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Biliary obstruction: Not always simple!

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Bile ducts; Dilatation; Jaundice; Lithiasis

Abstract  Exploration of biliary obstruction may involve many imaging methods and a large number of people. Radiologists, hepatogastro-enterologists and surgeons may examine using ultrasound, CT, MRI, endoscopic ultrasonography, and percutaneous, intraoperative or endoscopic retrograde cholangiography. Interpreting radiological examinations and choosing an optimal strategy can be difficult. The aim of this paper is therefore: to explain how to explore a clinical and laboratory picture of biliary obstruction using imaging, by presenting its main causes, the methods of exploring them and their radiological signs; to suggest suitable exploration strategies; and to illustrate some of the traps that can make it difficult to diagnose the cause of the obstruction.

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Biliary obstruction: sometimes it is simple

Data from the initial radiological examination

The radiologist will have fulfilled his initial mission if he reveals a cause for the biliary obstruction. Imaging can show the presence of an obvious obstructing mass, for example an endobiliary polyoid lesion, extrinsic compression by tumour adenomegaly or a pancreatic pseudocyst (Figs. 1 and 2). When there is a low obstruction, the lesion may be peri-ampullary (a carcinoma of the head of the pancreas or duodenum, chronic calcifying pancreatitis, a cholangiocarcinoma, an intraductal papillary mucinous tumour of the pancreas) or ampullary (an adenoma or adenocarcinoma of the ampulla of Vater) [1]. In the latter case, the lesion may appear as hypertrophy of the papilla (by more than 10 mm) with protrusion of the papilla into the duodenal lumen, best seen when the duodenum is filled with liquid (Fig. 3). When thickening of the papilla is regular and moderate (ampullary wall less than or equal to 3 mm), simple papillitis following a gallstone is a possibility to be discussed with the clinician [2].

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Figure 1. Obstruction of the common bile duct by an intraluminal mass (arrowhead). Endoscopic retrograde cholangiopancreatography (ERCP) with choledoscopy and biopsies provided a diagnosis of papillomatosis.

If there is no mass effect or calculus (see section below), obstruction may be explained by a stenosis (Figs. 4 and 5). Its benign or malignant nature must always be investigated: thickening by more than 1.5 mm of the walls of the common bile duct, a stenosis measuring more than one centimetre in length and unusually pronounced enhancement of the bile duct wall are aspects lending weight to the possibility of a malignant biliary stenosis [3]. In the absence of these unfavourable signs, a benign stenosis (resulting from a gallstone, surgery, trauma or cholangitis) should be considered.

Methods of management

The further management can be determined from the initial imaging examination, often during a multidisciplinary consultation, when the following options may be discussed:
- endoscopic retrograde cholangiopancreatography (ERCP) ± brushing ± drainage;
- endoscopic ultrasonography ± biopsy;
- duodenoscopy ± papillary biopsy;
- surgical exploration ± resection;
- percutaneous cholangiography ± drainage.

If there is a diagnostic or therapeutic procedure and magnetic resonance cholangiopancreatography (MRCP) was not performed initially, this is often requested by the endoscopist, interventional radiologist or surgeon, additionally. The MRCP indeed provides a useful map of the bile ducts and the area of obstruction.

When obstruction by a gallstone is suspected and the calculus cannot be found, continue to search

Exploration strategy

When faced with a clinical and laboratory picture suggesting obstruction by a calculus (migration, cholangitis, pancreatitis), the potential severity of the complications means that in all cases the explorations must be continued until a formal conclusion can be drawn as to whether there is a calculus in the CBD, or not.

Figure 2. Female patient with lupus vasculitis complicated by portal vein thrombosis. A cavernoma (arrowhead) can be seen and is responsible for biliary compression. Also note the presence of embolisation material (arrow) within a gastroduodenal aneurysm.

Figure 3. a: female patient with cholestasis, with dilatation, in MRCP, of the whole of the common bile duct as far as the papilla; the pancreatic duct is not dilated. b: T1-weighted axial slices after gadolinium injection show hypertrophy of the papilla projecting into the duodenal lumen, enhancement of which is accentuated (arrowhead). Thickening of the wall is still relatively moderate and regular; however, duodenoscopic biopsy provided a diagnosis of adenocarcinoma of the ampulla of Vater.
A CT scan, when performed, is only of use if it shows the presence of calculi, but if it does not show any, they still cannot be excluded: even though the detection of calculi by CT can be optimised by non-injected slices being analysed by carefully adjusting windowing for optimal contrast, 20% of calculi are missed (too close in density to the bile and too small) [4]. A CT scan is therefore less effective than ultrasound for detecting vesicular calculi and less effective than MRCP for those in the common bile duct (CBD) (Fig. 6).

Clinicians are not always aware of the poor negative predictive value of CT for biliary calculi. It may therefore be useful to make this explicitly clear in the radiological report by noting: “absence of calculi that are sufficiently dense to be visible on the CT scan”.

However, gallstone aetiology can sometimes be asserted without any visible calculus: thus, according to work by Delabrousse et al. [5], visualisation in a CT scan of a choledochal ring sign (difference of enhancement of the wall of the common bile duct greater than 15 HU relative to the pancreas) confirms the biliary origin of acute pancreatitis with a positive predictive value of 100%.

After the 1st line ultrasonography, the strategy recommended for exploring a patient with suspected obstruction by a calculus is set out in Fig. 7 [6]. In theory, this strategy avoids having to perform MRCP when intraoperative cholangiography or endoscopic ultrasonography is in any case indicated.

In practice however, MRCP is tending to become more and more systematic. Indeed, surgeons often prefer diagnosis of CBD lithiasis and a biliary map to be made preoperatively by MRCP rather than during intraoperative cholangiography. Similarly, gastroenterologists expect MRCP to confirm for them at the outset that endoscopic ultrasonography will be followed by therapeutic measures during ERCP.

Figure 4. Obstruction due to stenosis of the biliary anastomosis (arrowhead) in a male liver transplant patient.

Figure 5. Young female patient with an episode of gallstone migration, with vesicular calculi seen in ultrasonography. During cholecystectomy, intraoperative cholangiography showed biliary stenosis: a: MRCP found this stenosis 15 mm before the papilla (arrow), with dilatation of the common bile duct before it. Also note a pancreas divisum and the presence of the biliary T-drain left during cholecystectomy. No other abnormality was noted in the MRI, as regards the area of stenosis, even after gadolinium injection. This was confirmed by endoscopic ultrasonography which did not detect a mass or pathological thickening of the biliary walls; b: endoscopic retrograde cholangiopancreatography (ERCP) was performed at the same time for cytological verification by brushing and aspiration of bile and insertion of a prosthesis to recalibrate the stenosis. It was decided that this was a benign stricture, following an inflammatory reaction to wedged gallstones that were later evacuated.
Figure 6. Male patient with acute pancreatitis: a: CT (coronal oblique reconstruction) before and after injection shows dilatation of the common bile duct (CBD) but with no aetiological pointer; b: MRCP (2D coronal oblique acquisition) shows several vesicular calculi and lower bile duct lithiasis, invisible in CT; c: this calculus is too small inside the dilated CBD to be visible on the MIP from a thin slice 3D acquisition: analysis of native MRI slices is therefore essential.

Optimising the performance of MRCP

It should be remembered that, given the risks of ERCP, current recommendations exclude its use for purely diagnostic purposes [7]. Endoscopic ultrasonography is the reference examination, in principle, for the diagnosis of CBD lithiasis, with sensitivity and specificity of more than 95%. However, if the MRCP technique is optimal (Figs. 6c, 8 and 9 illustrate the danger of interpreting exclusively 3D MIP reformations and the complementary nature of 2D and 3D acquisitions), it is also highly efficient for detecting CBD calculi, with sensitivity of 80–100% and specificity of 90 to 100% depending on the series. In addition, MRCP has the advantage of exploring both the CBD and the intrahepatic bile ducts and of being non-invasive.

The traps

Traps can be encountered however during diagnosis of lithiasis; some are shown in Figs. 10–13: vascular indentation of the right branch of the hepatic artery, pneumobilia, haemobilia, intrabiliary contrast agent [8].

One cause can hide another: so make sure you have found the right one

Once calculi have been found, it is easy to suggest that they explain a biliary obstruction. However, while calculi can be a cause, they can also be just the result of an obstruction [4]. Where there is an obstruction by a gallstone, an underlying disease (malignant or benign stenosis) should therefore be sought, particularly in the following two cases:
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Figure 8. a: 3D thin slice MRCP acquisition. The failure of respiratory gating, necessary for acquiring this sequence, and the movement artefacts that resulted from it make the images very difficult to interpret in this case; b: it was the 2D thick slice, acquired during brief apnoea, which showed the bile duct stones (arrowheads) in this case.

Figure 9. The search for residual calculi in a female cholecystectomy patient: a: multiple acquisitions of thick 2D radial slices, while remaining centred on the lower bile duct; b: the acquisition shows dilatation of the common bile duct with a cupuliform ridge in the lower bile duct. A stone is suspected, but a pseudo-calculous image cannot be eliminated due to contraction of the sphincter; c: the following radial acquisition, during sphincter opening, formally establishes the diagnosis, showing the passage of bile around a calculus wedged in the lower bile duct. When multiple 2D radial acquisitions are not sufficient to correctly analyse the lower bile duct, a new series of dynamic acquisitions must be made at this level, to benefit from sphincter opening and be able to decide between a bile duct calculus and a possible morphological variant of the sphincter.

- when there are episodes of recurrent biliary obstruction;
- when the site of the obstruction is not choledochal but concerns the intrahepatic bile ducts.

Generally speaking, where there is biliary obstruction, we must be sure that we have actually found the real causal pathology, so we must earnestly continue to search for the aetiology. Figs. 14–16 illustrate situations [9,10] where the initial diagnosis of the cause of the obstruction was confirmed or challenged.

And what if nothing is found?

In a symptomatic patient: continue to search

When bile duct dilatation is associated with clinical symptoms or cholestasis, the aetiology must continue to be sought using MRCP combined with MRI exploration in slices without and after gadolinium injection [11] and/or endoscopic ultrasonography, the latter being very effective in this context [12] (Fig. 17).
Biliary pain without lithiasis: consider possible sphincter dysfunction

Faced with calculus migration but no lithiasis or other morphological biliary obstruction, dysfunction of the sphincter of Oddi can be surmised [13]. The absence of any visible sphincter opening on MRCP slices repeated up to 20 times and centred on the lower bile duct is an additional argument in favour of this diagnosis [14]. Dysfunction of the sphincter of Oddi can be related to stenosis or sphincter dyskinesia; it mainly occurs after cholecystectomy.

A dilated common bile duct combined with obvious biliary pain and alkaline phosphatase and AST elevated to more than twice the normal values classifies the patient as type I according to the classification of sphincter of Oddi dysfunction. These patients are cared for by gastroenterologists and can benefit from endoscopic sphincterotomy which relieves their symptoms. This procedure can be preceded by endoscopic ultrasonography in order to definitively eliminate a morphological cause of the biliary obstruction.

When patients are in pain and have CBD dilatation but no enzyme changes (type II of the classification), the benefit of sphincterotomy is less clear. Once medicinal products with risks (morphine, codeine) have been eliminated, some patients can benefit from simple medical treatment with trimebutine and nitrates in a spray prior to endoscopic sphincterotomy, which will only be offered if the treatment fails. Indeed, in patients with sphincter dysfunction,
the risk of post-sphincterotomy acute (sometimes severe) pancreatitis is four times higher. Pre-sphincterotomy screening of patients is classically supposed to be based on sphincter manometry data; however, this examination is currently little used and not without risk. Manometry can be replaced by biliary scintigraphy or by test injection of botulinum toxin. A functional MRI with injection of a contrast agent excreted in the bile [15] could also be useful for selecting patients who would benefit from sphincterotomy.

**Isolated dilatation of the common bile duct: consider the possibility of a choledochal cyst**

A choledochal cyst [16] is a relatively rare congenital abnormality, with clear female predominance. It consists of isolated, generally fusiform (80-90% of cases) dilatation of the CBD, or exceptionally it may be multicystic (type 1 and 4B, respectively, of the Todani classification); its association with cystic dilatation of the intrahepatic bile ducts is rarely observed (type 4A). The usefulness of the Todani classification has in fact been challenged, as it distinguishes three types – 1, 4A and 4B – of choledochal cysts, while their management is identical [17]. Moreover, this classification includes three other entities that have no real connection with choledochal cysts: Caroli’s disease, which only affects the intrahepatic bile ducts (type 5), choledochocoele (type 3), and bile duct diverticulum (type 2).

A choledochal cyst must be considered if, on examining the MRCP, there is possibly pronounced dilatation of the CBD which nevertheless to a large extent spares the super- and subjacent bile ducts. A long, common duct of 15 mm or more (formed by the junction of the CBD and pancreatic duct) must be sought; this anomaly is very often associated with a choledochal cyst and is considered a factor in its formation, because it causes a reflux of pancreatic juice into the CBD. Choledochal cysts are associated with an increased risk of biliary cancer that can be prevented by resecting the cyst as completely as possible and combining this with a biliary-digestive anastomosis. It is therefore important to consider this diagnosis and for possible surgery to be discussed in a multidisciplinary meeting.

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**Figure 12.** Dilatation of the bile ducts (a, arrowheads), associated with a spontaneously hyperdense rounded image of the lower bile duct (b, arrowhead) leads to suspected obstruction by a gallstone; c: in ultrasonography, the common bile duct is dilated and filled with echogenic material. There are no calculi, in fact, but an obstruction due to haemobilia following a liver biopsy.
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Figure 13. a: in this male patient with hepato-portal sclerosis who presented with acute pancreatitis, the MRCP showed the lower bile duct filled with a gallstone-like sediment (arrowhead). This appeared as spontaneous hyperintensity with T1-weighting (b, arrowhead) and was also found in the gallbladder (c). In reality, it was not a gallstone condition but iodinated contrast material, injected the day before for a CT scan, that showed up during its biliary excretion.

Figure 14. Dilatation of the intrahepatic bile ducts, associated with the presence of several calculi (arrowhead). Retrograde catheterisation was performed with cytological sampling by aspiration of bile and biliary brushing. Here the calculi were a consequence and not the cause of the obstruction; cytology showed the presence of an underlying cholangiocarcinoma.

What should be done for isolated asymptomatic dilatation of the common bile duct?

When no other aetiology can be identified, certain benign causes of CBD dilatation can sometimes be suggested (Figs. 18 and 19).

In the end, if the dilated common bile duct is discovered accidentally in an asymptomatic patient without any obstructive lesion being found, the question to ask is whether this dilatation is really pathological, or not. The threshold generally used when talking of dilatation of the CBD is a diameter of more than 7 mm. In a cholecystectomy patient, a CBD measuring up to 10 mm is not generally considered pathological [18]; a moderate increase in diameter is also considered to be normal with age, or during pregnancy. Although no studies have formally validated these data, in certain cases they justify the following radiological conclusion, particularly in elderly or cholecystectomy patients: “in the absence of biliary symptoms and cholestasis, this moderate dilatation of the CBD without any identified cause of obstruction can be considered normal”.

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Figure 15. Obstruction of the superior biliary confluence responsible for dilatation of the left (a) and right intrahepatic bile ducts, drained by a plastic prosthesis (b). A cholangiocarcinoma (Klatskin tumour) was suspected. After left hepatectomy, histopathological examination found no carcinomatous cells: it was actually autoimmune cholangitis (IgG4-associated cholangitis). This disease, causing stenosis of the bile ducts, and characterised by infiltration of the bile ducts by IgG4 plasma cells, is frequently associated with autoimmune pancreatitis. It regresses in a spectacular way with simple corticosteroid treatment; measurement of serum IgG4 can provide the diagnosis.

Figure 16. Two different female patients: a: intrahepatic calculi found by MRCP; b: cholesterol deposited along the small intrahepatic bile ducts, visible with ultrasound in the form of a classic comet tail image, but which requires careful targeted exploration to be detected. These patients with a history of obstetric cholestasis, presenting biliary symptoms before 40 years of age, with recurrence after cholecystectomy, have, with the imaging, all the diagnostic criteria for low phospholipid-associated cholelithiasis (LPAC). This predisposition to biliary disease can be confirmed by genetic research and lead to medical treatment and family screening.
Figure 17. a: a female patient with progressively increasing jaundice, a distended gallbladder and considerable dilatation of the supra-pancreatic common bile duct in a contrast-enhanced CT scan, but with no identified obstructive condition; b: additional endoscopic ultrasonography detected a 15 mm hypoechoic tumour of the head of the pancreas with carcinomatous cells in the samples of bile produced during drainage by endoscopic retrograde cholangiopancreatography (ERCP).

Figure 18. Ultrasound detection of dilatation of the common bile duct (CBD) in a 75-year-old minimally symptomatic patient: a: the dilatation stopped next to a round formation (arrowheads) the contours of which were discretely visible with MRCP; b: T1-weighted axial slices with gadolinium injection identified this formation as a para-papillary duodenal diverticulum (arrowhead). Although the causal link between a para-papillary diverticulum and dilatation of the CBD has not been formally supported by published data, this aetiology seems to be occasionally accepted.
**Conclusion**

Dilatation of the common bile duct is often discovered by chance when using ultrasonography in the elderly, and may have been encouraged by earlier cholecystectomy. In most cases, it is not a pathological phenomenon.

However, MRCP may need to be offered to these patients to avoid missing the migration of a calculus (especially if there is a history of calculous cholecystitis) together with contrast-enhanced acquisitions to detect an obstacle caused by a tumour. In all cases, the action to be taken must be dictated by the clinical context and results of laboratory tests; endoscopic explorations may be indicated as a second line.

**TAKE-HOME MESSAGES**

- **When** the initial assessment finds an ‘‘obvious’’ cause for the biliary obstruction, the radiologist may nevertheless be asked to explore further (especially by MRCP) to assist the multidisciplinary decision concerning treatment and/or perform an interventional radiological procedure.
- **When** the clinical and laboratory picture suggests an obstruction due to gallstones, exploration should be continued to formally decide on the presence or absence of CBD calculi, given the severity of potential complications (pancreatitis, cholangitis). Although, depending on the case, we may call directly on intraoperative cholangiography or endoscopic ultrasonography, MRCP is often an essential step in management of the patient. Its undeniable contribution requires strict acquisition and interpretation methodology.
- **For** some forms, the aetiology must be sought and the search should not stop at the first cause suspected. This is particularly the case for a recurrent gallstone or intrahepatic obstruction, where an underlying causal condition needs to be investigated.

- **In the absence of an identified obstruction**, investigations need to be continued including endoscopic ultrasonography and/or consideration given, depending on the case, to the possibility of sphincter dysfunction or a rare choledochal cyst.
- ‘‘**Normal**’’ dilatation of the bile ducts can only be considered as a last resort, when the dilatation is moderate and discovered by accident in a patient with no biliary or cholestatic symptoms.

**Clinical case**

This 72-year-old female patient, with a history of cholecystectomy, presented a 12 mm dilatation of the common bile duct in an ultrasound examination. MRCP was performed (Fig. 20).

**Figure 19.** a: in this male patient who had undergone colectomy, there was a postoperative shift of the pancreas, the head of which was on the left side of the aorta; b: the moderately dilated bile ducts were followed to the point where they crossed the aorta, which was probably responsible for a mass effect explaining the dilatation.

**Figure 20.** MRCP: acquisition in 3D mode, MIP reconstruction.
Questions

1. Can we eliminate a condition due to a calculus on the basis of this image?
2. Are there pointers suggesting a choledochal cyst in this image?
3. Can we eliminate a tumour on the basis of this image?
4. The examination did not find any systematic abdominal pain and the patient’s liver tests were normal. MRI with the addition of acquisitions after gadolinium injection found no cause for the dilatation of the CBD. In these conditions, is it necessary to continue the investigations using endoscopy?

Answers

1. A condition due to gallstones cannot be eliminated on the basis of this image. With MIP, superimposition effects can make a small stone invisible within a dilated bile duct. It is essential to examine the native slices before a condition due to gallstones can be eliminated.
2. There are no pointers suggesting a choledochal cyst. A fusiform cyst (type 1c of Todani’s classification) could always be considered, but here the appearance is non-specific. It would be better to suggest a choledochal cyst where the dilatation of the CBD seems to be focal, pronounced and not affecting the intrahepatic bile ducts. Moreover, the age of the patient makes this less likely, and in addition, there is no long common duct here. Then again, it is a rare condition. A choledochal cyst will not therefore be discussed in the first instance, in this context.
3. Tumour disease cannot be eliminated on the basis of this image. It may be an obstruction that is ampullary or peri-ampullary caused by a tumour, even if the main pancreatic duct is not dilated. An MRI with gadolinium injection is essential to make tumour detection more sensitive.
4. Further investigations by endoscopy are not necessary. Given the age of the patient, the absence of symptoms and cholestasis, the history of cholecystectomy and the imaging data, the dilatation can be considered as not being pathological. On the other hand, if there were biliary pain and cholestasis, endoscopy would be indicated to look for a gallstone or small tumour not seen in the MRI, or possible symptomatic sphincter dysfunction, so as to provide treatment.

Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

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