Clinics and Research in Hepatology and Gastroenterology 46 (2022) 101858

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REVIEW

Direct intrahepatic portocaval shunt (DIPS) or transjugular transcaval intrahepatic portosystemic shunt (TTIPS) to treat complications of portal hypertension: Indications, technique, and outcomes beyond Budd-Chiari syndrome

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Available online 7 January 2022

KEYWORDS
Direct intrahepatic portocaval shunt (DIPS);
Transjugular transcaval intrahepatic portosystemic shunt (TTIPS);
Transjugular intrahepatic portosystemic shunt (TIPS);
Cirrhosis;
Portal hypertension (PH)

Abstract Transjugular intrahepatic portosystemic shunt (TIPS) is nowadays the benchmark treatment of severe portal hypertension complications. However, besides usual contraindication to the procedure (namely recurrent hepatic encephalopathy, severe liver dysfunction, right heart failure and/or pulmonary hypertension), TIPS appears regularly unfeasible due to abnormal and/or distorted anatomy. In this situation, the only non-surgical approaches to treat severe portal hypertension consist in the creation of an intrahepatic portocaval shunt from percutaneous (direct intrahepatic portocaval shunt - DIPS) or transjugular route (transjugular transcaval intrahepatic portosystemic shunt – TTIPS). These procedures have been rapidly adopted in patients with Budd-Chiari syndrome but are only poorly reported in patients with cirrhosis and without BCS. Considering the broadening landscape of TIPS indication in patients with cirrhosis within the last ten years, we aimed to describe the techniques, safety and efficacy of DIPS and TTIPS procedures as an alternative to TIPS in case of unfavourable anatomy.

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https://doi.org/10.1016/j.clinre.2022.101858

Introduction

Portal hypertension (PH) is one of the main complications of liver cirrhosis and represents a turning point in the disease [1]. pH may also occur in patients with vascular disease of the liver in the absence of cirrhosis. The best-known consequences of pH are the growth of oesophagal and gastric varices with a risk of gastrointestinal bleeding and the development of peritoneal and/or pleural ascites. These events are responsible for a dramatic decrease in patients' survival and are widely accepted indications for liver transplantation. To improve pH and its complications, a radiological insertion of a transjugular intrahepatic portosystemic shunt (TIPS) has been proposed. This procedure has been optimized with the adoption of polytetrafluoroethylene (PTFE) that allowed to significantly improve the medium and long-term patency of the stents [2]. From an initial position of "salvage" or late secondary prophylaxis of the TIPS insertion, the procedure is nowadays proposed earlier to prevent recurrence of severe pH related events. Indeed, the last 10−15 years confirmed the beneficial impact of early (or preemptive) TIPS placement in the setting of controlled variceal bleeding. In parallel, when placed early in the course of ascites occurrence, TIPS procedure has been recently shown to improve transplant-free survival [3,4]. Consequently, these approaches significantly enlarged the population eligible for TIPS placement.

Besides its classical contraindication (recurrent HE, severe liver insufficiency, pulmonary arterial hypertension and/or cardiac failure), some anatomical/technical issues can prevent TIPS insertion. This is particularly observed in patients demonstrating hepatic venous abnormalities, intra- or extrahepatic portal obstruction or again distorted postsurgical anatomy [5]. The frequency of patients with cirrhosis eligible for TIPS presenting such anatomical/technical issues hasn't been prospectively evaluated. However, according to available data, this population could represent up to 5 to 10% of patients eligible to TIPS placement [6−9]. In these patients, the only non-surgical approach aiming to decrease the portal pressure gradient (PPG) is represented by the creation of a direct intrahepatic portocaval shunt (DIPS) or a TIPS from transcaval approach (transjugular transcaval intrahepatic portosystemic shunt - TTIPS). At the end of these procedures, a stent linking the portal circulation to the vena cava is in place. These procedures have been mainly and successfully reported in patients with Budd-Chiari syndrome (BCS) [9,10]. The broadening of indication for conventional TIPS insertion in cirrhosis and the frequency of anatomical/technical issues preventing its placement suggests that there is a need for greater attention to the DIPS and TTIPS techniques. We, therefore, aimed, in the present review, to discuss the 2 procedures, their advantages and limitations in the cirrhotic population under the light of our recent experience [11].

Techniques

Rosch and col. first proposed the TTIPS technique as an alternative to surgical portosystemic shunt in dogs and human cadavers. In their study, they accomplished portocaval shunt through a transjugular route with the use of a modified Ross needle-catheter system from IVC to PV through fluoroscopy guidance only [12]. It is only 20 years later, that Haskal and col [13] and Soares and col [14] have reported the first clinical cases of successful fluoroscopy-guided DIPS and TTIPS respectively in patients with failure of conventional TIPS insertion of recanalisation.

Petersen and col. first reported in 2001 the TTIPS technique in five patients as an alternative to conventional TIPS to evaluate whether this new technique could offer a decreased risk of stenosis as compared to conventional TIPS [15]. Indeed, conventional TIPS were performed with bare stents at this time, favouring bile leaks, tissue ingrowth and subsequent stenosis. In the TTIPS technique described by Petersen and col. they used a custom-made PTFE-covered stent to overcome this issue. The second main cause of stenosis in conventional TIPS was (and still is) the site of the hepatic vein itself that is entirely shunted in TTIPS and DIPS procedures. Petersen and col. created a side-to-side portocaval shunt using the caudate lobe as a parenchymal tract with the use of intravascular ultrasound to guide portal vein access through the inferior vena cava [16,17]. This technique requires double venous access - femoral and transjugular - to place in the inferior vena cava (IVC) the intravascular US and the liver access set respectively. From the IVC, the intravascular US is used to guide the puncture of the portal vein (PV) near the bifurcation through the caudate lobe. After the successful puncture, the custom-made PTFE-covered stents were deployed and initially dilated to 8 mm. When necessary, secondary dilatations to 9 and 10 mm were performed to obtain a less than 15 mmHg portocaval pressure gradient. After their first experience, a series of 40 patients with severe pH were treated successfully and published in 200,4[16]. A derivative of this technique has been described with a puncture from the IVC to PV under fluoroscopy and transabdominal US approach instead of intravascular US [18,19].

Also, intending to address the patency issues of the conventional TIPS in the early 2000s, Quinn and Col. proposed a DIPS procedure creating an IVC to PV shunt via a transabdominal percutaneous access [20]. The procedure consisted of a direct CT-guided percutaneous puncture of IVC through the PV avoiding the use of an intravascular US device. This technique required aligning a large portal branch to the IVC to allow stent placement in a proper angulation. A direct route was created through liver parenchyma to portal branch and then IVC. The transhepatic guidewire was then captured with a loop snare in the IVC and exteriorized via transjugular access. A needle was then advanced on this guidewire through IVC and PV and when the extremity of this catheter was in the PV lumen, a second guidewire was pushed in the PV to secure the access. A balloon was used to dilate the intrahepatic route to 8 mm. A PTFE-covered stent was finally placed and dilated to 10 mm. This technique was first reported in 1997 in 7 patients with complicated pH and the results were confirmed in 16 patients in 2002 [20,21]. This technique has also been described under transabdominal guidance [22].

Technical advantages of the DIPS and TTIPS procedures

Three main advantages of the DIPS and TTIPS procedures have been advocated since their first description. The first

one was the use of a PTFE-covered stent in the early 2000s' to decrease the high incidence of stenosis observed with non-covered conventional TIPS [2]. This argument is no longer valid with the advent of PTFE-covered stents in the conventional procedure. The second one is the benefit expected in terms of long-term patency related to the shunting of the hepatic veins (HVs) that still represent the main site of conventional TIPS stenosis to date. The third one is a shorter trans-parenchymal route from PV to IVC than from PV to HVs of the conventional TIPS. This allows accordingly to shorten the stenting and theoretically decrease the risk of stenosis [23].

Obstacles and issues related to the DIPS and TTIPS procedures

The first obstacle in the use of the DIPS and TTIPS techniques is the lack of experience in these procedures of most interventional radiology teams (even in tertiary centres). This lead to consider DIPS and TTIPS as more technically challenging procedures than conventional TIPS. A learning curve by the pioneers' teams has been described and prevents wider use of the technique. This is particularly the case on the intravascular US-guided technique requiring a rarely used and costly device [15,16]. The coaxial positioning of the intravascular US and the sheath of the portal access kit may also be challenging in patients with a very large inferior vena cava, with massive ascites or with prior liver transplantation. Moreover, the puncture of IVC could make physicians reluctant to DIPS and TTIPS techniques. However, in an applied anatomical study, Yu and col. reported that more than 70% of the retrohepatic IVC - of approximately 5.5 cm long - could be identified as a safe area while being connected to the liver capsule with a minor risk of blood effusion in the retroperitoneum from puncture at the time of tract creation [23].

Other technical issues must be acknowledged: the first one relies on the placement of the stents within the PV and the IVC. Indeed, placing the stent too far into the vessels induces a risk of occlusion by obstructing the lumen against the opposite wall [16]. On the other hand, there is a theoretical risk of narrowing due to tissue overgrowth through the uncovered part of the stents. To avoid these possibilities, Petersen and col. proposed to extend the covered stent at least 5 mm into the vascular structure without positioning it against the opposite wall. The second issue is the abrupt angle of nearly 90° of the stent in the DIPS technique creating a turbulent flow [21]. A less acute angulation and its consequences may be partially corrected with the TTIPS technique [16] and or the secondary placement of a guidewire from the IVC through the PV and the deployment of uncovered stent to optimize angulation in the DIPS technique. The last issue is the potential interference on liver transplantation procedure that may preclude the use of piggyback technique [5,20]. A schematic illustration of DIPS or TTIPS stent placement is provided in Fig. 1a. Finally, as compared to the conventional TIPS, the US follow-up of the patency may be difficult due to the deep placement of the shunt resulting in more frequent CT-scan, venography and manometry to assess shunt occlusion or dysfunction.

DIPS and TTIPS in patients with Budd-Chiari syndrome (BCS)

When indicated, conventional TIPS placement is successful in a large majority of the case in BCS [8]. However, in BCS the occlusion of hepatic veins is a regular obstacle to stent placement, of which the exact frequency is unknown, as physicians have rapidly implemented DIPS and TTIPS creation as an alternative to conventional TIPS [9,24]. The usual caudate lobe overgrowth in BCS makes it a theoretically ideal condition to perform shunt placement through this route (even if it could be a technical obstacle due to the compression on IVC). However, despite a large acceptance of the procedure, only a few dedicated studies reporting the post DIPS or TTIPS outcome are available in BCS. In a recent

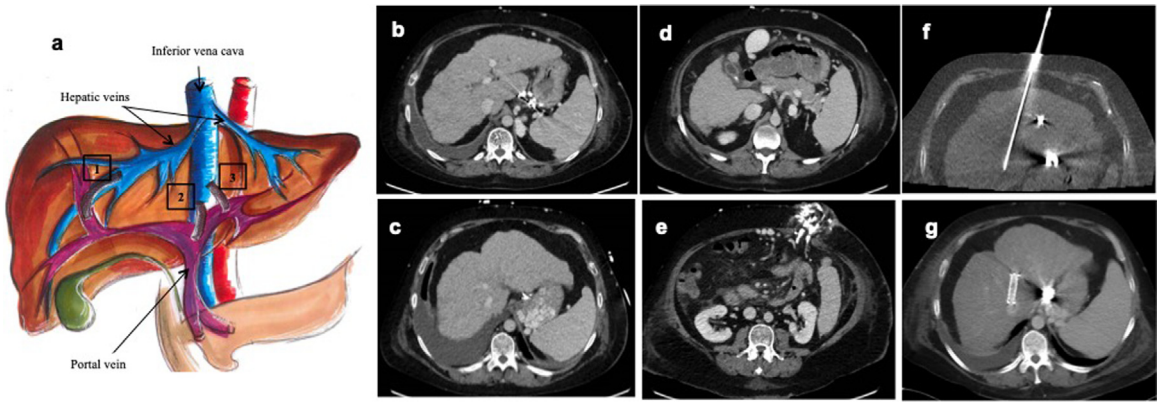

Fig. 1 a) schematic illustration of 1. usual position of transjugular intrahepatic portosystemic shunt 2. usual position of DIPS (direct intrahepatic portocaval shunt) or TTIPS (transjugular transcaval intrahepatic portosystemic shunt) inserted via intravascular route 3. usual position of DIPS inserted via the percutaneous route (illustration by V.Rykart - see acknowledgement). Computed tomographic image (CT) before DIPS procedure in a patient showing b) severe portal hypertension with large gastric varices and dysmorphic liver with left lobe hypertrophy c) right portal vein thrombosis and embolization stigmata of the gastric varices d) pseudoaneurysmal dilatation of umbilical repermeabilized vein e) embolization stigmata of peristomal varices f) image of native CT with Chiba needle in place during DIPS procedure g) computed tomographic image showing the patency of the stent 1 month after DIPS procedure.

retrospective study, 44 patients with BCS underwent DIPS creation with a 5-year actuarial survival of 91% with only 7% stent occlusion during follow-up. 1 patient developed a post-procedural acute-on-chronic liver failure and 4 patients developed HE. Interestingly authors observed a dramatic decrease in liver stiffness assessed by transient elastography in these patients after the procedure (from 68 kPa to 23 kPa) [18].

Eligibility, feasibility, patency rates and complications related to the DIPS and TTIPS procedures

The successful placement of conventional TIPS is obtained in around 90−95% of patients without BCS [5−7]. As a consequence, and as illustrated in the Ward and col. study, 5−10% of patients could be eligible patients to the DIPS or TTIPS techniques as an alternative to conventional TIPS due to unfavourable anatomy. To our knowledge, and despite the first description of these techniques more than 20 years ago, only 107 patients have been reported in the literature so far (Table 1) [5,11,13,14,16,20,21,25−28]

In these retrospective cohort studies, case series and case reports, a highly successful procedure rate was reported (81% to 100%). Main indications for DIPS and TTIPS placement were severe pH complications (ascites and gastrointestinal (GI) bleeding) in cirrhotic patients. Twenty-four DIPS/TTIPS were created in patients with failure of conventional TIPS creation/recanalisation (N = 11) or with prohibitive anatomy for conventional TIPS (N = 13). In the remaining patients (N = 83), DIPS or TTIPS procedures were performed as an alternative to conventional TIPS with the initial aim to improve medium and long-term patency of the shunt in the early 2000s'. A significant drop in the portosystemic gradient of 13 mmHg (62%) (Table 1) was observed after DIPS or TTIPS placement after placement of 1 to 3 stents with a total stenting tract of 4 to 10 cm. Of note, all but one patient obtained a post-procedural gradient $\leq$ 12 mmHg. When provided, the procedure was reported to last from 1 to 4 h.

Primary and secondary patency at one year ranged between 66% to 100% with a majority of PTFE-stent used to cover the intra-parenchymal route (Table 1). Amongst main complications, 5 hemoperitoneum occurred and were treated successfully conservatively due to extrahepatic portal vein puncture and/or malposition of stents and 3 patients developed acute-on-chronic liver failure with fatal issue (Table 1). A portal vein laceration occurred in 1 patient treated successfully with balloon tamponade and covered stent placement. Acute-on-chronic liver failure with subsequent death occurred in 8% of the patients (Table 1). A worsening or occurrence of HE was reported in 30% of patients. The development of heart failure and/or pulmonary hypertension was not reported.

For comparison purposes, the PPG decrease recommended during conventional TIPS insertion ($\leq$ 12 mmHg − and $\geq$ 20% in patients with variceal bleeding [29]) was obtained in 99% of patients with a mean percentage of decrease as high as 62%, a much higher decrease than the one − around 40% - observed in conventional TIPS placement [30,31]. Of note, in the covered conventional TIPS era, patency rates are around 80% at 1-year [32,33] and newly developed or occurrence is reported in both indication of refractory ascites and acute GI bleeding from 18% to up to 60% [34]. Acute liver dysfunction is nowadays rarely reported in the setting of conventional TIPS insertion particularly with the help of identification of liver-related variables associated with this event [2] and is as low as 6% of patients in a large recent monocentric retrospective study [35].

Results of the DIPS and TTIPS procedures according to indication

Ascites

Fifty-nine out of the 107 patients who underwent DIPS or TTIPS creation underwent the procedure in the context of refractory ascites. In these patients, authors reported an initial better-controlled ascites in 41 cases (69%) after the procedure. Amongst these, 5 patients experienced a recurrence of ascites during follow-up, 4 underwent revision with 2 successful procedures allowing to control the decompensation. Control of ascites was finally reported in 38 patients (64%). However, only a few clinical data are available in these series regarding the follow-up, compliance to treatment and control of the liver disease's aetiology precluding to draw any firm conclusion in this indication. For comparison purposes and according to the 7 RCTs that have been published so far, conventional TIPS offers a 30 to 60% of ascites control at 1-year [4,36−40]

Acute GL bleeding

Forty-five out of the 107 patients who underwent DIPS or TTIPS creation underwent the procedure in the context of acute GI bleeding. During follow-up, only 3 patients (8%) experienced bleeding recurrence and were attributed to stent occlusion. Interestingly, 18 out of the 39 DIPS/TTIPS were indicated for uncontrolled bleeding or early placement after variceal haemorrhage. Amongst these patients, only 1 experienced bleeding recurrence (6%). For comparison purposes, in the setting of salvage or preemptive/early insertion, the risk of 1-year rebleeding following conventional TIPS placement is below 15% [3,41−45].

Overall considerations

Many major improvements have been made in the last 25 years in the conventional TIPS approach broadening its indication in parallel to safer use. The larger steps forward consisted in the use of PTFE-covered stent, the optimal timeframe of placement allowing to improve survival in selected populations (particularly in variceal bleeding and recurrent ascites) as well as the identification of relative and absolute contraindications. Considering these points and the few data available in TTIPS and DIPS techniques, we strongly feel that these last should only be considered to date as an alternative to conventional TIPS in case of failed attempts and/or unfavourable anatomy in patients with cirrhosis and severe pH and without BCS.

Table 1 a table gathering all case report, case series, cohort of patients without Budd-Chiari syndrome who underwent DIPS (direct intrahepatic portocaval shunt) or TTIPS (transjugular transcaval intrahepatic portosystemic shunt) creation to treat severe portal hypertension.

Authors and year	Technique	Sample size	Liver disease	Child-Pugh scoreA/B/C	Indication for DIPS/ TTIPS	Successfull procedure	Stents	Decrease in porto-caval gradient	Follow-up (mean)	Patency	Complications	New or worsened	New or worsened	New or worsened
Haskal et al., 1996	Percutaneous Fluoroscopy	1	Cirrhosis 100%	0/0/1	Ascites	1/1 100%	Uncovered	13 mmHg (50%)	2 months	Primary patency rate = 100%	None	0/1 (0%)	1/1 (100%)	Succesfull LT 2 month later
Soares et al., 1999	Intravascular Fluoroscopy	2	Cirrhosis 100%	0/2/0	GI bleeding (*N* = 2)	2/2 100%	Uncovered	15.5 mmHg (58%)	9 months	Primary patency rate during follow-up = 50%	Femoral vein thrombosis	1/2 (50%)	2/2 (100%)	Death at 9 weeks and 15 months non attributed to the procedure
Quinn et al., 1997	Percutaneous CT-guided	7	Cirrhosis 100%	N/A	GI bleeding (*N* = 6) HRS (*N* = 1)	7/7 100%	Covered	12 mmHg (75%)	5 months	N/A	None	N/A	6/7 (86%)	1 death non attributed to the procedure
Quinn et al., 2002	Percutaneous CT-guided	16	Cirrhosis 100%	0/2/14	Ascites (*N* = 4) GI bleeding (*N* = 11) HRS (*N* = 1)	13/16 81%	Covered	10.4 mmHg (67%)	12 months	Primary patency rate = 60% at 1-year Secondary patency = 65% at 1 year	1 extrahepatic PV puncture with haemo-peritoneum 2 malpositionned stent requiring addi-tional stenting	6/13 (46%)	13/16 (81%)	1 death secondary to acute liver failure and 5 others non attributed to the procedure
Aytekin et al., 2003	Percutaneous US-guided	4	Cirrhosis 75% Congeni-tal hepatic fibrosis 25%	0/3/1	Ascites (*N* = 2) GI bleeding (*N* = 2)	4/4 100%	Covered	13.8 mmHg (61%)	12 months	Primary patency rate = 75% during follow-up	1 early DIPS thrombo-sis treated success-fully with local thrombolysis and anti-coagulant therapy	1/4 (25%)	3/4 (75%)	No death 1 LT in the patient with recurrent GI bleeding due to occlusion of the stent
Petersen et al., 2004	Intravascular US guided	40	Cirrhosis 100%	1/26/13	Ascites (*N* = 35) GI bleeding (*N* = 5)	40/40 100%	Covered	14 mmHg (61%)	12 months	Primary patency rate = 75% at 1-year Secondary patency = 100% at 1 year	2 extrahepatic PV puncture with haemoperitoneum	10/40 (25%)	30/40 (75%)	3 deaths related to acute liver failure and 16 deaths non attributed to the pro-cedure 3 LT
Hoppe et al., 2008	Intravascular US guided	19	Cirrhosis 100%	2/7/10	Ascites (*N* = 16) GI bleeding (*N* = 3)	19/19 100%	Covered	15 mmHg (65%)	9 months	Primary patency rate during follow-up = 100%	1 haemoperitoneum due to initial stent malpositioning requir-ing additional stenting	8/19 (42%)	12/16 (75%)	4 deaths related to acute liver failure And 4 non attributed to the procedure 1 LT
Ward et al., 2015	Intravascular US guided	13	Cirrhosis 100%	1/8/4	GI bleeding (*N* = 13)	13/13 100%	Covered	8.3 mmHg (59%)	9 months	Primary patency rate = 75% at 1-year Secondary patency = 100% at 1 year	1 portal vein wall lac-eration treated suc-cessfully with balloon tamponade and stents placement 1 early TTIPS throm-bosis with recanaliza-tion failure requiring creation of a parallel TTIPS	4/13 (31%)	12/13 (92%)	2 deaths non attributed to the procedure 1 LT
Kawahara et al., 2017	Intravascular US guided	1	Cirrhosis 100%	0/0/1	Ascites	1/1 100%	Covered	N/A	N/A	N/A	None	0/1 (0%)	1/1 (100%)	No death
Leung et al., 2020	Percutaneous US guided	1	Cirrhosis 100%	0/1/0	GI bleeding	1/1 100%	Covered	N/A	N/A	N/A	None	N/A	1/1 (100%)	No death
Moschouri et al., 2021	Percutaneous CT-guided	3	Cirrhosis 67% Presinu-soidal por-tal hyper-tension 33%	1/1/1	GI bleeding (*N* = 2) Severe endoscopic portal hyperten-sion (*N* = 1)	3/3 100%	Covered	11.6 mmHg (66%)	12 months	Primary patency rate during follow-up = 66% Secondary patency rate during follow-up= 100%	1 early DIPS thrombo-sis with recanalization after anticoagulant therapy	0/3 (0%)	3/3 (100%)	No death

CTcomputed tomography, DIPS direct intrahepatic portocaval shunt, HRS hepatorenal syndrome, GI gastrointestinal, PV portal vein, TTIPS transjugular transcaval intrahepatic portosystemic shunt, US ultrasonography.

Indeed, even if the data presented in this review suggest that DIPS and TTIPS could be safe and efficient alternatives to conventional TIPS there remain several uncertainties of the consequences of these procedures in the short and long term. In this line, in the available data, the lack of predefined assessment focused on the expected complications of portosystemic shunting that are observed after conventional TIPS placement (i.e. HE, liver failure, cardiac failure) together with the variable follow-up prevent us to define specific contraindication related to DIPS or TTIPS procedures.

Interestingly, the reported range of decrease of PPG after DIPS/TTIPS procedure eventually suggests that the impact on splanchnic hemodynamic (and consequently liver perfusion) could be more important than after conventional TIPS. Consequently, we would cautiously suggest the placement of an under dilated stent as soon as the target decrease in PPG is obtained.

This review highlights the potential benefit of the procedure particularly in patients with acute and refractory GI bleeding related to severe pH that was the indication in patients we recently reported [11]. In our tertiary centre, we had never performed a DIPS or TTIPS until 2020 in the setting of cirrhosis or BCS. We have chosen the CT-guided percutaneous approach for our three patients. The first DIPS was placed due to right PV thrombosis, left lobe hypertrophy in an urgent condition of refractory peristomal bleeding despite variceal embolization (Figure 1). The procedure was successful without any per-procedural issues or DIPS dysfunction during follow-up. The procedure only lasted 90 min. In the same week, a patient with severe GI bleeding and failure to preemptive conventional TIPS underwent a second DIPS that lasted 120 min with the same success and the absence of DIPS dysfunction until now. The third patient underwent DIPS for persistent threatening varices (despite conventional endoscopic treatment and B-blockers) and after two failed attempts of conventional TIPS placement and one recanalisation failure. The procedure was more complex in this patient and lasted 150 min however without per-procedural events. Early stent thrombosis was successfully treated with anticoagulant therapy without revision of the stents. The endoscopic grade III high-risk oesophagal varices regressed to grade I-II without red wall marks with a 3-months follow-up.

In our opinion, a few main obstacles stand in the way of DIPS and TTIPS techniques. Amongst them, the unawareness of hepatologists and interventional radiologists on DIPS or TTIPS techniques in cirrhotic patients whereas has been particularly reported as a lifesaving procedure in refractory GI bleeding [5,28]. One of the purposes of this review is to divulge the possibility of using these approaches and to reassure novice teams on the expected learning curve considering the high success rate of the procedure even in inexperienced centres. Another obstacle could be the reluctance to create a trans-IVC route. However, and as discussed earlier the use of covered stent, the CT-guided procedure and the length of the safe area of retrohepatic IVC for puncture should reassure physicians of these approaches. Finally, the impact on liver transplant surgery itself has been questioned. As shown in table 1, at least 7 patients successfully underwent LT without complications. However, as these procedures could interfere with the surgery in case of low positioning of the stent in the IVC - which is not expected as it should be in the intrahepatic IVC segment — the surgeon transplant team should be systematically consulted before any DIPS or TTIPS procedure. These procedures indeed don't impede LT but probably force to plan a classical approach with cava's recipient resection and a venovenous bypass.

Conclusion

A DIPS or TTIPS corresponds to the creation of a portocaval shunt from a percutaneous (from PV to IVC) or transvenous (from IVC to PV) approach respectively. These procedures, which are often performed in patients with Budd-Chiari syndrome, appear also to be safe and potential lifesaving alternatives in patients with cirrhosis and pH and particularly in the setting of acute GI bleeding in case of unfavourable anatomy for conventional TIPS. The few available data prevent to extent our conclusion on indication or contraindication specific to these procedures. In an era marked by the broadening indication of conventional TIPS, it is worthwhile ensuring hepatologists and interventional radiologists are aware of these techniques to propose them in selected patients when conventional TIPS appears not feasible.

Financial support

None

Disclosures

None of the contributing authors has disclosures related to this work

Writing assistance

None

Authors' contributions

Design of the study: EM, AD, FA; Acquisition of data: EM, AH, MV, AD, FA; Statistical analysis: N/A; Drafting of the manuscript and critical review: EM, AH, MV, AD, FA

Acknowledgements

We deeply thank Mrs Virginie Rykart (RYK'ART - +41 79 675 94 80) for the illustration in Figure 1.

References

[1] D'Amico G, Garcia-Tsao G, Pagliaro L. Natural history and prognostic indicators of survival in cirrhosis: a systematic review of 118 studies. J Hepatol 2006;44:217–31.
[2] Rössle M. TIPS: 25 years later. J Hepatol 2013;59:1081–93.

[3] García-Pagán JC, Caca K, Bureau C, et al. Early use of TIPS in patients with cirrhosis and variceal bleeding. N Engl J Med 2010;362:2370–9.
[4] Bureau C, Thabut D, Oberti F, et al. Transjugular intrahepatic portosystemic shunts with covered stents increase transplant-free survival of patients with cirrhosis and recurrent ascites. Gastroenterology 2017;152:157–63.
[5] Ward TJ, Techasith T, Louie JD, Hwang GL, Hofmann LV, Sze DY. Emergent salvage direct intrahepatic portocaval shunt procedure for acute variceal hemorrhage. J Vasc Interv Radiol 2015;26:829–34.
[6] Rössle M, Haag K, Ochs A, et al. The transjugular intrahepatic portosystemic stent-shunt procedure for variceal bleeding. N Engl J Med 1994;330:165–71.
[7] Jalan R, Elton RA, Redhead DN, Finlayson ND, Hayes PC. Analysis of prognostic variables in the prediction of mortality, shunt failure, variceal rebleeding and encephalopathy following the transjugular intrahepatic portosystemic stent-shunt for variceal haemorrhage. J Hepatol 1995;23:123–8.
[8] Sterling KM, Darcy MD. Stenosis of transjugular intrahepatic portosystemic shunts: presentation and management. AJR Am J Roentgenol 1997;168:239–44.
[9] Garcia-Pagán JC, Heydtmann M, Raffa S, et al. TIPS for Budd-Chiari syndrome: long-term results and prognostics factors in 124 patients. Gastroenterology 2008;135:808–15.
[10] Luo X, Leanza J, Massie AB, et al. MELD as a metric for survival benefit of liver transplantation. Am J Transplant 2018;18:1231–7.
[11] Moschouri E, Hocquelet A, Vermersch M, Fraga M, Denys A, Artru F. DIPS, a safe and effective alternative in patients with unfavorable anatomy to TIPSS: first experience in a tertiary center. Clin Res Hepatol Gastroenterol 2021;45:101715.
[12] Rösch J, Hanafee W, Snow H, Barenfus M, Gray R. Transjugular intrahepatic portacaval shunt. An experimental work. Am J Surg 1971;121:588–92.
[13] Haskal ZJ, Duszak R, Furth EE. Transjugular intrahepatic transcaval portosystemic shunt: the gun-sight approach. J Vasc Interv Radiol 1996;7:139–42.
[14] Soares GM, Murphy TP. Transcaval TIPS: indications and anatomic considerations. J Vasc Interv Radiol 1999;10:1233–8.
[15] Petersen B, Uchida BT, Timmermans H, Keller FS, Rosch J. Intravascular US-guided direct intrahepatic portacaval shunt with a PTFE-covered stent-graft: feasibility study in swine and initial clinical results. J Vasc Interv Radiol 2001;12:475–86.
[16] Petersen B, Binkert C. Intravascular ultrasound-guided direct intrahepatic portacaval shunt: midterm follow-up. J Vasc Interv Radiol 2004;15:927–38.
[17] Petersen BD, Clark TWI. Direct intrahepatic portocaval shunt. Tech Vasc Interv Radiol 2008;11:230–4.
[18] Mukund A, Mittal K, Mondal A, Sarin SK. Anatomic Recanalization of Hepatic Vein and Inferior Vena Cava versus Direct Intrahepatic Portosystemic Shunt Creation in Budd-Chiari Syndrome: overall Outcome and Midterm Transplant-Free Survival. J Vasc Interv Radiol 2018;29:790–9.
[19] Patidar Y, Pal CK, Mukund A, Kumar G, Sarin SK. Retrospective comparative study of efficacy, safety and outcome of percutaneous intervention for Budd-Chiari syndrome patients with bilirubin less than 3 and 3-6mg/dl. Br J Radiol 2021;94:20201157.
[20] Quinn SF, Sheley RC, Semonsen KG. Creation of a portal vein to inferior vena cava shunt using CT guidance and a covered endovascular stent. AJR Am J Roentgenol 1997;169:1159–60.
[21] Quinn SF, Kim J, Sheley RC. Percutaneous inferior vena cava-to-portal vein shunt (PIPS) using a stent-graft: preliminary results. J Endovasc Ther 2002;9:503–10.
[22] Boyvat F, Aytekin C, Harman A, Ozin Y. Transjugular intrahepatic portosystemic shunt creation in Budd-Chiari syndrome: percutaneous ultrasound-guided direct simultaneous puncture of the portal vein and vena cava. Cardiovasc Intervent Radiol 2006;29:857–61.
[23] Yu S, Chu G, Yang J, He L, Wang H. Direct intrahepatic portocaval shunt through transhepatic puncture via retrohepatic inferior vena cava: applied anatomical study. Surg Radiol Anat 2009;31:325–9.
[24] Qi X, Guo W, He C, et al. Transjugular intrahepatic portosystemic shunt for Budd-Chiari syndrome: techniques, indications and results on 51 Chinese patients from a single centre. Liver Int 2014;34:1164–75.
[25] Aytekin C, Boyvat F, Firat A, Coşkun M, Boyacioğlu S. Portacaval shunt creation using the percutaneous transhepatic-transjugular technique. Abdom Imaging 2003;28:287–92.
[26] Hoppe H, Wang SL, Petersen BD. Intravascular US-guided direct intrahepatic portocaval shunt with an expanded polytetrafluoroethylene-covered stent-graft. Radiology 2008;246:306–14.
[27] Kawahara Y, Tanaka Y, Isoi N, et al. Direct intrahepatic portocaval shunt for refractory hepatic hydrothorax: a case report. Acute Med Surg 2017;4:306–10.
[28] Leung KK, James PD, Jaberi A, Hirschfield GM. Esophageal stenting as bridge therapy to direct intrahepatic portocaval shunt for refractory variceal bleeding. Hepatology 2021;73:1618–20.
[29] Tripathi D, Stanley AJ, Hayes PC, et al. Transjugular intrahepatic portosystemic stent-shunt in the management of portal hypertension. Gut 2020;69:1173–92.
[30] Schepis F, Vizzutti F, Garcia-Tsao G, et al. Under-dilated TIPS associate with efficacy and reduced encephalopathy in a prospective, non-randomized study of patients with cirrhosis. Clin Gastroenterol Hepatol 2018;16:1153–1162.e7.
[31] Trebicka J, Bastgen D, Byrtus J, et al. Smaller-diameter covered transjugular intrahepatic portosystemic shunt stents are associated with increased survival. Clin Gastroenterol Hepatol 2019;17:2793–2799.e1.
[32] Tan HK, James PD, Sniderman KW, Wong F. Long-term clinical outcome of patients with cirrhosis and refractory ascites treated with transjugular intrahepatic portosystemic shunt insertion. J Gastroenterol Hepatol 2015;30:389–95.
[33] Bercu ZL, Fischman AM, Kim E, et al. TIPS for refractory ascites: a 6-year single-center experience with expanded polytetrafluoroethylene-covered stent-grafts. AJR Am J Roentgenol 2015;204:654–61.
[34] Hung ML, Lee EW. Role of transjugular intrahepatic portosystemic shunt in the management of portal hypertension: review and update of the literature. Clin Liver Dis 2019;23:737–54.
[35] De Keyzer B, Nevens F, Laenen A, et al. Percutaneous shunt reduction for the management of TIPS-induced acute liver decompensation: a follow-up study. Ann Hepatol 2016;15:911–7.
[36] Lebrec D, Giuily N, Hadengue A, et al. Transjugular intrahepatic portosystemic shunts: comparison with paracentesis in patients with cirrhosis and refractory ascites: a randomized trial. French group of clinicians and a group of biologists. J Hepatol 1996;25:135–44.
[37] Rössle M, Ochs A, Gülberg V, et al. A comparison of paracentesis and transjugular intrahepatic portosystemic shunting in patients with ascites. N Engl J Med 2000;342:1701–7.
[38] Ginès P, Uriz J, Calahorra B, et al. Transjugular intrahepatic portosystemic shunting versus paracentesis plus albumin for refractory ascites in cirrhosis. Gastroenterology 2002;123:1839–47.
[39] Sanyal AJ, Genning C, Reddy KR, et al. The North American study for the treatment of refractory ascites. Gastroenterology 2003;124:634–41.
[40] Salerno F, Merli M, Riggio O, et al. Randomized controlled study of TIPS versus paracentesis plus albumin in cirrhosis with severe ascites. Hepatology 2004;40:629–35.
[41] Walter A, Rudler M, Olivas P, et al. Combination of model for end-stage liver disease and lactate predicts death in patients treated with salvage transjugular intrahepatic portosystemic

shunt for refractory variceal bleeding. Hepatology 2021;74:2085–101.
[42] Azoulay D, Castaing D, Majno P, et al. Salvage transjugular intrahepatic portosystemic shunt for uncontrolled variceal bleeding in patients with decompensated cirrhosis. J Hepatol 2001;35:590–7.
[43] Early-TIPSS placement prevents rebleeding in high-risk patients with variceal bleeding, without improving survival - PubMed. https://pubmed.ncbi.nlm.nih.gov/25230051/. Accessed October 25, 2021
[44] Hernández-Gea V, Procopet B, Giráldez Á, et al. Preemptive-TIPS improves outcome in high-risk variceal bleeding: an observational study. Hepatology 2019;69:282–93.
[45] Lv Y, Zuo L, Zhu X, et al. Identifying optimal candidates for early TIPS among patients with cirrhosis and acute variceal bleeding: a multicentre observational study. Gut 2019;68:1297–310.