An Approach to Imaging of Biliary Ductal Dilatation

Dr Kenneth Kwan

Diagnostic Radiology, Tan Tock Seng Hospital

Singapore

Tan Tock Seng HOSPITAL

Learning Objectives

1. Provide a practical approach to diagnosis and choice of imaging for evaluation of the dilated biliary tree.
2. Discuss the values and limitations of the various imaging modalities routinely used in imaging of bile duct dilatation.
3. Review the spectrum of imaging findings of biliary obstruction on ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI).

Normal diameters of CBD

- Multiple factors affect measured duct diameter
  - Imaging modality
  - Patient age
  - Prior cholecystectomy
  - Other minor factors e.g. time of day, respiration, patient positioning

Normal diameters of CBD

- Rules of thumb
- US: 6-8 mm
- CT: 8-10 mm
- 1 mm per decade of life after 60 years old
- Post-cholecystectomy: up to 10 mm

- **Duct diameter should be interpreted with knowledge of the clinical presentation**
- **Clinical context of potential biliary obstruction and/or abnormal liver function tests warrant further diagnostic evaluation**

Imaging modalities

- Transabdominal Sonography (US)
- Endoscopic Retrograde Cholangio-pancreatography (ERCP)
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)

Imaging modalities

- **Transabdominal Sonography (US)**
- Commonly used as first line investigation for evaluation of biliary system
- Advantages: Inexpensive, sensitive, non-invasive, easy access
- Disadvantages: Operator dependence, less accurate for determination of level and cause of obstruction

Imaging modalities

- **Endoscopic Retrograde Cholangio-pancreatography (ERCP)**
- Allows for concurrent imaging of biliary tree and therapeutic intervention e.g. stone removal, stent placement
- Advantages: Allows for concurrent histological diagnosis and/or intervention
- Disadvantages: Invasive, risk of cholangitis/pancreatitis, high operator dependency, failure rates increase with altered anatomy, poor sensitivity for stones due to size, poor contrast opacification, air bubbles
- **ERCP now predominantly a therapeutic procedure due to its risks and availability of other non-invasive imaging modalities**

Imaging modalities

- **Computed Tomography (CT)**
- Fairly sensitive and able to determine cause of obstruction with a high degree of accuracy
- Unenhanced images helpful in detecting calculi e.g. choledocholithiasis, hepatolithiasis
- Advantages: Non-invasive, operator independence, low technical failure rate
- Disadvantages: Radiation, risk of adverse reactions to iodinated contrast

Imaging modalities

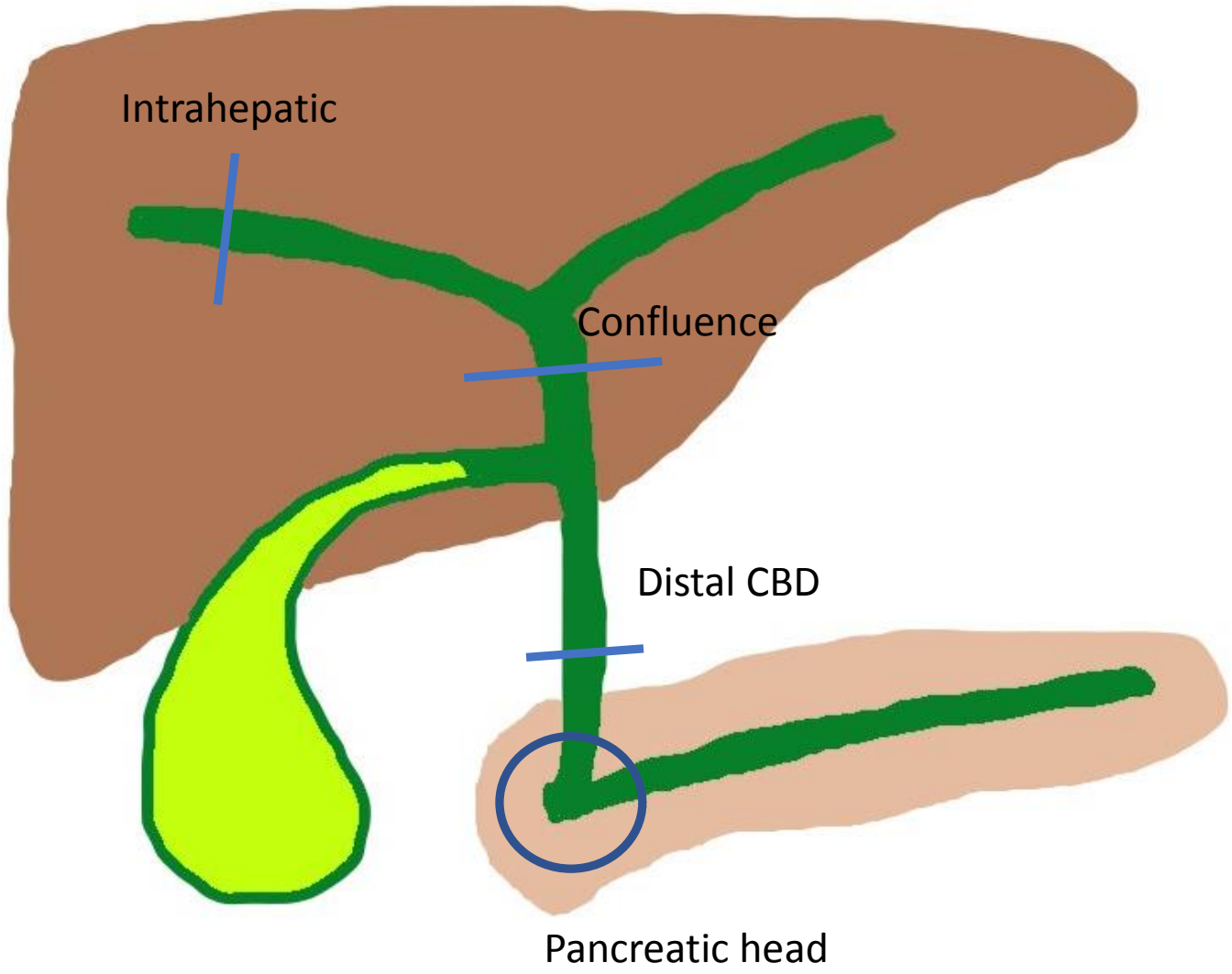
- **Magnetic Resonance Imaging/ Magnetic Resonance Cholangio-pancreatography (MRI/MRCP)**
- Current techniques permit imaging of entire biliary tract in a single breath hold for MRCP
- 2D (SSFSE, HASTE) and 3D MRCP sequences are excellent in demonstration level and site of obstruction and configuration of obstruction
- High spatial resolution up to 4^{th} order intrahepatic ducts

Imaging modalities

- **Magnetic Resonance Imaging/ Magnetic Resonanc Cholangio-pancreatography (MRI/MRCP)**
- Hepatobiliary phase images with hepatocyte-specific contrast (e.g. Multihance, Primovist) are useful in differentiating dilated ducts from cystic lesions, depicting severity of obstruction and demonstrating biliary anatomical variants
- DWI and T2 FS images are excellent in picking up small obstructing lesions which may be occult on other sequences
- Advantages: Highly sensitive for demonstrating level and presence of biliary obstruction, relatively fast, non-invasive
- Disadvantages: Inability to evaluate patients with ferromagnetic implants or pacemakers, claustrophobia, prone to artefacts e.g. pneumobilia, flow artefacts, surgical clips in periampullary region

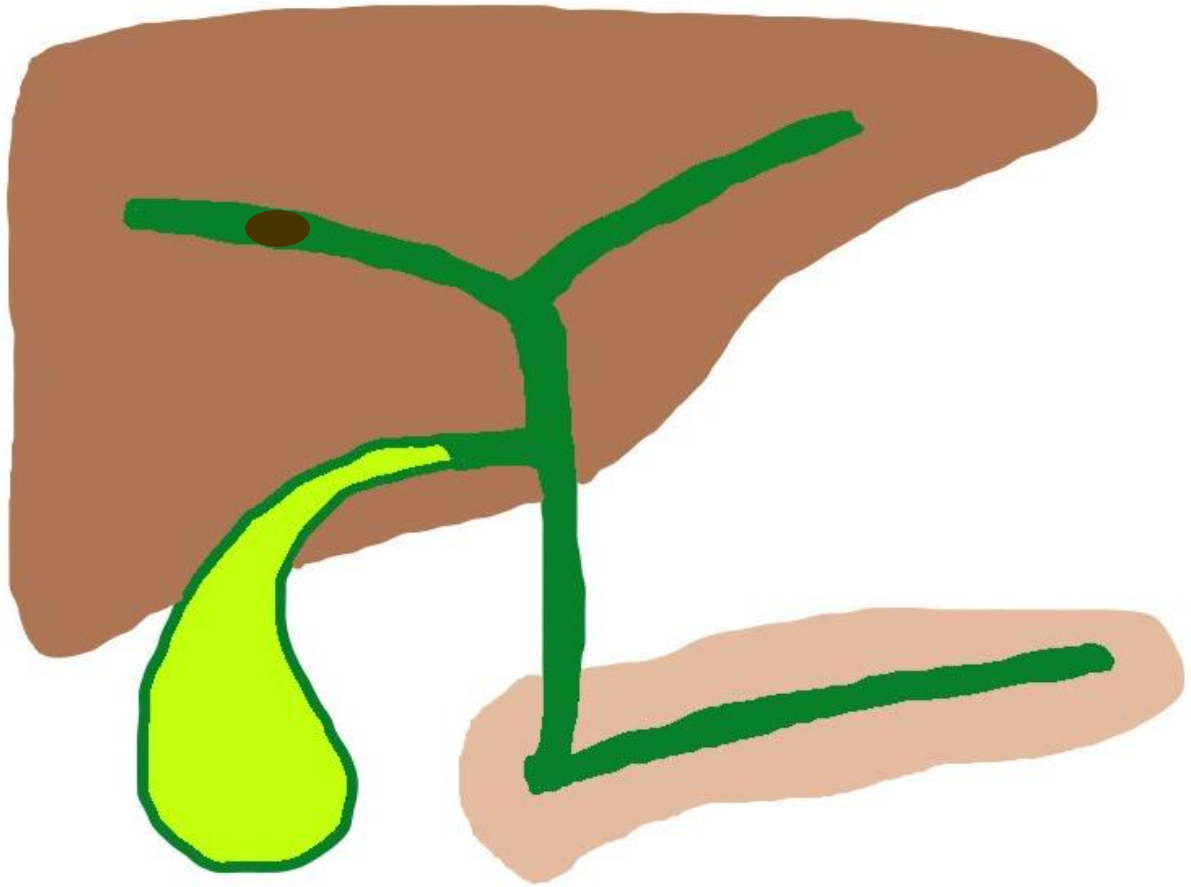
Approach

- Level of obstruction
- Distal obstruction leads to diffuse ductal dilatation
- Site of obstruction
- Intraluminal
- Intramural
- Extraluminal
- Smooth tapering vs abrupt cut-off

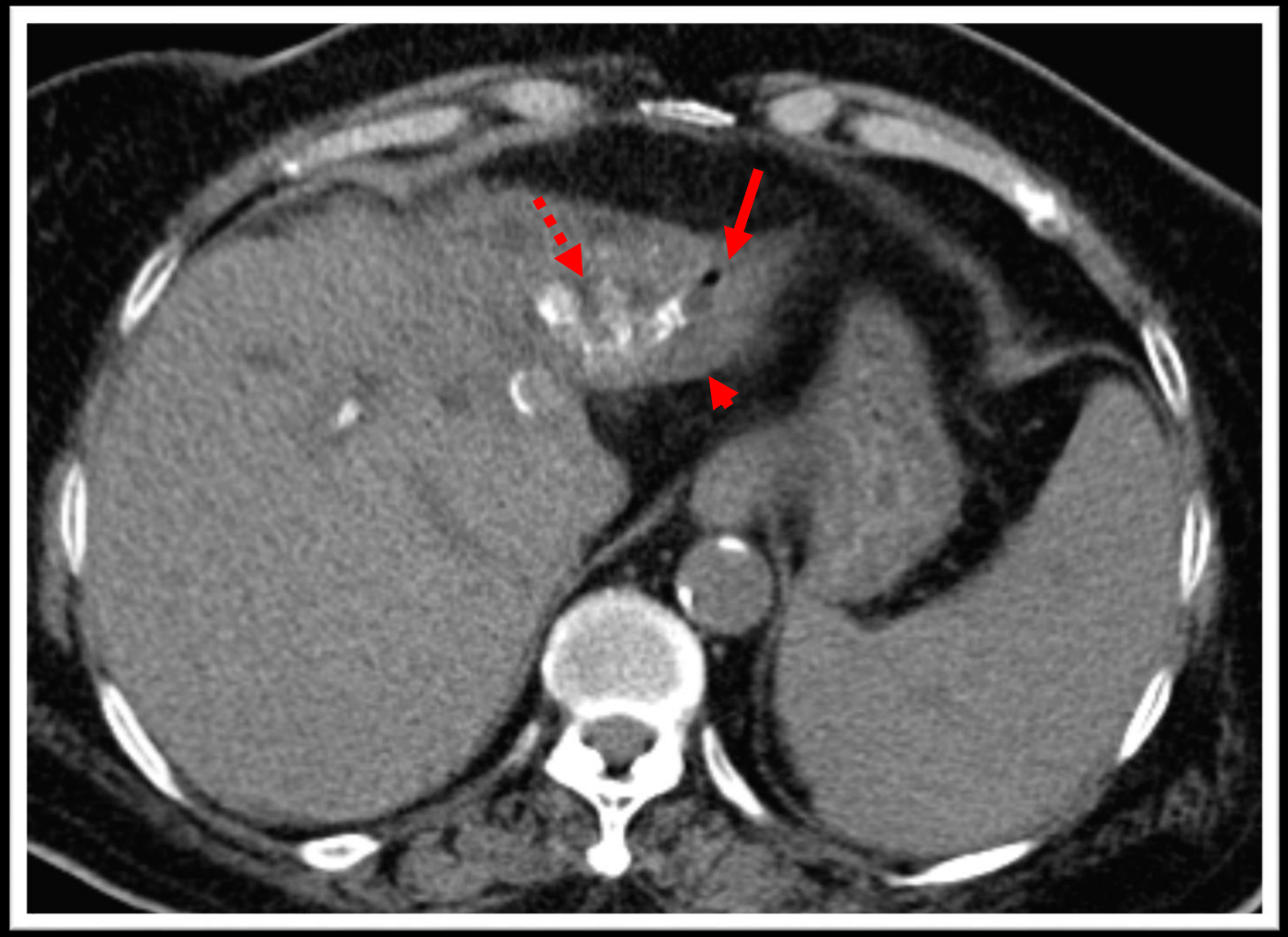


Intrahepatic ductal dilatation

- Intraluminal
- Calculi: think of recurrent pyogenic cholangitis
- Sludge
- Cholangiocarcinoma: primary lesion may be radiologically occult



Recurrent pyogenic cholangitis (RPC)

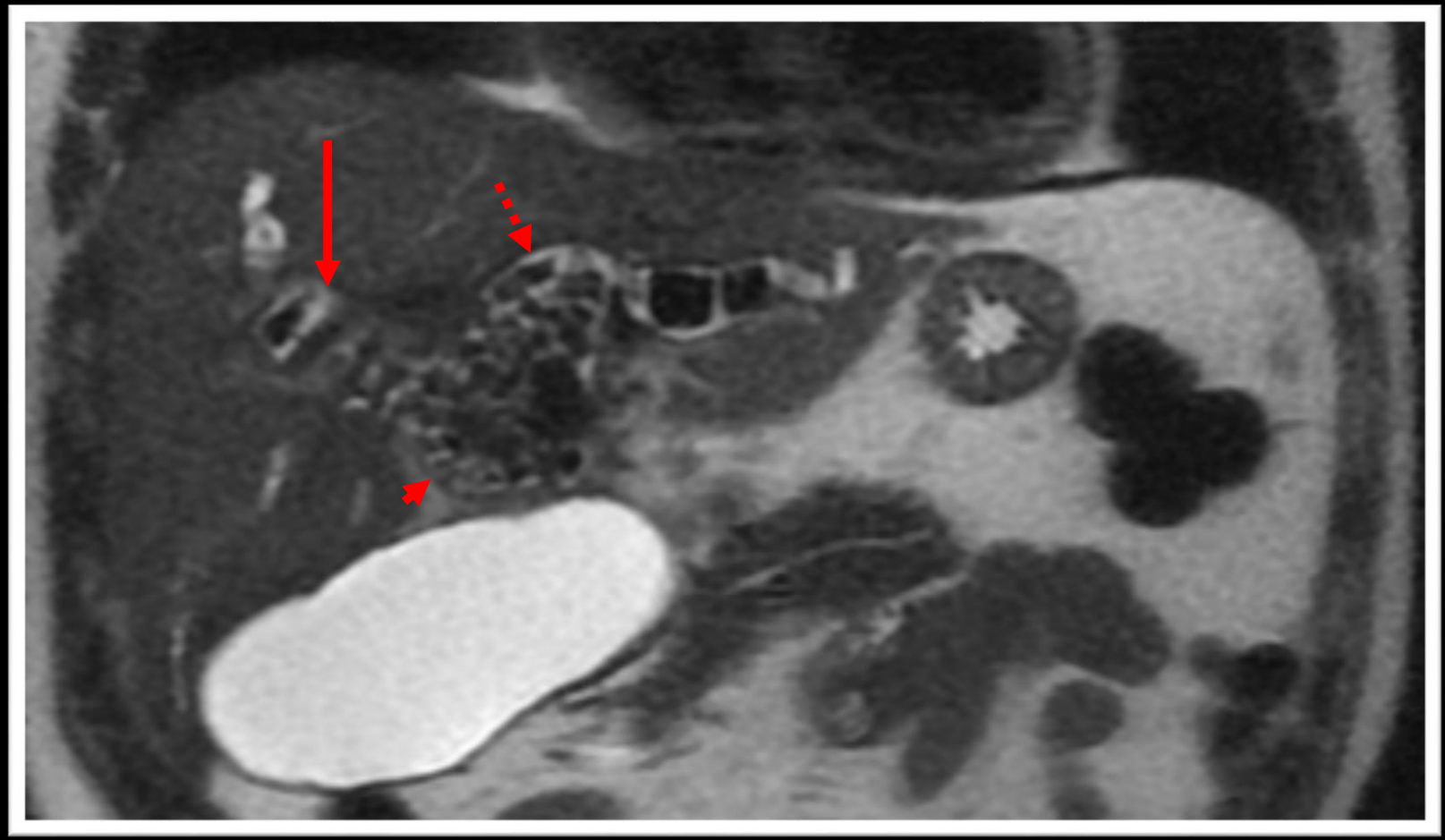


Unenhanced axial CT of the liver in an 82 year old woman showing an atrophic left lobe (arrowhead), with multiple hyperdense intraductal calculi (dotted arrow). Pneumobilia is noted (arrow).

Recurrent pyogenic cholangitis (RPC)

Axial fat suppressed T2-weighted fast spin echo image of the liver showing dilated intrahepatic ducts (arrow) with multiple intraductal calculi, appearing as foci with signal void (arrowhead) involving the right posterior segment ducts.

Recurrent pyogenic cholangitis (RPC)



Coronal SSFSE T2 weighted images of the liver in a man with recurrent right hypochondrial pain demonstrating disproportionate dilatation of the right hepatic duct (long arrow), left hepatic duct (dotted arrow) and common duct (arrowhead) with innumerable intraductal calculi within. There is relative sparing of the peripheral biliary tree.

Recurrent pyogenic cholangitis (RPC)

- Infective process involving the biliary tree typified by pigmented intraductal calculi with dilatation of the intra- and extrahepatic biliary tree
- Previously endemic to Southeast Asia, now seen in Western countries with the increasing access to international travel and immigration
- Patients get recurrent bouts of cholangitis, and commonly suffer from complications such as abscess formation and biliary strictures

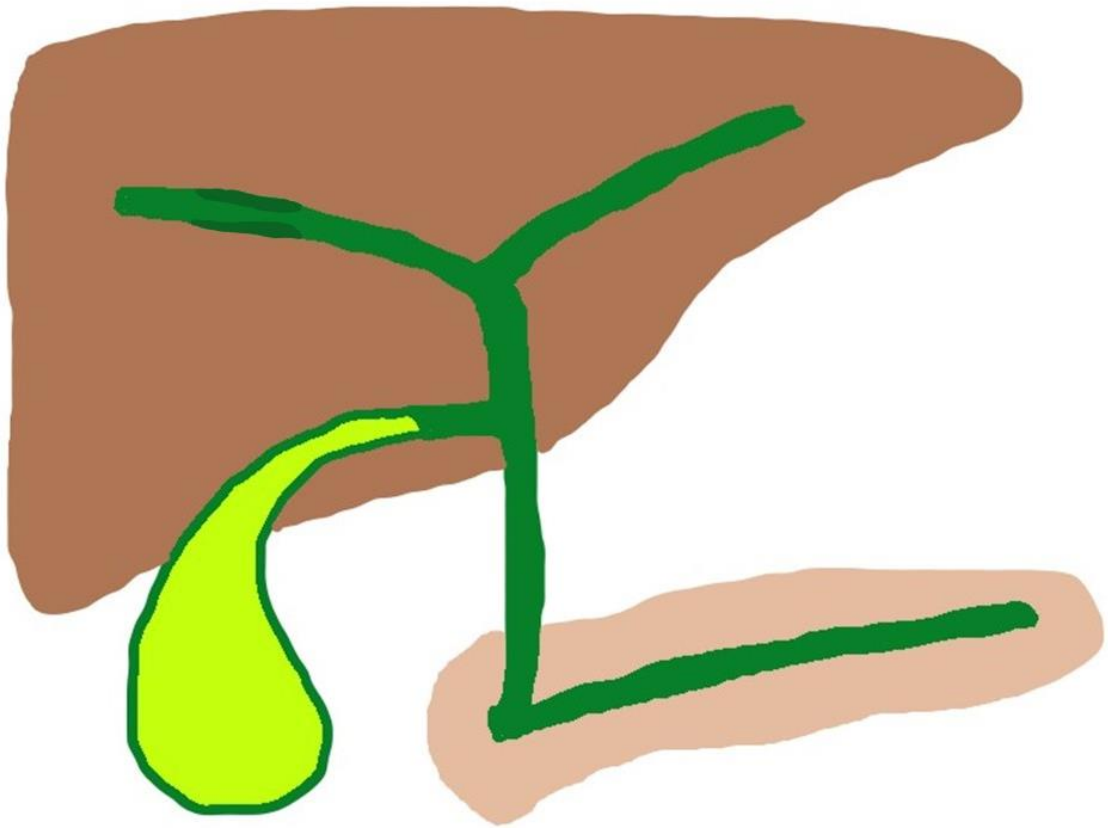
Recurrent pyogenic cholangitis (RPC)

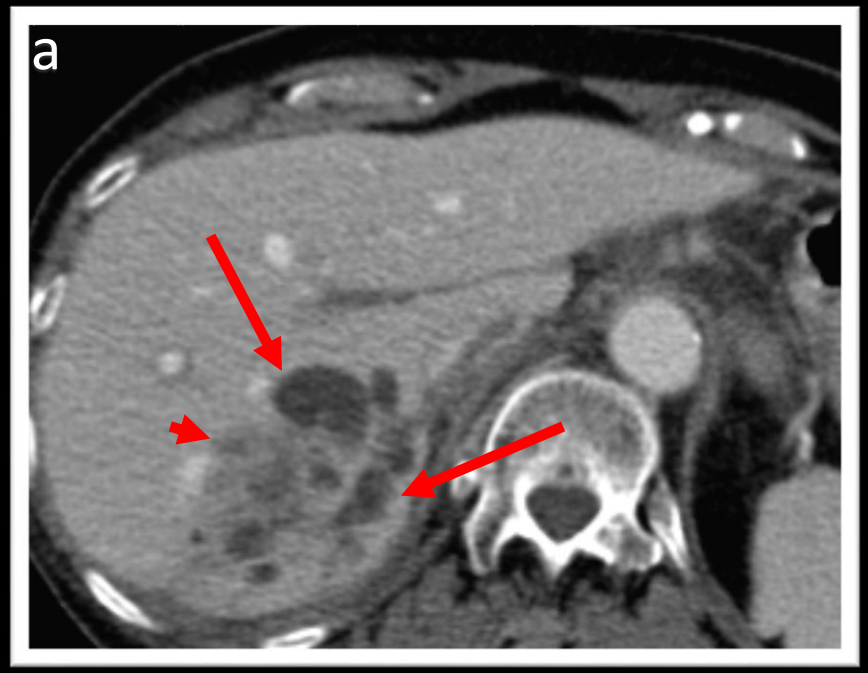
- Imaging features
- Intrahepatic ductal calculi: best seen on unenhanced CT scans or as intraductal signal voids on MRI/MRCP
- Often associated with parenchymal atrophy, most commonly affecting the left lateral segment followed by the right posterior segment
- Pneumobilia secondary to previous intervention, stone passage or gas-forming organisms such as Klebsiella

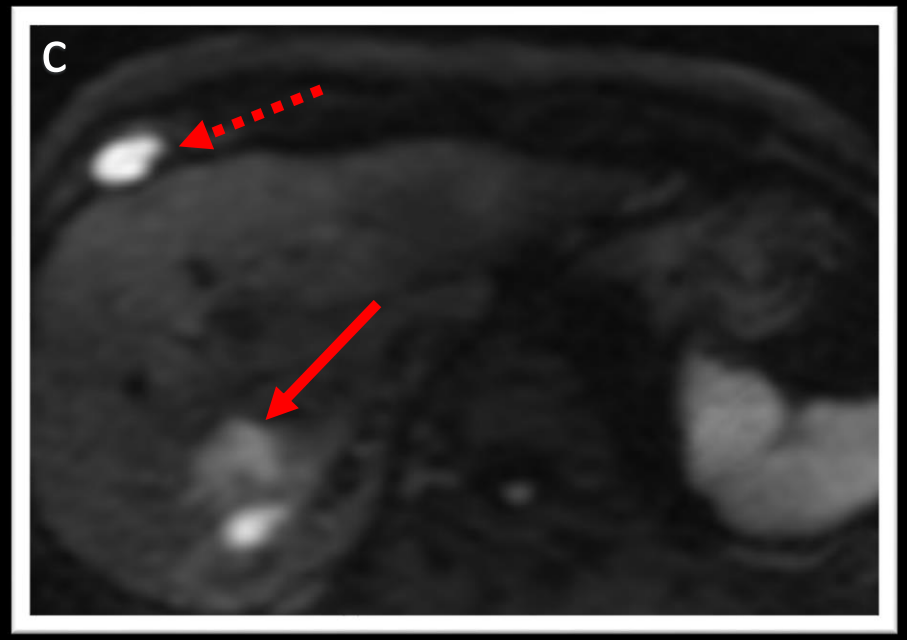
Intrahepatic ductal dilatation

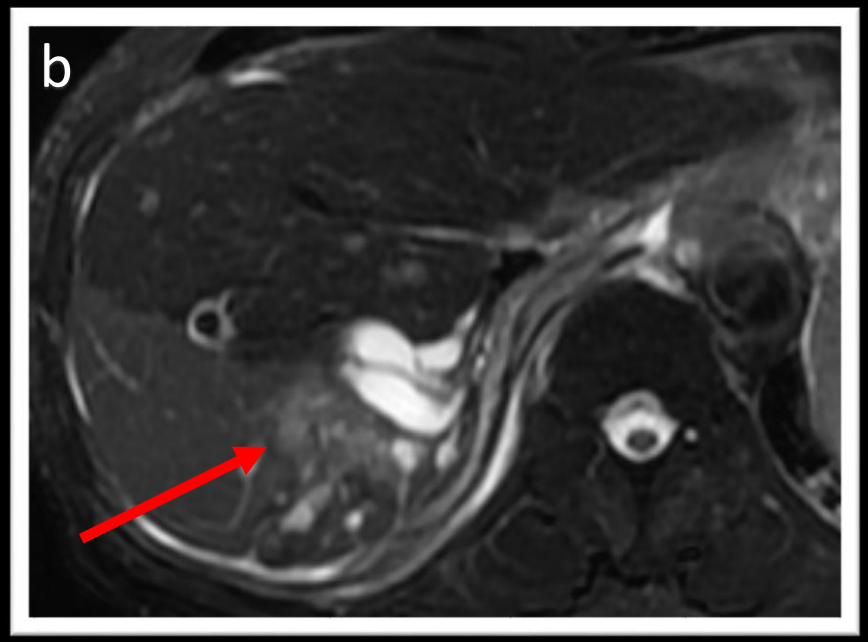
- Intraductal

- Cholangiocarcinoma
- Inflammatory stricture e.g. previous cholangitis, RPC



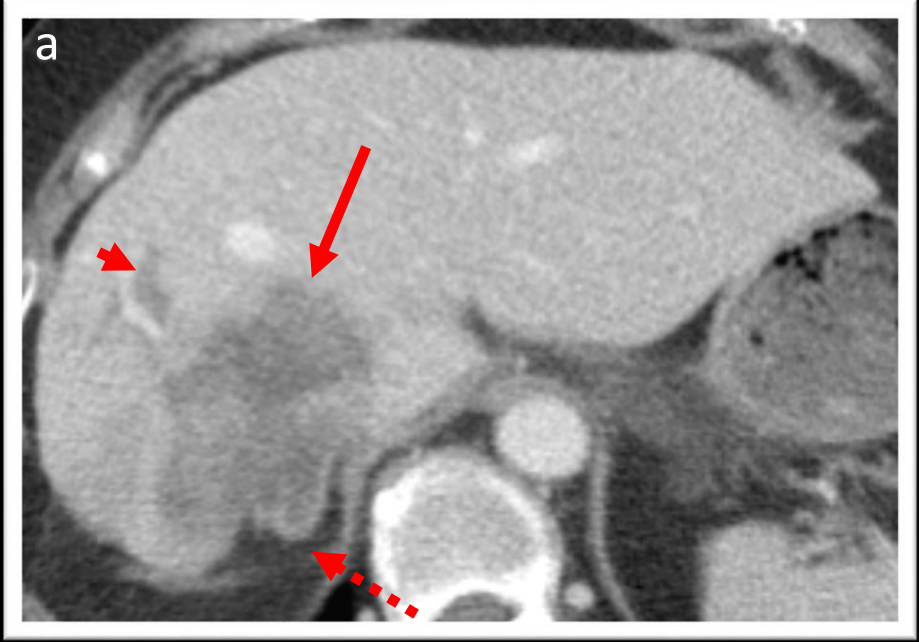


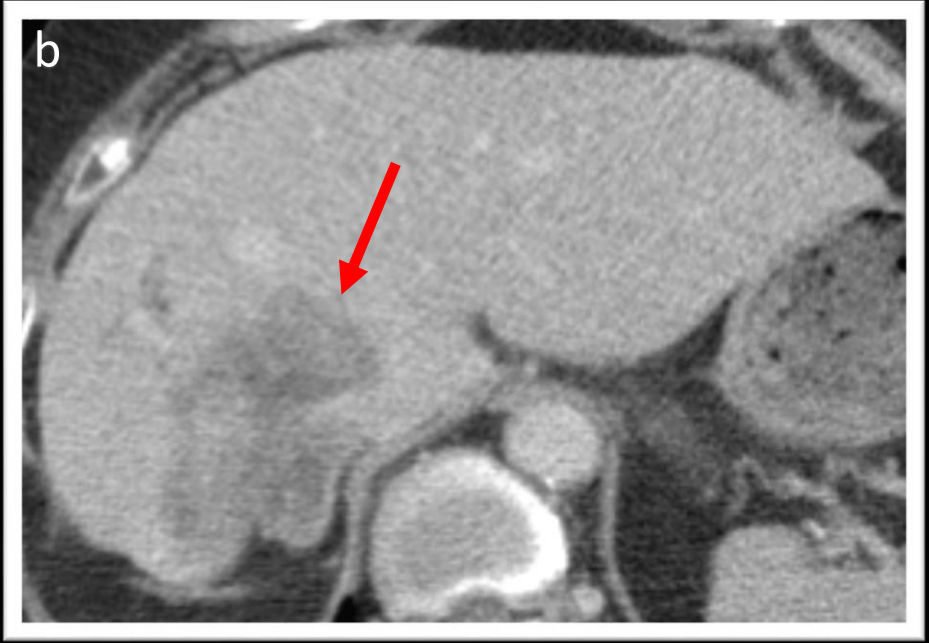


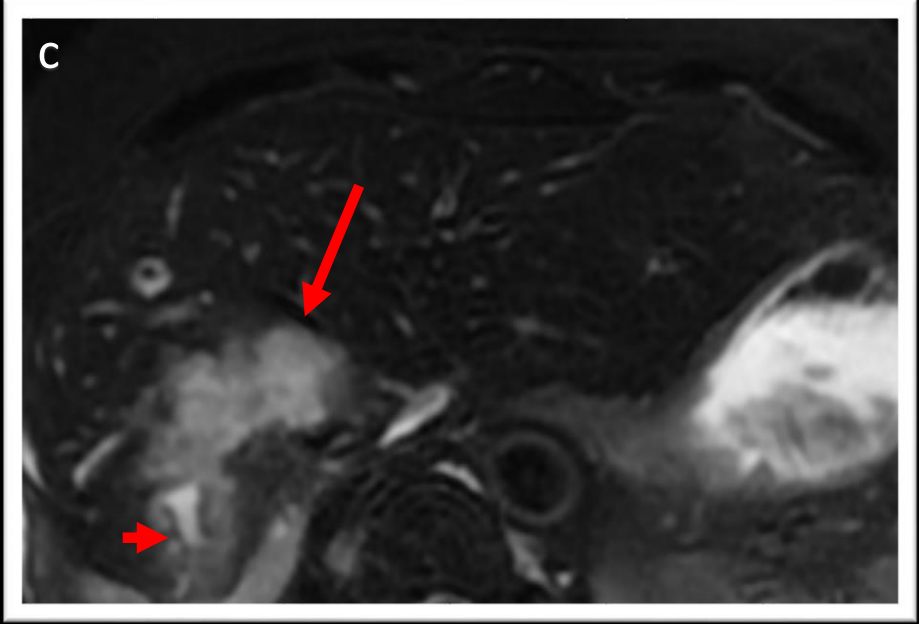


Intrahepatic cholangiocarcinoma

(a) Grossly dilated right posterior sectoral ducts on axial post-contrast CT (arrows) with an ill-defined mass around the duct walls (arrowhead) (b) T2w FS images of the liver with the mass demonstrating intermediate signal (arrow). Geographic raised T2 signal in the right posterior segment likely due to altered perfusion. (c) High b-value DWI with the mass demonstrating restricted diffusion (arrow). A peritoneal metastasis is also noted (dotted arrow).





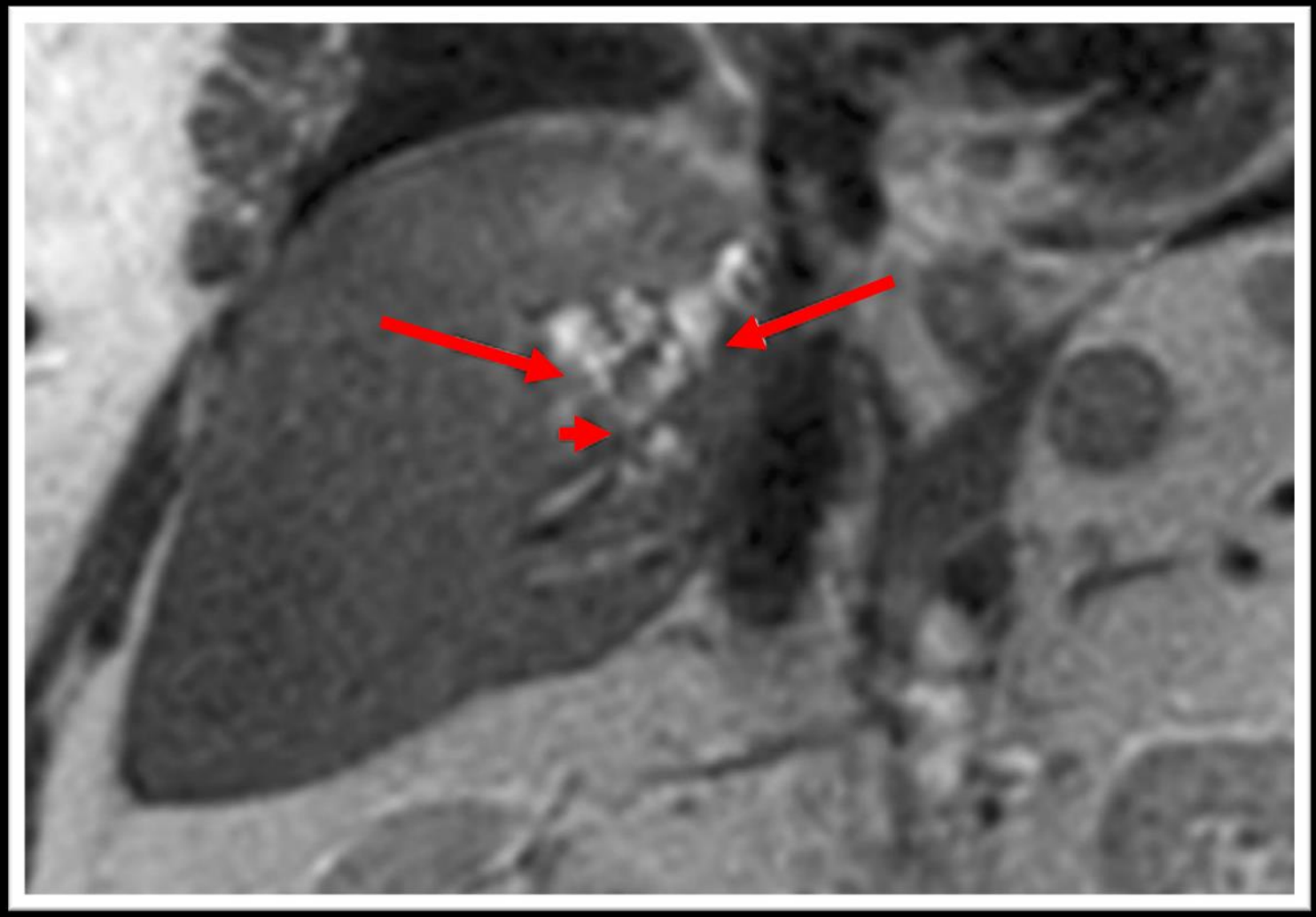


Intrahepatic cholangiocarcinoma

Follow up CT for a patient with segmental dilatation of intrahepatic duct (a) Axial CT in portal venous phase showing an ill-defined hypodense mass in segment 7/8 (arrow) with capsular retraction (dotted arrow) and adjacent ductal dilatation (dotted arrow) (b) Delayed enhancement of the mass is seen (arrow). (c) The mass is demonstrated on T2 FS images as a T2 high signal lesion infiltrating around an adjacent dilated duct (arrowhead).

Case courtesy of Dr Low Hsien Min

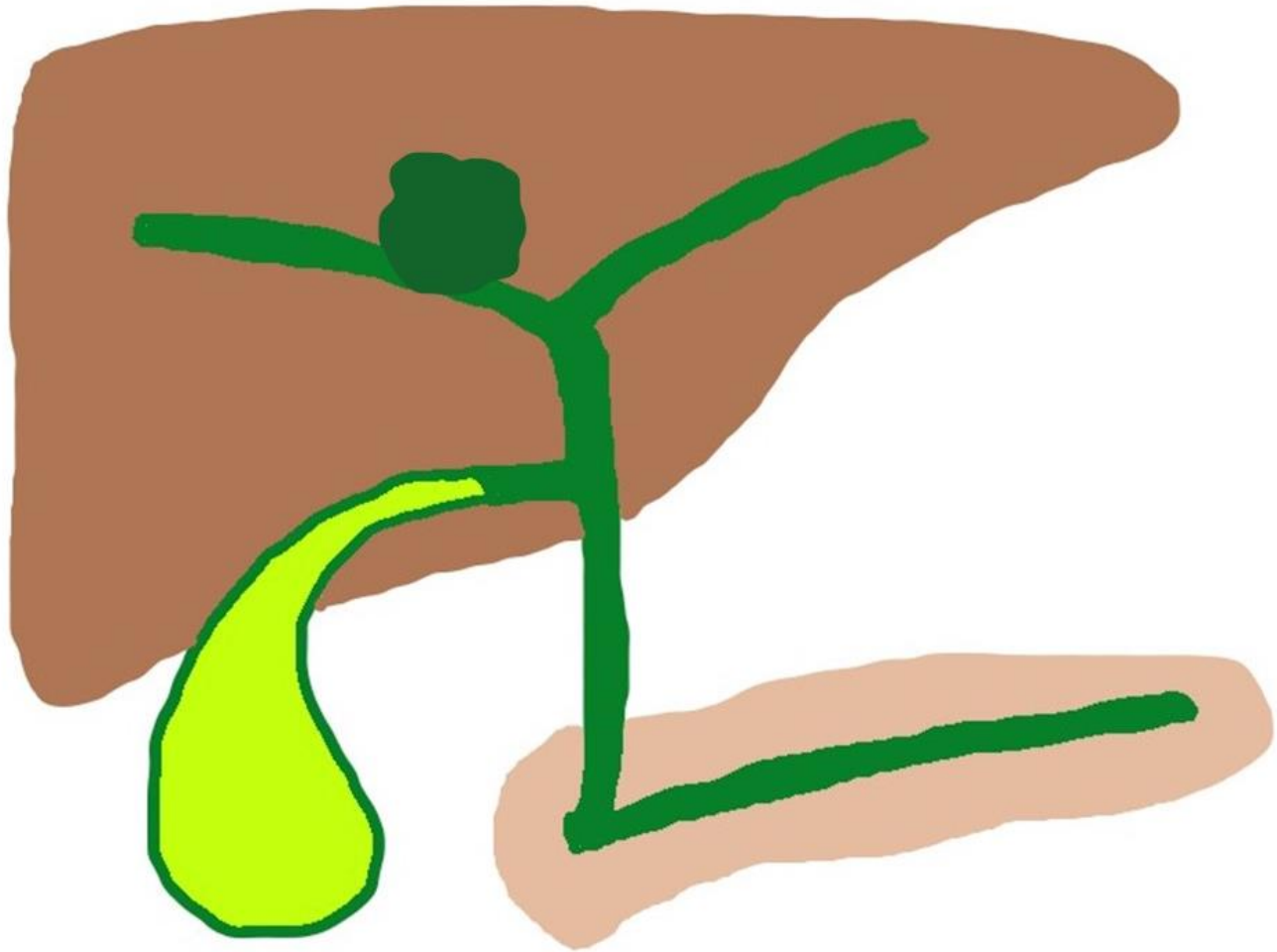
Inflammatory Stricture

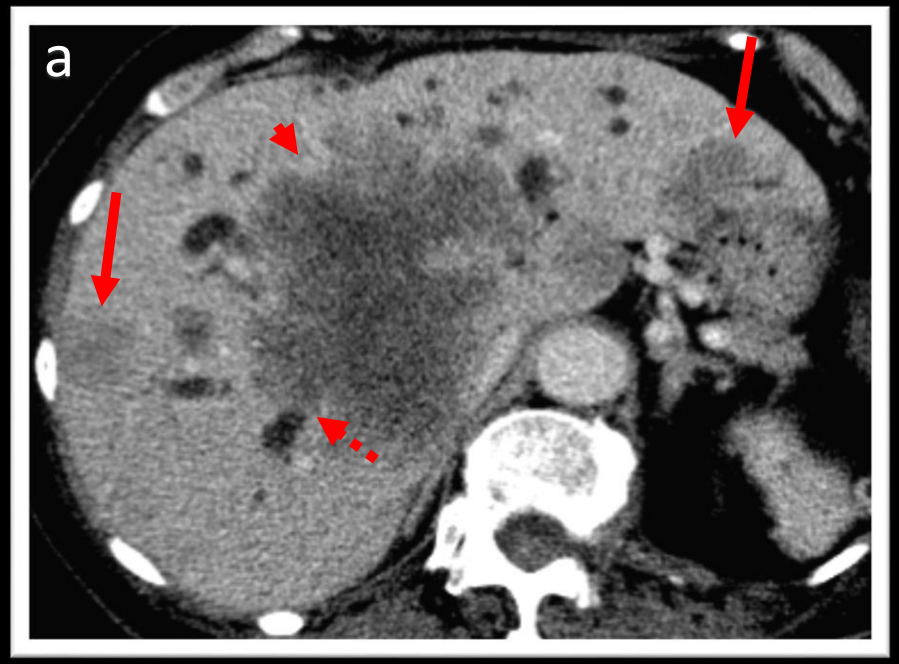


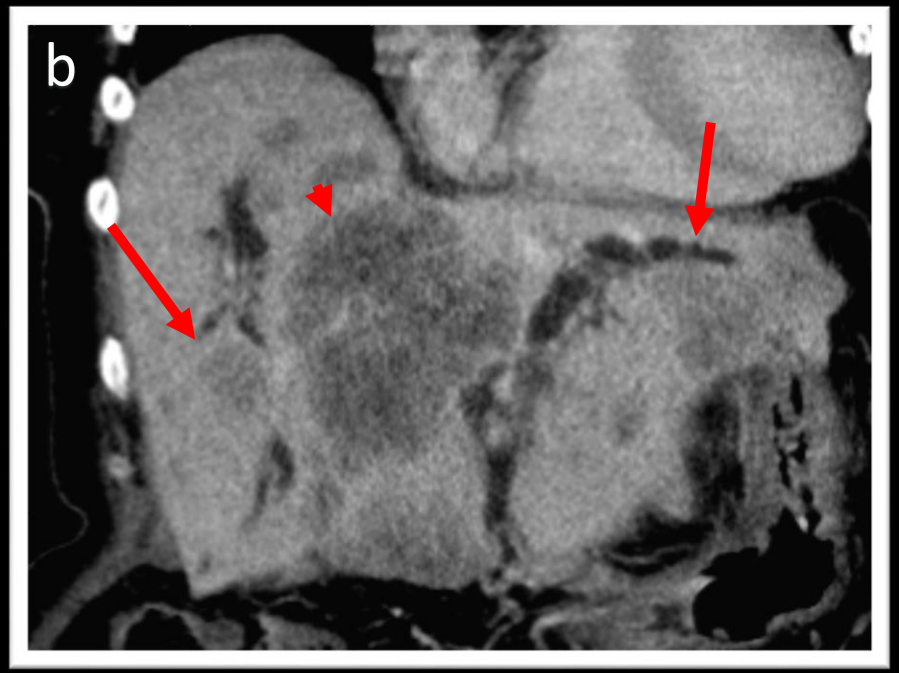
Coronal T2-weighted fast spin echo image of the liver showing segmental ductal dilatation (arrows) secondary to an inflammatory stricture (arrowhead).

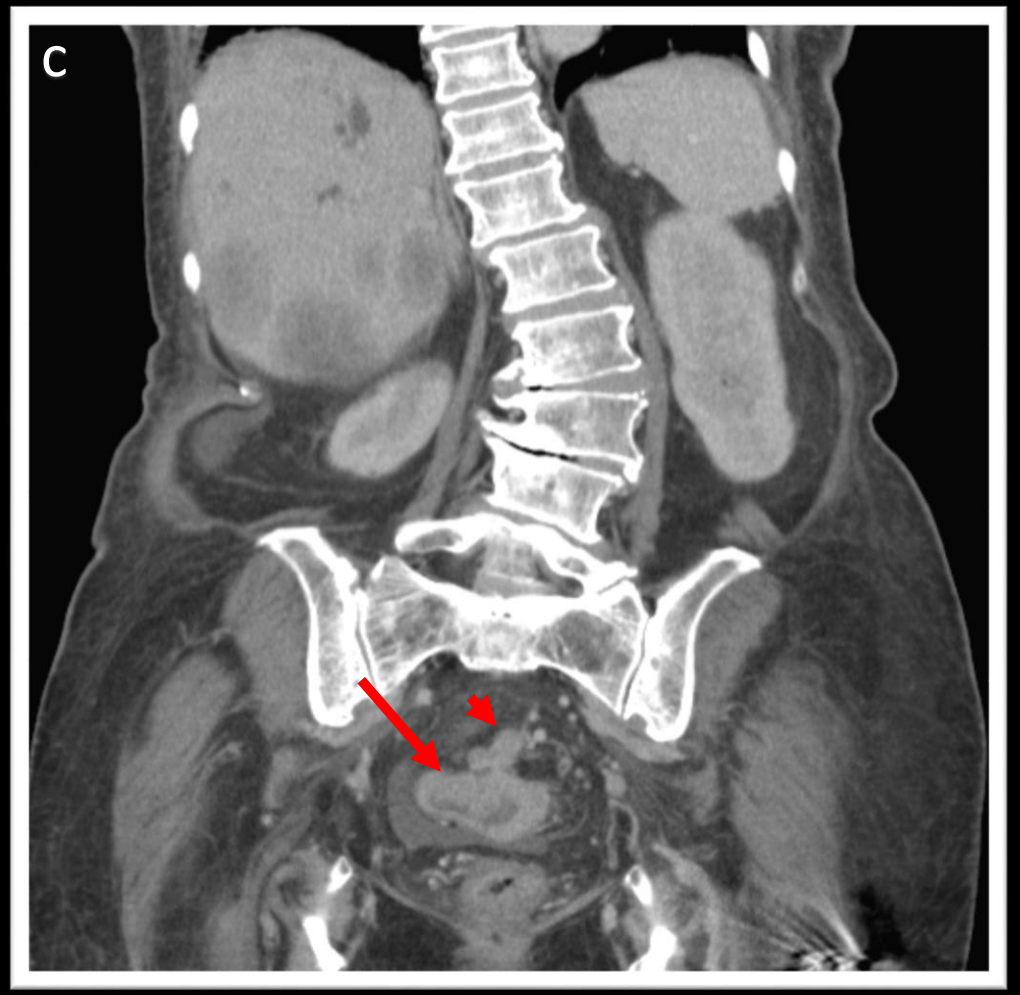
Intrahepatic ductal dilatation

- Extraluminal
- Benign or malignant intrahepatic lesions
- Intraluminal extension should raise suspicion for a malignant cause







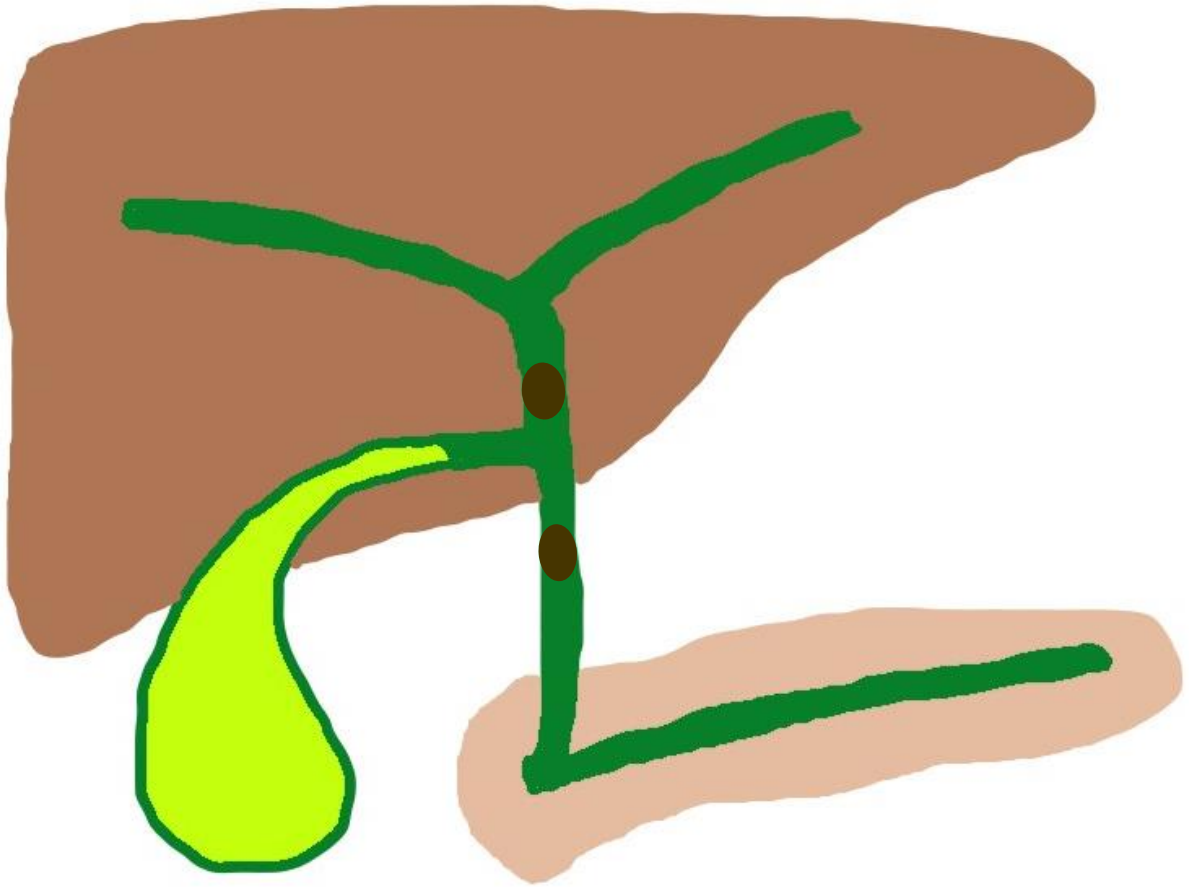


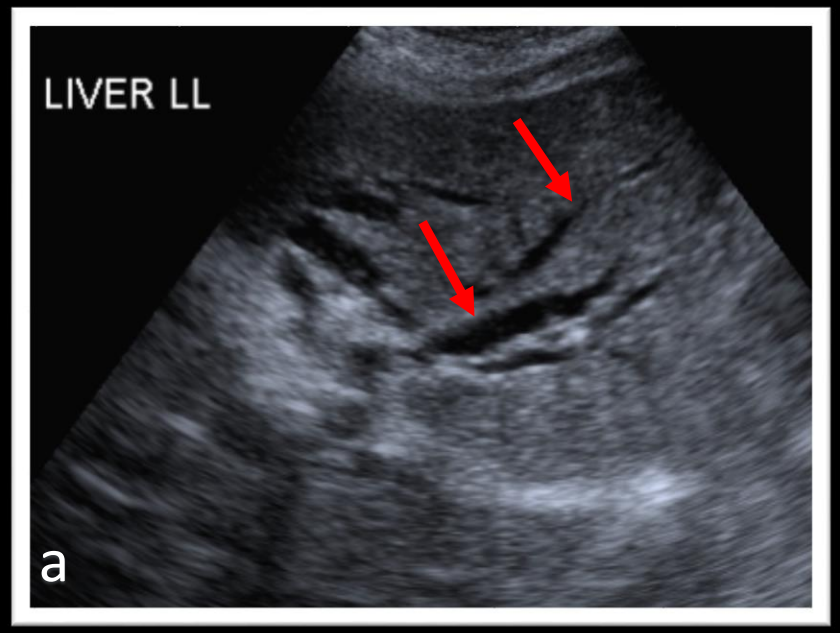
Metastases

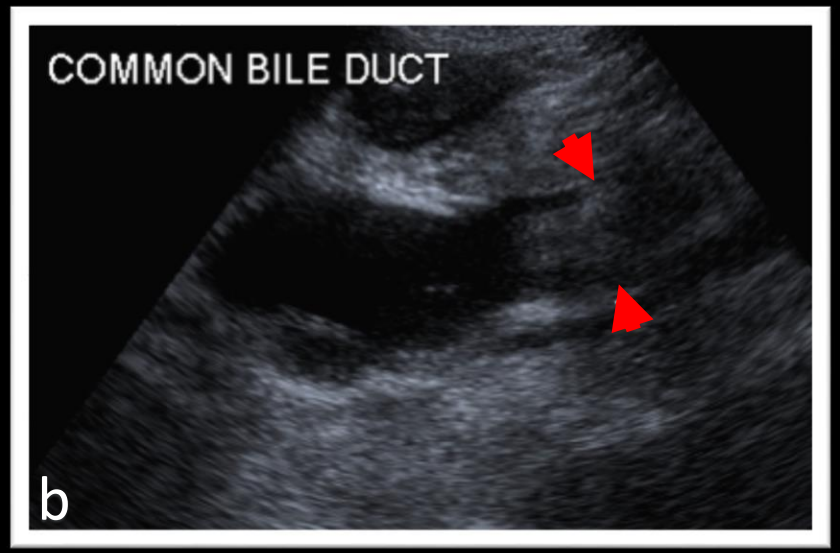
Elderly lady presenting with presenting with weight loss and painless jaundice. CT abdomen and pelvis performed in the portal venous phase to elucidate cause. (a,b) Bilobar hepatic masses seen (arrows) with a dominant mass at the hepatic confluence (arrowhead) with dilatation of the intrahepatic ducts. Abrupt cut-off of right posterior sectoral duct (dotted arrow) raising possibility of intraluminal extension. (c) Irregular thickening was noted in the rectosigmoid junction (arrow) with superior rectal lymphadenopathy (arrowhead). This was histologically proven adenocarcinoma.

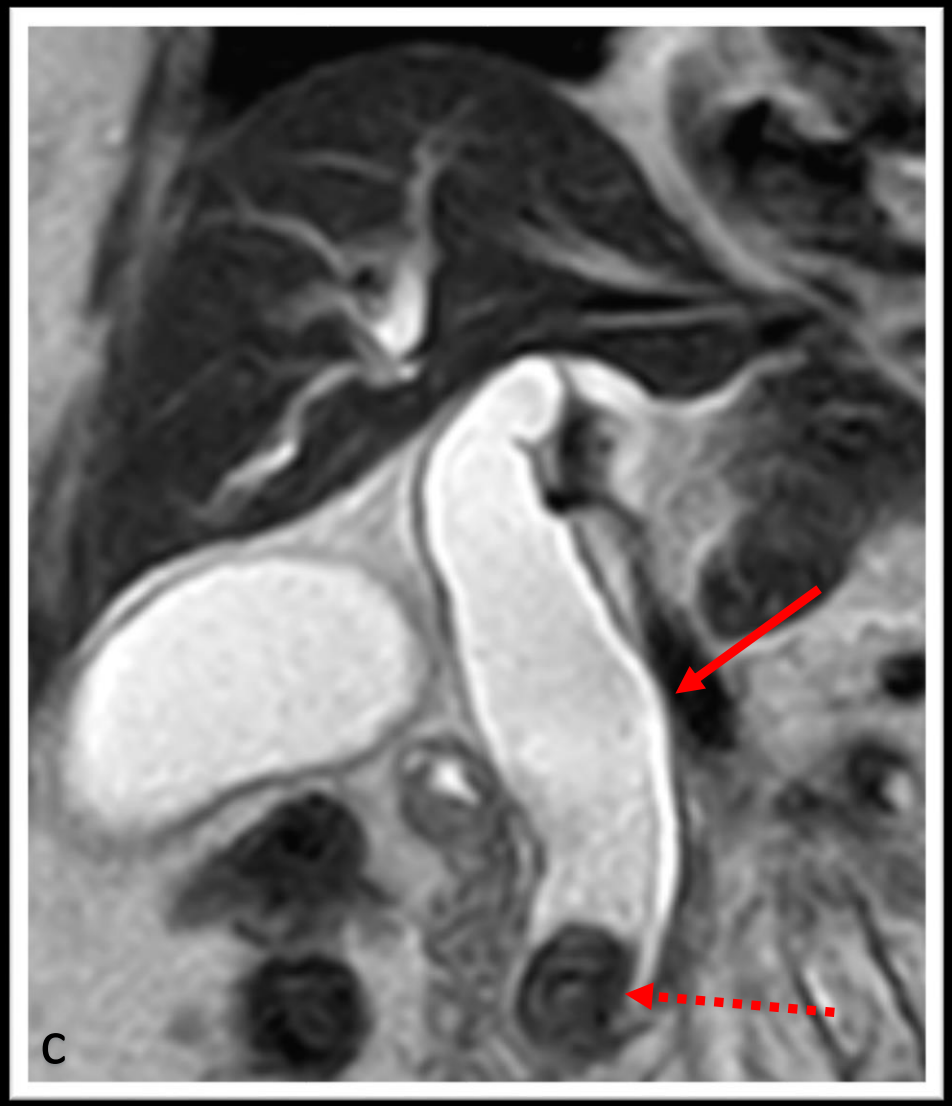
Dilatation at the level of the CHD/CBD

- Intraluminal
- Calculi/sludge
- Gas
- Parasites









Choledocholithiasis

Cholestatic LFTs. (a,b) Greyscale ultrasound demonstrating dilatation of the intrahepatic ducts (arrows) with a calculus in the distal common duct (arrow heads). (c) Coronal single-shot T2-weighted MR image showing a large calculus in the common duct (dotted arrow) with dilatation of the common duct (arrow).

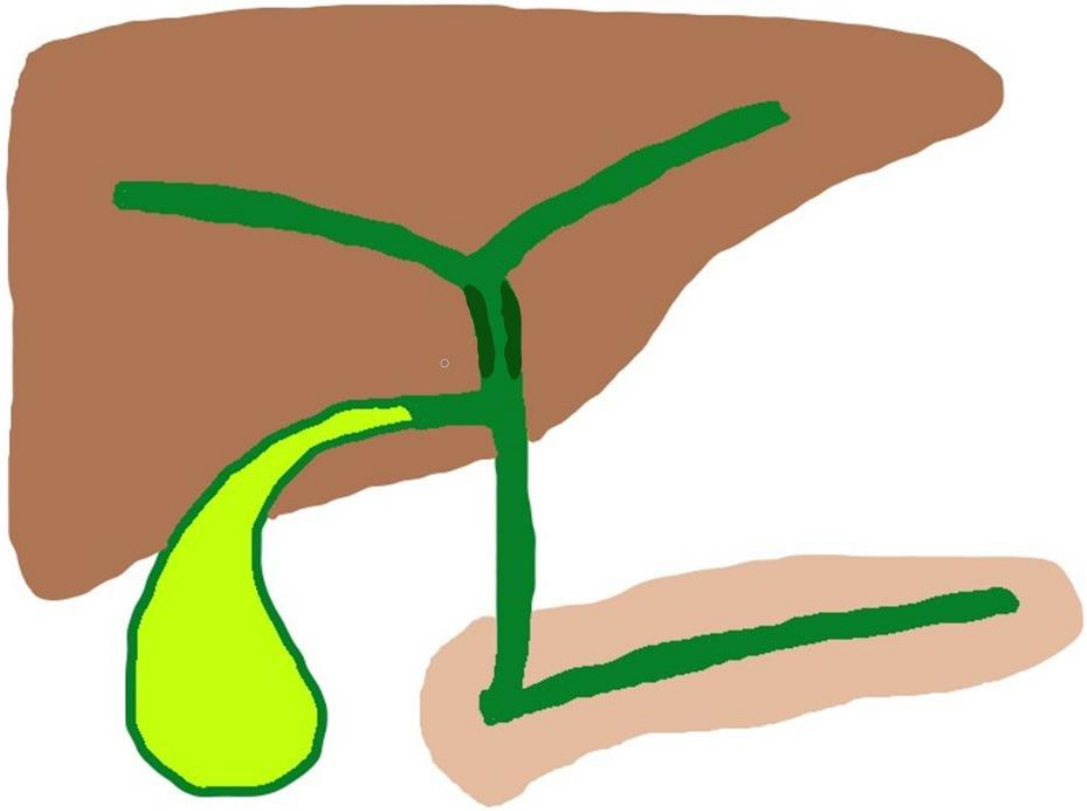
Dilatation at the level of the CHD/CBD

- Intraductal

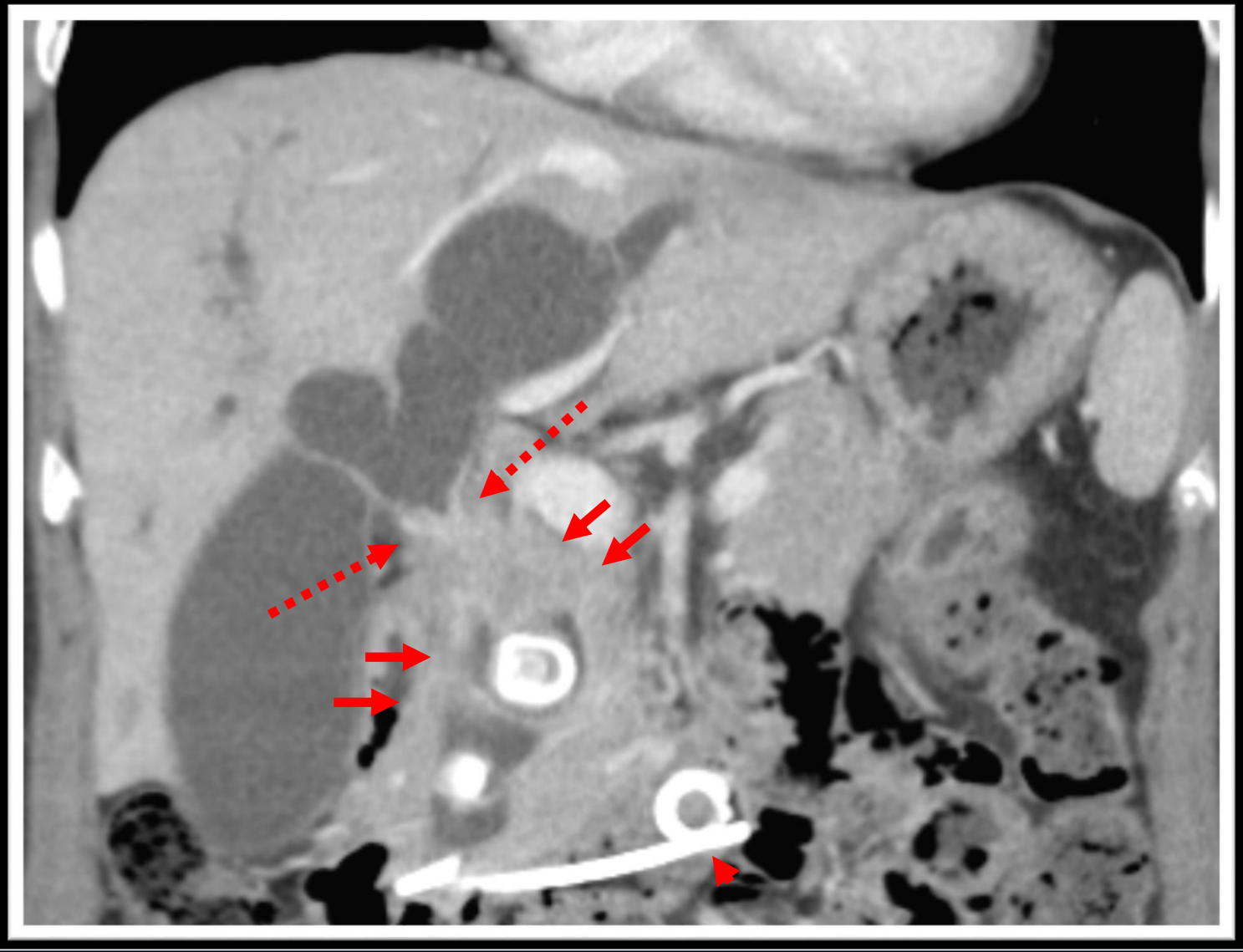
- Inflammatory stricture

- Previous biliary surgery or choledocholithiasis
- Difficult to distinguish radiologically from malignant stricture

- Cholangiocarcinoma

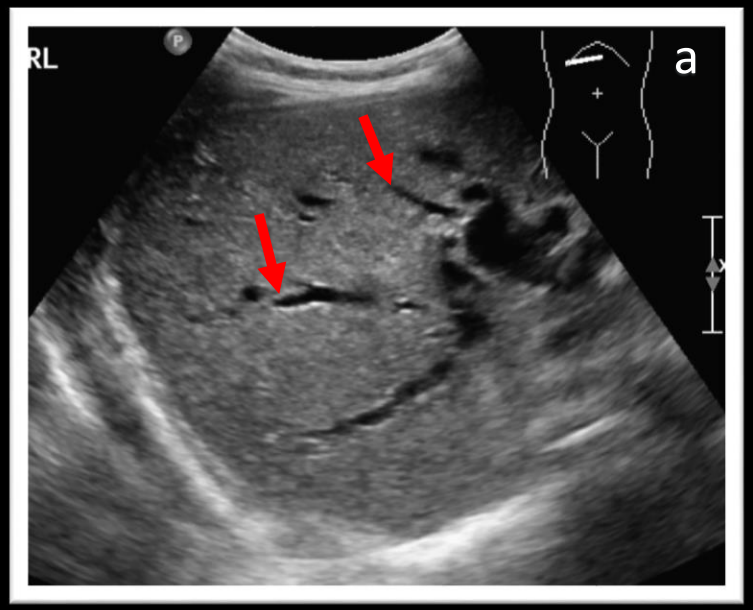


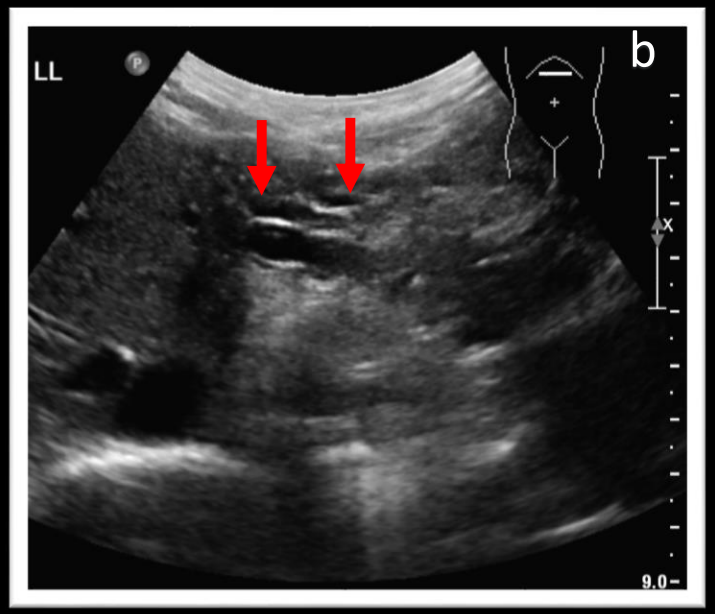
Hilar cholangiocarcinoma (Klatskin tumour)



Extrahepatic periductal cholangiocarcinoma manifesting as a stricture beginning in the proximal common duct on coronal post-contrast CT (dotted arrows). Extensive thickening is seen in the rest of the common duct (arrows) with intraductal calculi. Note the displaced double-J stent in D3 (arrowhead).

Hilar cholangiocarcinoma

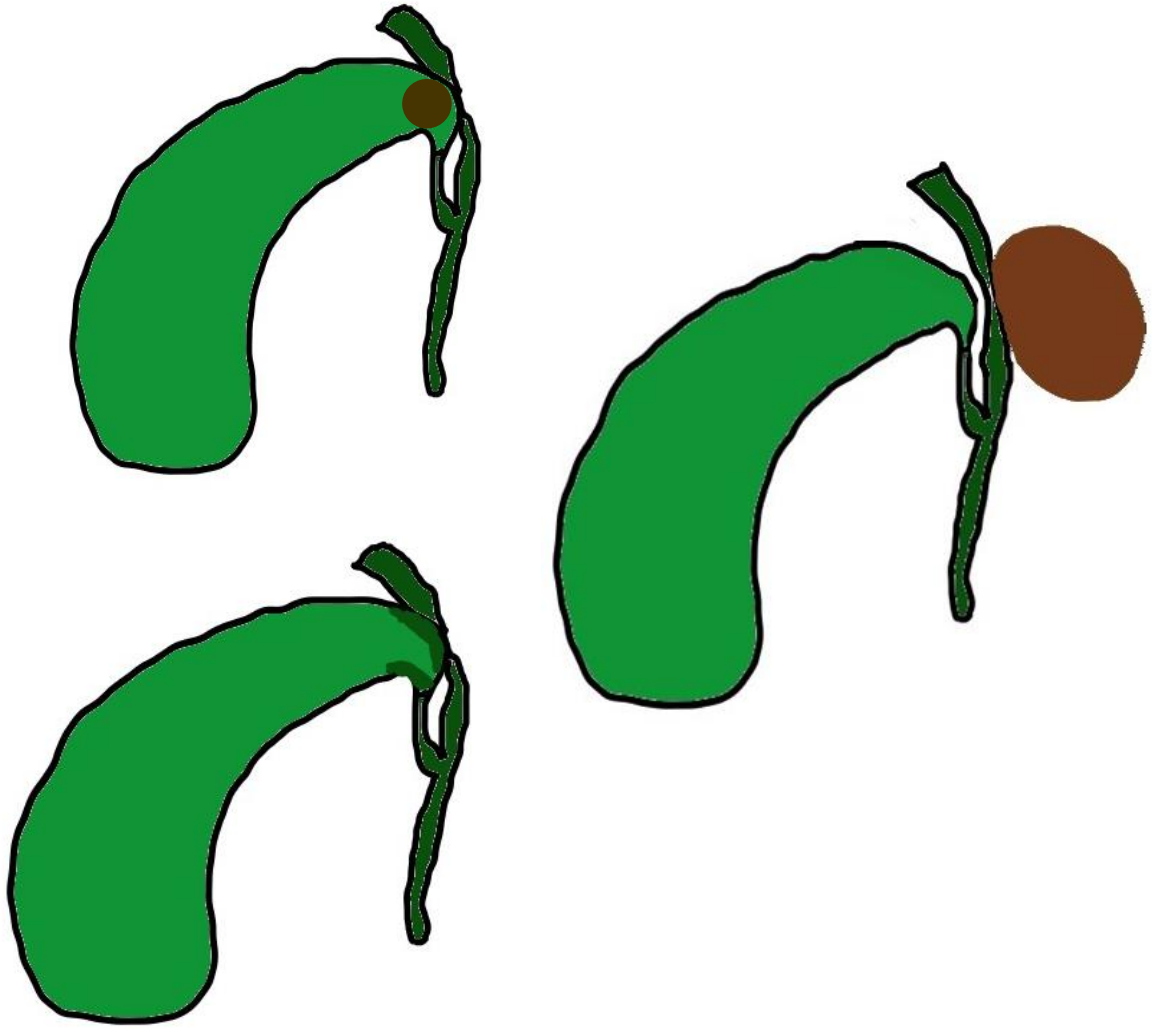


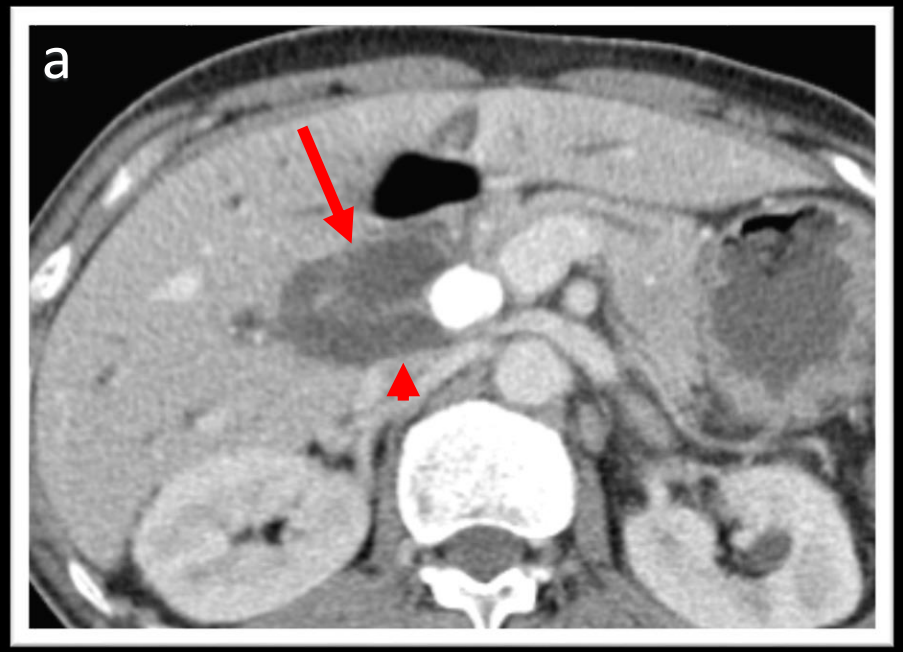


(a,b) Dilated intrahepatic ducts on greyscale ultrasound in a patient presenting with painless obstructive jaundice (arrows). (c) MIP MRCP demonstrating marked dilatation of left and right intrahepatic ducts, converging toward the hepatic confluence (arrow). (d) Dilated right intrahepatic ducts seen during PTC insertion. Left sided ducts were not opacified due to tight stricture at the confluence (arrow).

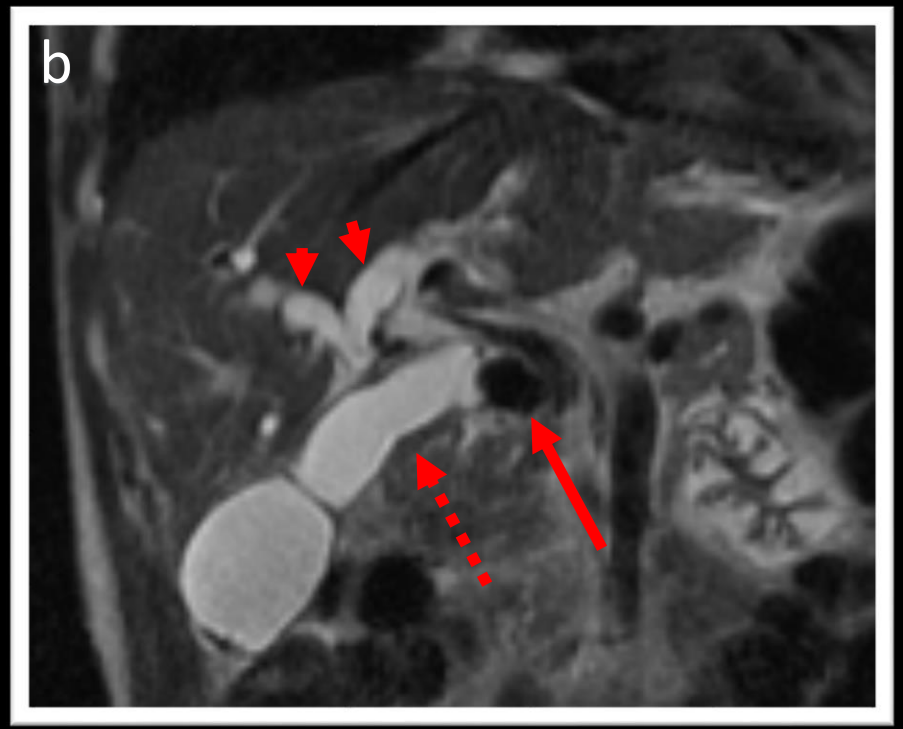
Dilatation at the level of the CHD/CBD

- Extraluminal
- Mirizzi’s syndrome
- Periportal lymphadenopathy
- Malignant infiltration from adjacent malignancy e.g. gallbladder, stomach, pancreas
- Portal biliopathy





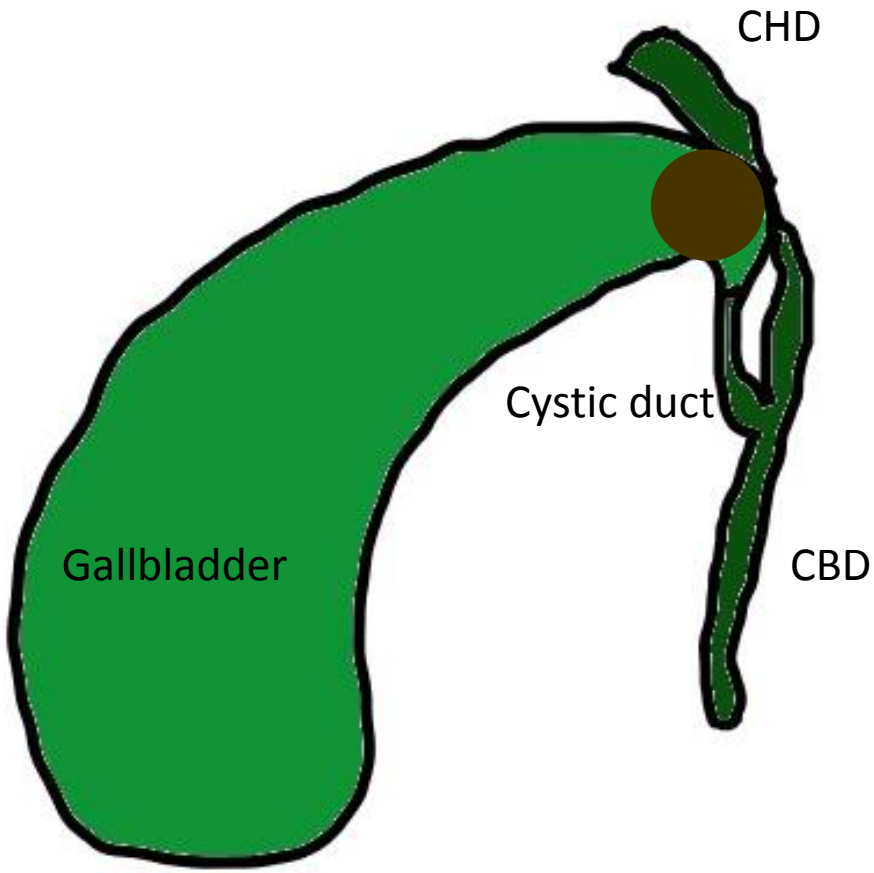
Patient with severe right hypochondrial pain and elevated ALP/GGT levels. (a) CT abdomen and pelvis in the portal venous phase demonstrates a large calculus at the junction of the cystic duct and common duct with marked dilatation of the cystic duct (arrow) and upstream ductal dilatation (arrowhead). (b) Coronal SSFSE T2w images of the biliary tree demonstrating the calculus (arrow) with dilatation of the cystic duct (dotted arrow) and intrahepatic ducts (arrowheads). (c) 3D MRCP demonstrating the extent of intrahepatic ductal dilatation.

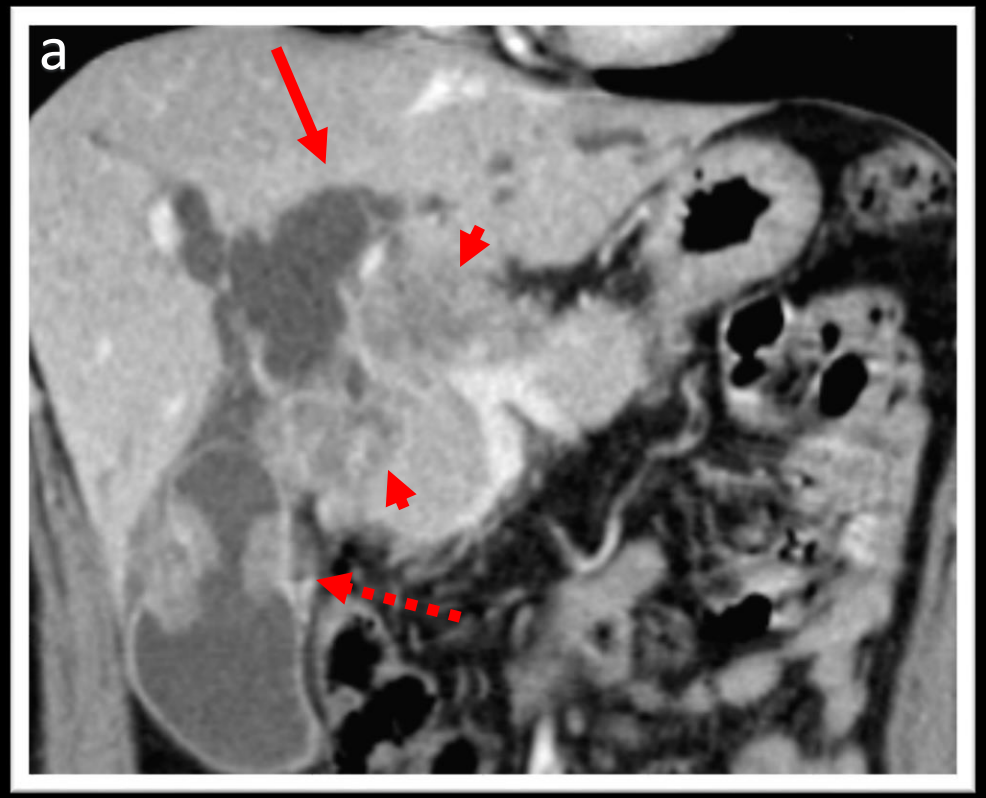


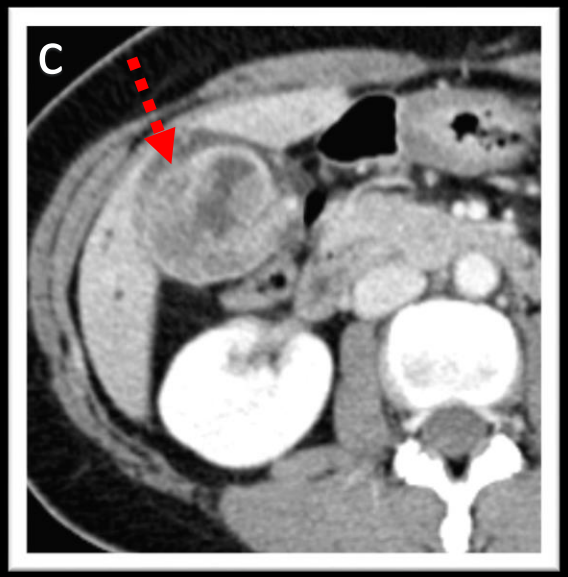
Mirizzi syndrome

Mirizzi syndrome

- Extrinsic compression of common hepatic duct (CHD) from an impacted stone at the gallbladder neck or cystic duct



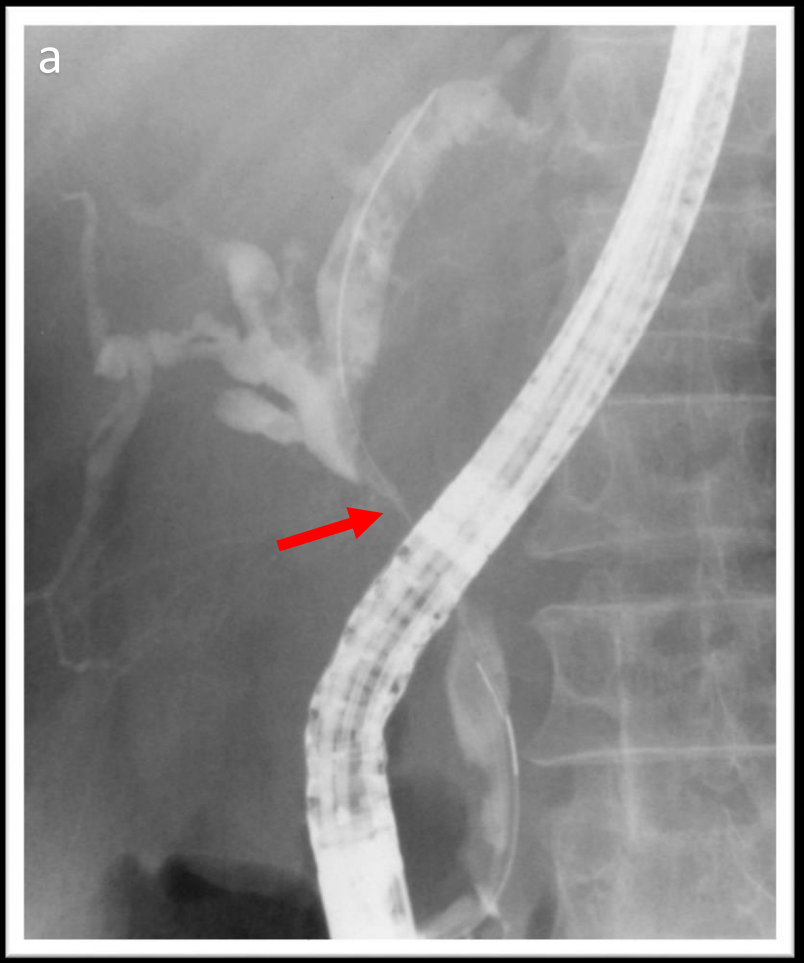


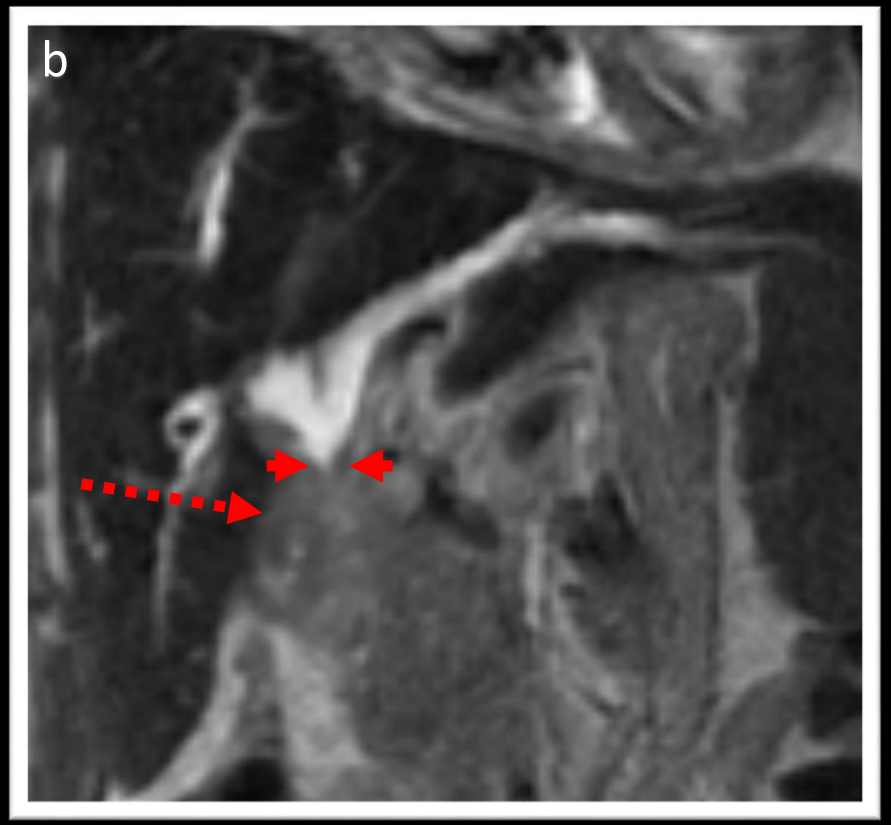


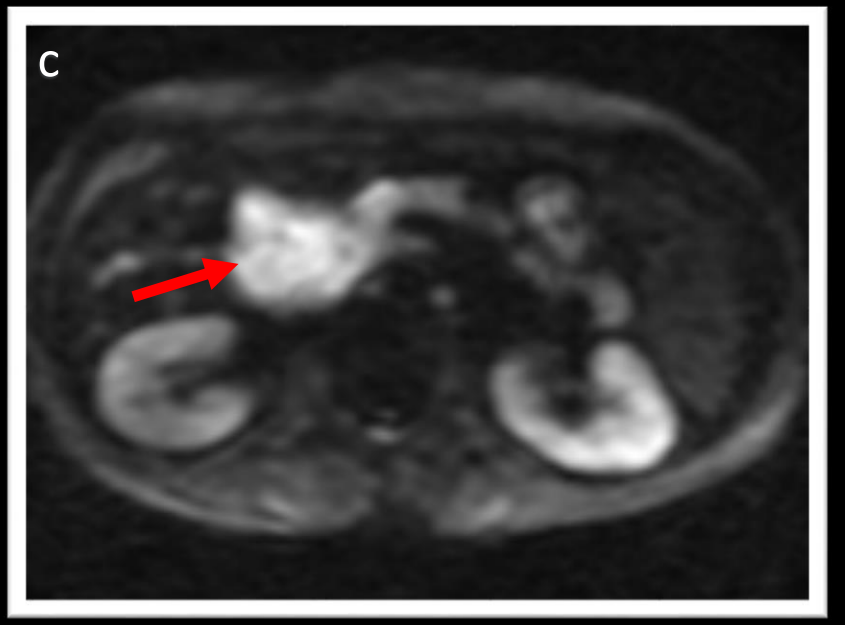
Porta hepatis lymphadenopathy

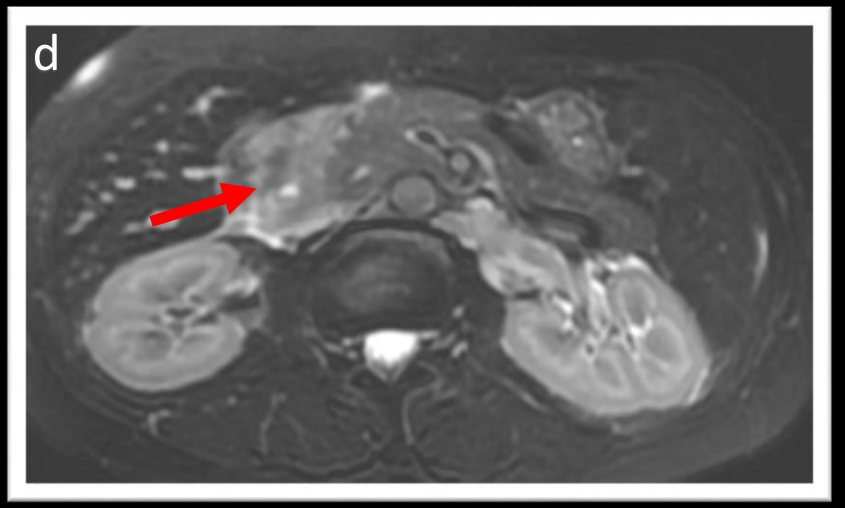
Middle-aged patient with dyspepsia and obstructive jaundice (a) Coronal CT images in the portal venous phase demonstrates an irregular mass in the gallbladder (dotted arrow) with heterogeneous nodal masses at the portal hepatis (arrowheads) resulting in intrahepatic duct dilatation (arrow). (b) Axial CT images demonstrates the nodal masses (arrowheads) involving the main portal vein (arrow). (c) Irregular mass in the gallbladder (dotted arrow) with extraluminal extension suspicious for gallbladder carcinoma.

Case courtesy of Dr Low Hsien Min





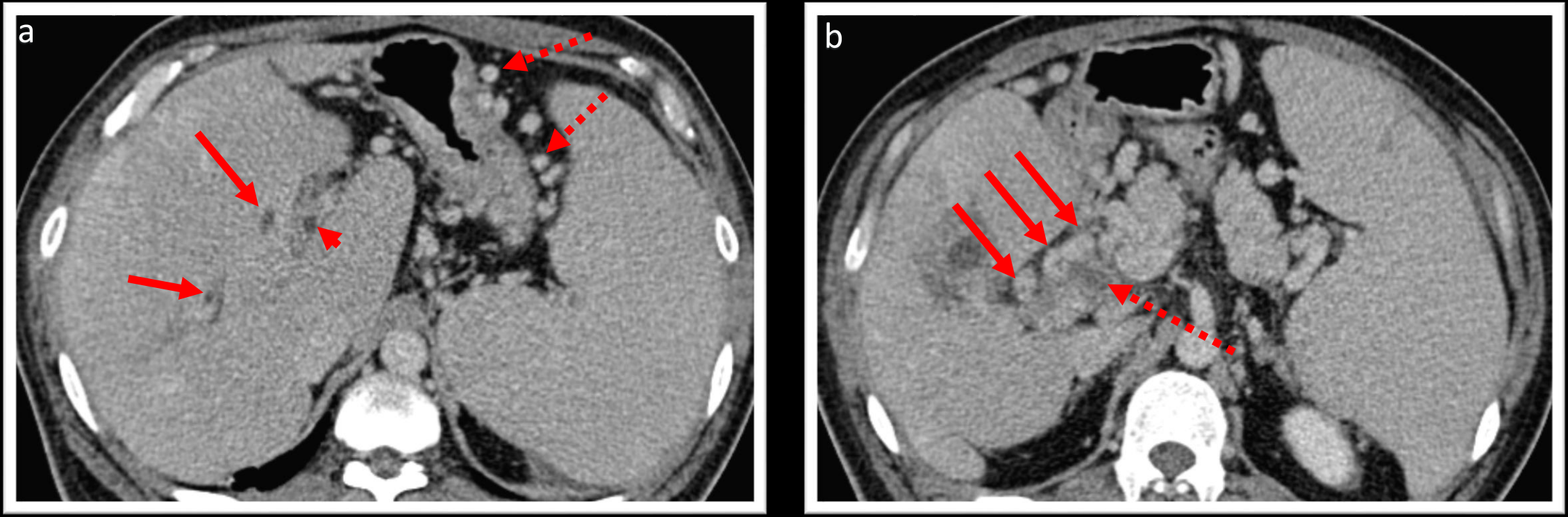




Elderly patient with a history of partial cholecystectomy for Mirizzi syndrome and new onset of jaundice. ERCP was initially performed to exclude choledocholithiasis. (a) ERCP demonstrates a stricture in the proximal common duct (arrow). No filling defects were seen distally. (b) Coronal SSFSE T2w images demonstrating irregular thickening at the remnant gallbladder neck (dotted arrow) with contiguous thickening and structuring of the adjacent proximal duct (arrowheads) resulting in upstream dilatation. (c) The mass demonstrates high signal on high B-value DWI (arrow). (d) High T2 signal (arrow) is seen on T2 FS images. This was histologically proven gallbladder carcinoma.

Gallbladder neck carcinoma

Portal biliopathy



Axial contrast-enhanced CT in the portal venous phase in a patient with portal vein thrombosis, cranial to caudal. (a) Mild dilatation of the intrahepatic ducts (arrows) and common hepatic duct (arrowhead). Multiple perigastric varices (dotted arrows) and massive splenomegaly also noted. (b) Cause of obstruction due to extrinsic compression by cavernous transformation of portal vein at the porta hepatis (arrows). The main portal vein is thrombosed (dotted arrow).

Portal biliopathy

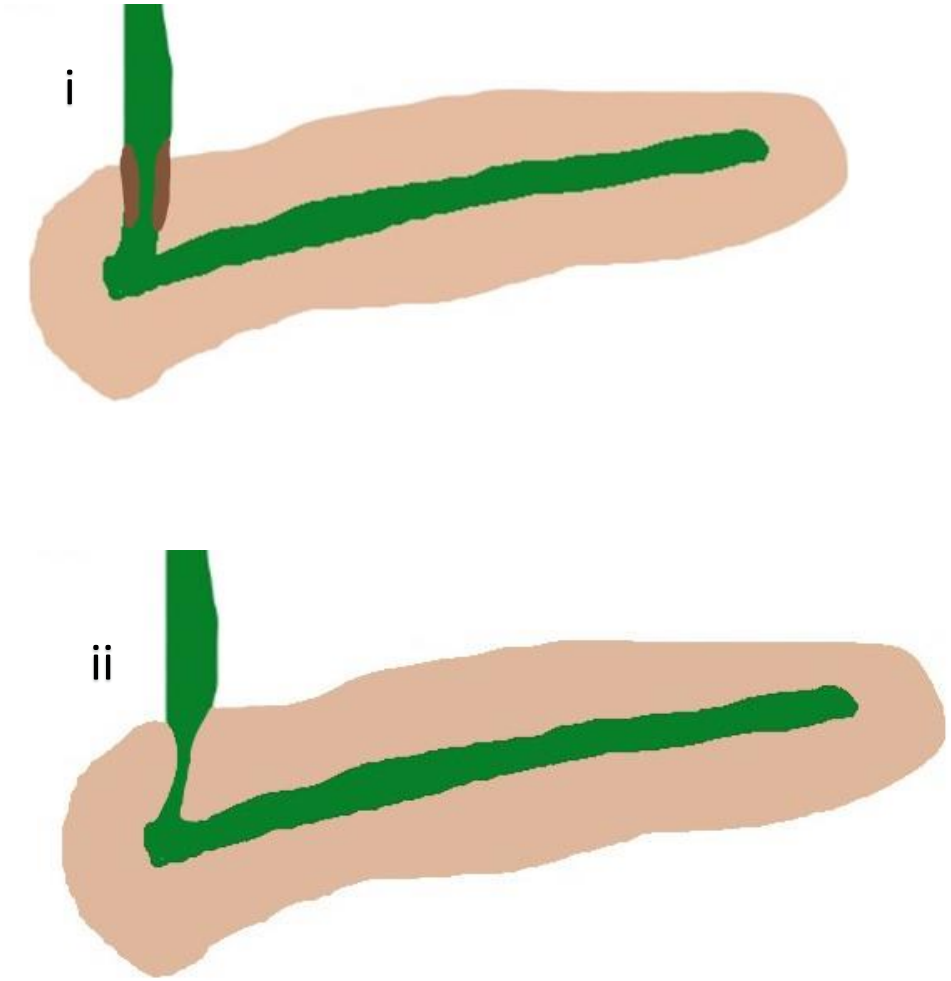
- Biliary obstruction secondary to obstruction by venous collaterals from cavernous transformation of portal vein secondary to underlying portal vein thrombosis
- Imaging features

- Multiple collateral vessels around porta hepatis
- Abrupt cut-off of dilated duct around venous collaterals
- May see features of cirrhosis and portal hypertension e.g. splenomegaly

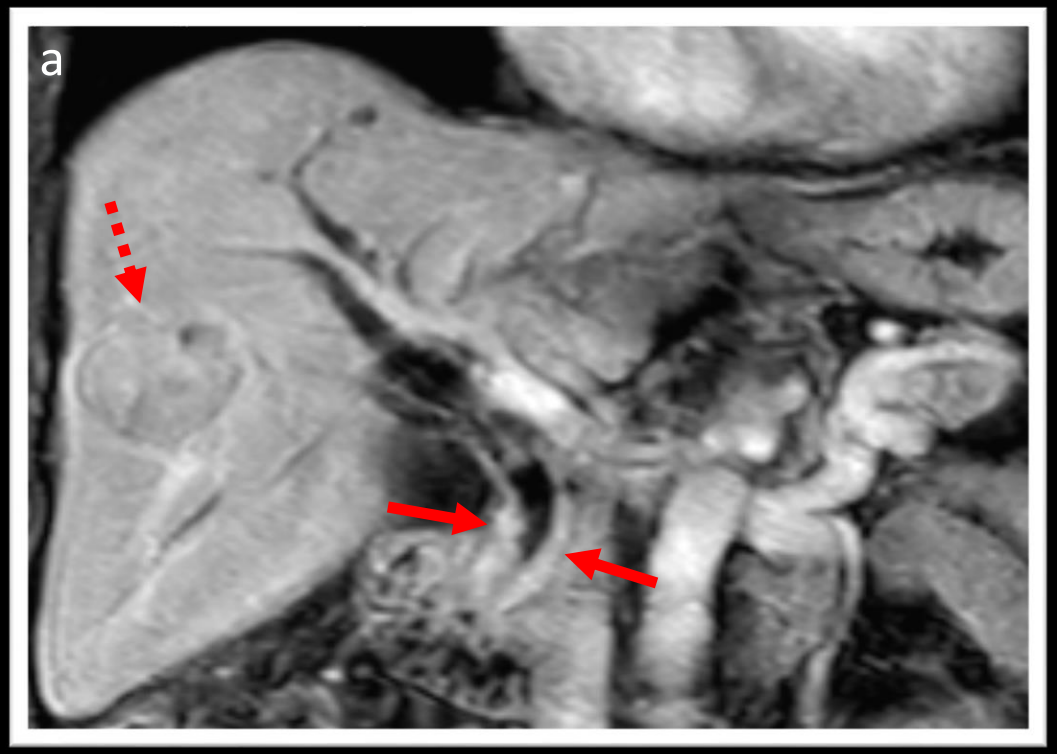
Dilatation of the distal CBD without pancreatic ductal dilatation

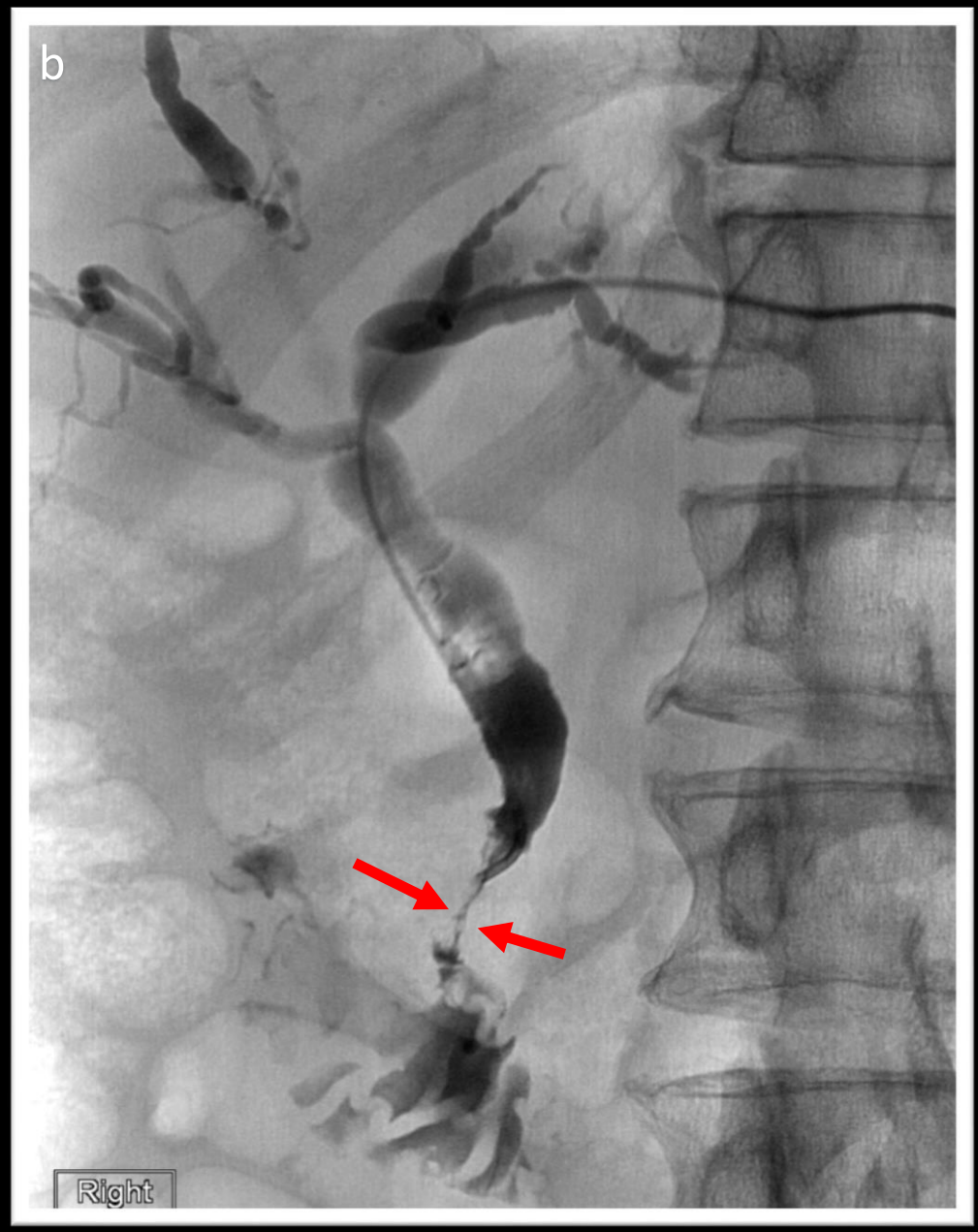
i) Distal CBD cholangiocarcinoma proximal to pancreaticobiliary ductal union

ii) Extrinsic compression due to underlying acute pancreatitis, stricturing or occult tumour



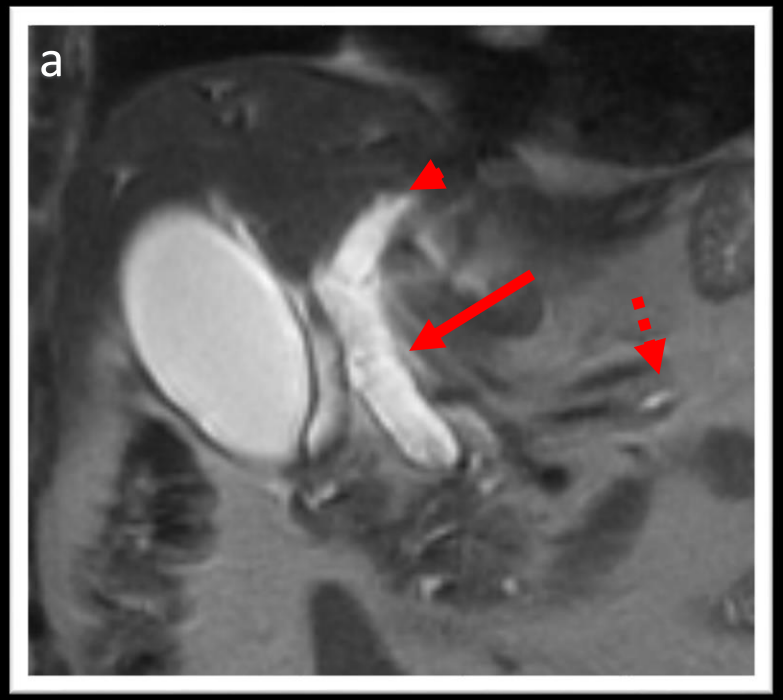
Distal CBD cholangiocarcinoma (with incidental HCC)

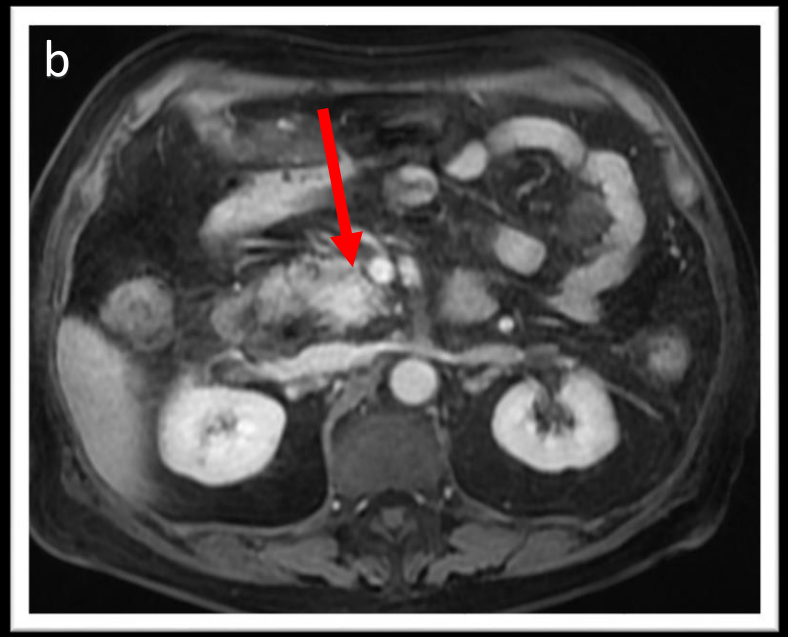


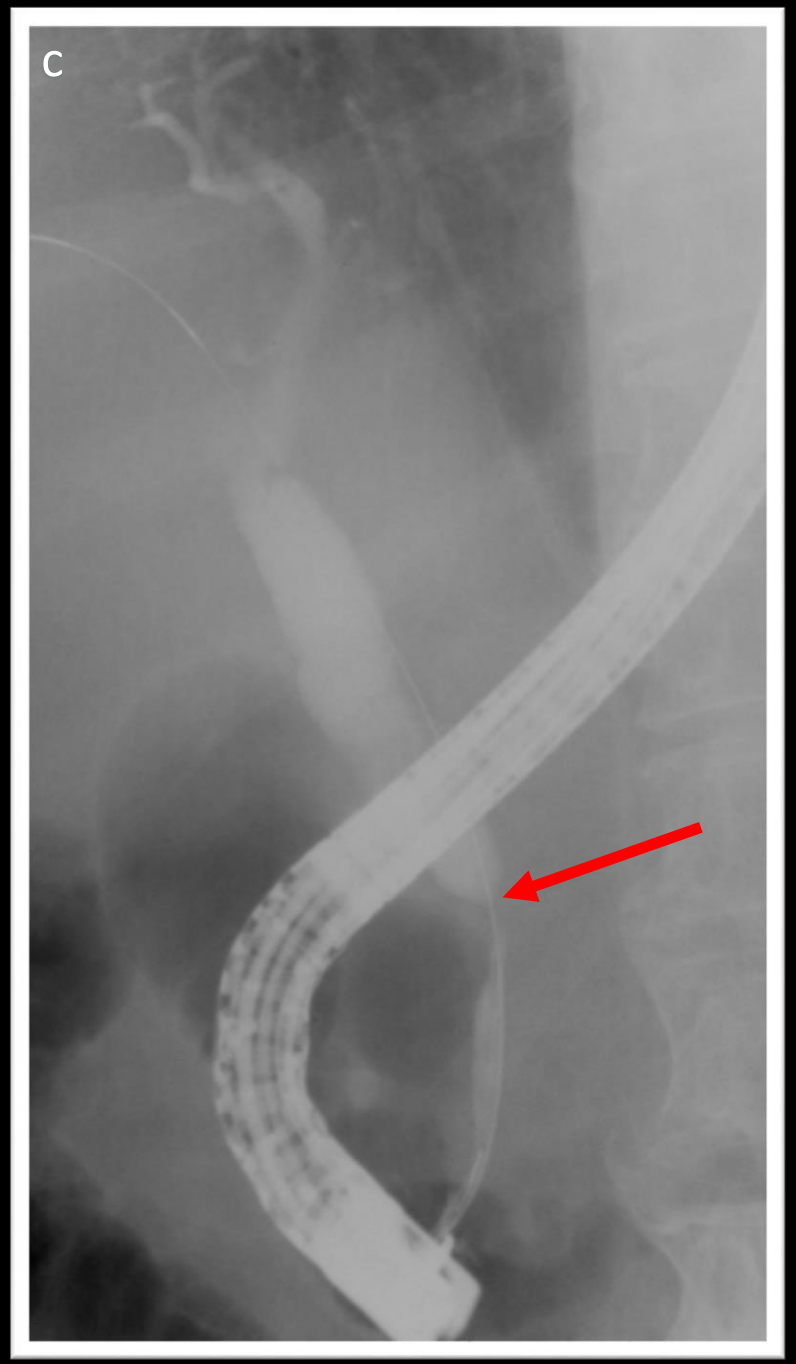


Patient presenting with obstructive jaundice. (a) Coronal T1w FS post-contrast images in the portal venous phase demonstrates stricturing in the distal common duct (arrows). Incidental note of a mass in the right lobe with a pseudocapsule (arrowhead). The pancreatic duct was not dilated. (b) Stricturing demonstrating in the distal common duct on fluoroscopy during PTC insertion for biliary drainage.

The patient underwent a Whipple's operation and right hemihepatectomy. Histology: Cholangiocarcinoma and hepatocellular carcinoma.







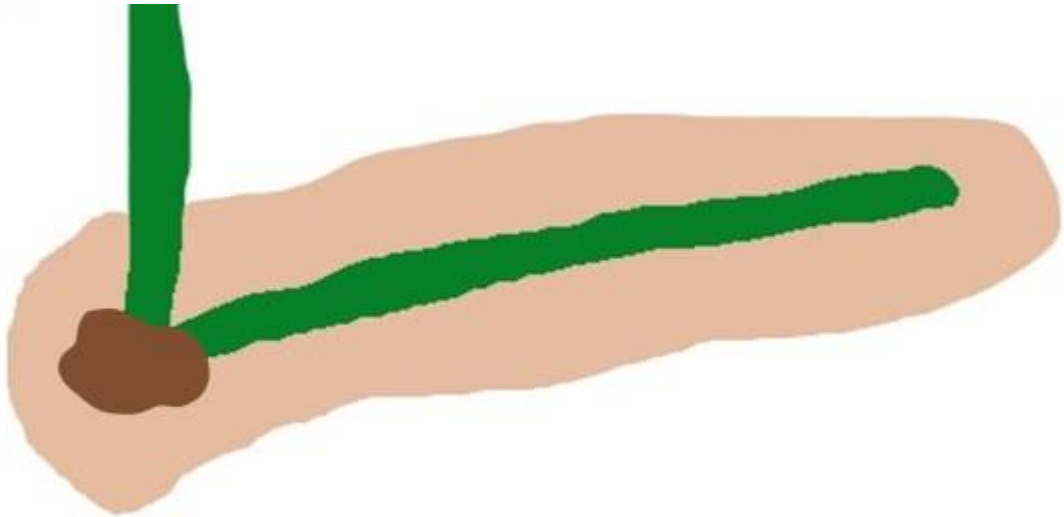
Pancreatic head carcinoma

Patient presenting with painless jaundice. (a) Coronal SSFSE T2w images demonstrating dilatation of the common duct (arrow) with involvement of the intrahepatic ducts (arrowhead). The main pancreatic duct is not dilated (dotted arrow). (b) FS post-gadolinium images in the portal venous phase demonstrates a vague enhancing mass in the pancreatic head (arrow). (c) Stricturing demonstrating in the distal common duct on fluoroscopy during ERCP.

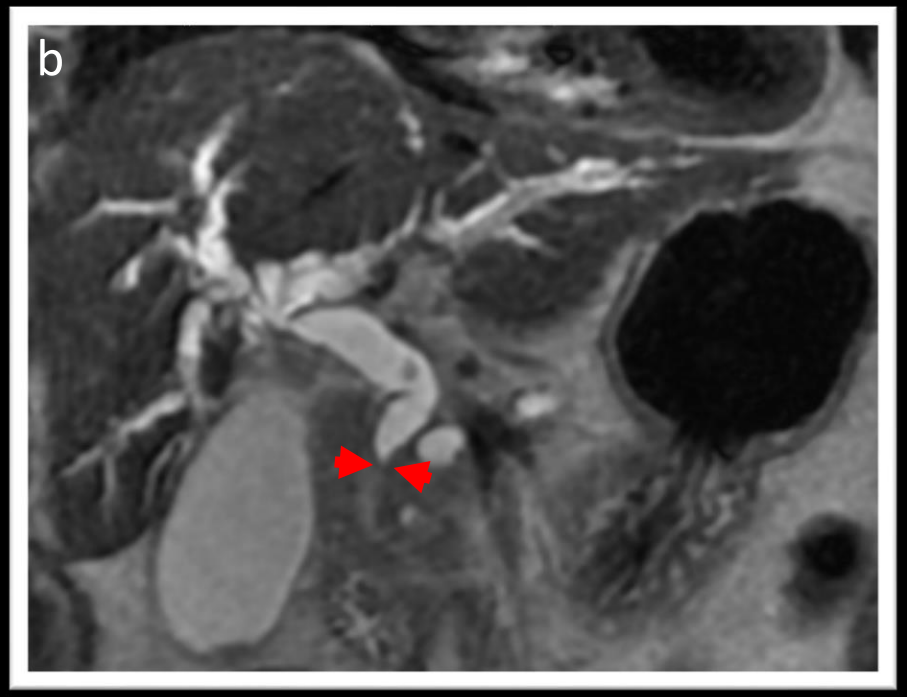
The patient underwent a Whipple's operation.
Histology: Pancreatic adenocarcinoma

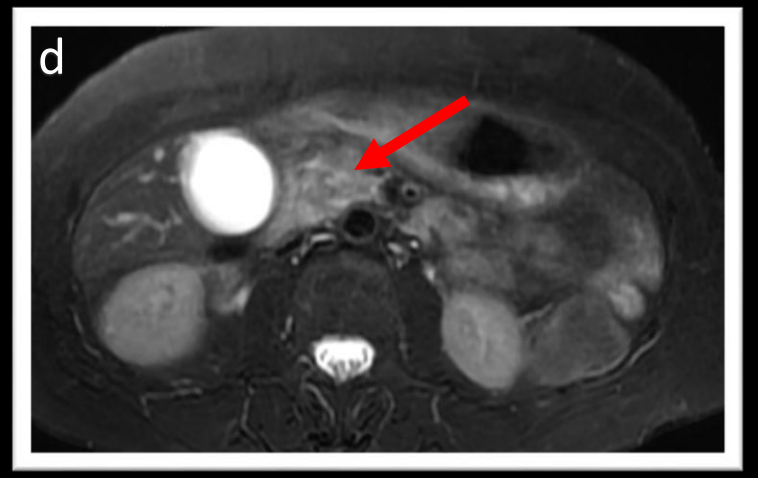
Dilatation of the distal CBD with pancreatic ductal dilatation (double duct sign)

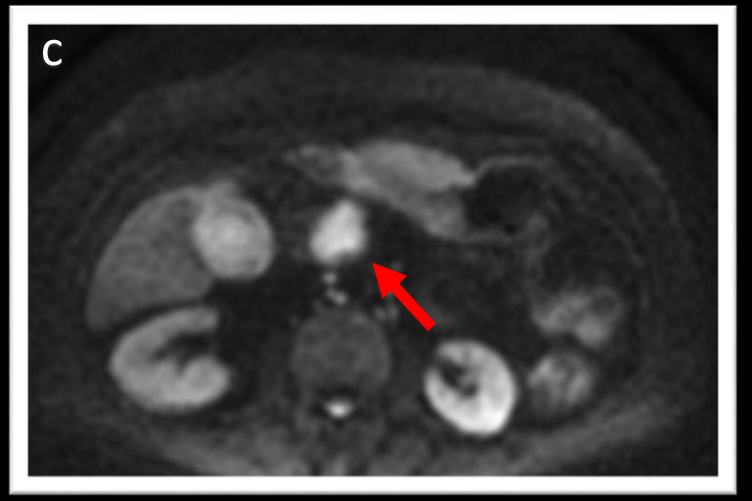
- Lesion at pancreatic head/uncinate process
- Periampullary lesion arising from distal CBD, pancreas or duodenum
- Often radiologically occult; may require EUS for further evaluation



Pancreatic head carcinoma



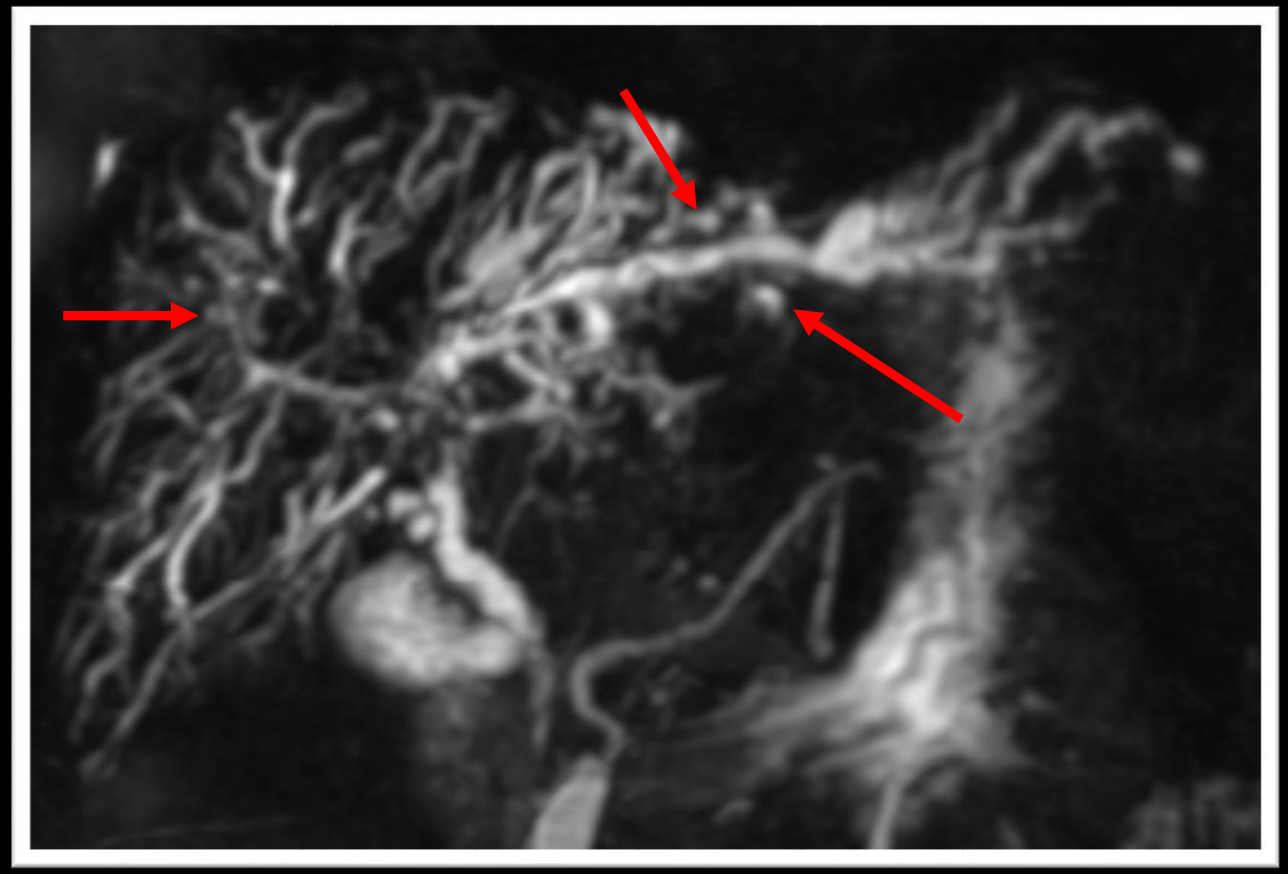




Patient on follow up for main duct IPMN (a) Coronal CT in the portal venous phase worsening dilatation of the main pancreatic duct (arrow) with new onset intra- and extrahepatic ductal dilatation (dotted arrow) - “double duct sign” (b) Coronal SSFSE T2w images of the biliary tree the double duct sign with abrupt cut-off at the pancreatic head (arrowheads) (c) A vague T2 hyperintense mass is seen at the pancreatic head (arrow) with corresponding (d) High signal on DWI b-1000 images (arrow).

Multi-level biliary dilatation

- Involvement of intra- and extrahepatic ducts usually favours inflammatory process
- Primary Sclerosing Cholangitis
- Recurrent Pyogenic Cholangitis



MIP MRCP demonstrating multifocal ductal dilatation, worse in the left lobe in a patient with Crohn's disease, suspicious for primary sclerosing cholangitis.

Primary Sclerosing Cholangitis

Primary Sclerosing Cholangitis

- Idiopathic inflammatory condition affecting the biliary tree, manifesting as multifocal biliary strictures
- Strongly associated with inflammatory bowel disease (Crohn's disease, ulcerative colitis) and thus seen in younger patients
- Imaging features
- Multifocal, short segment biliary strictures
- Atrophy of the left lobe

Mimics of Biliary Tree Dilatation

- Choledochal cysts
- Caroli’s disease
- Peribiliary cysts

Type IVa Choledochal Cyst

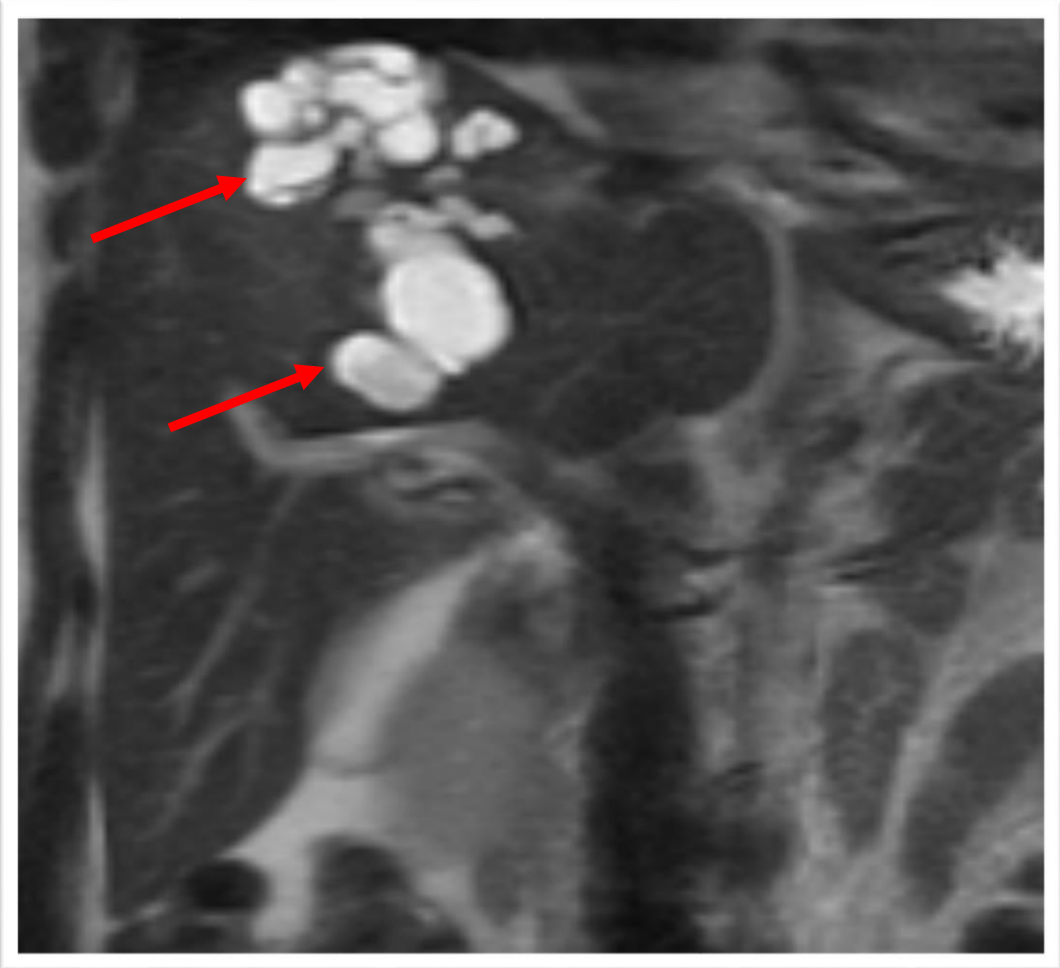
Patient evaluated for dilated bile ducts on US.

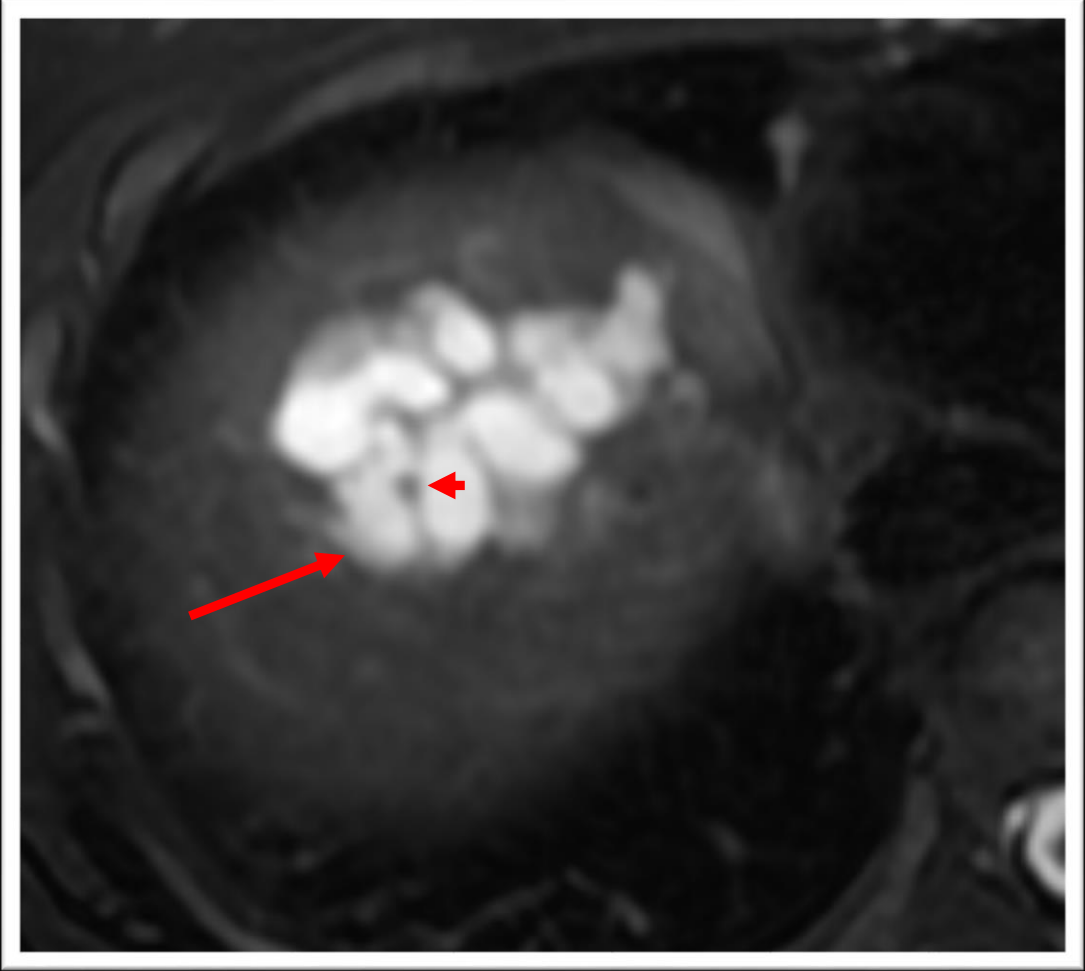
Coronal SSFSE T2w images demonstrating fusiform dilatation of the right hepatic duct (arrowhead) and common duct (long arrow). No intraluminal signal void seen to suggest a calculus. Note the large common channel draining the bile duct and pancreatic duct which is a well known association. Incidental cystic pancreatic lesion (short arrows).

Choledochal cyst

- Congenital cystic dilation of the biliary tree
- Postulated to be secondary to chronic reflux of pancreatic juice into biliary tree from anomalous pancreaticobiliary ductal junction, resulting in ductal irritation and dilation
- Five main types using the Todani classification
- Imaging features
- Long common channel between common duct and main pancreatic duct before duodenum
- Need to exclude other causes of ductal dilatation e.g. stones, strictures

Caroli's disease





Caroli's disease in a young female patient. (a) Coronal SSFSE T2w images demonstrating segmental dilatation of ducts in segment 4/8 (arrows) with no obstructing cause demonstrated. (b) A central dot sign (arrowhead) is noted on T2w FS images representing the fibrovascular bundle surrounded by dilated bile ducts.

Caroli’s disease

- Congenital autosomal recessive disorder with multifocal cystic dilatation of intrahepatic ducts; may involve extrahepatic ducts in 53%
- Associated with congenital hepatic fibrosis
- Presentation in childhood or early adulthood
- Imaging features
- Saccular or fusiform dilation of intrahepatic ducts and occasionally extrahepatic ducts
- Enhancing central fibrovascular bundle (central dot sign)
- Multiple foci of narrowing/stenoses

Management of incidentally detected biliary ductal dilatation

- Few studies available on management of incidentally detected biliary ductal dilatation
- Kim et al: 49 asymptomatic patients with CBD dilatation (>7 mm) received ERCP; clinically significant lesions including CBD cancer, adenoma, and choledochal cyst were found in 16.3 %
- Malik et al: causative lesions of bile duct dilatation were found in 53% of patients with elevated liver enzymes through EUS.
- Jeon et al: 7.4% of patients had clinically significant cause of biliary diltation. High incidence rate of pancreaticobiliary malignancies.
- **Asymptomatic biliary dilatation may be a prodrome of significant biliary disease and further evaluation and regular follow-up should be considered**

Conclusion

- Imaging plays a vital role in the evaluation of biliary ductal dilatation
- Important to consider clinical context and liver function test results when evaluating duct diameter
- Differential diagnoses should be considered based on level and site of obstruction
- Apart from conventional morphological CT and MR which provide information based on anatomy, other sequences such as diffusion MRI, T2 FS images and contrast-enhanced studies with hepatocyte specific agents can help improve sensitivity and diagnostic ability

References

- SG Parulekar. Ultrasound Evaluation of Common Bile Duct Size. Radiology 133 (1979): 703-707.
- S Senturk et al. Diameters of the common bile duct in adults and postcholecystectomy patients: A study with 64-slice CT. Eur J Radiol 81 (2012); 39–42.
- F Tse et al. Nonoperative imaging techniques in suspected biliary tract obstruction. *HPB : The Official Journal of the International Hepato Pancreato Biliary Association*. 2006;8(6):409-425.
- KEL Kwan et al. Recurrent pyogenic cholangitis: a review of imaging findings and clinical management. Abdom Radiol (NY). 2017 Jan;42(1):46-56.
- AD Levy et al. Caroli's Disease: Radiologic Spectrum with Pathologic Correlation. AJR 2002;179:1053–1057.
- OH Kim et al. Imaging of the choledochal cyst. Radiographics. 1995;15 (1): 69-88.
- JE Kim et al. The clinical significance of common bile-duct dilatation in patients without biliary symptoms or causative lesions on ultrasonography. Endoscopy. 2001;33:495–500.
- S Malik et al. EUS yield in evaluating biliary dilatation in patients with normal serum liver enzymes. Dig Dis Sci. 2007;52:508–512.
- J Jeon et al. Clinical Significance and Long-Term Outcome of Incidentally Found Bile Duct Dilatation. Dig Dis Sci 2013; 2792-9.