion. Primary assisted patency was defined as continuous shunt patency, with or without further intervention. Primary assisted patency period ended with shunt occlusion. Secondary patency was defined as shunt patency, with or without prior shunt occlusion (15, 16).

Shunt dysfunction was defined as occlusion or thrombosis on imaging; significant stenosis suspected based on alterations on Doppler ultrasound but confirmed via a venographic study; or when the PSG was >12 mmHg (9, 14, 17).

If an intervention to the TIPS was performed after the day of the placement, then it was considered as a revision of the TIPS for all cases.

Complications were recorded as minor or major according to the Quality Improvement Guidelines for Transjugular Intrahepatic Portosystemic Shunts, 2016 (14). We included hepatic encephalopathy as a complication. Any degree of hepatic encephalopathy that appeared at the time of the TIPS until the end of the follow-up period was recorded based on the data obtained in the electronic medical record.

Main points

- TIPS are a very effective intervention to decompress the portal venous system in patients with liver cirrhosis, among other diseases. Most common indications are secondary prevention of the bleeding of esophageal varices, second-line treatment in acute refractory bleeding, and treatment of refractory ascites.
- TIPS have been used since 1989, but it was not until the early 2000s, with the use of the stent-graft, that there was a significant improvement in patency at short- and medium-term rates.
- The aim of this study was to evaluate the long-term clinical and patency results after the placement of TIPS with stent-graft. We performed 132 TIPS with a median follow-up of 43 months, one of the longest among the published studies.
- Patency rates in our study decreased in the first years, as previously published. However, none decreased after 6 years in our study. Taking into account the progression over time of our patency rates and those of other publications, follow-up for the assessment of patency is likely not necessary in the long term.

Demographics

The demographic data are shown in Table 1. The median follow-up time was 43 months (range, 2 weeks to 14.5 years). One patient presented with high gastrointestinal (GI) bleeding and refractory ascites, but this condition was recorded as "indication by bleeding" because bleeding was the main symptom. The Model for End-stage Liver Disease (MELD) values of five patients were unavailable. Endoscopic treatment (bands, sclerotherapy, or both) was performed between

Table 1. Demographic data of patients at the time of TIPS placement

Characteristics	n (%)
Sex (%)	
Male	93 (70)
Female	39 (30)
Age (years), median (range)	59.5 (15–78)
Etiology of chronic liver disease	
Alcohol abuse	69 (52)
Viral (HBV, HVC, HBV + HVC)	26 (20)
Mixed (viral + alcohol abuse)	19 (14)
Cryptogenetic	6 (4)
Autoimmune	5 (4)
Budd-Chiari	4 (3)
Primary biliary cirrhosis	3 (2)
Pre-TIPS Child Pugh	
A	25 (19)
B	93 (71)
C	12 (9)
MELD, median (range)	13 (7–35)
Pre-TIPS encephalopathy	16 (12)
Pre-TIPS portal thrombosis	20 (15)
Indication	
Bleeding (high or low GI)	110 (83)
Elective	56 (42)
Emergent	54 (41)
Hemorrhagic shock	18 (14)
Ascites (or hydrothorax)	22 (17)

HBV, hepatitis B virus; HVC, hepatitis C virus; TIPS, transjugular intrahepatic portosystemic shunt; MELD, model for end-stage liver disease; GI, gastrointestinal.

0 and 12 times, with a median of two times, before a TIPS procedure was performed for patients with high GI bleeding.

Regarding the medical histories of our patients, we emphasize that three had a history of hepatocarcinoma, 12 had a history of other neoplasms, and two had received liver transplants.

Procedure

After obtaining informed consent, all TIPS procedures were performed in an interventional radiology room using standard technique (14) guided by ultrasound and fluoroscopy. The only modification was to place a 5F "pig-tail" catheter in the inferior vena cava to perform a cavography immediately before the stent-graft release to place it in the ostium of the hepatic vein. Interventional radiologists with 8–28 years of experience performed all of the procedures by working in teams of two. The patients were in deep sedation, except for unstable patients who had assisted respiration.

In all cases, a 10 mm VIATORR stent-graft (the first "non-controlled expansion" version) was used (WL Gore and Associates) and opened to 8 mm. The stent-graft was only opened to 10 mm if the post-TIPS PSG was >12 mmHg. When splenoportal venous thrombosis was observed, the stent-graft was prolonged with a bare-metal stent 12 mm in diameter (WALLSTENT, Boston Scientific). The esophageal varices were embolized after the creation of the TIPS, only if they were observed on post-TIPS portography using 0.035-inch metal coils (MReye coils, Cook Medical). No anticoagulant or antiplatelet therapy was administered during or after the procedure.

Follow-up

The follow-up protocol included a hemodynamic study with portography 1 week after TIPS, and Doppler ultrasound performed by an interventional radiologist at 1, 3, and 6 months as well as at 6-month intervals or if clinical symptoms appeared. The sonographic findings of the absence of Doppler flow, abnormal velocity (<90 cm/s or >190 cm/s) or a significant change with respect to the systolic peak of the previous ultrasound (>50 cm/s) were indications for hemodynamic study and portography (9, 10, 18). When necessary, another stent, thrombolysis, thromboaspiration, varicose embolization, or a combination therein was used.

Statistical analysis

The quantitative variables are presented as medians and ranges. Descriptive statistics was used to determine the demographic characteristics of the population under study and to check and correct erroneous entries in the database. The overall survival as well as the primary, primary assisted, and secondary patency rates were estimated using the Kaplan-Meier method. The patients were censored at the time of death, liver transplantation, or the last follow-up date. Comparisons between the variables of interest were performed using the log-rank test. ROC curve analysis was used to obtain the optimal cutoff value for overall survival (death event) and to determine the cutoff value for the MELD score. All of the *P* values presented are two-tailed, and statistical significance was established as $P < 0.05$. The statistical analyses were performed with SPSS, version 20 (IBM Corp.).

Results

Pre-TIPS PSG was not recorded for 4 patients. The median pre-TIPS PSG was 21 mmHg (10–35 mmHg), and the median post-TIPS PSG was 9 mmHg (2–23 mmHg). The median reduction of PSG was 12 mmHg (3–28 mmHg).

For 17 patients, the stent-graft was dilated to 10 mm; 16 presented with bleeding: 7 had recurrent bleeding (elective cases), and 9 had uncontrollable bleeding (emergent cases).

In 6 of 20 patients with pre-TIPS portal thrombosis, an additional stent was placed (a VIATORR in one patient and a WALLSTENT in others). A tumor thrombus was found in one patient later; therefore, two more VIATORR stents and another WALLSTENT were placed during subsequent revisions.

No significant differences were found in the control of bleeding amongst patients in whom varicose veins had been embolized versus patients without varicose embolization ($P = 0.24$).

Technical success was achieved in 130 of the patients (98%) and hemodynamic success in 116 (88%). A total of 115 of the patients concluded with clinical success (88%). The bleeding was controlled in 94 of the 110 patients who presented with this symptom. In fact, bleeding was controlled in 49 of the 54 patients in whom we performed an elective TIPS; and in 44 of the 54 patients with an emergent TIPS. Patients with an emergent TIPS due to bleeding accompanied by hemorrhagic shock presented with poorer clinical success rates (61%) compared with those with emergent TIPS due to bleeding but without hemorrhagic shock (92%; $P = 0.023$). Varicose embolization was performed in 42 patients (32%).

Clinical success was achieved in 21 of the 22 patients who presented with ascites or hydrothorax.

Re-bleeding occurred after a TIPS was placed in 16 patients (median, 10 months; range, 0–61 months). Of these patients, 57% (n=9) had an episode of re-bleeding during the first 2 years, and none had episodes of re-bleeding after 6 years.

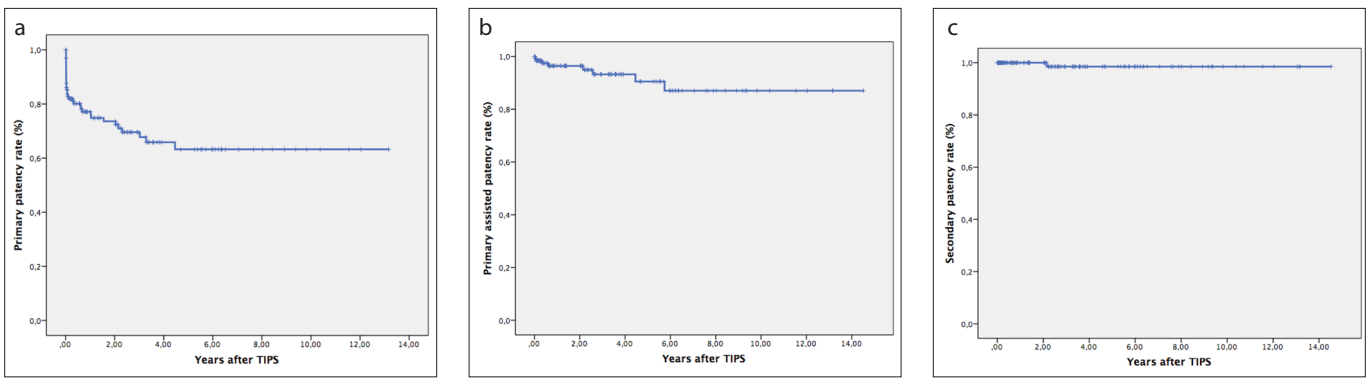

Figure 1. a–c. Primary **(a)**, primary assisted **(b)** and secondary **(c)** patency rates.

The primary, primary assisted and secondary patency rates are represented in Fig. 1 and Table 2. No significant differences were found with regard to primary patency according to the pre-TIPS PSG (greater or less than 20 mmHg; $P = 0.55$) or between the presence and absence and pre-TIPS portal thrombosis ($P = 0.23$).

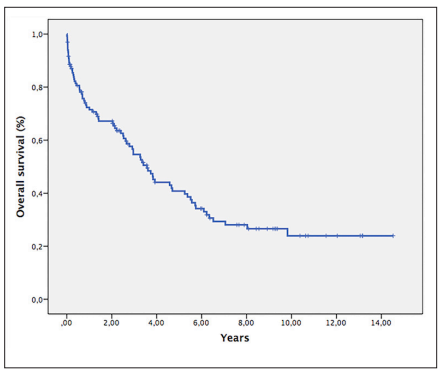

Figure 2. Kaplan-Meier global survival curves.

The median overall survival was 42.8 months (95% confidence interval [CI], 33.8–51.8 months). Survival rates at 1, 2, 4, 6, 8, 10 and 12 years were 88%±7.8%, 67%±8.2%, 44%±9.4%, 34%±9.2%, 28%±9%, 24%±9.4% and 24%±9.4% (Fig. 2).

The mortality rate estimated at 30 days was 8.4%. A total of 80 patients (61%) died during the follow-up period. The cause of death of 32 patients was related to liver disease; in 26 patients, it was related to tumors, infections, or other conditions; and in 22 patients, the cause of death was unclear. Of the 18 patients with emergent TIPS in hemorrhagic shock, 6 (34%) died during the first 30 days after the TIPS procedure.

Significant differences ($P < 0.001$) were found in the overall survival rate between patients under and over 60 years of age. The median overall survival of the first group was 78 months (95% CI, 32–124 months), whereas the median overall survival was 27 months in the second group (95% CI, 10–44 months; Fig. 3a). Significant differences were also found in the overall survival between patients with Child-Pugh A and those with Child-Pugh B or C ($P = 0.019$). Patients with Child-Pugh A had a median overall survival of 96 months (95% CI, 42–151 months), whereas patients with Child-Pugh B or C had a median overall survival of 35 months (95% CI, 24–47 months; Fig. 3b). No significant differences were found amongst patients with Child-Pugh A, B, or C when they were analyzed separately ($P = 0.061$). Patients with

Table 2. Actuarial primary, primary assisted and secondary patency rates at 1 through 12 years

	1 year	2 years	4 years	6 years	8 years	10 years	12 years
Patients at risk[a]	132	69	60	25	17	9	4
Events[b]	28	3	5	1	0	0	0
Death[c]	28	5	16	6	4	2	0
Lost to follow-up[d]	1	0	1	1	1	1	0
End of study[e]	5	1	13	0	3	2	4
Transplant[f]	1	0	0	0	0	0	0
Primary patency (%)[g]	77±7.4	74±8.2	66±9.8	63±10.8	63±10.8	63±10.8	63±10.8
Patients at risk[a]	132	81	72	34	24	13	6
Events[b]	4	0	2	2	0	0	0
Death[c]	35	6	22	7	5	2	0
Lost to follow-up[d]	1	0	0	1	1	2	0
End of study[e]	9	3	14	0	4	3	6
Transplant[f]	2	0	0	0	1	0	0
Primary assisted patency (%)[g]	96±3.5	96±3.5	93±5.5	87±9.8	87±9.8	87±9.8	87±9.8
Patients at risk[a]	132	83	74	36	26	15	8
Events[b]	0	0	1	0	0	0	0
Death[c]	35	6	23	9	5	2	0
Lost to follow-up[d]	1	0	0	1	1	2	0
End of study[e]	10	3	14	0	4	3	8
Transplant[f]	3	0	0	0	1	0	0
Secondary patency (%)[g]	100	100	98±2.9	98±2.9	98±2.9	98±2.9	98±2.9

[a]Number of patients at risk of losing the primary, primary assisted and secondary patency at the beginning of each time period; [b]Number of patients that lost the patency during each time period. [c]Number of patients that died during each time period; [d]Number of patients that were lost to follow-up during each time period. [e]Number of patients that did not have a TIPS of more duration due to the study ending during the corresponding time period. [f]Number of patients that received a transplant during each time period; [g]Actuarial patency rates at each time period and their corresponding 95% confidence intervals, estimated using the Kaplan-Meier method.

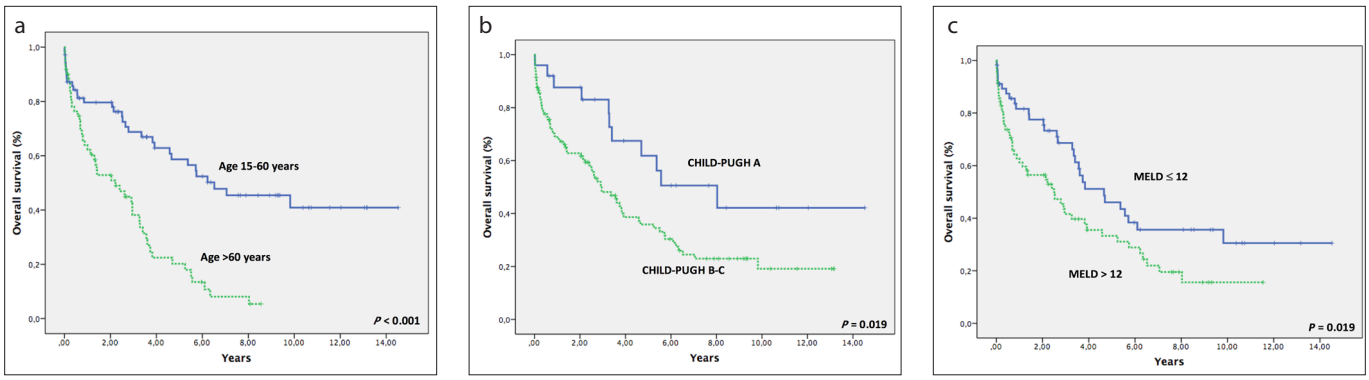

Figure 3. a–c. Kaplan-Meier curves of overall survival grouped by age **(a)**, Child-Pugh **(b)** and MELD **(c)**.

Table 3. Findings and techniques performed in TIPS revisions

Findings	Incidence (%)
Total number of TIPS revisions	58 (100)
Finding in the revision	
Occlusion	7 (12)
Stenosis	27 (47)
High PSG	25 (43)
Only high PSG	24 (41)
Location of the stenosis	
End of the suprahepatic vein	4 (7)
Half of the TIPS	1 (2)
Portal end	20 (34)
Multifocal	2 (3)
Technique performed in the revisions	
Angioplasty	46 (79)
Angioplasty + stent	10 (17)
Thromboaspiration, thrombolysis	4 (7)
Creating a parallel TIPS	2 (3)

TIPS, transjugular intrahepatic portosystemic shunt; PSG, portosystemic gradient.

Table 4. Major and minor complications

Complications	n
Major (%)	21 (16)
Death	14
Accelerated liver failure	9
Septic shock	3
Hemorrhagic shock	2
Pneumonia	7
Minor (%)	61 (46)
Encephalopathy	48
Fever	7
Transient pulmonary edema	4
Acute transient renal failure	1
Nonobstructive jaundice	1

Child-Pugh B showed a median overall survival of 35 months (95% CI, 23–47 months), whereas those with Child-Pugh C showed a median overall survival of 3 months (95% CI, 0–73 months). Likewise, significant differences were found with regard to patients with MELD values ≤12 and those >12 ($P = 0.019$). Patients with MELD values ≤12 had a median overall survival of 56 months (95% CI, 31–81 months), whereas patients with MELD values >12 had a median overall survival of 30 months (95% CI, 12–48 months; Fig. 3c). No significant differences in overall survival were found amongst the different etiologies of cirrhosis ($P = 0.38$), between the indications of TIPS ($P = 0.97$), amongst the number of revisions made to the TIPS (0 or ≥1; $P = 0.42$), or between patients with and without the loss of primary patency ($P = 0.15$).

Shunt dysfunction occurred in 27 patients (36%). Revisions were performed for 38 patients (29%), 10 (6%) of whom required between 2 and 6 revisions (Table 3). Approximately 74% of the revisions were performed during the first 2 years after the TIPS procedure. Only varicose embolization was performed for two patients during the angiographic check-up visit; therefore, they were not recorded as shunt revisions.

Of the 7 TIPS occlusions, 3 occurred in the same patient who had Budd-Chiari syndrome.

The associated complications according to the Quality Improvement Guidelines for Transjugular Intrahepatic Portosystemic Shunts, 2016 (14) are shown in Table 4.

Twelve patients died during the first days/weeks after the TIPS procedure. The indications for TIPS were bleeding in the context of emergent TIPS for 11 of the patients and hemorrhagic shock for 8 patients.

Three patients underwent TIPS reductions due to severe encephalopathy. The indications for TIPS were ascites in two patients and bleeding in the other (elective TIPS).

In our case series, no significant increase was observed in the post-TIPS encephalop-

athy rate based on the presence of pre-TIPS encephalopathy (P = 0.42), and no significant differences were found with regard to post-TIPS encephalopathy depending on the indications for TIPS (P = 0.48).

Five patients were lost to follow-up. During the follow-up period, 4 patients (3%) received a liver transplant, 13 (10%) patients developed hepatocarcinoma, and 6 patients (4.5%) had other neoplasms.

Discussion

This study reviewed more than 14 years of data with a median follow-up time of 43 months, corresponding to one of the longest published TIPS studies with stent-graft; furthermore, it emphasizes the importance of evaluating the long-term results of clinical success, patency, survival, and complications in TIPS procedures with stent-grafts.

We measured the PSG at the time of the TIPS procedure and a week after to ensure that patients were discharged with a PSG of ≤12 mmHg. This is the limit that defines primary patency for us. We follow the same protocol that we started with bare-metal stent, which had more problems with early thrombosis. We also know that PSG increases a few days after TIPS and stabilizes after a week. This finding has also been described recently (19).

The clinical success rate of the patients with ascites in our study (95%) was similar to those reported in other studies (7, 8, 12, 18, 20). As recommended by the American Association for the Study of Liver Diseases (21) and published previously (20), the use of a target PSG of 12 mmHg (and not of 8 mmHg) for patients with ascites did not worsen the clinical success rates of our patients. Other studies also used 12 mmHg as the target PSG to indicate a TIPS for patients with either ascites or bleeding (19). However, the number of patients with indications for a TIPS due to ascites is low (22 patients, 17%) and not likely to be representative.

As has also been previously published (22), our study did not find significant differences in the control of bleeding between patients who underwent varicose vein embolization and those who did not (P = 0.24). However, others have reported that the occlusion of varicose veins after the completion of a TIPS procedure does reduce the risk of re-bleeding (9, 23).

We observed that most stenoses in the TIPS appeared at the end of the portal vein and not at the end of the suprahepatic vein. This observation is contrary to the findings of other publications (8, 12). The finding of less stenosis at the end of the suprahepatic vein might be caused by the technical variation of keeping a "pig-tail" catheter in the inferior vena cava and performing a cavography immediately before releasing the stent-graft to fit into the ostium of the hepatic vein. It is possible that less care was taken with the portal end, where the wall of the vein is more resistant to dilation. The decision to post-dilate the shunt to 8 mm instead of 10 mm may have also influenced these results.

Shunt dysfunction in our series was high (36%). We noted that the definition of shunt dysfunction was vague in some studies (8, 17, 24), nor did they specify the exact parameters used to define TIPS dysfunction. Other studies (10) based the definition only on sonographic findings, unlike the current study. Therefore, we believe that TIPS dysfunction rates are not comparable across different studies.

The definitions of the different patency types were also vague in many studies (6, 13, 17, 24), which referred only to the presence of significant stenosis or an occlusion as the definition of a loss of patency. In fact, the Quality Improvement Guidelines for Transjugular Intrahepatic Portosystemic Shunts, 2016 (14) state that the application of universal thresholds for different rates of results is difficult, and each hospital should apply the values required by their own program. Consequently, our patency rates were only compared with studies in which the definition for patency was the same as ours (11, 20).

Our first-year primary patency is low compared to other authors who use VIATORR stent-grafts. Geeroms et al. (24) reports a primary patency of over 80% after follow-up periods of 5 and 10 years. Our results are more similar to those of Weber et al. (20) which uses exactly the same definitions for patency as we do. The differences in patency definitions with respect to Geeroms et al. (24) may also be because they opened the shunt to 10 mm in 58.5% of their patients. Those patients showed a significantly larger free interval of dysfunction (P = 0.026), mainly in the first year. However, they had to make a reduction of the shunt due to TIPS-induced hepatic encephalopathy in 16.3% of their patients. In our hospital, the initial dilation of the VIATORR stent-graft was always to 8 mm, only increasing to 10 mm if the PSG was >12 mmHg. The result was that only 2.2% of the patients required a shunt reduction due to hepatic encephalopathy.

Despite the decrease in the patency rates during the first years, none of the rates decreased after 6 years in our study, which is similar to the findings of Geeroms et al. (24), who did not observe any new shunt dysfunction after a 5-year follow-up period. Considering the progression over time of our patency rates and those of other publications, a follow-up assessment of patency is most likely not necessary in the long term, although it is necessary after 2 years, as Weber et al. (20) reported in their study.

Some authors (15, 18) consider that long-term follow-up with Doppler ultrasound is unnecessary because of the high patency rates of TIPS with stent-grafts and because patients with TIPS patency are asymptomatic and become symptomatic in cases of thrombosis. In fact, in our study, neither the patency rates nor the clinical success rates decreased after 6 years.

The survival rates of our patients were similar to those of others published (7, 9, 11, 12, 17, 20, 24). Nevertheless, 61% of patients died during the follow-up period, which is a high percentage compared with other studies (7, 8, 18, 20). However, this figure is not relevant because our follow-up period was longer. Importantly, the cause of death in our series was not related to liver disease in 20% of all patients who died during follow-up; the post-TIPS liver transplantation rate was only 3%; and a high 30-day mortality rate (34%) was present amongst patients who underwent an emergent TIPS and who suffered from hemorrhagic shock. These patients also showed poorer clinical success rates than those with emergent TIPS due to bleeding but without hemorrhagic shock (6% vs. 92%).

The mortality rates in our sample were significantly higher amongst older patients, which corroborates previous reports (11, 17). However, other studies did not find significant differences with regard to mortality or patient age (12), or they found that it did not affect the 90-day mortality rate (25).

We did not find significant differences in mortality amongst our patients with regard to the different etiologies of cirrhosis, corroborating several previous studies (11, 12, 17); however, some authors have published findings with higher survival rates concerning patients with alcoholic cirrhosis (24).

The median MELD score in our sample was similar to those published in other

studies (6, 17, 18, 24). Patients with MELD scores >15–18 should be informed of their poor prognosis, and a TIPS procedure should only be performed when other therapeutic options are not available (1, 12). The analyses of our data supports these claims, because we found significant differences with regard to the median survival between patients with MELD scores >12 and ≤12.

The limitations of this study are consistent with those of a retrospective study. The lack of significant differences in survival found in our sample amongst the different etiologies of cirrhosis, indication for TIPS, number of revisions made to the TIPS, with or without primary patency might be because of the sample size. This limitation might also explain the fact that no significant differences were found in the primary patency of patients with or without pre-TIPS portal thrombosis.

In conclusion, this study reports the long follow-up of the clinical success, patency, survival, and complications of patients with TIPS and stent-grafts. A post-TIPS PSG limit should be chosen for the entire follow-up. The most frequent in the published articles is ≤12 mmHg, as is our case. It is important to do a hemodynamic study and portography a week after TIPS, as justified by previously published literature (19), and corroborated with our observations. Depending on the results of this follow-up, a first shunt angioplasty may be required, therefore decreasing primary patency. An important decision is to choose between opening the VIATORR stent-graft to 8 mm or to 10 mm. With a diameter of 8 mm the primary patency will decrease, but less shunt reductions will be necessary. The follow-up protocol can include a Doppler ultrasound at 1, 3, and 6 months after TIPS; and at 6-months intervals or if clinical symptoms appear. This follow-up should last up to 5–6 years, after which the patency rates remain stable.

Conflict of interest disclosure

The authors declared no conflicts of interest.

References

1. Krajina A, Hulek P, Fejfar T, Valek V. Quality improvement guidelines for transjugular intrahepatic portosystemic shunt (TIPS). Cardiovasc Intervent Radiol 2012; 35:1295–1300. [CrossRef]
2. Copelan A, Kapoor B, Sands M. Transjugular intrahepatic portosystemic shunt: indications, contraindications, and patient work-up. Semin Intervent Radiol 2014; 31:235–242. [CrossRef]
3. Berry K, Lerrigo R, Liou IW, Ioannou GN. Association between transjugular intrahepatic portosystemic shunt and survival in patients with cirrhosis. Clin Gastroenterol Hepatol 2016; 14:118–123. [CrossRef]
4. Richter GM, Palmaz JC, Nöldge G, et al. Der Transjuguläre intrahepatische portosystemische Stent-Shunt (TIPSS). Eine neue nichtoperative, perkutane methode. Radiologe 1989; 29:406–411.
5. Barrio J, Ripoll C, Bañares R, et al. Comparison of transjugular intrahepatic portosystemic shunt dysfunction in PTFE-covered stent-grafts versus bare stents. Eur J Radiol 2005; 55:120–124. [CrossRef]
6. Gupta AC, Wang W, Shah C, et al. Added value of covered stents in transjugular intrahepatic portosystemic shunt: a large single-center experience. Cardiovasc Intervent Radiol 2017; 40:1723–1731. [CrossRef]
7. Charon JP, Alaeddin FH, Pimpalwar SA, et al. Results of a retrospective multicenter trial of the Viatorr expanded polytetrafluoroethylene-covered stent-graft for transjugular intrahepatic portosystemic shunt creation. J Vasc Interv Radiol 2004; 15:1219–1230. [CrossRef]
8. Rössle M, Siegerstetter V, Euringer W, et al. The use of a polytetrafluoroethylene-covered stent graft for transjugular intrahepatic portosystemic shunt (TIPS): Long-term follow-up of 100 patients. Acta Radiol 2006; 47:660–666. [CrossRef]
9. Gaba RC, Omene BO, Podczerwinski ES, et al. TIPS for treatment of variceal hemorrhage: clinical outcomes in 128 patients at a single institution over a 12-year period. J Vasc Interv Radiol 2012; 23:227–235. [CrossRef]
10. Saad WE, Darwish WM, Davies MG, Waldman DL. Stent-grafts for transjugular intrahepatic portosystemic shunt creation: specialized TIPS stent-graft versus generic stent-graft/bare stent combination. J Vasc Interv Radiol 2010; 21:1512–1520. [CrossRef]
11. Tripathi D, Ferguson J, Barkell H, et al. Improved clinical outcome with transjugular intrahepatic portosystemic stent-shunt utilizing polytetrafluoroethylene-covered stents. Eur J Gastroenterol Hepatol 2006; 18:225–232. [CrossRef]
12. Vignali C, Bargellini I, Grosso M, et al. TIPS with expanded polytetrafluoroethylene-covered stent: Results of an Italian multicenter study. AJR Am J Roentgenol 2005; 185:472–480. [CrossRef]
13. Lauermann, J, Potthoff A, Mc Cavert M, et al. Comparison of technical and clinical outcome of transjugular portosystemic shunt placement between a bare metal stent and a PTFE-stent-graft device. Cardiovasc Intervent Radiol 2016; 39:547–556. [CrossRef]
14. Dariushnia SR, Haskal ZJ, Midia M, et al. Quality improvement guidelines for transjugular intrahepatic portosystemic shunts. J Vasc Interv Radiol 2016; 27:1–7. [CrossRef]
15. Latimer J, Bawa SM, Rees CJ, Hudson M, Rose JD. Patency and reintervention rates during routine TIPSS surveillance. Cardiovasc Intervent Radiol 1998; 21:234–239. [CrossRef]
16. Rutherford RB, Becker GJ. Standards for evaluating and reporting the results of surgical and percutaneous therapy for peripheral arterial disease. J Vasc Interv Radiol 1991; 2:169–174. [CrossRef]
17. Kim HK, Kim YJ, Chung WJ, et al. Clinical outcomes of transjugular intrahepatic portosystemic shunt for portal hypertension: Korean multicenter real-practice data. Clin Mol Hepatol 2014; 20:18–27. [CrossRef]
18. Sajja KC, Dolmatch BL, Rockey DC. Long-term follow-up of TIPS created with expanded poly-tetrafluoroethylene covered stents. Dig Dis Sci 2013; 58:2100–2106. [CrossRef]
19. Silva-Junior G, Turon F, Baiges A, et al. Timing affects measurement of portal pressure gradient after placement of transjugular intrahepatic portosystemic shunts in patients with portal hypertension. Gastroenterology 2017; 152:1358–1365. [CrossRef]
20. Weber CN, Nadolski GJ, White SB, et al. Long-term patency and clinical analysis of expanded polytetrafluoroethylene-covered transjugular intrahepatic portosystemic shunt stent grafts. J Vasc Interv Radiol 2015; 26:1257–1265. [CrossRef]
21. Strader DB, Wright T, Thomas DL, Seeff LB. Diagnosis, management, and treatment of hepatitis C. American association for the study of liver diseases. Hepatology 2004; 39:1147–1171. [CrossRef]
22. Weber CN, Ge BH, Clark T, Soulen MC, Nadolski G. Clinical outcomes of selective variceal coil embolization during PTFE-covered transjugular intrahepatic portosystemic shunt (TIPS) placement for variceal hemorrhage. J Vasc Interv Radiol 2015; 2:S92–S93. [CrossRef]
23. Salahi M, Laidlaw G, Moradzadeh N, et al. Effect of embolization or sclerosis on variceal hemorrhage after transjugular intrahepatic portosystemic shunt placement. J Vasc Interv Radiol 2017; 2:S168–S169. [CrossRef]
24. Geeroms B, Laleman W, Laenen A, et al. Expanded polytetrafluoroethylene-covered stent-grafts for transjugular intrahepatic portosystemic shunts in cirrhotic patients: Long-term patency and clinical outcome results. Eur Radiol 2017; 27:1795–1803. [CrossRef]
25. Catron TD, Chiu S, Kim S, Aal AKA, Singal A. Age does not impact outcomes of transjugular intrahepatic portosystemic shunt. Gastroenterology 2017; 152: S1148. [CrossRef]