Diagnosis and Management of Hemorrhagic Complications of Interventional Radiology Procedures

Mark L. Lessne, MD¹ Brian Holly, MD² Steven Y. Huang, MD³ Charles Y. Kim, MD, FSIR⁴

¹ Vascular and Interventional Specialists of Charlotte Radiology, Charlotte, North Carolina

² Department of Radiology, The Johns Hopkins Hospital, Baltimore, Maryland

³ Department of Interventional Radiology, The University of Texas MD Anderson Cancer Center, Houston, Texas

⁴ Division of Vascular and Interventional Radiology, Duke University Medical Center, Durham, North Carolina

Address for correspondence Charles Y. Kim, MD, FSIR, Division of Vascular and Interventional Radiology, Department of Radiology, Duke University Medical Center, Box 3808, 2301 Erwin Road, Durham, NC 27710 (e-mail: charles.kim@duke.edu).

Semin Intervent Radiol 2015;32:89–97

Abstract

Keywords

- interventional radiology
- complications
- hemorrhage
- percutaneous

Image-guided interventions have allowed for minimally invasive treatment of many common diseases, obviating the need for open surgery. While percutaneous interventions usually represent a safer approach than traditional surgical alternatives, complications do arise nonetheless. Inadvertent injury to blood vessels represents one of the most common types of complications, and its affect can range from inconsequential to catastrophic. The interventional radiologist must be prepared to manage hemorrhagic risks from percutaneous interventions. This manuscript discusses this type of iatrogenic injury, as well as preventative measures and treatments for postintervention bleeding.

Objectives: Upon completion of this article, the reader will be able to identify the hemorrhagic risks associated with interventional radiology procedures, as well as their recognition and management.

Accreditation: This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of Tufts University School of Medicine (TUSM) and Thieme Medical Publishers, New York. TUSM is accredited by the ACCME to provide continuing medical education for physicians.

Credit: Tufts University School of Medicine designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Although interventional radiologic procedures are minimally invasive, the risk of hemorrhage is present for virtually all procedures. Proper patient selection and preparation can

mitigate these risks; thus, adherence to established guidelines designed to minimize hemorrhagic risks is essential but is outside the scope of this review article.¹ Additionally, the practicing interventionalist must be familiar with general principles of hemostasis, including systemic factors contributing to bleeding, correction of coagulopathy when possible, and guidelines regarding the need for transfusion of blood products.^{1,2} This review article focuses on prevention and management of hemorrhagic complications specific to common percutaneous procedures.

Assessment of Bleeding

The initial step in the approach to the patient with post-procedural bleeding is assessment of the severity of bleeding. This should begin with a visual inspection combined with an understanding of the anatomic routes taken during the initial procedure and potential sources of hemorrhage. Assessment of the patient's vital signs is crucial. Typically, patients will demonstrate signs of hemodynamic instability, namely,

hypotension and tachycardia, when the volume loss is severe. When there is concern for hemorrhage, the frequency of vital sign assessments should be increased, to identify trends that may indicate impending hemorrhagic shock.

Volume resuscitation is an important initial step when there is significant hemorrhage. Normal saline or lactated ringer solutions are often used for this purpose, in bolus volumes of 500 mL (less in patients with congestive heart failure or renal failure). Blood draws for measurement of hemoglobin and hematocrit are also crucial measures for determining the degree and severity of blood loss. In patients undergoing blood transfusions, constant monitoring of hemoglobin and hematocrit are important to assess for an appropriate response to the transfusion. If not, then ongoing bleeding must be assumed. An immediate assessment of current medications or conditions that may cause coagulopathy or platelet dysfunction should be performed, so that reversal agents can be administered if available and appropriate. Recent laboratory coagulation parameters should likewise be reviewed for deficiencies that can be corrected with transfusions; if no recent results are available, then immediate blood draws are warranted. Noninvasive imaging tests such as computed tomography (CT) and ultrasound should be considered to confirm or exclude the presence of hemorrhage and, if present, to guide appropriate therapy. Noncontrast CT is an excellent technique for identifying the presence of acute hemorrhage; however, exact localization typically requires contrast-enhanced arterial phase imaging. In patients with severe hemorrhage as evidenced by hemodynamic instability or other signs of hemorrhagic shock, urgent angiography should be performed for diagnosis and treatment with embolization. Perhaps the most important advice to follow is this: if the patient's status is progressively becoming critical, it is crucial to escalate the level of care and involve appropriate care teams.

Percutaneous Biliary and Gallbladder Interventions

While endoscopic access to the biliary system can provide a less invasive route to diagnose and treat pathology of the biliary system, endoscopists may be limited by altered gastrointestinal tract anatomy, or hilar or intrahepatic biliary disease.³ Percutaneous access to the biliary tree has become an essential therapeutic component for patients with both benign and malignant diseases. However, bleeding risks of such access are classified as moderate or significant, requiring special attention to coagulation status and technique.¹ While transhepatic biliary procedures carry a relatively low major complication rate, hemorrhagic and septic complications are most common with reported rates of 2.5% each, although death more often results from bleeding rather than sepsis.^{4,5} Notably, left-sided hepatic transhepatic access is reported to carry a higher risk for hepatic arterial injury than right-sided catheters.⁶

When vascular complications do occur, the clinical presentation can range from asymptomatic hemobilia to massive hemorrhage with hemodynamic compromise. The clinical setting often depends on the type of vessel injured, anatomic

location, and the baseline condition of the patient. Mild periprocedural hemobilia is a frequent transient phenomenon, often of venous etiology, typically presenting as bloody percutaneous biliary drain (PBD) output or melena. In the several weeks following tube insertion but prior to tract maturation, retraction of the catheter from respiratory motion or physical pulling can result in the catheter side holes withdrawing into the transhepatic tract, allowing the potential for communication between the side holes and any vascular structure that may have been traversed by the drainage catheter (►Fig. 1). Catheter evaluation and repositioning using fluoroscopy will often resolve bleeding from this etiology. When evaluating the catheter, special attention should be paid to ensuring that all side holes lie within the biliary tree and not within the parenchymal tract. When it is difficult to visualize the holes, comparing the position of the radiopaque marker that is commonly present on PBD catheters with imaging obtained at initial placement can be helpful. Upsizing the biliary catheter can also effectively serve to tamponade and control the bleeding.³

For more severe or symptomatic bleeding (as evidenced by increasing amounts of blood in the drainage bag, decreasing serum hemoglobin/hematocrit levels, and/or hemodynamic instability), localization of the injured vessel is warranted. Although bleeding from the liver may manifest as hemobilia or melena if blood tracks within the catheter, it can be less clinically apparent in the setting of intraperitoneal hemorrhage or a subcapsular hematoma. Although major hemorrhage is most often arterial in nature, it must be kept in mind that major bleeding can also result from portal venous injury, particularly in the setting of portal hypertension and coagulopathy. Since biliary ducts travel in the portal triad with the corresponding artery and portal vein, these vessels can easily be injured or traversed during PBD insertion. Risks of major

Fig. 1 Hemobilia caused by transportal vein puncture during percutaneous biliary drainage catheter placement. Patient presented 2 weeks following biliary catheter placement with bloody drainage. Pullback cholangiogram demonstrated traversal of branches of right portal vein (arrowheads). The catheter was upsized with resolution of hemobilia.

arterial or portal venous injury increase with access of the central biliary tree, which may result in injury to the main arterial or portal vein branches.³

Noninvasive imaging evaluation can be performed with a triple-phase CT scan for identification of active extravasation, pseudoaneurysm, or arteriportal fistula on arterial, portal, and venous phases. Perhaps, more importantly, CT can help identify nonhepatic sources of arterial injury, such as the intercostal arteries or epigastric arteries. While positive studies can help direct the interventionalist to the appropriate site for subsequent intervention, a negative CT scan does not rule out vascular injury, since the bleeding may be intermittent. It should be remembered that if the CT scan is performed soon after initial PBD insertion, residual intra-biliary or perihepatic contrast may be present and can mimic hemorrhage or active contrast extravasation—therefore, pre-contrast scans are crucial. Given these limitations of CT, any patient suspected to have massive bleeding with hemodynamic instability should proceed directly to arteriography. Important angiographic findings include contrast extravasation (including into the biliary tree), pseudoaneurysms, arteriovenous or arteriportal fistulae, and arterial truncation. If the angiogram is negative, the PBD catheter should be removed over a guidewire, with repeat arteriography, to increase the chance to identify and definitively treat the

injured artery (► **Fig. 2**). Maintaining wire access across the biliary tree is crucial, as this allows for rapid reinsertion of the catheter to help tamponade active bleeding, as well as an opportunity to advance a sheath and perform an over-the-wire tractogram to assess for any traversed vessels. Tract embolization with gelatin sponge material can also be attempted. It is important to avoid performing a cholangiographic evaluation for the site of hemorrhage prior to angiography, as intrabiliary contrast may obscure the presence and site of active extravasation or vascular injury.³

Once a vessel injury is identified and it is determined that embolization is required, standard techniques and agents of transarterial embolization can be used, including Gelfoam, metallic coils, plugs, or liquid embolic agents. Due to the existence of intrahepatic collateral arteries, a bleeding site should be ideally embolized proximal and distal to the site of injury to avoid retrograde flow via collaterals to the arterial injury and subsequent continued hemorrhage. When transcatheter embolization is required, the technical and clinical success rates are >95% and rarely result in major complications.⁶ The use of stent grafts may be considered when the injured vessel is centrally located, such as the common, main right, or main left hepatic arteries; smaller stent graft sizes appropriate for the hepatic vasculature are becoming more readily available. If the main hepatic arteries are injured,

Fig. 2 Arterial injury after PBD insertion. The patient presented with overnight hemobilia after PBD insertion with dropping serial hematocrit levels. (a) The initial image obtained after insertion of a right-sided PBD. A left-sided PBD was then placed (not pictured). (b) Initial celiac arteriogram demonstrates no evidence of arterial injury. (c) Repeat celiac arteriogram after removal of bilateral PBDs over guidewires demonstrates brisk active extravasation (arrowheads) originating from the proximal right anterior hepatic artery (white arrow). (d) Follow-up arteriogram of the common hepatic artery after coil embolization of the right anterior hepatic artery and main right hepatic artery. Variant middle/left hepatic artery anatomy is present, with separate branches supplying segments 2 and 3 (white arrow) and segment 4 (black arrow). Notice that multiple branches of the right hepatic artery (black arrow) are reconstituted by interlobar collaterals (arrowheads) from the middle hepatic artery (black arrow).

another option is embolization of the main right or left hepatic artery proximal and distal to the site of injury (►Fig. 2). While this practice may seem extreme, it should be kept in mind that the main left and right hepatic arteries are routinely embolized for hepatic tumor therapy. Furthermore, when the proximal hepatic arteries are segmentally embolized with plugs or coils, the more distal arterial distribution will be reconstituted by intrahepatic collateral arteries. When symptoms of vessel injury persist, but no hepatic source can be determined, potential “bystander” vessels should be assessed, such as the intercostal arteries, cystic artery, and epigastric arteries. Variant hepatic arterial anatomy should also be kept in mind when angiographically searching for injured arteries.

Percutaneous cholecystostomy catheter placement is generally indicated for patients with acute cholecystitis who are at high risk for cholecystectomy.⁷ Two routes have been advocated for gaining access into the gallbladder: transhepatic and transperitoneal. The transhepatic route targets the “bare area” of the gallbladder where it attaches to the liver, theoretically minimizing bile leak into the peritoneal cavity and maximizing catheter stability.^{7,8} However, advocates of the transperitoneal route cite a lower bleeding risk by virtue of avoiding traversal of the hepatic parenchyma. Regardless of the route, hemorrhagic complications from ultrasound-guided cholecystostomy are uncommon, occurring in ~2% of procedures, despite the fact that the gallbladder wall is relatively well vascularized (►Fig. 3).⁴ In a recent study, 242 patients underwent percutaneous cholecystostomy, of which 132 were coagulopathic, with only a single instance of hemorrhage requiring transfusion in the group with normal coagulation, and 3 minor hemorrhagic complications overall.⁹ Given that the gallbladder may be inflamed with reactive hypervascularity in the setting of acute cholecystitis, mild and transient parenchymal hemorrhage is not unexpected. However, as with all percutaneous interventions, when symptomatic hemorrhage recalcitrant to conservative management occurs, transarterial embolization of the symptomatic artery may be indicated. Similar to transhepatic cholangiography, hepatic and intercostal arteries should be

Fig. 3 Angiographic image of a cystic arteriogram demonstrates the arterial vascularity of a normal gallbladder.

interrogated by cross-sectional imaging or conventional angiography. Generally, the gallbladder itself is supplied by a single cystic artery, originating from right hepatic artery, though anatomical variations are common, including double cystic arteries in ~15% of patients.¹⁰

Percutaneous Renal Interventions

Image-guided access into the renal collecting system allows for the diagnosis and treatment of numerous pathologies, from renal failure to obstruction to malignancies. A highly vascular organ, the kidney may be injured during percutaneous interventions resulting in clinically significant hemorrhage, although this occurs less frequently than might be expected. A 1 to 4% rate of hemorrhage requiring transfusion, and a <1% rate of vascular injury requiring arterial intervention or nephrectomy, is reported.¹¹ In a recent analysis of 341 patients who underwent 1,036 percutaneous renal interventions (including nephrostomy, ureteral stent placement, or catheter exchanges), 1 patient suffered fatal retroperitoneal bleeding and 1.2% of procedures resulted in persistent hematuria.¹² Regardless, knowledge of the vascular anatomy of the kidney is critical to avoid and manage these injuries.

The renal artery branches into anterior and posterior divisions that then supply three to four segmental branches anteriorly and one segmental branch posteriorly. Arcuate arteries at the base of the renal pyramids supply the renal cortex through interlobular branches. The governing principle for minimization of hemorrhagic complications is with percutaneous transrenal access by traversal of as little parenchyma as possible at anatomic regions of kidney with terminal arteries. To traverse minimal parenchyma, a posteriorly located renal calyx should be targeted. By doing so, the larger main and segmental arteries can be avoided. In fact, the avascular line of Brödel is often considered during renal intervention as a plane in the posterolateral kidney between anterior and posterior intrapolar vessels, with a relative paucity of large arterial branches; although an appealing target, this plane is often difficult to identify by imaging.¹³ Injury to vessels along the access tract may result in bleeding from nonrenal arteries, namely, the intercostal, lumbar, and renal capsular artery (which usually originates from the proximal renal artery along with inferior adrenal and ureteric arteries, but may also originate from accessory renal or lumbar arteries).

After percutaneous catheter nephrostomy insertion, hematuria (ranging from blood-tinged urine to gross hematuria) is common and usually self-limited, resolving within 1 to 2 days. Filling defects noted on completion nephrostograms are also common and typically of no clinical significance (►Fig. 4). In the setting of asymptomatic or mildly symptomatic hematuria after percutaneous renal intervention, conservative management is usually indicated. Upsizing the nephrostomy catheter can be effective as definitive treatment of minor bleeding by tamponading the bleeding parenchyma and small vessels. Continuous bladder irrigation may be helpful to prevent outlet obstruction from clot. Similarly, perirenal hematomas detected on CT are not uncommon

Fig. 4 Anterograde nephrostogram obtained immediately after PCN insertion. Notice the filling defects in the collecting system, which are consistent with clot formation from bleeding. This episode was self-limited without significant hematocrit drop on next-day blood draws.

and are usually self-limited. However, if hemorrhage is persistent as evidenced by continuously dropping hemoglobin/hematocrit with the need for serial transfusions or if the patient becomes hemodynamically unstable, renal arteriography is indicated. Active extravasation, pseudoaneurysms, arteriovenous fistulas, and arterial truncation are angiographic signs of arterial injury that warrant treatment (► **Fig. 5**). Coil embolization should generally be performed as distally as possible. Unlike the liver, the renal arteries are “end-arteries”; thus renal parenchyma is more susceptible to ischemic damage and infarction due to lack of collateralization. However, because of this end arterial supply, proximal embolization techniques without distal control of the bleeding vessel are generally adequate to treat renal arterial injuries. In addition to traditional transarterial embolization, transrenal techniques have been described, including advancement of a 10 French sheath through the percutaneous catheter tract allowing for coil embolization of the parenchymal tract while balloon occluding entry to the renal collecting system to minimize risk of coil migration.¹⁴ If no signs of arterial injury are encountered, the percutaneous nephrostomy (PCN) should be removed over a guidewire, and repeat arteriography performed, for reasons analogous to detection of PBD-related bleeding. If angiograms are negative, catheter upsizing and a final repeat angiogram (in case of rebleeding after catheter manipulation) can be performed.

Percutaneous Gastrostomy Access

For patients who are unable to consume adequate nutrition orally, percutaneous placement of gastrostomy or gastrojejunostomy can allow for maintenance of nutritional requirements and dramatically improve quality of life. Minor bleeding occurs after most percutaneous gastrostomy access

Fig. 5 Arterial injury following PCN insertion. This patient had large quantity, frankly bloody PCN output immediately after PCN insertion. (a) Renal arteriography demonstrates a pseudoaneurysm (arrow). (b) Follow-up renal arteriogram after coil embolization of the injured branch demonstrates nonfilling of the pseudoaneurysm.

procedures, often from cutaneous or subcutaneous vessel traversal or from gastric mucosal irritation by the tube.¹⁵ Superficial bleeding usually resolves as the catheter or retention balloon and disc act to tamponade the bleeding vessel; cinching retention discs that have loosened is often an effective first step.

Major bleeding more commonly occurs from direct injury to the vessels associated with the stomach. The stomach has a rich vascular supply from left and right gastric, gastroduodenal, short gastric, and gastroepiploic arteries. Considering that the ideal gastric access should be performed in the distal gastric body or antrum below the costal margin, the artery at greatest risk of injury is the gastroepiploic artery and its branches. Inadvertent vascular injury occurs in up to 2.5% of gastrostomy tube placements.^{15,16} As with all procedures, proper technique can aid in avoiding bleeding complications from gastrostomy tube placement. Adequate insufflation of the stomach can help displace blood vessels, thus minimizing the risk of injury. The inferior margin of the stomach should be avoided due to the presence of the gastroepiploic vessels.

T-fastener gastropexy may help decrease bleeding risk by tamponading vessels adjacent to the G-tube.¹⁷

Patients with bleeding related to transgastric access can manifest with bloody tube output, hematemesis, and/or bleeding from the exit site—however, it should be kept in mind that a large amount of bleeding can occur into the peritoneum, where it can continue undetected until the patient becomes symptomatic. Most episodes of bleeding are self-limited, but some require corrective measures. As described above, for patients with balloon or bumper-retained tubes, cinching the tube will effectively compress the gastric wall and abdominal wall around the tube, which can help tamponade bleeding and resolve minor episodes. For patients with more severe episodes of hemorrhage recalcitrant to conservative therapies, CT should be considered. Not only can CT demonstrate the presence of active bleeding, but also it can identify a site for angiographic interrogation if needed, particularly considering the potential for an abdominal wall source (►Fig. 6). On celiac arteriography, particular attention should be paid to the gastric arterial supply based on the location of the tube. Given its redundant blood supply, transcatheter embolization of the gastroepiploic, left gastric, or gastroduodenal arteries can usually be performed without adverse effects and has been reported with a variety of embolic agents, including Gelfoam, coils, and *N*-butyl cyanoacrylate.¹⁸ For coils, plugs, and liquid agents, embolization should be performed proximal and distal to the site of injury similar to other forms of traumatic injury. In cases where arteriography is unrevealing or contraindicated, endoscopy may allow for treatment or localization of the bleeding site; furthermore, although direct arterial injury is commonly the cause of major bleeding during gastrostomy tube placement, patients with portal hypertension are at risk for gastric variceal injury, which can result in substantial blood loss.¹⁷

Fig. 6 Inferior epigastric artery pseudoaneurysm following gastrostomy tube placement. Axial thick-slab reformatted image from a contrast-enhanced CT scan during the arterial phase demonstrates a pseudoaneurysm arising from the inferior epigastric artery (arrow). The inferior epigastric artery was successfully coil embolized across the site of extravasation (not shown).

In these cases, endoscopy and cross-sectional imaging can be helpful for identifying this etiology.

Percutaneous Abscess Drainage Catheter Placement

Bleeding during or after image-guided intraperitoneal abscess drainage catheter insertion is rare, likely related to the avascular or hypovascular structures that are typically traversed. In most cases, either CT or ultrasound is used to guide drain placement, allowing the operator to visualize and avoid intervening blood vessels. The reported incidence of hemorrhagic complications at the time of drain placement range from 0 to 2.5%.^{19–21} Certainly, drainage of abscesses within highly vascular organs such as the spleen or liver is at much higher risk for bleeding complications. In instances such as these, some authors suggest using the Seldinger technique over the trocar technique for drain placement to decrease complications, although no direct comparison has been reported.^{22,23}

Any signs of bleeding associated with the drain deserve attention. Bleeding can be seen coming out of the drain into the drainage container or along the tract. It is especially worrisome if previously nonbloody drainage changes to bloody output; in these cases, the catheter should not be removed until a thorough work-up of the source of bleeding has been undertaken. Some physicians advocate capping or upsizing of the tube to create a tamponade effect within the collection cavity.²³ Contrast-enhanced CT should be performed early to potentially identify active extravasation from an adjacent blood vessel. If an arterial bleed is suspected, angiography should be performed with the intent of embolizing the culprit vessel. If the bleeding site is within a vascular organ, the arterial supply to that organ needs to be interrogated. Arterial vessels supplying the region of the drain tract should also be evaluated (i.e., intercostal arteries, lumbar arteries, etc.).

Percutaneous Biopsy

Percutaneous image-guided biopsy has become an extremely important means of providing a tissue diagnoses. Bleeding, although usually clinically insignificant, is frequently encountered during and after these biopsy procedures. However, a recent, single center, retrospective review of over 15,000 percutaneous biopsies reported a significant hemorrhage within 3 months of the biopsy in only 0.5% of cases. The same study found organ-specific incidences of bleeding after biopsy of 0.5% for liver, 0.7% for kidney, 0.2% for lung, 0.1% for pancreas, and 0.2% for other organs.²⁴

Some interventionalists routinely instruct the patient to lay in a particular position, so that the site of biopsy is facing downward, following the biopsy procedure. In theory, there may be some degree of pressure to the biopsied organ, such as the liver or spleen. Lung biopsy patients are often placed in the recumbent position with the side of biopsy facing downward to prevent pneumothorax, although more recent research suggests this precaution is unnecessary.²⁵ There is

one report in the literature of a case where intrapulmonary bleeding was encountered during attempted drainage of a lung abscess. The authors strongly recommended placing the patient in the lateral position with the bleeding lung dependent, and this has been deemed conventional practice despite the lack of scientific evidence.²⁶

For biopsy of vascular organs such as liver, spleen, and kidney, there are several reports of prophylactic tract embolization to prevent postbiopsy bleeding.^{27–29} The biopsy is performed through a vascular sheath or with a coaxial needle system. Based on the imaging used for guidance, the length of the biopsy tract from the target to the organ capsule is measured. A strip of gelatin sponge is cut to the same length, of ~2 mm, and rolled into a rod-like structure (Gelfoam torpedo). The Gelfoam torpedo is then inserted into the sheath or coaxial guide needle, and advanced using the inner dilator or stylet until it is completely within the tract. By withdrawing the sheath or needle over the inner dilator or stylet, the Gelfoam torpedo is laid across the tract, which subsequently expands and contributes to hemostasis. Although theoretically helpful to avoid hemorrhage, there have been no well-controlled clinical studies analyzing the actual benefit. However, in a dog model comparing radiofrequency tract ablation, gelatin sponge tract embolization, and glue for biopsy tract embolization, all three methods demonstrated improved hemostasis over the control group. However, the authors concluded that radiofrequency ablation was the most useful due to shortened procedure time relative to the Gelfoam method and due to embolization of the Histoacryl–lipiodol mixture into splenic artery branches in several cases.³⁰

Given the likely high incidence of minor bleeding with biopsy of vascular organs but a very low incidence of clinical significant hemorrhage, routine postbiopsy imaging is likely not warranted. However, if the patient exhibits signs or symptoms of significant hemorrhage, appropriate action should be taken. In many cases, a noncontrast CT can be helpful to verify the presence of hemorrhage (→**Fig. 7**) followed by a contrast-enhanced CT to identify the source of the bleeding and whether the vessel is actively bleeding. If a vascular injury is identified, immediate angiography should be performed; in the setting of hemodynamic instability, urgent angiography is warranted. Depending on the location of the biopsy, the operator must consider all vascular supplies. For example, if significant intraparenchymal bleeding is noted after a lung biopsy, one should consider interrogation of the both the bronchial and pulmonary arteries.

Central Venous Access

Long-term central venous access device placement, including tunneled catheters and implantable ports, is one of the most common procedures performed by interventional radiologists. Iatrogenic bleeding complications of this common procedure have largely been mitigated by the widespread use of ultrasound guidance for venous access. Bleeding, hematoma, and/or arterial puncture occur in

Fig. 7 Perisplenic hematoma following percutaneous biopsy. (a) Ultrasound image demonstrates a faint hypoechoic splenic lesion (arrows). The lesion was percutaneously sampled with a 22-gauge Chiba needle (arrowhead). (b) Immediately following biopsy, the patient complained of left upper quadrant pain. An axial image from a noncontrast CT demonstrates a perisplenic hematoma (thin arrows). The patient was taken emergently to angiography and a branch of the splenic artery was successfully particle embolized (not shown).

between 0.3 and 6.4% of central venous port placement, but most of these are clinically insignificant.^{31,32} Minor bleeding is commonly encountered, especially in hemodialysis patients who have poor platelet function. A literature review by Kerr et al found that bleeding after tunneled dialysis catheter placement has been reported in 0 to 42% of patients, but is usually self-limiting or resolves quickly with manual compression.³³

Appropriate coagulation parameters should be confirmed and a directed history, focusing on the venous access history and other risk factors for central venous stenosis, should be obtained. Central venous stenosis or occlusion can lead to enlarged venous collaterals on the chest wall or neck, which in turn increases the risk of bleeding during tunnel or pocket creation. If a large pressurized collateral vein is injured, identification and suture ligation should be attempted. Thermal cautery is often ineffective for these large caliber vessels. Alternatively, one or more mattress-type sutures placed through the subcutaneous tissues in the general region of the suspected bleeding vessel location can be helpful to stop the bleeding.

In patients with tunneled catheters, persistent oozing of blood from the catheter exit site often results in numerous persistent bandage changes and catheter manipulations, which may increase the risk for catheter infection. While bleeding is typically manifested at the exit site, it should be kept in mind that the actual source of bleeding is often the venotomy site, and thus direction compression should be applied at that site initially. If bleeding stops, the source is confirmed, and pressure can be continued. If there is no change in bleeding rate, then pressure should be applied to various points along the subcutaneous catheter tract as treatment for an alternative source for the bleeding vessel(s). Pressure dressings may prove helpful. Other strategies include injecting lidocaine with epinephrine along the catheter tunnel or injections of a flowable hemostatic powder in the tunnel. However, suturing at the exit site may be the most

definitive therapy. For this purpose, nylon monofilament sutures should be used. The goal of suturing is to physically impede the flow of blood out of the exit site; by doing so, the blood will accumulate in the tract until it reaches equilibrium pressure with the venous system, with resulting thrombosis within the tract due to stasis. A variety of methods can be used, including purse string suture around the catheter at the exit site, a simple suture that encircles the catheter and surrounding tract near the exit site, or a simple suture across one side of the incision that allows the exit site diameter to be tightened. Inserting a tubular object, such as a cut piece of sheath, will be helpful to allow tightening of the closure by twisting, and will allow laxity in the suture when it is removed, to allow easier cutting of the suture. The suture should be removed within a few days to minimize the risk of skin necrosis and pain. In fact, purse string sutures placed routinely around the catheter exit site in hemodialysis patients was reported to nearly eliminate exit site oozing.³³ When all efforts fail, removal of the catheter with refractory bleeding often allows hemostasis; however, any additionally inserted catheters may carry the same bleeding risk.

Patients receiving tunneled catheters for hemodialysis are at particular risk for minor bleeding, because uremia associated with chronic renal failure can induce platelet dysfunction. In patients who are uremic, initiation or resumption of hemodialysis can mitigate bleeding by resolving the uremia. Desmopressin is a synthetic derivative of antidiuretic hormone that induces the release of autologous von Willebrand factor from storage sites in plasma. In dialysis patients with acute bleeding, desmopressin can be used at a dose of 0.3 µg/kg intravenously (added to 50 mL of saline over 30 minutes) or subcutaneously. Intranasal administration at a dose of 3 µg/kg is also effective and well tolerated.³⁴ The effect of desmopressin lasts only for a few hours and loses efficacy when repeatedly administered, likely related to depletion of von Willebrand factor stores.

When placing central venous ports, lidocaine with epinephrine for local anesthesia can be helpful to minimize bleeding during pocket creation. Additionally, use of electrocautery is favored for pocket creation if superficial venous bleeding is encountered or in patients who are at higher risk for bleeding.³⁵ Small pocket hematomas can usually be observed and treated conservatively, but larger hematomas are at risk of infection or pocket dehiscence and should be evacuated.

Conclusion

The evolution of minimally invasive, image-guided procedures has allowed effective and generally safe therapies for many common diseases. While the safety profile of these interventions is usually favorable—both absolutely and relative to an open surgical alternative—they are not without risk. The ability to avoid hemorrhagic complications or manage these when they do occur is a critical skill for the interventional radiologist. Fortunately, with proper operator training, procedural planning, and patient selection, the vast majority of interventional therapies offer substantial benefit to the patient relative to their risk.

References

- 1 Patel IJ, Davidson JC, Nikolic B, et al; Standards of Practice Committee, with Cardiovascular and Interventional Radiological Society of Europe (CIRSE) Endorsement. Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. *J Vasc Interv Radiol* 2012;23(6):727–736
- 2 Szczepiorkowski ZM, Dunbar NM. Transfusion guidelines: when to transfuse. *Hematology (Am Soc Hematol Educ Program)* 2013; 2013:638–644
- 3 Winick AB, Waybill PN, Venbrux AC. Complications of percutaneous transhepatic biliary interventions. *Tech Vasc Interv Radiol* 2001;4(3):200–206
- 4 Saad WE, Wallace MJ, Wojak JC, Kundu S, Cardella JF. Quality improvement guidelines for percutaneous transhepatic cholangiography, biliary drainage, and percutaneous cholecystostomy. *J Vasc Interv Radiol* 2010;21(6):789–795
- 5 Lynskey GE, Banovac F, Chang T. Vascular complications associated with percutaneous biliary drainage: a report of three cases. *Semin Intervent Radiol* 2007;24(3):316–319
- 6 Choi SH, Gwon DI, Ko GY, et al. Hepatic arterial injuries in 3110 patients following percutaneous transhepatic biliary drainage. *Radiology* 2011;261(3):969–975
- 7 Akhan O, Akinci D, Ozmen MN. Percutaneous cholecystostomy. *Eur J Radiol* 2002;43(3):229–236
- 8 Garber SJ, Mathieson JR, Cooperberg PL, MacFarlane JK. Percutaneous cholecystostomy: safety of the transperitoneal route. *J Vasc Interv Radiol* 1994;5(2):295–298
- 9 Dewhurst C, Kane RA, Mhuircheartaigh JN, Brook O, Sun M, Siewert B. Complication rate of ultrasound-guided percutaneous cholecystostomy in patients with coagulopathy. *AJR Am J Roentgenol* 2012;199(6):W753–60
- 10 Mlakar B, Gadzijev EM, Ravnik D, Hribernik M. Anatomical variations of the cystic artery. *Eur J Morphol* 2003;41(1):31–34
- 11 Ramchandani P, Cardella JF, Grassi CJ, et al; Society of Interventional Radiology Standards of Practice Committee. Quality improvement guidelines for percutaneous nephrostomy. *J Vasc Interv Radiol* 2003;14(9, Pt 2):S277–S281
- 12 Kaskarelis IS, Papadakis MG, Malliaraki NE, Robotis ED, Malagari KS, Piperopoulos PN. Complications of percutaneous nephrostomy, percutaneous insertion of ureteral endoprosthesis, and replacement procedures. *Cardiovasc Intervent Radiol* 2001;24(4):224–228
- 13 Kaufman JA, Lee MJ. Vascular and interventional radiology. Available at: <http://ezproxy.lib.utexas.edu/login?url=https://www.clinicalkey.com/dura/browse/bookChapter/3-s2.0-C20090467941>. Accessed November 20, 2014
- 14 Tokue H, Takeuchi Y, Arai Y, Tsushima Y, Endo K. Anchoring system-assisted coil tract embolization: a new technique for management of arterial bleeding associated with percutaneous nephrostomy. *J Vasc Interv Radiol* 2011;22(11):1625–1629
- 15 Covarrubias DA, O'Connor OJ, McDermott S, Arellano RS. Radiologic percutaneous gastrostomy: review of potential complications and approach to managing the unexpected outcome. *AJR Am J Roentgenol* 2013;200(4):921–931
- 16 Itkin M, DeLegge MH, Fang JC, et al; Interventional Radiology and American Gastroenterological Association; American Gastroenterological Association Institute; Canadian Interventional Radiological Association; Cardiovascular and Interventional Radiological Society of Europe. Multidisciplinary practical guidelines for gastrointestinal access for enteral nutrition and decompression from the Society of Interventional Radiology and American Gastroenterological Association (AGA) Institute, with endorsement by Canadian Interventional Radiological Association (CIRA) and Cardiovascular and Interventional Radiological Society of Europe (CIRSE). *J Vasc Interv Radiol* 2011;22(8):1089–1106

- 17 Ozmen MN, Akhan O. Percutaneous radiologic gastrostomy. *Eur J Radiol* 2002;43(3):186–195
- 18 Seo N, Shin JH, Ko GY, et al. Incidence and management of bleeding complications following percutaneous radiologic gastrostomy. *Korean J Radiol* 2012;13(2):174–181
- 19 Marin D, Ho LM, Barnhart H, Neville AM, White RR, Paulson EK. Percutaneous abscess drainage in patients with perforated acute appendicitis: effectiveness, safety, and prediction of outcome. *AJR Am J Roentgenol* 2010;194(2):422–429
- 20 Akinci D, Akhan O, Ozmen MN, et al. Percutaneous drainage of 300 intraperitoneal abscesses with long-term follow-up. *Cardiovasc Intervent Radiol* 2005;28(6):744–750
- 21 Goletti O, Lippolis PV, Chiarugi M, et al. Percutaneous ultrasound-guided drainage of intra-abdominal abscesses. *Br J Surg* 1993;80(3):336–339
- 22 Erasmus JJ, McAdams HP, Rossi S, Kelley MJ. Percutaneous management of intrapulmonary air and fluid collections. *Radiol Clin North Am* 2000;38(2):385–393
- 23 Lorenz J, Thomas JL. Complications of percutaneous fluid drainage. *Semin Intervent Radiol* 2006;23(2):194–204
- 24 Atwell TD, Smith RL, Hesley GK, et al. Incidence of bleeding after 15,181 percutaneous biopsies and the role of aspirin. *AJR Am J Roentgenol* 2010;194(3):784–789
- 25 Collings CL, Westcott JL, Banson NL, Lange RC. Pneumothorax and dependent versus nondependent patient position after needle biopsy of the lung. *Radiology* 1999;210(1):59–64
- 26 Mueller PR, Berlin L. Complications of lung abscess aspiration and drainage. *AJR Am J Roentgenol* 2002;178(5):1083–1086
- 27 Smith TP, McDermott VG, Ayoub DM, Suhocki PV, Stackhouse DJ. Percutaneous transhepatic liver biopsy with tract embolization. *Radiology* 1996;198(3):769–774
- 28 Fandrich CA, Davies RP, Hall PM. Small gauge gelfoam plug liver biopsy in high risk patients: safety and diagnostic value. *Australas Radiol* 1996;40(3):230–234
- 29 Tsang WK, Luk WH, Lo A. Ultrasound-guided plugged percutaneous biopsy of solid organs in patients with bleeding tendencies. *Hong Kong Med J* 2014;20(2):107–112
- 30 Choi SH, Lee JM, Lee KH, et al. Postbiopsy splenic bleeding in a dog model: comparison of cauterization, embolization, and plugging of the needle tract. *AJR Am J Roentgenol* 2005;185(4):878–884
- 31 Lorch H, Zwaan M, Kagel C, Weiss HD. Central venous access ports placed by interventional radiologists: experience with 125 consecutive patients. *Cardiovasc Intervent Radiol* 2001;24(3):180–184
- 32 Teichgräber UK, Kausche S, Nagel SN, Gebauer B. Outcome analysis in 3,160 implantations of radiologically guided placements of totally implantable central venous port systems. *Eur Radiol* 2011;21(6):1224–1232
- 33 Kerr A, Pathalapathi R, Qiuhiu S, Baumstein D. Purse-string suture to prevent bleeding after tunneled dialysis catheter insertion. *J Vasc Interv Radiol* 2008;19(8):1176–1179
- 34 Galbusera M, Remuzzi G, Boccardo P. Treatment of bleeding in dialysis patients. *Semin Dial* 2009;22(3):279–286
- 35 Walser EM. Venous access ports: indications, implantation technique, follow-up, and complications. *Cardiovasc Intervent Radiol* 2012;35(4):751–764