Percutaneous Portal Vein Access and Transhepatic Tract Hemostasis

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Semin Intervent Radiol 2012;29:71–80

Abstract

Keywords

- ▶ Liver
- ▶ percutaneous
- ▶ coils
- ▶ glue (N-butyl cyanoacrylate)
- ▶ Gelfoam
- ▶ portal vein
- ▶ hemostasis

Percutaneous portal vein interventions require minimally invasive access to the portal venous system. Common approaches to the portal vein include transjugular hepatic vein to portal vein access and direct transhepatic portal vein access. A major concern of the transhepatic route is the risk of postprocedural bleeding, which is increased when patients are anticoagulated or receiving pharmaceutical thrombolytic therapy. Thus percutaneous portal vein access and subsequent closure are important technical parts of percutaneous portal vein procedures. At present, various techniques have been used for either portal access or subsequent transhepatic tract closure and hemostasis. Regardless of the method used, meticulous technique is required to achieve the overall safety and effectiveness of portal venous procedures. This article reviews the various techniques of percutaneous transhepatic portal vein access and the various closure and hemostatic methods used to reduce the risk of postprocedural bleeding.

Objectives: On completion of this article, the reader will be able to explain the indications for and technical details of accessing the portal vein and embolizing the transhepatic tract following portal vein access.

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The portal vein is an “end vessel” that ends in the hepatic sinusoids. The portal vein tributaries are the outflow veins of the spleen (splenic vein) and gastrointestinal tract (superior and inferior mesenteric veins); the confluence of the splenic vein and the mesenteric vein(s) forms the portal vein.

Percutaneous portal vein interventions require minimally invasive access to the portal vein. This access can be in the form

of transjugular hepatic vein to portal vein access (transvenous intrahepatic portosystemic shunt [TIPS] access), direct transhepatic portal vein access, and transplenic access. The first two access routes are currently the most commonly used.^{1–22} ▶ **Table 1** summarizes the advantages and disadvantages of the transjugular and direct transhepatic portal venous access routes. Percutaneous transhepatic portal vein access can be performed utilizing real-time ultrasound guidance followed by fluoroscopy or by fluoroscopy alone in a manner similar to that used during percutaneous transhepatic cholangiography.

A major concern of the transhepatic route is the risk of postprocedural bleeding, which is increased when patients are anticoagulated or receiving pharmaceutical thrombolytic therapy.¹³ In the literature, bleeding following percutaneous portal vein access without transhepatic tract closure exceeds 30%,¹³ and in certain cases significant bleeding has led to mortalities.^{13–16} ▶ **Table 2** lists the percutaneous portal venous procedures that can be performed, their more common portal access routes, and the need for concurrent anticoagulation or thrombolytic therapy.

Table 1 Advantages and Disadvantages of Transjugular Intrahepatic Portosystemic and Percutaneous Transhepatic Direct Portal Venous Access

	TIPS Portal Access	PTD Portal Access
Advantages	<ul style="list-style-type: none"> • Theoretically less bleeding risk • Allows a greater portal of entry to the portal vein (can pass large platforms into PV) • Provides an outflow to the portal vein in cases of PVT 	<ul style="list-style-type: none"> • Direct access to the portal vein along the long axis of the portal vein • Provides easier access to the peripheral intrahepatic portal vein branches (ipsilateral and contralateral)
Disadvantages	<ul style="list-style-type: none"> • Poor access to the peripheral intrahepatic portal vein branches • Enters at an angle to the main portal vein 	<ul style="list-style-type: none"> • More bleeding risk, especially in the presence of anticoagulants and thrombolytic agents • Limited by the size of the access. Access is usually limited to 8F. The larger the sheath, the greater the risk of bleeding

TIPS, transjugular intrahepatic portosystemic shunt; PTD, percutaneous transhepatic direct portal vein access; PV, portal vein; PVT, portal vein thrombosis.

This article reviews the techniques used for percutaneous transhepatic portal vein access and the methods for tract closure and hemostasis. Knowledge of these techniques is critical to reduce the bleeding risks after portal vein procedures and to ensure these procedures can be done as safely as possible.

Percutaneous Transhepatic Portal Vein Access

Direct percutaneous transhepatic portal vein access can be either left sided (into the left portal vein branches) or right sided (into the right portal vein branches). Ultrasound-guided portal vein access is more commonly used for a left-sided puncture, although it can also be used for right-sided puncture. The opposite is true for fluoroscopic-guided portal vein access. It is more commonly used for right-sided than for left-sided access. ►Table 3 lists the advantages and disadvantages of right- versus left-sided percutaneous transhepatic portal vein access. The advantages and disadvantages of ultrasound-versus fluoroscopic-guided access are largely based on their laterality (►Table 4).

Ultrasound-Guided Percutaneous Portal Vein Access

The features, advantages, and disadvantages of ultrasound-guided percutaneous portal vein access are listed in ►Table 4. Ultrasound guidance is typically used in left portal vein approaches, although it can also be used in right portal vein approaches.^{9,12} The primary disadvantage of this technique is that the access is often obtained in a larger portal vein branch when compared with fluoroscopic guidance, particularly when the operator utilizing fluoroscopic guidance is cognizant of accessing a very small portal vein radical/branch. The portal vein branch size is relative. In the opinion of one of the authors (W.E.S.), smaller, more minuscule, portal vein branches can be accessed with fluoroscopy. In the setting of ipsilateral transhepatic portal access for portal vein embolization, the primary advantage of ultrasound-guided access is visualization of right hepatic lobe tumors, enabling the operator to avoid transgressing the tumor.

Typically, a 21- to 22-gauge needle is advanced under real-time ultrasound guidance either with an ultrasound guide or free hand (►Fig. 1). Once the needle tip is seen entering the target portal vein branch, the procedure switches to fluoroscopic guidance. Contrast is injected to confirm adequate

Table 2 Portal Procedures, Their Common Access Routes, and the Likelihood of the Concomitant Use of Anticoagulation and Thrombolytic Agents

	Common Access	Anticoagulant and/or Lytic*
TIPS procedure	TIPS with or without PTD†	None
PVT thrombolysis	TIPS and/or PTD	Anticoagulant plus Lytic
PV angioplasty/stent placement	PTD >>>> TIPS	Anticoagulant
PV embolization	PTD	None
Pancreatic islet cell transplant	PTD	Anticoagulant
BATO for gastric varices and P-S-Collats	PTD	None

*Obtaining percutaneous transhepatic direct portal vein access can be performed to mark the portal vein for puncture during the TIPS procedure.

†Anticoagulation (Heparin, Fragmin); Lytic: Fibrinolytic/thrombolytic (tissue plasminogen activator).

TIPS, transjugular intrahepatic portosystemic shunt or TIPS access; PTD, percutaneous transhepatic direct portal vein access; PVT, portal vein thrombosis; PV, portal vein; BATO: balloon-occluded antegrade transvenous obliteration/sclerosis of gastric varices; P-S-Collats, portosystemic collaterals.

Table 3 Advantages and Disadvantages of Left-sided versus Right-sided Percutaneous Transhepatic Direct Portal Venous Access

	Left-sided Portal Vein Access	Right-sided Portal Vein Access
Advantages	<ul style="list-style-type: none"> • Makes most of the right-sided intrahepatic branches more readily accessible in the setting of PVE procedure • May have a lower bleeding risk, especially in the setting of ascites • Less risk of pleural complications 	<ul style="list-style-type: none"> • Access more inline with main PV for central PV interventions • More “running room” to the central PV for central PV interventions • Less radiation to operator hands overall • In the setting of PVE: Any vascular injuries will be excised with right hepatectomy
Disadvantages	<ul style="list-style-type: none"> • More radiation to operator hands • Less “running room” to the central PV for central PV interventions • Not inline with the main PV for central PV interventions • In the setting of PVE, any vascular injuries from the PV access will not be excised with right hepatectomy because the left lobe is the FLR 	<ul style="list-style-type: none"> • May be more technically challenging in the presence of ascites • May have a higher risk of bleeding in the presence of ascites • High risk of pleural complications especially if patient is under GA*

PV, portal vein; PVE, portal vein embolization; GA, general anesthesia; FLR, future liver remnant (the residual left lobe after the right hepatectomy).

*Anecdotally, percutaneous transhepatic right-sided portal vein access under GA may have a higher risk of pleural complications (pneumothorax and/or hemothorax) because without GA, patients have pain during needle access/lidocaine infusion. This causes splinting and reduced inspiratory effort; therefore the visceral pleura does not extend low, reducing the risk of transgressing the visceral pleura.

placement of the needle in the target portal vein branch. A guidewire is advanced centrally into the main portal vein. When using a 21- or 22-gauge needle, a 0.018-inch guidewire (stainless-steel or nitinol guidewire can be used) is advanced through the access needle under fluoroscopy. The 0.018-inch guidewire is then upsized to a 0.035-inch working guidewire using a telescoped transitional sheath system, such as a micro-puncture kit with or without a metal stiffener (Cook Inc., Bloomington, IN), an AccuStick access system (Boston Scientific Corp., Natick, MA), or a Neff-set (Neff Percutaneous Access Set, Cook Medical Bloomington, IN) system (Cook). Once the 0.035-inch wire is advanced into the central portal veins (preferably the main portal vein), a definitive access vascular sheath is advanced over the 0.035-inch guidewire.

Fluoroscopic-Guided Percutaneous Portal Vein Access

► **Table 4** lists the features, advantages, and disadvantages of fluoroscopic-guided percutaneous portal vein access. Typically, a 21- to 22-gauge needle is advanced under real-time fluoroscopy in a manner similar to that used for percutaneous transhepatic cholangiography (PTC), passing intercostally along the midaxillary line (► **Figs. 2 and 3**). The current author (W.E.S.) uses a 7.5-cm 21-gauge needle instead of a 15-cm 21- or 22-gauge Chiba needle. This is because the operator prefers to access a small subcapsular peripheral portal branch and not a more central portal vein branch. This reduces the chance for the needle (and eventually the definitive access sheath) to traverse larger portal veins, hepatic veins, or bile ducts on its way to the target peripheral portal vein branch. Similar to the

Table 4 Features, Advantages, and Disadvantages of Ultrasound-guided versus Fluoroscopic-guided Percutaneous Transhepatic Direct Portal Venous Access

	Initial Ultrasound-Guided Portal Access	Initial Fluoroscopic-Guided Portal Access
Features	<ul style="list-style-type: none"> • More likely to be a left-sided PV access • Can be right-sided PV access 	<ul style="list-style-type: none"> • More likely to be a right-sided PV access • Can be left-sided PV access
Advantages	<ul style="list-style-type: none"> • Less radiation at initial access • May be less time consuming 	<ul style="list-style-type: none"> • Access to a smaller portal vein branch • If right-sided, more “running room” to the central PV for central PV interventions • If right-sided, more inline with main PV for central PV interventions • Less radiation to operator hands overall
Disadvantages	<ul style="list-style-type: none"> • If left sided, more radiation to operator hands • If left sided, less “running room” to the central PV for central PV interventions • If left sided, not inline with the main PV for central PV interventions 	<ul style="list-style-type: none"> • May be more technically challenging in the presence of ascites • May have a higher risk of bleeding in the presence of ascites

PV, portal vein; PVT, portal vein thrombosis.

Figure 1 Ultrasound-guided percutaneous left portal vein access (images obtained, with permission, from the portal vein embolization article in this issue). (A) Gray scale ultrasound image (transverse on abdomen) demonstrating the tip (arrowheads) of a 22-gauge needle in a left portal vein branch. At this point in the procedure, the image guidance is changed to fluoroscopy. Contrast is injected to confirm adequate placement of the needle tip in the portal vein; this is followed by serial guidewire upsizing to a 0.035-inch wire. (B) Digital subtraction angiogram (portogram) of the same patient with left portal vein access. The initial diagnostic catheter is seen passing through the left portal vein (arrowheads) and ending in the main portal vein (arrow).

definitive biliary access for PTC and subsequent biliary drain placement, the operator must be cognizant of the entry angle (needle trajectory) that makes a smooth curve (obtuse angle) with the main portal vein.²³ The needle is advanced and contrast is injected very gently as the needle is withdrawn in a PTC manner, except the target is the portal veins and not the biliary tract. The operator carefully scrutinizes the vessels that are opacified. Once a portal vein is visualized, a stronger injection to evaluate the portal vein and its branches is performed to decide if the access obtained can be definitive or not (►Fig. 2). Once the definitive needle access is in the target portal vein branch, a 0.018-inch wire is advanced into the portal vein branch and advanced further centrally into the right or left portal vein. The 0.018-inch guidewire can be stainless steel, nitinol, or a 0.018-inch hydrophilic guidewire (precurved by the manufacturer) (►Fig. 3). The operator should concentrate on the path and the degree of resistance while passing the guidewire.²³

When utilizing a hydrophilic guidewire, the wire should not coil around the vicinity of the target portal vein branch but should pass smoothly in the portal vein branch.²³ Simple buckling of the hydrophilic guidewire is acceptable and, in fact, encouraged (►Fig. 3). However, complete coiling of the hydrophilic guidewire (even if completely confined and projecting over the target portal vein branch) may be due to dissection in the portal triad outside the portal vein lumen. Compared with stainless steel and nitinol guidewires, the hydrophilic guidewire presents a different “feel” when it is passed through a needle (►Fig. 3).

The primary disadvantage of the use of a hydrophilic guidewire is that its hydrophilic coating can sheer off if the wire is withdrawn back through the needle, leading to wire-needle jamming and/or foreign body deposition in the liver

(the foreign body deposition is not a problem in one of the current author's opinion (W.E.S.). However, if the guidewire jams at the access needle bevel, both wire and needle commonly need to be removed as one unit, leading to loss of access.²³ The primary advantage of utilizing a hydrophilic guidewire is that it buckles without deformation (►Fig. 3E), and if it buckles within the lumen it allows advancement of the wire without trauma to the portal vein (►Fig. 3F and 3G). It can allow plenty of purchase despite multiple turns and curves in its course (►Fig. 3).

Once a central portal vein is accessed with 0.018-inch guidewire, the 0.018-inch guidewire is upsized to a 0.035-inch working guidewire utilizing a telescoped coaxial transitional sheath system such as micro-puncture kit with or without a metal stiffener (Cook), an AccuStick access system (Boston Scientific Corp) or a Neff-set system (Cook) (►Fig. 3H). Once the 0.035-inch wire is advanced into the central portal veins (preferably the main portal vein), a definitive access vascular sheath is advanced over the 0.035-inch guidewire (►Fig. 3I).

Transhepatic Portal Vein Access Closure

Bleeding from the transhepatic tract after percutaneous portal vein access has been reported in >30% of percutaneous intraportal pancreatic islet cell transplant cases where transhepatic access site closure was not performed.¹³ In case series with inconsistent tract closure, the overall bleeding risk is 10 to 13.5%^{13,15}; in reports where operators routinely embolize or close transhepatic tracts in percutaneous intraportal pancreatic islet cell transplants, the bleeding risk is reported to be between 0% and 6.5%.^{17–22} Bleeding from the percutaneous portal access following portal vein embolization (PVE)

Figure 2 Fluoroscopic-guided percutaneous right portal vein access. (A, B) Two sequential images of a digital subtraction angiogram (portogram) from a 21-gauge 7.5-cm-long micropuncture needle. The needle is placed in the right midaxillary line through an intercostal approach. The needle tip (black arrow) is in a small (<3 mm diameter) peripheral portal vein branch. (C) Unsubtracted portogram image demonstrating the definitive needle access (dashed ellipse). The portal vein branch is less than twice the diameter of the 21-gauge needle, which computes to a diameter <3 mm.

is less common (<5%). This may be because many portal vein accesses are now performed via an ipsilateral approach (through the diseased lobe, which is embolized) and not via a contralateral approach (through the anticipated future liver remnant); studies suggest that ipsilateral access has a lower risk of bleeding than contralateral access.^{9–12} In addition to having a patent portal vein, portal pressures often increase after PVE. This elevation in portal pressure has been suggested as a risk factor for post-PVE bleeding.¹³ Furthermore, those who use the contralateral approach may not want to use “permanent” embolization or closure material in the future liver remnant during catheter removal, leading to a potential open tract to the liver capsule.

Overall, the causes of increased risk of portal bleeding postpercutaneous access include the use of antiplatelet therapy; possibly low platelet count; high dose heparin (>70 IU/kg body weight) administration; increased portal pressure (including repeated pancreatic islet cell transplant sessions); and most significantly, the lack of transhepatic tract closure or embolization.¹³ It is the authors' opinion that good postprocedure hemostasis starts with meticulous nontraumatic portal vein access, preferably in the smallest portal vein that is accessible.

The traditional “closure” or embolization of the percutaneous transhepatic tract after portal interventions is usually by Gelfoam pledgets or torpedoes (Gelfoam, Pharmacia & UpJohn Corp, New York) (►Fig. 4) and/or coils (►Fig. 5).^{13–22} However, N-butyl cyanoacrylate (N-BCA) (Trufill, Codman Johnson & Johnson, Neurovascular, Raynham, MA) has also been utilized for portal vein embolization and for percutaneous transhepatic access closure after biliary interventions.^{24,25}

Transhepatic Closure Using Gelfoam with or without Coil Embolization

The percutaneous transhepatic access sheath is left in place, and absorbable gelatin sponge (occasionally referred to as “tissue fibrin”) (►Fig. 4), is prepared in 2- to 3-mm-diameter rolls that

are usually referred to as Gelfoam torpedoes or pledgets. These Gelfoam torpedoes can be slightly impregnated with contrast so they can be seen fluoroscopically (►Fig. 4), and/or they can also be impregnated with reconstituted thrombin to promote thrombosis of blood bleeding back along the transhepatic tract. Once these Gelfoam torpedoes are rolled, they are introduced through the transhepatic sheath one at a time and pushed with a blunted sheath dilator as the sheath is withdrawn. Usually two to five torpedoes are deposited, depending on the length of the transhepatic tract (►Fig. 4). Some operators alternate Gelfoam torpedoes with 0.035-inch coils, usually between 6 and 8 mm in diameter; others only use coils to embolize the tract without Gelfoam torpedo placement (►Fig. 5). If other alloy embolic agents are used, such as Amplatzer Vascular Plugs (AGA Medical Corp., Plymouth, MN), one of the current authors (W.E.S.) suggests using undersized plugs and not what is recommended for intravascular use by the manufacturer. In ►Fig. 6, the Amplatzer plug is oversized, which may cause transhepatic tract damage or at least keep the transhepatic tract open because the plug does not attain its fully deployed configuration.

One of the authors (D.C.M.) uses only coil embolization for the access tract. In his experience, it is best to advance and deploy the coils through a 5F end-hole catheter rather than simply deploying them through the sheath because it is possible that the coils may “open” up within the sheath and may make advancing coils with a standard 0.035-inch or 0.038-inch guidewire difficult. Furthermore, it is very important to inject the catheter with a small amount of contrast to assess the tract itself. Given the proximity to the hepatic artery, bile ducts, and even the hepatic veins, it is possible to have traversed these structures to achieve adequate access into the portal venous system. Therefore, operators should be diligent to assess whether or not these structures have been traversed to avoid potential nontarget embolization of coils (e.g., coils placed inadvertently into a hepatic vein branch that may embolize to the lungs).

Figure 3 Fluoroscopic-guided percutaneous right portal vein access. (A) Fluoroscopic image during right intercostal access of the right portal vein using a 21-gauge 7.5-cm-long micropuncture needle. Contrast is injected as the needle (open black arrow) is withdrawn under fluoroscopy. Contrast is seen in the biliary tract (solid white arrows). Incidentally, the patient has a metal biliary stent (open white arrows). (B) Fluoroscopic image during right intercostal access of the right portal vein using a 21-gauge needle. Contrast is injected as the needle (open black arrow) is withdrawn under fluoroscopy. Contrast is seen in the portal circulation with a focal area of portal venous contrast blush (asterisk). (C) Fluoroscopic image after the 21-gauge needle was withdrawn into a larger portal vein branch at a portal vein trifurcation (dashed ellipse). Contrast is injected demonstrating the portal vein branches. The asterisk marks the prior portal vein parenchymal stain in (B). The white arrow points to the exact access site at which the needle enters the portal vein branch point. (D) Fluoroscopic image demonstrates a 0.018-inch angled hydrophilic wire (solid white arrow) as it is advanced through the 21-gauge needle (open black arrow). Notice that the bevel (solid black arrow) of the 21-gauge needle is pointed upward to facilitate the passage of the wire in the desired upward direction. The operator at this point feels the passage of the wire without resistance and watches the course of the wire, keeping in mind the course of the portal vein (C). (E) Fluoroscopic image as the 0.018-inch angled wire (solid white arrow) is advanced further through the 21-gauge needle (open black arrow). The wire has buckled and its passage continues to be without resistance along the course of the prior visualized portal vein branch (C). (F) Fluoroscopic image as the 0.018-inch angled wire (open white arrow) continues to be advanced further through the 21-gauge needle. The dashed arrows point to opacified peripheral portal vein branches. The buckled end of the wire (solid white arrow) has met resistance because it has been passed into another peripheral branch. As the operator continues to push the wire despite resistance, the wire starts to buckle (open white arrow) into a larger and more central (desired path) portal vein branch (see [G]). (G) Fluoroscopic image as the 0.018-inch angled guidewire is buckled into a larger and more central portal vein branch (open white arrow). (H) Fluoroscopic image after advancing a transitional 5F dilator (open white arrow) over the 0.018-inch wire. Contrast is being injected through the transitional sheath and the portal vein branches (solid white arrows) are visualized, confirming adequate access to the portal vein. (I) Fluoroscopic image after advancing a 7F vascular access sheath (open white arrow) over an already upsized 0.035-inch guidewire (upsized from 0.018-inch to 0.035-inch using the transitional 5F sheath seen in (H)). The wire is buckled (open black arrow) in the portal vein. (J, K) Fluoroscopic image and digitally subtracted image during contrast injection through the 7F vascular access sheath (open white arrow) confirms adequate placement of the 0.035-inch guidewire and sheath in the portal venous system. The 0.035-inch wire is seen buckled (open black arrow) in the portal vein. (L) Fluoroscopic image obtained during contrast injection in the portal vein after an angled 5F catheter (open black arrow) has been advanced through the 7F sheath (open white arrow) and directed toward the main portal vein, which demonstrates near occlusion (between solid black arrows).

Transhepatic Closure Utilizing N-Butyl Cyanoacrylate

In recent years, the use of N-butyl cyanoacrylate (NBCA) or glue (Trufill, Codman Johnson & Johnson- Neurovascular, Raynham, MA) has been described for PVE⁹⁻¹² and for the closure of percutaneous transhepatic tracts after biliary access and biliary interventions.^{24,25} NBCA is a liquid embolic agent that quickly solidifies by polymerization on exposure to ionic solutions such as blood.^{24,25} Polymerization of NBCA-Lipiodol mixtures occurs in 0.2 to 5.0 seconds depending on the percentage of NBCA in the mixture (the higher the NBCA component, the faster the polymerization).^{25,26} It makes sense to continue NBCA embolization of the transhepatic tract if preoperative PVE is already performed using NBCA. However, one of the current authors (W.E.S.) uses NBCA (Trufill, Codman Johnson & Johnson, Neurovascular, Raynham, MA) as a transhepatic closure (hemostatic agent) in all percutaneous transhepatic portal vein accesses, whether for PVE or not. However, a word or caution: "Gluing" the trans-

hepatic tract in the absence of PVE is technically challenging and requires a particular skill set (► **Fig. 7**). This is because it is not difficult to inadvertently "overshoot" NBCA into a patent (non-embolized) portal vein. Furthermore, it is not uncommon, excluding PVE and pancreatic islet cell transplant cases, to have portal hypertension in cases requiring percutaneous portal vein access. The high portal pressure (>10 to 12 mm Hg) has a likelihood of pushing the liquid embolic agent out of the tract before it hardens and sets, causing an incomplete tract embolization.

Technically, the current authors utilize 1 part lipiodol to 1 part NBCA, a 50% NBCA mixture, which is between the 33% NBCA mixture described by Iezzi and coworkers²⁴ and 90% NBCA mixture described by Cekirge and coworkers.²⁵ This usually gives a mixture totaling 2 mL, which is usually enough to embolize a short percutaneous transhepatic tract (see earlier for short access technique) occupied by a 4 to 7F 11-cm-length sheath. Percutaneous transhepatic sheaths

Figure 4 Gelfoam closure (embolization) of the transhepatic tract after portal vein access procedure. (A) Unsubtracted portogram image demonstrating needle access (dashed ellipse). The portal vein branch is less than twice the diameter of the 21-gauge needle, which computes to a diameter <3 mm. The two solid arrows point to two portal vein branches which are the same two branches seen in the magnified view of Fig 4B. This is the original access image used and referenced by the operator to help identify the exact portal venous access site when withdrawing and embolizing the transhepatic tract (compare with [B]). (B) Unsubtracted portogram/sinogram image as the 7F access sheath is withdrawn. This is the same access site (dashed ellipse) as (A). Compare the branching of the portal vein branch with the branches of (A). The beginning of the transhepatic tract is between the sheath tip (open black arrow) and the portal access/entry site (dashed ellipse) (also marked between the two solid black arrows). Between the portal access/entry site (dashed ellipse) and the level of the straight dashed arrows is the accessed portal branch, which was <3 mm in diameter. Now this portal vein branch (running along the bidirectional dotted curved arrow) is dilated and featureless, and it is continuous with the transhepatic tract because the sheath had been placed through and dilated it. (C) Fluoroscopic image as the first contrast-impregnated Gelfoam torpedo is being deployed into the transhepatic tract (between arrows) from the 7F sheath as the sheath is withdrawn. (D) Fluoroscopic image after deployment of the first contrast-impregnated Gelfoam torpedo (boxed arrow no. 1). (E) Fluoroscopic image as the third contrast-impregnated Gelfoam torpedo (between arrows) is deployed into the transhepatic tract from the 7F sheath as the sheath is withdrawn (open arrow at sheath tip). The numbered boxed arrows point to the first and second contrast-impregnated Gelfoam torpedo, respectively. (F) Fluoroscopic image after the three contrast-impregnated Gelfoam torpedoes have been deployed into the transhepatic tract (boxed numbered arrows). The 7F sheath (hollow arrow at sheath tip) has been pulled back and is outside the transhepatic tract.

Figure 5 Transhepatic tract coil embolization after portal procedure. (A) Fluoroscopic image with minimal contrast injected in the transhepatic tract (between open arrows). The black open arrow points to the beginning of the transhepatic tract at the portal venous entry site, and the white open arrow points to the tip of the access sheath. (B) Fluoroscopic image as a 6-mm 0.035-inch coil (open black arrow) is being deployed through the sheath (open white arrow). (C) Fluoroscopic image after deploying the first coil (open black arrow) in the transhepatic tract (between the open arrows). (D) Fluoroscopic image as a second 6-mm 0.035-inch coil is being pushed out the sheath (open white arrow) and deployed between the first coil (open black arrow) and the sheath. (E) Fluoroscopic image after deploying the two coils (between the open black arrows) in the transhepatic tract. The sheath has been removed.

>8F or longer than 11 cm have a larger dead space/capacity that is ≥ 2 mL of glue mixture. In these larger sheath sizes, additional glue mixture is usually required. Alternatively, a 5% dextrose chase bolus is used to push the glue (NBCA) out into

the tract, compensating for the dead space of the sheath. The technique is shown and described in detail in ►Fig. 7.

One of the current authors (W.E.S.) initially flushes the sheath with 5% dextrose solution, followed by the 2 mL of 50%

Figure 6 Transhepatic tract embolization utilizing an oversized Amplatzer vascular plug. (A) Fluoroscopic image with minimal contrast injected in the transhepatic tract through the already deployed type I Amplatzer vascular plug (open arrow). The Amplatzer vascular plug (between open arrows in inset) is at least four times the size of the tract (between solid white arrows in inset). One of the authors (W.E.S.) does not recommend this degree of oversizing of the Amplatzer plug. (B) Contrast-enhanced computed tomography image of the same patient as (A) demonstrating the oversized Amplatzer vascular plug (open arrow).

Figure 7 Transhepatic tract embolization utilizing N-butyl cyanoacrylate (NBCA). (A) Fluoroscopic image during contrast injection through the 7F sheath placed over a 0.035-inch wire (open white arrow) showing contrast in the portal vein (solid black arrows). The transhepatic tract is seen between the solid white arrows. The actual sheath tip is marked by the dashed arrow and not the radiopaque marker (open black arrow). (B) Fluoroscopic image during NBCA injection through the 7F sheath as the 7F sheath (open black arrow) is pulled back over the 0.035-inch wire (open white arrow). The column of NBCA is seen between the solid white arrows. (C) Fluoroscopic image after NBCA injection. The 7F sheath has been removed and the 0.035-inch wire has also been removed. The wire is removed last, and it leaves a linear path (dashed arrow) that runs along the entire tract and not its transhepatic section. The sections of the entire tract are the intrahepatic portion (between solid white arrows), the transperitoneal and trans-chest wall portions (between solid black arrows), and the subcutaneous portion (open black arrow).

NBCA/50% Lipiodol mixture. The 0.035-inch wire is kept in place within the portal vein and removed last after tract embolization has been completed and the sheath has been removed (►Fig. 7). The glue mixture is pushed very slowly, like toothpaste, to the tip of the sheath. The exact access into the portal vein branch should be known by reviewing the access images. Additional injection causes the glue mixture to exit the sheath. The sheath is then slowly pulled back as the glue mixture is advanced out of the sheath (►Fig. 7). The operator intends to embolize the entire tract including the transhepatic tract, the hepatic capsule-peritoneum interface, the chest wall or abdominal wall, and the subcutaneous tract. In this technique, the glue mixture is not confined to the intrahepatic and subcapsular tract, in a similar way as described by Cekirge and coworkers.²⁵ Once the glue mixture has been placed uniformly throughout the tract, the 0.035-inch wire is slowly and steadily removed (the 0.035-inch wire should be straight and not have a “J” tip configuration) (►Fig. 7). Gentle pressure is applied to stabilize the glue-mixture plug but not enough to fracture it or fragment it. A word of caution: NBCA causes exquisite but very short-lived pain when it touches the peritoneal lining. Patients should be warned about this beforehand.

Conclusion

Percutaneous portal vein access and its subsequent closure are critical technical aspects of substantial portal venous procedures, especially in the setting of anticoagulation and portal hypertension. Sufficient postprocedure hemostasis starts with meticulous technique for portal access and closure. Regardless of the method used, meticulous technique is required to maintain the overall safety and effectiveness of the procedure.

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