DIR

Diagn Interv Radiol 2024; DOI: 10.4274/dir.2022.221539

INTERVENTIONAL RADIOLOGY

PICTORIAL ESSAY

Techniques for portal vein targeting during a transjugular intrahepatic portosystemic shunt

Dan Laney
Hector Ferral
Alexandra Fairchild
Bahri Üstünsöz

Louisiana State University Health Sciences Center, Department of Radiology, Division of Interventional Radiology, Los Angeles, USA

ABSTRACT

A transjugular intrahepatic portosystemic shunt (TIPS) is one of the most challenging procedures in interventional radiology. Hepatic and portal venous anatomy can be highly variable, and access to the portal vein, which can be quite difficult even for experienced surgeons, is the most critical step in a TIPS. Although there are multiple techniques to achieve a portal venous puncture, each access technique carries a unique set of risks and benefits. Thus, knowledge of these assistive techniques will add to the resources available to the surgeon when planning and subsequently performing a TIPS and, ultimately, increase the likelihood of a safe and successful procedure.

KEYWORDS

Hepatic vein, interventional, portal hypertension, portal vein, TIPS

A transjugular intrahepatic portosystemic shunt (TIPS) is one of the most challenging procedures in interventional radiology. It entails the creation of a shunt between the portal and hepatic venous systems, and access into the portal venous system is the critical step in a TIPS creation. Multiple techniques have been described concerning portal venous access, and each one carries a unique set of risks and benefits. The purpose of this article is to investigate the different techniques that have been described for portal venous access during a TIPS procedure.

Access techniques in patients with a patent portal vein

Direct and indirect portograms

The direct portogram technique was one of the first described techniques for guiding portal vein access during a TIPS procedure. This technique requires the placement of a catheter into a patent portal vein branch. The catheter is advanced into the main portal vein, and contrast is injected to demonstrate the portal venous anatomy. Direct access to the portal vein can be obtained by using an ultrasound-guided transhepatic approach or by ultrasound-guided access into a patent paraumbilical vein (Figure 1). An indirect portogram is another of the first described TIPS guiding techniques. A high-quality portal venogram is obtained by imaging the venous phase of a selective power injection of contrast into the superior mesenteric artery. Figure 2 illustrates the indirect portogram technique.

Iodinated contrast wedge portogram

With this technique, a contrast wedge portogram is obtained by injecting iodinated contrast through an end-hole catheter placed in a wedged position in the distal hepatic vein (Figure 3). Some of the iodinated contrast will pass through the sinusoids resulting in opacification of the portal venous system. Using this technique, the main portal vein is seldom opacified because of the viscous nature of the iodinated contrast. Krajina et al.[1] found that a wedged contrast portogram resulted in the visualization of the bifurcation of the portal vein

Corresponding author: Dan Laney

E-mail: dlane1@lsuhsc.edu

Received 06 Aug; revision requested 19 Sept; accepted 14 Nov 2022.

Epub: 21.12.2022

Publication date: 08.01.2023

DOI: 10.4274/dir.2022.221539

You may cite this article as: Laney D, Ferral H, Fairchild A, Üstünsöz B. Techniques for portal vein targeting during a transjugular intrahepatic portosystemic shunt. *Diagn Interv Radiol.* 2024;30(1):42-47.

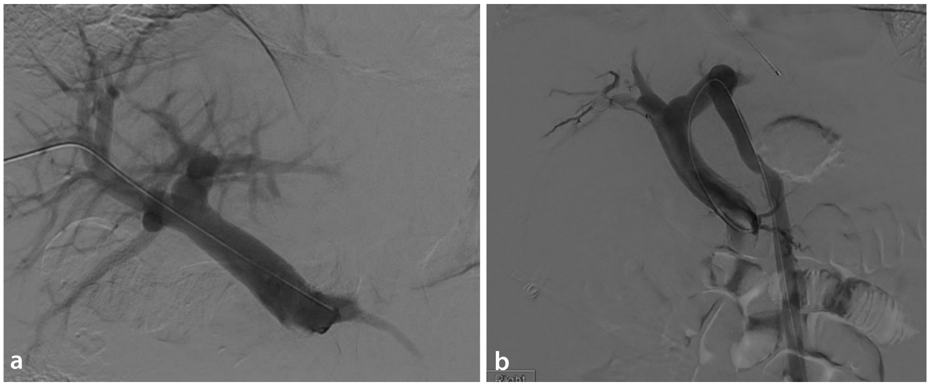

Figure 1. Direct portography techniques: the catheter is inserted directly into the portal vein via a transhepatic approach **(a)** or a via a patent umbilical vein (white arrow) **(b)**.

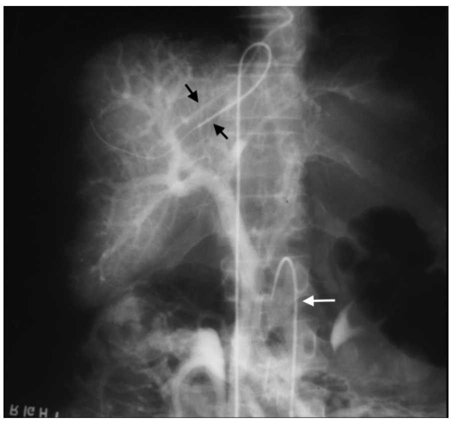

Figure 2. Indirect portogram: the radiograph shows a selected image obtained during the venous phase of a superior mesenteric artery (SMA) arteriogram. There are two catheters in the hepatic veins for reference (black arrows). An arterial catheter was placed in the SMA (white arrow), and an SMA portogram was performed (40 mL at 5 mL/sec). The image shows the relationship between the portal veins and the hepatic veins.

in 25% of patients, while only part of the portal vein was visualized in 36% of patients, and there was no portal vein opacification in 39% of patients. The major drawback of this technique is that the injected iodinated contrast can dissect into the liver parenchyma, resulting in permanent staining and obscuring visualization of the relevant vascular anatomy later in the procedure. This technique also carries the risk of liver laceration with capsular perforation.

Main points

- Multiple techniques exist to assist in portal venous puncture during a transjugular intrahepatic portosystemic shunt.
- Each portal vein access technique carries a unique set of risks, benefits, advantages, and disadvantages.
- Knowledge of these techniques increases the likelihood of a safe and successful procedure.

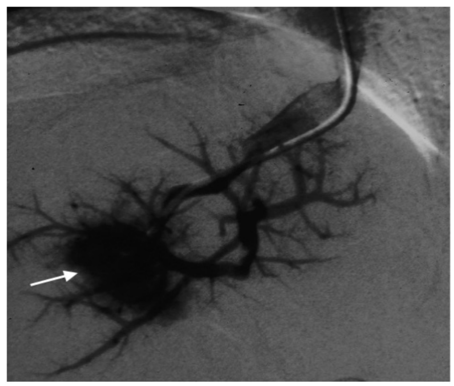

Figure 3. Contrast wedge injection: a catheter was wedged distally within the right hepatic vein to perform a portogram with iodinated contrast, resulting in opacification of the portal vein and an area of parenchymal staining (white arrow).

CO_2 wedge portogram and direct parenchymal CO_2 injection

A CO_2 wedge portogram is a very effective technique to map the position of the portal vein. The CO_2 wedge portogram is obtained by placing either an end-hole catheter or an occlusion balloon in the wedged position in the distal hepatic vein and gently injecting 10–15 mL of CO_2 (Figure 4). The two techniques are comparable, although it has been proposed that the occlusion balloon technique could be safer. Multiple studies have shown CO_2 to be a useful contrast agent for opacification of the portal venous system during a TIPS. Krajina et al.[1] demonstrated that the use of CO_2 leads to superior visualization of the portal vein compared to iodinated contrast during wedged hepatic venography due to the less viscous nature of CO_2. Using CO_2 as the contrast medium for wedged hepatic venography, opacification of the portal vein bifurcation was seen in 87% of patients, and there was no visualization of the portal venous system in 7% of patients, compared with 25% and 39%, respectively, when an iodinated contrast medium was used. Additionally, the CO_2 does not stain the liver parenchyma, but, as with the previous technique, liver laceration with capsular rupture is a risk of this procedure.

Direct parenchymal injection of CO_2 can be used as an alternative to a CO_2-wedged hepatic venogram. This technique is useful when the portal vein is not visible after a CO_2-wedged venogram during a TIPS procedure (Figure 5) and involves advancing the transhepatic needle into the liver parenchyma. This is followed by a gentle injection of 10–15 mL of CO_2 directly into the parenchyma. Forceful injection of CO_2 should be avoided due to the risk of capsular rupture. An alternative technique is to perform a direct ultrasound-guided transhepatic puncture with a 21-gauge Chiba needle directly into the liver parenchyma and gently inject 10–15 mL of CO_2.

Percutaneous portal venous access

Percutaneous portal venous access is a localization technique that is useful in instances where an adequate contrast portogram cannot be achieved. A peripheral branch of the portal vein is punctured under ultrasound guidance. This is followed by the placement of a snare or a wire that can be used as a target for puncture. Alternatively, a snare or wire can be placed into the portal vein by first percutaneously accessing the splenic vein or a patent umbilical vein (Figure 6). A balloon occlusion catheter can be used as a target as well, instead of a snare or wire. The authors have not used this technique. In a 2021 study, Cam et al.[2] examined the effect of different techniques of portal vein cannulation during a TIPS placement on procedure efficiency. The study demonstrated that percutaneous portal vein guidewire placement for fluoroscopic targeting during a TIPS was associated with shorter procedure times, shorter fluoroscopic times, and potentially decreased complications when compared to more traditional fluoroscopically-guided wedged hepatic portography.

Intravascular sonographic imaging

The use of an intravascular ultrasound (IVUS) probe to obtain intravenous ultrasound images is a newer technique that involves using a catheter with a miniature ultrasound probe at the tip to assist in locating and puncturing the portal vein (Figure 7). The advantages of this technique include the ability to adjust the trajectory of the puncture and visualize the needle puncturing the portal vein based on real-time visualization with

Figure 4. CO_2 Wedge injection: **(a)** A catheter was wedged distally within the right hepatic vein to perform a CO_2 portogram with excellent opacification of the portal vein, **(b)** An iodinated contrast portogram was obtained in the anteroposterior projection view following a successful portal vein puncture, **(c)** A final transjugular intrahepatic portosystemic shunt (TIPS) completion venogram with iodinated contrast demonstrates portal vein opacification and opacification of the successfully created TIPS.

a level of spatial and anatomic detail that is not possible when utilizing fluoroscopy alone. In a 2016 study, Pillai et al.[3] compared the safety and effectiveness of IVUS–guided portal vein access during a TIPS with conventional TIPS techniques. The study showed that IVUS–guided portal vein access during a TIPS procedure is associated with shorter portal vein access times, decreased needle pass-related capsular perforations, and reduced radiation dose when compared to conventional TIPS techniques. Recently, the intracardiac echocardiography (ICE) catheter has become the preferred tool for performing sonographic imaging guidance during a TIPS. With either jugular or femoral access, the ICE catheter can be advanced to the level of the intrahepatic inferior vena cava, allowing puncture of the portal vein under live ultrasound imaging.[4] The use of the ICE allows the surgeon to increase the safety and technical success of the procedure by maximizing the accuracy of the portal vein puncture while also decreasing the radiation time and contrast dose.[4]

Overlay technique

The overlay technique involves superimposing cross-sectional imaging [magnetic resonance imaging, computed tomography (CT), or cone beam CT] on fluoroscopic imaging to help guide portal vein puncture. A study by Meine et al.[5] assessed the technical feasibility, success rate, puncture complications, and procedural characteristics of a TIPS using a three-dimensional vascular map overlay based on image registration of pre-procedural contrast-enhanced multidetector CT for portal vein puncture guidance. The study found that a TIPS using registra-

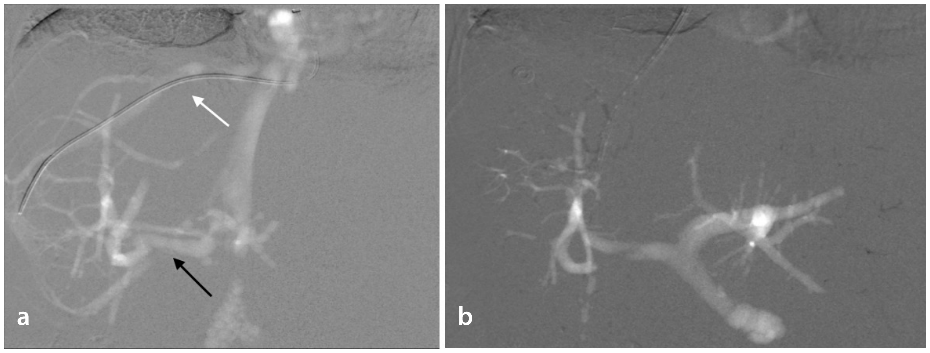

Figure 5. Direct intraparenchymal CO_2 injection: **(a)** the wedge portogram demonstrates a long distance between the right hepatic vein (white arrow) and the portal vein target (black arrow). The opacification of an accessory hepatic vein and the inferior vena cava is clear. The main trunk of the portal vein is not shown, **(b)** This shows direct intraparenchymal injection of CO_2 through the access needle to target the portal vein. The main portal and the right and left main portal branches are opacified.

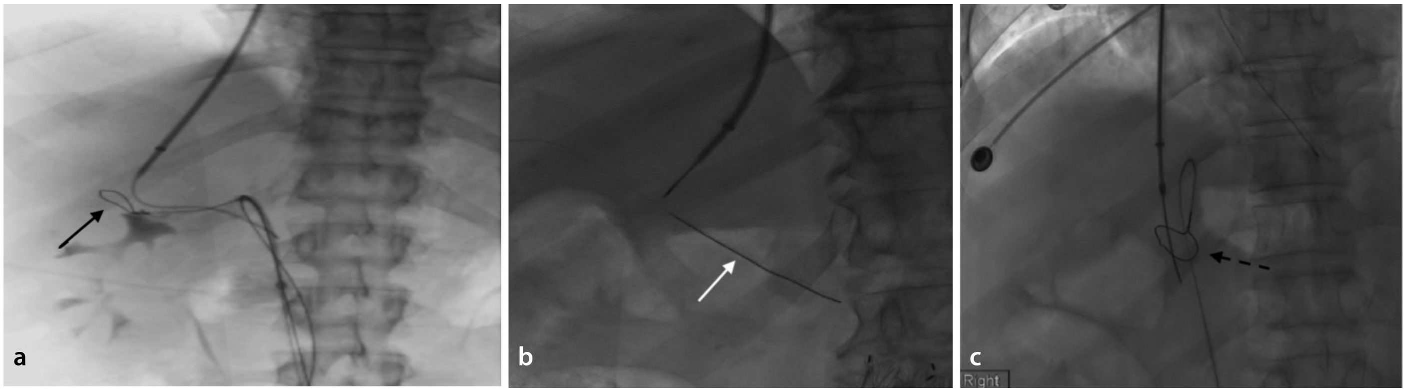

Figure 6. Snare technique: **(a)** a percutaneously inserted snare via the umbilical vein (black arrow) was used as a target for successful access into the portal vein from the right hepatic vein, **(b)** A percutaneously inserted wire (white arrow) can also be used for the same purpose. Please note that only the wire tip is radiopaque, **(c)** A snare (dashed arrow) was used as a target for portal vein access and placed into the portal system by first percutaneously accessing a patent umbilical vein.

tion-based contrast-enhanced multidetector CT vessel information for puncture guidance is feasible and safe. Additionally, this overlay technique was found to have the potential to improve hepatic vein catheterization, increase the ease of portal vein puncture, and decrease radiation exposure for the patient and surgeon.[5] The example in Figure 8 utilizes cone beam CT performed in the angiography suite at the time of the procedure to create a plot of the locations of the right hepatic and portal veins, which is then used to direct the needle puncture under fluoroscopy. A drawback of this technique is that patient respiration and/or movement cannot be accounted for, leading to imprecise portal vein targeting.

Additional techniques

Additional techniques have been used to guide portal venous puncture during a TIPS procedure. Blind transparenchymal puncture involves inserting a transparenchymal needle into the hepatic veins in the direction of the anticipated anatomic location of the portal venous system under fluoroscopy without specific additional imaging guidance. However, this technique is not recommended, as it carries an elevated risk of technical failure, multiple unsuccessful puncture attempts, and a higher risk of complications. Additionally, surgically-assisted direct access to the superior mesenteric vein has been described. In this technique, femoral access is used to gain access to the hepatic vein, and a mini-laparotomy is performed to allow for transmesenteric access into the portal venous system.[6] While this technique does allow for technical success, the involvement of a surgical team to perform a laparotomy is a logistical challenge. Neither of the aforementioned techniques has been used by the authors in their practice.

Access techniques in patients with a portal vein thrombosis

Transsplenic access to the portal venous system

Transsplenic access is a technique that allows for portal vein access in patients with both acute and chronic portal vein occlusion. A needle is inserted through the spleen into the splenic venous system. Once splenic vein access is established, the occluded portal vein can be recanalized to allow for the subsequent TIPS (Figure 9).[7] Transsplenic access is a safe technique. As with transhepatic access, the main complication of concern is bleeding from the access tract leading to a

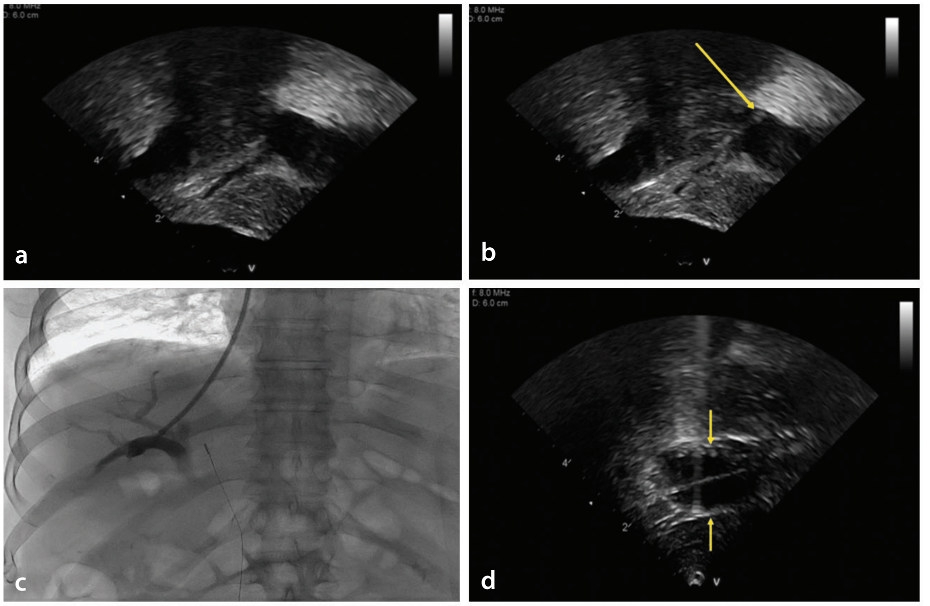

Figure 7. Intracardiac echocardiography-assisted puncture: images were obtained using an intracardiac echocardiography (ICE) catheter that demonstrate how the catheter advanced to the portal vein **(a)** and the needle (yellow arrow) within the portal vein **(b)**. Fluoroscopic confirmation of successful access into the portal vein from the right hepatic vein can be seen here **(c)**. The successful deployment of the stent (yellow arrows) from the hepatic vein to the portal veins is demonstrated in these ICE images **(d)**.

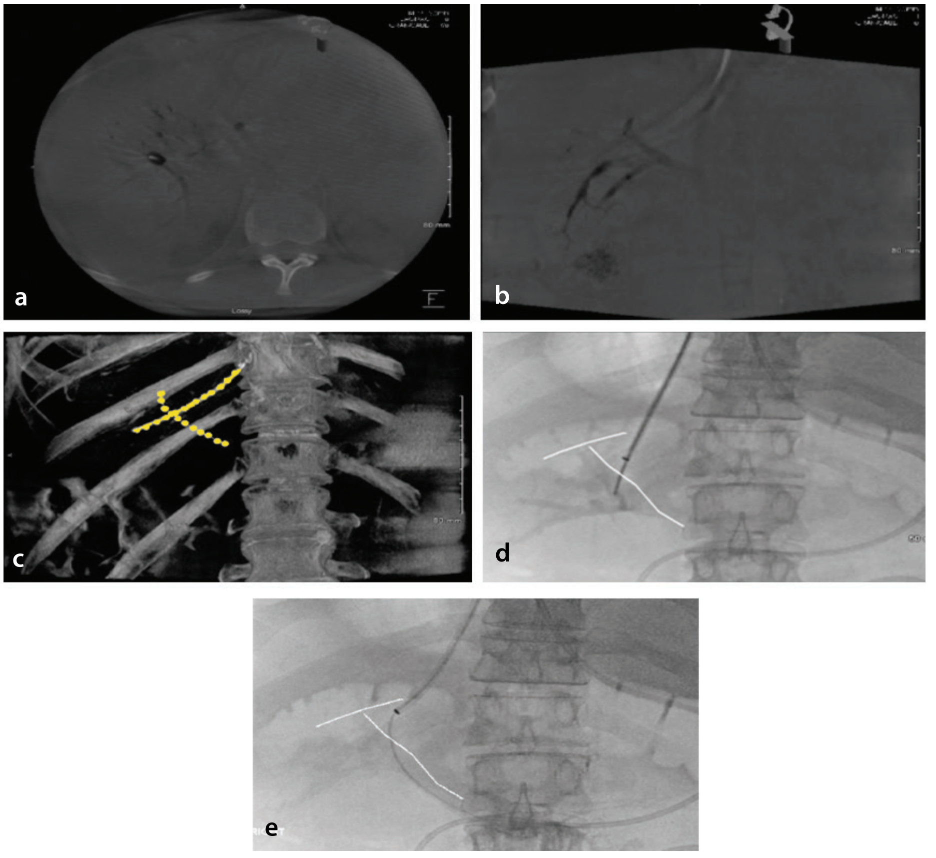

Figure 8. Imaging overlay technique: axial **(a)** and coronal **(b)** images from a wedged hepatic venogram during a 5-second cone beam computed tomography (CT) scan, which was performed at the time of the procedure. The images show a balloon occlusion catheter within the right hepatic vein and CO_2 opacifying the distal right hepatic vein and portal vein. A volume-rendered CT image **(c)** demonstrates the plotting of the right hepatic and portal veins (yellow dots). This plot is then translated to live fluoroscopy as lines on the monitor that mark the portal vein location with the movement of the detector. Two intra-procedure fluoroscopic images **(d, e)** demonstrate the marked portal vein appearing as white lines on the screen.

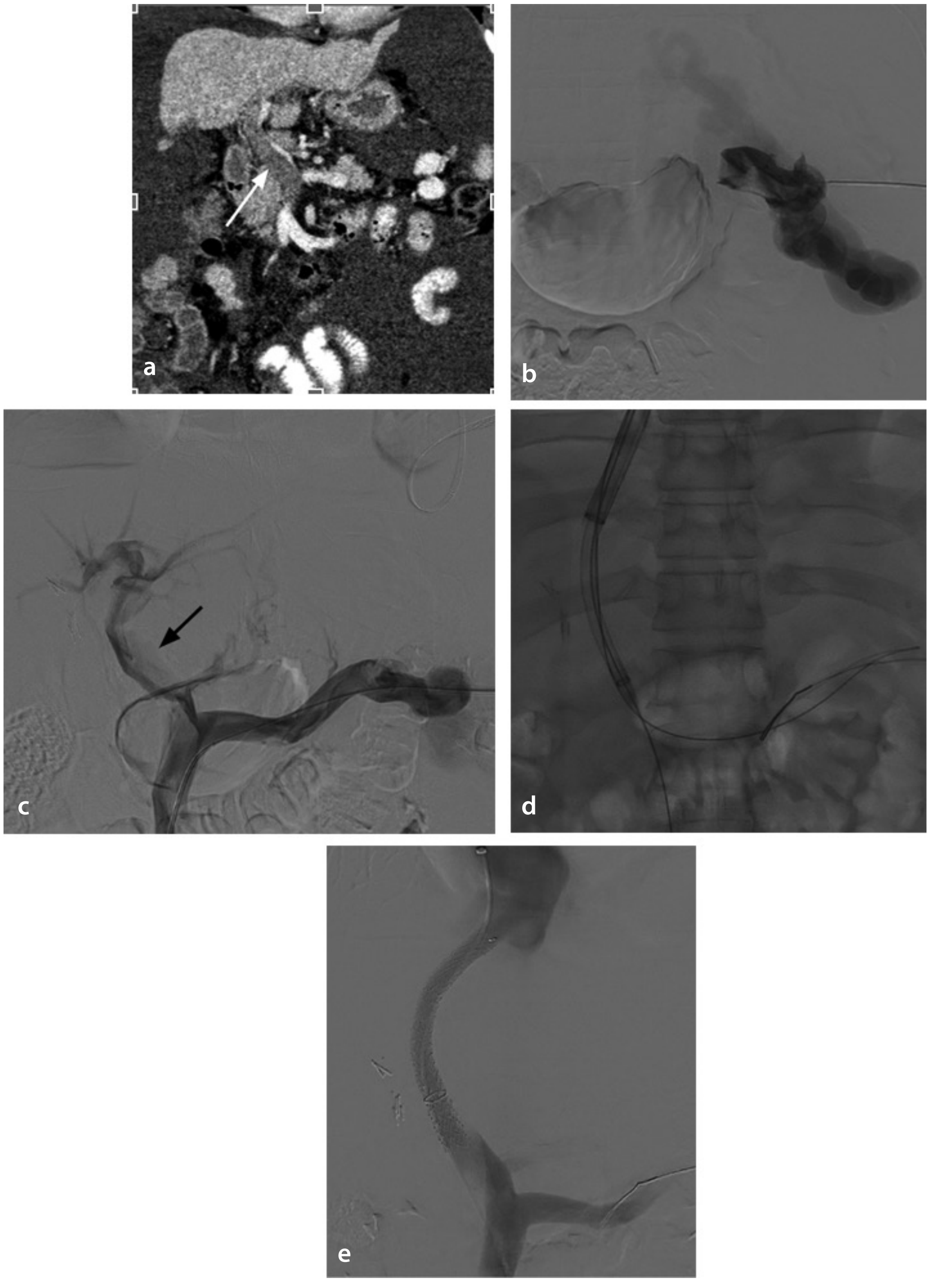

Figure 9. Transsplenic access to the thrombosed portal vein: **(a)** this coronal computed tomography image shows a thrombus within the main portal vein (white arrow), **(b)** This is a digital subtraction angiography (DSA) image of the splenic vein following transplenic access, **(c)** This is a DSA image of the portal venous system demonstrating a large filling defect (black arrow) within the main portal vein representing a thrombus, **(d)** This shows an aspiration thrombectomy of the portal vein being performed using a 20 French FlowTriever device (Inari Medical), **(e)** This is an angiography image following a successful transjugular intrahepatic portosystemic shunt.

hematoma formation, which can be mitigated by a coil or plug embolizing the transsplenic tract.[7]

Transabdominal ultrasound guidance

A TIPS under fluoroscopic guidance with additional transabdominal ultrasound guidance is another technique that is particularly useful when patients have acute portal vein thrombosis or when the hepatic venous system is not patent.[8] While the technical success rate utilizing this technique is high and the complication rate is low, the use of this technique is limited in obese patients and when ascites is present.[8]

Complications

Liver laceration with capsular injury is a complication that can occur during hepatic vein wedge or intraparenchymal contrast injection. Carbon dioxide is preferred over iodinated contrast because of the higher rate of main portal vein visualization and its associated lower risk of capsular perforation. Previous research has found that extravasation of contrast occurs at a rate of 1.8% when using CO_2 and 7.5% when using iodinated contrast.[9] The use of an occlusion balloon catheter for contrast injection may also decrease the risk of this complication by redirecting the flow of the contrast agent over a larger surface area of the liver. Lastly, and perhaps most importantly, the surgeon should always remember that forceful injection of contrast increases the risk of this complication, so the injection of the contrast material should be slow and gentle to decrease the risk of traumatic injury to the liver (Figure 10). If capsular perforation is detected, the surgeon should be prepared to proceed with further intervention to manage the complication.

Puncture of the biliary system, including the gallbladder, is not uncommon during TIPS procedures (Figure 11) and is typically well tolerated. However, there is a 5% chance of creating a fistula between the biliary and vascular systems after an accidental puncture of the biliary system.[9] A fistula between the biliary and vascular systems can result in hemobilia, cholangitis, sepsis, and stent infection. In such cases, further intervention, including a biliary diversion via stenting or drainage, may be necessary.[9]

Accidental arterial puncture (Figure 12) occurs in approximately 6% of TIPS procedures. However, clinically significant arterial puncture only occurs in approximately 2% of cases. Complications associated with arterial puncture include hemorrhage, pseudoaneurysm, dissection or occlusion of the artery, and fistula formation.[9] If such complications arise, angiography is the next best step in evaluation, with subsequent embolization if warranted. The surgeon should be careful to avoid dilating a tract between the hepatic vein and hepatic artery as this can result in patient death secondary to a sudden increase in right atrial pressure after arterial to venous shunt creation.[10]

A possible complication of direct transhepatic or transplenic access to the portal venous system is bleeding through the puncture tract with subsequent perihepatic or perisplenic hematoma. Embolization of the portal vein access tract, with coils or plugs, has proven very effective in preventing this complication.[2]

Figure 10. Capsular perforation after CO_2 injection: forceful injection of CO_2 resulted in capsular perforation. Note the jet of extracapsular CO_2 extravasation (black arrow).

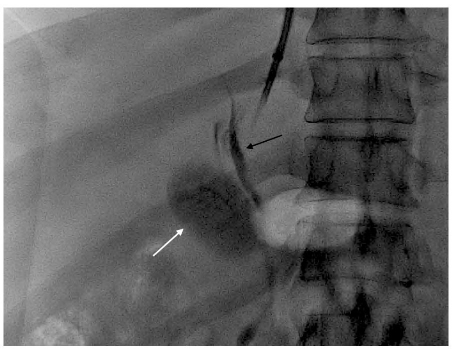

Figure 11. Biliary system puncture: this shows an accidental puncture of the biliary system with the transjugular intrahepatic portosystemic shunt access system, resulting in opacification of the bile ducts (black arrow) and the gallbladder (white arrow) with contrast. Dilation of this tract should be avoided to prevent major biliary injury.

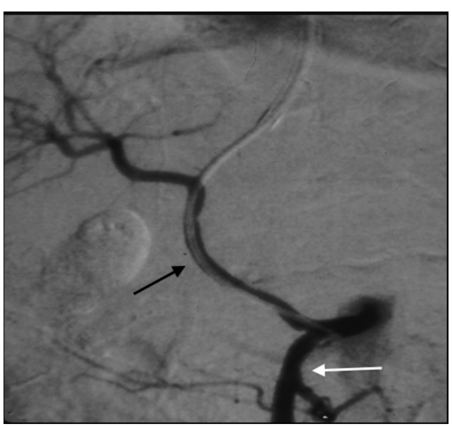

Figure 12. Arterial injury during a TIPS: this digital subtraction angiography image shows an arterial injection during a transjugular intrahepatic portosystemic shunt (TIPS) procedure. There is a complete hepatic artery (black arrow) replacement from the superior mesenteric artery trunk (white arrow). It is important to identify this complication and halt the TIPS in such a case as it could result in the patient's immediate death.

Conclusion

There are multiple reported techniques to assist in portal venous access during a TIPS procedure, all of which are aimed at obtaining access into the portal vein with the least number of attempts in the least amount of time. The correct use of these techniques increases the chance of technical success and decreases the chances of complications.

Conflict of interest disclosure

Bahri Üstünsöz, MD, is Section Editor in Diagnostic and Interventional Radiology. He had no involvement in the peer-review of this article and had no access to information regarding its peer-review. Other authors have nothing to disclose.

References

1. Krajina A, Lojik M, Chovanec V, Raupach J, Hulek P. Wedged hepatic venography for targeting the portal vein during TIPS: comparison of carbon dioxide and iodinated contrast agents. *Cardiovasc Intervent Radiol.* 2002;25(3):171-175. [Crossref]
2. Cam I, Gencturk M, Shrestha P, et al. Ultrasound-Guided portal vein access and percutaneous wire placement in the portal vein are associated with shorter procedure times and lower radiation doses during TIPS placement. *AJR Am J Roentgenol.* 2021;216(5):1291-1299. [Crossref]
3. Pillai AK, Andring B, Faulconer N, et al. Utility of intravascular US-guided portal vein access during transjugular intrahepatic portosystemic shunt creation: retrospective comparison with conventional technique in 109 patients. *J Vasc Interv Radiol.* 2016;27(8):1154-1159. [Crossref]
4. Grimsbo MC, Brown MA, Lindquist JD, et al. Intracardiac echocardiography-guided TIPS: a primer for new operators. *Semin Intervent Radiol.* 2020;37(4):405-413. [Crossref]
5. Meine TC, Dewald CLA, Becker LS, et al. Transjugular intrahepatic portosystemic shunt placement: portal vein puncture guided by 3D/2D image registration of contrast-enhanced multi-detector computed tomography and fluoroscopy. *Abdom Radiol (NY).* 2020;45(11):3934-3943. Erratum in: *Abdom Radiol (NY)*. 2020. [Crossref]
6. Rozenblit G, DelGuercio LR, Savino JA, et al. Transmesenteric-transfemoral method of intrahepatic portosystemic shunt placement with minilaparotomy. *J Vasc Interv Radiol.* 1996;7(4):499-506.
7. Ahmed O, Salaskar AL, Zangan S, Pillai A, Baker T. Transsplenic portal vein recanalization and direct intrahepatic portosystemic shunt placement to optimize liver transplantation. *CVIR Endovasc.* 2020;3(1):5. [Crossref]
8. Keshava SN, Moses V, Sharma A, et al. Technical and medium-term clinical outcomes of transjugular intrahepatic portosystemic shunt with fluoroscopy and additional trans-abdominal ultrasound guidance. *Indian J Radiol Imaging.* 2021;31(4):858-866. [Crossref]
9. Gaba RC, Khiatani VL, Knuttinen MG, et al. Comprehensive review of TIPS technical complications and how to avoid them. *AJR Am J Roentgenol.* 2011;196(3):675-685. [Crossref]
10. Pattynama PM, van Hoek B, Kool LJ. Inadvertent arteriovenous stenting during transjugular intrahepatic portosystemic shunt procedure and the importance of hepatic artery perfusion. *Cardiovasc Intervent Radiol.* 1995;18(3):192-195. [Crossref]