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# Clinics in Diagnostic Imaging (79)

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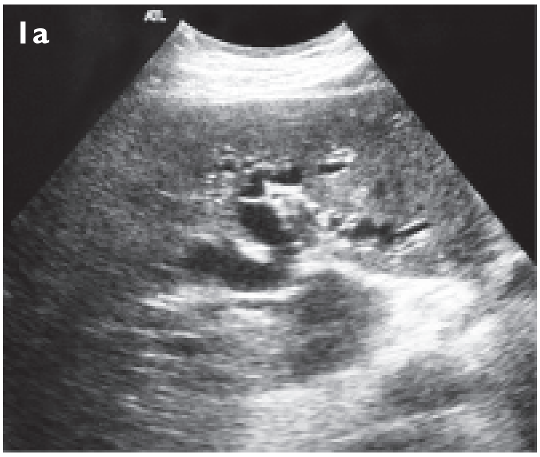


**Fig. 1a** Subcostal US scan taken at the porta hepatis.

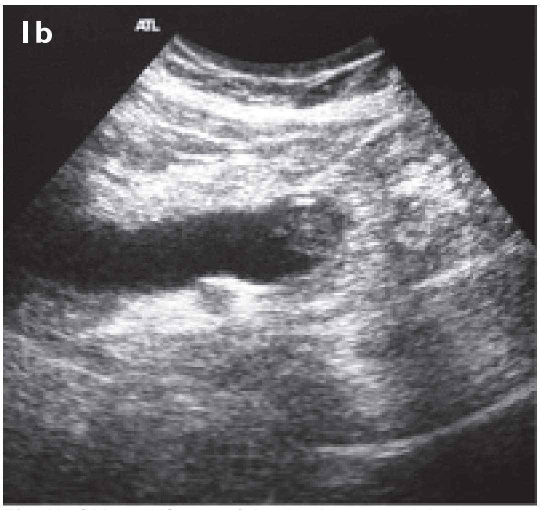


**Fig. 1b** Oblique US scan of the distal common bile duct.

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## CASE PRESENTATION

A 58-year-old man presented with jaundice and passage of deep yellow urine for two weeks. He had no fever nor abdominal pain. Two years ago, he had a cholecystectomy and common bile duct (CBD) exploration performed at another hospital. There was no CBD stone demonstrated then. Physical examination showed jaundice. There was no hepatosplenomegaly. Laboratory investigations revealed a serum haemoglobin level of 11.9 g/dL, and a leukocyte count of 6.5 x $10^3$/dL with 84% neutrophils, 13% lymphocytes, and 3% monocytes. The liver function test showed increased serum bilirubin level (total bilirubin 28.46 mg/dL and direct bilirubin 11.22 mg/dL), total protein of 7.8 gm/dL with albumin level of 4.9 gm/dL and globulin level of 2.9 gm/dL, cholesterol level of 257 mg/dL, ALT of 34 U/L, AST of 72 U/L and alkaline phosphatase level of 429 U/L. Ultrasonography (US) of the upper abdomen was done (Figs. 1a,b) to identify the cause of jaundice. What does US show?

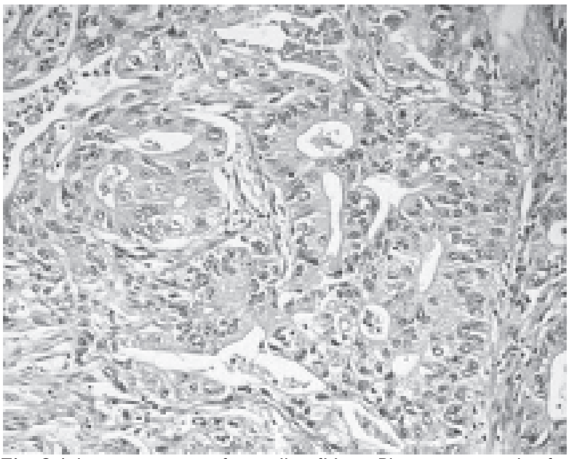

**Fig. 2** Adenocarcinoma of ampulla of Vater. Photomicrograph of a section taken from the ampulla of Vater shows tumour cells forming a glandular pattern with stratification, high pleomorphism and hyperchromatic nuclei (H&E stain, x400 magnification).

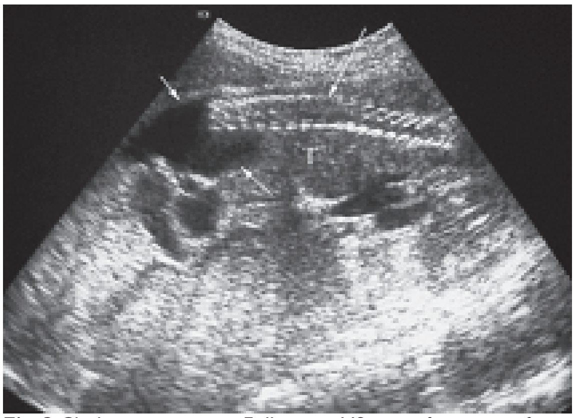

**Fig. 3** Cholangiocarcinoma. Follow- up US scan of a patient after a stent placement due to CBD cholangiocarcinoma shows tumour growth within the CBD (T) and the stent lumen (long arrow) causing proximal bile duct dilatation (short arrows).


**Fig. 4** Cholangiocarcinoma. Enhanced axial CT scan shows a low density mass (arrows) in the right lobe of the liver with bile duct dilatation in the periphery of the mass (arrowheads).

## IMAGE INTERPRETATION

US (Figs. 1a,b) show dilatation of both the intrahepatic and the common bile ducts. There is an echogenic mass without acoustic shadow at the distal common bile duct.

## DIAGNOSIS

Ampulla of Vater carcinoma.

## CLINICAL COURSE

Endoscopic retrograde cholangiography (ERCP) showed a markedly-enlarged papilla with ulceration and bleeding. Cannulation of the ampulla was not successful. Biopsy of the papillary surface showed adenocarcinoma. The patient underwent a Whipple's operation. The gross specimen showed a 1 x 2 cm ulcerative lesion around the ampulla of Vater extending into the common bile duct and causing obstruction of the bile duct. Histology revealed a poorly-differentiated adenocarcinoma of ampulla of Vater invading the duodenal wall and common bile duct (Fig. 2). The patient had upper gastrointestinal haemorrhage on the $5^{th}$ post-operative day that responded to conservative treatment. He developed fever on the $7^{th}$ post-operative day and was found later to have intra-abdominal abscesses. Antibiotics were given for two weeks, with reduction in size of the abscesses on follow-up imaging. He improved and was subsequently discharged.

## DISCUSSION

Imaging plays an important role to identify the cause of jaundice as it allows visualisation of bile duct dilatation. If there is no bile duct dilatation, the patients may undergo liver biopsy or ERCP, depending on the clinical suspicion. If imaging shows bile duct dilatation, mechanical obstruction is suggested. Most imaging studies are able to show the level of bile duct obstruction and demonstrate the cause of obstruction. Treatment options depend on the cause and the level of obstruction. ERCP, percutaneous biliary intervention and surgery are among the treatment options. Various imaging techniques such as US, radionuclide imaging, computed tomography (CT), CT cholangiography, magnetic resonance (MR) imaging, MR cholangiopancreaticography (MRCP), percutaneous transhepatic cholangiography (PTC) and ERCP may be used to diagnose biliary obstruction in clinical practice.

US is usually the initial investigation in those patients suspected of obstructive jaundice and can be used for follow-up imaging after treatment (Fig. 3). It is non-invasive, lacks radiation exposure and widely available. Its sensitivity and accuracy are high[1], although it is dependent on the operator's experience. Limitations of US are poor visualisation of the bile duct in pneumobilia, obscuration of the extrahepatic bile duct by bowel gas, decreased resolution in thick patients, and difficulty in applying the US probe in post-operative patients. The upper limit for the normal common bile duct diameter on US is 8 mm in patients under 70 years old who have never had cholecystectomy[2]. A dilated intrahepatic bile duct

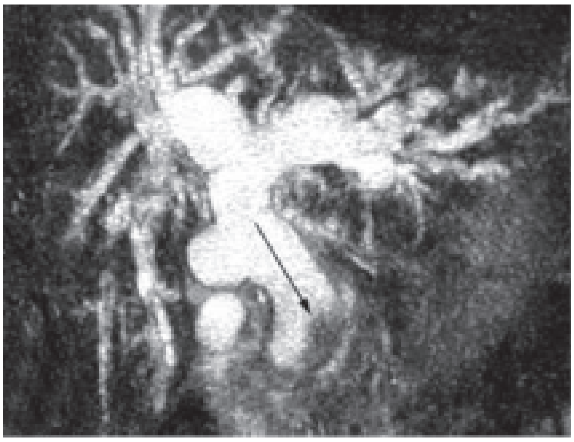

**Fig. 5a** MRCP of a patient with cholangiocarcinoma shows high signal intensity of the dilated intrahepatic bile ducts and irregular narrowing at the distal CBD caused by the tumour (arrow).

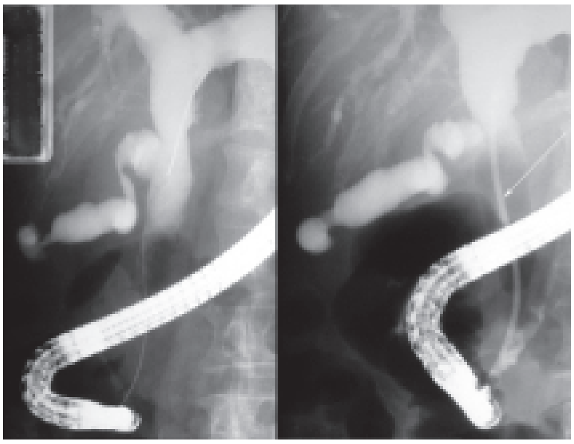

**Fig. 5b** ERCP of the same patient shows bile duct dilatation corresponding to the MRCP finding. Biliary stent was placed in the CBD (arrow).

is seen as a linear branching anechoic structure parallel to the portal vein, measuring more than 2 mm or exceeding 40% of adjacent portal vein diameter[1]. Colour Doppler US can help distinguish between a dilated bile duct and an enlarged hepatic artery. In patients where US cannot identify the cause of bile duct obstruction, CT or MR imaging should be used for further investigation.

In the majority of cases, CT scan can clearly depict the dilated bile duct and the cause of obstruction, such as choledocholithiasis, cholangiocarcinoma (Fig. 4) and periampullary carcinoma or extraluminal mass compressing on bile duct. In cases of malignancy, CT can define the extent of tumour and is useful in staging the disease. CT is also better than US in evaluation of the biliary system in cases of pneumobilia or haemobilia[1]. CT cholangiography, using spiral CT with oral or intravenous (IV) cholangiographic contrast agents to opacify the biliary system, allows good visualisation of the bile duct. CT cholangiography has been found to be as reliable as direct cholangiography in visualisation of biliary anatomy, anatomical variants and choledocholithiasis[3]. It also has similar sensitivity to MRCP and has a higher sensitivity than unenhanced spiral CT and US in detecting bile duct stones[3,4]. Although non-invasive, CT and CT cholangiography give a relatively high dose of radiation to patients. IV or oral contrast agents are usually required, and its usage in the patients who are allergic is limited. Furthermore, patients who have impaired hepatic function, high serum bilirubin (>3-5 mg/dl)[3,4], impaired renal function or hyperuricemia are not suitable for CT cholangiography.

The high rate of severe reaction to the IV cholangiographic agents limited its usage in the past but the toxicity is now much decreased with utilisation of newer cholangiographic contrast agents administered by oral or by slow IV infusion (within 40-60 min). The adverse reaction rates from the newer cholangiographic contrast agents range between less than 1% to 10%[4,5]. Adverse effects include rash, itching, nausea, vomiting, epigastric pain and diarrhoea. These symptoms are mild and most are self limited. Although the cholangiographic contrast agents have not yet been approved by the Food and Drug Administration in the United States, CT cholangiography has been accepted by many institutions in other countries as an excellent non-invasive technique for investigating the bile duct. There are some studies that try to use spiral CT for detecting choledocholithiasis without using any intravenous or oral contrast agents but the reported sensitivity and specificity are not as high as oral contrast-enhanced CT cholangiography and MRCP[4,6].

MR imaging can demonstrate dilated bile ducts, the tumour causing bile duct dilatation, as well as the tumour extent. Newer techniques such as MRCP give excellent visualisation of the bile duct and the cause of obstruction, including stone, tumour and stricture, without the need for IV or oral contrast agents[7]. It is non-invasive, has no radiation hazard, and has short scanning time. On MRCP, the bile ducts appear as branching structures of bright signal intensity (Fig. 5a). Disadvantages of the MR imaging and MRCP are that these modalities are not widely available, expensive, and cannot be done in claustrophobic patients or patients with aneurysm clips or cardiac pacemakers. Patient motion may also degrade the image quality.

ERCP is generally used in distal common bile duct obstruction. This technique gives direct visualisation of the bile duct and the cause of obstruction. Treatment such as stone removal, sphincterotomy or stent placement (Fig. 5b) can be

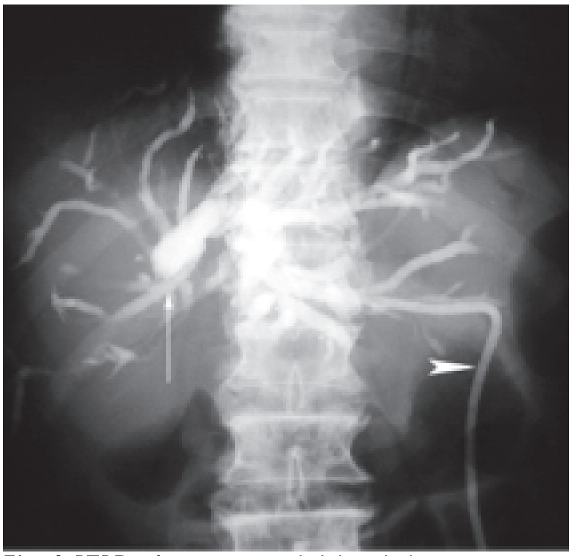

**Fig. 6** PTBD of a patient with hilar cholangiocarcinoma. Cholangiogram shows dilatation of intrahepatic bile ducts in both lobes of the liver with obstruction at the confluence of right and left hepatic ducts (arrow). The indwelling catheter is in the dilated left hepatic bile duct (arrowhead).

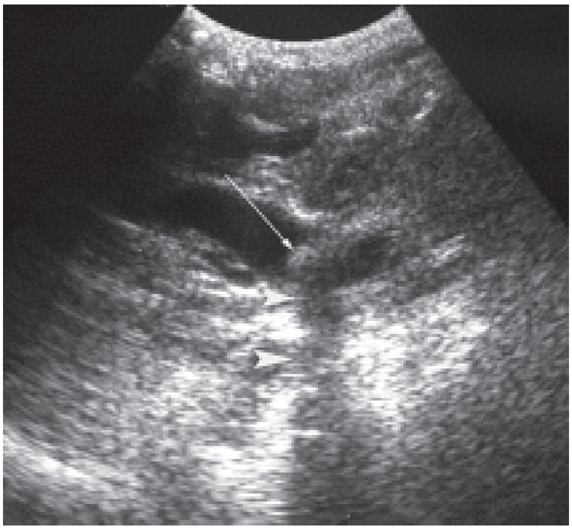

**Fig. 7** Distal CBD stone. Oblique US scan of the distal common bile duct shows CBD dilatation and an intraluminal echogenic mass (arrow) with acoustic shadowing (arrowheads) posterior to the mass. This is the typical appearance of a stone.

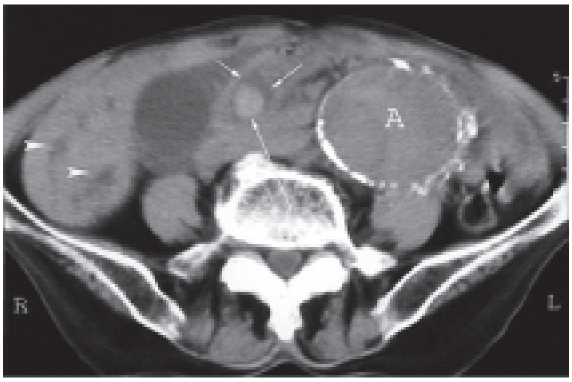


**Fig. 8** Choledocholithiasis. Unenhanced axial CT scan shows a high attenuation (calcified) stone (long arrow) surrounded by low attenuation bile within the distal common bile duct (short arrows). Intrahepatic bile duct dilatation (arrowheads) is also seen. This patient also has an intra-abdominal aortic aneurysm (A).

**Table I. Common causes of obstructive jaundice.**

| Site of obstruction | Causes |
|---|---|
| Intrahepatic | Intrahepatic tumours, Caroli disease, cholangitis, haemobilia |
| Extrahepatic | |
| 1. Distal CBD | Choledocholithiasis, periampullary tumours, stricture |
| 2. Suprapancreatic level | Cholangiocarcinoma, metastatic lymph node |
| 3. Porta hepatic level | Cholangiocarcinoma, spread from gallbladder carcinoma or hepatic tumours, surgical stricture |

performed at the same time as when diagnosis is made. It is relatively safe and has a high success rate in experienced hands[1]. ERCP can demonstrate intrahepatic bile duct irregularity, such as in cholangitis, with more detail compared to the CT cholangiography[8]. The papilla may not be successfully cannulated in some cases of papillary obstruction but biopsy can be done at the suspected region, as in our current case. In cases of proximal bile duct obstruction, the proximal duct may not be adequately opacified. PTC, CT cholangiography and MRCP are better than ERCP for visualising the proximal bile duct[7,8]. As ERCP is an invasive procedure, it should not be done in cases of acute pancreatitis. Complications include pancreatitis, cholangitis, haemorrhage and duodenal perforation[3,9].

PTC is more invasive than ERCP but better demonstrates proximal bile duct dilatation. Therapeutic interventions such as percutaneous transhepatic biliary drainage (PTBD) (Fig. 6) or stent placement can be performed at the same time. Infection, bleeding and bile leak are complications of PTC and PTBD. Patients who have coagulopathy, ascites or cholangitis should not be investigated with PTC. Radionuclide imaging is rarely used currently because of poor anatomical detail and lack of therapeutic options.

Obstruction of the bile duct may be classified into intrahepatic and extrahepatic types (Table I). Intrahepatic obstruction may be due to causes such as intrahepatic tumours, Caroli disease and cholangitis. Extrahepatic causes may be classified into three levels which can help in the differential diagnosis. Most extrahepatic obstructions (90%) occur at the level of the distal common bile duct. Another 5% occurs at the porta hepatis level and the rest (5%) occurs at the suprapancreatic level (between the porta hepatis and the pancreas)[1]. Malignancy is the most common cause of obstruction at the latter two levels, e.g. cholangiocarcinoma, metastatic lymph nodes, gallbladder carcinoma, and spread from intrahepatic tumour. Since most obstructions occur

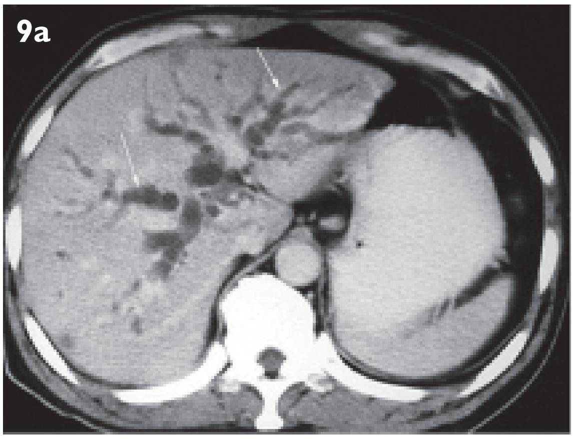
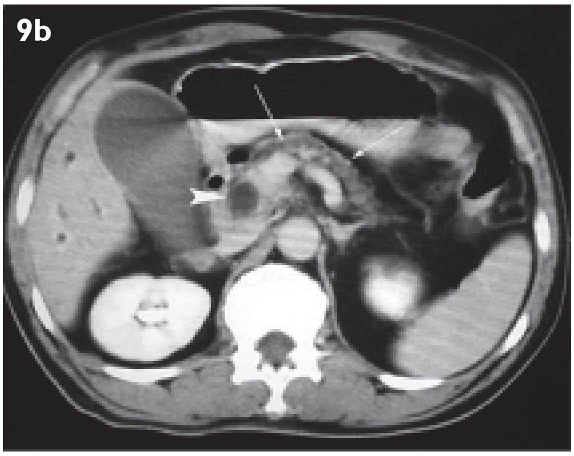
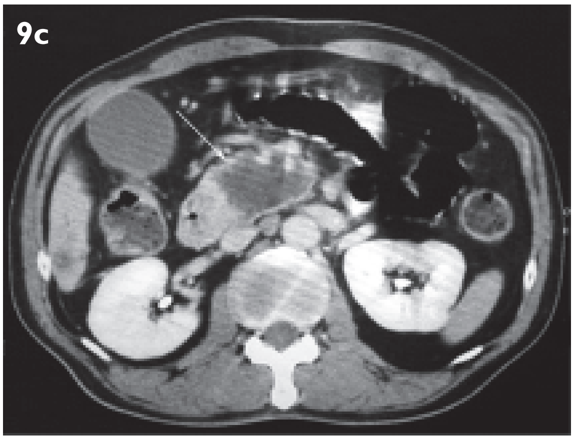

**Fig. 9** Pancreatic head carcinoma. Enhanced axial CT scans show (a) intrahepatic bile duct dilatation (arrows), (b) dilatation of the common bile duct (arrowhead) and an atrophic pancreas with dilated pancreatic duct (arrows) producing the "double-duct sign", and (c) a low-density mass (arrow) at the head of pancreas.

at the distal common bile duct, imaging findings of the common causes at this level are discussed in more detail.

**Choledocholithiasis**

The classical US appearance of a common bile duct stone is a hyperechoic structure with acoustic shadow within the bile duct (Fig. 7). However, 20% of common bile duct stones do not have an acoustic shadow on US[10]. On unenhanced spiral CT, stones have a variable appearances, depending on the stone composition and bile attenuation[4]. They may have a calcific density (Fig. 8), soft tissue density, and be isoattenuating or hypoattenuating with a hyperattenuating rim compared to the surrounding bile[4,6]. Stones composed mainly of calcium birirubinate, common in the East, have a high attenuation which makes them easily detected[4]. Pure cholesterol stones may be missed with unenhanced CT because they are isoattenuating relative to bile[6]. Nearly 90% of stones have lower attenuation than the opacified bile duct on CT cholangiography, while the remainder are hyperattenuating compared to the opacified bile[4].

**Periampullary tumours**

Periampullary tumours may originate from the head of pancreas, ampulla of Vater, or mucosa of duodenum or bile duct itself (cholangiocarcinoma). They produce the same obstructive effect on the distal common bile duct regardless of organ of origin, hence differentiation among these types of tumours on imaging sometimes is impossible. Ampullary carcinoma accounts for about 4% of periampullary tumours[11]. The tumour is usually small (<3 cm) when discovered because the patients usually have signs and symptoms of obstruction at the early stage of the disease. All imaging studies frequently reveal only distal common bile duct obstruction but fail to demonstrate the small tumour. On US, if the mass can be detected, it appears as an intraluminal echogenic mass without acoustic shadows at the distal common bile duct (Fig. 1b). On CT, a soft tissue mass protruding from the ampulla into the duodenum is suggestive of the diagnosis[11].

Carcinoma of the head of the pancreas is the second most common cause of distal common bile duct obstrution[1]. Bile duct obstruction occurs when the carcinoma arises at the head of the pancreas (Figs. 9a-c) or cause lymphadenopathy adjacent to the bile duct. Most pancreatic carcinomas are hypoechoic on US. Common bile duct dilatation may accompanied by a dilated pancreatic duct, resulting in the "double-duct sign" (Fig. 9b). Pancreatitis and pancreatic atrophy are associated findings.

## BILIARY STRICTURE

Biliary stricture is the third most common cause of distal common bile duct obstruction, usually secondary to chronic pancreatitis[1,12]. Proximal bile duct dilatation with abrupt cut-off at the distal common bile duct, without any demonstrable cause on imaging, suggests a stricture. The stricture from chronic pancreatitis usually has smooth, gradual tapering rather than abrupt tapering margins[13].

## ABSTRACT

**A 58-year-old man presented with signs of obstructive jaundice for two weeks. Ultrasonography showed dilatation of the intrahepatic ducts and common bile duct, due to a distal common bile duct mass. ERCP showed a papillary mass. A Whipple's operation was done for the ampulla of Vater carcinoma. The role of imaging in the diagnosis and treatment of obstructive jaundice is reviewed. The common causes of distal extrahepatic obstructive lesions are also discussed.**

**Keywords: computed tomography (CT), magnetic resonance (MR) imaging, MR cholangiopancreatography (MRCP), obstructive jaundice, ultrasonography (US)**

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