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TECHNICAL NOTE

Pull-Through Technique for Recanalization of Occluded Portosystemic Shunts (TIPS): Technical Note and Review of the Literature

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Abstract Transjugular intrahepatic portosystemic shunt (TIPS) dysfunction is an important problem after creation of shunts. Most commonly, TIPS recanalization is performed via the jugular vein approach. Occasionally it is difficult to cross the occlusion. We describe a hybrid technique for TIPS revision via a direct transhepatic access combined with a transjugular approach. In two cases, bare metal stents or polytetrafluoroethylene (PTFE)-covered stent grafts had been placed in TIPS tract previously, and they were completely obstructed. The tracts were inaccessible via the jugular vein route alone. In each case, after fluoroscopy or computed tomography-guided transhepatic puncture of the stented segment of the TIPS, a wire was threaded through the shunt and snared into the right jugular vein. The TIPS was revised by balloon angioplasty and additional in-stent placement of PTFE-covered stent grafts. The patients were discharged without any complications. Doppler sonography 6 weeks after TIPS revision confirmed patency in the TIPS tract and the disappearance of ascites. We conclude that this technique is feasible and useful, even in patients with previous PTFE-covered stent graft placement.

Keywords Recanalization · Transjugular intrahepatic portosystemic shunt (TIPS) · Stenting/stent graft

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Introduction

Transjugular intrahepatic portosystemic shunt (TIPS) is an effective treatment to control the sequelae of portal hypertension [1]. However, shunt dysfunction is a common problem, arising in up to 50% of patients when bare metal stents are used [2]. It is less frequent in case polytetrafluoroethylene (PTFE)-covered stent graft were used [3], but may occur in 17% of patients treated with covered stents [4]. The standard shunt revision technique is angioplasty or additional stent placement via the jugular vein approach; however, the access to the shunt is sometimes difficult [5].

We describe our experience with two cases in which an occluded TIPS, inaccessible via the jugular vein route, was recanalized by transhepatic direct puncture of the TIPS tract combined with a transjugular pull-through technique.

Case 1

A 68-year-old woman had undergone TIPS in December 1998 to treat primary biliary cirrhosis complicated by

ruptured esophageal varices. Two overlapping bare metal stents (8 mm/65 mm and 10 mm/65 mm; Easy Wallstent; Boston Scientific, Natick, MA) had been placed in the TIPS tract from the right portal vein into the right hepatic vein. Subsequently the esophageal varices disappeared, and the patient remained asymptomatic for 11 years. In August 2009, endoscopy showed the recurrence of esophageal varices (grade 2). Doppler ultrasonography revealed complete occlusion of the TIPS tract and increasing ascites. The Child-Pugh score of this patient was 5 (Child A) at this time. We first attempted to access the shunt via the right internal jugular vein; however, catheter insertion into the proximal end of the shunt was impossible (Fig. 1A). To avoid a second TIPS procedure, recanalization of the occluded shunt via a transhepatic approach was considered. Under conventional fluoroscopy guidance, the stented TIPS tract was transhepatically punctured with an 18-cm-long 18G catheter needle (Cook, Bloomington, IL) via a right intercostal approach in the midaxillary line. Once direct TIPS tract puncture through the interspaces between the stent struts was successful, contrast medium was manually injected via the puncture needle to confirm proper needle position within the stent. Thereafter a 0.035-inch guide wire (Radiofocus; Terumo Europe, Leuven, Belgium) was inserted and successfully negotiated through the occlusion into the inferior vena cava followed by insertion of a 5F catheter (AC-1; Cook).

At this stage, a 10F sheath (Cook) was placed into the superior vena cava from the right internal jugular vein (Fig. 1B). A 30-mm snare (AndraMed, Reutlingen, Germany) was introduced via the jugular access to grasp the transhepatically placed guide wire in the right atrium (Fig. 1C) and to withdraw it through the transjugular sheath, leaving the distal end outside the patient. After reinforcement of the sheath by insertion of the inner coaxial 10F catheter, the sheath was advanced into the TIPS. (Fig. 1D). Once that sheath was lying safely within the proximal end of the stent, the catheter was exchanged for a second 0.035-inch hydrophilic guide wire (Radiofocus), which was then easily advanced into the main trunk of the portal vein. Then the pull-through guide wire was pulled back, leaving the tip of transhepatic catheter outside the TIPS tract. Injection of contrast medium showed intimal hyperplasia within the stent.

After sequential balloon dilatation of the entire TIPS tract with 6- and 8-mm balloon catheters (Fox Plus; Abbott Molecular, Des Plaines, IL), a 10 × 80-mm Viatorr stent graft (WL Gore, Flagstaff, AZ) was placed inside the bare metal stent, thereby extending the TIPS tract to the orifice of the right hepatic vein (Fig. 1E). Final pressure measurements showed gradients between the portal vein and vena cava of 24 mmHg with and 14 mmHg without balloon occlusion of the TIPS tract. Before the transhepatic catheter was withdrawn, a 3F catheter was inserted coaxially, and the puncture tract was embolized with a single 3-mm microcoil (Tornado; Cook) and 1 ml of a mixture of n-butyl-2-cyanoacrylate (Histoacryl; B Braum, Melsungen, Germany) and iodized oil (Lipiodol Ultra-Fluid; Guerbet, Roissy, France) at a 1:1 ratio. Polymerization within the catheter was avoided by filling it with glucose 50% before embolization. Four days later, the patient was discharged from the hospital without any complications. Doppler sonography 6 weeks after TIPS revision showed unimpaired patency of the TIPS tract and the disappearance of ascites.

Case 2

A 55-year-old man had undergone a TIPS procedure in August 2004 to treat alcoholic liver cirrhosis complicated by uncontrolled ascites and esophageal varices (Grade 2). An 8 × 70-mm Viatorr stent graft with a 50-mm PTFE-covered portion (WL Gore) had been placed in the TIPS tract. In 2007, complete TIPS tract obstruction was detected during routine ultrasound. Because the patient had recurrent esophageal varices (grade 2) but was otherwise asymptomatic, the patient was treated conservatively, and no interventional treatment was performed. In December 2009, he experienced severe abdominal distension due to ascites, and esophageal varices became more serious (grade 3). The Child-Pugh score of this patient was 7 (Child B) at this time. Consequently, it was decided to recanalize the TIPS.

At first, we attempted to access the shunt via the right internal jugular vein, which proved to be inaccessible via this approach (Fig. 2A). Thus, fluoroscopy-guided transhepatic puncture of the stent graft with a 30-cm-long 22G Chiba needle was tried, applying the same technique as described in patient 1. However, the cirrhotic liver was so rigid that the puncture needle could not be directed into to the stent graft lumen. Even though a fine needle was used, the patient bled from the puncture site, as demonstrated by computed tomography (CT). Bleeding subsided spontaneously without sequelae.

One week later, recanalization was attempted again. This time, the TIPS tract was punctured under CT–fluoroscopy guidance (Somatom Definition; Siemens, Erlangen, Germany) with a 19G coaxial needle (Sika-Med, Wiehl, Germany). An anterior access route was chosen to avoid passage of the ascites, which surrounded the right lobe of the liver (Fig. 2B). After the needle tip was placed in the stent graft lumen, a 0.035-inch hydrophilic guide wire (Radiofocus) was inserted and placed in the TIPS tract and deeply into the portal vein. The position of the guide wire was confirmed by use of a CT scout view. After fixation of

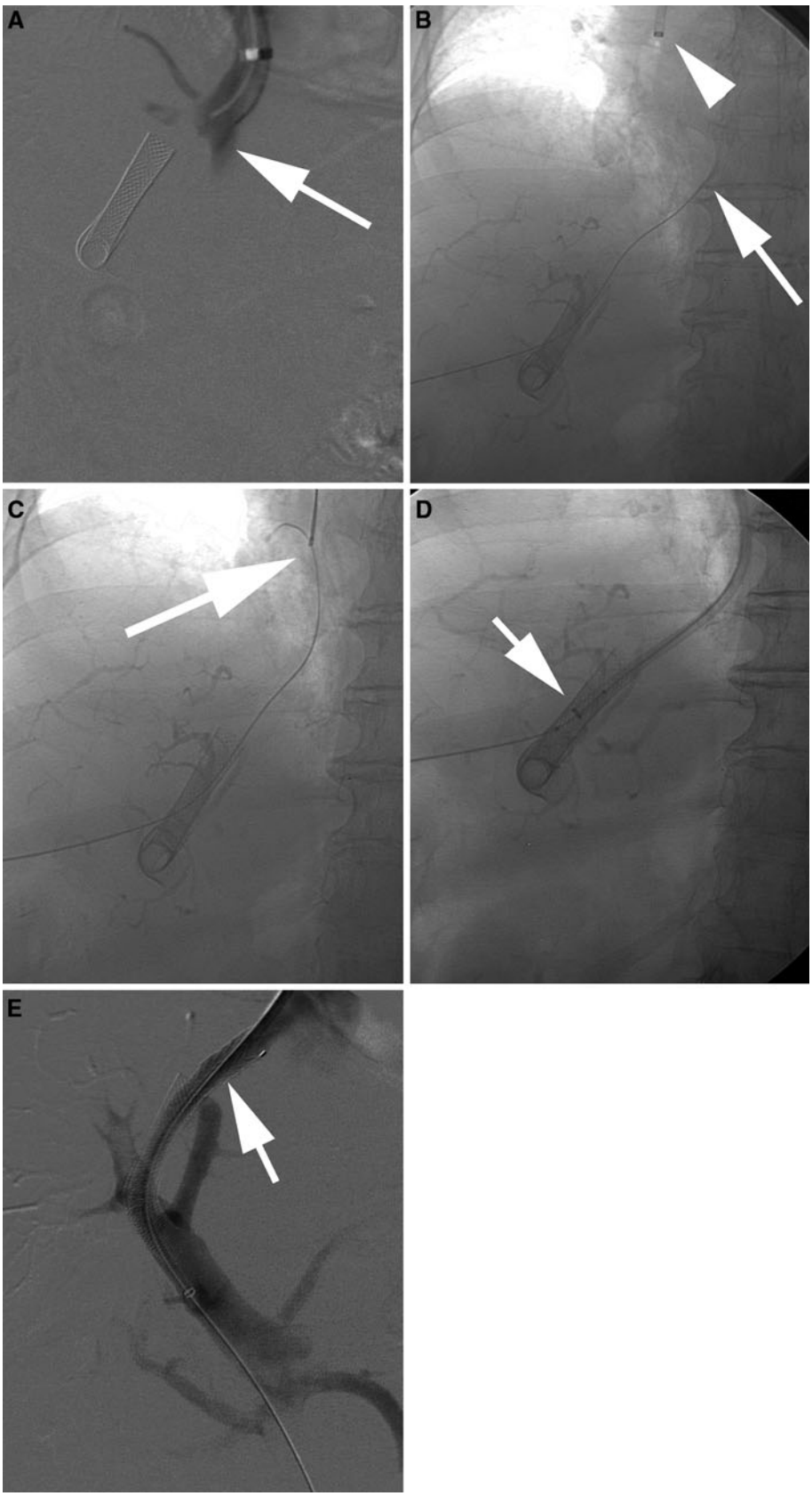

Fig. 1 **A** The transjugular intrahepatic portosystemic shunt (TIPS) tract was completely obstructed in the proximal portion of right hepatic vein (*arrow*) and inaccessible via the transjugular approach. **B** After transhepatic puncture of the TIPS with a 18G catheter needle, a 0.035-inch hydrophilic guide wire was inserted transhepatically and negotiated through the stenosis into the inferior vena cava (*arrow*). A 10F sheath was inserted from the right internal jugular vein (*arrowhead*). **C** A 30-mm gooseneck snare introduced via the jugular access grasped the guide wire (*arrow*). **D** A 10F sheath was advanced into the TIPS tract (*arrow*). **E** Placement of a polytetrafluoroethylene-covered stent graft inside the bare metal stents of the initial TIPS. The TIPS tract is thereby extended to the proximal portion of right hepatic vein (*arrow*)

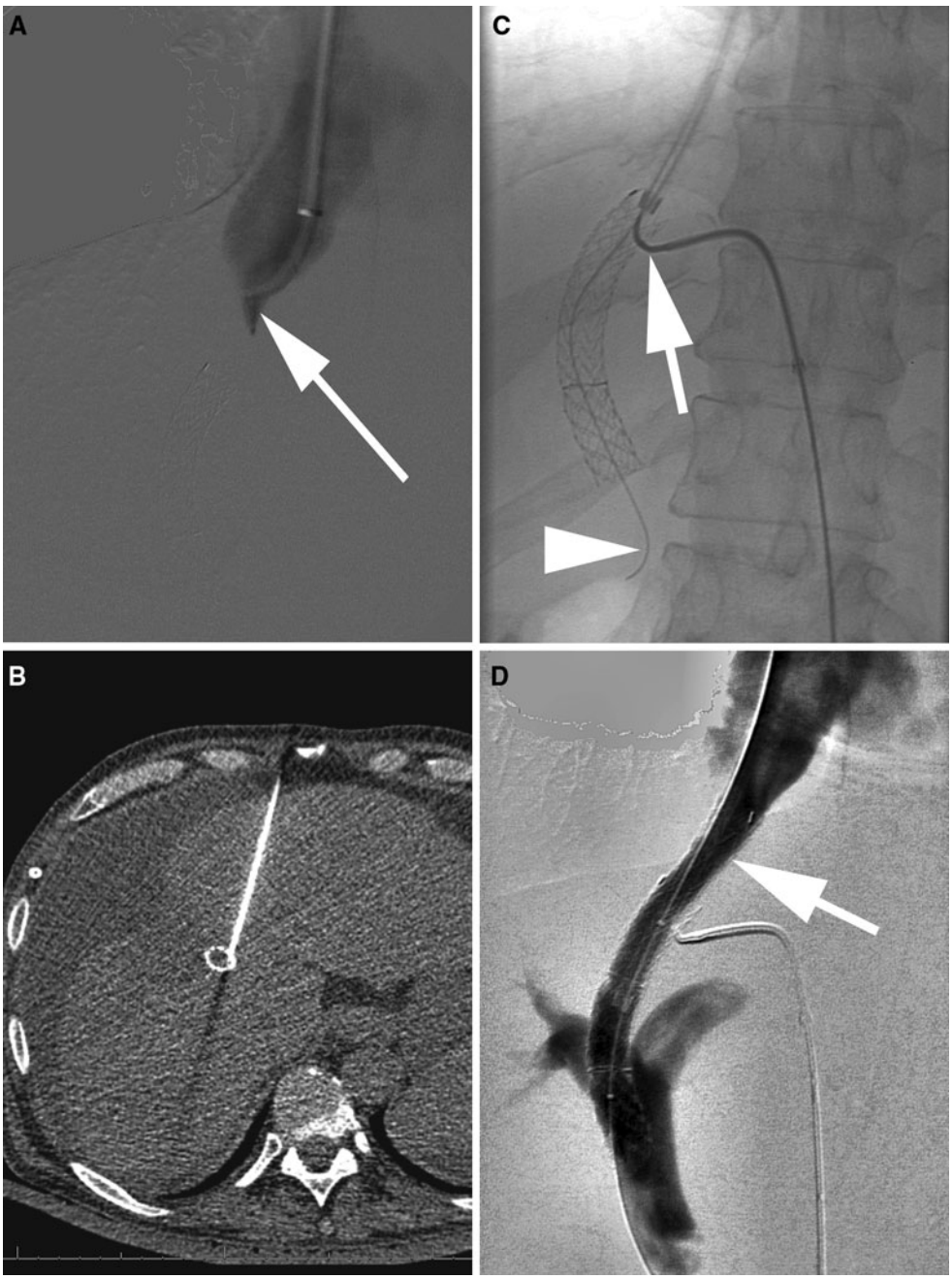

Fig. 2 **A** The transjugular intrahepatic portosystemic shunt (TIPS) tract was completely occluded in the proximal portion of right hepatic vein (*arrow*), preventing transjugular recanalization. **B** Computed tomography–fluoroscopy image obtained during the transhepatic puncture of the TIPS tract. An anterior access route was chosen to avoid passage through the ascites. **C** A 5F catheter was pushed through the polytetrafluoroethylene (PTFE)-covered stent graft (*arrow*). The guide wire inserted through the catheter was grasped with a gooseneck snare, and a 10F sheath was placed at the entrance of the TIPS tract. A 0.035-inch hydrophilic guide wire was advanced through the stenosis with its tip in the portal vein (*arrowhead*). **D** After placement of an additional PTFE-covered stent graft, the TIPS tract was extended proximally into the hepatic vein, thereby covering the entire shunt (*arrow*). Portography shows complete recanalization of the TIPS tract

the needle with sterile tape, the patient was transferred to the angiography suite and the following procedure was performed by using a similar technique as described in patient 1 (Fig. 2C). There were two difficulties. First, the membrane of the stent proved to be an obstacle for insertion the 5F catheter. Rotation of the catheter finally allowed advancement of the catheter into the TIPS tract. Second, because the tract had to be punctured far proximally, it was

difficult to direct the catheter to the proximal end of the occluded stent. This was finally accomplished by the use of a 5F van Schie 4 catheter (Cook). The occlusion was overcome after probing with a straight 0.035-inch spiral guide wire and finally with the aid of a 0.035-inch hydrophilic guide wire (Radiofocus).

Contrast injection during the procedure proved that only the unstented section of the hepatic vein was occluded as a result of tissue overgrowth, whereas the segment stented with the stent graft was patent. There was no significant thrombus within the Viatorr endoprosthesis, nor any thrombi in the distal bare end. Therefore, the proximal part of the TIPS tract was dilated with a 4-cm-long, 8-mm balloon (Fox Plus; Abbott) and extended into the hepatic vein by using a 10 × 50-mm Viatorr stent graft (WL Gore) (Fig. 2D). The portocaval gradients with and without balloon occlusion of the TIPS tract were 29 and 18 mmHg, respectively. Final portography showed complete unimpaired patency of the TIPS. Before removal of the transhepatic catheter, the puncture tract was also embolized with n-butyl-2-cyanoacrylate/lipiodol as described above. The next day, the patient was discharged with improvement of the abdominal distension. Doppler sonography and endoscopy 6 weeks after TIPS revision confirmed patency in the TIPS tract and the disappearance of ascites and esophageal varices.

Literature Review

All English-language literature describing secondary interventional procedures for treating TIPS stenosis and occlusion were searched in Medline database, and all relevant references cited in the identified articles were reviewed. Twenty-one articles, published from 1992 to 2008, including two review articles, were found (Table 1). The most commonly applied technique for treating TIPS stenosis and occlusion is recanalization via the jugular vein approach with a hydrophilic guide wire. Alternative therapeutic strategies are as follows: (1) transjugular access via a Colapinto needle (Cook) for extra support [5, 6]; (2) transjugular direct stent puncture via a Rosch-Uchida needle (Cook) [5]; (3) transhepatic stent puncture [5, 7]; (4) creation of new parallel shunt [8–12]; (5) creation of new shunt by the so-called gun sight approach [13]; (6) creation of a new shunt via direct cavoportal puncture [14]. In large-sample-size studies, the success of TIPS recanalization was reported in 56 (89%) of 63 patients [11], 30 (91%) of 33 patients [10], and 16 (89%) of 18 patients [9]. Techniques for completion of TIPS tract recanalization include thrombolysis [15], mechanical thrombectomy [16], balloon dilatation, self-expandable bare metal stent [2, 5, 9–11], balloon-expandable stent [17, 18], and PTFE-covered stent graft [12, 19–24]. Recently, several articles showed that

Table 1 Articles focused on secondary interventions for TIPS stenosis and occlusion

Study no.	Study	Year	Total no. of cases (no. of occlusions)	Procedures
1	Darcy [15]	1992	1 (1)	JV approach, thrombolysis
2	Haskal [8]	1992	2 (0)	Parallel TIPS
3	Goldon [6]	1993	11 (11)	JV approach via Colapinto needle
4	Hausegger [9]	1994	24 (8)	JV approach, PTA/stent; parallel TIPS
5	Haskal [7]	1994	4 (0)	Transhepatic approach
6	Schmitz-Rode [16]	1994	1 (1)	JV approach, mechanical thrombectomy
7	Haskal [2]	1994	36 (0)	JV approach, PTA/stent
8	Haskal [13]	1996	1 (0)	New TIPS by gun sight approach
9	Cope [17]	1996	1 (0)	JV approach, balloon-expandable stent
10	Sterling [10]	1997	48 (8)	JV approach, PTA/stent; parallel TIPS
11	Saxon [19]	1997	6 (–[a])	JV approach, PTA/stent graft
12	Ferral [5]	1998	–[b]	Direct puncture trans-JV, Colapinto needle, and transhepatic approach
13	Saxon [11]	1998	63 (28)	JV approach, PTA/stent; parallel TIPS
14	Haskal [20]	1999	7 (–[a])	JV approach, PTA/stent graft
15	Sze [21]	1999	5 (3)	JV approach, PTA/stent graft
16	Seong [14]	2001	4 (4)	New TIPS by transcaval approach
17	Cejna [22]	2002	16 (–[a])	JV approach, PTA/stent graft
18	Kuhlman [18]	2002	10 (0)	JV approach, balloon-expandable stent
19	Haskal [23]	2002	3 (3)	JV approach, PTA/stent graft
20	Rossi [24]	2004	9 (1)	JV approach, PTA/stent graft
21	Cura [12]	2008	–[b]	JV approach, stent graft; parallel TIPS

TIPS transjugular intrahepatic portosystemic shunt, *JV* jugular vein, *PTA* balloon angioplasty

[a] Did not distinguish between stenosis and occlusion

[b] Review article (no number of cases)

PTFE-covered stent grafts demonstrate excellent uninterrupted patency after TIPS revision.

Discussion

Shunt dysfunction after TIPS creation is a well-known complication, the result of thrombosis or intimal hyperplasia within the stent or at the nonstented portion of the hepatic vein [12]. The latter seemed to be the primary cause of obstruction in both of our patients. When bare metal stents were used, shunt dysfunction may occur in more than 50% of patients [2]. With currently available PTFE-covered stent grafts, the rate of hemodynamically significant in-stent stenosis or stent occlusion within the first year after treatment dropped to 11% and 6%, respectively [4]. The Wallstent (bare metal stent) in the first patient was patent for remarkably long time. Despite the improved shunt patency, with PTFE-covered stent grafts, shunt dysfunction remains a major issue in TIPS treatment.

In the case of TIPS dysfunction, shunt recanalization is preferred to the creation of a new TIPS tract. Recanalization is usually attempted via the transjugular, or less commonly via the transfemoral, venous approach. However, it is occasionally difficult to cross the occlusion with a purely endovascular approach because of the location of the stent and angulation in relation to the hepatic vein [5]. In 1994, Haskal and Cope first described a transhepatic approach for TIPS revision, in which a 22G needle advanced percutaneously through the liver into the lumen of the stent [7]. This technique is quick and simple to perform under conventional fluoroscopy; the stent provides a good radiopaque and tactile intrahepatic target. Therefore, in patient 1, a technique modified according to Haskal and Cope was successfully applied by means of conventional fluoroscopic guidance.

Fluoroscopically guided transhepatic puncture, however, may be both difficult and risky because of ascites and tissue induration due to liver cirrhosis. Ultrasound guidance may be helpful in principle, but CT is certainly the most accurate technique under these circumstances. CT was chosen for puncture because it provides excellent information on the spatial relationship between the target and its adjacent organs and vessels. In addition, CT-fluoroscopy helps to reduce the number of unsuccessful punctures because of its 3-D imaging at a high spatial resolution. A ventral access route was chosen to avoid passage of the ascites and because of the shorter distance from the cutaneous entry point to the stent graft. A 19G coaxial needle was used to minimize needle bending, as occurs in fine needles, for the initial unsuccessful puncture and to increase pushability. By combining these techniques, the needle was successfully placed into the stent graft lumen with a single puncture, even in this patient with severe cirrhotic liver and ascites.

As mentioned above, PTFE-covered stent grafts seem to be useful for ensuring long-term TIPS patency, although in patient 1, patency of the Wallstent was astonishingly long. Some reports directly compared the use of PTFE-covered stent grafts with bare metal stents and showed the advantage of stent graft in terms of shunt patency and clinical outcome [4, 25]. When attempting transhepatic TIPS revision in the presence of a stent graft, one has to consider whether a needle can penetrate the wall of the stent graft. Theoretically, a bare stent offers less resistance to a percutaneous puncture. To our knowledge, there are no previous reports in which transhepatic puncture of the TIPS stent graft was performed. With a rigid 19G needle, we successfully punctured through the PTFE-covered stent graft. Only the insertion of a 5F catheter met some resistance.

Bloss et al. reported the recanalization of TIPS, and portal and splenic venous occlusions via the direct transhepatic approach in one instance [26]. They concluded that the transhepatic approach was preferable in their case of chronic occlusion, as it was in patient 2. Moreover, this technique may also be useful for portal vein recanalization if inaccessible via the jugular vein.

In both of our patients, the transhepatic puncture tract was embolized with a mixture of n-butyl-2-cyanoacrylate and lipiodol to avoid bleeding after removal of the catheter. This is safer in patients with ascites and increased tendency to bleed. In patient 1, a microcoil was placed first to prevent migration of n-butyl-2-cyanoacrylate and lipiodol through the interspaces of the bare stent into the shunt. In patient 2, the use of a coil was omitted because of the presence of the stent graft.

Previous reports have indicated the risk of severe encephalopathy and acute liver failure after TIPS revision [5, 27]. In both of our cases, there were no sequelae during 6 weeks' follow-up.

Review of the literature indicates that over the last decade, the reported number of TIPS recanalization procedures decreased. There is thus evidently a decreasing need for TIPS recanalization, presumably because of the use of PTFE-covered stent grafts. In addition, the lessons learned from the past tell us that the hepatic vein should be stented long enough to the entrance into the inferior vena cava to avoid tissue overgrowth of the proximal stent end.

In conclusion, TIPS revision via percutaneous transhepatic puncture in combination with a transjugular pull-through technique approach is feasible and useful, even in PTFE-covered stent grafts. If it is successful, it eliminates the need for creation of a second TIPS. CT-guided puncture can be particularly helpful in transhepatic puncture of the

TIPS in complex situations, such as the presence of liver cirrhosis and ascites.

Conflict of Interest Statement The authors declare that they have no conflict of interest.

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