Complications after Pancreatoduodenectomy: Imaging and Imaging-guided Interventional Procedures[1]

Debra A. Gervais, MD • Carlos Fernandez-del Castillo, MD
Mary Jane O'Neill, MD • Peter F. Hahn, MD, PhD • Peter R. Mueller, MD

ONLINE-ONLY CME

See www.rsna.org/education/rg_cme.html.

LEARNING OBJECTIVES

After reading this article and taking the test, the reader will be able to:

- List the common complications after pancreatoduodenectomy.
- Describe the various appearances of the jejunal loop at CT and differentiation of the jejunal loop from abscess.
- List basic techniques of abscess drainage in various abdominal and pelvic locations.
- List the interventions that can be useful in the management of biliary complications after pancreatoduodenectomy.

Over the past decade, performance of the Whipple procedure, or pancreatoduodenectomy, to treat both malignant and benign disease has increased. This increase is in large part due to the decreasing perioperative mortality rate, which is down from historic highs of 25% to the 1.0%–1.5% now achieved in large centers. Although advances in surgical management have improved the outlook for patients undergoing pancreatoduodenectomy, the improving mortality rate is also in part attributed to improvements over the past 2 decades in cross-sectional imaging and imaging-guided interventional procedures. Although the mortality rates have improved, the morbidity, or rate of complications, has remained relatively constant. Contributions by radiologists in both diagnosis and treatment of complications are crucial in certain patients with postpancreatoduodenectomy abdominal abscesses, bilomas, liver abscess, and biliary obstruction. Familiarity with normal variations in the postoperative appearance of the upper abdomen, awareness of pitfalls in interpretation, and knowledge of the available imaging-guided interventions will facilitate recognition of postpancreatoduodenectomy complications and allow prompt triage of patients to imaging-guided interventions.

Index terms: Abdomen, abscess, 71.21 • Pancreas, 770.21 • Pancreas, CT, 770.1211 • Pancreas, interventional procedures, 770.126 • Pancreas, neoplasms, 770.30 • Pancreas, surgery, 770.458 • Pancreas, US, 770.1298

RadioGraphics 2001; 21:673–690

[1]From the Department of Radiology, Division of Abdominal Imaging and Intervention (D.A.G., M.J.O., P.F.H., P.R.M.), and Department of Surgery (C.F.C.), Massachusetts General Hospital, 55 Fruit St, Boston, MA 02114. Presented as a scientific exhibit at the 1999 RSNA scientific assembly. Received October 9, 2000; revision requested October 26 and received December 13; accepted December 18. **Address correspondence to** D.A.G. (e-mail: *dgervais@partners.org*).

Introduction

Pancreatoduodenectomy for resection of periampullary cancer was reported in 1912 by Kausch (1) and later popularized by Whipple et al (2), who reported their initial experience in 1935. Pancreatoduodenectomy has been associated historically with high mortality and morbidity (2–4). Over the decades, perioperative mortality has been reduced from historic highs of 25% to a more recent 4%–5% (5–8). Some centers that perform a high volume of pancreatoduodenectomy procedures have even lower mortality rates of 1.0%–1.5% (7–9).

The strong impetus to improve these mortality rates stems from the fact that pancreatoduodenectomy is the only potential cure for pancreatic adenocarcinoma, which is otherwise fatal. With improvements in perioperative mortality, indications for the procedure have expanded to include benign disease (7,10). The number of overall pancreatoduodenectomy procedures performed has increased in the past decade, and the procedure is performed increasingly in both elderly and younger patients (9,11,12). Still, even today the morbidity of the procedure approaches 50% (7,9,10).

Because many of the complications of pancreatoduodenectomy are diagnosed by means of cross-sectional imaging, the radiologist must be familiar with the normal postoperative imaging appearance of the upper abdomen and recognize imaging findings that indicate complications. Furthermore, many complications are amenable to imaging-guided interventions such as catheter drainage, needle aspiration, or needle biopsy. Advances in interventional radiology are believed by many surgeons to have contributed to the declining mortality rate of pancreatoduodenectomy (9,13). Therefore, radiologists, even those who do not perform interventional procedures, must also be familiar with the interventional techniques available to recommend the appropriate treatment.

This article reviews the postoperative anatomy and complications of the procedure, with emphasis on those complications diagnosed with cross-sectional imaging and managed with interventional radiologic techniques. These complications include postoperative abdominal abscess, pelvic abscess, pancreatitis, hepatic infarct with or without abscess formation, bile duct injury or stricture from recurrent disease, and bile leak.

The Whipple Procedure or Pancreatoduodenectomy

The conventional standard Whipple procedure involves resection of the pancreatic head, duodenum, and gastric antrum. The gallbladder is almost always removed. A jejunal loop is brought up to the right upper quadrant for gastrojejunal, choledochojejunal or hepaticojejunal, and pancreatojejunal anastomosis (Fig 1) (14).

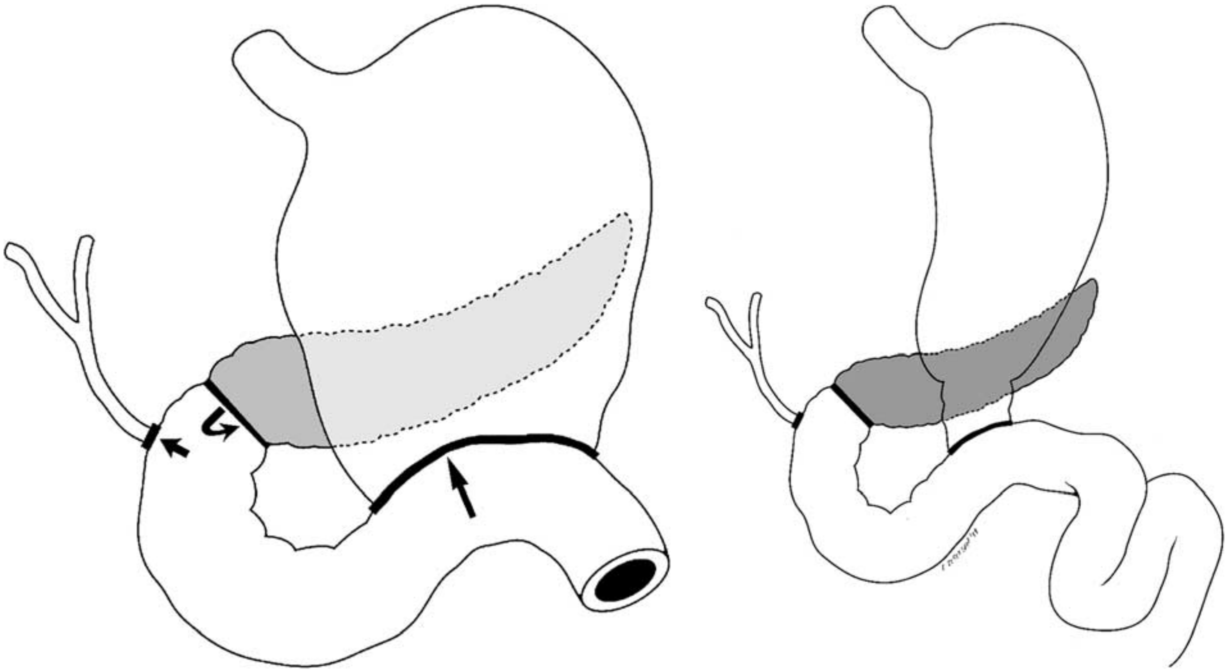
Some surgeons prefer to perform pancreatoduodenectomy to preserve the pylorus when possible, but the debate in the surgery literature is ongoing with regard to the advantages and disadvantages of standard pancreatoduodenectomy compared with pylorus-preserving pancreatoduodenectomy (7,8,15–21). In pylorus-preserving pancreatoduodenectomy, the stomach is left intact and the proximal duodenum is used for a duodenojejunal anastomosis. The examples included in this review article are all of the standard Whipple procedure.

Complications after Pancreatoduodenectomy

Most complications of pancreatoduodenectomy are managed without radiologic intervention, although many are demonstrated at imaging. These complications include delayed gastric emptying, pancreatic fistula, wound infection, hemorrhage, and pancreatitis.

Delayed gastric emptying and pancreatic fistula are both clinical diagnoses and are the most common complications after pancreatoduodenectomy. Delayed gastric emptying is defined as the persistent need for a nasogastric tube for longer than 10 days and is seen in 11%–29% of patients (7,9,10). Pancreatic fistula is defined as surgical drain output of amylase-rich fluid greater than 50 mL a day at or beyond 7–10 days (9,18). Patients with the clinical diagnosis of pancreatic fistula usually undergo computed tomography (CT) to assess for associated abscess formation, but approximately 80% of fistulas heal with conservative management (18). Ten to 15 percent of patients with pancreatic fistulas require percutaneous drainage, and 5% require repeat surgery (18). Wound infection is the next most common complication, occurring in 5%–20% of patients (9,10,18).

Hemorrhage in the postoperative period occurs in approximately 7% of patients and generally requires endoscopic evaluation or urgent surgical exploration, and the need for arteriography and embolization is not common (22). Postpancre-



a. b.

Figure 1. Illustrations depict anatomy after the Whipple procedure. **(a)** After pancreatoduodenectomy, the pancreatic head, duodenum, and gastric antrum have been removed. A loop of jejunum has been brought up to the right upper quadrant for anastomoses with the bile duct, stomach, and pancreas. Anastomoses depicted include the gastrojejunostomy (long straight arrow), pancreatojejunostomy (curved arrow), and choledochojejunostomy (short arrow). **(b)** After pylorus-sparing pancreatoduodenectomy, the pylorus is retained with a short segment of duodenum, and a gastroduodenal anastomosis is created.

atoduodenectomy pancreatitis is rarer, occurring in fewer than 5% of patients (10,18).

Finally, there are short- and long-term complications that, while generally first suspected on the basis of clinical parameters (fever, leukocytosis, and elevation in bilirubin or pancreatic enzyme levels), are amenable to both imaging diagnosis and imaging-guided intervention. These complications include abscess formation and biliary complications. Both are often evaluated first at CT. Abscesses occur after approximately 10% of pancreatoduodenectomies, and biliary complications are rarer (18).

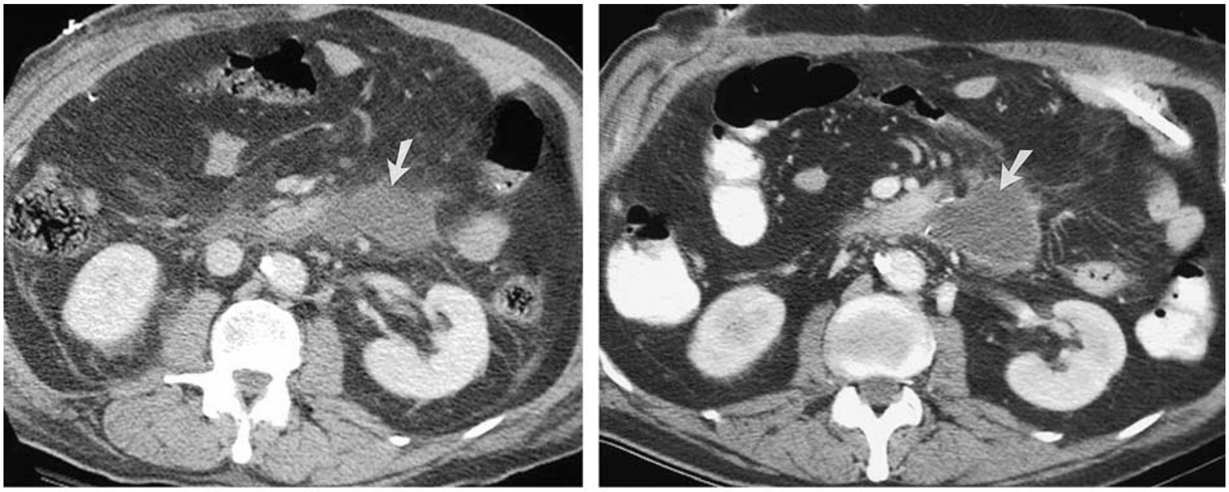
Postpancreato-duodenectomy Imaging

Modalities and Technique

Fluid collections, abscesses, bile leaks and bilomas, and biliary obstruction are most often evaluated best with CT and further assessed as necessary by means of fluoroscopic studies such as tube injection with contrast material, transhepatic cholangiography, and biliary drainage. CT can be performed with multi–detector row or helical CT with 5-mm section thickness in the portal venous phase of liver enhancement. Ideally, both oral and intravenous contrast material should be administered. In the acute postpancreatoduodenectomy period, however, renal insufficiency may preclude the use of intravenous contrast material, and delayed gastric emptying or ileus may prevent optimal bowel opacification. Furthermore, the Roux limb with the biliary-enteric and pancreatic-enteric anastomoses only rarely opacifies by means of retrograde flow. These limitations pose challenges to interpretation, and the radiologist must be able to recognize normal and abnormal postpancreatoduodenectomy findings both with and without optimal contrast material opacification.

Small Postoperative Fluid Collections

Small collections of fluid in the surgical bed are common in the immediate postprocedural period and usually resolve spontaneously (Fig 2a)



a. b.

Figure 2. Small postpancreatoduodenectomy fluid collections. **(a)** CT scan shows a small collection (arrow) that was not aspirated because abscess was not suspected clinically. **(b)** CT scan obtained 5 days later shows the collection developed into an abscess (arrow).

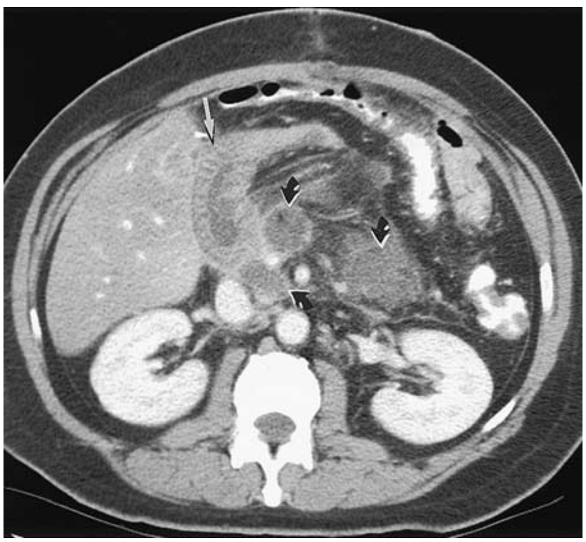


Figure 3. Small fluid collections in the setting of postpancreatoduodenectomy pancreatitis. CT scan shows peripancreatic inflammation and small fluid collections (curved arrows) that were not aspirated. The folds (straight arrow) of the jejunal loop are well demonstrated.

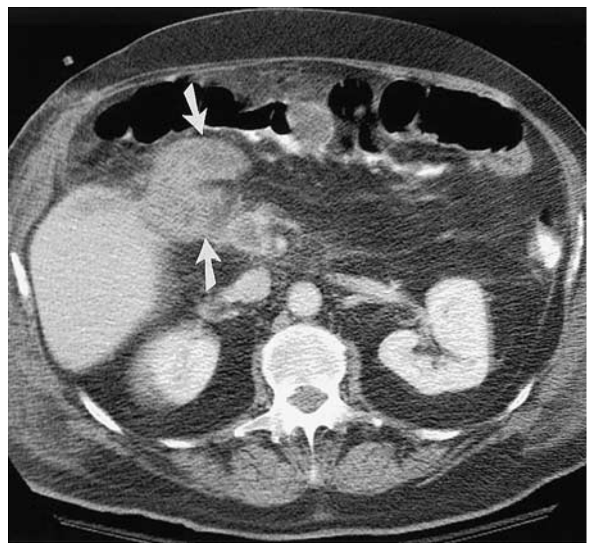
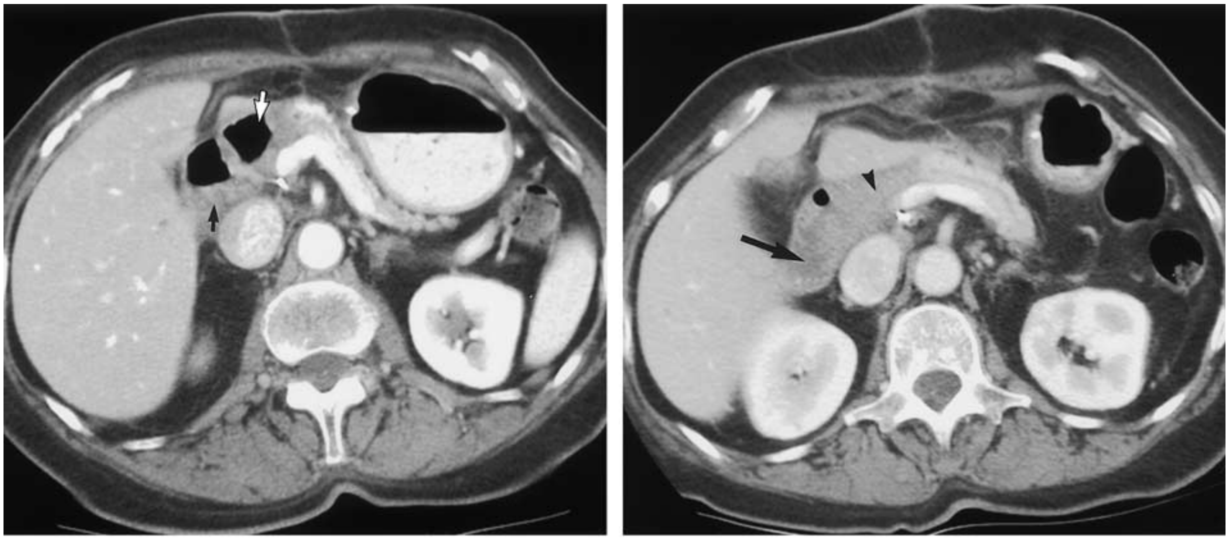


Figure 4. Jejunal loop. Intravenous contrast material–enhanced CT scan shows a segment of the jejunal loop (arrows). Definition of this partially collapsed loop is facilitated by the difference in attenuation between the enhancing jejunal wall and the intraluminal fluid.

(23,24). These collections generally do not require an interventional procedure, but they can be aspirated with a needle if there is strong clinical suspicion for infection (ie, unexplained fever and leukocytosis). If the subsequent clinical course is worrisome for infection, repeat imaging is useful and may demonstrate interval evolution into an abscess (Fig 2b). Small fluid collections can also be associated with pancreatitis as a complication of pancreatoduodenectomy (Fig 3) and are managed in a similar manner (25,26).

The Jejunal Loop

The loop of jejunum brought from the proximal jejunum for anastomosis with the gastric remnant, bile duct, and pancreatic duct can be mistaken for a fluid collection at CT. Knowledge of the postoperative anatomy, familiarity with the various CT appearances of a normal loop, and careful evaluation of the loop and its surroundings usually allow definitive diagnosis of the presence or absence of an adjacent abscess. The jejunal loop is identified at CT on the basis of two characteristics: the appearance of the loop and the course of the loop.



a. b.

Figure 6. Different appearance of the jejunal loop at different times in the same patient. **(a)** CT scan shows the jejunal loop distended with air (arrows). **(b)** CT scan acquired 1 year later shows the jejunal loop as partially collapsed (arrowhead) and partially fluid filled (arrow).

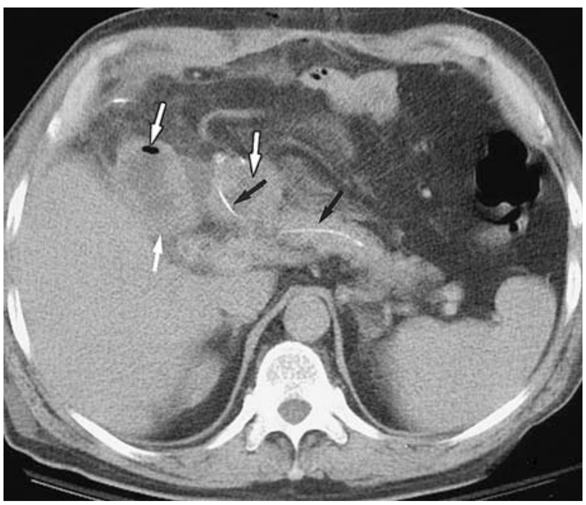
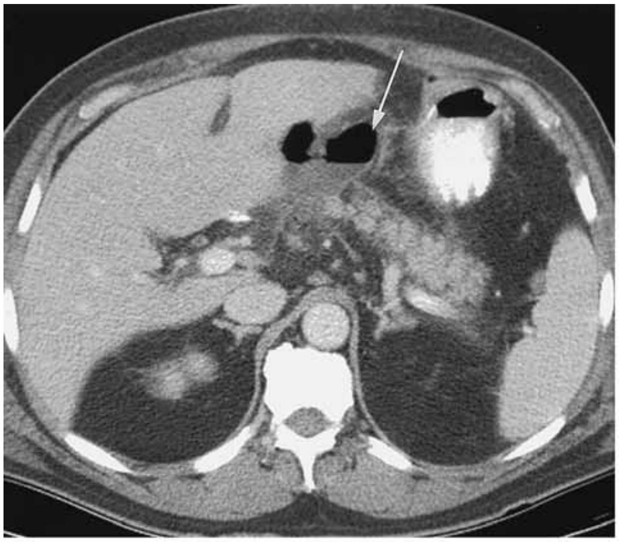


Figure 5. Jejunal loop. Nonenhanced CT scan shows the jejunal loop (white arrows) clearly because the loop contains fluid with attenuation lower than that of the bowel wall. Small-bowel folds can also be recognized. At surgery, a drain (black arrows) was placed across the pancreatojejunal anastomosis to define the pancreatic aspect of the loop.

Figure 7. Jejunal loop origin delineated by means of reflux of orally administered contrast material. CT scan at the level of the origin of the jejunal loop demonstrates a long segment of the loop (arrows). Oral contrast material has refluxed into only a short segment of the loop (arrowhead).

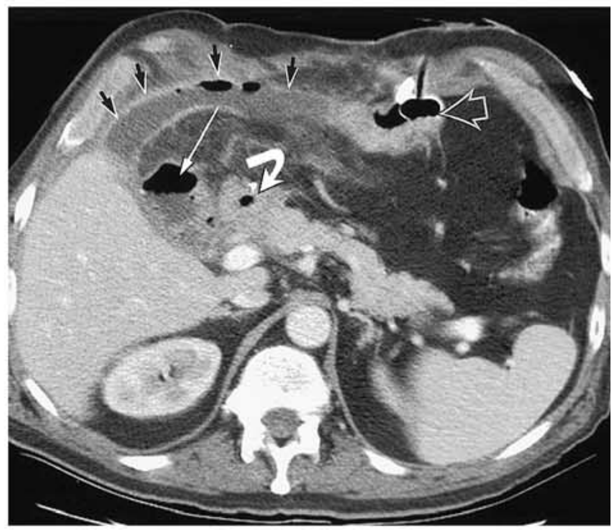
The CT appearance of the normal jejunal loop will vary depending on the presence or absence of a number of factors, including intravenous contrast material, air in the loop, low-attenuation fluid in the loop, and oral contrast material in the loop. Intravenous contrast material will facilitate recognition of the loop since the enhancing walls will be more easily identified (Fig 4). Air or fluid with attenuation lower than that of the walls of the loop serves as a natural contrast agent within the lumen of the loop (Figs 5, 6). Small-bowel folds are often outlined by fluid, which allows definitive identification of the loop (Figs 3, 5). Oral contrast material within the loop makes definitive identification straightforward (Fig 7). However, oral contrast material very rarely refluxes into this loop, leaving it either collapsed or filled partially or completely with low-attenuation fluid. In the immediate postoperative period, the surgical drain left by some surgeons across the pancreatojejunal anastomosis (Fig 5) facilitates identification of the pancreatic end of the loop.



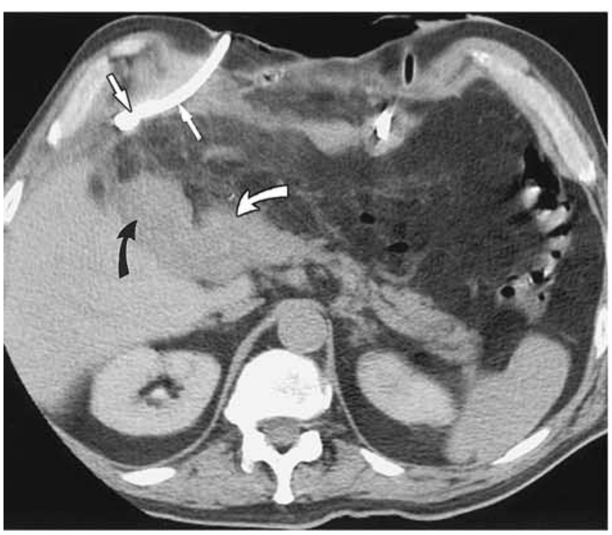
8a.

8b.

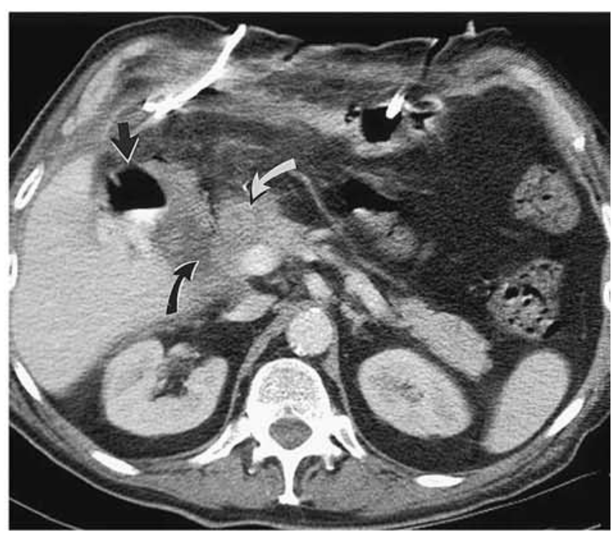
8c.



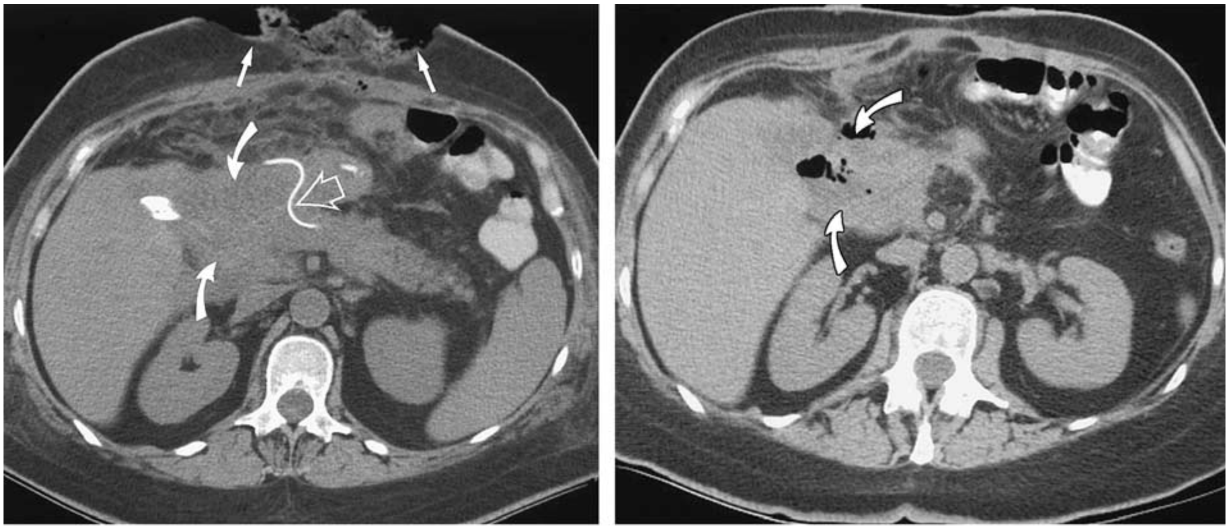
9a.



9b.



9c.



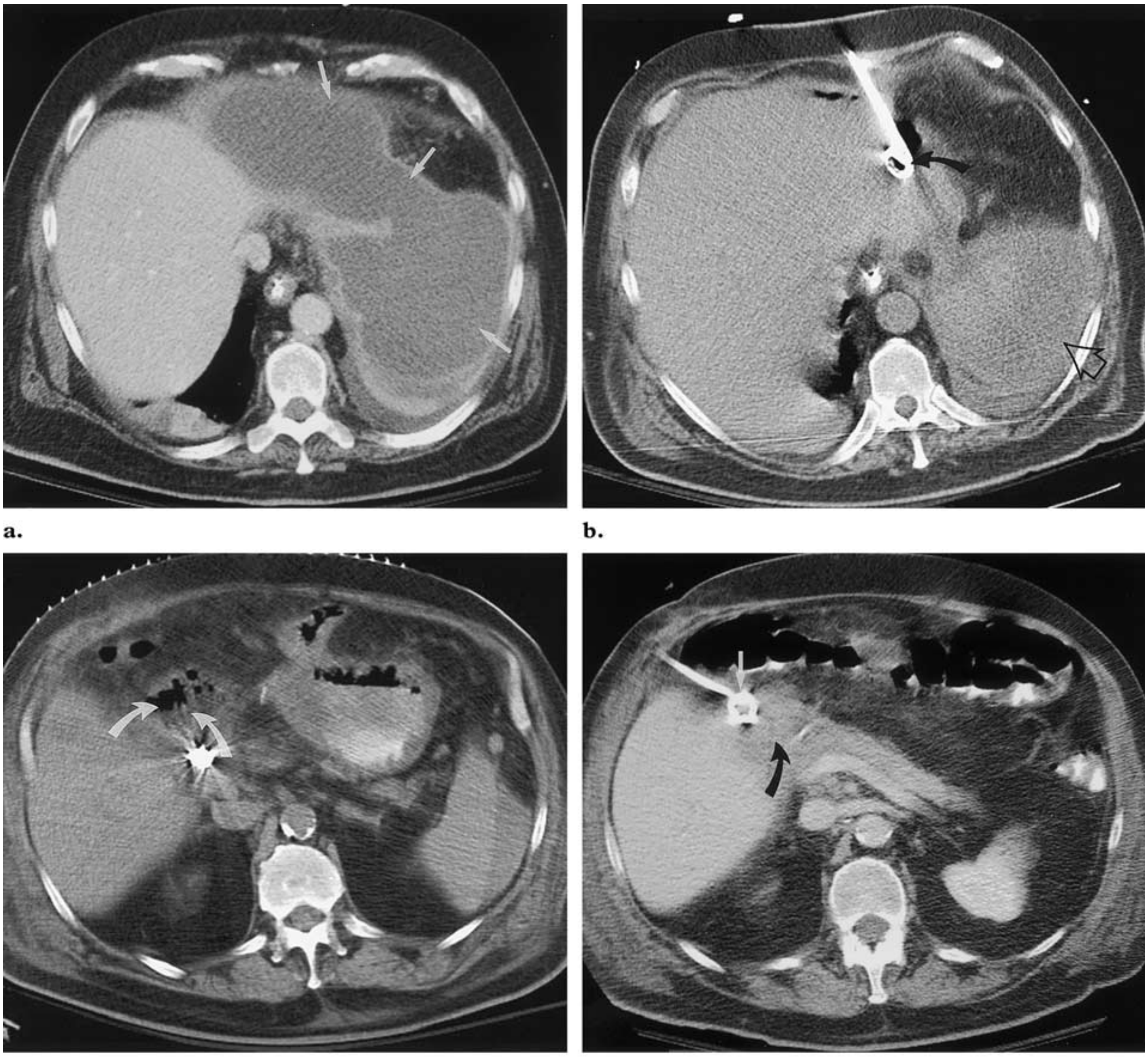
a. b.

Figure 10. Poor definition of a jejunal loop mimics an abscess in a patient unable to receive intravenous contrast material. **(a)** CT scan obtained in the immediate postoperative period shows postoperative change and poor definition of the jejunal loop (curved arrows) because of the presence of intraluminal fluid that has the same attenuation as bowel wall and of two juxtaposed bowel segments. In this case, the imaging appearance of the jejunal loop does not exclude abscess, but the patient's fever was from wound infection (straight solid arrows). Had there been no other identifiable source of fever, the pancreatic drain (open arrow) could have been injected with dilute contrast material to opacify the jejunal loop and to better define any potential abscesses. **(b)** CT scan obtained months later shows air in the jejunal loop (arrows) that delineates the two adjacent segments.

The course of the jejunal loop can be followed in a caudocephalic direction on serial axial images and traced from its origin to the regions of the biliary and pancreatic anastomoses. Careful evaluation of the loop in this manner should preclude mistaking it for a fluid collection. At its pancreatic end, the loop is lateral to the pancreas and courses laterally from the pancreas to the gallbladder fossa. In a similar fashion, the area adjacent to the loop at all levels should be carefully assessed for small collections of extraluminal fluid or air to ensure an abscess is not missed (Fig 8). Not every tubular structure with an enhancing wall is a jejunal loop. An abscess will rarely assume this configuration (Fig 9). In such cases, the abscess should be recognized by carefully identifying the loop as a structure that is separate from the abscess in question. Likewise, not every fluid-filled structure in this region that is separate from the jejunal loop is an abscess. Figure 9 demonstrates that a segment of the hepatic flexure of the colon next to a portion of the jejunal loop is not clearly different from the jejunal loop on a CT scan obtained when neither the loop nor the colon contained intraluminal contrast material. Enhancement of the colon on a CT scan obtained at a later date, however, helped clear identification of this loop as colon. At initial CT, following the colon on serial axial images prevented mistaking the nonenhanced hepatic flexure for an abscess.

In rare cases, a question of abscess remains on the basis of the imaging appearance alone (Fig 10).

◀ **Figures 8, 9.** **(8)** Abscess adjacent to the jejunal loop. **(a, b)** Serial axial cephalocaudal CT scans show a postpancreatoduodenectomy abscess (straight arrow) in the left subhepatic space adjacent to the jejunal loop (curved arrows). Following the jejunal loop on serial images should help prevent mistaking this abscess for an extension of the loop. **(c)** CT scan obtained after placement of a catheter (straight arrows) shows the subhepatic abscess (curved arrow). **(9)** Elongated abdominal abscess mimics bowel loop. **(a)** CT scan shows a long tubular fluid and air collection with an enhancing wall (black arrows) in the anterior left subhepatic space. This collection extends to a segment of the proximal jejunum that contains a feeding tube (open arrow). A portion of the jejunal loop (curved arrow) is shown near the pancreas. The abscess was recognized as separate from the loop by means of careful assessment of both structures on multiple axial CT images. A collection of fluid and air (straight solid white arrow) near the loop and medial to the liver appears similar to the abscess. **(b)** CT scan acquired at the time of drainage shows the abscess cavity collapsed around the percutaneous catheter (straight arrows). Poorly defined bowel (curved arrows) is shown in the region of the jejunal loop. **(c)** CT scan obtained 5 days after drainage helps confirm resolution of the abscess. The poorly defined bowel is now shown to be a combination of jejunal loop (curved arrows) and hepatic flexure of the colon (straight arrow).

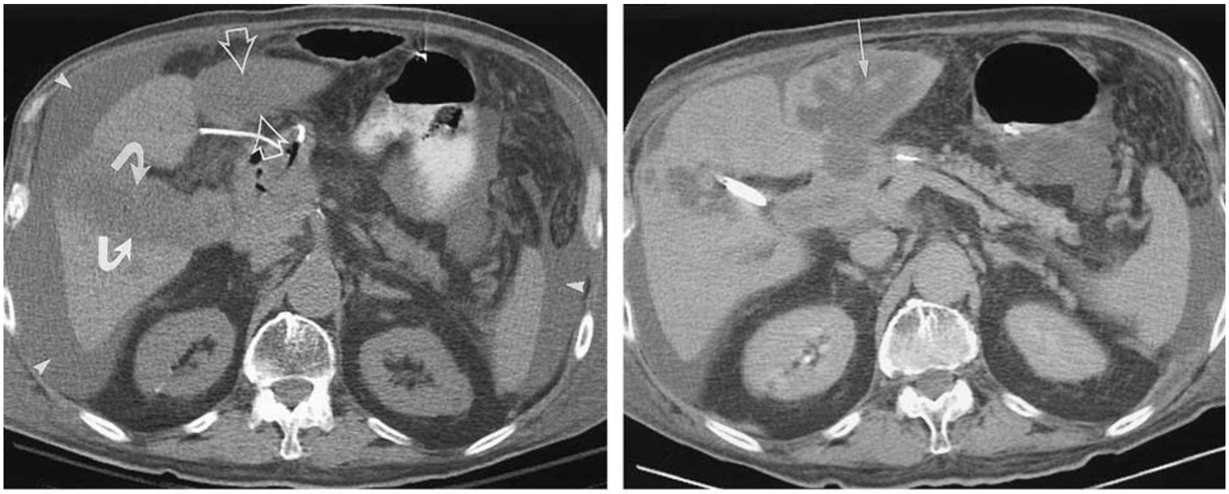


a. b. c. d.

Figure 11. Postpancreatoduodenectomy subhepatic and subphrenic abscesses. **(a, b)** CT scans obtained at different levels 4 days after pancreatoduodenectomy show a large subphrenic abscess (white arrows) partially drained by means of an anterior percutaneous catheter (curved arrow). Residual fluid in the left subphrenic space (open arrow) was drained by placing a second catheter (not shown). Large collections may require placement of more than one catheter for complete drainage. **(c)** CT scan obtained the same day depicts a subhepatic abscess (arrows) caudad to the jejunal loop. **(d)** CT scan obtained after placement of the second catheter (white arrow) shows resolution of the abscess and the catheter (black arrow) adjacent to the jejunal loop.

Depending on the degree of clinical suspicion for infected fluid collection, the dilemma can be solved over time by means of subsequent imaging, because the loop often appears different at different times depending on factors discussed previously (Figs 6, 10). If there is strong suspicion for abscess clinically, the diagnosis must be confirmed before catheter drainage to avoid draining a normal bowel loop.

Problem-solving tools include administration of intravenous contrast material. Alternatively,



a. b.

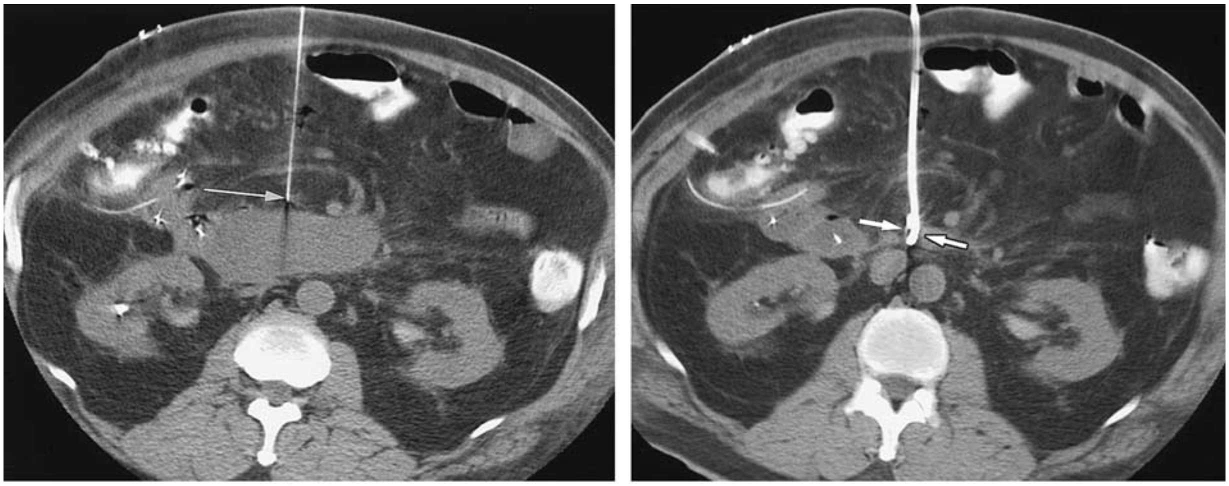
Figure 12. Postpancreatoduodenectomy peritonitis, gallbladder fossa abscess, and liver abscess. **(a)** CT scan shows an organized fluid collection (curved arrows) in the gallbladder fossa that was originally mistaken for the gallbladder. This is a gallbladder fossa abscess. Massive ascites (arrowheads) is also present, and *Escherichia coli* was cultured after needle aspiration. Despite the absence of intravenous contrast material, the left lobe of the liver (open arrows) demonstrates abnormally low attenuation, which suggests abscess. Drainage catheters (not shown) were placed in both the gallbladder fossa abscess and massive ascites. The left lobe of the liver was aspirated and yielded only scant thick bloody material that was positive for *Morganella* species. **(b)** Contrast-enhanced CT scan obtained after drainage of the gallbladder fossa abscess demonstrates the left lobe liver abscess (arrow) more clearly. This abscess was also drained.

the surgical drain left across the pancreatojejunal anastomosis can be gently injected with dilute contrast material to opacify the loop. If injection through the surgical drain is not possible or does not solve the dilemma, then a small (19–21-gauge) needle can be placed into the area in question to allow direct administration of contrast material. If the structure is the jejunal loop, contrast material within its lumen will allow identification, and a small needle puncture is safe and will preclude errant placement of a much larger drainage catheter.

Abdominal, Retroperitoneal, or Pelvic Abscess

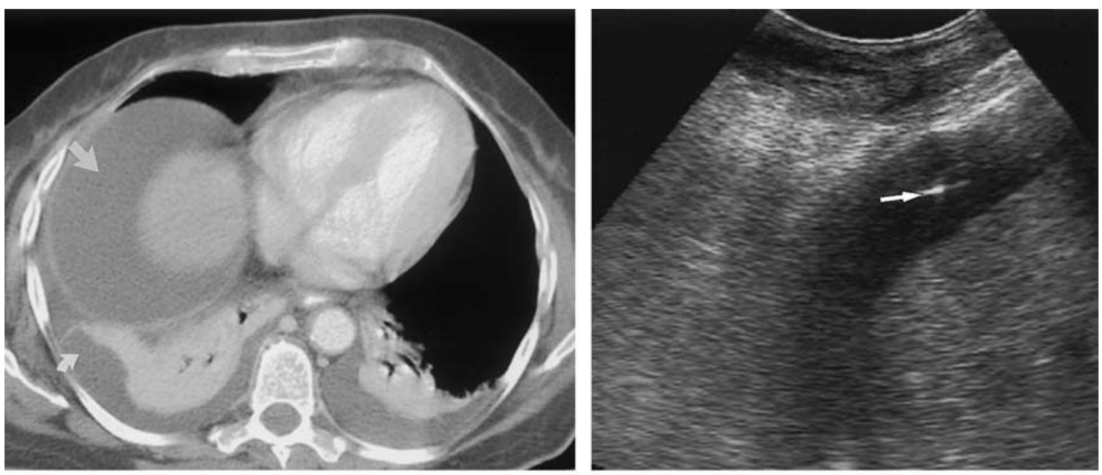
Postoperative abscesses may occur in the retroperitoneal surgical bed. Because of the extensive intraperitoneal component of the procedure, however, postoperative abscesses may also be intraperitoneal. The peritoneum allows fluid to migrate easily, and collections can be found remote from the surgical site. A classic example is a pelvic collection deep in the cul-de-sac. Fluid collections can also be found cephalad to the surgical bed in the subphrenic space (Fig 11). Multiple separate abscesses may be present, and each must be drained separately (Figs 11, 12). The importance of recognizing abscesses in the vicinity of the jejunal loop or that mimic the loop has already been emphasized (Figs 8, 9). One additional interpretive pitfall is a collection in the gallbladder fossa that may mimic the appearance of the gallbladder (Fig 12). This finding should not be misinterpreted as the gallbladder, however, because the gallbladder is usually removed during pancreatoduodenectomy. Finally, in the patient with sepsis, all possible sources of infection, including abundant free fluid that may be infected, must be evaluated (Fig 12).

Abscess drainage can be performed with ultrasonographic (US) or CT guidance (27,28). Because of the deep location of many abscesses in the surgical bed, CT guidance is used more often. Drainage catheters can be placed by using the trocar technique, which involves direct catheter placement tandem to a guiding needle (Fig 13), or the Seldinger over-the-wire technique (Fig 14).



a. b.

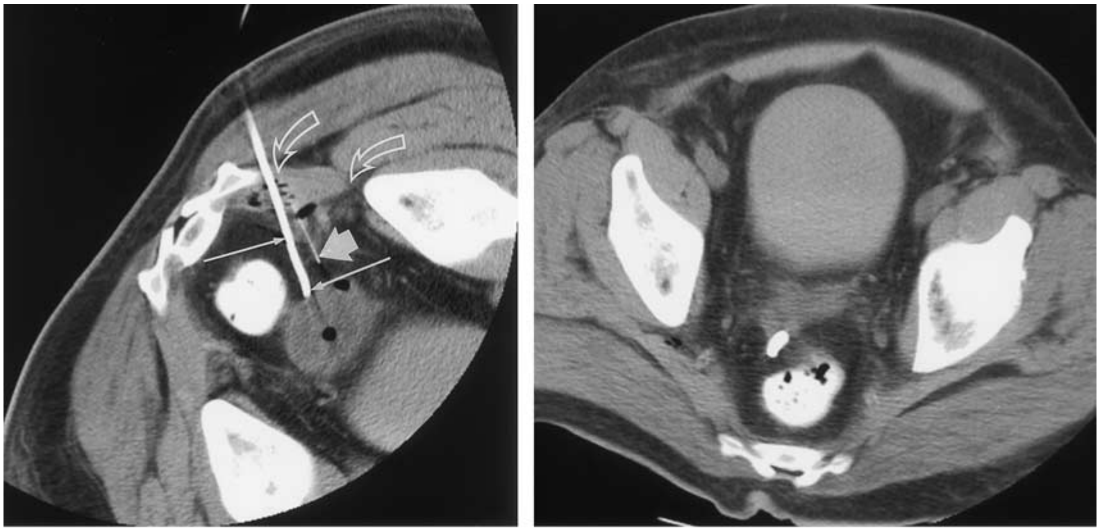
Figure 13. Tandem trocar technique for percutaneous abscess drainage. **(a)** CT scan acquired during drainage shows a retroperitoneal abscess being drained by means of trocar technique. A 20-gauge needle (arrow) was first advanced toward the collection until pus was obtained. A 12-F catheter was then placed parallel to the needle by using the needle trajectory as a guide; 150 mL of pus was removed. **(b)** CT scan obtained after catheter placement and pus aspiration shows collapse of the abscess about the catheter (arrows).



a. b.

Figure 14. Seldinger technique for drainage of a subphrenic collection. **(a)** CT scan shows a large subphrenic fluid collection (straight arrow) that extends inferiorly along the liver. Direct access to the collection at its apex would almost certainly cross the pleural effusion (curved arrow). **(b)** US scan obtained when combined US and fluoroscopic guidance was used to access the collection along its inferior aspect with a needle (arrow) and to direct a wire toward the apex of the collection in the location desired for catheter deployment. **(c)** Fluoroscopic image acquired at drainage shows a long drainage catheter (arrowhead) with multiple side holes along its shaft in the distal loop; 190 mL of infected bile was removed. Subphrenic contrast material was injected during catheter placement. The entry site (arrow) of the catheter is much lower than the dome level.

c.

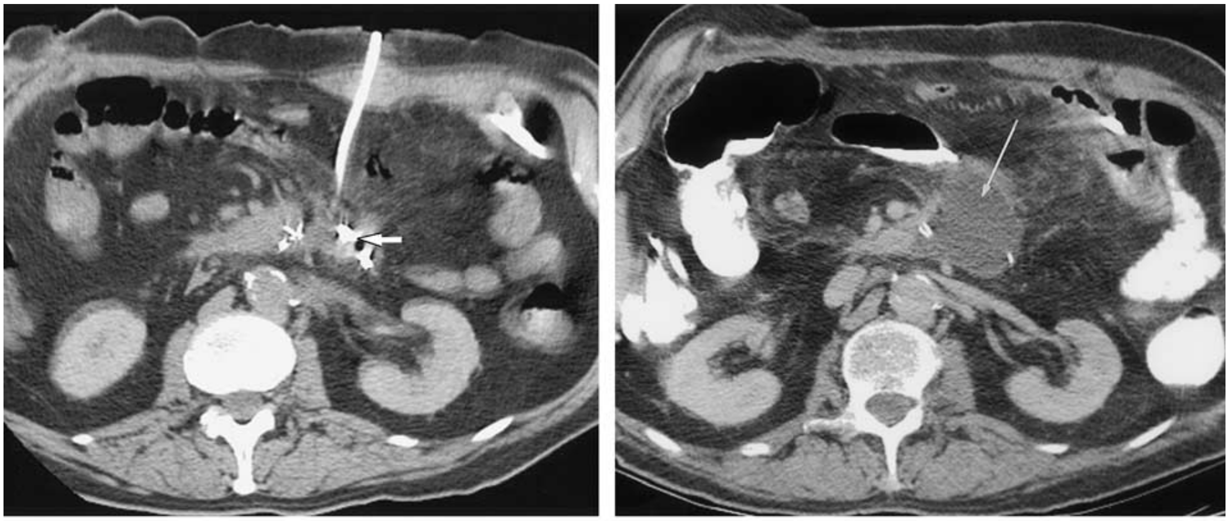


a. b.

Figure 15. Transgluteal approach to deep pelvic abscess drainage. **(a)** CT scan was acquired at drainage with the patient placed in the decubitus position to allow access through the greater sciatic foramen (curved arrows). A catheter (long solid arrows) was placed by using the tandem trocar technique. The catheter courses out of the axial plane; therefore, two images were required for complete depiction. Likewise, a portion of the tandem guiding needle (short solid arrow) is seen. The proximal and distal aspects of the needle are not in this plane. The approach is medial to avoid the sciatic nerve, which is not seen but courses along the lateral foramen. **(b)** CT scan obtained 3 days after drainage shows the collection has resolved.

Direct percutaneous access to deep pelvic abscesses in the cul-de-sac can pose problems because of overlying bowel, as well as bladder anteriorly and blood vessels and osseous structures laterally. In these instances, the interventional radiologist has up to three approaches to consider: the CT-guided transgluteal approach through the greater sciatic foramen (29) (Fig 15), the transrectal approach with CT or endoluminal US guidance (30,31), and the transvaginal approach with endoluminal US guidance (31). With US-guided approaches, catheter placement can be viewed with real-time imaging. For the CT-guided transgluteal approach, the radiologist must be familiar with structures coursing through the greater sciatic foramen, namely, the sciatic nerve laterally and the superior and inferior gluteal arteries and veins along the cephalic aspect of the foramen (29). The nerve is usually not seen at CT but courses laterally so that a medial approach provides safe access to deep pelvic abscesses (29) (Fig 15).

After catheter deployment, the abscess is emptied and irrigated. The catheter is connected to a bag for gravity drainage. Specimens from each collection are sent for Gram stain and culture and sensitivity testing. In addition, any collection in the pancreatic region is sent for amylase analysis to assess for chemical evidence of a communication with the pancreatic duct. To prevent clogging, the catheter is flushed with sterile 0.9% saline two to three times a day. The volume of catheter output is monitored, as is the clinical response to catheter drainage. Little or slow clinical improvement after abscess drainage should prompt repeat imaging to assess for incomplete abscess drainage or development of additional abscesses. If the patient shows sustained clinical improvement (defervescence, improved leukocytosis, improvement in septic parameters), the



a. c.

Figure 16. Abscess recurrence from pancreatic duct fistula. **(a)** CT scan obtained after drainage of the abscess in Figure 2b shows resolution of the abscess with the cavity collapsed about the catheter (arrow). **(b)** Fluoroscopic image obtained after tube injection of contrast material shows persistent communication with the pancreatic duct (arrow) despite abscess resolution depicted at CT (not shown) and low catheter outputs. We recommended that the catheter be left in place until the fistula closed. However, the referring surgeon and patient wanted the catheter removed, and it was. **(c)** CT scan obtained to evaluate fevers that occurred 3 weeks after catheter removal shows a recurrent abscess (arrow). The abscess was drained again. This time the fistula was allowed to close before the catheter was removed, and the abscess did not recur.

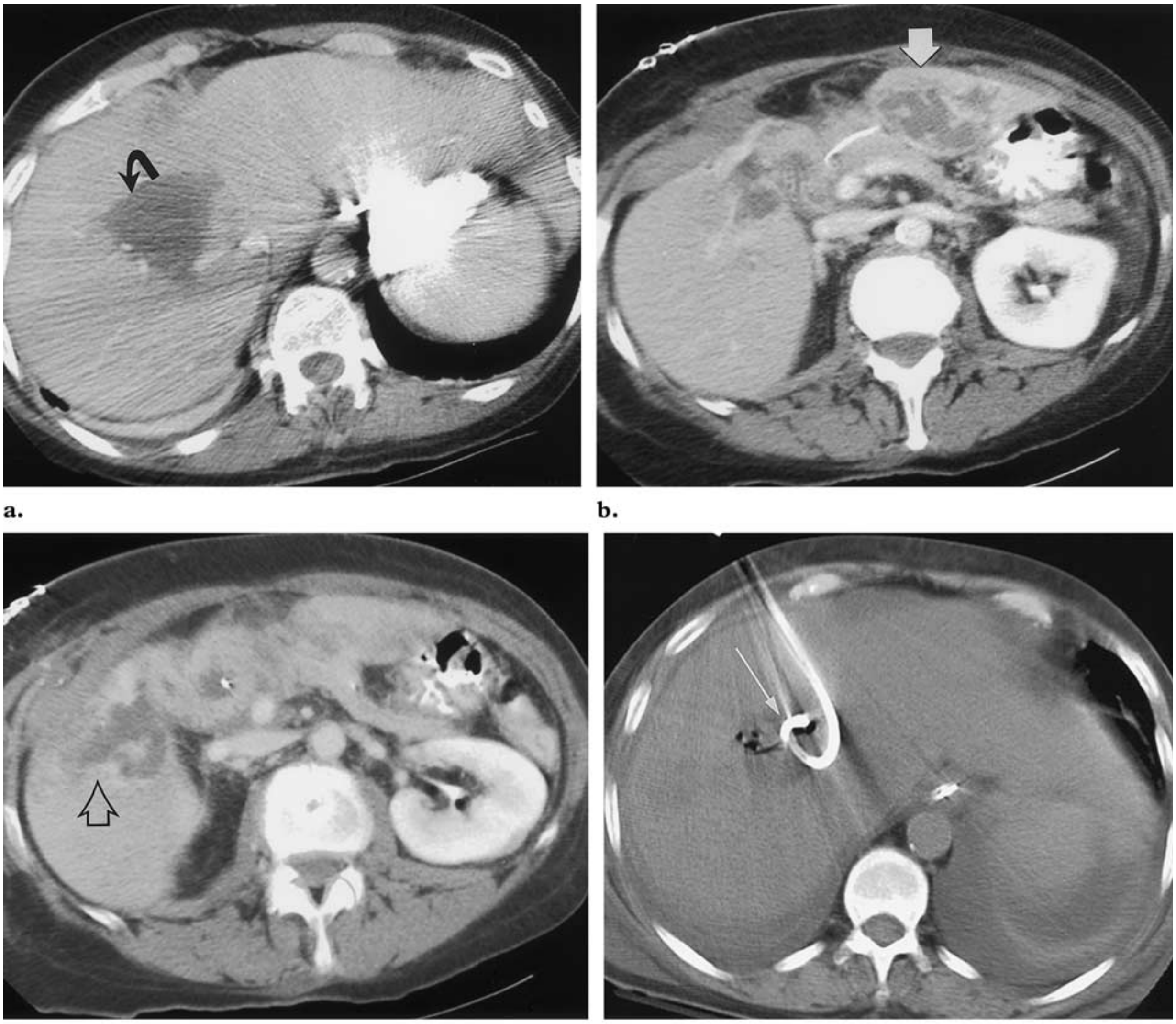
b.

drainage catheters can be removed once the volume of drainage decreases to 10–20 mL per day.

Before catheters are removed from any collection containing amylase-rich fluid in the initial aspirate, tube injection of contrast material at fluoroscopy is performed to exclude a persistent communication with the pancreatic duct (Fig 16). A communication may exist even with low catheter output, and removal of the catheter under these conditions can result in abscess recurrence and the need for repeat drainage (Fig 16).

Hepatic Abscess and Intrahepatic Biloma

The bile ducts are very sensitive to ischemia, and violation of the integrity of the intrahepatic bile ducts may result in hepatic abscess or intrahepatic biloma. Hepatic abscesses are best demonstrated by performing imaging with intravenous contrast material, but they can also be seen by carefully evaluating nonenhanced images if intravenous contrast material cannot be administered (Figs 12, 17). In general, the need for catheter drainage of hepatic abscesses is based on the clinical status of the patient and the imaging findings. Small abscesses may respond to treatment with antibiotics. Sicker patients, however, should undergo aspiration of intrahepatic collections for culture and sensitivity testing to ensure the appropriate antibiotic coverage. Initial needle aspiration may yield pus, but not uncommonly scant thick bloody fluid



a. b. c. d.

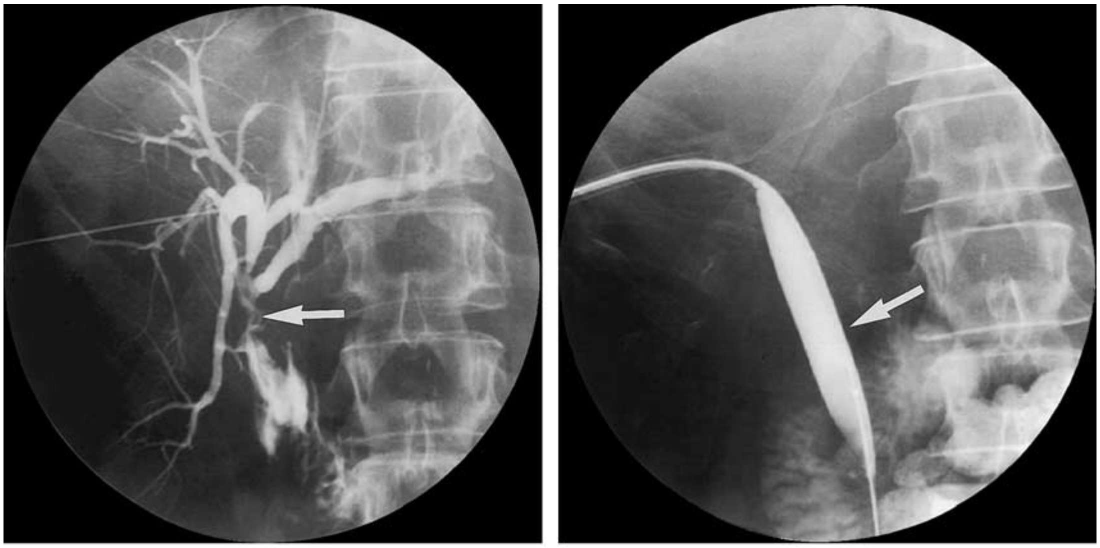
Figure 17. Multiple hepatic abscesses and drainage. **(a–c)** CT scans acquired in a 69-year-old woman with fever and leukocytosis 5 days after pancreatoduodenectomy show three areas of focal low attenuation in the liver dome (curved arrow), left lobe (white arrow), and inferior right lobe (open arrow). These areas were aspirated with a needle. Scant bloody fluid was obtained at needle aspiration from all three sites. Because these sites were thought to be multiple infarcts, the decision was made to wait for culture results before catheter drainage was performed. During the wait, however, the patient developed septic hemodynamics, respiratory failure, and disseminated intravascular coagulation. A decision was made to drain all three areas. **(d)** CT scan acquired during drainage shows a catheter tandem to a guiding needle in the most cephalic collection (arrow). The other areas were drained in similar fashion. Although frank pus was not obtained, the patient improved with catheter drainage, which yielded 15–25 mL per day. Cultures were positive for *E coli* in all three abscesses.

is all that can be withdrawn. In the authors' experience, catheter drainage can be beneficial in the critically ill patient even if the yield at needle aspiration is scant (Fig 17).

Techniques for intrahepatic catheter placement are as described previously. Likewise, catheter management is similar except that catheter output may be scant from the outset in those abscesses in which infected regions of liver are not completely liquefied. The catheter should not be removed until the patient improves. Imaging after several days of drainage may depict persistently abnormal liver surrounding the catheter, even in the setting of clinical improvement, and these persistent changes should not preclude catheter removal once the patient has improved and the output has ceased (32).

a. b. c. d.

Figure 18. Intrahepatic biloma drainage. **(a)** CT scan of the dome abscess depicted in Figure 17 shows an increase in the abscess (arrowheads) despite the presence of the catheter. The outputs from this catheter increased from the time of initial drainage, becoming less bloody and more bilious. **(b)** Fluoroscopic image obtained after tube injection with contrast material shows a large abscess cavity (curved arrow) that communicates with the bile duct (long straight arrow). A short segment of jejunal loop is opacified (short straight arrow). **(c)** Fluoroscopic image shows a longer catheter with more side holes that was placed in the cavity to achieve improved drainage of this large biloma. The catheter was placed by means of over-the-wire exchange. **(d)** CT scan acquired after catheter placement shows the longer catheter (arrowheads) looped in all the spaces of the large biloma cavity.



a. b.

Figure 19. Biliary obstruction from recurrent tumor. **(a)** Transhepatic cholangiogram acquired in a patient with biliary obstruction 2 months after pancreatoduodenectomy shows an extrahepatic biliary stricture (arrow). Cytologic examination of bile was negative for malignancy. **(b)** Fluoroscopic image was acquired at balloon dilation (arrow) of the stricture. The balloon and brush biopsy specimens were sent for cytologic examination, which yielded recurrent adenocarcinoma. A metal stent is placed in most patients with inoperable malignant stricture, but this patient developed multisegmental obstruction from intrahepatic metastases, and catheter drainage was required for optimal drainage.

In some cases, initial aspiration and drainage of pure pus or thick bloody material will be followed after a few days of drainage by high outputs of bilious material. In these cases, the abscess was an infected biloma, and tube injection of contrast material at fluoroscopy will help confirm communication with the biliary system (Fig 18). Bilomas tend to be large and may require catheter repositioning, the use of catheters with extra side holes along the shaft, or both for adequate drainage (Fig 18c, 18d). Biloma drainage catheters should never be removed until the communication with the biliary tree is confirmed to have closed by means of tube injection of contrast material at fluoroscopy. Otherwise, the patient is at risk for recurrent biloma.

Biliary Obstruction

Biliary obstruction in a patient after pancreatoduodenectomy can result from recurrent tumor (Fig 19), anastomotic stricture (Fig 20), or bile duct injury. Since conventional pancreatoduodenectomy alters the bowel anatomy, access to the biliary system by the endoscopist is often impossible, and such patients require percutaneous management of the biliary obstruction. Differentiation of benign from malignant strictures in this setting can be difficult in the absence of documented local recurrence or metastatic liver or abdominal lesions. Bile specimens obtained at percutaneous biliary drainage should be sent for cytologic examination. If balloon dilation of a stricture is performed (Fig 19), the balloon can be sent as a specimen to the cytology laboratory to evaluate for possible malignant cells.

Malignant strictures can be dilated with balloon catheters (Fig 19) to facilitate drainage catheter placement but will likely recur rapidly and require continued catheter drainage. Metal stents can be placed in this setting for palliation, which

Figure 20. Biliary obstruction from benign anastomotic stricture. **(a)** CT scan obtained in a 55-year-old woman with fever and jaundice 2 years after pancreatoduodenectomy for pancreatic head lymphoma shows dilation of the biliary duct (arrows). **(b)** Cholangiogram obtained through a small percutaneous catheter (solid straight arrow) advanced from the left into the right distal duct shows intraductal debris (curved arrow) above a stricture that involves the right and left hepatic systems separately (open arrow). **(c, d)** Bilateral cholangiograms obtained through a sheath proximal to the anastomosis depict balloon dilation of both sides. Balloon waists (arrow) were effaced bilaterally. Biliary dilation was successful, and the biliary drainage catheters were ultimately removed after 3 months of drainage and confirmation of stricture resolution at cholangiography (not shown).

a. b. c. d.

will allow catheter removal, but these stents are likely to occlude in months (33). This approach may be appropriate for the patient with short life expectancy. Benign strictures can be treated with catheter drainage and balloon dilation (Fig 20). They may recur and can be redilated (34,35).

In rare instances, biliary obstruction may result in a bile leak and extrahepatic biloma formation. In this setting, the bile ducts may not be very dilated since they are decompressed by the leak. This was true of the patient with images in Figure 14, which demonstrate drainage of the biloma. Management of such a biloma, however, requires not only biloma catheter drainage but also biliary drainage. Biliary drainage will divert the flow of bile from the biloma and allow the leak to heal.

When transhepatic cholangiography and biliary drainage are performed, the cholangiogram must be carefully assessed to ensure that all hepatic segment ducts are demonstrated. Absent ducts suggest multifocal obstruction or isolated segmental obstruction. Multifocal obstruction of central ducts may require placement of two catheters for complete drainage and adequate access for interventions such as dilation (Fig 17). Recognition of the need for a second catheter is important to ensure that undrained segments or lobes are not left in a patient with sepsis. In cases of complete obstruction isolated to one segment or lobe in which the obstruction cannot be crossed with a wire to allow dilation or stent placement, complex interventions may allow establishment of an extraanatomic path to the bowel or to the anatomically drained portion of the biliary tree.

Summary

Pancreatoduodenectomy is associated with high morbidity, and management of the most common complications remains in the hands of the surgical team. Many complications are demonstrated at cross-sectional imaging, however, and are amenable to imaging-guided interventions that range from simple needle aspiration to complex biliary procedures. Familiarity with the normal postoperative anatomy will help the radiologist diagnose these complications and avoid misinterpretation of infected fluid collections as normal structures. Knowledge of the interventions available will help radiologists make the appropriate management recommendations. Together, diagnostic and interventional radiologists play important roles in the assessment and management of several complications after the Whipple procedure.

References

1. Kausch W. Das carcinom der papilla duodeni und seine radikale entfeinung. Beitr Z Clin Chir 1912; 78:439–486.
2. Whipple AO, Parsons WB, Mullins CR. Treatment of carcinoma of the ampulla of Vater. Ann Surg 1935; 102:763–779.
3. Crile G. The advantages of bypass operations over radical pancreaticoduodenectomy in the treatment of pancreatic carcinoma. Surg Gynecol Obstet 1970; 130:1049–1053.
4. Gudjousson B. Cancer of the pancreas: 50 years of surgery. Cancer 1987; 60:2284–2303.
5. Grace PA, Pitt HA, Tompkins RK, et al. Decreased morbidity and mortality after pancreaticoduodenectomy. Am J Surg 1986; 151:141–149.
6. Crist DW, Sitzmann JV, Cameron JL. Improved hospital morbidity, mortality, and survival after the Whipple procedure. Ann Surg 1987; 206:358–365.
7. Fernandez-del Castillo C, Rattner DW, Warshaw AL. Standards for pancreatic resection in the 1990's. Arch Surg 1995; 130:295–300.
8. Cameron JL, Pitt HA, Yeo CJ, et al. One hundred and forty-five consecutive pancreaticoduodenectomies without mortality. Ann Surg 1993; 217:430–438.
9. Yeo CJ, Cameron JL, Sohn TA, et al. Six hundred fifty consecutive pancreaticoduodenectomies in the 1990's: pathology, complications, and outcomes. Ann Surg 1997; 226:248–260.
10. Barnes SA, Lillemoe KD, Kaufman HS, et al. Pancreaticoduodenectomy for benign disease. Am J Surg 1996; 171:131–135.
11. Dicarlo V, Balzano G, Zerbi A, Villa E. Pancreatic cancer resection in elderly patients. Br J Surg 1998; 85:607–610.
12. Sohn TA, Yeo CJ, Cameron JL, et al. Should pancreaticoduodenectomy be performed in octogenarians (abstr)? Gastroenterology 1997; 112(suppl A):A1475.
13. Pellegrini CA, Heck CF, Raper S, Way LW. An analysis of the reduced morbidity and mortality rates after pancreaticoduodenectomy. Arch Surg 1989; 124:778–781.
14. Silen W. Pancreas. In: Schwartz SI, ed. Principles of surgery. New York, NY: McGraw-Hill, 1969; 1112–1137.
15. Itani KMF, Coleman RE, Akwari OE, et al. Pylorus-preserving pancreaticoduodenectomy: a clinical and physiologic appraisal. Ann Surg 1986; 204:655–664.
16. Warshaw AL, Torchiana DL. Delayed gastric emptying after pylorus-preserving pancreaticoduodenectomy. Surg Gynecol Obstet 1985; 160:1–4.
17. Yeo CJ, Barry MK, Sauter PK, et al. Erythromycin accelerates gastric emptying after pancreaticoduodenectomy: a prospective, randomized placebo-controlled trial. Ann Surg 1993; 218:229–238.

18. Yeo CJ. Management of complications following pancreaticoduodenectomy. Surg Clin North Am 1995; 75:913–924.
19. Patel AG, Toyama MT, Kusske AM, Alexander P, Ashley SW, Reber HA. Pylorus-preserving Whipple resection for pancreatic cancer: is it any better? Arch Surg 1995; 130:838–843.
20. Sharp KW, Ross CB, Halter SA, et al. Pancreatoduodenectomy with pyloric preservation for carcinoma of the pancreas: a cautionary note. Surgery 1989; 105:645–653.
21. Tsap JI, Rossi RL, Lowell JA. Pylorus-preserving pancreaticoduodenectomy: is it an adequate cancer operation? Arch Surg 1994; 129:405–412.
22. Rumstadt B, Schwab M, Korth P, Samman M, Trede M. Hemorrhage after pancreaticoduodenectomy. Ann Surg 1998; 227:236–241.
23. Coombs RJ, Zeiss J, Howard JM, Thomford NR, Merrick HW. CT of the abdomen after the Whipple procedure: value in depicting postoperative anatomy, surgical complications, and tumor recurrence. AJR Am J Roentgenol 1990; 154:1011–1014.
24. Lepanto L, Gianfelice D, Dery R, Dagenais M, Lapointe R, Roy A. Postoperative changes, complications, and recurrent disease after Whipple's operation: CT features. AJR Am J Roentgenol 1994; 163:841–846.
25. Balthazar EF, Freeny PC, vanSonnenberg E. Imaging and intervention in acute pancreatitis. Radiology 1994; 193:297–306.
26. Wittich GR, vanSonnenberg E. When should radiologists intervene in management of pancreatic pseudocysts and other complications of acute pancreatitis? AJR Am J Roentgenol 1996; 166:211.
27. vanSonnenberg E, Mueller PR, Ferrucci JT. Percutaneous drainage of 250 abdominal abscesses and fluid collections. I. Results, failures, and complications. Radiology 1984; 151:337–341.
28. Mueller PR, vanSonnenberg E, Ferrucci JT. Percutaneous drainage of 250 abdominal abscesses and fluid collections. II. Current procedural concepts. Radiology 1984; 151:343–347.
29. Butch RJ, Mueller PR, Ferrucci JT, et al. Drainage of pelvic abscesses through the greater sciatic foramen. Radiology 1986; 158:487–491.
30. Gazelle GS, Haaga JR, Stellato TA, et al. Pelvic abscesses: CT-guided transrectal drainage. Radiology 1991; 181:49–51.
31. Hovsepian DM. Transrectal and transvaginal abscess drainage. J Vasc Interv Radiol 1997; 8:501–515.
32. Miller FJ, Ahola DT, Bretzman PA, Fillmore DJ. Percutaneous management of hepatic abscess: a perspective by interventional radiologists. J Vasc Interv Radiol 1997; 8:241–247.
33. Vitale GC, Larson GM, Tatum C. Management of malignant biliary stricture with self-expanding metal stent. Surg Endosc 1996; 10:970–973.
34. Vos PM, van Beek EF, Smits NJ, Rauws EA, Gouma DJ, Reeders JW. Percutaneous balloon dilatation for benign hepaticojejunostomy strictures. Abdom Imaging 2000; 25:134–138.
35. Moore AV, Illescas FF, Mills SR, et al. Percutaneous dilation of benign biliary strictures. Radiology 1987; 163:625–628.

This article meets the criteria for 1.0 credit hour in category 1 of the AMA Physician's Recognition Award. To obtain credit, see www.rsna.org/education/rg_cme.html.