Transjugular Intrahepatic Portosystemic Shunt - Radiology

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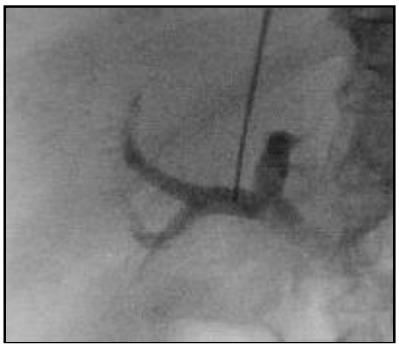
Overview

A transjugular intrahepatic portosystemic shunt (TIPS) is a percutaneously created connection within the liver between the portal and systemic circulations. A TIPS is placed to reduce portal pressure in patients with complications related to portal hypertension.[1, 2] This procedure has emerged as a less invasive alternative to surgery in patients with end-stage liver disease.

Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. A curved catheter is placed into the right hepatic vein.



Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. Image demonstrates advancement of a Colapinto needle into the right portal vein.

The goal of TIPS placement is to divert portal blood flow into the hepatic vein, so as to reduce the pressure gradient between portal and systemic circulations. Shunt patency is maintained by placing an expandable metal stent across the intrahepatic tract.

History

In 1969, Rosch first described the establishment of a percutaneous tract between the portal vein (PV) and the hepatic vein from a jugular approach.[3] He used serial dilators to create a shunt within the liver and advocated the use of silicone tubing across the hepatic parenchyma to create a functional shunt. Further progress was made in 1977, with the work of Reich and coworkers, who used a 9-mm cryoprobe to create larger parenchymal tract in a swine model.[4] These early pioneers realized that intraparenchymal tracts, either unsupported or supported with a

silastic stent, had poor patency and were usually complicated by complete occlusion within a short period.

Colapinto reported the first clinical use of transjugular intrahepatic portosystemic shunt in a patient with cirrhosis that involved a 12-mm angioplasty balloon to expand the intrahepatic tract. However, this technique also resulted in poor patency.[5] Long-term TIPS patency was not accomplished until the introduction of metallic stents in the 1980s. This resulted in the establishment of TIPS as a percutaneous alternative to the surgical portosystemic shunts.

The TIPS procedure has gained worldwide acceptance. Technical refinements have resulted in reduced morbidity and improved clinical success.

The Gore VIATORR TIPS Endoprosthesis was approved by the FDA in 2004 for the treatment of portal hypertension and can be used in both de novo and revision procedures. The expanded polytetrafluoroethylene graft lining reduces bile and mucin permeation, thereby improving patency. It also reduces ingrowth of tissue into the graft, which can be advantageous for subsequent liver transplantation.

Indications

The United States National Digestive Diseases Advisory Board has established a set of clinical indications for TIPS placement.[1] These accepted indications are as follows:

- Acute variceal bleeding that cannot be successfully controlled with medical treatment, including sclerotherapy
- Recurrent and refractory variceal bleeding or recurrent variceal bleeding in patients who cannot tolerate conventional medical treatment, including sclerotherapy and pharmacologic therapy

Unproven but promising indications include the following:

- Therapy for refractory ascites[6]
- Portal decompression in patients with hepatic venous outflow obstruction (Budd-Chiari syndrome),[7] hepatic hydrothorax, or hepatorenal syndrome

Unproven uses include the following:

- Initial therapy of acute variceal hemorrhage
- Initial therapy to prevent initial or recurrent variceal hemorrhage
- Reduction of intraoperative morbidity during liver transplantation

Absolute contraindications include the following:

- Right-sided heart failure with increased central venous pressure
- Polycystic liver disease
- Severe hepatic failure

Relative contraindications include the following:

- Active intrahepatic or systemic infection (bacteria can colonize the stent, causing persistent infection)
- Severe hepatic encephalopathy poorly controlled with medical therapy
- Hypervascular hepatic tumors
- PV thrombosis (Although PV thrombus may make the procedure more technically demanding, it is not an absolute contraindication to TIPS placement.)

Patient Preparation For Tips Placement

All patients undergoing transjugular intrahepatic portosystemic shunt placement should receive prophylactic broad-spectrum antibiotics. Appropriate resuscitation with fluid and blood products is indicated prior to the procedure. Portal vein (PV) patency should be confirmed prior to attempts at TIPS placement.

At the author's institution, all potential patients for TIPS placement undergo preoperative evaluation with duplex sonography to determine if the PV is patent. If the Doppler sonographic findings are inconclusive, arterial portography via the splenic or superior mesenteric arteries can be performed to evaluate PV anatomy and patency. In the presence of reversed intrahepatic portal flow, the PV may not fill during arterial portography, however. Magnetic resonance venography may have a role in assessing PV patency prior to TIPS. An alternative approach in

a patient with inconclusive sonograms can be wedged hepatic venography with CO_2 from the jugular vein.

Patients with cirrhosis often have coagulopathy, and severe coagulopathy should be addressed prior to any invasive procedure. Platelets are routinely administered when platelet counts are less than 50,000 mm^3, and fresh frozen plasma (FFP) is used with an international normalized ratio (INR) greater than 2.0.

Tips Placement Technique

Most patients can safely undergo transjugular intrahepatic portosystemic shunt placement with intravenous conscious sedation involving short-acting benzodiazepines and opiates. Some institutions prefer general anesthesia during TIPS procedures because of the prolonged nature of the procedure and the degree of discomfort that many patients experience during the transvenous punctures. The technique is fairly standard and has been well described in the scientific literature, with some minor variations related to the interventionalist or the center at which the procedure is performed.

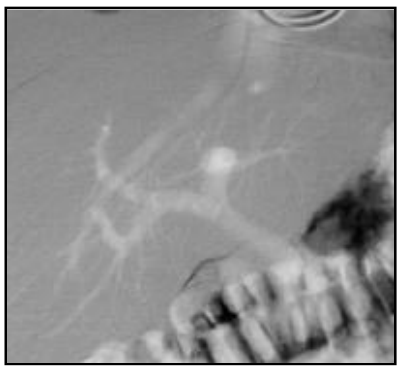
Commercially available sets that are specifically designed for TIPS placement are available in the United States:

- Colapinto transjugular cholangiography liver biopsy set (Cook). This includes a 16-gauge Colapinto puncture needle.
- Rosch-Uchida transjugular liver access set (Cook). This includes a 14-gauge needle with a trocar.
- Angiodynamics transjugular access set (Angiodynamics).
- Ring transjugular intrahepatic access set (Cook)

At the author's institution, the right internal jugular vein is accessed, usually with ultrasonographic guidance. The left jugular vein may also used if the right vein is unsuitable for any reason. Techniques involving a femoral venous approach have also been described, but these are used much less commonly, and they are technically more demanding.[8, 9, 10]

With standard catheter exchange, a 5F catheter with a multipurpose curve is placed into the right hepatic vein. The catheter is wedged in a peripheral branch of the right hepatic vein. Wedged hepatic venography is then performed with carbon dioxide gas to opacify the portal venous system.

Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. A curved catheter is placed into the right hepatic vein.



Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. A wedged hepatic venogram obtained by using the digital subtraction technique obtained with CO2 gas demonstrates the location of the portal vein. The catheter is wedged in a branch of the right hepatic vein.

Typically, a 50-mL manual injection of CO_2 is used. This procedure usually demonstrates the location of the main PV, as well as that of the left and right branches. Frequently, more than one CO_2 injection is required to obtain a good portogram. If wedged injection fails to fill the PV, an occlusion balloon catheter may be used. Biplane CO_2 wedged hepatic venograms and biplane fluoroscopy can be used.

By using the wedged hepatic venogram images as a guide, the Colapinto needle is advanced through the wall of the right hepatic vein and directed in an anteroinferior direction to access the right PV.

Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. Image demonstrates advancement of a Colapinto needle into the right portal vein.

Some have advocated injecting CO_2 as the 21-gauge fine needle is advanced through the liver to more definitively guide the puncture. Once the portal vein has been cannulated, CO_2 is injected into the parenchymal tract to exclude transgression of the bile duct or hepatic artery. If the bile duct has been transgressed, the access may be abandoned; or if a small branch has been transgressed, a covered stent such as the Gore VIATORR TIPS Endoprosthesis is placed.

The Viatorr Gore polytetrafluoroethylene-covered stent (in 316 patients) was compared with standard uncovered stents (in 157 patients) for measurement of shunt function and clinical efficacy by Tripathi et al. The investigators found that the Viatorr covered stent had lower rates of shunt insufficiency (8% vs 54%), variceal bleeding (6% vs 11%), and hepatic encephalopathy (22% vs 32%). Mortality rates were similar for the 2 groups.[11]

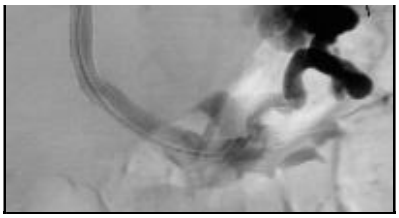
If a good wedged venogram cannot be obtained, selection of an appropriate site for puncture from the hepatic vein to PV is accomplished with a thorough understanding of the hepatic anatomy. The right hepatic vein lies superior and posterior to the PV bifurcation, and the right PV usually courses lateral to the T11 vertebral body. The portal bifurcation may be extrahepatic in a large percentage of patients. An extrahepatic puncture can lead to life-threatening hemorrhage, whereas puncture of a peripheral portal venous branch can create an angle that is too acute for successful TIPS placement.

From the right hepatic vein, the needle is usually aimed anteromedially and caudally then advanced 3-4 cm within the liver. Several punctures may be necessary for success. Large-volume paracentesis before TIPS in a patient with massive ascites can facilitate cannulation of the hepatic vein and puncture of the PV.

The needle is gently aspirated as it is withdrawn across the parenchymal tract. Once portal venous blood is freely aspirated, contrast material is injected through the needle to verify the point of entry into the vessel. An intrahepatic access site with entry into the right PV at least 1 cm from the main PV bifurcation is desired. A guidewire and catheter are advanced into the PV, and portal venography is performed.

Pressure measurements are obtained in the PV as well as in the right atrium. The difference between the measured pressures yields the portosystemic gradient. If the pressure gradient is significantly elevated (>12 mm Hg), the TIPS is placed. If the gradient is not elevated, the presence of a competitive shunt, such as a spontaneous splenorenal shunt, must be evaluated. The spontaneous shunts can be used to lower the portosystemic gradient, but they are not true vessels and lack normal vascular integrity, which poses a risk for rupture.

The intrahepatic parenchymal tract is dilated with an 8- or 10-mm high-pressure balloon such as Conquest high-pressure balloon (Bard). Images of the initial balloon waist are saved because they demonstrate the locations of the PV entry site and the hepatic vein exit site. A self-expanding metallic stent, such as the Wallstent (Boston Scientific), is then deployed across the tract and dilated to the desired diameter by using an angioplastic balloon.



Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. A TIPS (10 X 68 mm Wallstent dilated with 10 mm X 4 cm balloon) has been placed. Note flow through the Wallstent and filling of the splenorenal shunt. The intrahepatic portal flow became reversed after TIPS placement.

Proper stent placement is crucial, especially if the patient is undergoing subsequent orthotopic liver transplantation. The stent should form a smooth and gentle curve and must extend adequately into the portal and hepatic veins. Overextension of a stent into the PV, hepatic vein, or inferior vena cava can be problematic for the transplant surgeon. The Wallstent significantly shortens as it is deployed, and the ability to predict and achieve appropriate final stent placement improves with experience. Self-expanding nitinol stents minimally shorten with deployment are also available from multiple manufacturers, and the use of one of these may be helpful for more predictable stent placement.

The stent may need to be dilated 8-12 mm, depending on the indication for TIPS and the stent used. Postplacement venography is performed and pressures are measured to confirm adequate stent positioning, good flow through the TIPS, and reduction in the portosystemic gradient. If needed, additional stent placement or further balloon dilation can be performed to obtain a final portosystemic gradient of 8-12 mm Hg. Postplacement venography revealing persistent variceal filling indicates that insufficient decompression has been achieved with the stent. These varices can be selectively catheterized and embolized with coils.

Complications And Advanced Techniques

Complications

A large number of complications can occur during and after placement of a TIPS.[12, 13] Complications related to the puncture site include pneumothorax, vessel or tissue injury, and arteriovenous fistula formation. Ultrasonographic guidance for the jugular puncture can minimize these complications. Placement of the catheter in the right atrium can cause serious cardiac dysrhythmias. Cardiac monitoring should be continued throughout the TIPS procedure and during the initial postprocedural period.

Complications can occur during the creation of the intrahepatic tract. The needle can injure the hepatic artery or bile ducts. Capsular tears can result in life-threatening hemorrhage when they occur in association with a hepatic artery puncture. Portal venous puncture in an extrahepatic location can result in significant bleeding complications. Puncture of the right PV at least 1-2 cm distal to the PV bifurcation more often than not assures that an intrahepatic TIPS has been created.

A major concern of a newly placed TIPS is new-onset or worsened encephalopathy, which occurs in about 25% of treated patients.[14, 15] Patients with preprocedural hepatic encephalopathy or Child class C cirrhosis are more likely to have this complication. Shunt diameter and degree of portosystemic gradient reduction are related to the development of encephalopathy. Most often, hepatic encephalopathy can be medically treated with lactulose and dietary protein restriction, although shunt revision to a smaller diameter or intentional shunt thrombosis may be necessary. Patients often have hepatic encephalopathy immediately after shunt placement, and symptoms diminish as the shunt undergoes fibrous changes and resultant narrowing over time.

In a retrospective case analysis of 136 patients post-TIPS by Masson et al, hepatic encephalopathy developed in 34.5% of patients, and the frequencies were similar with covered and uncovered stents. The most significant predicting factor was the presence of pre-TIPS hepatic encephalopathy. Minimal encephalopathy occurred in 49% of patients at 26-month follow-up; and 10.3% of patients developed post-TIPS encephalopathy that required liver transplantation or contributed to death. The authors concluded that although post-TIPS hepatic encephalopathy is rather common, it is usually short-lived and well managed if patients are carefully selected for the procedure.[16]

Aside from hepatic encephalopathy, the second most common complication associated with TIPS placement is shunt stenosis and occlusion. Early shunt thrombosis (often within 24 h) is usually believed to be secondary to extension of the intrahepatic tract across a bile duct. Such early shunt occlusions can be treated with balloon dilation of the stent. The use of covered (polytetrafluoroethylene [PTFE], polyester) stents to improve primary and secondary shunt

patency may prove helpful.

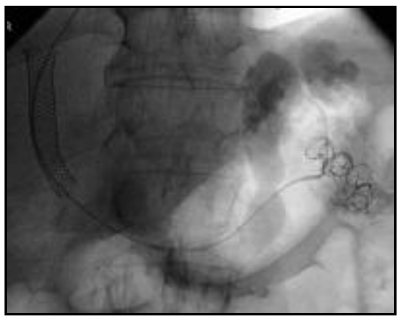
Deterioration of the patient's hemodynamic status is also a concern after TIPS placement because acute increases in cardiac output and central venous and pulmonary wedge pressures can result in acute pulmonary edema and congestive heart failure.[17] Patients should be closely monitored after the procedure until their hemodynamic status stabilizes.

Advanced TIPS techniques

Various techniques to facilitate portal venous access, including ultrasound guidance, have been described. If standard portal venous access fails, the author prefers to percutaneously place a transhepatic Chiba needle, which can be used as a target under fluoroscopy to advance the Colapinto needle. This approach adds an extra step to the procedure, and it is usually not appropriate in patients with large amounts of perihepatic ascites. Alternatively, puncture of a patent umbilical vein can provide access into the portal system. An approach for creating a TIPS by using a combination of transfemoral access to the hepatic vein with transmesenteric access to the portal system by means of minilaparotomy has also been described.[18]

If direct PV and right atrial pressures (measured to determine the portosystemic gradient) show a less-than-expected gradient, a competitive shunt (spontaneous splenorenal or large varices) should be excluded by advancing the catheter into the splenic or mesenteric vein and injecting bolus of contrast agent with digital imaging.

Competitive shunts can be selectively embolized with coils, if necessary. Although the shunts may decrease the portosystemic gradient, they are thin walled and can spontaneously rupture, causing life-threatening hemorrhage. If no competitive shunt is found and if the gradient is less than 12 mm Hg, TIPS is not indicated, and alternative explanations for the bleeding should be sought. Upper GI bleeding may be related to a cause other than portal hypertension in as many as 25% of cases.



Basic transjugular intrahepatic portosystemic shunt (TIPS) procedure. Coil embolization of the splenorenal shunt has been performed.

An 8-mm diameter stent is usually acceptable in patients with refractory ascites, whereas a 10-12 mm shunt may be needed in patients with life-threatening hemorrhage. Wallstents can be overdilated to about 10% larger than their nominal diameter to allow further gradient reduction. Nitinol stents cannot be overdilated in this way. In some cases, 2 parallel shunts are required to effectively lower the portosystemic gradient. Most commonly, TIPS results in complete reversal of intrahepatic PV flow and markedly reduces variceal blood flow.

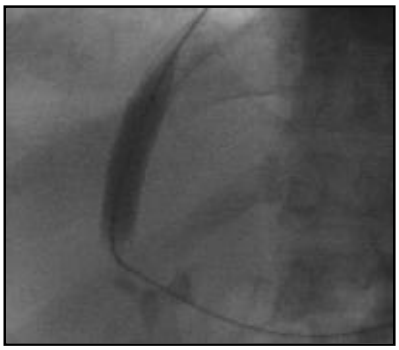
Clinical Results And Imaging Follow Up

Clinical results

The technical success of TIPS placement is related to the experience and skill of the interventional radiologist. Data from 3 large centers (University of California–San Francisco, University of Pennsylvania, and Freiberg group) demonstrate technical success rates of more than 90%. Successful TIPS placement results in a portosystemic gradient of less than 12 mm Hg and immediate control of variceal-related bleeding.[19, 20, 21] A target portosystemic gradient of 12 mm Hg is used as varices tend not to bleed when the gradient is less than 12 mm Hg. When technical failure occurs, it is usually due to an anatomic situation that prevents acceptable portal venous puncture. Significant reduction in ascites usually occurs within 1 month of the procedure, and this is estimated to occur in 50-90% of cases.[6, 8, 22]

Late stenosis and occlusion are usually related to pseudointimal hyperplasia within the stent or, more commonly,

intimal hyperplasia within the hepatic vein. In most cases, the stenotic stent can be crossed with a guidewire and recanalized with balloon dilation or repeat stent placement to improve long-term patency rates. Primary patency after TIPS placement has been reported to be 66% and 42% after 1 and 2 years. Primary-assisted patencies at 1 and 2 years are reported to be 83% and 79%, respectively, and secondary patency at 1 and 2 years are reported to be 96% and 90%.[8]



Balloon angioplasty used to treat hyperplasia.

Mortality rates at 30 days vary among centers, and nearly all centers report few or no deaths directly related to the procedure itself. Early mortality has been shown to be related to an Acute Physiology and Chronic Health Evaluation (APACHE) score of II. Patients with severe systemic disease with an APACHE II score higher than 20 have a greater risk for early mortality, compared with others.[23]

Patients with active bleeding during the procedure also have increased early mortality. The 30-day mortality rates are 3-30%; the variation in the range is related to the preprocedural Child classification and whether the procedure was performed on an emergent or elective basis.[9, 24, 25, 26] In 1995, LaBerge et al reported that cumulative survival rates in patients with Child grades of A, B, and C, respectively, were 75%, 68%, and 49% at 1 year and 75%, 55%, and 43% at 2 years.

Clinical imaging follow-up

The high frequency of shunt stenosis warrants close surveillance with Doppler ultrasonography or portography. At the author's institution, patients undergo a baseline Doppler study within 24 hours of the procedure to document functional parameters, including the direction of PV flow and flow velocities throughout the shunt and within the hepatic vein. Although TIPS venography with direct portal and right atrial pressure measurements is the criterion standard for stent assessment, high sensitivity and specificity for shunt function has been reported with certain Doppler criteria.[27, 28]

- Absent flow
- Low peak shunt velocity (< 50 to 90 cm/s)
- High peak shunt velocity (190 cm/s)
- Low mean PV velocity (< 30 cm/s)
- Return of antegrade flow in the intrahepatic PVs
- Significant change in shunt velocity (>50 cm/s) compared with the immediate postprocedural result

Surveillance ultrasonography is performed at the author's institution at 3 and 6 months after the procedure and twice yearly thereafter. If clinical evidence of TIPS malfunction is present, ultrasonography may be performed more frequently.

Conclusion

TIPS placement is an effective means of lowering portal venous pressure and controlling acute and recurrent variceal bleeding. The shunt can be placed in almost all patients who require portal decompression. Procedural times have decreased, and success rates have increased with operator experience. Unlike surgically placed shunts, TIPS does not alter the extrahepatic anatomy; therefore, it remains a feasible nonsurgical alternative in many patients, and it is particularly effective as a bridge to liver transplantation.

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