Spectrum of imaging findings of obstructive jaundice: A pictorial essay

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Learning objectives

The purpose of this educational exhibit is to list the clinical features of various pathologies of biliary dilatation, review the main causes of biliary dilatation and describe the spectrum of radiological findings of obstructive jaundice.

Background

In considering bile duct disease, the initial task is to establish whether jaundice is secondary to nonobstructive or obstructive causes. Clinical evaluation, including blood tests, makes this distinction in a majority of patients. The causes of nonobstructive jaundice range from diffuse liver disease, such as cancer, cirrhosis, and inflammation, to a congenital or metabolic condition. Obstructive jaundice is defined as “surgical” jaundice, i.e., obstruction at the major intra-hepatic or extra-hepatic duct level, and the probability of interventional is high. The most common causes of ductal dilatation are gallstones in the common bile duct and pancreatic cancer in the head of the pancreas. Less common causes include ductal carcinoma, benign stricture of the common duct, pancreatitis or pancreatic pseudocyst, and sclerosing cholangitis, among others. Once biliary obstruction is suspected, the etiology is best approached by subdividing patients by age and site of obstruction (Table 1). Thus a differential diagnosis can be narrowed down considerably by combining the clinical and imaging findings.

Table 1

<p>| Intrahepatic biliary obstruction | Porta hepatis biliary obstruction | Suprapancreatic biliary obstruction | Intrapancreatic sites (including ampullary) |</p>
<table>
<thead>
<tr>
<th>Primary sclerosing cholangitis</th>
<th>Cholangiocarcinoma</th>
<th>Pancreatic carcinoma</th>
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<td>Primary sclerosing cholangitis</td>
<td>Metastatic disease</td>
<td>Pancreatidis</td>
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<td>Gallbladder carcinoma</td>
<td>Pancreatidis</td>
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<td>Ampullary stenosis</td>
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<td>Cholangiocarcinoma</td>
<td>Ampullary or duodenal carcinoma</td>
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<td>Cholangiocarcinoma</td>
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**Imaging findings OR Procedure details**

Ultrasound (US) and Computed Tomography (CT) can demonstrate the level and the extent of an obstructing lesion, and can define its nature. Sonography is usually the preferred screening study because of its availability, relatively low cost and lack of radiation hazard. Magnetic resonance (MR) imaging can be a valuable complement to US and CT.

US is an essential first-line investigation in suspected gallbladder and biliary duct disease. It is usually performed using the highest-frequency transducer at 3.5 MHz in obese patients and 5 MHz in thin patients.

On CT, bile ducts appear as water-dense tubular branching structures converging at the porta hepatis. The common hepatic duct and the common biliary ducts have a similar shape, and are generally visible within the hepatoduodenal ligament. The distal common biliary duct appears on cross-section as a circular, low-density structure in the pancreatic head. The normal hepatic duct on CT scans is 3-6mm in diameter, and the common bile duct is 6-7 mm in diameter. Dilatation of the biliary tree was defined as larger than 7mm in maximal diameter in patients without history of cholecystectomy who were younger than 60 years, 9mm in patients without prior cholecystectomy who were 60 years or older, and 10mm in patients with prior cholecystectomy.

MR imaging has become more useful for biliary system imaging since the introduction of fast imaging strategies, gradient echo sequences, fast spin-echo sequences, and half-Fourier acquisition single-shot sequences (HASTE). MR-cholangiopancreatography (MRCP) in association with morphologic imaging using T1- and T2-weighted sequences has emerged as an accurate, non-invasive alternative to
diagnostic endoscopic retrograde cholangiography (ERC) for the evaluation of diseases of the biliary tract.

MRCP is performed using heavily T2-weighted sequences that depict the hyperintense fluid contained within the bile ducts with high signal intensity, whereas suppression of the signal of surrounding, non-fluid containing structures is achieved due to the long echo-time. MR images are acquired in the coronal and axial planes, typically with the use of a phase-array imaging coil to increase overall accuracy.

Key to achieving the proper diagnosis with a dilated bile duct is evaluating the zone of transition from dilated to nondilated or nonvisualized duct. Special attention should be paid to this region, regardless of imaging modality. During an US examination, real-time US should scrutinize the transition zone carefully in all planes. Abrupt termination of the bile duct is a cholangiographic sign that has a high correlation with malignancy, whereas a gradually tapering duct correlates with benign processes. These features can be visualized through cholangiographic images or with correlation with sequential axial images. At the zone of transition, one should obtain thin-section (2.5-5mm) CT or MR images at close intervals (2.5-5mm, with overlapping reconstruction at 1.25-2.5mm intervals for optimal multiformatted images) to look for changes in the duct wall or within the duct lumen that may aid in diagnosis. Diffuse concentric thickening of the duct wall is found in cholangitis. Focal concentric thickening in the distal CBD is a nonspecific finding that can alert the radiologist to the presence of duct stones, pancreatitis, or pancreatic carcinoma. Focal eccentric thickening of the duct just proximal to obstruction is a sign suggestive of cholangiocarcinoma. Examples of all of these are provided in the imaging sections that follow.

**Traumatic evaluation**

Iatrogenic strictures are common postoperative complications in the biliary tract. These can be caused from clamp injury, inclusion of a portion of the duct in a surgical ligature, local duct ischemia caused by dissection around the duct with injury to arterial supply, inflammation resulting from bile leakage, trauma to the duct from instrumentation during duct exploration, or anastomotic strictures. These short segment strictures are usually visualized at CT, ultrasound, or MR due to the proximal duct dilatation with gradual tapering of the duct diameter. Biliary dilatation may be mild or absent if a coexistent bile leak decompresses the proximal biliary tree. The lack of a surrounding soft-tissue mass to suggest tumor or inflammation can suggest the diagnosis, given the appropriate clinical history.
Bismuth classification of traumatic bile duct injuries. In type 1, >2cm of hepatic duct is intact; in type 2, <2 cm remains; in type 3, little viable hepatic duct is available; and in type 4, the main right and left lobe ducts are involved.

Fig.: 1

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
A 57-years-old woman with benign stenosis after iatrogenic lesion during cholecystectomy. US images (A,B) show mild biliary dilatation (arrowhead) and common bile duct (CBD) (white arrow). MR confirmed short segment strictures (black arrow) of the distal CBD with proximal duct dilatation.

Fig.: 2

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
Stricture of the biliary-enteric hepaticojejunal anastomosis in a 43-year-old woman with history of iatrogenic lesion of the common bile duct during cholecystectomy. US (A,B) and MR (C-G) images showing a short anastomotic stricture (white arrows) of hepaticojejunostomy and secondary dilatation of the intrahepatic bile ducts (black arrows). Jejunum (asterisk).

Fig.: 3

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL

Benign hepatic cyst in the hepatic confluence
The etiology of **choledochal cysts** is unknown. In 1959, Alonso-Lej et al. classified choledochal cysts into three types: I, fusiform dilation of a portion or entire extrahepatic bile duct system; II, saccular diverticular-like outpouching in extrahepatic ducts; and III, focal dilation of distal common bile duct segment (or common pancreatobiliary channel) within the wall of the duodenum. Type III is also called a choledochocele. Todani et al. expanded this system in 1977 to better reflect a surgical approach. The Todani modification subdivides type I cysts into Ia, aneurysmal dilation; Ib, segmental dilation; and Ic, diffuse, cylindrical dilation; and also includes type IV cysts: IVa, multiple intra- and extrahepatic duct cysts; and IVb, multiple extrahepatic cysts only. Also added was a type V: single or multiple intrahepatic duct cysts.
Fig.: 5

A 17-year-old boy with type IC choledochal cyst involving hepatic duct. Unenhanced axial CT images (A,B) show well-defined, round, hyperdense intraductal structures (black arrow) that correspond to stone within dilated CBD. RM (C-F), after removed of calculi with endoscopic ERCP, demonstrated the choledochal cyst appears as a fusiform, markedly hyperintense structure (asterisk), with reduction in calibre (red arrow) just above the union with the Wirsung duct and the ductal dilatation that involves the left and right hepatic ducts (white arrow).

**Fig.: 6**

**References:** S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
Stones in the ducts

Probably the most common biliary tract disease is duct stones, which occur in 8% to 20% of patients undergoing cholecystectomy and 2% to 4% of patients after cholecystectomy. Small calculi may intermittently cause colicky pain as they obstruct at the ampulla of Vater, but generally pass into the duodenum. Larger stones 5 to 10mm are difficult to pass and can result in intermittent long-term obstructive symptoms and sequelae, such as cholangitis and sepsis. Detecting stones in the ducts is easiest when biliary dilatation is also present. Unfortunately, because biliary dilatation is present in only about two-thirds to three-fourths of patients, it can be difficult to image stones in many patients.
Intrahepatic lithiasis in a 31-year-old man with recurrent upper abdominal pain and vomiting. US images (A,B) show dilated intrahepatic ducts of the left lobe and CBD, and multiple calculi (arrow). CT scanning demonstrates dilation of the intrahepatic bile ducts in the left lobe (arrowhead, C). RM images (D-G) show multiple intraluminal filling defects (arrows) in the left hepatic duct, corresponding to multiple small stones and causing dilatation.

Fig.: 8
References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
Choledocholithiasis in a 79-year-old man with a 1 week history of jaundice, pruritus, vomiting, and abdominal pain. US (A-C) and contrast enhanced CT (CECT, D-E) images show a large stone in the distal CBD (arrows) with secondary bile duct dilatation (asterisk).

Fig.: 9

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
Mirizzi syndrome is produced by a gallstone impacting either in the neck of the gallbladder or within the cystic duct and secondarily obstructing the hepatic duct. The initial classification of a gallstone either simply compressing adjacent bile ducts as part of an acute episode or a cholecystocholedochal fistula forming on a chronic basis was subsequently expanded to include:

Type I: hepatic duct stenosis due to a stone impacting in the cystic duct or gallbladder neck. This is the most common.

Type II: hepatic duct fistula due to a stone impacting in the cystic duct or gallbladder neck.

Type III: hepatic duct stenosis due to a stone at the duct confluence.

Type IV: hepatic duct stenosis as a complication of cholecystitis and no impacted calculus.

**Fig.:** 10

**References:** S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
One of the more common causes of biliary obstruction is extrinsic disease—benign and malignant. Pancreatic carcinoma commonly obstructs the distal CBD, and jaundice is often the first sign of the tumor. As with the primary biliary tract tumors described above, the characteristic finding at CT, US, or MR is that of abnormal dilatation of the extrahepatic bile duct to the level of the tumor. Abrupt termination of the bile duct with a short transition from dilated to nonvisualization is characteristic. Small pancreatic carcinomas, although not always apparent at imaging, may be critically placed to cause obstruction. The use of CT and MR contrast techniques that optimize pancreatic parenchymal enhancement during the late arterial phase can be an aid in visualizing small tumors. Chronic pancreatitis often creates mass effect surrounding the distal CBD with biliary obstruction. Calcifications within the head of the pancreas, associated with chronic pancreatitis, can aid in distinguishing chronic inflammation from pancreatic adenocarcinoma. Pancreatic carcinoma can occur within chronic pancreatitis, however,
making differentiation difficult. The changes that are caused by chronic pancreatitis on the biliary tree are usually different from those caused by pancreatic carcinoma. Rather than the mass causing abrupt termination of the bile duct with a short transition zone, it is more common for chronic pancreatitis to cause gradual narrowing of the duct with a longer, tapered transition zone when imaged at CT, ultrasound, or MR. These are only guidelines, however, because severe cases of pancreatitis can occasionally cause a focal mass with abrupt termination of the bile duct.

Fig.: 12

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
A 45-year-old man with chronic pancreatitis with complaints of upper quadrant abdominal pain and jaundice. US (A-C) and unenhanced CT (D-F) images demonstrated pseudocyst (asterisk) in the head of pancreas, conditioning compression of distal CBD and mild biliary dilatation (arrows). RM (G-I) realized 1 month later demonstrated decrease of the pseudocyst and no signs of biliary dilatation.

**Fig.:** 13

**References:** S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL

**Villous adenoma** in the second portion of the duodenum
Tumors of the bile ducts

Cholangiocarcinoma
The most common tumor of the bile ducts is cholangiocarcinoma. Many cases are associated with predisposing conditions such as PSC, liver fluke disease, choledochal cysts, and thorium dioxide (Thorotrast) exposure. Cholangiocarcinomas generally can be classified as (1) intrahepatic (peripheral) lesions; (2) hilar lesions occurring just past the confluence of the right and left hepatic ducts, commonly referred to as "Klatskin" tumors; and (3) distal ductal tumors. Cholangiocarcinomas also may occur in locations in between these general locations. Understanding the pathologic basis for these tumors is essential to understanding their imaging appearances. Morphologic tumor types seen are most commonly scirrhous infiltrating neoplasms causing duct stricture of the larger ducts; exophytic bulky masses (most commonly in the intrahepatic peripheral location); and, rarely, polypoid intraluminal ductal lesions (most commonly seen distally in the duct). The tumor stroma is composed of two major elements that affect imaging-fibrous tissue
and mucin-producing glandular tumor, which, as we will see, dramatically impacts the CT and MR imaging appearances.

**Fig.**: 15


**Intrahepatic cholangiocellular carcinoma**

About 20% to 30% of cholangiocarcinomas are peripheral intrahepatic masses. These masses often appear similar to metastases, and can easily be misdiagnosed as adenocarcinoma metastases of unknown primary. Sonographically these masses may have mixed echogenicity, or predominantly hypoechogenicity or hyperechogenicity, depending on the predominant underlying stroma, fibrous tissues versus mucin-producing glandular material.

CT and MR appearances are often nonspecific. The tumors are of lesser attenuation than liver on unenhanced CT and have a variable enhancement pattern: usually not strongly enhancing during arterial phases of enhancement, but showing patchy and usually peripheral enhancement that may start mildly during the arterial contrast phase and become more prominent during the portal venous phase.
Hilar cholangiocarcinoma

The most common location for cholangiocarcinoma is either at the confluence of the right and left hepatic ducts, or at the proximal CHD, and has been termed a “Klatskin tumor.” These tumors can be small and difficult to visualize early at imaging. Hilar cholangiocarcinoma can usually be differentiated from adjacent adenopathy or extrinsic masses causing biliary obstruction due to the latter causing compression and displacement of the duct. Occasionally large masses can envelope the biliary tree, in which case the site of origin may be difficult to determine.
Hilar cholangiocarcinoma with periductal infiltration type in a 87-year-old man, complaining of jaundice, colic upper abdominal pain, and anorexia. US (A-C) and CECT (D,H) reveals severe intrahepatic biliary dilatation (white arrows) without dilatation of CBD (arrowhead). MR images (E-G) documents the level of stenosis at the hepatic confluence, corresponding to Klatskin tumour, grade II of Bismuth classification. The biopsy of the mass proved it to be cholangiocarcinoma and external biliary drainage was performed.

**Fig.**: 17

**References**: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL

**Distal duct cholangiocarcinoma**
The least common location for cholangiocarcinoma is in the distal duct. When cholangiocarcinoma is scirrhous and compressing the duct, it is virtually indistinguishable at imaging from small pancreatic carcinoma. These lesions have a better prognosis than the more proximal hilar tumors and pancreatic carcinoma, and thus the differentiation is important clinically. Although papillary cholangiocarcinoma is uncommon, when present it occurs more often distally Such papillary lesions can be seen best with US, which, by virtue of its real-time acquisition of images and multiplanar capabilities, can best demonstrate the surrounding bile around the mass. Small masses of the distal CBD are extremely difficult to visualize with ultrasound, CT, or MR and cannot be differentiated from critically placed pancreatic or ampullary carcinoma. The use of multiplanar reformatted images can be helpful to denote an extrinsic location of a distal obstructing mass.
Most extrinsic tumors displace the biliary tree, or occasionally will encircle it, narrowing the duct lumen and causing obstruction. The classic tumor narrowing the bile duct in this way is pancreatic carcinoma. Extension of gallbladder carcinoma through the hepatic hilum can entrap and narrow the bile duct. Other less common tumors with extension include duodenal and gastric tumors. In rare occasions, lymphoma can encircle the bile duct and, similar to its effect in the intestinal tract, has a propensity initially to encircle the duct with minimal obstructive effects. Intrahepatic metastatic disease may displace the biliary tree, but rarely directly invades the biliary system. Primary hepatocellular carcinoma (HCC), however, which has a propensity to invade hepatic vessels, also may invade the biliary tree. It is important to differentiate HCC invading the biliary tree from a primary biliary tumor with liver metastases, because treatments for these tumors are quite different.
A 64-year-old man with obstructive jaundice. A dilated common bile duct ends at the papilla (arrow). No tumor was identified either with US (A-C), CT (D-F) or MRI (G-J) study. Note gastric wall thickening (asterisk). Dilated bile ducts secondary to invasion into ampullary region from gastric carcinoma, was confirmed at surgery.

**Fig.**: 19

**References**: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
A 77-year-old woman with ampullary carcinoma of the nodular mass type. T2WI (A,B) show a heterogeneous mass protruding into the duodenum (arrow). Contrast-enhanced RM images (C,D) show marked enhance of mass there is a suggestion of a faint enhancing mass (white arrow) at the ampulla. Note moderated biliary duct and CBD dilatation (E, black arrow).

**Fig.:** 20

**References:** S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
85-year-old man with adenocarcinoma of ascending colon. Axial CT images showing portal vein (asterisk) with invasion by metastatic disease and mild dilated bile ducts (arrows).

Fig.: 21

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
A 63-year-old woman with adenocarcinoma in the pancreatic head. US (A,B) and RM (C-G) images revealed dilated pancreatic and biliary ducts, and CBD (arrows) caused by a 3,5 cm carcinoma (asterisk) in the pancreatic head.

*Fig.: 22*

*References:* S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
A 76-year-old woman who had upper abdominal pain, significant weight loss, anorexia, jaundice and pruritus at presentation. US (A-D) and CECT (E-G) images shows distal CBD obstruction (black arrows) secondary to metastatic gallbladder carcinoma (arrows). RM images (H-L) confirmed moderate narrowing of the distal CBD (white arrows) due to infiltration of gallbladder carcinoma (asterisk).

Fig.: 23

References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL

Conclusion

A variety of modalities are used to evaluate hepatobiliary diseases.
An understanding of underlying biliary pathology and the corresponding subtle changes reflected at imaging can greatly improve imaging accuracy in evaluating the biliary tract. The optimal demonstration of biliary tract imaging findings requires attention to specific imaging and contrast techniques, regardless of the modality used. The radiologist can have a fundamental role, providing a systematic approach to the work-up of jaundice, facilitating prompt treatment.

CONCLUSION

• A variety of modalities are used to evaluate hepatobiliary diseases.

• The radiologist can have a fundamental role, providing a systematic approach to the work-up of jaundice, facilitating prompt treatment.

Fig.
References: S. Kurochka; Radiology, Hospital São Marcos, Braga, PORTUGAL
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