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REVIEW

An Algorithm for Management After Transjugular Intrahepatic Portosystemic Shunt Placement According to Clinical Manifestations

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Abstract We propose an algorithm for management after transjugular intrahepatic portosystemic shunt (TIPS) placement according to clinical manifestations. For patients with an initial good clinical response, surveillance Doppler ultrasound is recommended to detect stenosis or occlusion. A TIPS revision can be performed using basic or advanced techniques to treat stenosis or occlusion. In patients with an initial poor clinical response, a TIPS venogram with pressure measurements should be performed to assess shunt patency. The creation of a parallel TIPS may also be required if the patient is symptomatic and the portal pressure remains high after TIPS revision. Additional procedures may also be necessary, such as peritoneovenous shunt (Denver shunt) placement for refractory ascites, tunneled pleural catheter for hepatic hydrothorax, and balloon-occluded retrograde transvenous obliteration procedure for gastric variceal bleeding. A TIPS reduction procedure can also be performed in patients with uncontrolled hepatic encephalopathy or hepatic failure.

Keywords Portosystemic shunt · Portal hypertension · Balloon occlusion · Gastric varices

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Introduction

Transjugular intrahepatic portosystemic shunt (TIPS) is an established and effective treatment for the complications of portal hypertension, such as variceal bleeding, refractory ascites and hepatic hydrothorax, hepatorenal syndrome, Budd–Chiari syndrome, and veno-occlusive disease [1, 2]. The initial TIPS stents were made of bare metal; however, these resulted in high rates of in-stent stenosis or shunt occlusion and recurrent symptoms; the reported 1-year primary patency rate for bare metal stents ranges from 36 to 50% [3–5]. The development of expanded polytetrafluoroethylene (ePTFE)-covered stents led to improved shunt patency rates and better clinical outcomes; these covered stents have a 1-year primary patency rate of 76–84% [5–10]. The mechanical stresses created due to the suboptimal position of a TIPS stent may cause pseudointimal hyperplasia, which can result in stenosis and may eventually lead to thrombosis and shunt occlusion [11, 12]. There is currently no consensus guideline or protocol for the best management of post-TIPS placement, although there is a general method for the evaluation and management of TIPS [13]. A systematic approach that can be used to guide further management and timely re-intervention and is based on clinical manifestations is needed to achieve optimal patient outcomes. Herein, we propose an algorithm for management after TIPS placement according to clinical manifestations.

Post-TIPS Surveillance

To date, no rigorous studies have described the optimal follow-up time intervals for post-TIPS surveillance. Our institution uses Doppler ultrasound (US) at 1, 3, 6, and 12 months following shunt placement and every 6–12 months thereafter

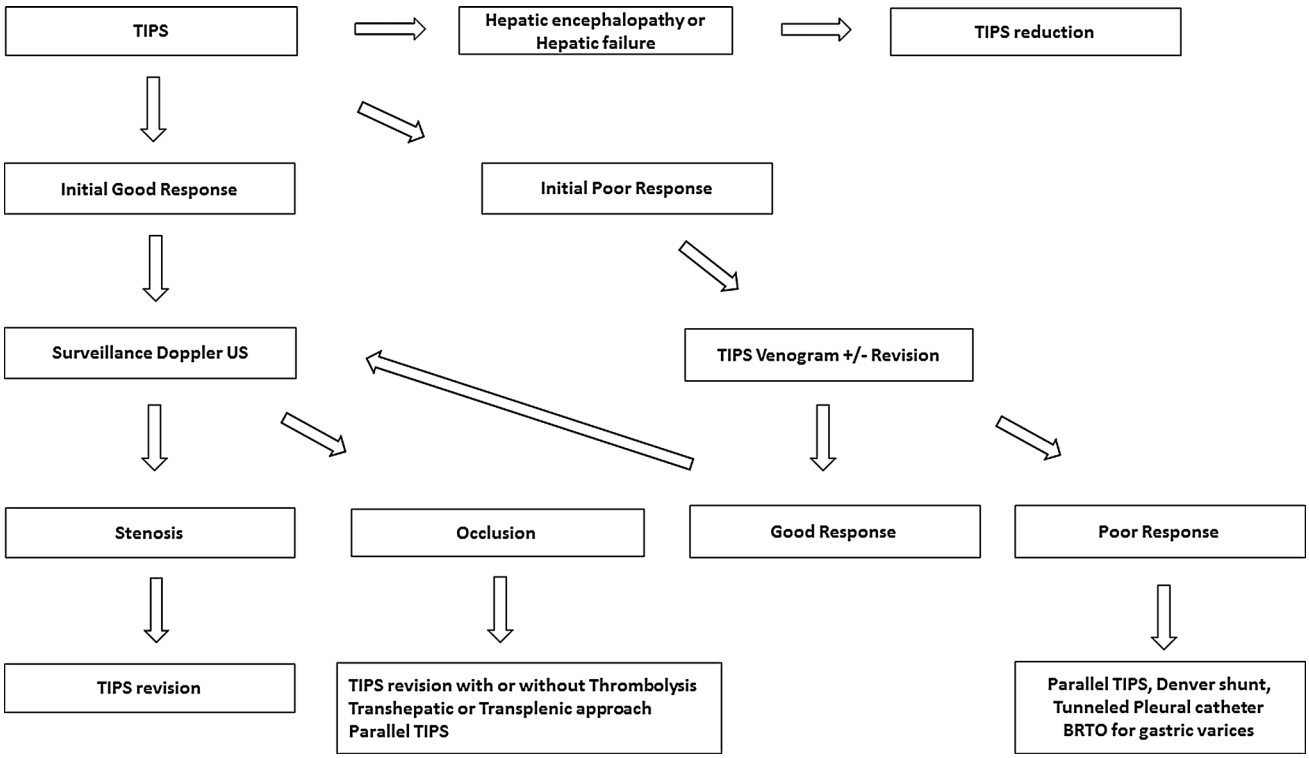


Fig. 1 An algorithm for management after TIPS placement according to clinical manifestations. *Note*: initial good response: resolution of symptoms, initial poor response: no resolution of symptoms. US criteria for TIPS stenosis: (1) in-stent flow velocity outside the accepted normal range (90–190 cm/s), (2) an interval change >25% interval change in peak TIPS velocity, (3) main portal vein velocity <30 cm/s. Surveillance Doppler US: 1, 3, 6, and 12 months following TIPS placement and every 6–12 months thereafter

unless clinical deterioration occurs [13]. Although this schedule has not been scientifically validated, it has served us well in our relatively large TIPS experience (more than 1500 patients since 1991) and is similar to the protocols used by others. With this protocol, many hemodynamically significant TIPS stenosis cases have been detected and repaired before the patients experienced recurrent symptoms [13].

The sonographic evaluation of in-stent shunt flow velocities is the primary tool for evaluation of shunt patency. In most cases, in-stent flow velocities outside of the accepted normal range (90–190 cm/s) indicate shunt dysfunction [14]. A main portal vein velocity below 30 cm/s is another useful parameter. When a shunt becomes stenotic, the flow in the portal vein leading up to the TIPS is diminished, and the main portal velocity often drops down below 30 cm/s [15]. Another recent study found that a greater than 25% interval change in peak TIPS velocity was significantly more sensitive at detecting dysfunction in a covered TIPS stent [16].

Using helical computed tomography (CT) angiography, the sensitivity and specificity of all morphologic abnormalities were determined to be 97 and 89%, respectively, while those for hemodynamically significant abnormalities were 92 and 77% [17].

One comparative study between multidetector spiral computed tomography (MDCT) and Doppler US showed

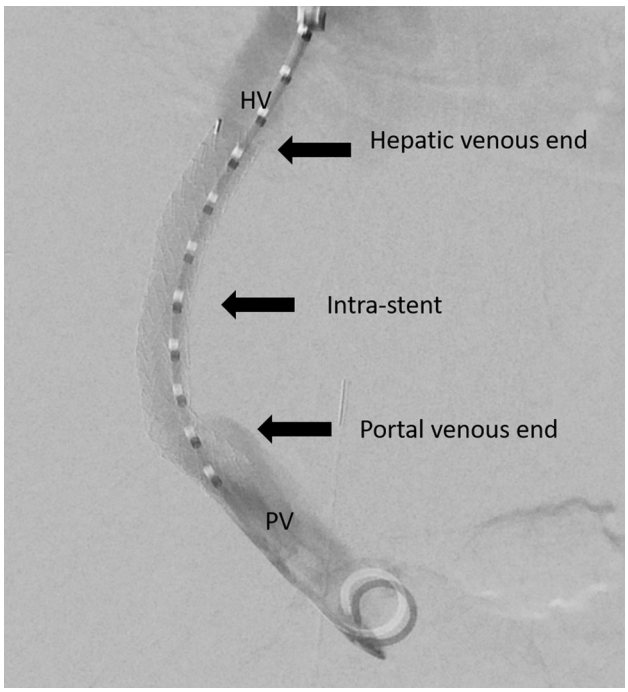


Fig. 2 Post-TIPS placement venogram shows the locations of TIPS stent stenosis (hepatic venous end stenosis, intra-stent stenosis, and portal venous end stenosis). *HV* hepatic vein, *PV* portal vein

that CT had superior sensitivity (95.2%) and specificity (96.6%) for identifying TIPS stenosis compared with Doppler US [18]. However, the only ultrasound criterion used to identify TIPS dysfunction was a 50% increase or decrease in TIPS velocity.

Algorithm for Management After TIPS Placement According to Clinical Manifestations

We propose an algorithmic and staged approach for management after TIPS placement according to clinical manifestations (Fig. 1). In this approach, patients are separated into two categories: good clinical responders, which include those who were asymptomatic and experienced resolution of symptoms or no recurrence of any symptoms, and poor clinical responders, which described patients who remained symptomatic and reported no resolution of symptoms.

Surveillance Doppler US is recommended to detect stenosis or occlusion that warrants the need for re-intervention in patients with an initially good clinical response. If in-stent stenosis or occlusion is noted on surveillance Doppler US, then a TIPS venogram and pressure measurements will be recommended. Some patients with TIPS stenosis or occlusion on US might also be asymptomatic

Fig. 3 Basic TIPS revision technique. A 59-year-old man with hepatitis C cirrhosis and post-TIPS placement for refractory ascites. An US image (not shown) obtained 4 months after TIPS showed high-grade stenosis within the TIPS stent near the hepaticocaval junction (hepatic venous end) and a moderate amount of ascites. **a** TIPS venogram revealed tight stenosis (*arrow*) in the TIPS stent near the hepaticocaval junction. **b** Balloon angioplasty was performed, and a covered stent (10 mm × 40 mm, Fluency, Bard Peripheral Vascular, Tempe, AZ, USA) was placed. **c** After revision, the TIPS venogram showed an interval improvement of the stenosis (*arrow*), and the portosystemic gradient had decreased from 11 to 4 mmHg. **d** An US image obtained 4 months after TIPS revision showed a patent TIPS stent and resolution of the ascites

(resolution of symptoms or no recurrence of symptoms). We have routinely used US with a high degree of confidence to screen TIPS function with high sensitivity (92%) and specificity (72%) for detecting TIPS stenosis [14]. Therefore, when US findings suggest TIPS stenosis, we recommend a TIPS venogram and pressure measurements to confirm the presence of TIPS stenosis and reduce the associated morbidity from re-accumulation of ascites, hydrothrorax, or further variceal bleeding.

In patients with an initial poor clinical response (no resolution of symptoms), a TIPS venogram with pressure measurements should be performed to assess shunt patency. Although there is no consensus regarding the optimum time point within which to carry out a TIPS venogram in patients with an initial poor clinical response, we recommend a TIPS venogram 3 months after initial TIPS placement because time is required to show improvement in clinical symptoms. For patients with a poor clinical response, potential secondary causes must also be ruled out.

The creation of parallel TIPS may be warranted if the patient is symptomatic and the portosystemic gradient remains high (>12 mmHg) despite a TIPS revision. Additional procedures may also be required, such as peritoneovenous shunt (Denver shunt) placement for refractory ascites, a tunneled pleural catheter for hepatic hydrothorax, and the balloon-occluded retrograde transvenous obliteration (BRTO) procedure for gastric variceal bleeding. A TIPS reduction procedure can also be performed in patients with uncontrolled hepatic encephalopathy or hepatic failure.

TIPS Revision Techniques

Basic TIPS Revision Techniques

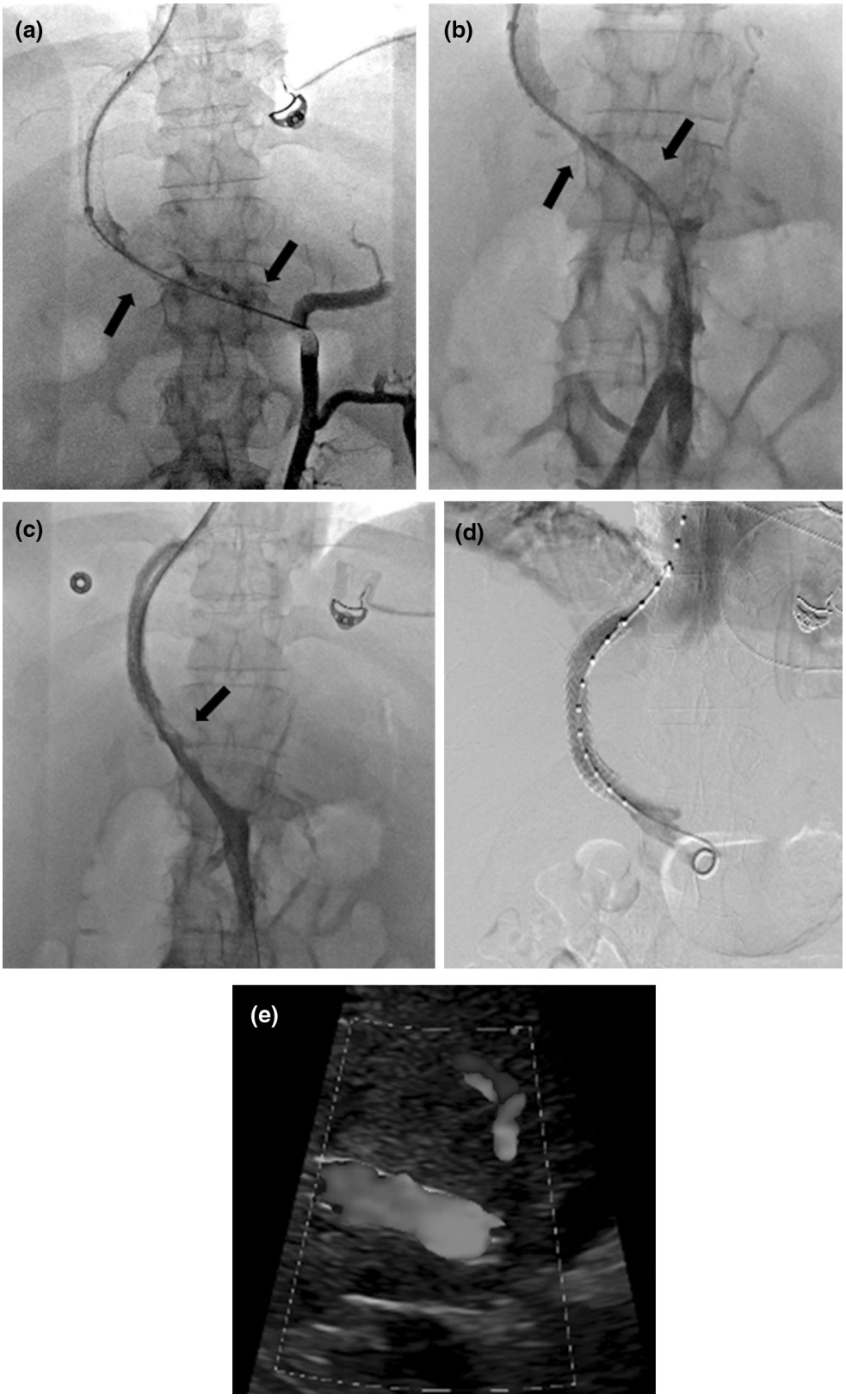
Basic TIPS revision techniques intended to reduce portosystemic gradients include angioplasty and stent placement across the area of stenosis to increase shunt patency. However, in-stent stenosis occurs most frequently at the hepatic-ocaval junction [3, 19]. Cardiac motion and respiratory motion make it difficult to identify stenoses using venography alone. Thus, if an area of stenosis is not readily identified on the venogram, but the pressures are elevated, a careful pull-back pressure measurement can help identify exactly where the pressures change in order to reveal the location of stenosis. This assessment can be accomplished by placing an end-hole catheter, such as a multipurpose angiographic catheter, into the portal vein. Then, a 0.018-inch guidewire is advanced through the catheter, and the hub-end is sealed with a Tuohy-Borst adapter. The catheter can then be connected to a pressure transducer and slowly pulled back across the shunt while maintaining access into the portal vein with the 0.018-inch guidewire [13]. The locations of TIPS stent stenosis can be divided into hepatic venous end stenosis, intra-stent stenosis, and portal venous end stenosis (Fig. 2).

Fig. 4 A TIPS revision with catheter-directed thrombolysis. A 44-year-old woman with alcoholic cirrhosis and post-TIPS placement for refractory ascites. Five months after TIPS placement, she presented with recurrent ascites. US images (not shown) revealed an occluded TIPS stent and a thrombosed portal vein. **a** TIPS venogram showed complete occlusion of the TIPS stent and a thrombosed main portal vein (*arrows*) with extension into the superior mesenteric vein and splenic vein. A multi-sidehole infusion catheter (Unifuse catheter, AngioDynamics, Queensbury, NY, USA) was placed for continuous infusion of alteplase (0.7 mg/h). **b** Eight hours after alteplase infusion, the venogram showed a residual thrombus in the main portal vein. **c** Venogram after mechanical thrombectomy with a Trerotola device (Teleflex medical, Arrow International Inc., PA, USA), and balloon angioplasty revealed interval reduction of the thrombus with partial/residual thrombus. A multi-sidehole infusion catheter (Unifuse catheter) was placed for continuous infusion of alteplase (0.7 mg/h). **b** After another 24 h of alteplase infusion, the venogram showed a patent TIPS stent and no definite thrombus in the main portal vein. The portosystemic gradient decreased from 39 to 10 mmHg. **e** An US image obtained 14 months after TIPS revision showed a patent TIPS stent and main portal vein

A TIPS revision with balloon angioplasty is the often treatment of choice for stenosis. However, angioplasty of stenosis with covered stent placement (Fig. 3) for TIPS revision is superior to angioplasty alone, as angioplasty rarely leads to long-term patency [20, 21]. Jirkovsky et al. [20] showed that primary patency rates after 12 and 24 months were 49.7 and 25.3%, respectively, in conventional angioplasty; 74.9 and 64.9% for bare metal stents; 75.2 and 64.5% with nondedicated ePTFE-covered stents (covered stents other than a Viatorr stent); and 88.1 and 80.8% for dedicated ePTFE-covered stents (Viatorr stent). Another study of TIPS revision with Viatorr-covered stents in 12 patients showed 1- and 2-year primary patency rates of 100 and 89%, respectively [21]. Therefore, we recommend using a covered stent for TIPS revision for better long-term patency [20–22]. Restenting (placement of another stent inside of an indwelling stent) is also useful in cases of stent shortening and/or portal venous stenosis. Shunt extension (placement of another stent in the portal vein end or the hepatic vein end) can additionally be used in combination or alone for managing hepatic and portal venous end stenosis or to correct problems with angulation.

Advanced TIPS Revision Techniques (Stent Occlusion)

If TIPS stent thrombosis with extension into the portal and mesenteric veins is present, mechanical thrombectomy or catheter-directed thrombolysis is required either with or without stent placement (Fig. 4). However, obtaining wire access with complete shunt occlusion may be difficult. In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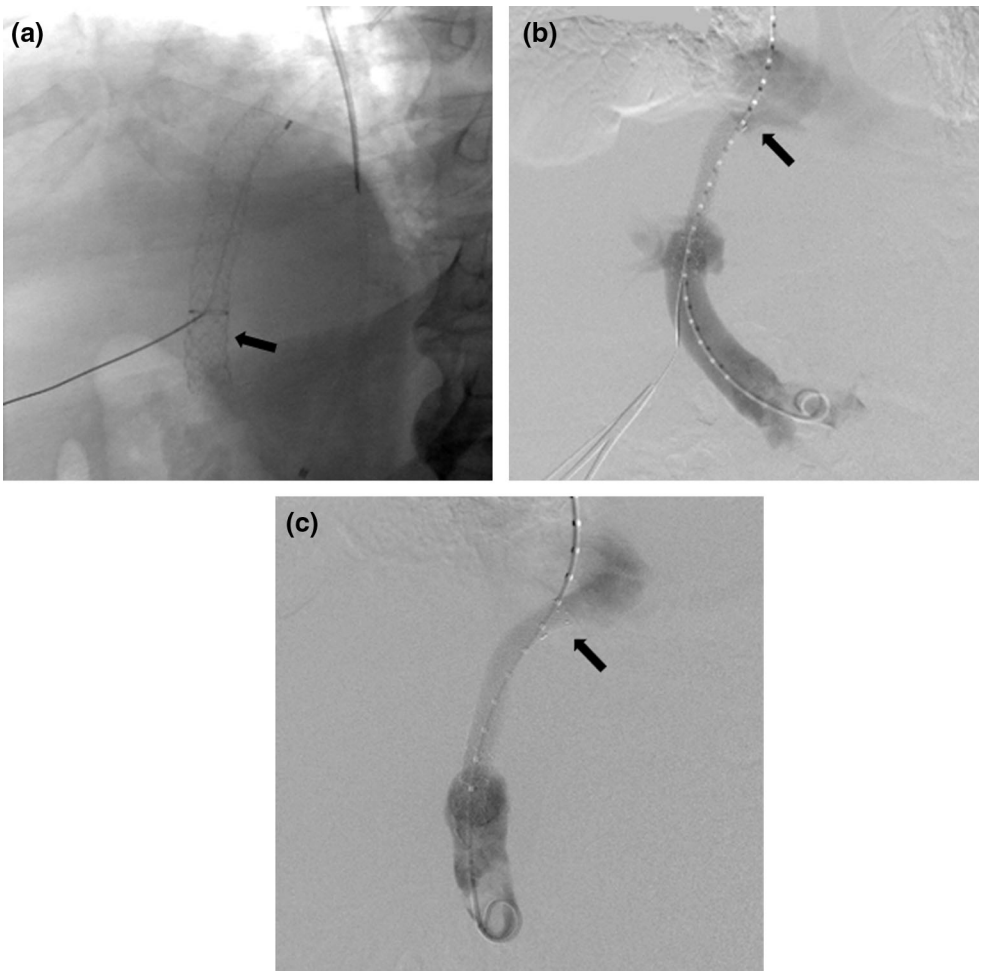

Fig. 5 A TIPS revision with percutaneous transhepatic access. A 60-year-old man with hepatitis C cirrhosis and post-TIPS for refractory ascites. An US image (not shown) obtained 3 months after TIPS showed possible stenosis within the TIPS stent near the hepaticocaval junction (hepatic venous end) and a moderate amount of ascites. A TIPS revision was attempted; however, it was impossible to access the TIPS stent from the hepatic vein. **a** A bare portion of the TIPS stent (Viatorr stent, W. L. Gore and Associates, Flagstaff, AZ, USA) was accessed using a 22-gauge Chiba needle, and an 0.018-inch guidewire (*arrow*) was advanced transhepatically through the needle into the TIPS stent and up into the right atrium. The wire was snared through internal jugular vein access and pulled out via through-and-through access using the body floss technique. **b** A TIPS venogram showed mild stenosis in the TIPS stent near the hepaticocaval junction (hepatic venous end). An uncovered stent (10 mm × 60 mm, Smart, Cordis Endovascular, Warren, NJ, USA) was placed at the hepaticocaval junction. **c** Following the revision, the TIPS venogram showed interval improvement of the stenosis (*arrow*); the portosystemic gradient decreased from 12 to 6 mmHg

these circumstances, failure to achieve shunt access with a transjugular approach requires advanced techniques to recannulate the occlusion. More advanced methods for successful wire access include percutaneous transhepatic and trans-splenic venous approaches.

Percutaneous transhepatic recanalization is a through-and-through approach that is accomplished by percutaneously puncturing the caudal end of the stent via a transhepatic approach and snaring a wire cephalad via internal jugular venous access (Fig. 5) [23]. Once the stent is recanalized, successful thrombolysis and restenting can be achieved. The trans-splenic route involves percutaneously puncturing the spleen to reach a small peripheral splenic vein and then accessing the portal vein so that revascularization of the stent can be achieved using traditional wire and catheter techniques (Fig. 6). A transhepatic or trans-splenic puncture tract must be embolized with a mixture of *n*-butyl-2-cyanoacrylate and lipiodol or coils to prevent bleeding after removal of the catheter or sheath. Zhu et al. [24] reported that percutaneous trans-splenic portal vein catheterization in patients with uncontrolled gastroesophageal variceal bleeding and portal vein occlusion had a 96% technical success rate (44/46), with major bleeding complications noted in three patients (6.5%).

In cases where the primary TIPS stent is unsalvageable, the creation of a parallel TIPS is required for symptomatic relief. A parallel TIPS can be placed in an anatomically suitable hepatic and portal vein (Fig. 7) [25, 26]. For

Fig. 6 A TIPS revision with percutaneous trans-splenic access. A 77-year-old man with hepatitis C cirrhosis and post-TIPS for variceal bleeding was lost to follow-up. **a** An US image obtained 16 months after TIPS showed complete occlusion of the TIPS stent. Transjugular and percutaneous transhepatic access was attempted; however, it was not possible to reach the TIPS stent. **b** The percutaneous splenic vein was accessed using a micropuncture needle; a 7-French-long sheath was placed, and a splenic venogram was obtained. The splenic venogram showed complete occlusion of the TIPS stent (*arrow*) and prominent gastric varices (*white arrow*). A guidewire was advanced through the TIPS stent and up into the right atrium. The wire was snared through internal jugular vein access and pulled out via through-and-through wire access (the body floss technique). **c** Balloon angioplasty was performed, and an uncovered stent (10 mm × 60 mm, Smart, Cordis) was placed at the hepaticocaval junction. **d** After revision, the venogram showed an interval patent TIPS stent; the portosystemic gradient decreased to 4 mmHg. Trans-splenic access was embolized using several microcoils

parallel TIPS placement, the left portal vein was accessed via the middle hepatic vein, and a covered stent (Viatorr) was deployed because the primary TIPS stent graft is usually placed between the right hepatic vein and the right portal vein. The parallel TIPS procedure might require less time if the stents from the first tract are used as a marker of the portal vein; this parallel procedure had a 100% technical success rate in a previous study [25]. Compared with primary TIPS placement, similar procedure-related complications are possible in parallel TIPS placement, such as injury to the biliary tract and hepatic vein and abdominal cavity hemorrhage. Hepatic encephalopathy is the main complication of the procedure after placement of a parallel TIPS. Previous studies [25, 26] have revealed that intractable ascites and hydrothorax improved markedly and variceal bleeding was controlled after the successful placement of a parallel TIPS.

A direct intrahepatic portocaval shunt (DIPS) could be an alternative option to avoid using the hepatic vein for shunt outflow [27, 28]. The DIPS procedure uses the caudate lobe as the parenchymal tract to create a side-to-side portocaval shunt. This technique is performed using an intravascular ultrasound (IVUS) probe via a femoral vein approach [27, 28].

Clinical Manifestations

Ascites

TIPS placement usually results in the improvement of refractory ascites (38–84%) [29–33]. Limited studies suggest that TIPS may afford a small survival advantage in cirrhotic patients with refractory ascites [29–33]. The most

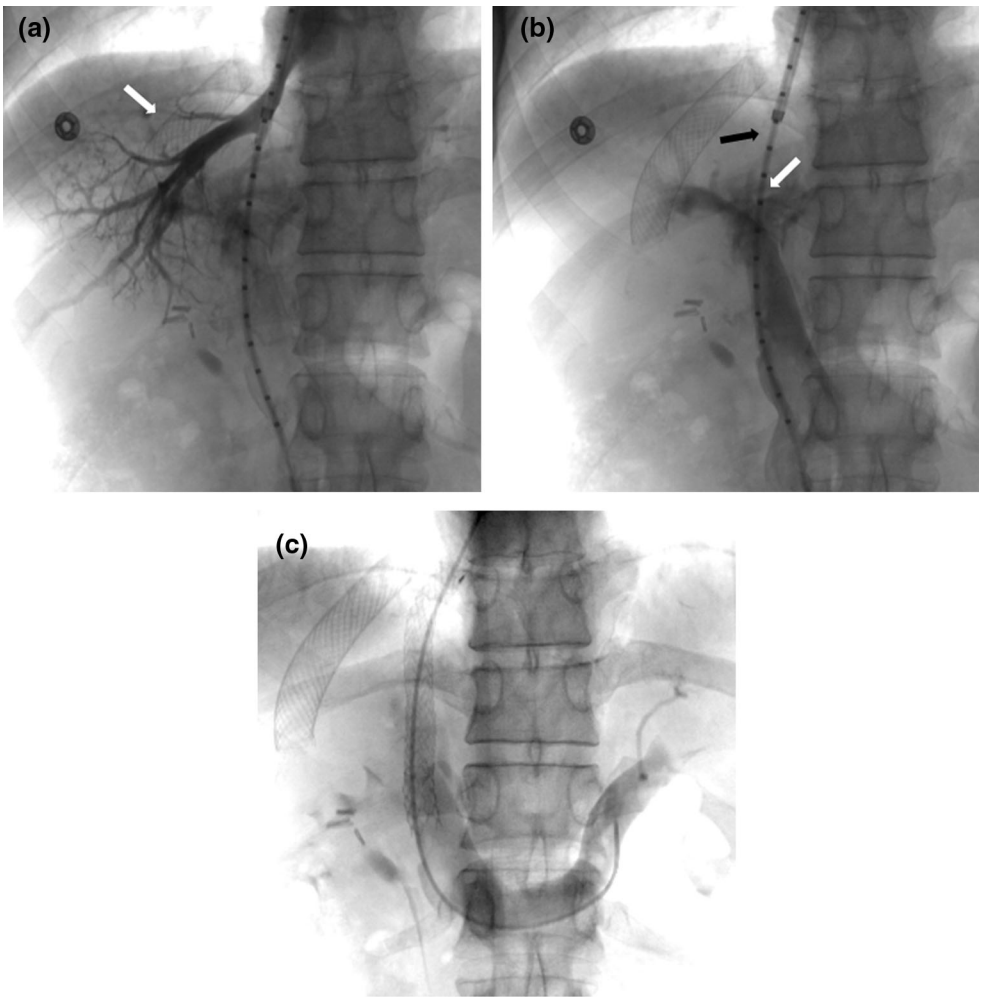

Fig. 7 Parallel TIPS placement. A 42-year-old male with ulcerative colitis, liver cirrhosis secondary to primary sclerosing cholangitis, and post-TIPS placement for variceal bleeding. A recent US revealed complete occlusion of the TIPS stent. **a** The plan was to place a new TIPS secondary to difficult angulation of the existing TIPS stent (*white arrow*) between the right hepatic vein and the right portal vein. **b** New TIPS access was obtained between the middle hepatic vein (*arrow*) and the left main portal vein (*white arrow*). **c** A new TIPS stent (Viatorr, 10 mm × 80 mm, Gore) was placed, and the portosystemic gradient decreased from 29 to 6 mmHg

common cause of symptom recurrence is stenosis or complete TIPS occlusion, resulting in increased portosystemic pressure gradients. Careful evaluation using US or a TIPS venogram is required to determine whether TIPS stenosis or occlusion is causing the symptoms. In cases of TIPS revision failure where insufficient portal systemic shunting is producing recurrent symptoms, the creation of a parallel TIPS may be required [25, 26].

A peritoneovenous shunt (Denver shunt) may be required for refractory ascites (Fig. 8) if the patient has symptomatic ascites following a TIPS revision [34]. Complications of the Denver shunt include shunt occlusion, peritoneal infection, ascitic leak, bleeding, disseminated intravascular coagulation, pneumothorax, and pneumoperitoneum [35–38]. These complications have limited the popularity and use of the Denver shunt.

Hydrothorax

The proposed pathogenic mechanisms for the formation of pleural effusion in patients with cirrhosis include the passage of transudative fluid from the peritoneal cavity to the pleural space through diaphragmatic defects, hypoalbuminemia leading to decreased oncotic pressure, and leakage of the thoracic duct [39]. Refractory hydrothorax occurs when patients fail to respond to the maximum tolerated doses of first-line therapy, which include sodium restriction and diuretics. Refractory hydrothorax can also be managed by repeated thoracocentesis and chest tube drainage, but these procedures are associated with decreased quality of life and result in hyponatremia and hypoalbuminemia due to excessive volume loss. Other surgical options are pleurodesis and peritoneovenous

Fig. 8 Denver shunt placement after TIPS placement. A 65-year-old woman with hepatitis C liver cirrhosis and post-TIPS for refractory ascites. **a** A TIPS venogram 4 months after TIPS placement showed stenosis at the hepaticocaval junction. A covered stent (10 mm × 40 mm, Fluency, Bard) was placed, and the portosystemic gradient decreased from 22 to 10 mmHg. The patient's ascites never resolved, even after TIPS revision. **b** TIPS venogram 2 months after TIPS revision showed a patent TIPS stent, and the portosystemic gradient was 14 mm Hg. It was decided to place a Denver shunt due to the patient's poor clinical response to TIPS. **c** A Denver shunt (*arrows*) was successfully placed

shunts [39]. TIPS placement improves refractory hydrothorax (68–82%) in the majority of patients [40–43].

A tunneled pleural catheter can be placed for refractory hepatic hydrothorax if the patient has symptomatic hydrothorax following a TIPS revision [44, 45]. One recent study [46] reported that tunneled pleural catheters may be successfully and safely used to control symptoms associated with hepatic hydrothorax and are associated with a 33% spontaneous pleurodesis rate (8/24) and a 16.7% infection rate (4/24).

Gastric Variceal Bleeding

Early TIPS creation in patients with cirrhosis and acute variceal bleeding has been shown to reduce treatment failure and mortality in select patient populations [47–49].

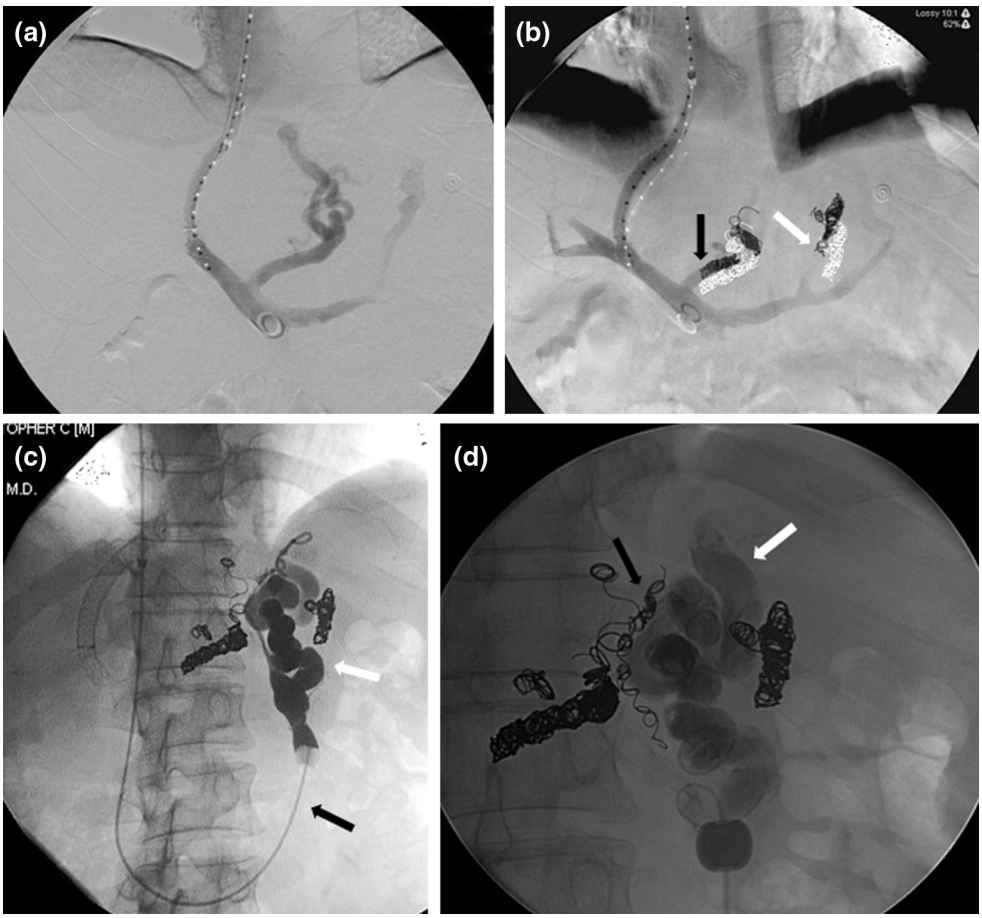

Fig. 9 BRTO after TIPS placement for recurrent gastric variceal bleeding. A 42-year-old man with hepatitis C cirrhosis presented with gastric variceal bleeding that was visualized on endoscopy. **a** The initial portal venogram demonstrates retrograde filling of the gastric varices from the left gastric (*arrow*) and posterior gastric (*white arrow*) veins. **b** Repeat venogram post-embolization of the collateral veins reveals no contrast flow to the gastric varices. However, the patient's gastric variceal bleeding did not resolve after TIPS revision with coil embolization, so he underwent the BRTO procedure. **c** Initial access through the right internal jugular vein was established, and the left renal vein was catheterized followed by the gastrorenal shunt. A balloon occlusion venogram of the gastrorenal shunt shows retrograde filling of the gastric varices. **d** The left inferior phrenic vein was embolized using multiple microcoils (*arrow*), and the gastric varices were then embolized using ethanolamine oleate mixed with lipoidol (*white arrow*). Follow-up of the patient for 628 days post-procedure did not reveal any endoscopic, imaging, or clinical evidence of recurrent gastric varices

Historically, the success of TIPS in preventing rebleeding of gastric varices is reportedly dismal, mainly due to shunt dysfunction of bare metal stents [50–53]. TIPS patency has greatly improved with the advent of covered stents [5–10]. The two most recent studies with TIPS using covered stents [54, 55] for treatment of gastric varices showed lower rebleeding rates (7–11%) compared with previous TIPS created with bare stents (14–31%) [50–53].

Several studies have shown BRTO to be an effective treatment method for isolated gastric varices bleeding [56–62]. The BRTO procedure involves the occlusion of the outflow veins of the portosystemic shunt, such as a gastrorenal shunt, using an occlusion balloon, followed by the injection of a sclerosing agent directly into the varix. Two recent intra-institutional comparative studies between TIPS with a covered stent and BRTO reported that both TIPS and BRTO effectively treated isolated gastric varices and had low rebleeding rates [50–53].

BRTO is a good alternative for patients in whom a TIPS placement is technically difficult or if there is recurrent gastric variceal bleeding even after TIPS revision with variceal embolization (Fig. 9). According to Chao et al. [63], the mean hepatic venous pressure gradient was 11.2 mmHg for gastric varices and 15.5 mmHg for esophageal varices. Therefore, there is a higher likelihood of diminished portal pressure (<12 mmHg) in patients with gastric varices. Thus, TIPS creation in these patients to further reduce the portosystemic gradient may not have a dramatically beneficial hemodynamic effect on the gastric variceal system and can result in higher rebleeding rates

Fig. 10 **A** TIPS reduction with parallel stent and covered stent deployment due to worsening encephalopathy. A 71-year-old man with hepatitis C cirrhosis of the liver, allograft, post-liver transplantation, and post-TIPS for refractory ascites. TIPS reduction was recommended due to worsening encephalopathy. **a** After placement of the 14-French vascular sheath, the TIPS stent and two guidewires were advanced into the splenic vein. **b** A 6 mm × 20 mm balloon-expandable stent (Genesis, Cordis) and covered stent (10 mm × 60 mm, Fluency, Bard) were advanced into the TIPS stent. The covered stent was deployed, and then the balloon-expandable stent (Genesis) (*arrow*) was deployed alongside the covered stent to a 6 mm diameter at the proximal portion of the TIPS stent. **c** Venogram after TIPS reduction showed greater filling of the intrahepatic portal vein branches (*arrows*). The portosystemic gradient increased from 4 to 14 mmHg. Following TIPS revision, the patient's mental status improved

than in patients with bleeding esophageal varices [63, 64]. Therefore, adding BRTO to TIPS can be effective for controlling gastric variceal bleeding.

Major Adverse Events: Hepatic Failure/Hepatic Encephalopathy

Poiseuille's law states that resistance of flow is related to shunt diameter. The main goal of decreasing the portosystemic gradient with TIPS insertion often results in hepatic encephalopathy and hepatic failure. The shunting of portal blood flow via TIPS decreases hepatic perfusion and may precipitate hepatic failure. Deterioration of hepatic function has also been reported in approximately 10% of patients following TIPS placement [65].

Elevated serum bilirubin and creatinine levels have been proposed as important predictors of poor patient prognosis [66, 67]. An elevated bilirubin level before TIPS placement has shown to be a powerful independent predictor of 30-day mortality after TIPS placement with a 40% increased risk of death for each 1-mg/dL increase above 3.0 mg/dL [66]. The model of end-stage liver disease (MELD) score was superior to Child-Pugh score as predictor of short-term outcome after TIPS placement [68], and patients with a MELD score of 18 or more have a significantly lower 3-month survival rate than do those with a MELD score of 17 or less [69]. Therefore,

thresholds for TIPS placement could be MELD <18–20 or total bilirubin <3.0 mg/dL.

Hepatic encephalopathy typically occurs 2–3 weeks after TIPS insertion. Following successful TIPS placement, new or worsened hepatic encephalopathy may be observed in 22–50% of patients. Encephalopathy is often clinically defined by cognitive impairment, asterixis, changes in mental state, and increased serum ammonia level. The treatment for hepatic encephalopathy after TIPS is the same as that for conventional hepatic encephalopathy [70–72].

One recent study [73] showed that the hepatic encephalopathy incidence within 30 days was 42% (81/191; 22% de novo, 12% stable, and 8% worsening). Medical therapy was typically used to address hepatic encephalopathy; TIPS shunt reduction was necessary in only three cases.

A TIPS reduction is only considered if the hepatic encephalopathy is refractory to medical therapy. The ultimate goal of a TIPS reduction to decrease shunt diameter is to reduce the amount of blood flow through the shunt and lower the incidence of portosystemic encephalopathy. Several TIPS reduction techniques have been reported [74, 75], including adjustable TIPS reduction using a parallel stent and covered stent deployment (Fig. 10) and TIPS reduction with an hourglass-shaped, balloon-expandable covered stent. In refractory cases, orthotopic liver transplantation is the treatment of choice.

Conclusion

We proposed a management algorithm to be used following TIPS placement according to clinical manifestations. In patients with a good initial clinical response, surveillance Doppler US is recommended to detect stenosis or occlusion. The TIPS revision can be performed using basic or advanced TIPS revision techniques for the treatment of TIPS stenosis or occlusion. For patients with a poor initial clinical response, a TIPS venogram with pressure measurements should be performed to assess shunt patency. The creation of a parallel TIPS may also be required if the patient is symptomatic and the portal pressure remains high after a TIPS revision. Additional procedures, such as a Denver shunt, tunneled pleural catheter, and the BRTO procedure, can also be used according to clinical manifestations following TIPS placement.

Compliance with ethical standards

Conflict of interest None.

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