Transjugular Intrahepatic Portosystemic Shunt Complications: Prevention and Management

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Abstract

Keywords

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Transjugular intrahepatic portosystemic shunt (TIPS) insertion has been well established as an effective treatment in the management of sequelae of portal hypertension. There are a wide variety of complications that can be encountered, such as hemorrhage, encephalopathy, TIPS dysfunction, and liver failure. This review article summarizes various approaches to preventing and managing these complications.

Objectives: Upon completion of this article, the reader will be able to describe how to prevent and address potential complications of transjugular intrahepatic portosystemic shunt (TIPS) procedures.

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Transjugular intrahepatic portosystemic shunt (TIPS) is the percutaneous creation of a conduit from the hepatic vein to the portal vein that is used to manage consequences of

portal venous hypertension (i.e., variceal hemorrhage and refractory ascites). While the primary technical success rate of TIPS placement is high, complications can occur and can drastically alter patient prognosis. Potential complications of TIPS include acute liver failure, hepatic encephalopathy, hemorrhage, biliary injury, injury to surrounding organs, TIPS thrombosis, TIPS dysfunction, and TIPS migration. This article reviews the myriad of TIPS-related complications with an emphasis on prevention and management.

Preprocedure Evaluation

Assessment of hepatic functional status is a crucial component of preprocedural evaluation, and is the topic of entire review articles.¹ Patients with poor hepatic reserve have worse outcomes after TIPS insertion that is related to accelerated hepatic deterioration and hepatic failure. Patients with poor hepatic reserve and bleeding gastric varices may be better served with a balloon-occluded retrograde transvenous obliteration (BRTO).^{2,3} In a coagulopathic patient,

parenchymal and vascular trauma during a TIPS procedure can cause increased bleeding risk.⁴ Thus, the patients coagulation profile and platelet count should be corrected to as near normal as possible.

Careful preprocedural image review is important for planning the approach for TIPS insertion. Computed tomography (CT) or magnetic resonance imaging (MRI) with portal venous phase imaging is helpful for assessing the hepatic and portal venous systems, which can be extremely useful in detecting portal venous thrombosis and in choosing the optimal hepatic vein and direction of TIPS needle punctures. Imaging may also reveal an elevated right hemidiaphragm, portal hepatic vein occlusion, massive ascites, or tumor located in the expected path of the TIPS, which can impact the approach. Furthermore, patients with ascites should be screened for abdominal and inguinal hernias, as rapid decompression has been associated with hernia incarceration.^{5,6} Ultrasound can also be helpful for determining portal vein and hepatic vein patency, but provides a less detailed assessment of the spatial relationship between vascular structures.

Intraprocedural Complications

Acute Hemorrhage

Right internal jugular vein access and sheath placement should be performed under ultrasound and fluoroscopic guidance to avoid carotid artery puncture and right atrial perforation.⁷ Although arterial injuries occur during fewer than 2% of TIPS cases,⁸ they must be anticipated so that they can be recognized and treated in an expeditious manner. Arterial puncture during passes with the TIPS needle can result in hemorrhage, pseudoaneurysm formation, arterial occlusion, arterioportal fistula,⁸ or arteriohepatic fistula formation.⁹ When the patients exhibit signs of intraprocedural hemorrhage, such as hemodynamic instability, hematemesis, increasing abdominal pain, or increasing abdominal distension, attention should be turned toward addressing a potentially fatal hemorrhagic complication. If the fluoroscopy unit is capable of cone-beam CT, this can be expeditiously used to assess for the presence and site of hemorrhage, which may help to guide therapy. Ultrasound can also be used to detect hemoperitoneum or a subcapsular hematoma. If an arterial source is suspected, angiography should be immediately performed, with use of embolization or covered stents to treat hemorrhage.¹⁰ It should also be kept in mind that patients with portal hypertension can also suffer rapid blood loss in the setting of significant injury to the portal venous system. In these cases, portal venography may help to diagnose the etiology once portal access has been achieved. While embolization can be performed, successful insertion of the actual TIPS is also a highly effective treatment, particularly considering that injury to the main, left, and right portal veins cannot be easily treated with embolization. Portal vein dissection is rare but may require extension of the TIPS stent to cover the dissection flap and maintain flow.¹¹

Nontarget TIPS Insertion

Successful TIPS needle puncture of the portal vein should be confirmed with contrast injection before proceeding with

tract dilation. Appropriate direction of flow, vessel size, vessel configuration, and contrast washout are important for confirmation of portal venous puncture. Reports of placing a TIPS in the common hepatic duct¹² or hepatic artery¹³ are exceedingly rare, but these misplacements can occur if confirmatory steps are not taken. Once intraportal vein position of the TIPS needle/catheter is confirmed, the appropriateness of the puncture location should be assessed, particularly as it relates to an extrahepatic portal vein access. In a study of 31 cadavers, the portal vein bifurcation was found outside of the liver in 15 (48%) cases.¹⁴ Placement of a TIPS via an extrahepatic portal vein access may result in intraperitoneal hemorrhage.¹⁵ However, while TIPS insertion through the extrahepatic portions of the left or right portal veins near or at the portal vein bifurcation has traditionally been considered to be unacceptably high risk for hemorrhage in the bare metal stent era, a recent study reported that the risk for significant hemorrhage may not be higher when the Viatorr endoprosthesis (W.L. Gore & Associates, Flagstaff, AZ) is used.¹⁶

Excessive Procedural Time

Although not a true complication, excessively long procedural time is not infrequently encountered with TIPS insertion. Since TIPS was first described,¹⁷ many researchers have described various methods aimed at reducing procedural time, radiation exposure, and risk of complications. The primary difficulty in TIPS insertion is the blind puncture of the right or left portal vein at an appropriate site. Wedged hepatic vein portography has been proposed for visualization of the portal venous system to facilitate successful portal venous puncture. Slow hand injection of carbon dioxide rather than iodinated contrast is recommended, as the incidence of contrast extravasation is 1.8% with carbon dioxide, compared with 7.5% with iodinated contrast.⁸ A rare complication of wedged hepatic venography is liver laceration.¹⁸ This complication has been reported to occur more often (and with greater severity) when iodinated contrast material is used rather than carbon dioxide.¹⁹ Due to the reported complication rates as a result of wedged injection during hepatic venography, balloon occlusion catheters with careful hand injection of carbon dioxide are recommended.¹⁹ Should a liver laceration be suspected during the course of attempted wedged portal venography, recognition by the operator is critical; depending on the severity of hemorrhage, management may include arteriography and embolization of a bleeding vessel.

As an alternative to wedged portal venography, a temporary radiopaque snare or wire can be placed via a transhepatic approach into the portal vein to serve as a target for the TIPS needle.⁷ The risk of bleeding from the transhepatic entry site can be minimized by depositing gelatin sponge, coils, or glue into the tract while retracting the sheath.²⁰ Alternatively, the accessed portal venous branch itself can be embolized with coils or liquid embolic agents just prior to removal.

Transabdominal and intravascular ultrasound have also been suggested as methods to reduce the risk of unintended needle puncture and procedure time. Leong et al used adjunctive transabdominal ultrasound to guide a 22-gauge

needle percutaneously between the portal and hepatic veins. A 0.018-inch wire was then passed through the needle and grasped with a snare, which was introduced via the transjugular approach providing through-and-through access for TIPS creation.²¹ Although there were no complications, procedure and fluoroscopy time were not reported. Intravascular ultrasound has also been shown to facilitate TIPS needle passage. Farsad et al positioned an intravascular ultrasound transducer in the inferior vena cava (IVC) to guide a TIPS needle from the hepatic vein into the portal vein.²² The authors compared 25 TIPS procedures with intravascular ultrasound and 75 "blind pass" TIPS procedures. While there was no significant reduction in fluoroscopy time, number of needle passes, or complications, this method may be useful for patients with portal vein thrombus, distorted vascular anatomy, Budd–Chiari syndrome, or intervening liver tumors.

Liver Capsule Transgression

Transgression of the liver capsule with the needle/catheter combination during TIPS needle passes can occur in 33% of cases, with intraperitoneal hemorrhage occurring in 1 to 2% of cases.²³ When the liver capsule is breached, the organ most commonly punctured is the gallbladder, with resulting hemobilia, cholangitis, and/or intrabiliary clot. Other organs affected include the right kidney, hepatic flexure of the colon, and duodenum. Such nontarget organ puncture is usually well tolerated with few reported cases of clinically significant sequela.⁸ The techniques described in the preceding paragraph may also serve to minimize the risk of liver capsule transgression with the TIPS needle.

Tabletop TIPS Maldeployment

Given that the steps required for Viatorr endoprosthesis deployment is markedly different than other types of stents and stent grafts, one of the complications sometimes encountered is unintended premature maldeployment of the stent prior to its insertion into the access sheath. There are two points during the preparation and deployment where operator error can occur. The first is the mistaken removal of the clear plastic access sleeve that constrains a Viatorr endoprosthesis; it can easily be mistaken for a protective covering that would normally be removed from an angioplasty balloon catheter. Once this self-expanding bare metal portion of the Viatorr endoprosthesis is deployed, it can no longer be used in a conventional manner.

The second and likely more common error in deployment occurs when the clear sleeve constraining the bare portion of the stent graft is being advanced through the hemostatic valve of the introducer sheath. If the clear plastic access sleeve is not completely loaded into the sheath until the black marker line aligns with the sheath valve, partial maldeployment of the bare portion of the Viatorr endoprosthesis can occur into the hub of the sheath, which results in an inability to advance the stent graft beyond the hub into the sheath. If this happens, the stent graft must be removed and is no longer usable.

Given the high cost of the Viatorr endoprosthesis, it is desirable to be able to reconstrain and deploy the

prematurely deployed stent. Although difficult, it is not impossible to collapse and recapture the stent for subsequent use; recently, a stepwise method has been described for reconstraining and subsequently redeploying the Viatorr stent after premature unsheathing.²⁴ The first step requires severing the Viatorr stent graft delivery system near the hub with scissors. Using a separate 10 French sheath, the hub is cut off with the goal of having an ~10-cm-long segment. One end is flared slightly by inserting the tip of forceps or hemostats and rotating circumferentially. This flared end of the sheath is then loaded on the back of the Viatorr delivery system and advanced across the constrained portion of the stent graft to the deployed bare portion, which is then carefully pulled into the 10 French sheath. The flared segment is then cut off, and the stent graft is now constrained. On the cut edge of the Viatorr delivery system, a 1- to 2-cm longitudinal slit is cut to visualize and grasp the ripcord. The Viatorr endoprosthesis can then be used in routine fashion.

Early Postprocedural Complications

Arterial Complications

Serious arterial complications can occasionally occur in the early postprocedural period following TIPS placement. Liver laceration and acute intra-abdominal hemorrhage have been reported 8 days following TIPS placement in a patient receiving low molecular weight heparin.⁴ Three intrahepatic hematomas have been reported in the second week following TIPS. In all three cases, the patients received either low molecular weight heparin or warfarin at the time of hemorrhage.^{25–27} In patients suspected of postprocedural hematoma formation, CT should be performed to identify the presence and site of hemorrhage. Anticoagulant and antiplatelet medications should be stopped and reversed if possible. If an arterial source is suspected, routine hepatic arteriography and embolization should be performed. Arterial compression by the TIPS, with subsequent segmental hepatic infarction, can be treated with antibiotic coverage and supportive care.²⁸

Acute Hepatic Encephalopathy

The onset of encephalopathy after TIPS insertion occurs in 5 to 35% of cases.⁷ Encephalopathy has been reported within 1 day or as late as 210 days after TIPS placement.²⁹ Ninety-five percent of these cases can be controlled medically with lactulose, protein-restricted diet, or branched-chain amino acids.⁷ Severe disabling encephalopathy can occur in 1 to 3% of TIPS patients.²⁹ For patients with persistent severe encephalopathy or acute liver failure, TIPS occlusion should be considered. TIPS occlusion can be achieved by inflating an angioplasty balloon inside the stent for a minimum of 12 hours.^{29,30} The Amplatzer Vascular Plug (St. Jude Medical, St. Paul, MN) has also been used to achieve the same result with immediate thrombosis (► Fig. 1).³¹ When TIPS occlusion is performed, it is important to monitor the patient closely. Paz-Fumagalli et al reported profound hemodynamic changes following TIPS closure, which ultimately resulted in patient death.³² Furthermore, the presenting symptoms of portal

Fig. 1 Intentional TIPS occlusion. A 65-year-old man developed severe, refractory encephalopathy and chronic pulmonary hypertension 4 months after TIPS insertion. (a) Digitally subtracted image demonstrates a widely patent TIPS. (b) After deployment of a 14-mm-diameter Amplatzer Vascular Plug (St. Jude Medical Inc., St. Paul, MN) (arrow), there is occlusion of flow through the TIPS. Clinically, there was significant improvement in the encephalopathy and pulmonary hypertension following TIPS occlusion.

hypertension, such as variceal hemorrhage or ascites, should be expected to return. In the case of variceal hemorrhage, embolization of the varices should be performed prior to TIPS occlusion. If the TIPS insertion was performed due to ascites, aggressive medical therapy or peritoneovenous shunting can be considered.

Rather than performing TIPS occlusion, another option to mitigate encephalopathy is reduction of the stent graft diameter. Several techniques have been described in the literature to accomplish this. Although prior reports described deployment of additional bare metal stents into the TIPS, contemporary techniques all involve deployment of a covered stent within the original TIPS using various mechanisms to narrow the internal stent diameter.^{33–39}

Madoff et al reported the use of a suture to constrain a self-expanding stent graft as a method for decreasing TIPS flow in six patients. After a 10- to 12-mm-diameter stent graft was deployed on the back table, an inflated angioplasty balloon or dilator 6 to 8 mm in diameter was placed within it. A 3–0 silk suture was then woven in the stent graft at a third the distance from its leading end and tightened around the template. The stent graft was then loaded into a 9 or 10 French sheath and pushed to the tip with a blunt pusher, then deployed at the desired position within the TIPS by retracting the sheath. Improvement in encephalopathy was demonstrated in five of six patients.

Fanelli et al reported the use of a constrained balloon technique in 12 patients that was highly successful in managing hepatic encephalopathy.⁴⁰ A 3–0 absorbable suture was tied in the middle of a 10 mm × 40 mm noncompliant balloon. A balloon-expandable covered stent 38 mm in length was then mounted onto this balloon, and deployed in the middle of the TIPS using the nominal pressure of the balloon. Due to the suture constraint, only the ends of the stent are flared to 10 mm diameter, creating an hourglass configuration. The middle of the constraining stent can then

be dilated to the desired diameter with a separate angioplasty balloon. One advantage of this approach is the ability to further dilate the stent graft at a later date, if desired.

In a similar approach to create an hourglass-shaped flow restrictor, Monnin-Bares et al reported the use of the “lasso technique” in five patients. A snare was created using a 0.021-inch guidewire doubled back within a 6 French guiding catheter, which was encircled around a 10-mm diameter balloon-expandable stent graft. The snare was then mounted around the middle of the stent graft, which was advanced through a 12 French sheath and inflated in the middle of the TIPS while keeping the snare tight to create an hourglass configuration. The diameter of the constrained portion could then be increased to the desired diameter with a separate angioplasty balloon. Improvement in encephalopathy was achieved in four of five patients.

Maleux et al reported a “parallel technique” for shunt reduction.⁴¹ Dual guidewire access was obtained across the TIPS from both an internal jugular and common femoral approach. A 6-mm diameter × 17-mm length balloon-expandable stent was positioned at the middle of the TIPS from one access. From the other access, a 10-mm-diameter Viatorr endoprosthesis was positioned adjacent to it. The balloon-expandable stent was first inflated, and with the balloon still inflated, the Viatorr endoprosthesis was deployed (►Fig. 2). Clinical improvement in encephalopathy was achieved in 76% of the 17 patients.

Acute Hepatic Failure

Hepatic failure after TIPS insertion is a rare but grave complication with a poor prognosis. Patients typically present with marked elevation in liver function test values, severe coagulopathy, and severe hepatic encephalopathy. Preprocedural assessment and patient selection are crucial for minimizing this complication. In patients with marginal hepatic functional status, care should be exercised in choosing a target

Fig. 2 TIPS flow reduction procedure using the parallel stent technique. A 50-year-old man developed acute hepatic failure and severe encephalopathy 1 month after TIPS insertion. (a) Digitally subtracted image demonstrates a widely patent TIPS extending from middle hepatic vein to right portal vein. (b) After insertion of a separate 10 French and 7 French vascular sheath via the right internal jugular vein with access through the TIPS, a 10 mm × 6 cm covered, 2 cm uncovered Viatorr endoprosthesis was positioned within the TIPS through the 10 French sheath. Prior to deployment, a 7 mm × 15 mm balloon-expandable bare metal stent was placed through the 7-French sheath at the midportion of the TIPS, which was expanded with balloon inflation (arrow). While the balloon was inflated, the Viatorr was deployed. (c) Fluoroscopic spot image demonstrates two overlapping Viatorr endoprostheses with a fully deployed balloon-expandable stent between the two Viatorr endoprostheses (arrow) that narrows the inner stent graft. (d) Patent TIPS after parallel TIPS flow reduction.

portosystemic gradient, since a large decrease may put at risk patients at higher risk for developing acute liver failure. It is recommended that patients with a Child–Pugh score >10 or MELD score >14 should not have their post-TIPS portosystemic gradient reduced to ≤ 5 mm Hg.⁴²

The actual etiology of hepatic decompensation after TIPS insertion is variable, but generally involves insult to an already-compromised liver in one or more of the following manners:

- TIPS insertion will markedly decrease the portal perfusion pressure and can in fact reverse portal vein flow, theoretically resulting in some degree of ischemia.⁴³
- Depending on its location and configuration, the TIPS can compress or occlude hepatic artery and/or portal vein

branches, resulting in ischemia or potentially infarction of that distribution.⁴⁴

- The covered portion of the TIPS can occlude one or more hepatic veins, particularly when there are shared origins, resulting in a Budd–Chiari-type hepatic ischemia and acute hepatic failure.⁴⁵

Contrast-enhanced CT can help ascertain the underlying etiology of acute hepatic failure. If no evidence of vessel occlusion or thrombosis is present, the etiology may be most likely related to the altered portal venous flow dynamics, and thus urgent TIPS occlusion with coils or plugs should be attempted.⁴³ Flow-decreasing techniques as described in the preceding section can also be attempted to avoid sacrificing the TIPS, although they may be of little or no benefit.⁴⁶

Ultimately, acute liver transplantation may be the only effective therapy for this disastrous complication.

Biliary Complications

Biliary obstruction is a contraindication for TIPS due to the high likelihood of biliary injury and resultant complications in this setting. However, TIPS-related biliary complications can occur even in a patient with nondilated bile ducts. During TIPS insertion, the TIPS can transect a bile duct. If a bare metal stent is used, there can be communication between the TIPS and the biliary tree resulting in a biliary-venous fistula, with clinical manifestations that include TIPS occlusion, hyperbilirubinemia, anemia, multiorgan failure, and/or sepsis.⁴⁷⁻⁴⁹ However, such fistulas should theoretically not occur with TIPS creation using the Viatorr endoprosthesis, since such fistulas would be sealed off by the expanded polytetrafluoroethylene (ePTFE) covering.⁵⁰ However, in the setting of a colonized biliary tree the TIPS could become infected at a later date.⁵¹ Indeed, biliary-venous fistulas are now less common with the widespread use of endografts for TIPS tract formation.⁵² TIPS stents can also cause bilomas and/or biliary occlusion secondary to bile duct compression,⁵³ requiring biliary decompression. Rarely, rapid hepatic decompensation may occur, expediting the need for orthotopic liver transplantation.⁵³

Transjugular Intrahepatic Portosystemic Shunt Migration

Migration is a recognized complication of TIPS stents. In the postdeployment period, it is important for the interventionalist to maintain wire access across the stent until satisfactory positioning is confirmed with portal venography, in case retrieval is needed. Cephalad migration of the stent into the IVC or heart may cause cardiac arrhythmia, atrial perforation, aorto-atrial fistula, or IVC thrombosis. Cephalad migration of the stent may also complicate clamping of the IVC during liver transplantation.^{8,54} If retrieval is necessary, it can be difficult or impossible to engage a snare over the struts of the stent, depending on the configuration and location of the central edge of the stent. In some cases, an angioplasty balloon can be used to help snare the stent for removal through the sheath.⁴⁵ To accomplish this, a snare is loaded over an angioplasty balloon that is sized appropriately to the TIPS stent size. The balloon is advanced partially into the TIPS. Once inflated, the balloon provides a gradual taper to the stent, thus allowing one or more snares to be advanced over the outside of the stent. The balloon is then deflated and removed, and the snare (s) can be cinched to grasp and constrain the TIPS stent. A jugular venotomy or surgical cutdown may be needed to facilitate removal if the stent is not well constrained. Stent migration may also be delayed, as in the 3-week stent migration to the heart reported in an 11-year-old child.⁵⁵ Extracting a stent from the heart is difficult because of cardiac motion, with reported complications including valve damage, myocardial penetration, fatal arrhythmia, and pericardial tamponade. Nonextraction of an intracardiac TIPS may also be an option, with one patient reported to be asymptomatic at 6 years.⁵⁵ In addition to superior migration, the stent may also

migrate inferiorly into the main portal vein. Excessive projection of the TIPS into the main portal vein can increase the complexity of liver transplantation, requiring reconstruction of the main portal vein and, possibly, the superior mesenteric vein and splenic vein. In these rare cases, the use of a retropancreatic “pant” donor-iliac vein graft may be required.^{56,57}

Early Acute Occlusion

Meta-analysis has shown that reintervention to reestablish or maintain the patency of the shunt is required in 70 to 90% of patients within 2 years of TIPS creation; the secondary- or primary-assisted patency rate during a 2- to 5-year follow-up period is reportedly between 72 and 91%.⁵⁸ In patients with recurrent thrombotic TIPS occlusion, hypercoagulopathy should be ruled out, as it is not uncommon that patients referred for TIPS have underlying risk factors predisposing them to thrombosis.⁵⁹ Despite this, acute shunt thrombosis is reported in fewer than 5% of TIPS insertions. With bare metal stents, acute TIPS occlusion is often thought to be related to biliary-venous fistulas, given the thrombogenicity of bile. Thus, it may not be surprising that the incidence of TIPS thrombosis has decreased considerably by the widespread adoption of PTFE-covered stents. In fact, much of the epidemiologic data regarding TIPS occlusion were reported prior to the widely adopted use of covered stents. When thrombosis occurs, management of acute TIPS occlusion is often via a combination of angioplasty and thrombolysis performed via local catheter-directed infusion of lytic agents such as recombinant tissue-type plasminogen activator. Currently, no convincing data are available regarding the use of anticoagulation for preventing episodes of rethrombosis.

With the Viatorr endoprosthesis, early acute TIPS thrombosis of uncertain etiology rarely occurs; much more common is structural obstruction of flow causing thrombosis related to suboptimal TIPS position or configuration (► **Fig. 3**). Causes include suboptimal TIPS positioning or migration of the TIPS due to the following:

- a. The central margin of the TIPS lies within the parenchymal tract,
- b. The central margin of the TIPS is directed toward the superior wall of the hepatic vein in a perpendicular fashion, or
- c. The central margin of the TIPS projects excessively into the IVC with the stent graft abutting the side of the IVC.

In all the three scenarios, flow through the TIPS is obstructed, potentially resulting in TIPS thrombosis. While portal venography performed immediately after TIPS insertion may show acceptable TIPS configuration and flow through the TIPS, removal of the guidewire or catheter may slightly alter the configuration of the TIPS, resulting in compromised flow that is much different than the final portal venogram. Doppler ultrasound is often suboptimal for assessment of TIPS patency in the immediate post-TIPS period with the Viatorr endoprosthesis due to microbubbles encapsulated within the ePTFE covering, making it impermeable to insonation.⁵²

Fig. 3 Various malpositioned TIPS configurations that have obstruction of flow with risk for spontaneous thrombosis. (a) The superior margin of the TIPS terminates within the hepatic parenchymal tract. (b) The superior margin of the TIPS abuts the hepatic vein wall. (c) The superior margin of the TIPS abuts the IVC wall. For scenarios B and C, there will be obstruction of flow if a Viatorr endoprosthesis is used. (d) Appropriate TIPS positioning.

Acute TIPS thrombosis can be treated with mechanical thrombectomy or catheter-directed thrombolysis.^{60–63} For cases of suboptimal configuration (a) and (b) above, attempts can be made to cannulate the TIPS and extend the TIPS with another stent. If this is not feasible, creation of a new TIPS will be required. In the case of scenario (c) above, consideration can be given to removing the stent graft using a snare. Alternatively, if the patient is not a liver transplant candidate, the TIPS could potentially be extended with an additional stent graft into the right atrium. If an underlying stenosis is identified that was unnoticed at the time of TIPS insertion, angioplasty can be performed with consideration given to deployment of a new Viatorr endoprosthesis within it.⁶⁴

Delayed Complications

Recurrent Symptoms of Portal Hypertension

Prior to the widespread adoption of the Viatorr endoprosthesis, recurrent variceal bleeding was seen in 23 to 40% of patients after 2 years largely due to the use of bare metal stents, which have primary patency rates of 8 to 48% at 2 years.⁶⁵ However, the use of the Viatorr endoprosthesis for TIPS has resulted in a markedly prolonged shunt patency up to 76% at 2 years.^{66,67}

When recurrent symptoms of portal hypertension are encountered, or when sonographic findings suggest shunt dysfunction, TIPS angiography with portosystemic gradient measurement is warranted. Stenosis of the hepatic vein at the margin of the TIPS is the most common site of pathology, followed by an intra-TIPS stenosis, both of which are typically well treated with balloon angioplasty.⁶⁸ The propensity for

hepatic vein stenosis underscores the need to extend the TIPS to the terminus of the hepatic vein at the time of deployment. Stenoses within the TIPS or outflow vein can sometimes be difficult to appreciate on TIPS angiography. Thus, if the portosystemic gradient is significantly elevated when compared with the initial post-TIPS insertion gradient, empiric angioplasty throughout the entire TIPS to the IVC is indicated. In cases where the lesion is nonresponsive to angioplasty, with a persistently elevated portosystemic gradient, relining the TIPS with a new Viatorr endoprosthesis is indicated.⁶⁹

In patients with TIPS occlusion, an underlying stenosis is typically present. In these cases, pharmacologic thrombolysis and/or mechanical thrombectomy followed by angioplasty and/or new Viatorr deployment can be considered (→ Fig. 4).^{61,62} If unsuccessful, a new (parallel) TIPS insertion can be attempted.

In cases where a high portosystemic gradient persists despite TIPS insertion and despite empiric angioplasty, the presence of a rare arterial-portal shunt, either congenital or acquired from previous liver biopsy or trauma, should be ruled out.⁷⁰ In the absence of such a shunt, placement of a second TIPS should again be considered. He et al placed 10 such “parallel” TIPS without complications, reducing the portosystemic gradient from 35.6 ± 2.9 mm Hg to 15.3 ± 3.3 mm Hg.⁷¹ The TIPS was created directly from the IVC in four patients in whom the right hepatic vein was not available for use.

Patients with portal hypertensive ectopic varices (i.e., colonic, ileal, jejunal, duodenal, parastomal) have a high rate of rebleeding following a successful TIPS. Vangeli et al reported that 5 (42%) of 12 patients who underwent a successful TIPS for ectopic varices rebled within 48 hours.⁷² The rate of rebleeding was reduced to 28% (two of seven patients) if the ectopic varices were embolized concurrently with TIPS creation. Variceal embolization can be performed before or after TIPS stent placement. An advantage of pre-TIPS embolization is the reduction of systemic coil migration and nontarget embolization risk.⁸

Hernia Incarceration

Patients with abdominal and inguinal hernias undergoing TIPS for refractory ascites are at increased risk for hernia complications, with an estimated incidence of up to 25%.⁷³ These potentially severe complications occur when resolution of massive ascites after TIPS insertion alters the intra-peritoneal anatomy and configuration, leaving bowel entrapped in hernias. In a study evaluating the risk of hernia incarceration following TIPS, Smith et al found that 13 of 14 (93%) patients with hernia complications required emergent surgery, of which 4 (29%) patients needed bowel resection for necrosis.⁷³ The median time to presentation is 62 days (range, 2–588 days) after TIPS; a high index of suspicion with prompt referral to a general surgeon should be undertaken.

Infection

Tipsitis or endotipsitis is the rare occurrence of TIPS stent infection.^{51,74,75} Kochar et al reported an incidence of 1% in their series of 785 patients.⁷⁶ Tipsitis should be suspected in a

Fig. 4 Successful revision of a thrombosed TIPS. A 48-year-old man presented with recurrent ascites six months after successful TIPS insertion using a Viatorr endoprosthesis. Sonographic evaluation of the TIPS was suggestive of TIPS thrombosis. (a) Portal venogram demonstrates complete lack of flow through the TIPS. The portosystemic gradient was 28 mm Hg. (b) Mechanical thrombectomy was performed with a rotational thrombectomy device throughout the TIPS followed by angioplasty throughout the TIPS with a 10-mm-diameter noncompliant balloon. A severe waist was demonstrated at the hepatic vein origin (arrow). Of note, the originally deployed TIPS did not extend to the hepatic vein origin. (c) Follow-up portal venogram demonstrates minimal flow through the TIPS with a persistent subtotal occlusion of the outflow hepatic vein. (d) Completion image demonstrating excellent flow through the TIPS after a 2-cm-longer Viatorr endoprosthesis was deployed within the existing Viatorr, resulting in coverage of the stenosis at the hepatic vein origin. The portosystemic gradient was 7 mm Hg at completion of the case, and the patient's ascites resolved several weeks later.

patient with TIPS experiencing sustained, unexplained bacteremia. Isolated organisms include *Enterococcus faecalis*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Candida albicans*, *Candida parapsilosis*, *Lactobacillus rhamnosus*, *Escherichia coli*, and *Enterobacter cloacae*.⁷⁶ Treatment options are limited to lifetime antibiotics or orthotopic liver transplantation, as the stent typically cannot be removed.

Conclusion

TIPS remains a relatively safe procedure, having become an established procedure for treatment of complications related to portal hypertension. However, the technical complexity of this intervention introduces risk, and morbidity rates can be as high as 20%. A clear understanding of the procedure and knowledge of potential complications can potentially reduce procedure-related complications.

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