Radiologic Assessment for Endoscopic US-guided Biliary Drainage

Shunsuke Sugawara, MD
Miyuki Sone, MD
Shinichi Morita, MD
Susumu Hijioka, MD
Yasunari Sakamoto, MD
Masahiko Kusumoto, MD
Yasuaki Arai, MD

Abbreviations: BD = biliary drainage, CDS = choledochoduodenostomy, GBD = gallbladder drainage, GI = gastrointestinal, HDS = hepaticoduodenostomy, HGS = hepaticogastrostomy, JS = hepaticojejunostomy

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From the Department of Diagnostic Radiology (S.S., M.S., M.K.,Y.A.) and Department of Hepatobiliary and Pancreatic Oncology (S.H., Y.S.), National Cancer Center Hospital, 5-1-1 Tsukiji, Chuo-ku, Tokyo 104-0045, Japan; and Department of Gastroenterology and Hepatology, Uonuma Institute of Community Medicine, Niigata University Hospital, Minamiuonuma, Niigata, Japan (S.M.). Recipient of a Certificate of Merit award for an education exhibit at the 2018 RSNA Annual Meeting. Received May 17, 2019; revision requested July 15 and received August 10; accepted August 27. For this journal-based SA-CME activity, the authors S.S., M.S., M.K., and Y.A. have provided disclosures; all other authors, the editor, and the reviewers have disclosed no relevant relationships. **Address correspondence to** S.S. (e-mail: *sugasuga_shun@yahoo.co.jp*).

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Identify the rationale for and types of endoscopic US-guided BD.
- Discuss the indications for endoscopic US-guided BD based on the type of biliary stricture (Bismuth classification) and the risk factors for various complications after endoscopic US-guided BD.
- Describe the findings specific to endoscopic US-guided BD, including subclinical findings and complications.

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Endoscopic US-guided biliary drainage (BD) is performed for various types of biliary obstruction and is mainly indicated for unsuccessful conventional transpapillary endoscopic retrograde cholangiodrainage. In endoscopic US BD, an extra-anatomic drainage route between the gastrointestinal (GI) tract and the biliary system is created with a covered metallic stent or plastic stent. Procedural types of endoscopic US BD include hepaticogastrostomy, hepaticojejunostomy (after gastrectomy), choledochoduodenostomy, hepaticoduodenostomy, and endoscopic US-guided gallbladder drainage. The technical and clinical success rates of endoscopic US BD are reported to be 94%–97% and 88%–100%, respectively. CT is crucial both in preprocedural assessment and postprocedural monitoring. CT is used to determine the indications for endoscopic US BD, which include the type of biliary obstruction, collateral vessels in the puncture route, ascites, the volume of the liver segment, the distribution of an intrahepatic tumor, and GI tract patency. After endoscopic US BD, common subclinical findings are a small amount of intraperitoneal gas, localized edematous change in the GI tract, a notch in the placed stent, and localized biliary dilatation caused by stent placement. Stent malfunction after endoscopic US BD is caused by impaction of debris and/or food, stent migration into the GI tract, or tumor overgrowth and/or hyperplasia. Complications that can occur include internal stent migration, intraperitoneal biloma, arterial bleeding or pseudoaneurysm, perforation of the GI tract, and portobiliary fistula. The incidence of clinical endoscopic US BD–related complications is 11%–23%.

Introduction

Percutaneous or endoscopic biliary drainage (BD) is widely performed in patients with obstructive jaundice. Percutaneous transhepatic BD is a traditional method that has been used to relieve obstructive jaundice since the 1970s (1). Endoscopic BD was developed in the 1970s and 1980s (2,3) and has become a standard procedure that is recommended for BD in the guidelines for acute cholangitis (4). Transpapillary drainage is a conventional endoscopic BD method used for various types of biliary stricture (4). However, transpapillary bile duct cannulation is unsuccessful in 5%–10% of cases (5,6) and has a risk of acute pancreatitis (7,8). When the transpapillary approach is unsuccessful, percutaneous transhepatic BD is a salvage technique. Endoscopic US–guided BD was first described in 2001 (9) and has been reported to be an alternative to percutaneous transhepatic BD for unsuccessful transpapillary endoscopic BD (10–14). Meta-analyses (5,15) and randomized controlled trials (14,16) have suggested that endoscopic US BD has a technical success rate similar to that of percutaneous transhepatic BD and a lower incidence of adverse events, a lower reintervention rate, and a similar or better clinical success rate than those for percutaneous

TEACHING POINTS

- HGS can be performed in combination with placement of a duodenal stent even if the patient has duodenal obstruction and is preferable to CDS combined with a duodenal stent because of its long patency.
- The type of biliary stricture that is most suitable for HGS is distal biliary stricture or Bismuth type I stricture.
- HDS is used as a supplemental drainage pathway with HGS or HJS or conventional transpapillary BD for a complicated biliary stricture such as Bismuth type II, III, or IV.
- Given that the aspect of the gallbladder that does not abut the liver is punctured, the risk of biliary peritonitis is higher in patients who have undergone endoscopic US GBD.
- Contrast-enhanced CT is recommended for patients who have symptoms after endoscopic US BD (eg, fever, abdominal pain, hematemesis, or jaundice).

transhepatic BD. However, endoscopic US BD is associated with adverse events that do not occur with conventional transpapillary BD, because a new anatomic drainage route is created artificially (12,13,17). Radiologic evaluation is important in the assessment of the indications for endoscopic US BD, the estimation of its risks, and the detection of complications after the procedure. This article describes representative types of endoscopic US BD, their indications, and tips for radiologic evaluation before and after the procedure, including characteristic complications.

Rationale for Use of Endoscopic US BD

In endoscopic US BD, an extra-anatomic route between the biliary and gastrointestinal (GI) tracts is created with a stent (10,14). Hepaticogastrostomy (HGS) and choledochoduodenostomy (CDS) are the main endoscopic US-guided biliary interventions, followed by hepaticojejunostomy (HJS), hepaticoduodenostomy (HDS), and endoscopic US-guided gallbladder drainage (GBD) (12–14,17–20). The advantage of endoscopic US BD is that the risk of acute pancreatitis is minimal compared to that with conventional endoscopic transpapillary BD, because the papilla of Vater and the pancreatic duct are not affected (10). The risk of a stent becoming obstructed by tumor ingrowth or overgrowth is also minimal, because the stent is not placed at a site that can be obstructed by the tumor. Placement of an antegrade stent that traverses the papilla through the HGS route is also feasible (13,21–24).

Indications for Endoscopic US BD

Endoscopic US BD can be applied when conventional transpapillary BD is unsuccessful because of technical difficulty or altered anatomy (eg, after gastrectomy or pancreatoduodenectomy) (4,12,13,25,26). Unsuccessful placement of a percutaneous biliary stent is also an indication for endoscopic US BD (27), and patients with a history of severe acute pancreatitis that was caused by previous conventional transpapillary BD may also be candidates for endoscopic US BD. According to previous studies (14,28–30), the technical and functional success rates are high, at 94%–97% and 88%–100%, respectively. However, these reports were from high-volume centers in which the procedures were performed by skilled endoscopists. A nationwide survey from Spain (31) reported that the technical success rate was 67.2%, suggesting that endoscopic US BD is still not a standardized technique and is dependent on the skills of the operator (4,5,17).

Types of Biliary Stricture

Anatomically, biliary stricture is classified as distal stricture or perihilar stricture. Distal biliary stricture is a simple type that does not extend to the hilar region and is localized in the distal common bile duct. The Bismuth classification system is widely used to classify the types of perihilar biliary stricture (Fig 1) (32,33). According to this classification system, perihilar biliary stricture is categorized into four types, according to its extent. Type I is a stricture in which the confluence of the hepatic duct is preserved. Type II is a stricture in which the confluence of the hepatic duct is occluded and the patency between the right and left hepatic ducts is not preserved. In a type III stricture, the unilateral segmental branch, the confluence of the hepatic duct, and the common bile duct are obstructed. Bismuth type IV is the most complicated stricture, in which the bilateral segmental branch, the confluence of the hepatic duct, and the common bile duct are obstructed. In endoscopic US BD, the indication and target bile duct for puncture are decided on the basis of the type of biliary stricture, the volume of the liver, the patency of the portal vein in each segment, and the localization of segmental cholangitis.

Types of Endoscopic US-guided BD and Their Indications

In endoscopic US BD, the bile duct is punctured under endoscopic US guidance through the endoscope, and an extra-anatomic drainage route is created between the biliary system and the GI tract through placement of a stent (Fig 2). A covered metallic stent or plastic stent is used in endoscopic US BD; these stents can be exchanged if they do not function correctly for any reason (25). Placement of a covered metallic stent rather than a plastic stent is recommended to reduce the risk of bile leakage (12,17,25).

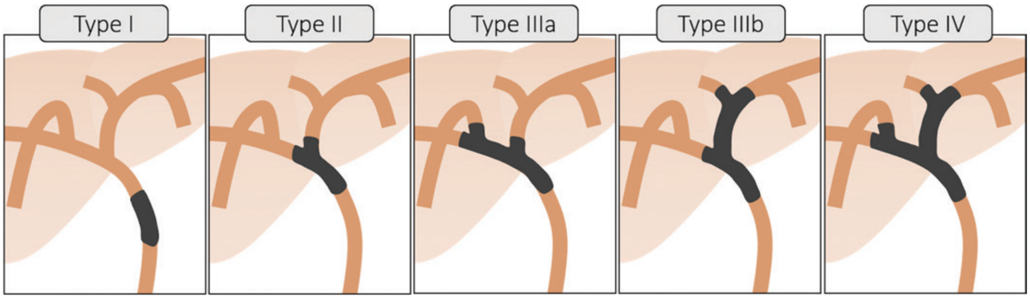


Figure 1. Illustration shows the Bismuth classification for biliary stricture in the hilar region. Type I stricture is the simplest type, in which the confluence of the hepatic duct is preserved. The confluence of the hepatic duct is invaded in Type II stricture, and the confluence of the second branch of the unilateral hepatic duct is invaded in Type III stricture. The confluence of the anterior and posterior segments is invaded in Type IIIa, and that of the medial and lateral segments is invaded in Type IIIb. Type IV is the most complicated type of biliary stricture in the hilar region, in which the confluence of the second branch of the hepatic duct is invaded bilaterally.

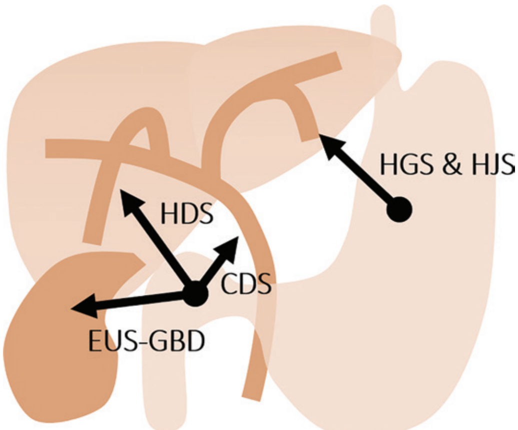


Figure 2. Illustration shows the types of endoscopic US-guided BD. In HGS and HJS, an intrahepatic bile duct in the lateral segment of the liver is punctured from the stomach. In CDS, HDS, and GBD, the common bile duct, intrahepatic bile duct in the right lobe of the liver (mainly B6), and the gallbladder are punctured from the duodenum, respectively. *EUS* = endoscopic US.

Choledochoduodenostomy

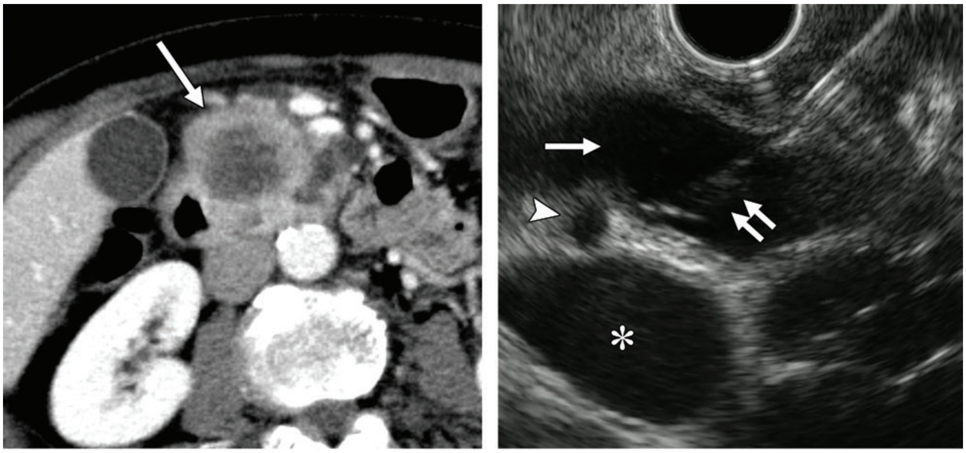
In CDS, the common bile duct is punctured under endoscopic US guidance from the duodenum, and a stent is placed between the common bile duct and the duodenum (Fig 3) (12–14,20,34). There is less risk of acute pancreatitis with CDS than with conventional transpapillary BD, because the papilla of Vater is not manipulated, and the pancreatic duct is not cannulated or visualized accidentally (10). Moreover, a report (10) suggested that the procedure time required for CDS is shorter than that needed for conventional transpapillary biliary intervention. CDS can provide antegrade flow of bile to the duodenum and is indicated in patients with a distal biliary stricture that does not extend to the hilar region (25).

Hepaticogastrostomy

In HGS, an intrahepatic bile duct in the lateral segment of the liver, usually B3, is punctured under endoscopic US guidance from the small curvature of the stomach, and a stent is placed between the intrahepatic bile duct and the stomach (Fig 4) (12–14,18,20,34). Puncturing the intrahepatic bile duct increases the risk of accidental transesophageal puncture through the mediastinum or pleural cavity (35). HGS is indicated for various types of biliary stricture and is sometimes combined with another type of endoscopic US BD, as long as liver function in the lateral segment is preserved. HGS is indicated for patients with a distal biliary stricture or Bismuth type I stricture (25). HGS can be performed in combination with placement of a duodenal stent even if the patient has duodenal obstruction (25,34) and is preferable to CDS combined with a duodenal stent because of its long patency (34).

Hepaticojejunostomy

HJS is a technique that is similar to HGS. HJS is used in patients with an anastomosis between the esophagus and jejunum after total gastrectomy (Fig 5) (24). Conventional transpapillary BD is technically difficult to perform in these patients for anatomic reasons, except in those who have undergone Billroth I reconstruction. In HJS, an intrahepatic bile duct in the lateral segment of the liver is punctured from the reconstructed jejunum, and a stent is placed between the intrahepatic bile duct and the reconstructed jejunum, as in HGS (23,24). The type of biliary stricture that is most suitable for HJS is distal biliary stricture or Bismuth type I stricture. The lumen of the jejunum is narrow compared with that of the stomach, so the edge of the placed stent is likely to attach to the wall of the jejunum, and the stent tends to be kinked or inclined toward the oral side.



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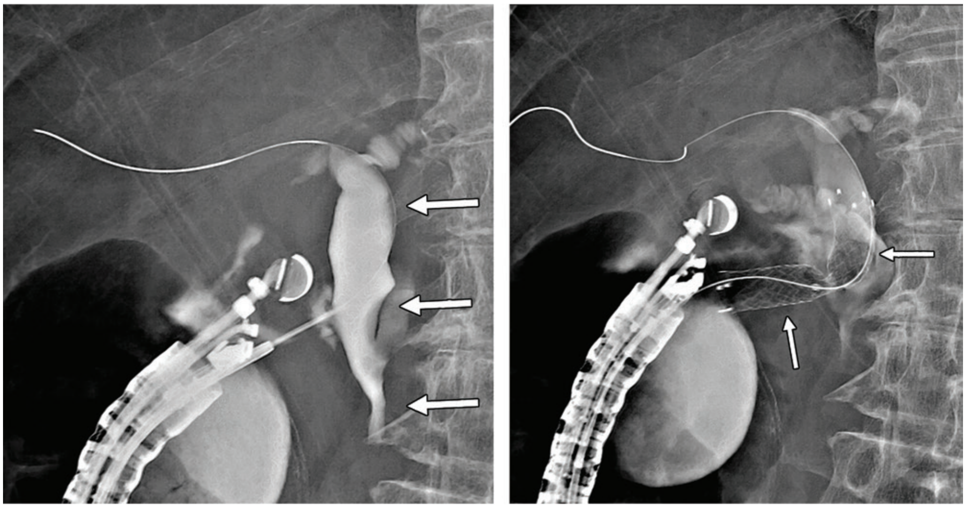

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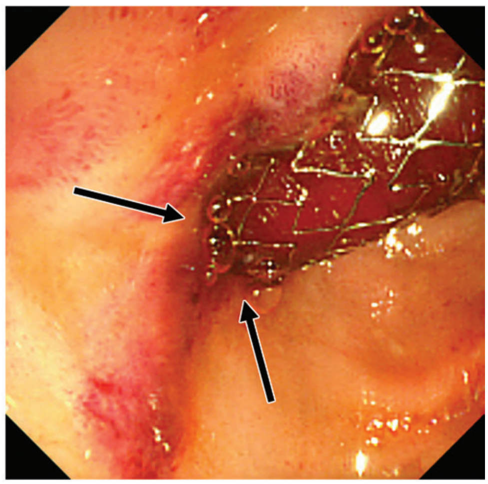


e.

Figure 3. Endoscopic US-guided CDS in a 74-year-old woman with obstructive jaundice caused by cancer of the head of the pancreas. **(a)** Axial contrast material–enhanced CT image shows a poorly enhancing cancerous tumor obstructing the common bile duct at the head of the pancreas (arrow). **(b)** Endoscopic US image from the duodenum shows a dilated common bile duct (single arrow) that was punctured under endoscopic US guidance with a 19-gauge needle (double arrow). Also visible are the right hepatic artery (arrowhead) and the main portal vein (*). **(c)** Cholangiogram shows a guidewire advanced with fluoroscopic guidance through the puncture needle and the common bile duct (arrows). **(d)** Cholangiogram shows placement of a covered metallic stent (arrows) from the duodenum to the common bile duct during CDS. **(e)** Endoscopic image after CDS shows the stent through the fistula (arrows) in the duodenum and no major bleeding.

Hepaticoduodenostomy

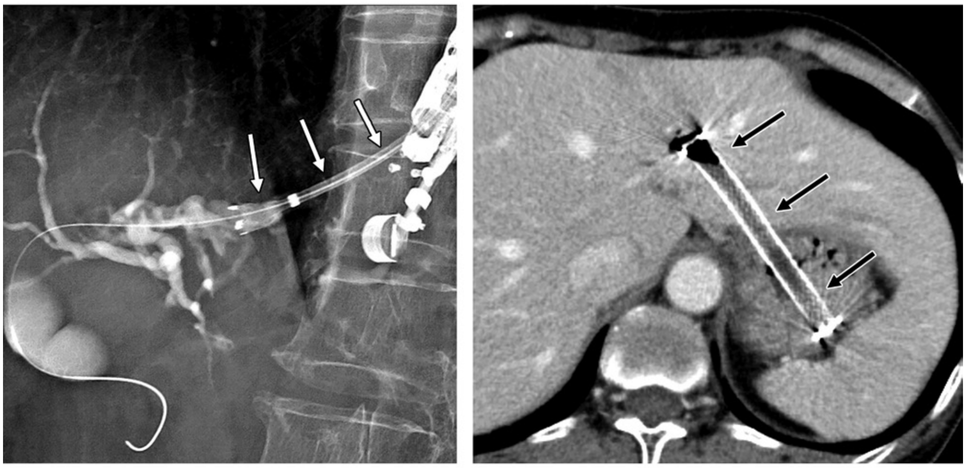
In HDS, the posterior branch of an intrahepatic bile duct (usually B6) is punctured, mainly from the duodenum, and a stent is placed between the intrahepatic bile duct in the right lobe of the liver and the duodenum (Fig 6) (36–38). HDS is presently performed only in institutions with experts in HDS, because it is more technically difficult than the other endoscopic US BD methods, and the long-term patency of the stent is not promising (36). HDS is used as a supplemental drainage pathway with HGS or HJS or conventional transpapillary BD for a complicated biliary stricture such as Bismuth type II, III, or IV (36–38).

Endoscopic US-guided GBD

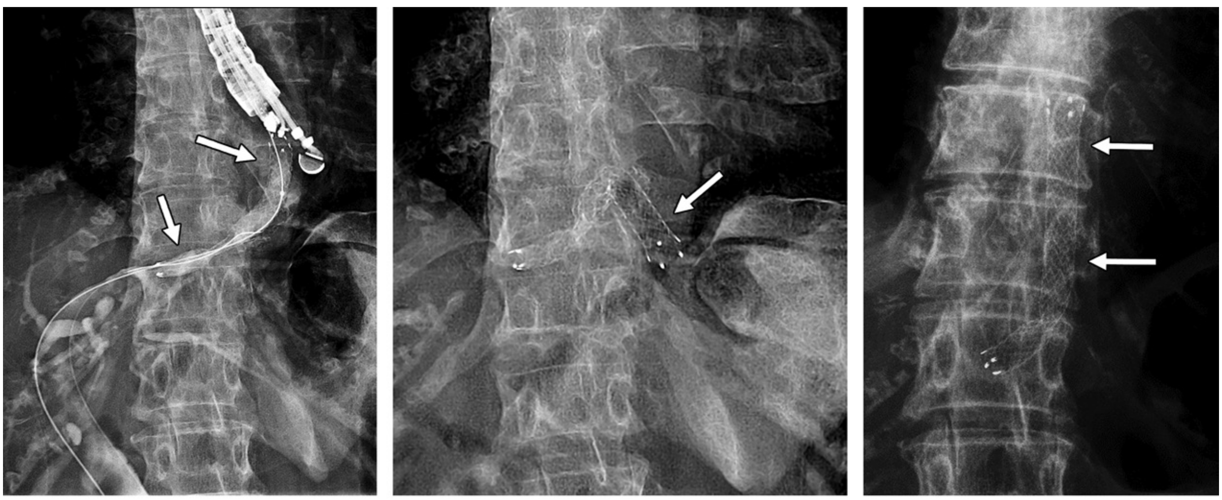
Endoscopic US GBD is performed in patients with acute cholecystitis who are not eligible for emergency cholecystectomy (11). In endoscopic US GBD, the gallbladder is punctured from the duodenum, and a plastic or metallic stent is placed between the gallbladder and duodenum (Fig 7) (11,39,40). Endoscopic US GBD is the endoscopic equivalent of percutaneous transhepatic GBD. There is no risk of pleuritis with endoscopic US GBD, and there is no need for a persistent

a.

Figure 4. Endoscopic US–guided HGS in a 60-year-old woman with pancreatic cancer. **(a)** Endoscopic US image shows a dilated intrahepatic bile duct (arrow) punctured with a 19-gauge needle. **(b)** Cholangiogram shows that an intrahepatic bile duct (in segment 2) was punctured under endoscopic US guidance and an HGS was created with placement of a covered metallic stent (arrows). **(c)** Axial CT image after HGS shows the metallic stent (arrows) between the intrahepatic bile duct and the stomach. The biliary system was decompressed without complications.

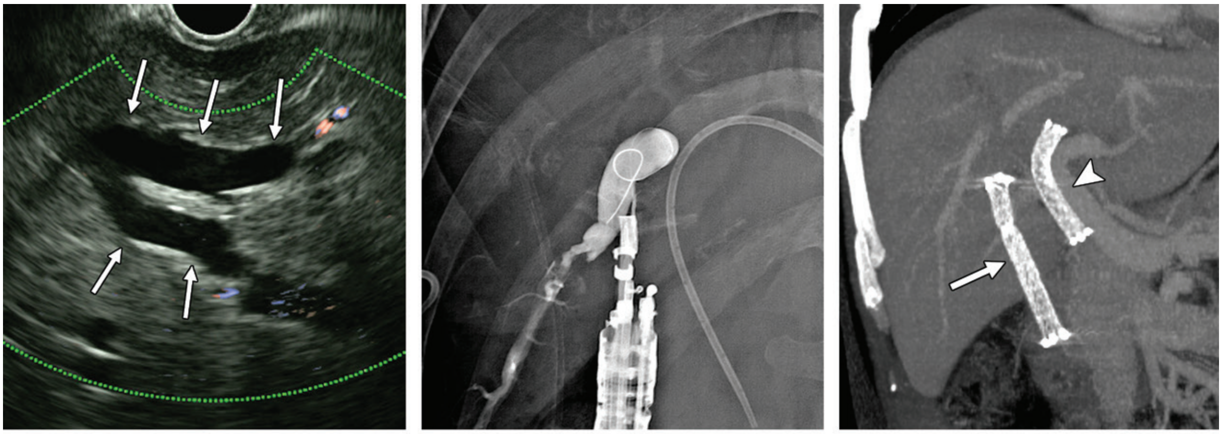


b. c.



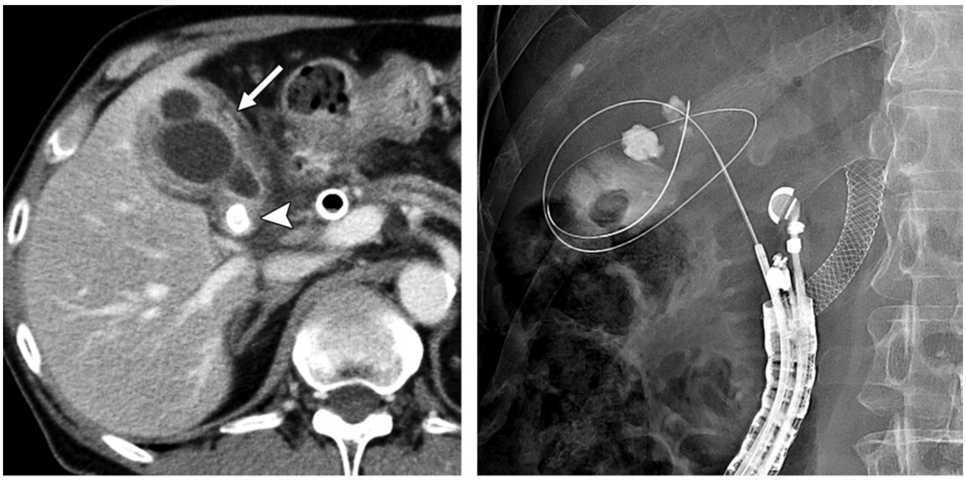
a. b. c.

Figure 5. Endoscopic US-guided HJS in a 74-year-old woman with obstructive jaundice caused by recurrence of gastric cancer after total gastrectomy. **(a)** Cholangiogram shows a dilated intrahepatic bile duct punctured under endoscopic US and an HJS created with the use of a covered metallic stent (arrows). **(b)** Fluoroscopic image acquired just after HJS shows the distal end of a stent placed toward the anal side of the stomach (arrow). **(c)** Radiograph acquired on the day after stent placement shows the proximal end of the stent in the esophagus and directed toward the oral side (arrows) as a result of the axial force, which increases the risk of food impaction.



a. b. c.

Figure 6. Endoscopic US-guided HDS in a 51-year-old woman with intrahepatic cholangiocarcinoma. **(a)** Endoscopic US image shows a dilated intrahepatic bile duct in the posterior segment (B6) (arrows). **(b)** Cholangiogram shows the B6 segment visualized with contrast material, with a guidewire inserted. **(c)** Oblique coronal maximum intensity projection CT image shows the stent between the B6 segment and the duodenum (arrow). The stent between the left hepatic duct and the common bile duct (arrowhead) was placed percutaneously.



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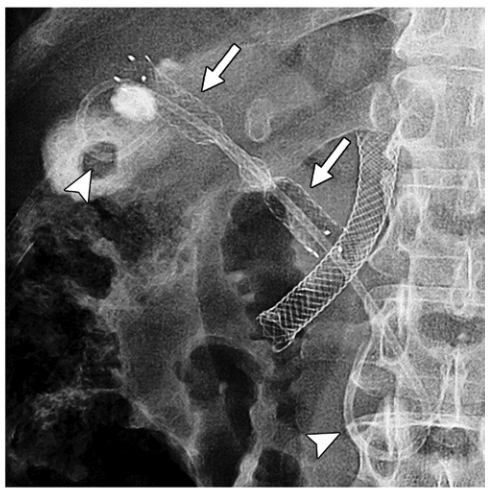


c.

Figure 7. Endoscopic US-guided GBD in a 68-year-old man with acute cholecystitis caused by a gallbladder stone after placement of a stent for a common bile duct stricture due to pancreatic cancer. **(a)** Axial contrast-enhanced CT image shows swelling of the gallbladder, a thickened wall (arrow), and a stone in the neck of the gallbladder (arrowhead). **(b)** Fluoroscopic image shows the gallbladder punctured under endoscopic US guidance from the duodenum and visualized with contrast material. The guidewire was inserted under fluoroscopic guidance. **(c)** Fluoroscopic image shows a metallic stent placed between the gallbladder and the duodenum and stomach (arrows). A double pigtail plastic stent (arrowheads) was placed through the metallic stent to prevent stent migration.

drainage tube. However, given that the aspect of the gallbladder that does not abut the liver is punctured, the risk of biliary peritonitis is higher in patients who have undergone endoscopic US GBD. In a small randomized controlled study (11) that compared percutaneous transhepatic GBD (n = 29) and endoscopic US GBD (n = 30), the clinical efficacy and incidence of adverse events were equivalent, and endoscopic US GBD was

Table 1: Imaging Evaluation before Endoscopic US-guided BD

Assessment Checklist	Assessment
Type of biliary obstruction	Type of endoscopic US BD indicated
Distal biliary obstruction	CDS, HGS, or HJS
Bismuth type I	HGS or HJS
Bismuth type II or IIIa	HGS or HJS (combined with HDS)
Bismuth type IIIb	HDS (combined with HGS or HJS)
Bismuth type IV	HGS, HJS, and/or HDS
Abnormal vessels on puncture route	Risk of hemorrhage
Collateral veins or varices between the stomach and liver	Risk of hemorrhagic complication in endoscopic US HGS
Cavernous transformation around the common bile duct	Risk of hemorrhagic complication in endoscopic US CDS
Ascites between the liver and GI tract	Risk of hemorrhagic complications or stent migration in HGS, HDS, or HJS due to incomplete creation of a track between the liver and the GI tract
Size of the parenchyma in each segment of the liver	Determine whether the segment can be salvaged
Segment with large volume of functional liver parenchyma	Higher priority for BD
Segment with small volume of functional liver parenchyma	Lower priority for BD
Size of the lateral segment of the liver	A large lateral liver segment increases the risks associated with puncture from the esophagus through the mediastinum for B2 access in HGS or HJS
Patency of intrahepatic portal vein in each liver segment	Determine whether the segment can be salvaged
Intrahepatic portal vein is patent	Higher priority for BD
Intrahepatic portal vein is occluded	Lower priority for BD
Location of intrahepatic tumor	Determine the risk of bleeding and stent malfunction
Hepatic tumor in the puncture route	Increased risk of bleeding
Tumor dissemination and overgrowth	Increased risk of stent malfunction

less painful. Endoscopic US GBD is also reported to be a useful method to convert from percutaneous transhepatic GBD for patients who cannot undergo cholecystectomy (41).

Imaging before and after Endoscopic US BD

Imaging before Endoscopic US BD

The checklist to be completed before endoscopic US BD is outlined in Table 1. The Bismuth classification of the biliary stricture is determined first for selection of the optimal endoscopic US BD method. Abnormal vessels in the puncture route (Fig 8), the presence of ascites, the size of each liver segment, the patency of the intrahepatic portal vein, and the location of an intrahepatic tumor are then evaluated to assess the safety and efficacy of endoscopic US BD. Ascites is considered a risk factor for bleeding and biliary peritonitis (18). Interposition of ascites can inhibit adhesion between the GI tract and the liver and can prevent formation of a track between the two structures. Inadequate adhesion between the GI tract and the liver can increase the risk of internal stent migration. Abnormal vessels are often found around the stomach or the common bile duct because of obstruction of the portal vein by a tumor.

CT is the imaging modality that is most reliable and used most frequently both before and after endoscopic US BD. Before endoscopic US BD, CT is used to evaluate the anatomic relationship between the GI tract and the liver, degree of bile duct dilatation, Bismuth classification of the biliary stricture, volume of the liver parenchyma in each segment, patency of the intrahepatic portal vein, and risk factors for endoscopic US BD (eg, ascites, vessels between the liver and the GI tract).

MR cholangiopancreatography can provide a road map of the biliary system to evaluate the type of biliary stricture before endoscopic US BD (25). It is a noninvasive and reliable imaging examination and is recommended by the consensus guidelines for endoscopic US BD (25). MR cholangiopancreatography is recommended particularly for patients with hilar obstruction to delineate

Table 2: Imaging Evaluation after Endoscopic Ultrasound-guided Biliary Intervention

Checklist	Assessment
Location of stent	
Is the stent not there (complete migration)?	Early stent migration can cause peritonitis, biloma, or abscess.
Is the end of the stent in the GI tract or bile duct (partial migration)?	In general, delayed stent migration after track formation does not cause serious complications other than obstructive jaundice and/or cholangitis. Shortening of a metallic stent after placement can cause partial migration and can result in stent malfunction.
Direction of the stent in the GI tract: Is the end of the stent toward the afferent stomach or bowel lumen side?	When the proximal end of the stent is toward the afferent stomach or bowel lumen, ingested food tends to flow into the stent, and food impaction is likely to occur. Food impaction can cause early stent obstruction or cholangitis.
Abnormal fluid and/or gas collection: Is there a biloma, abscess, or hematoma?	Symptomatic fluid collection (intra- or extrahepatic) requires drainage. Asymptomatic minor fluid or gas collection is acceptable. If bleeding is suspected, contrast-enhanced CT is required to assess arterial injury.
Bile duct dilatation: Is the bile duct decompressed?	A dilated bile duct suggests stent malfunction. Stent malfunction has various causes (eg, debris, food impaction, hyperplasia, tumor overgrowth, stent migration). A covered metallic stent can block the adjacent segmental bile duct and lead to localized dilatation. It is inevitable and acceptable unless patients have symptoms of obstructive cholangitis.

the type of obstruction (25). US is a noninvasive imaging modality that is used for screening both before and after endoscopic US BD.

Imaging after Endoscopic US BD

The checklist to be completed after endoscopic US BD is shown in Table 2. The imaging findings should be evaluated with consideration of clinical symptoms. After endoscopic US BD, the location of the stent, the direction of the stent in relation to the GI tract, abnormal fluid and gas collection, and decompression of the biliary system are evaluated.

CT is the most reliable imaging modality for evaluation of the efficacy of endoscopic US BD and any complications. After endoscopic US BD, CT is used to evaluate the position of the stent, complications, and decompression of the biliary system. Contrast-enhanced CT is recommended for patients who have symptoms after endoscopic US BD (eg, fever, abdominal pain, hematemesis, or jaundice).

Radiography is used to evaluate the configuration and direction of the stent placement after endoscopic US BD. Although the exact position of the stent cannot be determined on a radiograph, the approximate location can be evaluated. In patients with symptoms of cholangitis, radiography is performed to check for delayed stent migration (Fig 5).

US can be used after BD to evaluate fluid collection (eg, biloma, abscess, or hematoma) in and outside the liver. Dilatation of the intrahepatic bile duct is also evaluated with US when stent obstruction is suspected.

Figure 8. Abnormal vessels in the puncture route in a 55-year-old man with obstructive jaundice and complete occlusion of the portal vein as a result of advanced cancer of the head of the pancreas. Axial contrast-enhanced CT image shows collateral vessels (arrows) between the lateral segment of the liver and the stomach. Ascites, which is a risk factor for intraperitoneal bleeding and internal stent migration, is visible around the liver, stomach, and spleen.

Common CT Findings after Endoscopic US BD

Subclinical CT findings may be detected incidentally after endoscopic US BD. These incidental findings do not need additional intervention as long as they are asymptomatic.

Intraperitoneal Gas and Pneumomediastinum or Pneumothorax.—A small amount of intraperi-

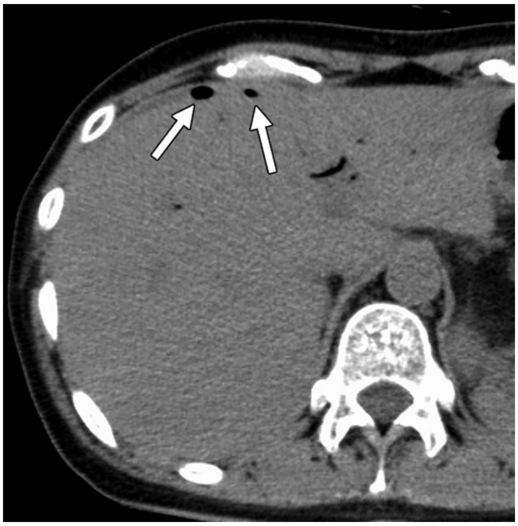


Figure 9. Axial CT image shows a small amount of asymptomatic intraperitoneal gas (arrows) in a 55-year-old woman who had undergone CDS 1 day earlier. Intraperitoneal gas can remain for a few days after endoscopic US-guided BD. It is a common finding and is self-limiting in most cases.

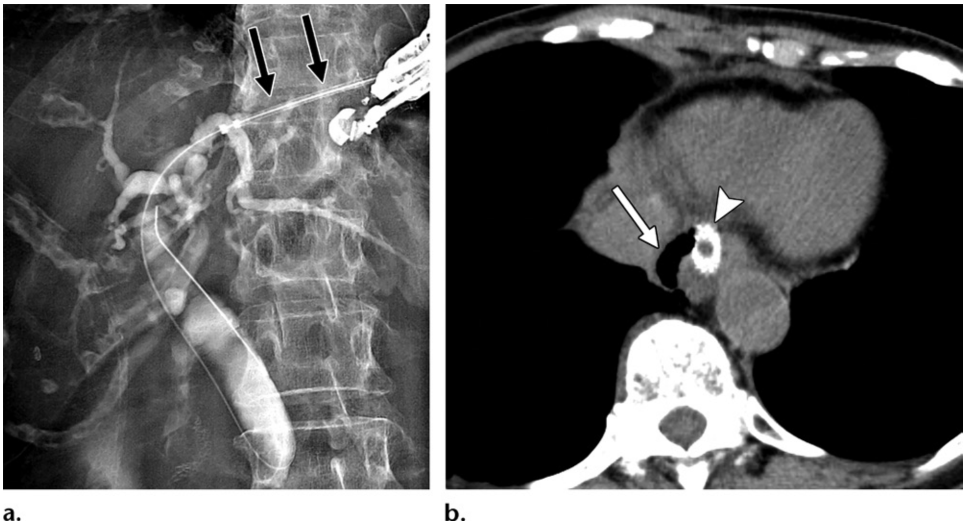
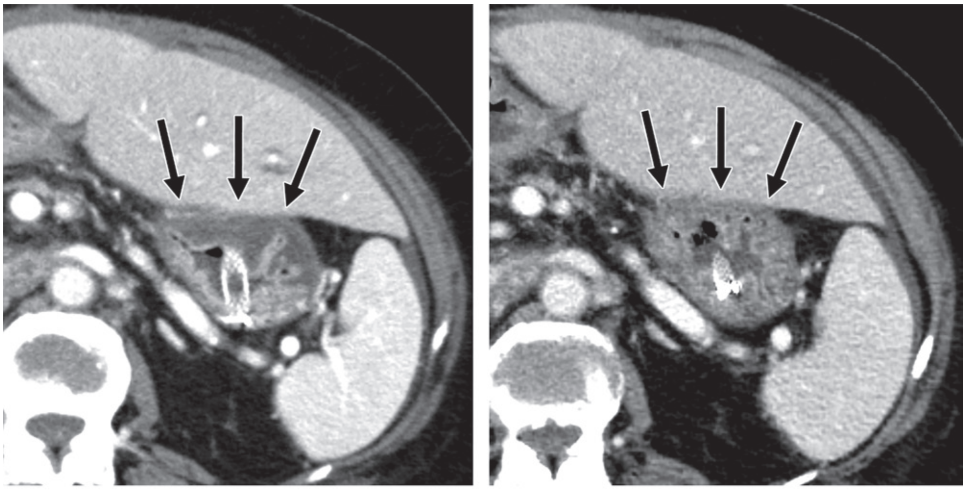


Figure 10. Pneumomediastinum in a 74-year-old man in whom HJS was performed after total gastrectomy for gastric cancer. **(a)** Fluoroscopic image shows the puncture of the intrahepatic bile duct under endoscopic US guidance and delivery and placement of a metallic stent (arrows). **(b)** Axial nonenhanced CT image obtained on the day after HJS shows a small amount of asymptomatic gas (arrow) around the esophagus in the mediastinum. The metallic stent can be seen in the esophagus (arrowhead).

toneal gas can remain for a few days after endoscopic US BD (Fig 9). It is a common finding and is self-limiting in most cases (29). Minor pneumomediastinum or pneumothorax can also occur with HGS or HJS because of accidental puncture from the esophagus or esophagogastric junction above the diaphragm (Fig 10). Accidental puncture through the mediastinum or pleural cavity should be avoided because of the risk of mediastinitis or pleuritis (35,42,43).

Localized Edematous Change in the GI Tract.— Localized edematous change in the GI tract is also a common finding. Although it is not always possible to verify the cause of edematous change (eg, inflammation caused by gastric wall puncture, infection, or another reason), the change is asymptomatic and self-limiting in most cases (Fig 11). This finding disappears within a few weeks.

Notch in the Placed Stent.—A notch in the placed stent can prevent early stent migration (44). It can be found in the wall of the GI tract and in the wall of the bile duct or liver parenchyma (Fig 12). A stent with two notches is reported as the "candy sign" (44). This finding does not directly represent stent obstruction, even if the lumen of the stent appears stenotic. A report (44) suggested that a shorter distance between the stomach wall and the liver parenchyma correlates with a lower risk of early stent migration. The notch gradually disappears in response to the radial force of a self-expandable stent.



a. b.

Figure 11. Localized edematous change in the GI tract of an 85-year-old man with intrahepatic cholangiocarcinoma and an HGS. **(a)** Axial contrast-enhanced CT image obtained 7 days after HGS shows a localized edematous change in the gastric wall (arrows). Edematous change in the GI tract is a common finding and is asymptomatic in most cases. **(b)** Axial follow-up contrast-enhanced CT image acquired 19 days after HGS shows the disappearance of the edematous change in the gastric wall (arrows). Edematous change in the GI tract after endoscopic US-guided BD disappears within a few weeks.

Localized Biliary Dilatation.—CT after endoscopic US HGS with a covered metallic stent can allow visualization of localized dilatation of an isolated bile duct (17). It is also a common finding after endoscopic US BD and is inevitable when a metallic stent is placed (Fig 13). In general, the localized dilatation is asymptomatic, and no treatment or intervention is required in most cases. However, it can be a cause of localized cholangitis.

Complications of Endoscopic US BD

The various endoscopic US BD–related complications (12,17,20,35,45,46) are listed in Table 3. The reported overall incidence of endoscopic US BD–related complications ranges from 11% to 23% (5,12,13,20,25,29). Some of the complications are the same as those of conventional transpapillary BD; however, some complications are specific to endoscopic US BD because of its invasive nature.

Localized Segmental Cholangitis and Liver Abscess

Blocking an isolated segmental intrahepatic bile duct with a covered metallic stent can cause localized segmental cholangitis after endoscopic US BD (17). It is suspected when the rest of the biliary system is well decompressed but the laboratory data and physical findings suggest cholangitis. Localized segmental cholangitis can lead to a liver abscess (17). To treat localized segmental cholangitis, a one-step puncture is performed, followed by suction of accumulated bile in the dilated bile duct or exchange of a covered metallic stent for a plastic stent to release the blockage of the isolated bile duct, with concurrent administration of antibiotics.

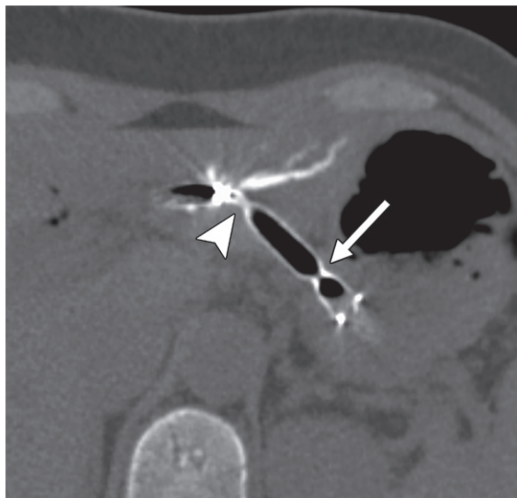
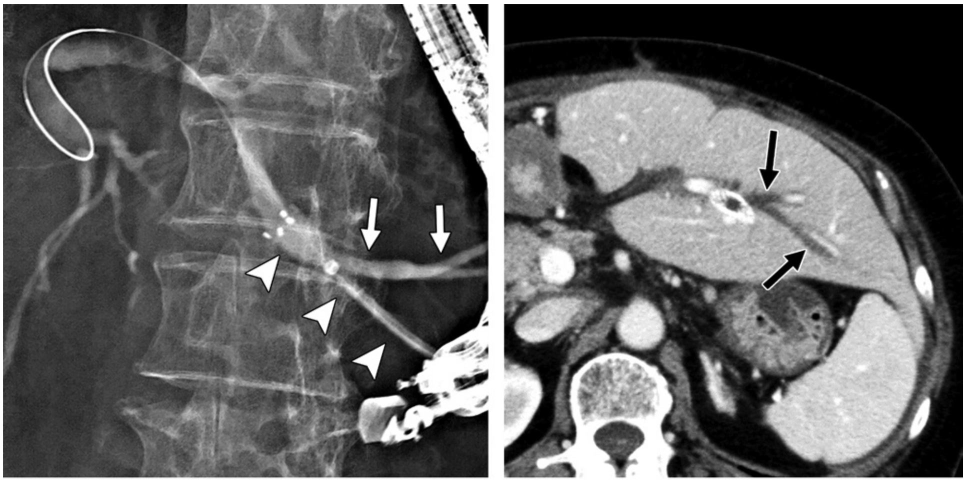


Figure 12. Axial CT image shows a notched stent that was placed in a 54-year-old woman who underwent HGS for obstructive jaundice as a result of malignant melanoma. CT image obtained one day after HGS shows a notch in the placed stent, which can prevent early stent migration. The notched stent was in the wall of the GI tract (arrow) and in the wall of the bile duct and liver parenchyma (arrowhead).

Bile Leak Followed by Biliary Peritonitis or Intraperitoneal Biloma

Bile can leak into the peritoneal cavity via the track and cause biliary peritonitis (10,12,13,20, 29,46). A limited collection of intraperitoneal bile (ie, biloma) can cause persistent fever and pain, and percutaneous drainage is required (Fig 14). The risk of bile leak decreases markedly



a. b.

Figure 13. Localized biliary dilatation in an 85-year-old woman with obstructive jaundice caused by recurrence of bile duct cancer after right hepatectomy. **(a)** Fluoroscopic image shows that the B3 segment was punctured under endoscopic US guidance, and an HGS was created with the use of a covered metallic stent (arrowheads). A peripheral bile duct (arrows) was blocked and isolated by the covered metallic stent. Isolation of a peripheral bile duct is inevitable in endoscopic US-guided BD with a covered metallic stent. **(b)** Axial CT image acquired after endoscopic US–guided HGS with a covered metallic stent shows localized dilatation of an isolated bile duct (arrows). This is also a common finding. Although it is asymptomatic in most patients, it can be a cause of localized cholangitis.

Table 3: Complications Related to Endoscopic US-guided BD

Complication (Frequency)	Learning Points
Internal stent migration (ie, migration into the peritoneal cavity) (rare)	The stent can migrate into the peritoneal cavity before the track is completely created. This is the most serious complication related to endoscopic US BD and can progress to fatal peritonitis. If endoscopic recovery fails, surgical removal of the stent and repair of the perforated site are required.
Bile leak or peritonitis (3.0%–3.5%)	Bile leak in initial endoscopic US BD or stent exchange before complete track formation can cause a bile leak or peritonitis. Drainage is required for symptomatic biloma.
Bleeding or pseudoaneurysm (2.7%)	A covered metallic stent can conceal arterial injury. Bleeding becomes evident when the stent is withdrawn. Dynamic contrast-enhanced CT is required to detect active bleeding or pseudoaneurysm. Angiography should be considered when bleeding or pseudoaneurysm are suspected.
Perforation of the gastrointestinal tract (rare)	Rough handling of the endoscope might lead to perforation of the gastrointestinal tract. Stent placement failure after endoscopic US-guided puncture and route dilation can also result in perforation. A closure device (an over-the-scope clip) is available to close the fistula.
Portobiliary fistula (rare)	A portobiliary fistula can cause direct inflow of bile into the portal vein, leading to septic shock and/or portal vein thrombosis. A venobiliary fistula can cause sepsis due to direct inflow of bile into the systemic circulation and result in hepatic vein occlusion.

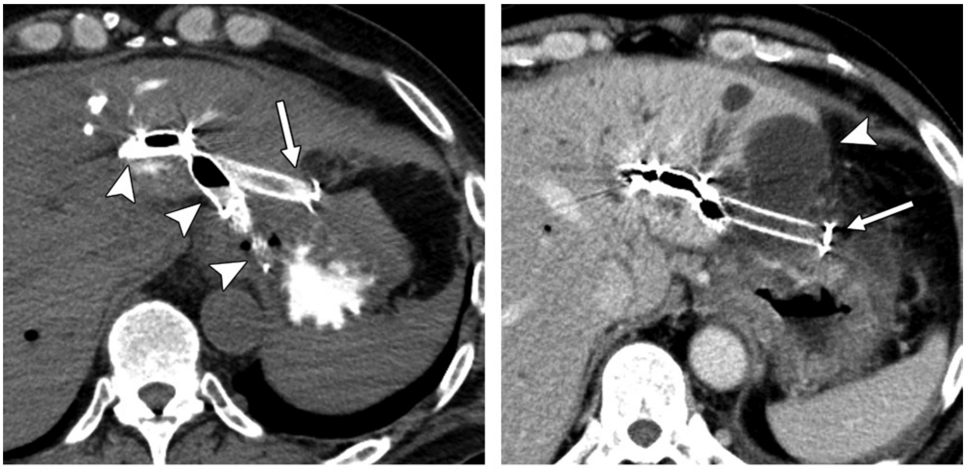
after formation of a complete track between the bile duct and GI tract.

Stent Migration

Stent migration has been reported to occur in 6%–30% of cases after endoscopic US BD (12,13,29,47–50) and may be classified as early (internal) or delayed. After endoscopic US BD, the GI tract and the liver gradually adhere, leading to creation of a track. In early stent migration typically within 1 week, the stent may migrate into the peritoneal cavity as a result of insufficient adhesion of the GI tract to the liver (eg, insufficient track formation). In comparison, delayed stent migration occurs after complete formation of a track between the GI tract and biliary system because of adhesion, and the stent migrates into the GI tract.

Early (Internal) Stent Migration

Migration of the stent into the peritoneal cavity can occur during endoscopic US BD or within the week after the procedure (51,52) and as a



a. b.

Figure 14. Bile leak and early stent migration in a 59-year-old man with extrahepatic bile duct cancer in whom HGS was attempted. **(a)** Axial CT image acquired just after HGS shows that the proximal end of the first stent (arrow) had migrated into the peritoneal cavity. A new stent (arrowheads) was placed via the new HGS route into the bile duct through the body of the migrated stent. The new stent blocked the flow of bile toward the peritoneal cavity in the migrated first stent. **(b)** Axial contrast-enhanced CT image obtained 3 days after HGS reveals a collection of fluid (arrowhead) around the migrated first stent (arrow). Inflammatory factors were elevated and percutaneous drainage was required in this case.

result of technical or anatomic issues (12,51). A stent deployed in the peritoneal cavity leads to persistent flow of bile or leakage of digestive contents into the peritoneal cavity, followed by severe peritonitis, which can be fatal (52). Endoscopic recovery with the use of a covered metallic stent to block the flow of bile into the peritoneal cavity can be attempted and is technically feasible (Fig 14) (13). However, when endoscopic recovery is unsuccessful, surgical removal of the migrated stent and repair of the punctured site are required (12,51).

Delayed Stent Migration

Delayed stent migration occurs when a stent migrates into the GI tract after creation of a track between the GI wall and the biliary system. As long as a complete track is formed, leakage of bile to the peritoneal cavity and biliary peritonitis do not occur. Delayed stent migration can be detected incidentally at imaging or on the basis of clinical symptoms such as recurrent obstructive jaundice and/or cholangitis (Fig 15). A new stent can be inserted endoscopically through a persistent track if the orifice of the track can be found and cannulated successfully before complete occlusion of the track (Fig 16).

Stent Malfunction

Stent malfunction has various causes and leads to obstructive jaundice or cholangitis. Obstruction of the stent is caused by debris or food impaction. Stent exchange is required to recover the function of the stent. The obstructed stent can be withdrawn, and a new one can be placed through the endoscope, if the track between the bile duct and GI tract has been created. Delayed stent migration can also cause symptoms that are similar to stent malfunction. Tumor growth or hyperplasia is another cause of stent malfunction (Fig 17) (17). It can block the distal end (hepatic side) of the stent and can be visualized at cholangiography through the blocked stent. In general, tumor ingrowth does not occur because a covered metallic stent or plastic stent is used in endoscopic US BD.

Arterial Injury or Pseudoaneurysm

Arterial injury or pseudoaneurysm can occur on the needle puncture route under endoscopic US guidance (Fig 18) (45). Bleeding can be concealed because the injured artery is compressed by the placed stent but becomes evident when the stent is withdrawn for stent exchange and the compression is relieved. A dynamic contrast-enhanced CT examination is needed when arterial injury is suspected (45) but is sometimes not diagnostic owing to artifacts from a metallic stent. If the CT examination is not sufficiently diagnostic, angiography followed by transcatheter arterial embolization should be considered (45).

Portobiliary Fistula

The portal vein runs parallel to the bile duct in the liver hilum and parenchyma, so there is a risk of portal vein injury in endoscopic US BD. A portobiliary fistula (ie, communication between the portal vein and the biliary system that is established by means of endoscopic US BD) can cause bile to flow directly into the portal vein (Fig 19). Although portobiliary fistula is a rare complication

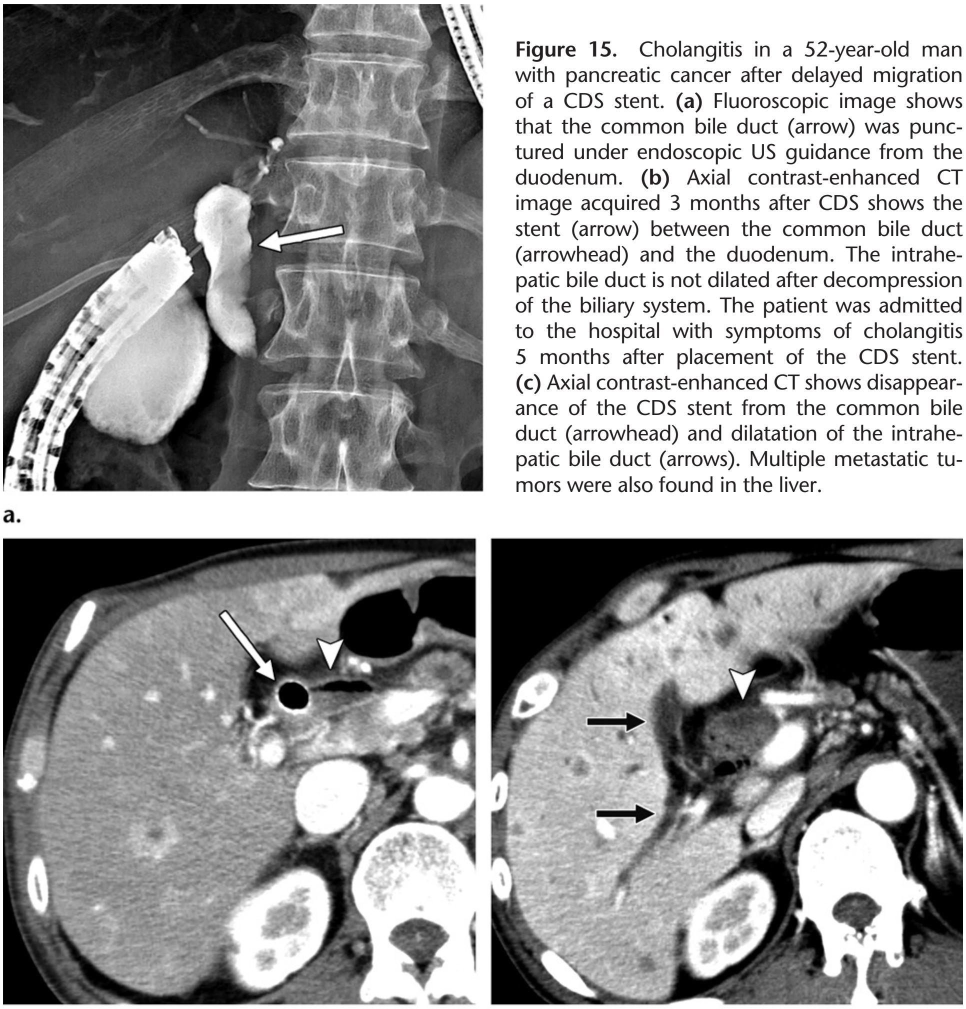
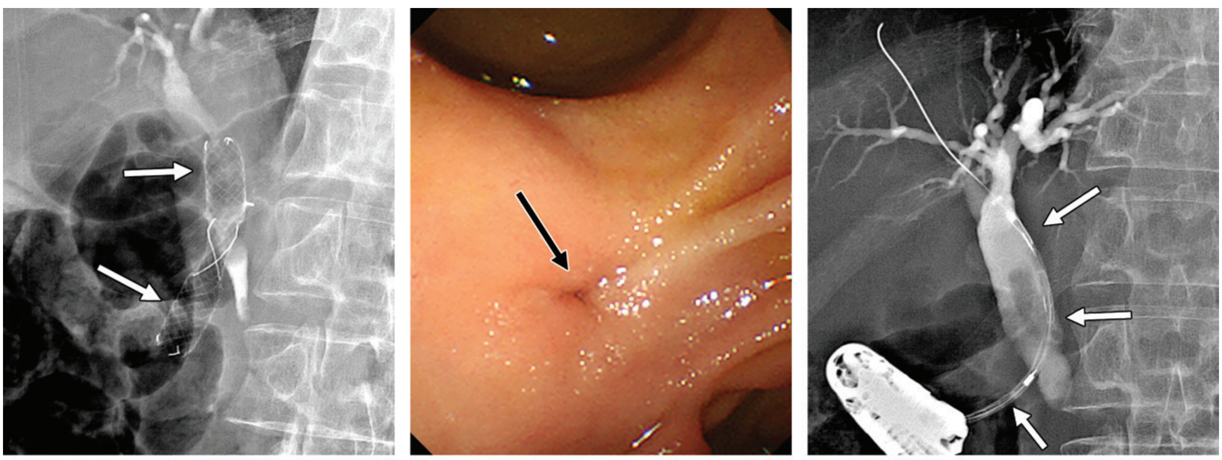


Figure 15. Cholangitis in a 52-year-old man with pancreatic cancer after delayed migration of a CDS stent. **(a)** Fluoroscopic image shows that the common bile duct (arrow) was punctured under endoscopic US guidance from the duodenum. **(b)** Axial contrast-enhanced CT image acquired 3 months after CDS shows the stent (arrow) between the common bile duct (arrowhead) and the duodenum. The intrahepatic bile duct is not dilated after decompression of the biliary system. The patient was admitted to the hospital with symptoms of cholangitis 5 months after placement of the CDS stent. **(c)** Axial contrast-enhanced CT shows disappearance of the CDS stent from the common bile duct (arrowhead) and dilatation of the intrahepatic bile duct (arrows). Multiple metastatic tumors were also found in the liver.

a. b. c.



a. b. c.

Figure 16. Delayed stent migration in a 64-year-old man with pancreatic cancer who developed obstructive jaundice that was treated with CDS. **(a)** Fluoroscopic image obtained just after CDS shows a metallic stent (arrows) between the common bile duct and duodenum. The patient had a recurrence of jaundice 2 months after CDS. **(b)** Endoscopic image shows a residual fistula (arrow) and disappearance of the metallic stent. **(c)** Fluoroscopic image shows that the fistula was successfully cannulated endoscopically, with placement of a new stent (arrows) as the CDS.

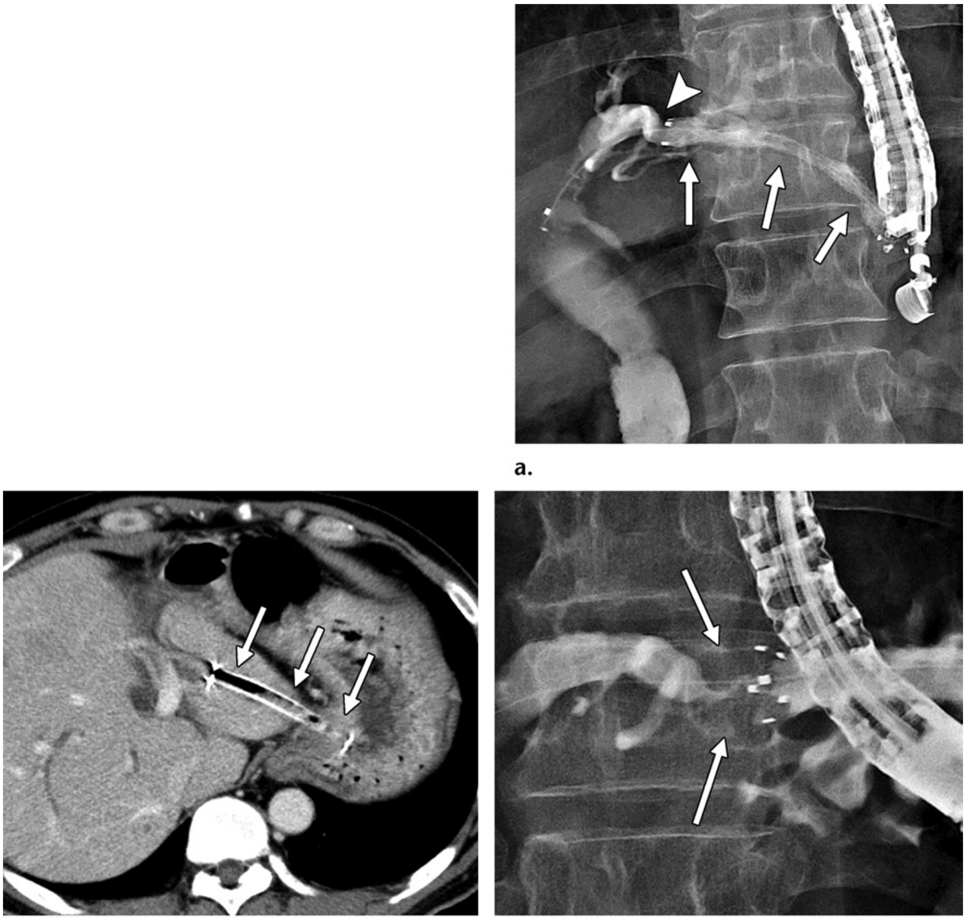


Figure 17. Stent malfunction due to hyperplasia in a 48-year-old man with obstructive jaundice caused by a pancreatic neuroendocrine tumor. **(a)** Fluoroscopic image shows that an intrahepatic bile duct was punctured under endoscopic US guidance from the stomach and an HGS was created with a metallic stent (arrows). There was no stricture between the stent and the intrahepatic bile duct (arrowhead). Obstructive jaundice recurred 12 weeks after HGS. **(b)** Axial contrast-enhanced CT image acquired at 12 weeks shows a metallic stent (arrows) between the intrahepatic bile duct in the lateral segment of the liver and the stomach. The intrahepatic bile duct was slightly dilated and no intrahepatic tumor was found. **(c)** Cholangiogram acquired endoscopically through the HGS route shows stenosis (arrows) adjacent to the distal end of the stent. This finding indicates stent malfunction caused by hyperplasia.

of endoscopic US BD, severe sepsis and thrombotic occlusion of the portal vein can occur.

Conclusion

Endoscopic US BD is a technique that can be used when conventional endoscopic transpapillary BD has been unsuccessful. Radiologic evaluation before endoscopic US BD is important to determine the type of endoscopic US BD to use and to estimate the risk of complications. Given that there are specific subclinical radiologic findings after endoscopic US BD and complications that are not found with conventional endoscopic BD, radiologists should be aware of these potential findings to detect abnormalities that require additional intervention.

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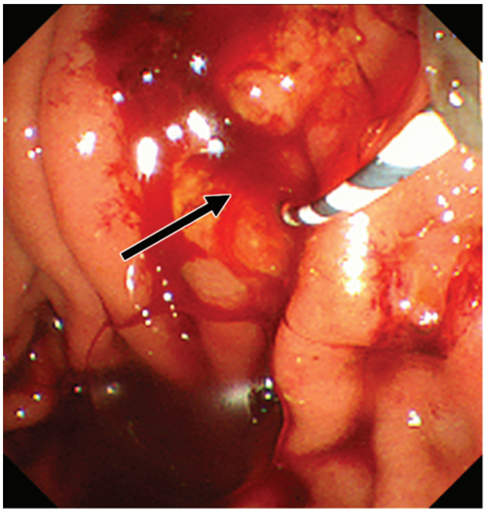
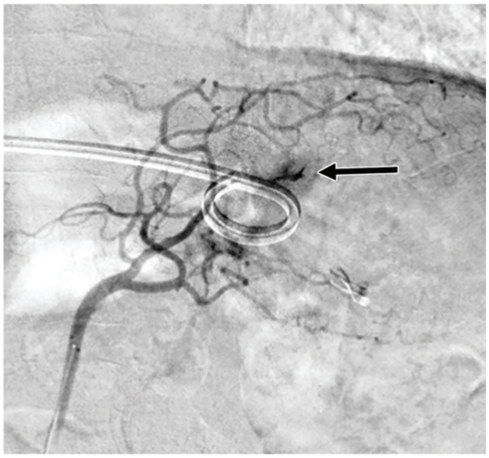


Figure 18. Arterial injury as a complication of endoscopic US–guided BD in a 48-year-old man with a pancreatic neuroendocrine tumor. An HGS had been created with a covered metallic stent 3 months earlier. The stent subsequently became obstructed and was exchanged for a plastic stent. **(a)** Endoscopic image shows bleeding (arrow) from the fistula when the obstructed covered metallic stent was withdrawn. **(b)** Axial contrast-enhanced CT image obtained after placement of the plastic stent (dashed arrow) reveals a small pseudoaneurysm (solid arrow) in the gastric wall adjacent to the fistula created by the HGS, the plastic stent, and active bleeding (arrowhead). **(c)** Selective angiogram of the left gastric artery shows extravasation of contrast agent (arrow). The injured artery was embolized with the use of n-butyl-2-cianoacrylate (NBCA).

a.

b.



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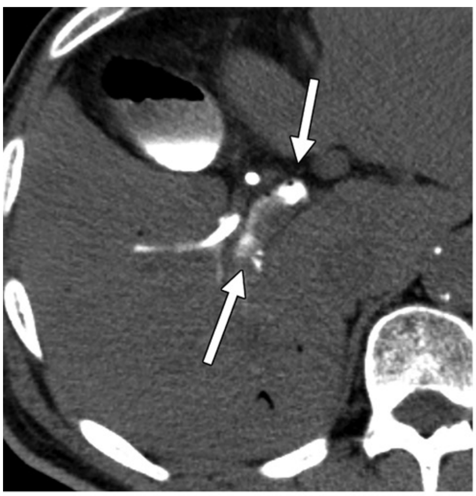

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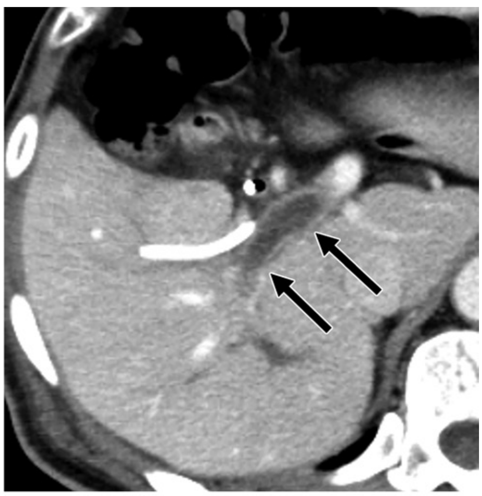

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Figure 19. Portobiliary fistula in a 68-year-old man with pancreatic cancer who underwent CDS. **(a)** Axial nonenhanced CT image obtained just after placement of a plastic stent shows contrast material (arrows) in the portal vein. A portobiliary fistula was suspected. **(b)** Axial contrast-enhanced CT image obtained 3 days after CDS reveals thrombotic occlusion of the right portal vein (arrows).

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