Hepatic and biliary pathology from radiological point of view

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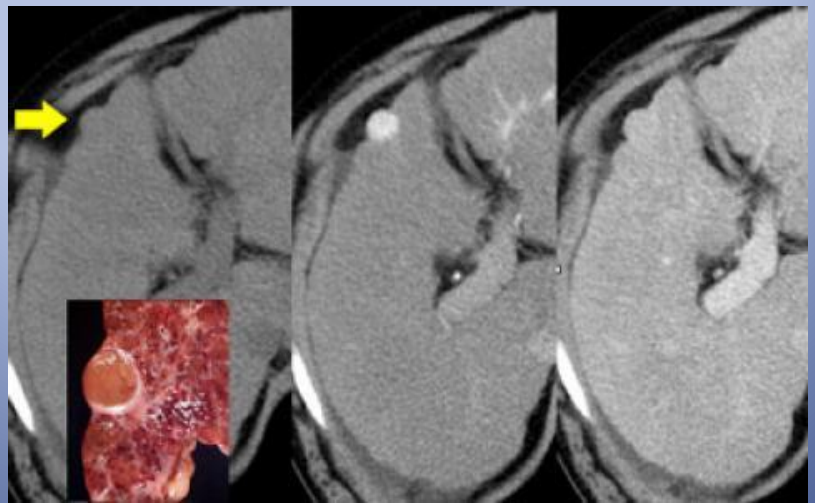
Characterisation of liver masses

- The conspicuity of a liver lesion depends on the attenuation difference between the lesion and the normal liver
- .On a non enhanced CT-scan (NECT) liver tumors usually are not visible, because the inherent contrast between tumor tissue and the surrounding liver parenchyma is too low.
  Only a minority of tumors contain calcifications, cystic components, fat or hemorrage and will be detected on a NECT.So i.v. contrast is needed to increase the conspicuity of lesions.
- When we give i.v. contrast, it is important to understand, that there is a dual blood supply to the liver.Normal parenchyma is supplied for 80% by the portal vein and only for 20% by the hepatic artery, so it will enhance in the portal venous phase.
- All liver tumors however get 100% of their blood supply from the hepatic artery, so when they enhance it will be in the arterial phase.
- This difference in bloodsupply results in different enhancement patterns between liver tumors and normal liver parenchyma in the various phases of contrast enhancement.

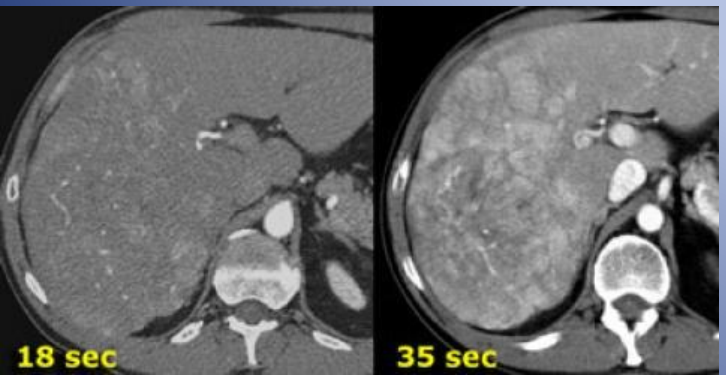


Multi-phasic CT scan

- In the **arterial phase** hypervascular tumors will enhance via the hepatic artery, when normal liver parenchyma does not yet enhances, because contrast is not yet in the portal venous system.
- These hypervascular tumors will be visible as hyperdense lesions in a relatively hypodense liver.
- However when the surrounding liver parenchyma starts to enhance in the portal venous phase, these hypervascular lesion may become obscured.
- In the **portal venous phase** hypovascular tumors are detected, when the normal liver parenchyma enhances maximally.
- These hypovascular tumors will be visible as hypodense lesions in a relatively hyperdense liver.
- In the **equilibrium phase** at about 10 minutes after contrast injection, tumors become visible, that either loose their contrast slower than normal liver, or wash out their contrast faster than normal liver parenchyma.
- These lesions will become either relatively hyperdense or hypodense to the normal liver.

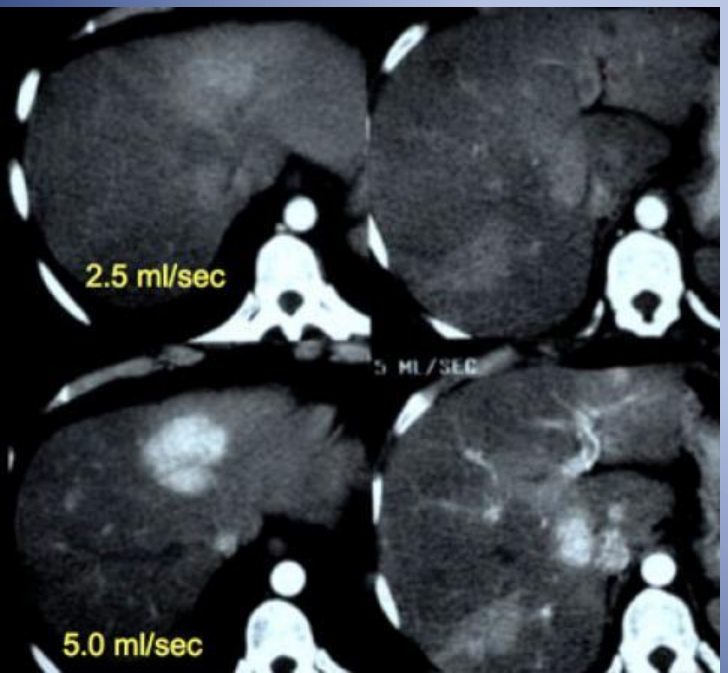
Arterial phase imaging

- Optimal timing and speed of contrast injection are very important for good arterial phase imaging.
- Hypervascular tumors will enhance optimally at 35 sec after contrast injection (late arterial phase).
- This time is needed for the contrast to get from the peripheral vein to the hepatic artery and to diffuse into the liver tumor.
- The only time that an early arterial phase is needed is when you need an arteriogram, for instance as a roadmap for chemoembolization of a liver tumor.



On the left a patient who underwent two phases of arterial imaging at 18 and 35 seconds. In the early arterial phase we nicely see the arteries, but we only see some irregular enhancement within the liver. In the late arterial phase we can clearly identify multiple tumor masses. Notice that in the late arterial phase there has to be some enhancement of the portal vein

- Timing of scanning is important, but almost as important is speed of contrast injection.
- For arterial phase imaging the best results are with an injection rate of 5ml/sec.
- There are two reasons for this better enhancement: at 5ml/sec there will be more contrast delivered to the liver when you start scanning and this contrast arrives in a higher concentration.
- On the following patient with cirrhosis examined after contrast injection at 2.5ml/sec and at 5ml/sec.
- At 5ml/sec there is far better contrast enhancement and better tumor detection.

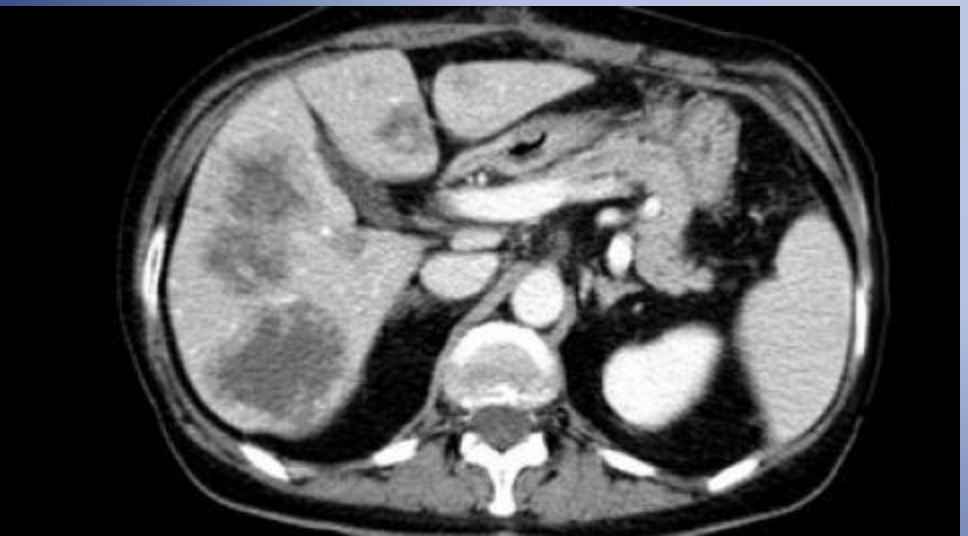


Use arterial phase imaging in the following situations:

1. Characterisaton of a liver lesion of unknown origin.
2. Detection of HCC in patients with a high alpha 1 foetoprotein.
3. Screening of cirrhotic patients for HCC.
4. Detection of metastases in patients with hypervascular tumors.

Portal Venous phase

- **Portal venous phase imaging works on the opposite idea.**
  We image the liver when it is loaded with contrast through the portal vein to detect hypovascular tumors (figure).
  The best moment to start scanning is at about 75 seconds, so this is a late portal venous phase.
- **because enhancement of the portal vein already starts at 35 sec in the late arterial phase.**
  This late portal venous phase is also called the hepatic phase because there already must be enhancement of the hepatic veins.
- If you do not seen enhancement of the hepatic veins, you are too early.
- If you only do portal venous imaging, for instance if you are only looking for hypovascular metastases in colorectal cancer, fast contrast injection is not needed, because in this phase the total amount of contrast is more important and 3ml/sec will be sufficient.



Hypovascular metastases seen as hypodense lesions in the late portal venous phase. Notice some rim enhancement of the more viable peripheral areas of the metastases.

Equilibrium Phase

- The equilibrium phase is when contrast is moving away from the liver and the liver starts to decrease in density.
- **This phase begins at about 3-4 minutes after contrast injection and imaging is best done at 10 minutes after contrast injection.**
  This phase can be valuable if you're looking for:

1. fast tumor washout in hypervascular tumors like HCC.
2. retention of contrast in the blood pool as in hemangiomas.
3. the retention of contrast in fibrous tissue in capsules (HCC) or scar tissue (FNH, Cholangioca).

Intravenous contrast agent

Phase	Time	Indications
No contrast	-	*Kidney/ureteral stones, arterial calcifications*
Arterial	*20 - 30 sec*	*Abdominal bleeding, aortic aneurysm, arterial stenosis/occlusions, hypervascular liver metastases, pancreas tumors*
Portal venous	*60 - 80 sec*	*Screening, hypovascular liver metastases, abscess formation, venous thrombosis*
Nephrogenic	*80 - 100 sec*	*Kidney tumors, kidney trauma*
Equilibrium /delayed	*6 - 10 min*	*Ureteral obstruction or leaks, characterization of liver tumors*

the approach to characterizing a focal liver lesion seen on CT:

- begins with the determination of its **density:**
- If the lesion is of near water density, homogeneous, has sharp margins and shows no enhancement, then it is a cyst.

- If the lesion does **enhance**, then the next step is to determine whether the lesion could be a hemangioma, since this is by far the most common liver tumor. The enhancement should be peripheral and nodular, with the same density as the bloodpool in all phases.

- If it is not a cyst nor a hemangioma, then we further have to study the lesion.
  Based on the **enhancement pattern**, we divide masses into hypervascular and hypovascular lesions.

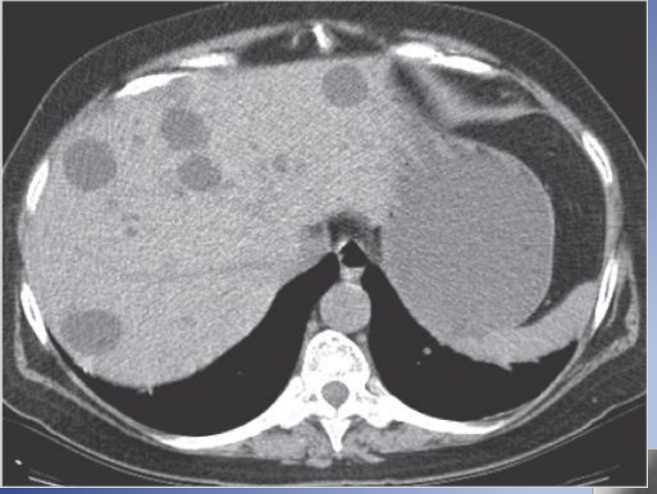
Focal liver lesion approach

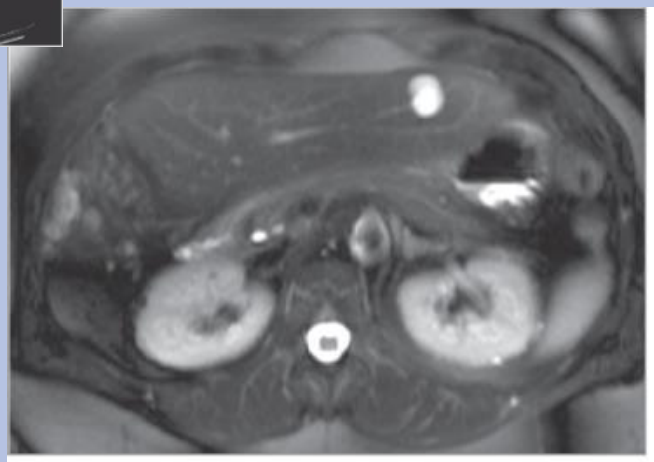
Cystic components

- If a lesion has a near water density in the centre and does not show enhancement in the centre, we usually will call it a cystic lesion.
- You have to realize, that it still can be a tumor as in cystic metastases or metastases with central necrosis.
- Secondly you always have to add abscess to the differential diagnosis.

Cystic Liver Lesions	
Simple cyst	Cystic Metastasis
Traumatic cyst	Abscess
Biloma	Ecchinococcus
Caroli's disease	Biliary cystadenoma

Hepatic cysts





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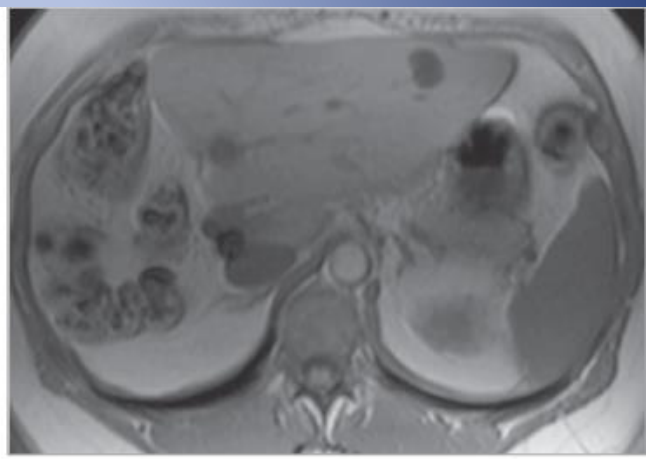

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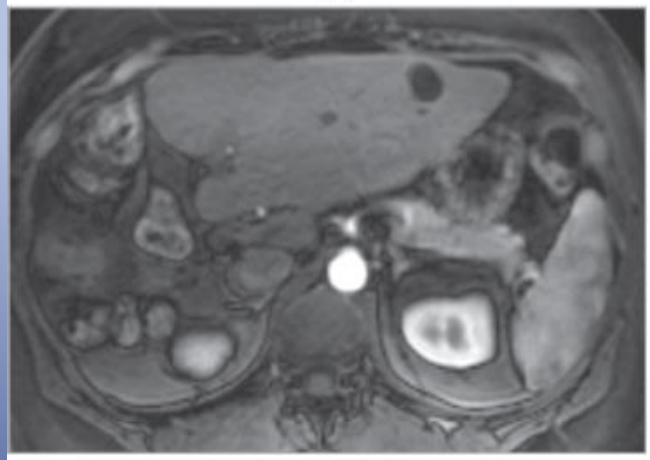

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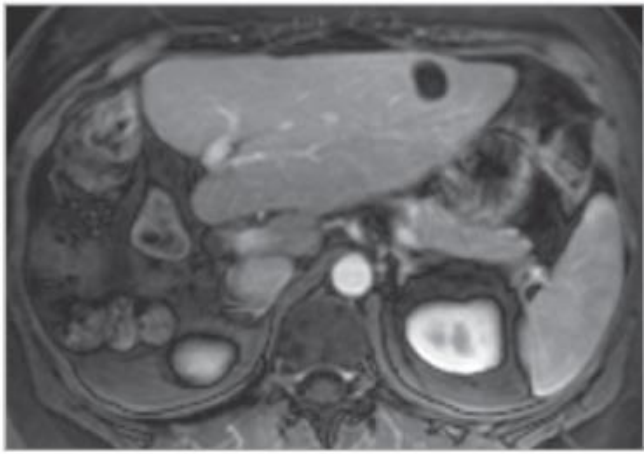

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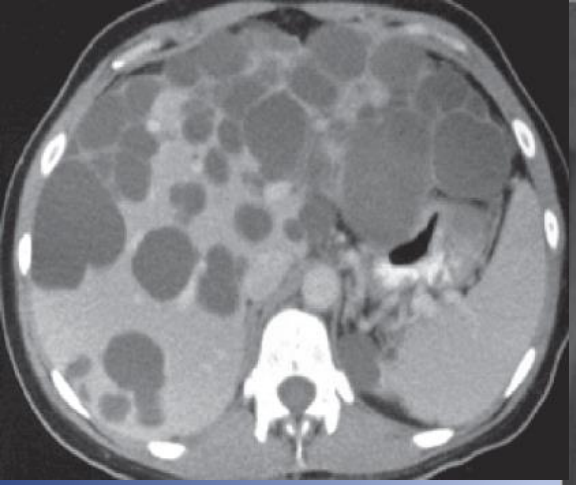
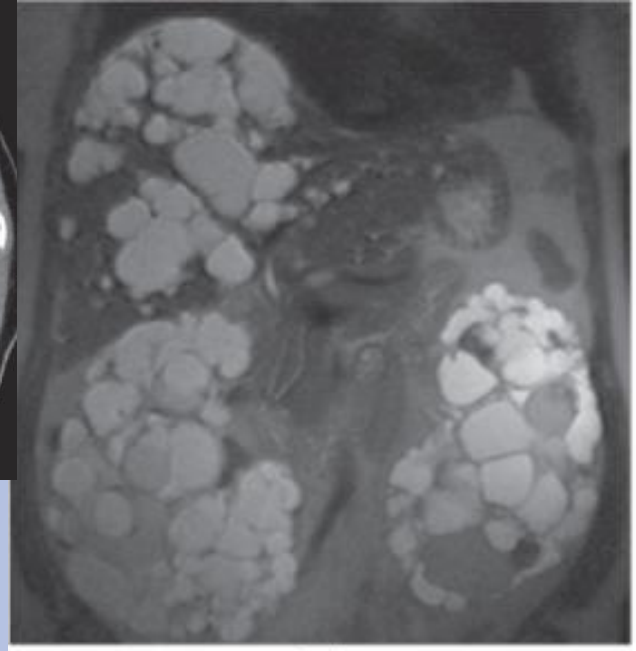
Polycystic liver disease





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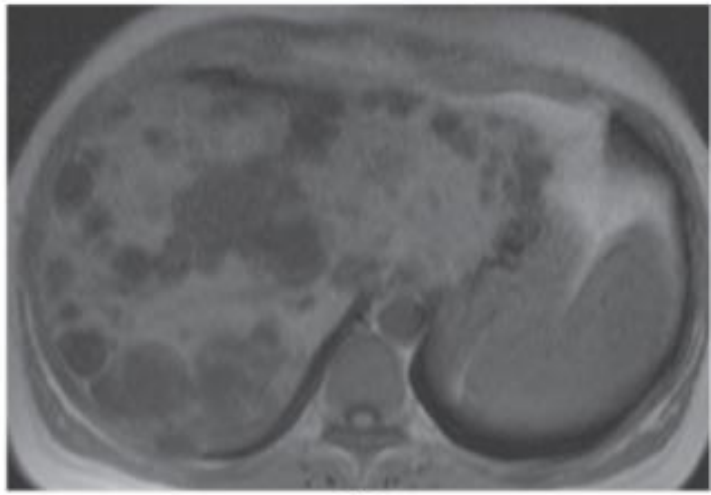

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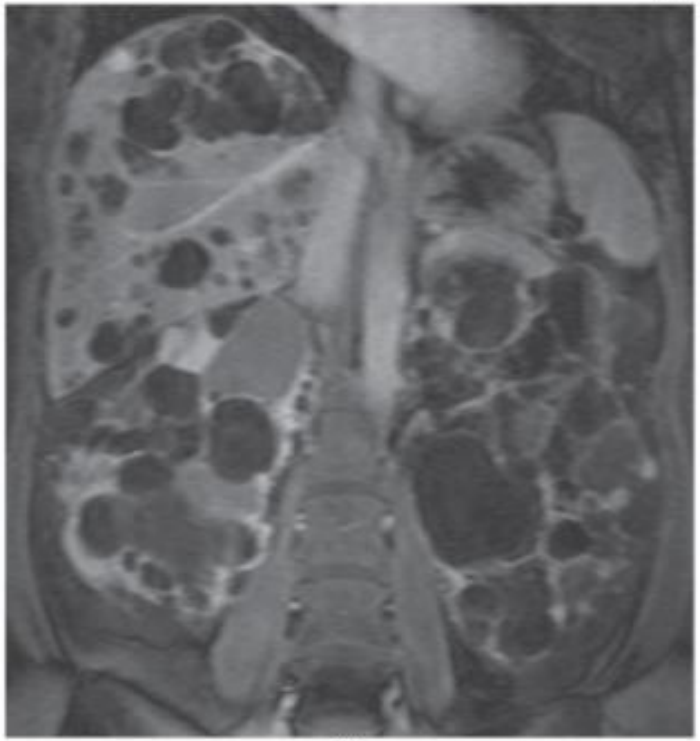
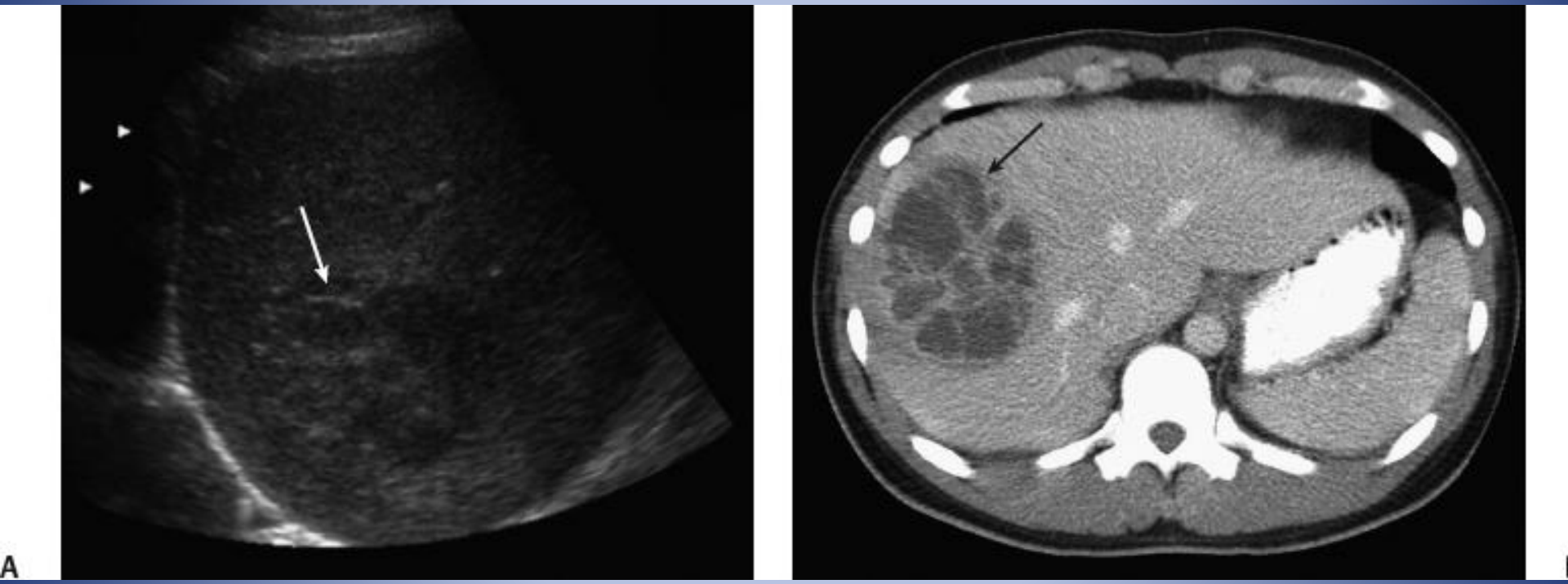
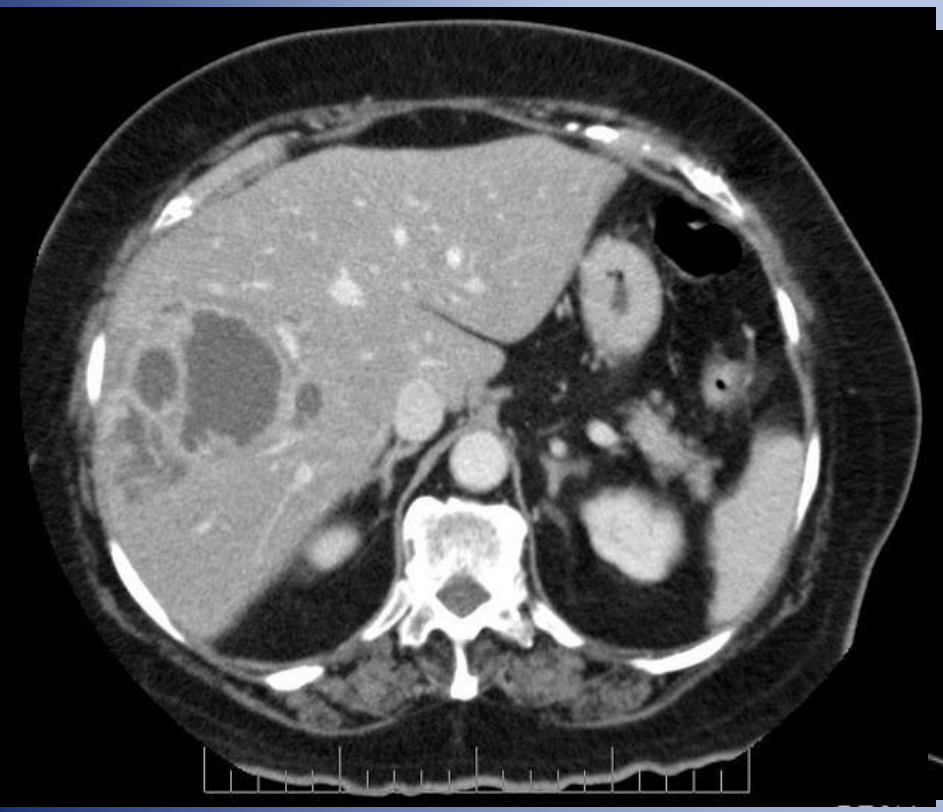


Abscess

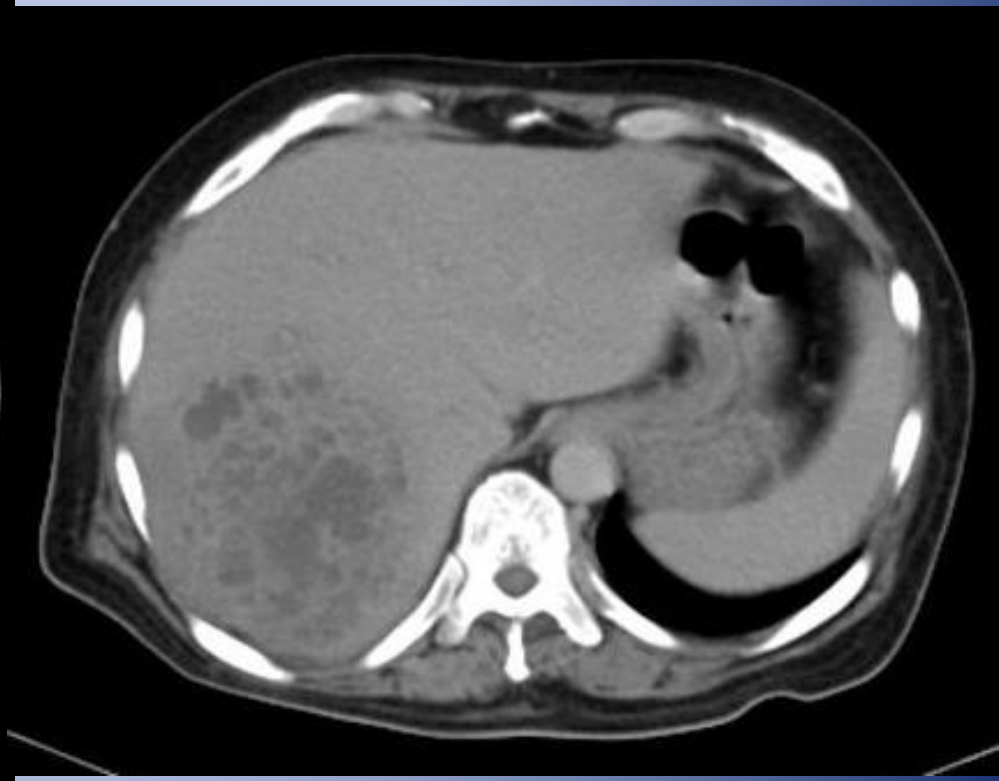


Abscess

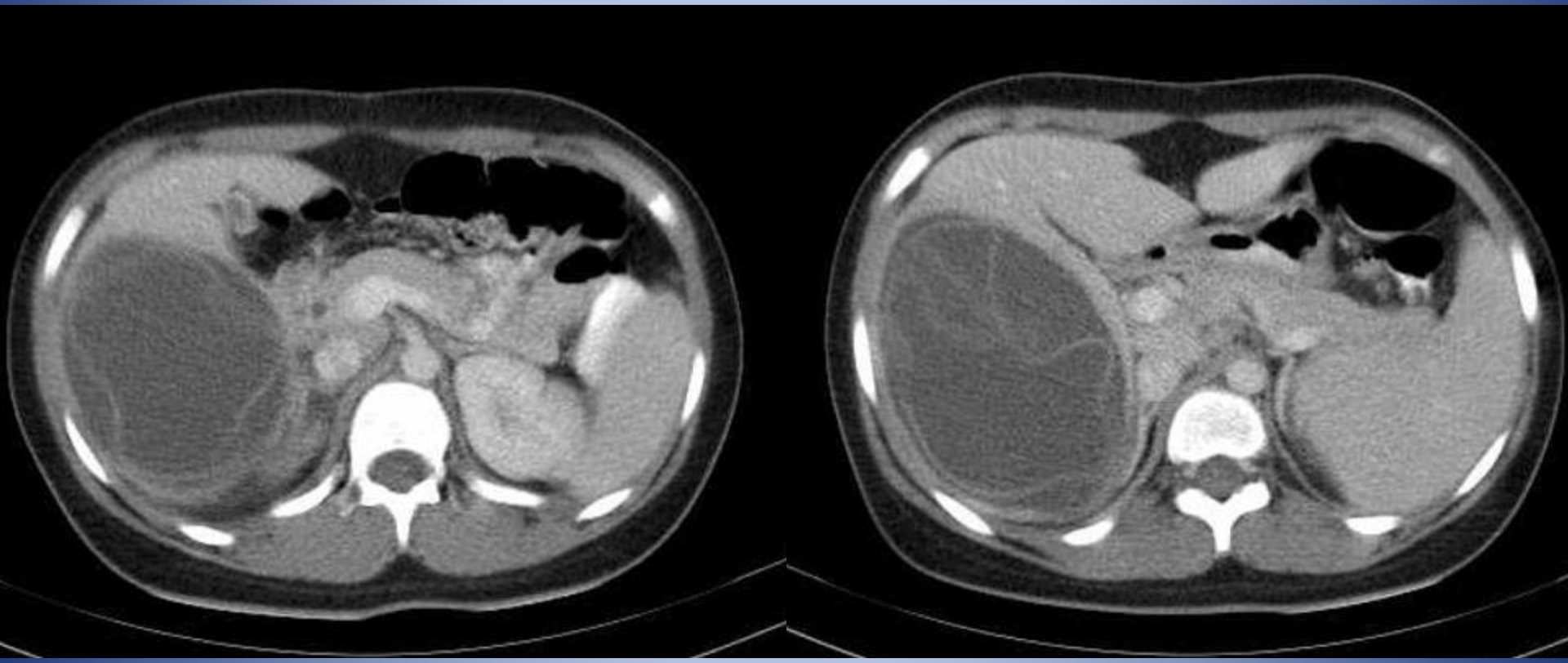
double target sign



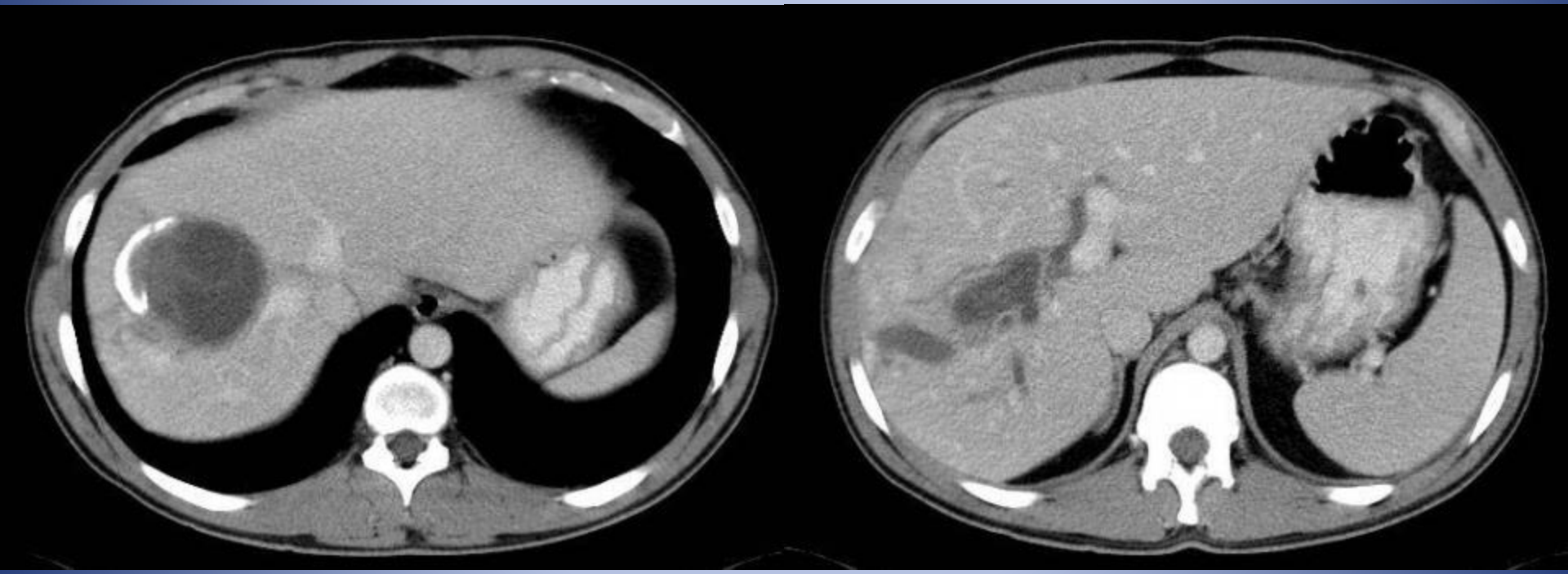
cluster sign



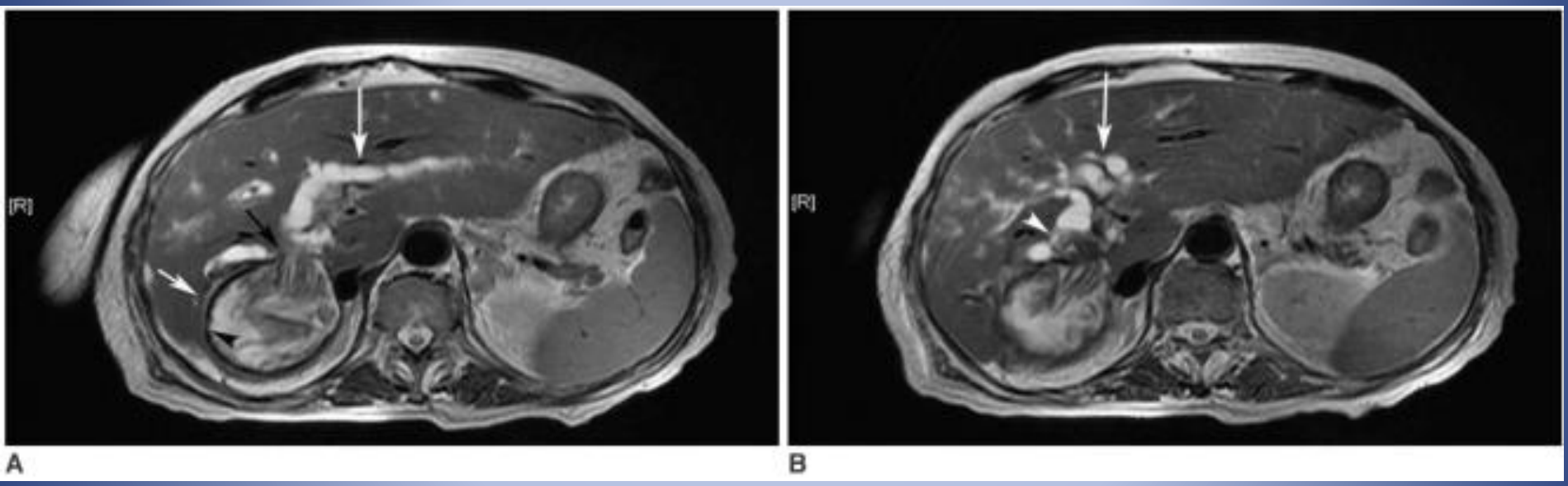
Non complicated hydatid cyst

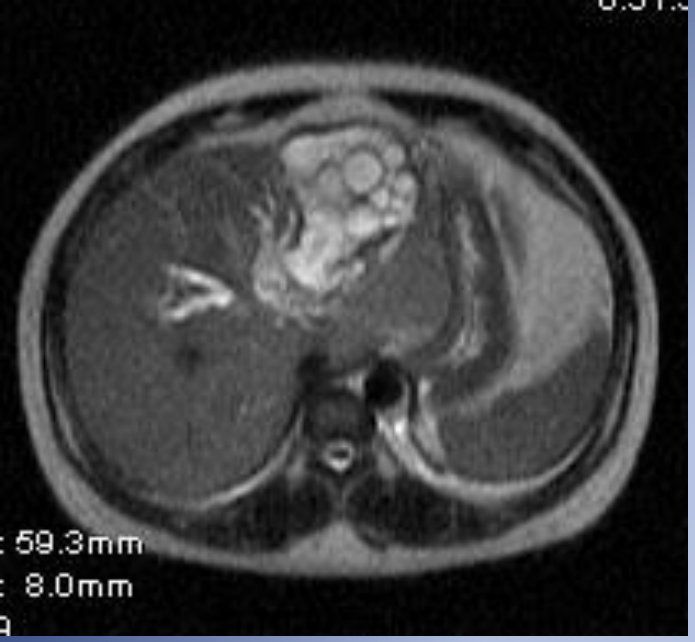


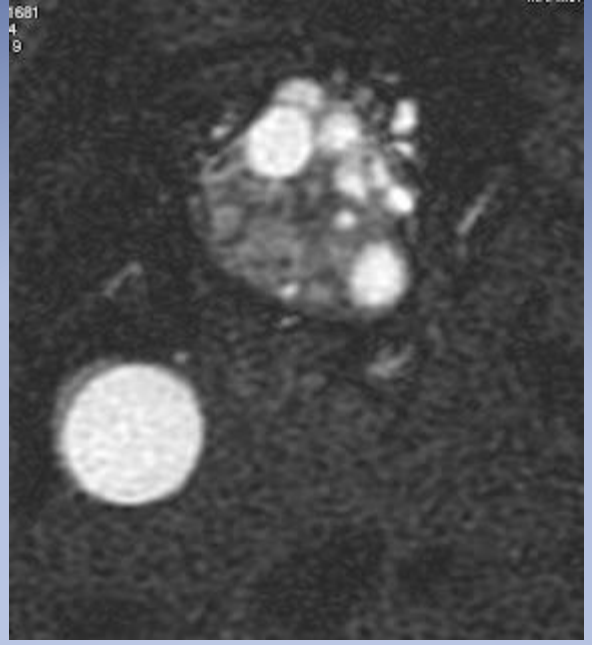
Ruptured hydatid cyst to billiary tree

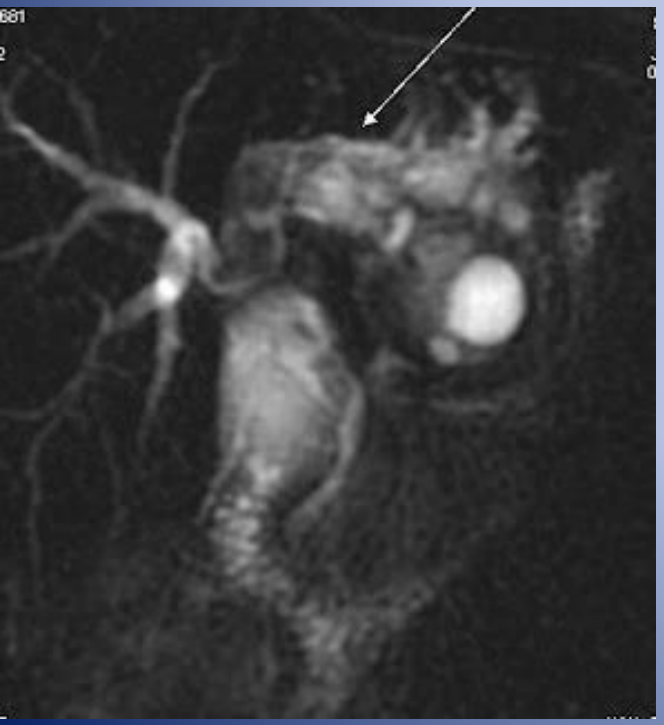


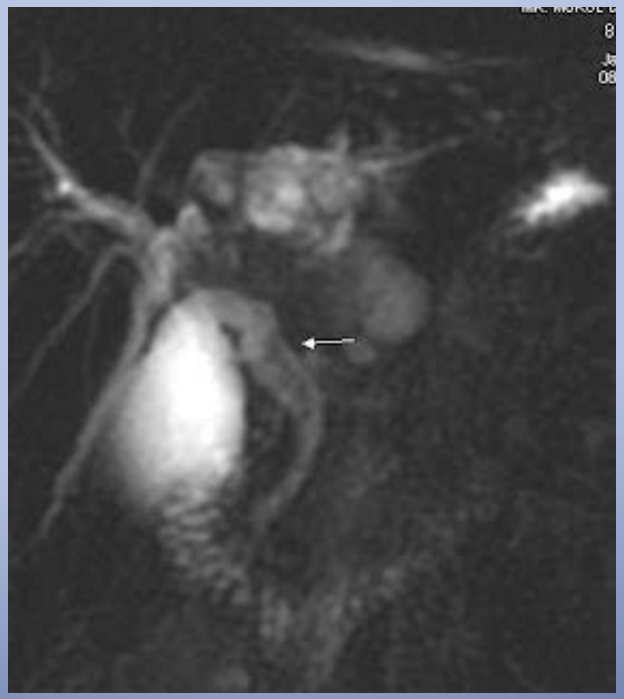
Rupture of hydatid cyst into the biliary tree




: 59.3mm
: 8.0mm





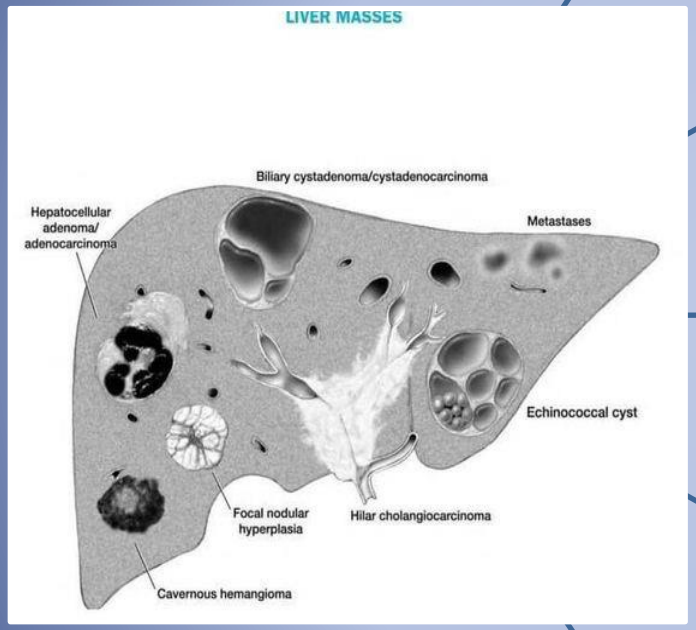


Hypervascular lesions

- They may look very similar in the arterial phase. Differentiation is done by **looking at the enhancement pattern in the other phases** and additional gross pathologic features together with clinical findings.
- Hypervascular metastases will be considered in patients with a known primary tumor.
- **In general HCC is considered when there is a setting of cirrhosis.**
- **FNH is considered in young women.**
- **hepatic adenoma in patients on oral contraceptives, anabolic steroids or with a history of glycogen storage disease.**

Hypovascular liver lesions

- Hypovascular liver tumors are more common than hypervascular tumors.
- Most hypovascular lesions are malignant and metastases are by far the most common.
- 10% of HCC is hypovascular.
- Cholangioca is hypovascular,



scar

capsule

calcification

fat

Hemorrhage

Scar

- **Liver lesions which may have a central scar are FNH, fibrolamellar carcinoma, cholangiocarcinoma, hemangioma and hepatocellular carcinoma.**
- On CT a scar is sometimes visible as a hypodense structure. On MR scar tissue is hypointense on both T1WI and T2WI due to intense fibrotic changes. An example is the central scar of fibrolamellar carcinoma (FLC)
- An exception to this rule is the central scar in FNH which is hyperintense on T2WI due to edema.
- T2WI can be very helpfull if there is a problem in differentiating FNH from FLC.
- Both on CT and MRI scar tissue will enhance in the delayed phase.

Liver Lesions with Central Scar

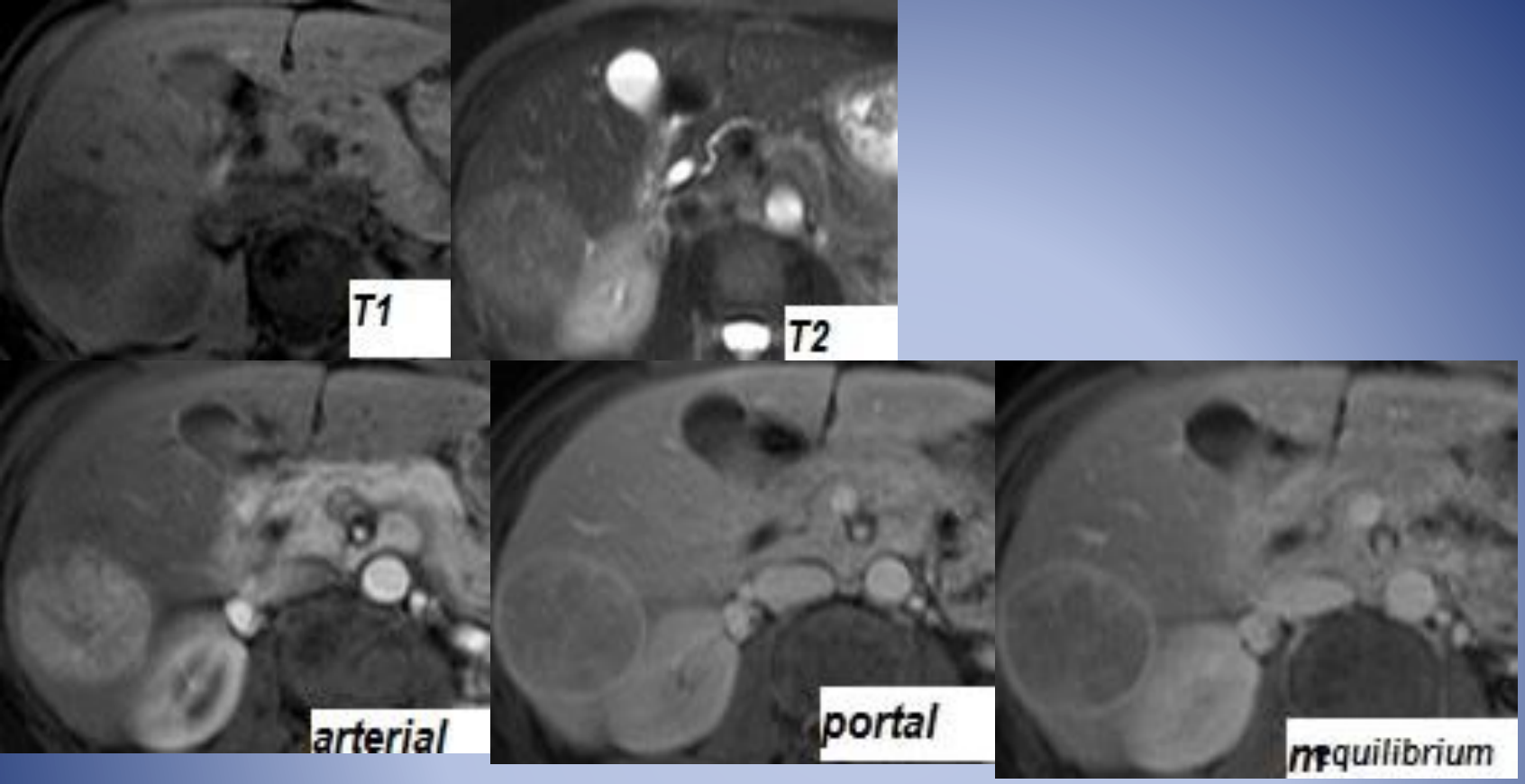
- **On CT a scar is sometimes visible as a hypodense structure.**
- **On MR scar tissue is hypo intense on both T1WI and T2WI due to intense fibrotic changes.**
- The most common lesions with a central scar are:
- focal nodular hyperplasia (FNH)
- fibrolamellar hepatocellular carcinoma (HCC).
- and hemangiomas.
- **central scar in FNH which is hyperintense on T2WI due to edema.**

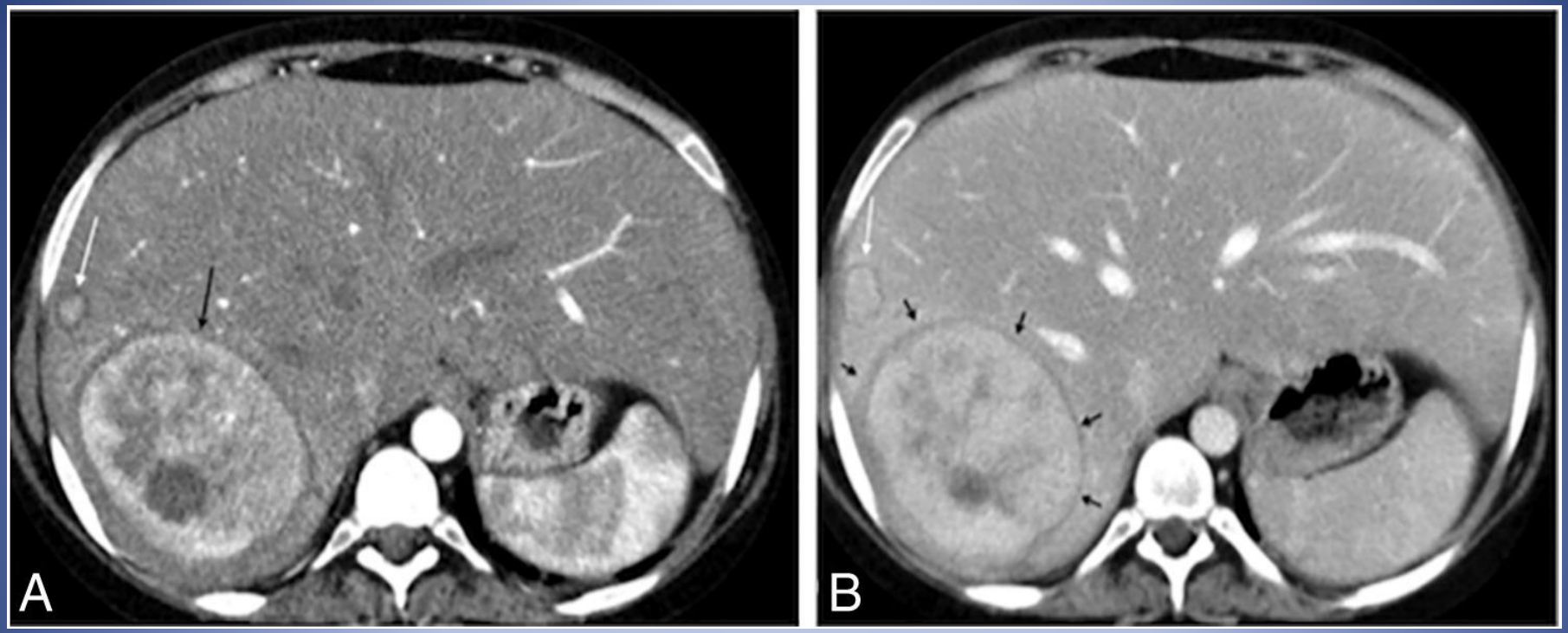
- Hemangiomas can usually be differentiated by the characteristic enhancement pattern. FNH and fibrolamellar HCC can be more difficult to differentiate as they are both hypervascular tumors with central scars seen in young patients. Many imaging features can be helpful in differentiation of these two lesions

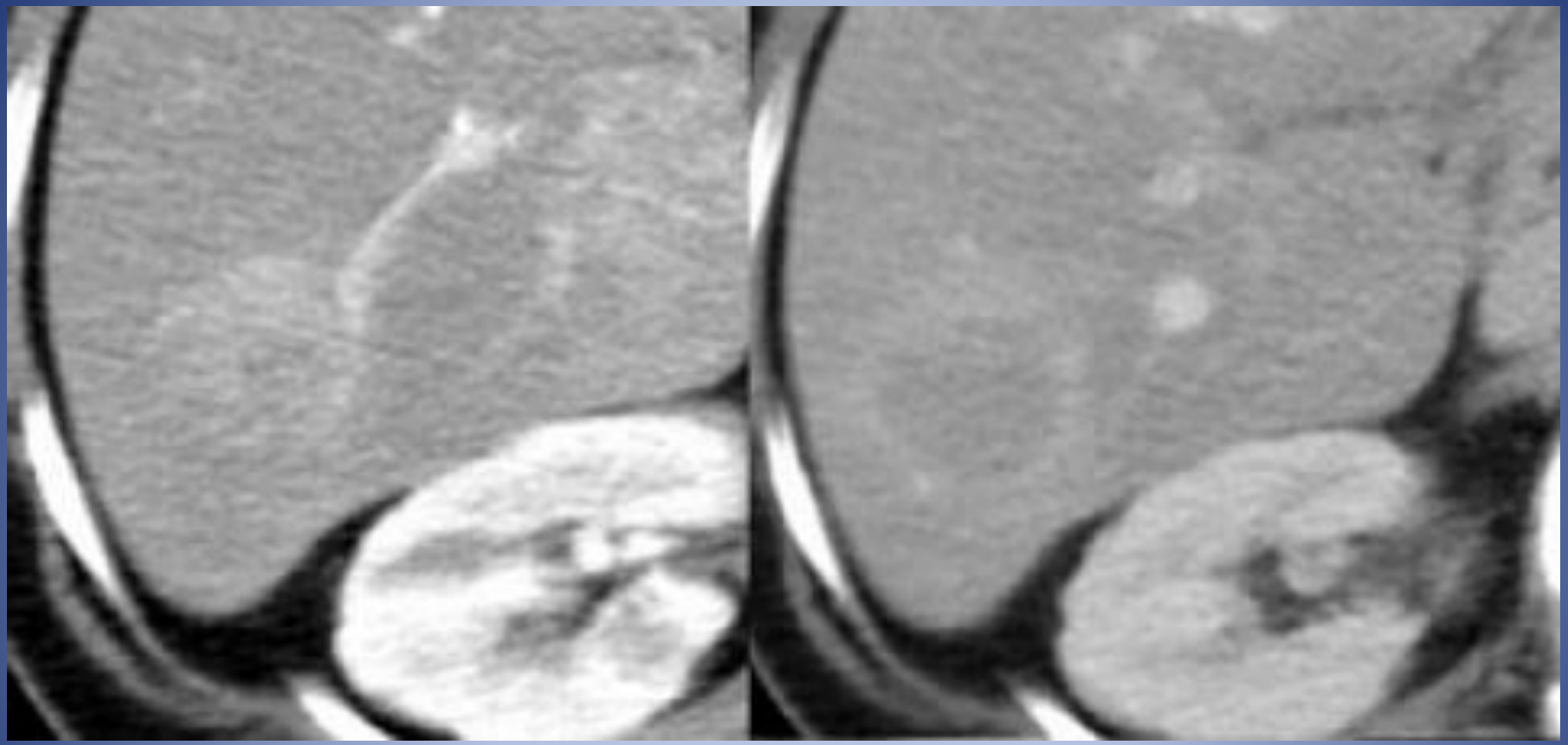
- FLC simulates FNH due to presence of central scar in both tumors FLC: Bigger, **more heterogeneous** mass frequently with **calcified central/eccentric scar** and **features of malignancy** (vessel &/or biliary obstruction, nodal invasion, and lung metastases)
- Scar on T2WI: Hypointense in FLC, hyperintense in FNH
- Large, heterogeneous, hypervascular tumor in young adult

Capsule

- Liver lesions which may have a capsule are Adenoma, HCC and cystadenoma or cystadenocarcinoma.
- The most common tumor with a capsule is HCC.
- The capsule will not enhance in the arterial phase and even in the portal venous phase it will be hypodense, because the fibrous tissue enhances very slowly.
- A capsule is usually best seen in the delayed phase as a relative hyperdense structure.


T1
T2
arterial
portal
equilibrium


A
B



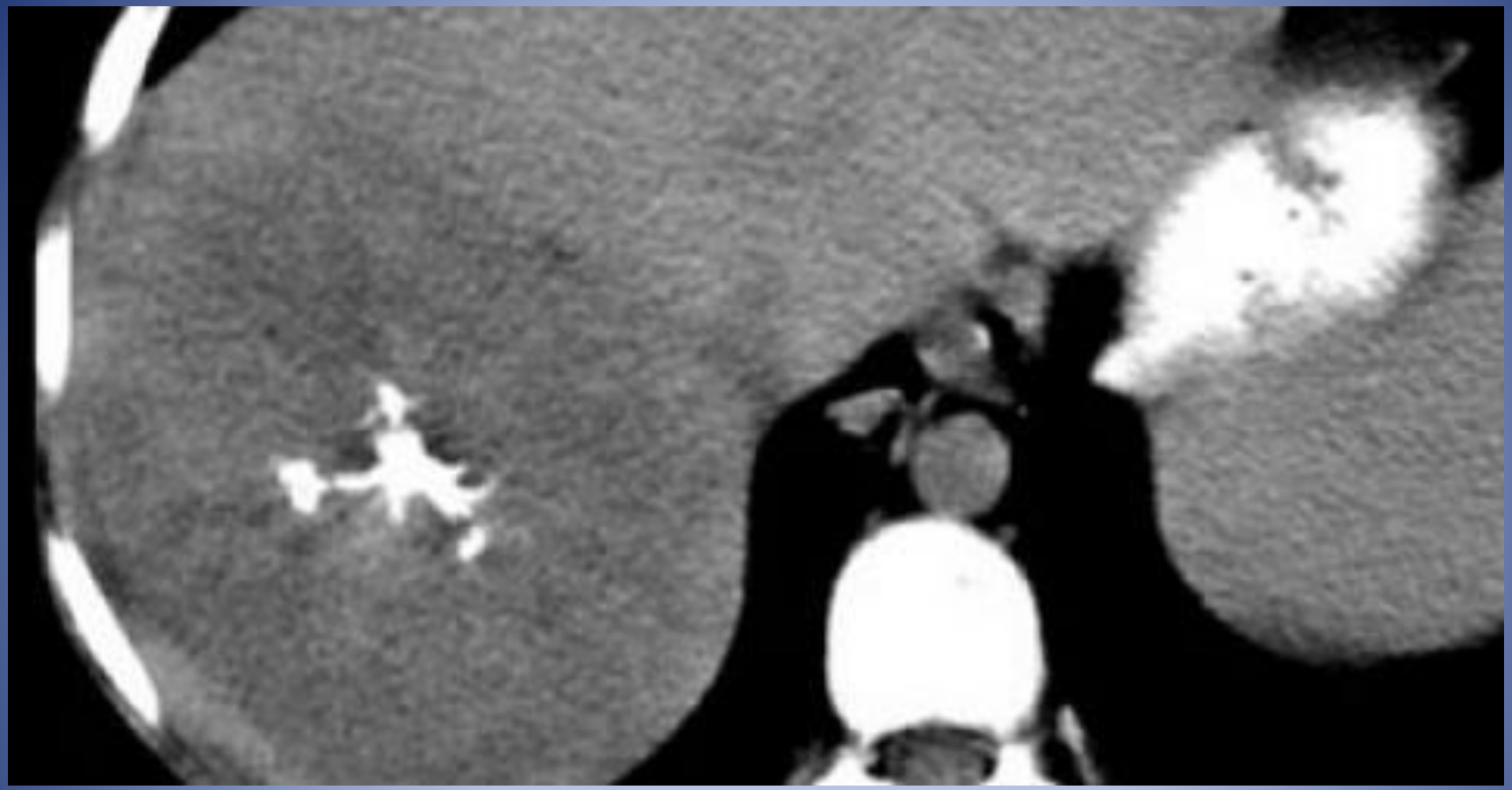
Adenoma frequently has a thin fibrous capsule seen in 30% of cases.
It has a well defined contour and subcapsular feeding arteries.

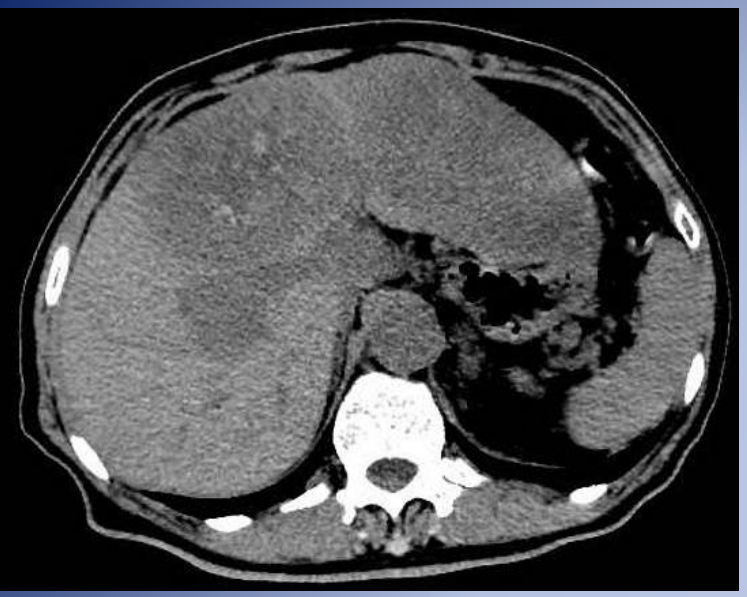
Calcifications

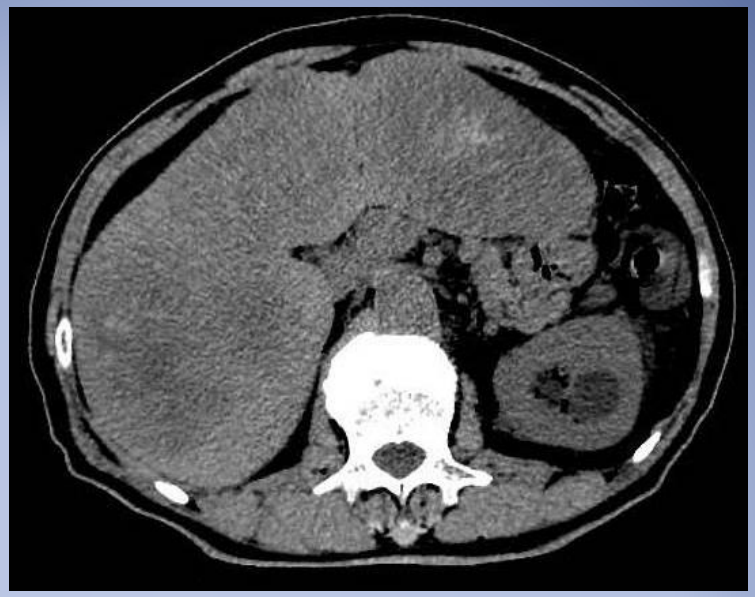
Central calcifications are seen in:

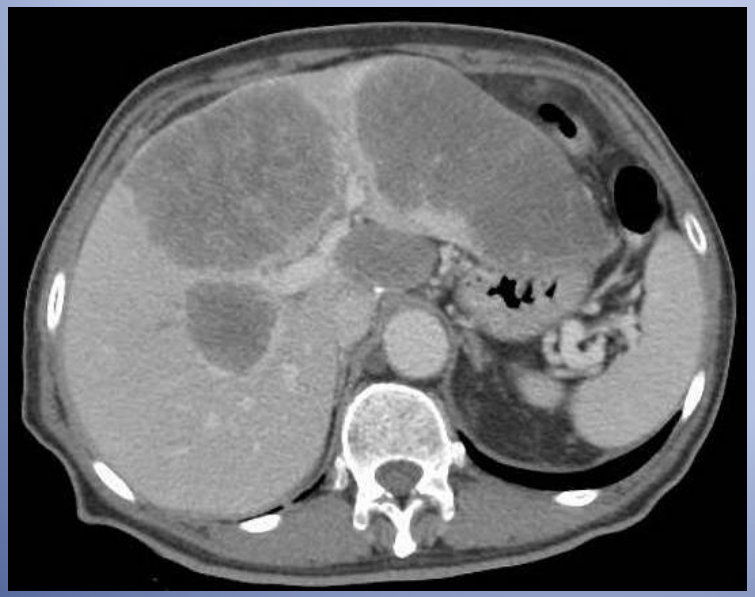
1. Metastases (especially in colorectal tumors)
2. Fibrolamellar carcinoma (FLC)
3. Cholangiocarcinomas
4. Hemangiomas

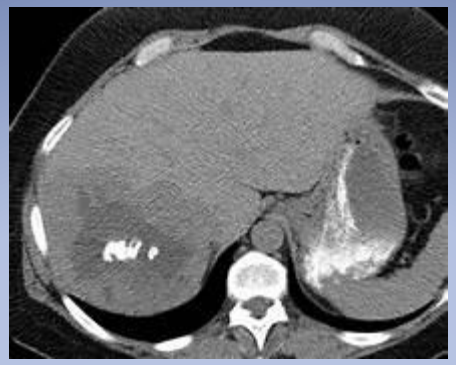
- **These calcifications are hyperdense on CT and hypointense on T1 and T2 MR images.**
- In FLC these calcifications are located within the central scar .

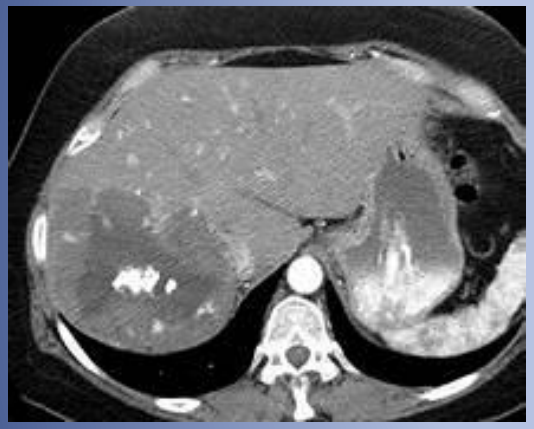


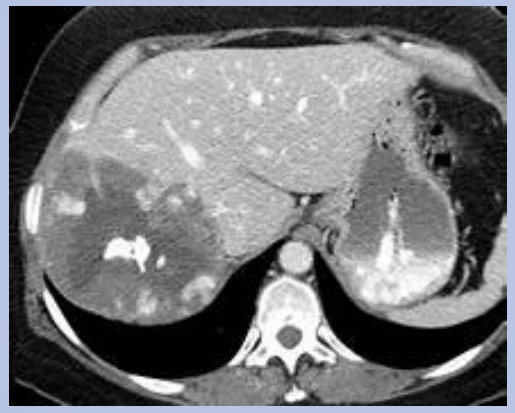


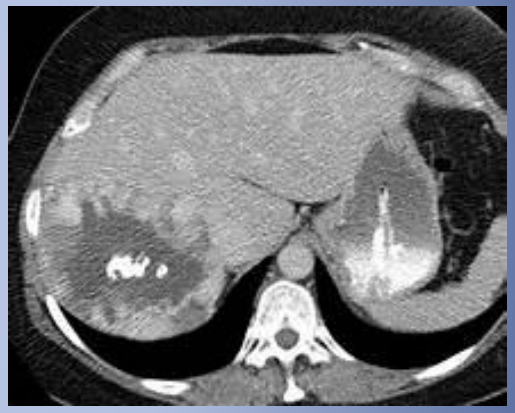








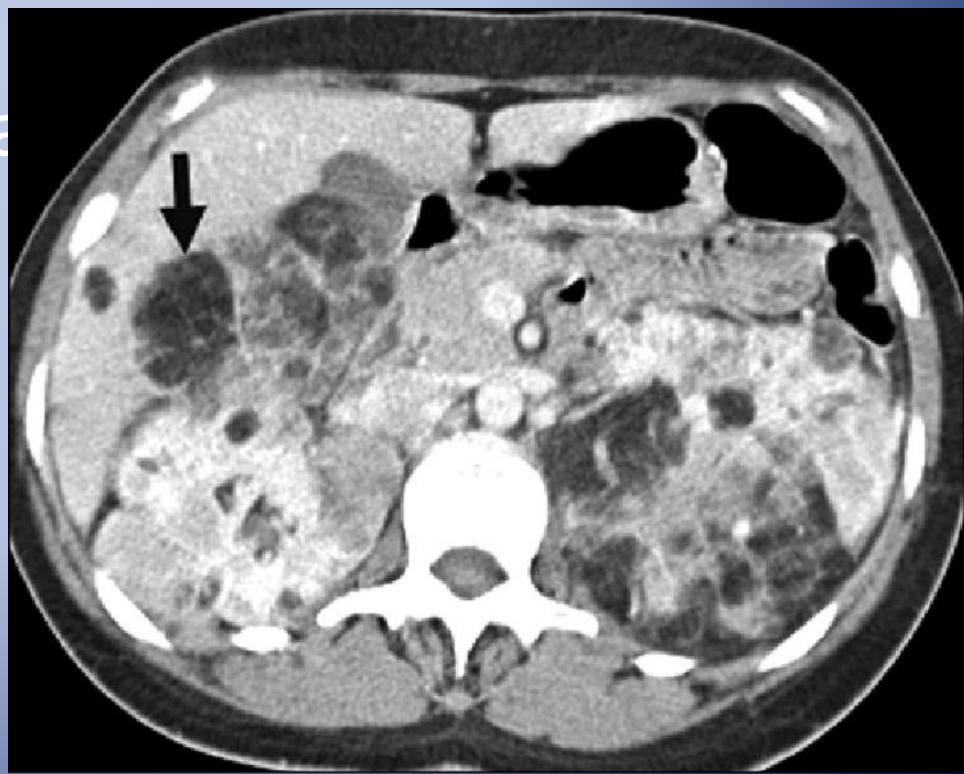


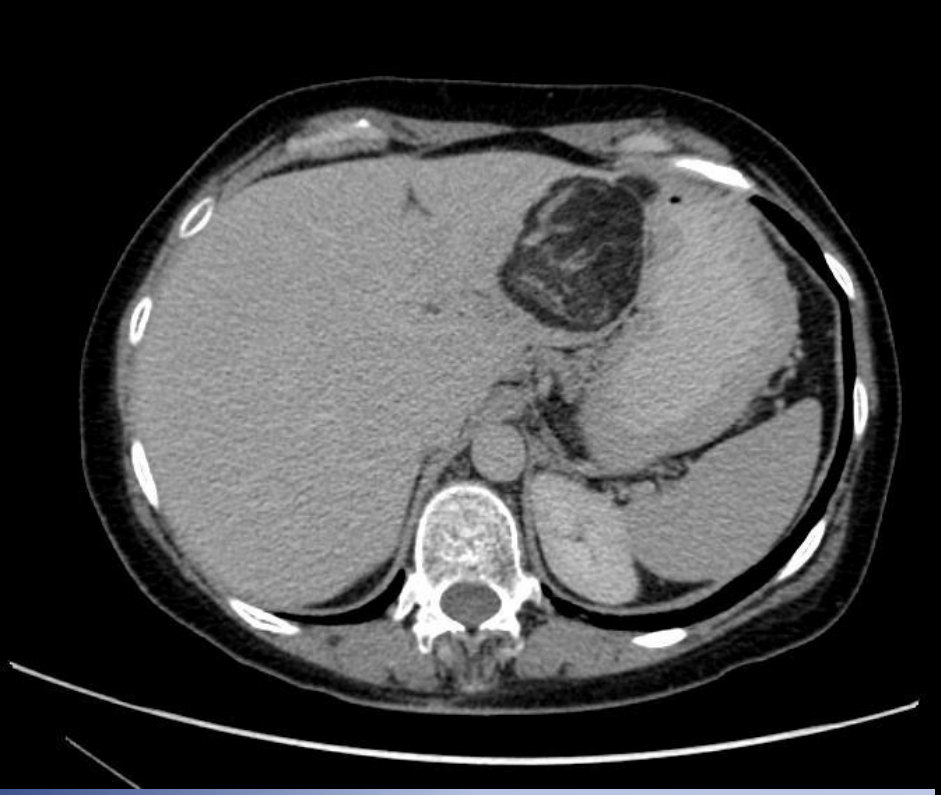


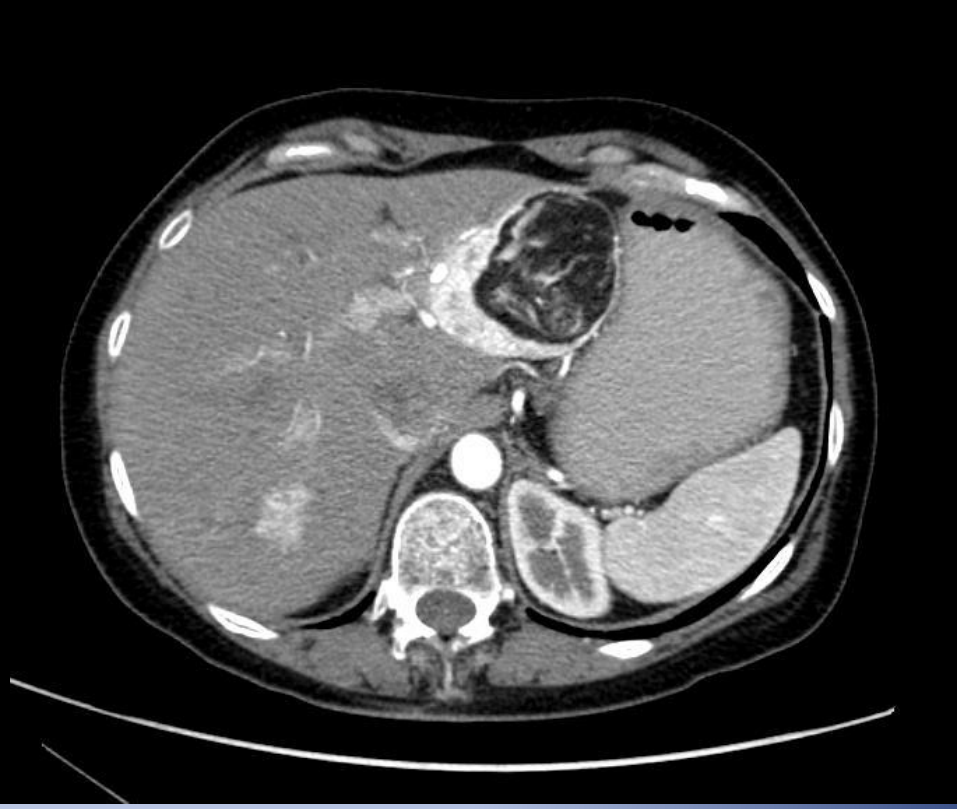
Fat

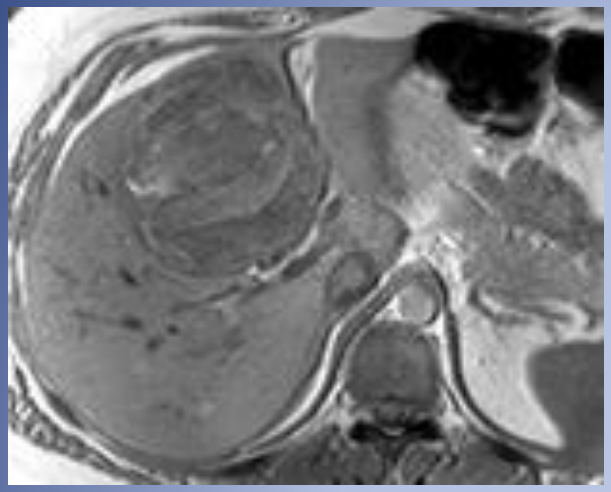
Fat within liver tumors is seen in:

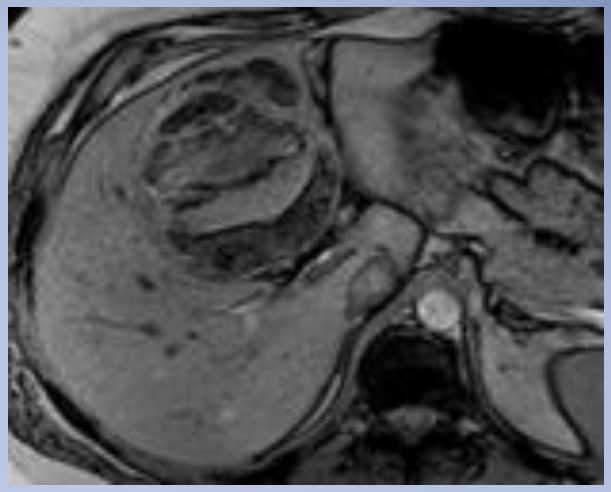
1. Adenoma
2. HCC
3. Metastatic liposarcoma
4. Angiomyolipoma

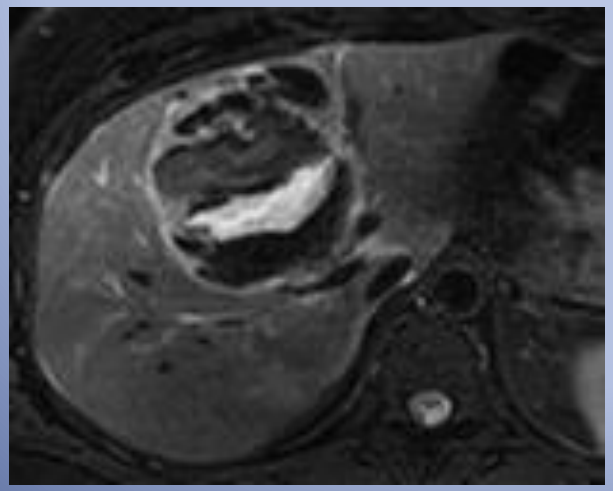










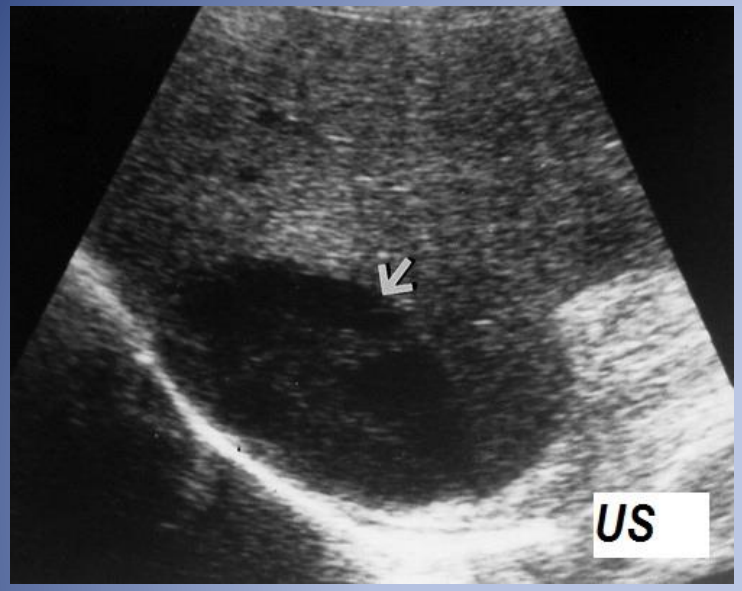


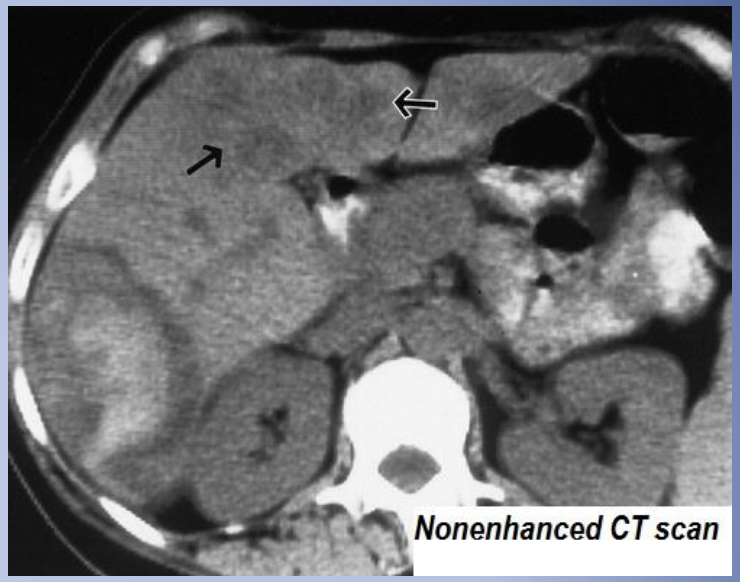
Hemorrhage

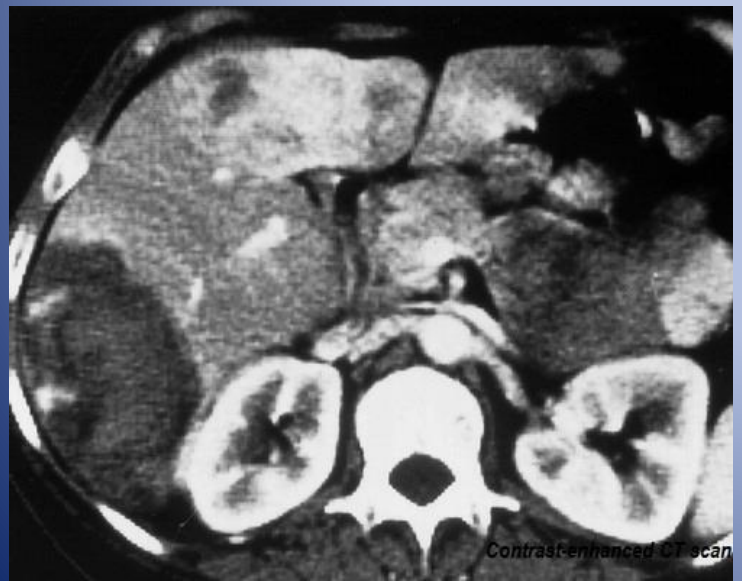
Hemorrhage in liver tumors is seen in:

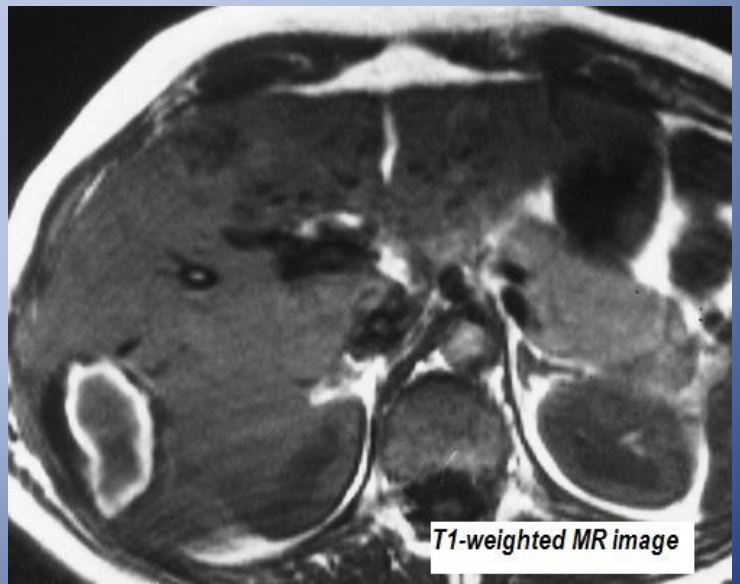
- Adenoma
- HCC.
- Hemorrhage is most commonly seen in adenomas.

34-year-old woman with RUQ pain



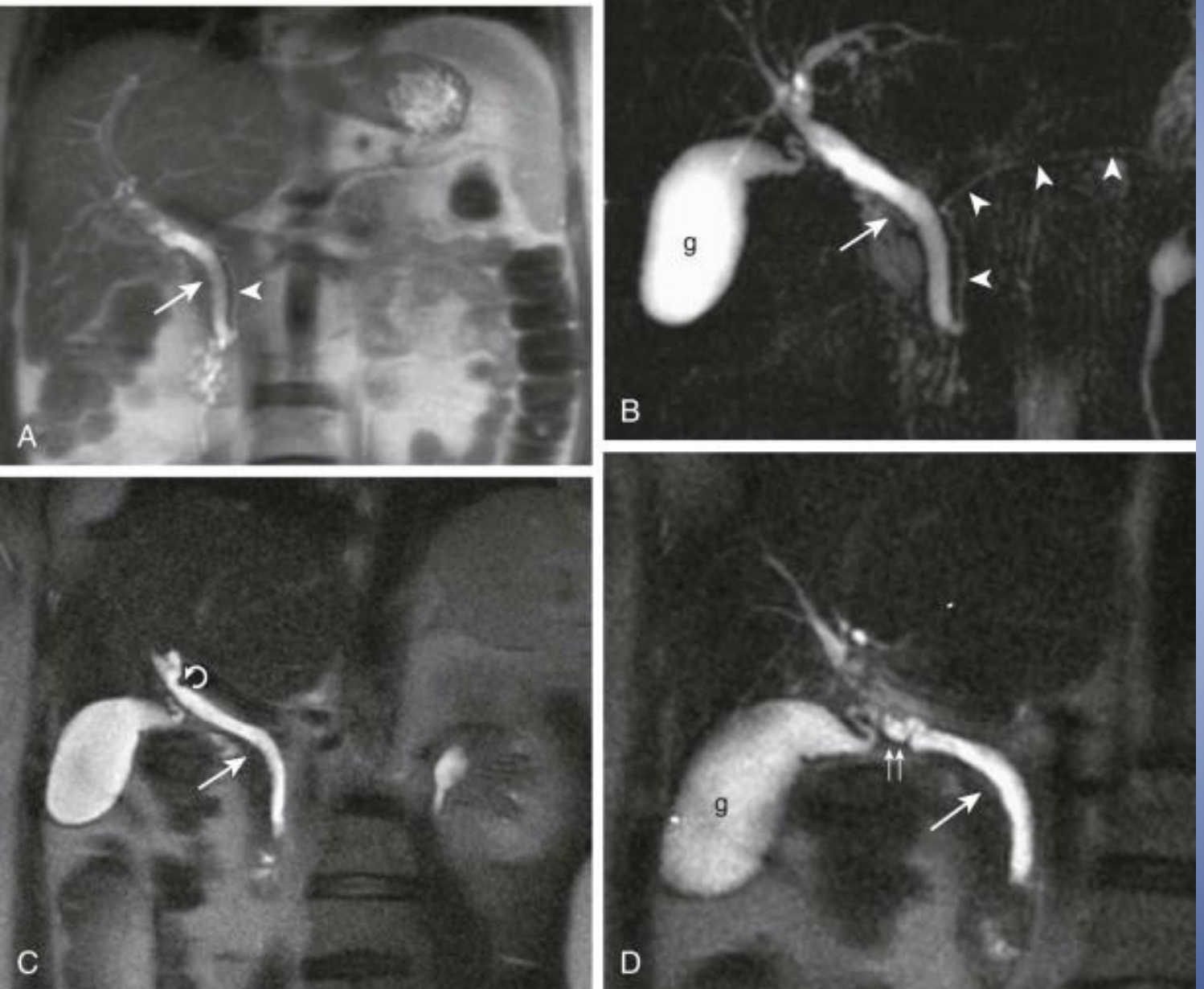




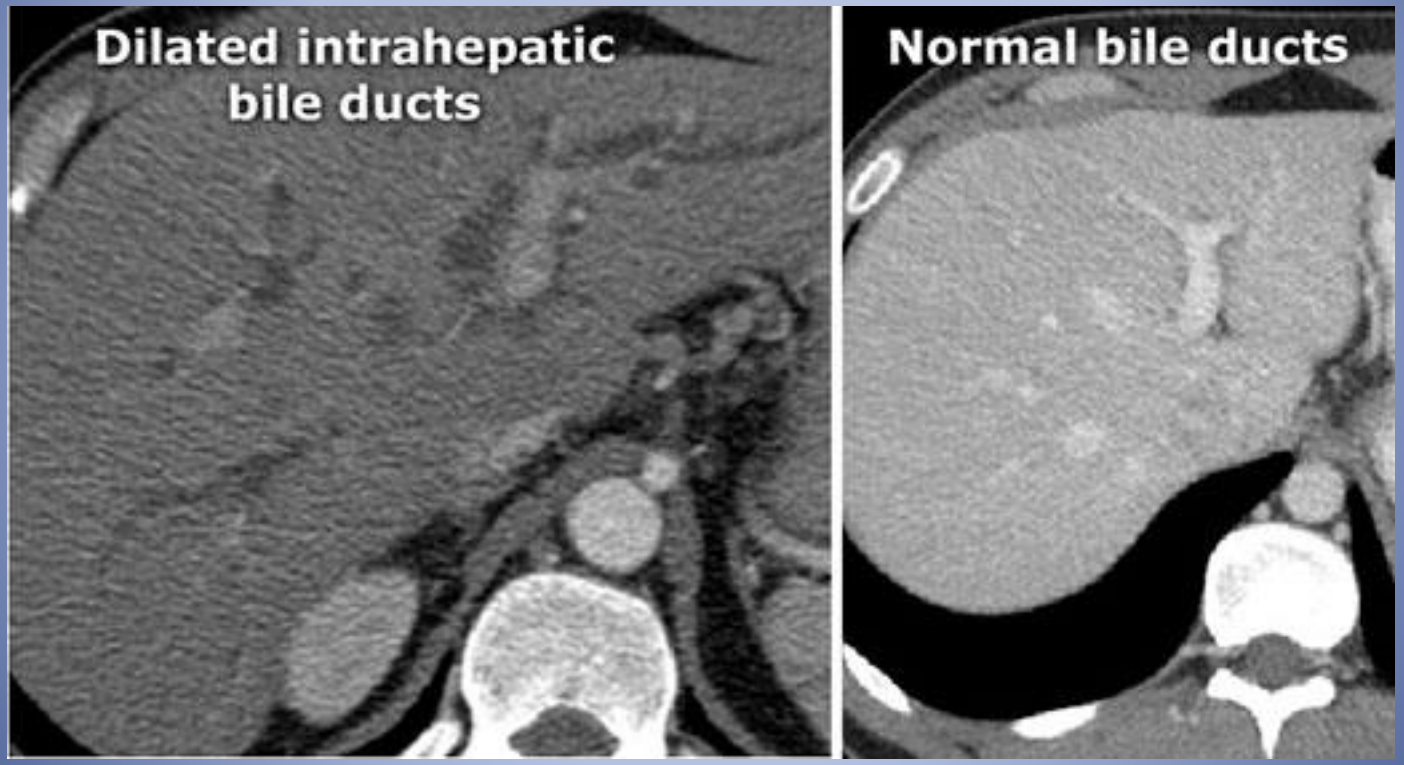


MRCP

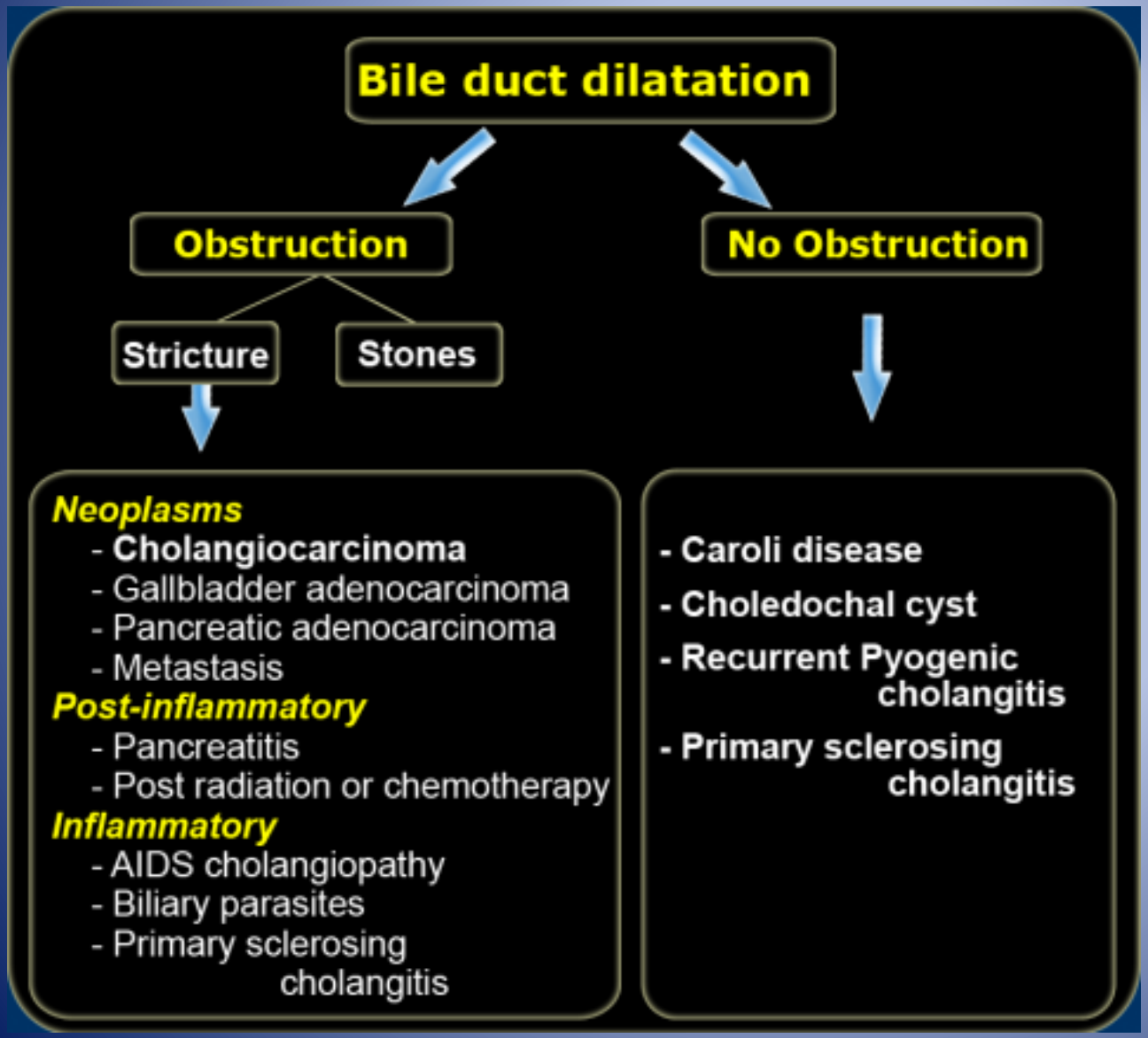
- **Magnetic resonance cholangiopancreatography (MRCP)** is a non-invasive imaging technique to visualize the intra and extrahepatic biliary tree and pancreatic ductal system.
- heavily T2 weighted sequences.
- fluid-filled structures in the abdomen have a long T2 relaxation time as compared to the surrounding soft tissue, these structures appear hyperintense against the surrounding non-fluid-containing tissues on a heavily T2 weighted sequence and can easily be distinguished.


A
B
g
C
D
g

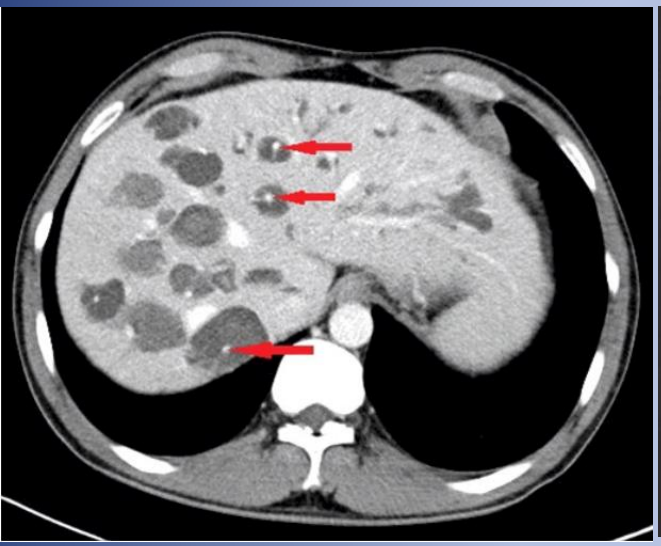
CT scan



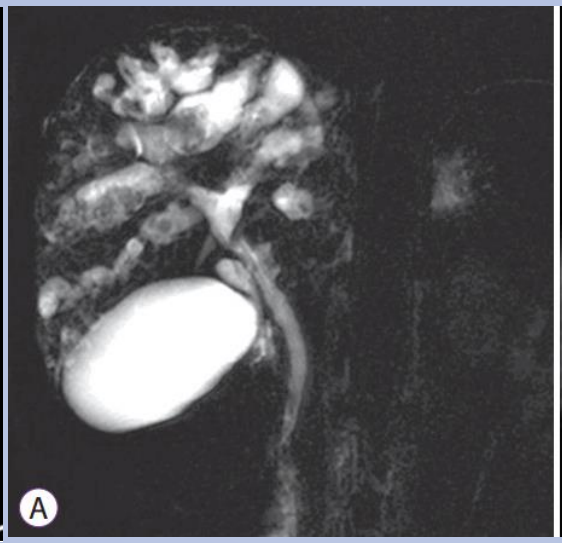
Differential Diagnosis of bile duct dilatation

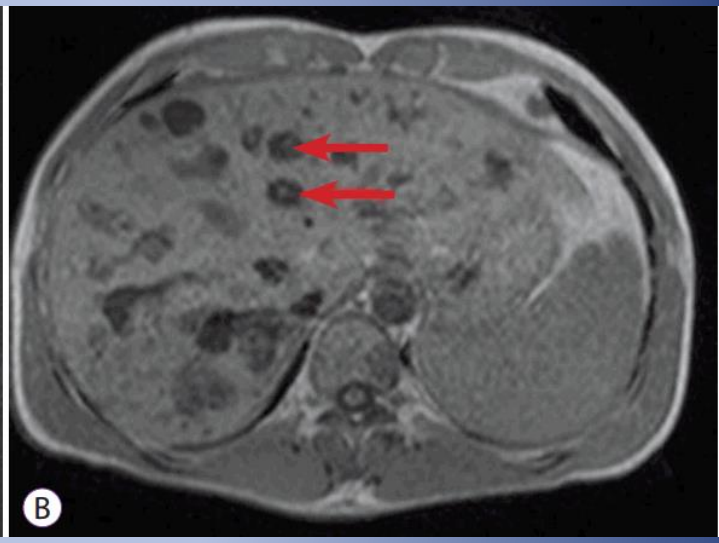


Carolie disease



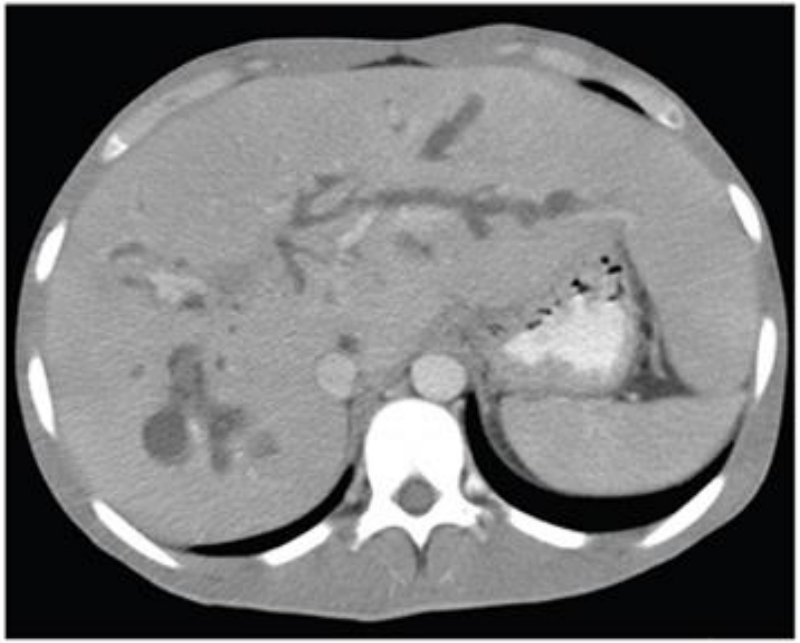
bdominal computed tomography. Multiple dilated intrahepatic ducts with tiny dots of strong contrast are seen in the liver (arrows). These represent portal radicles and constitute the characteristic central dot sign for Caroli disease.



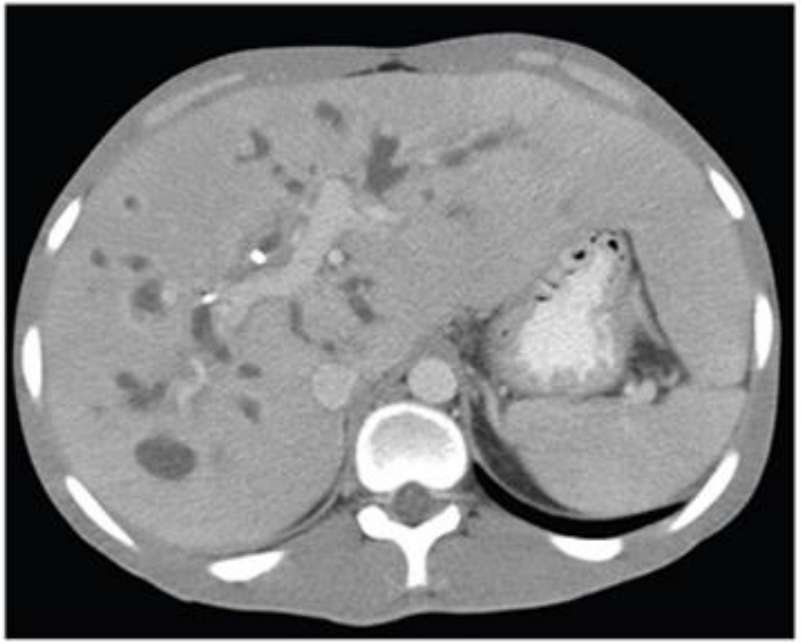


Magnetic resonance cholangiography. (A) Bile duct ectasia and irregular cystic dilation of the large proximal intrahepatic bile duct (IHD) with a normal common bile duct are noted. Multiple intrahepatic calculi were also demonstrated. (B) T1-weighted image again reveals central dot signs (arrows), which are enhancing dots within the dilated IHD, representing portal radicles (B).

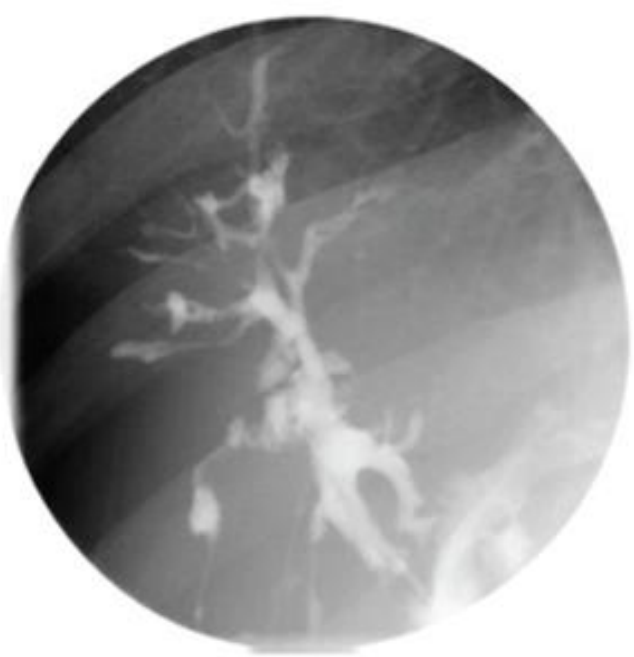
Choledochal cyst



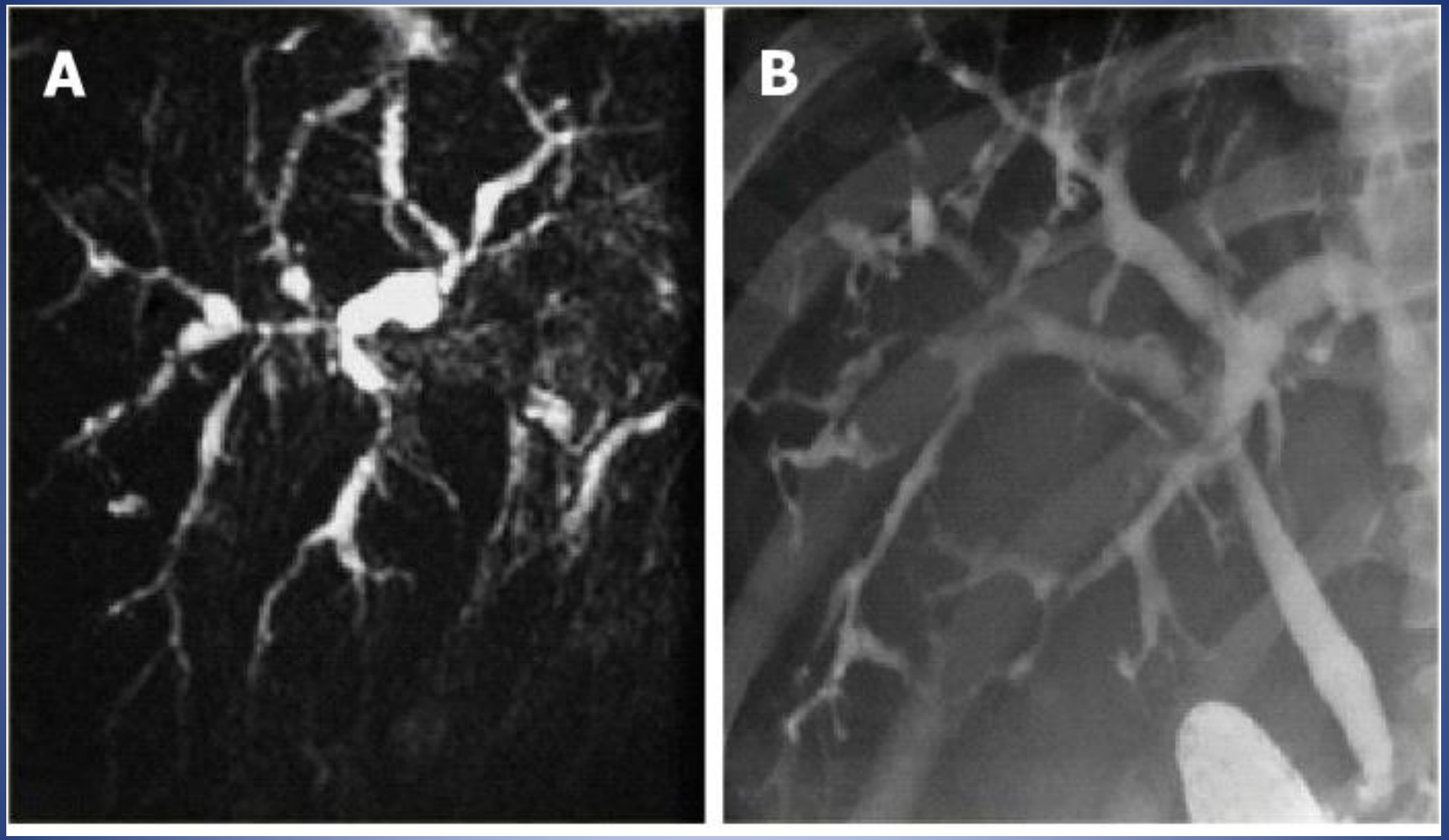
A



B



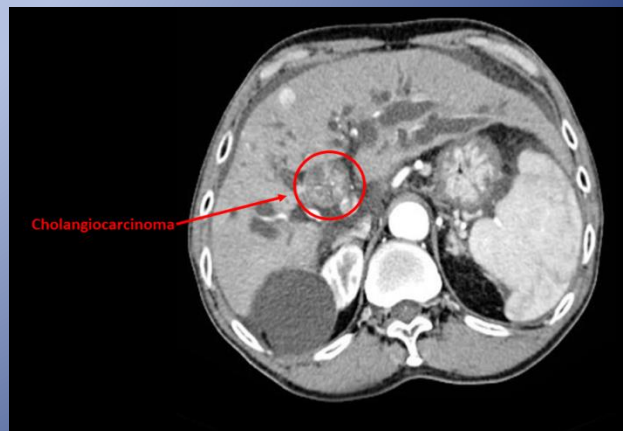
C


A
B

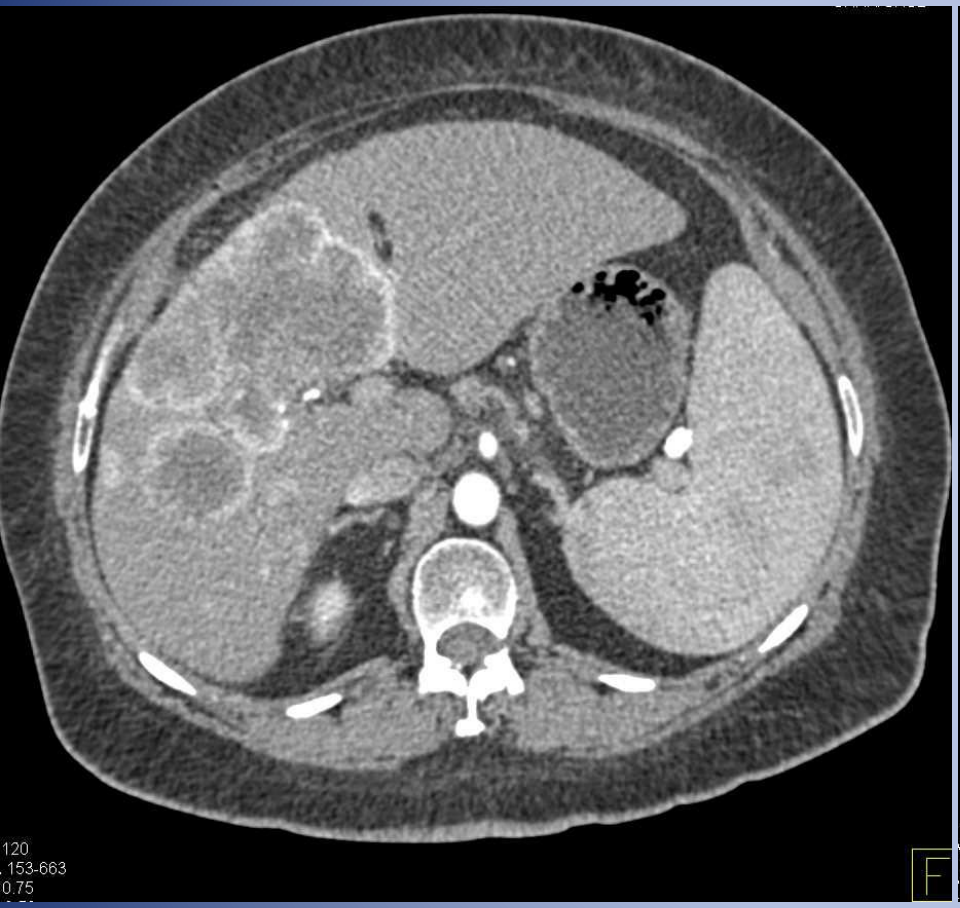
Cholangiocarcinoma

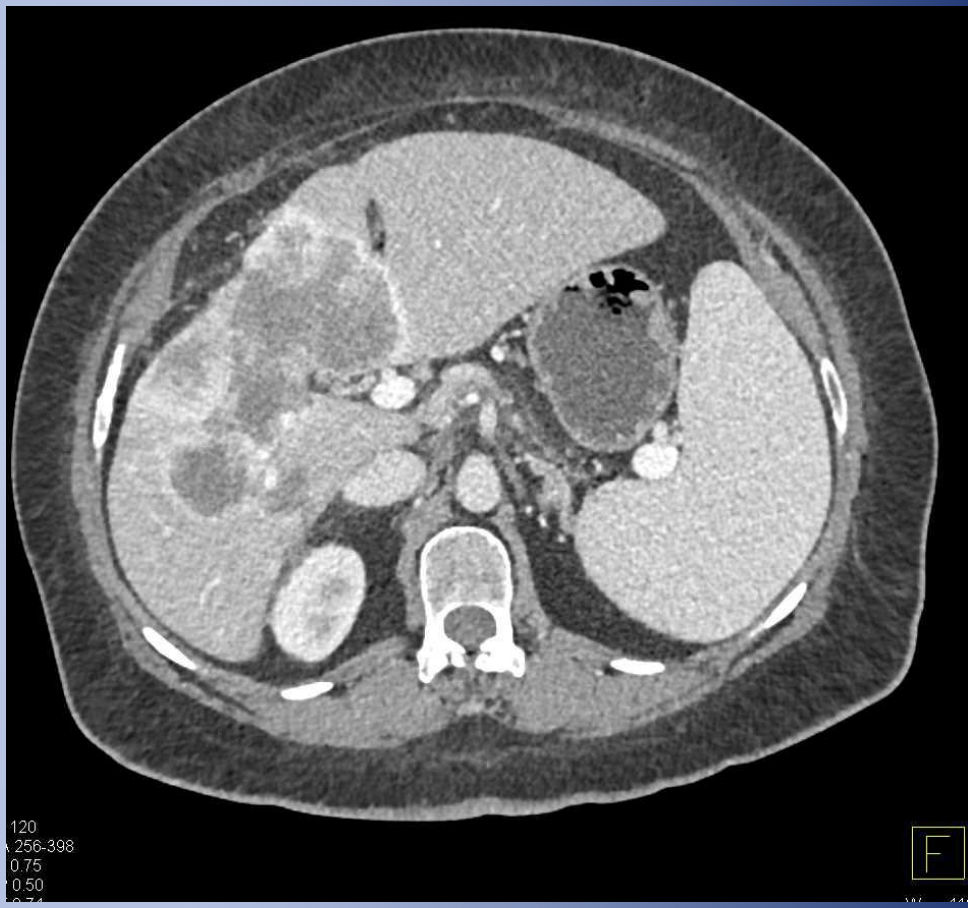
- Findings on CT scan suggestive of cholangiocarcinoma include:

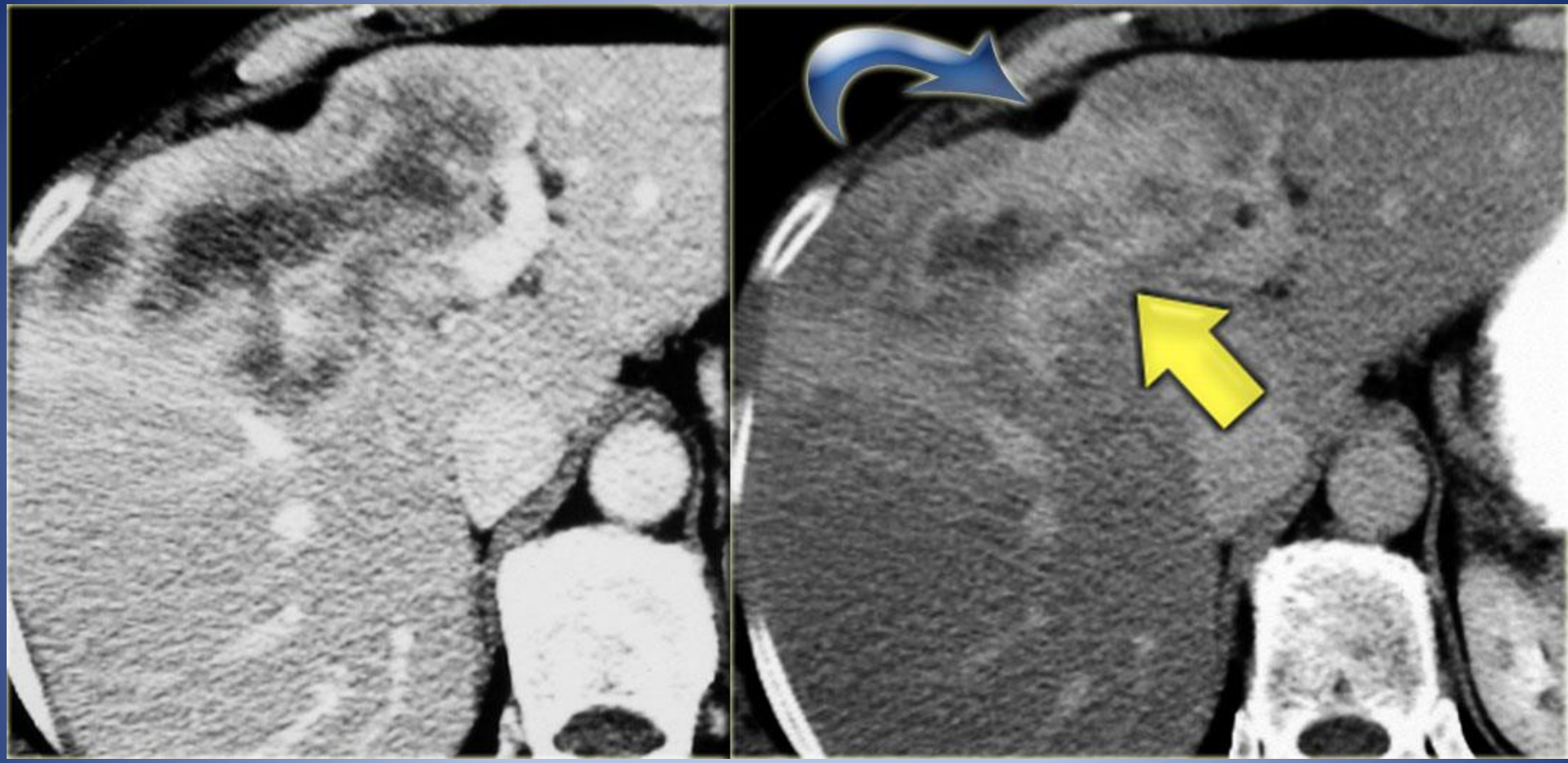
1. Capsular retraction
2. Dilation of bile ducts distal to the mass
3. Narrowing of the portal veins or hepatic veins
4. Lobar or segmental hepatic atrophy associated with vascular invasion



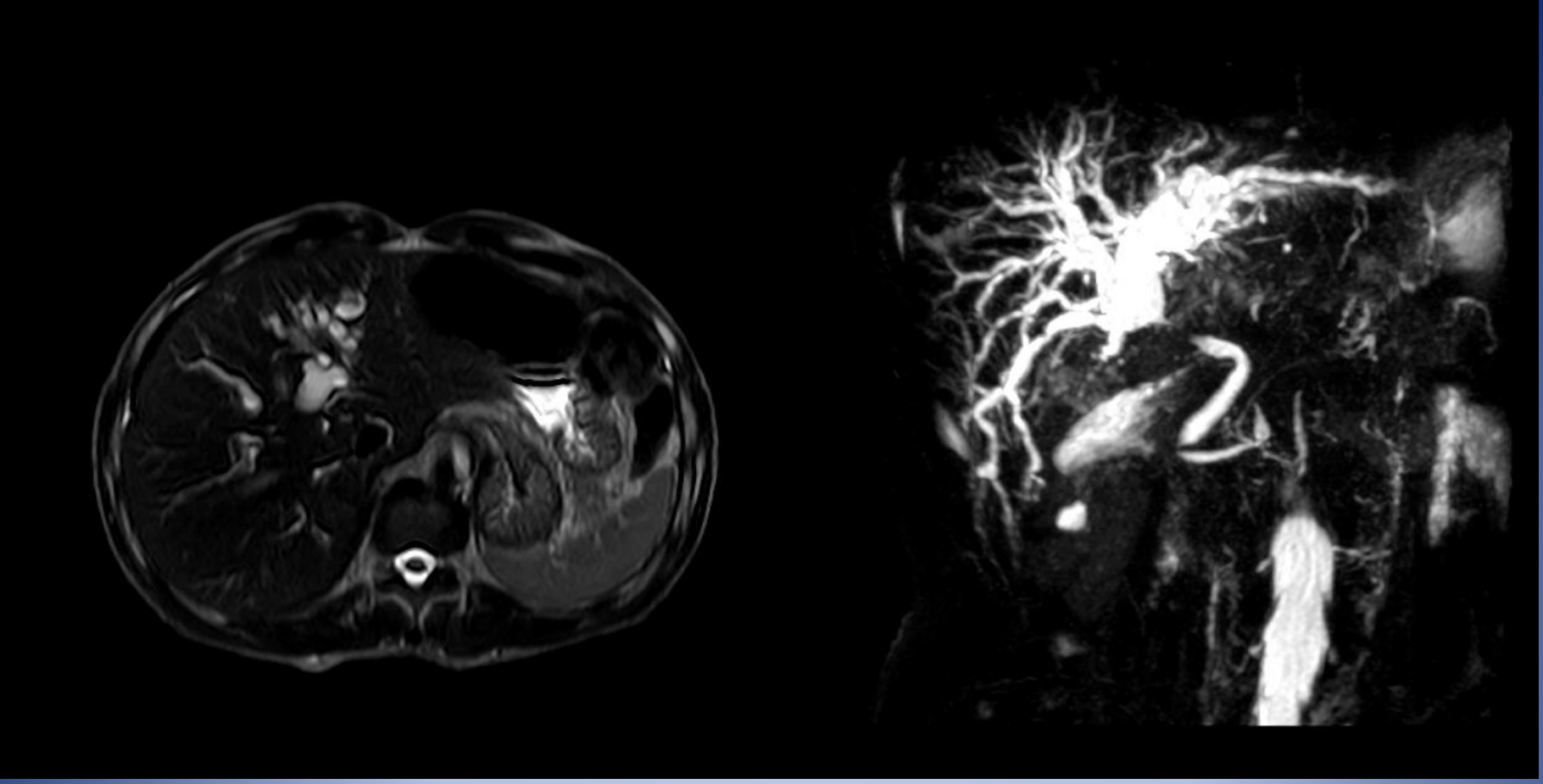
Intrahepatic chaolangiocarcinoma



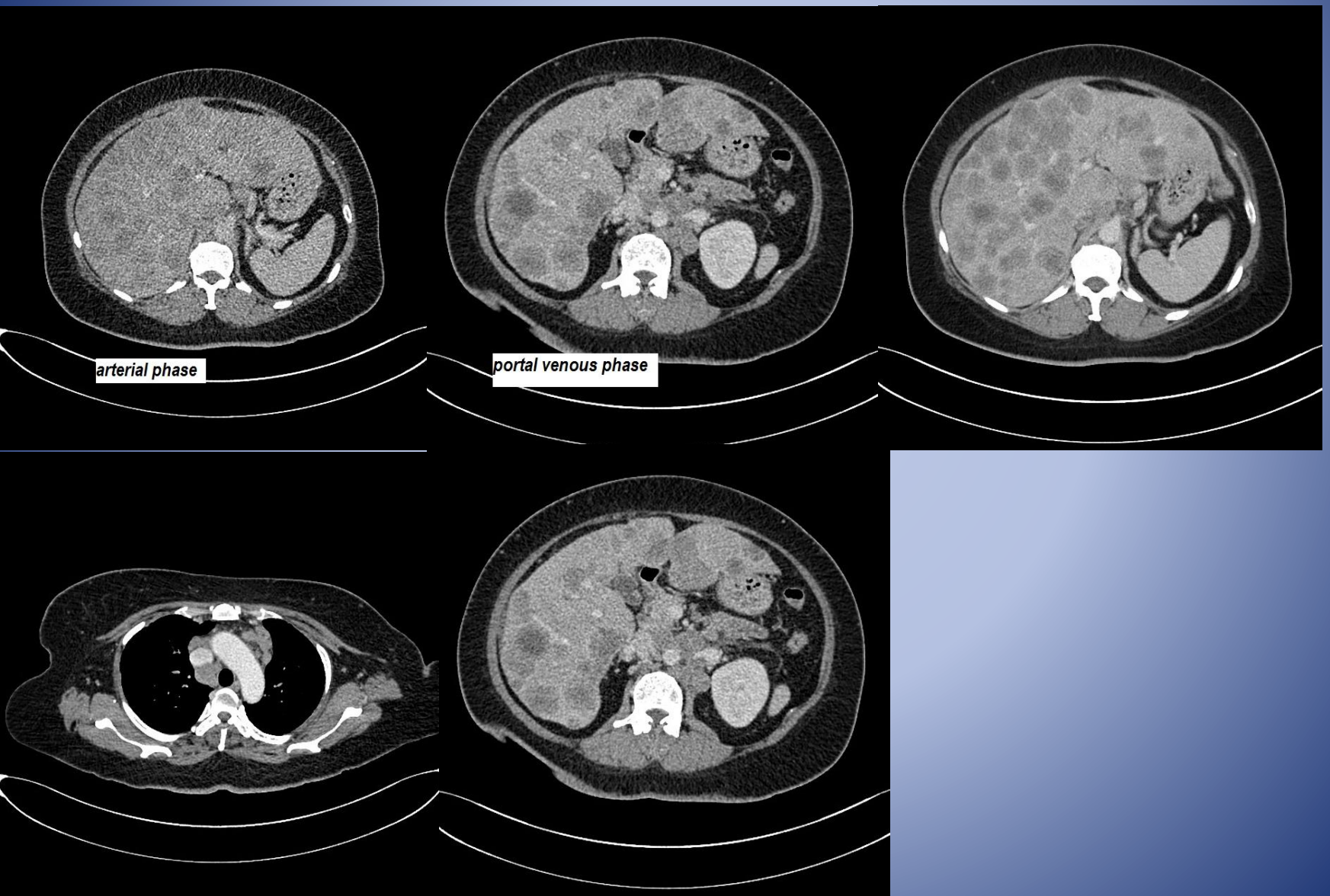


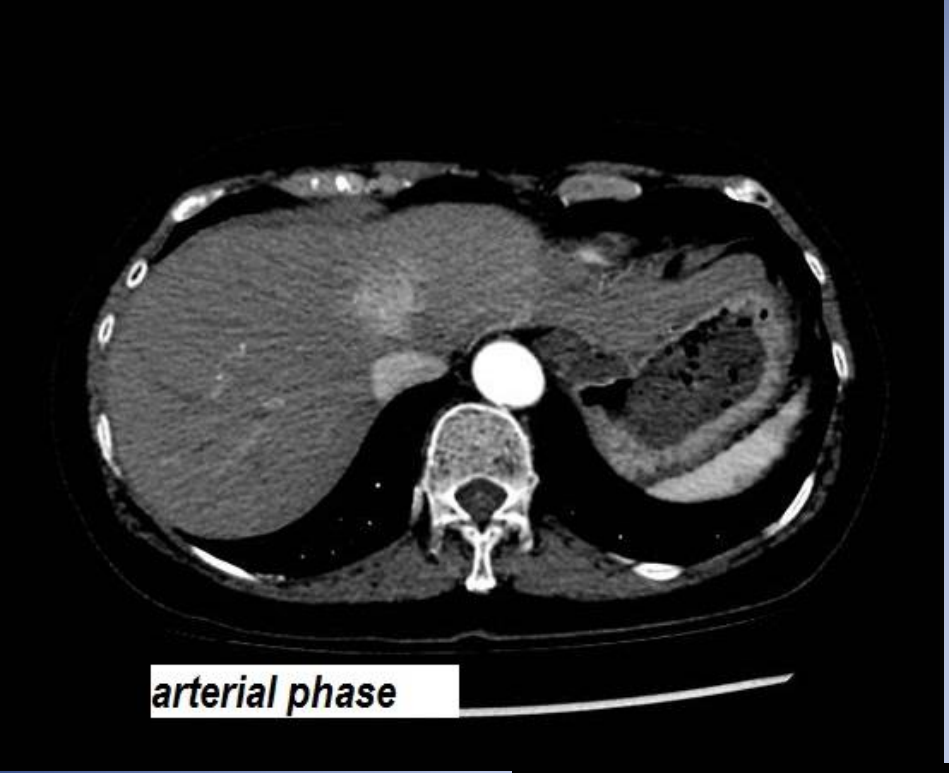


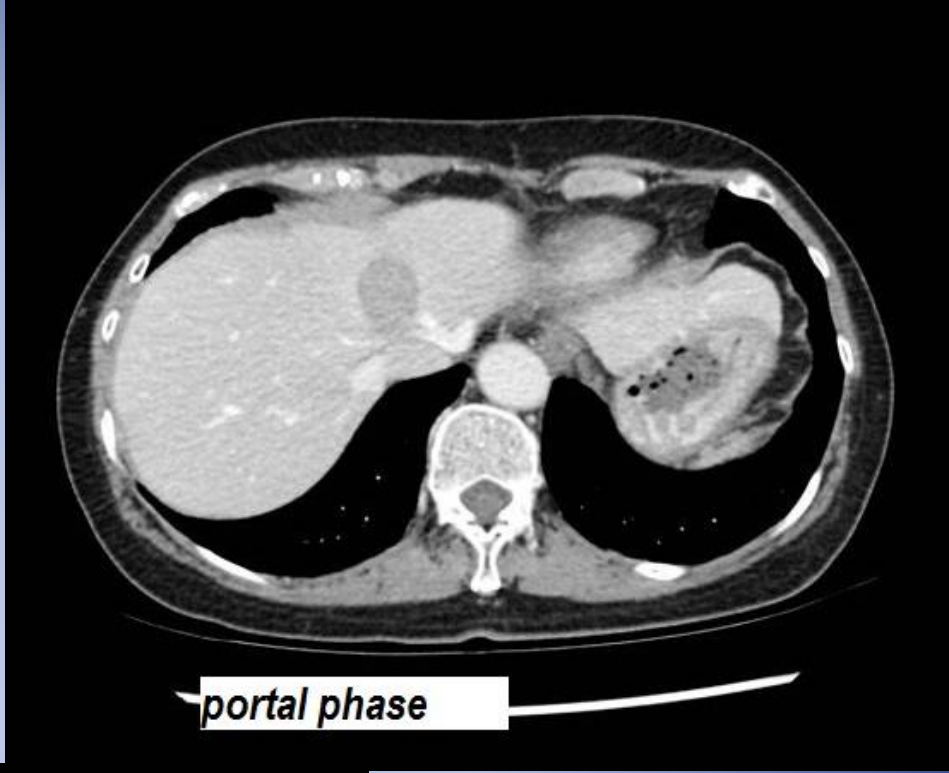
The key findings to look for are:
Delayed enhancement
Peripheral biliary dilatation
Capsular contraction

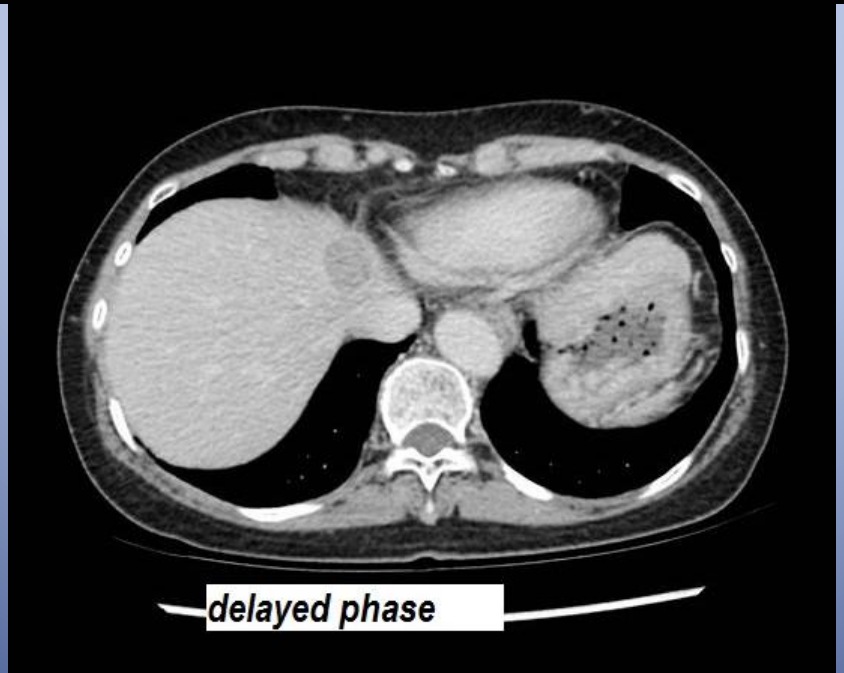


Metatstatic colorectal cancer



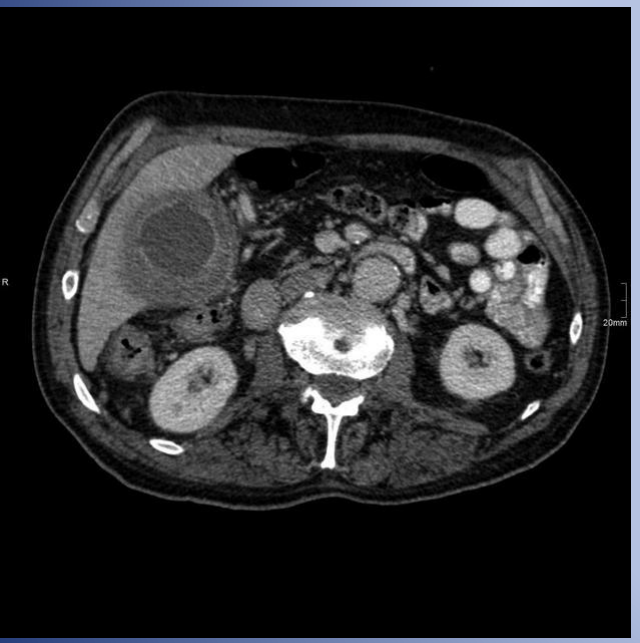


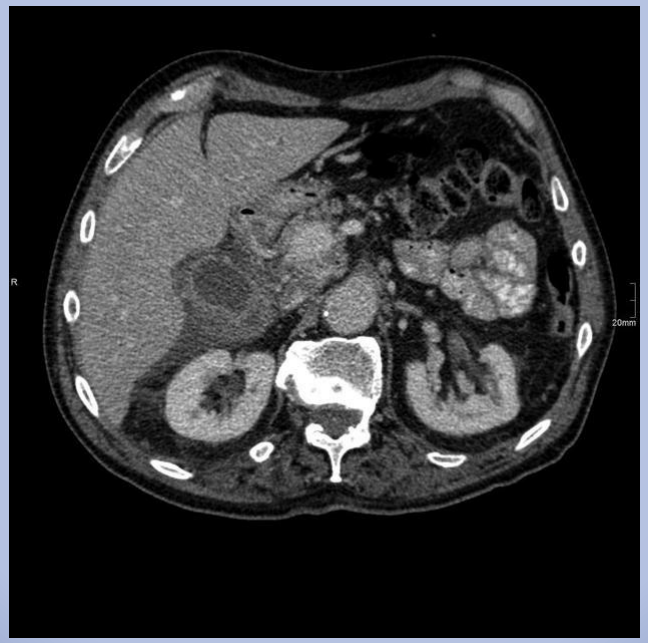


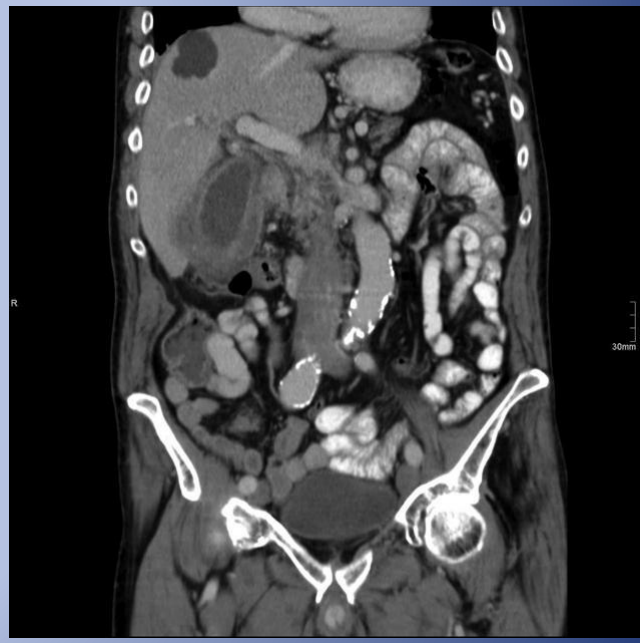


HCC

Acute cholecystitis

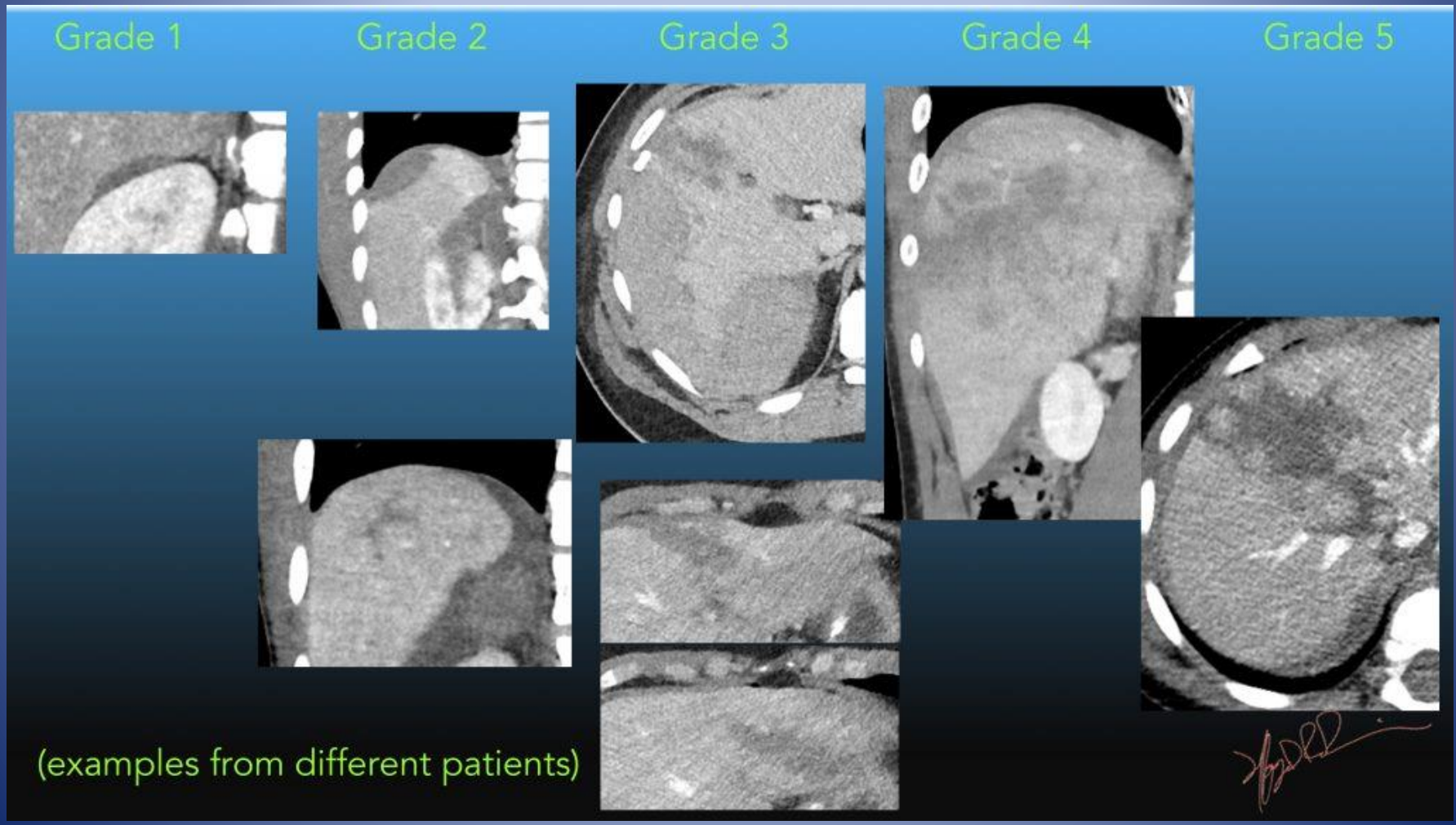


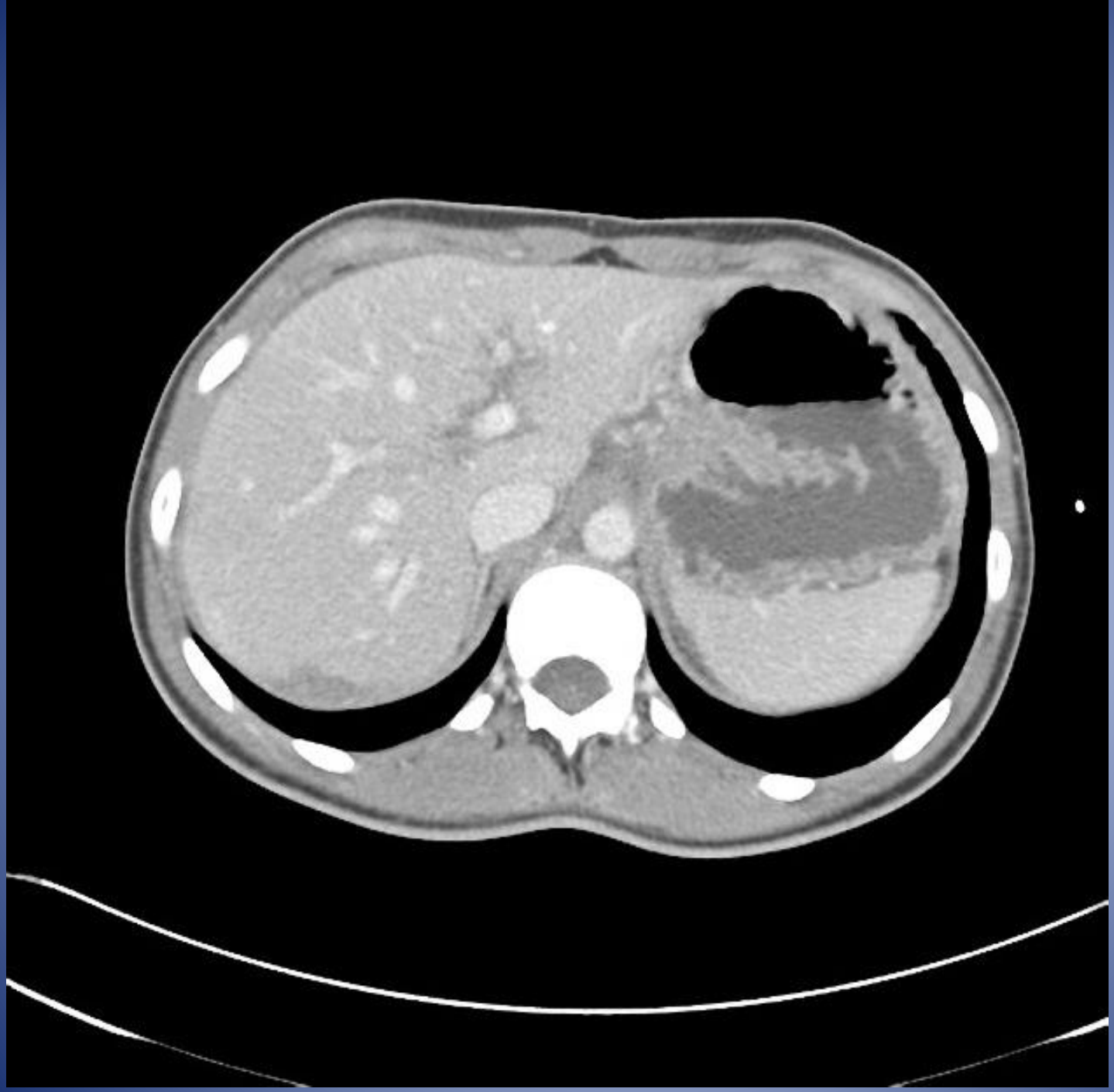


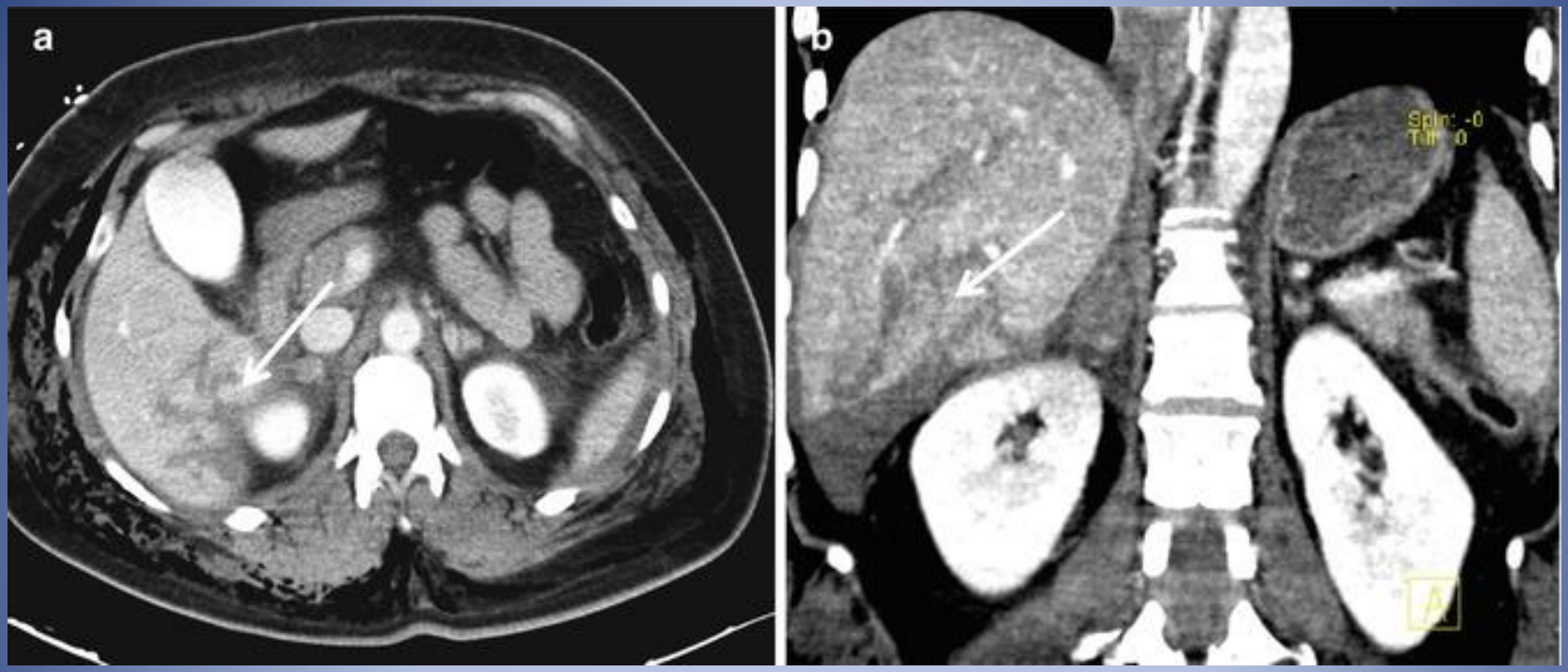



hemoperitoneum
hematomas
Active extravasation
Subcapsular hematomas
Liver trauma
laceration
contusion
devascularization
pneumoperitoneum

Grades of liver injury



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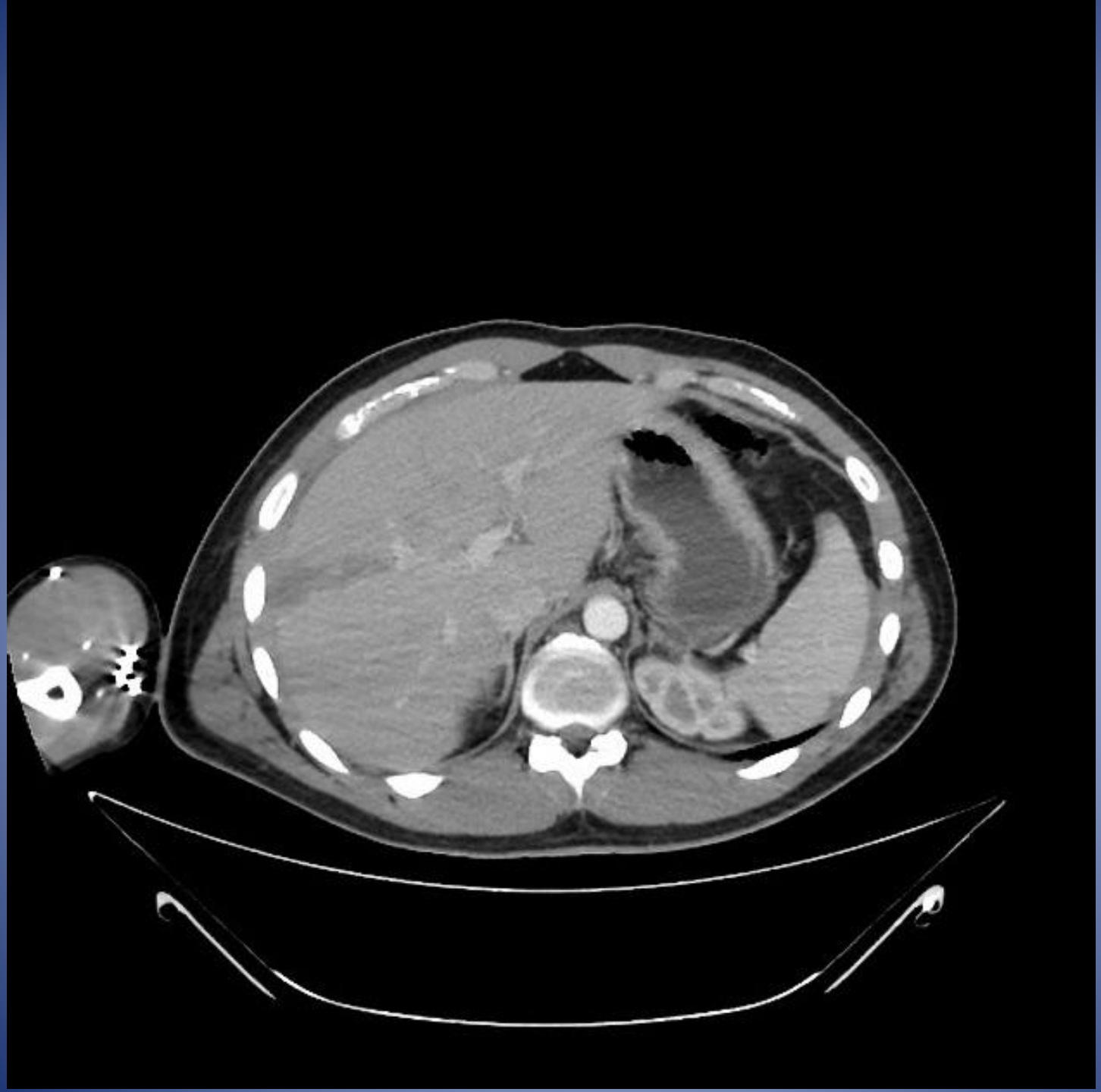
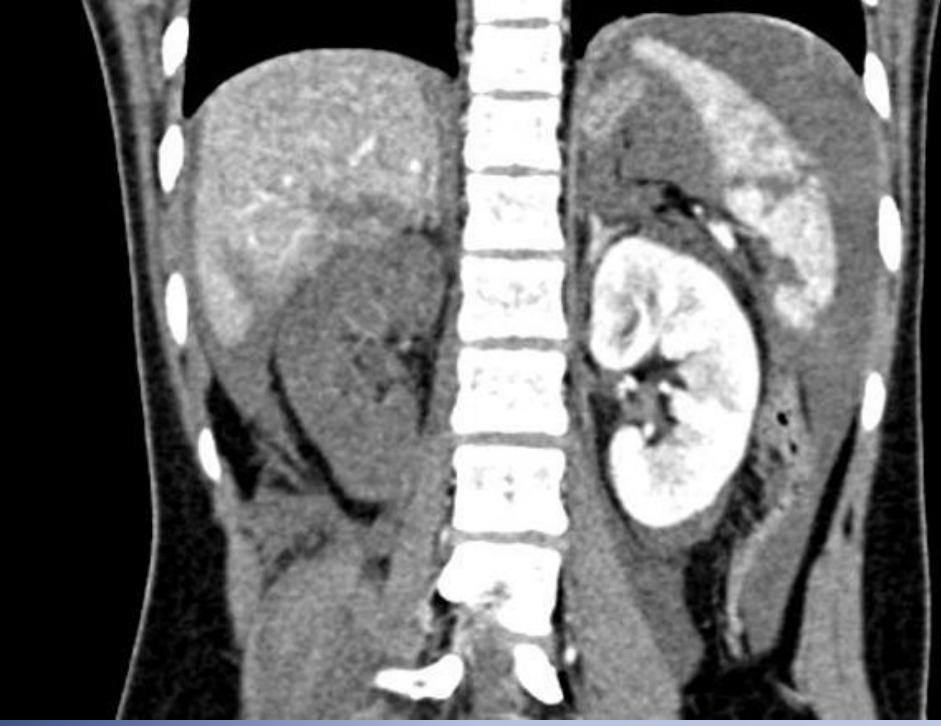
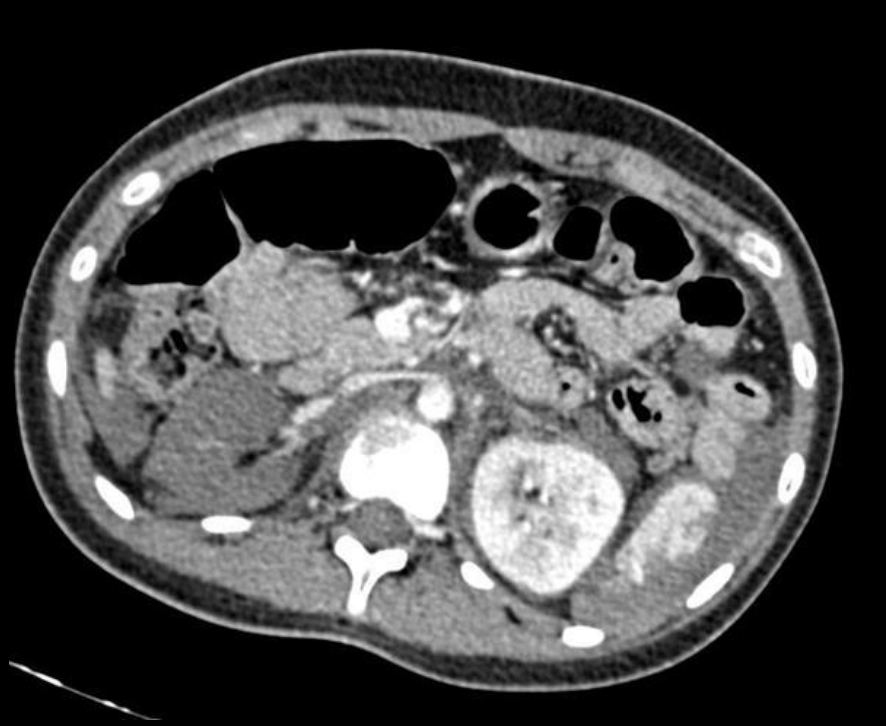
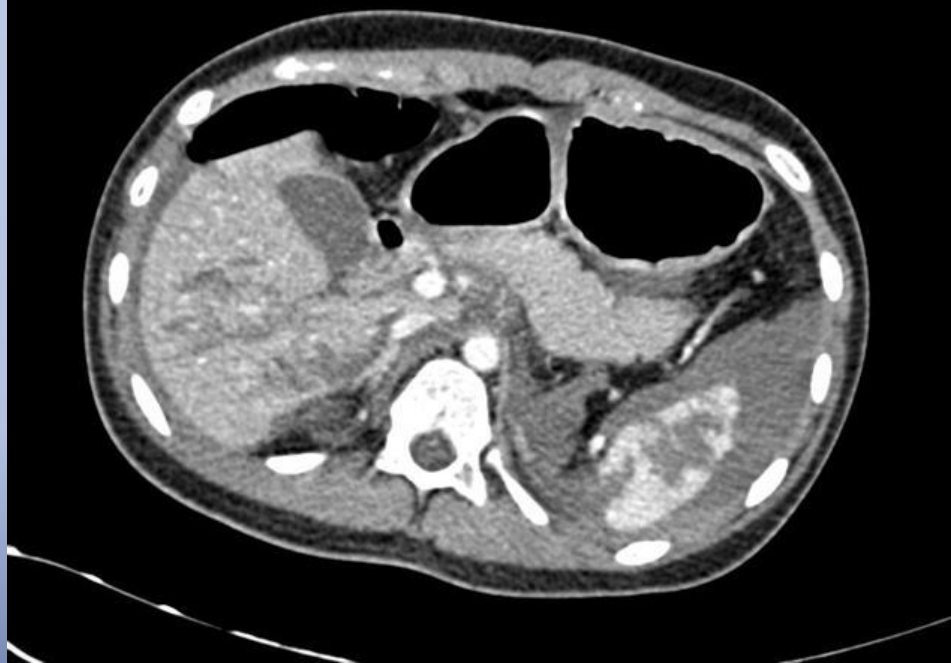
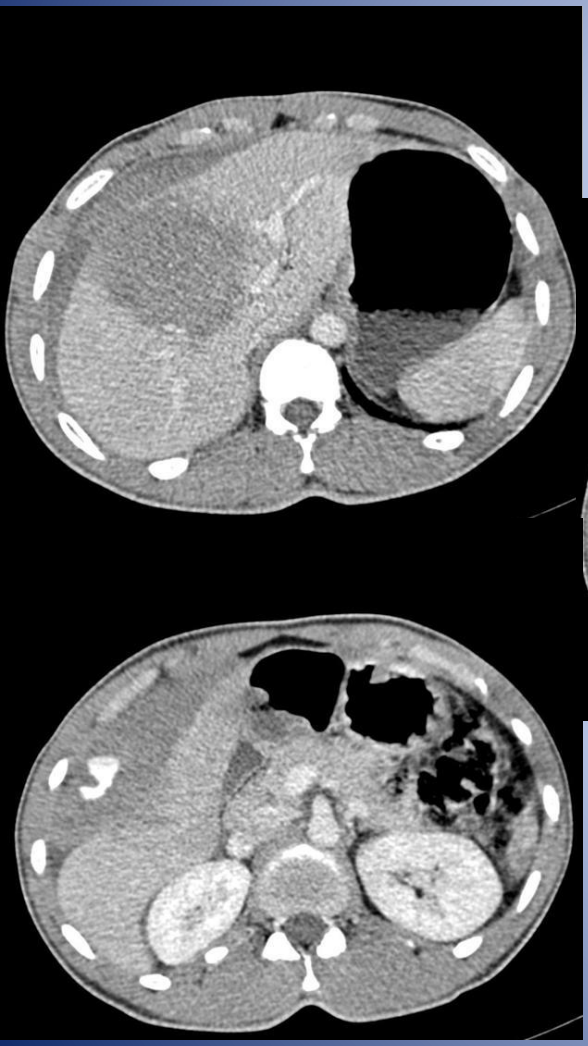


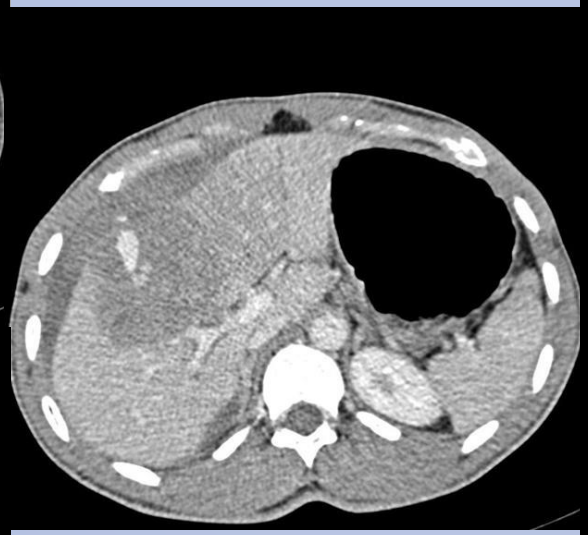


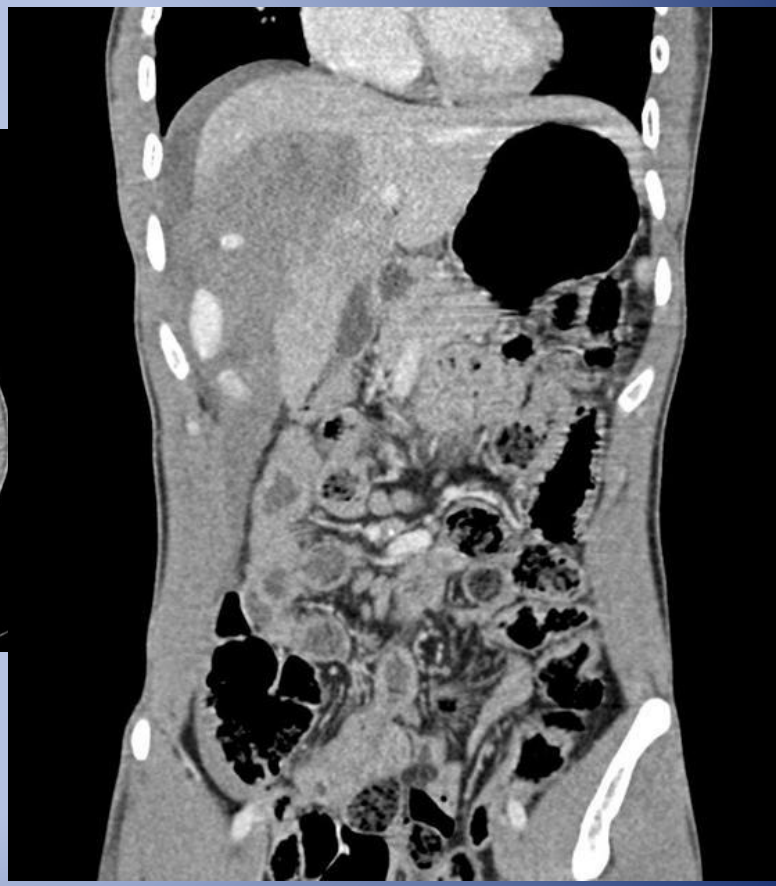


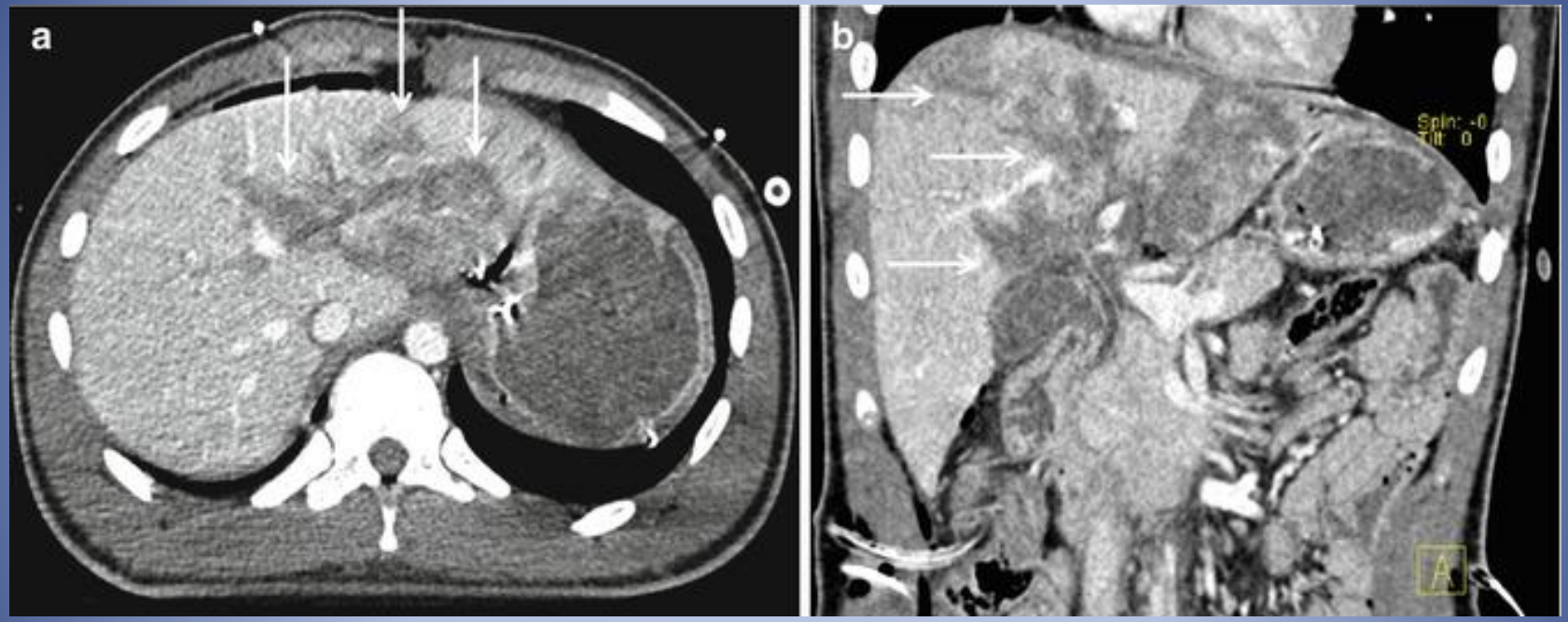


Liver laceration - AAST grade IV








a
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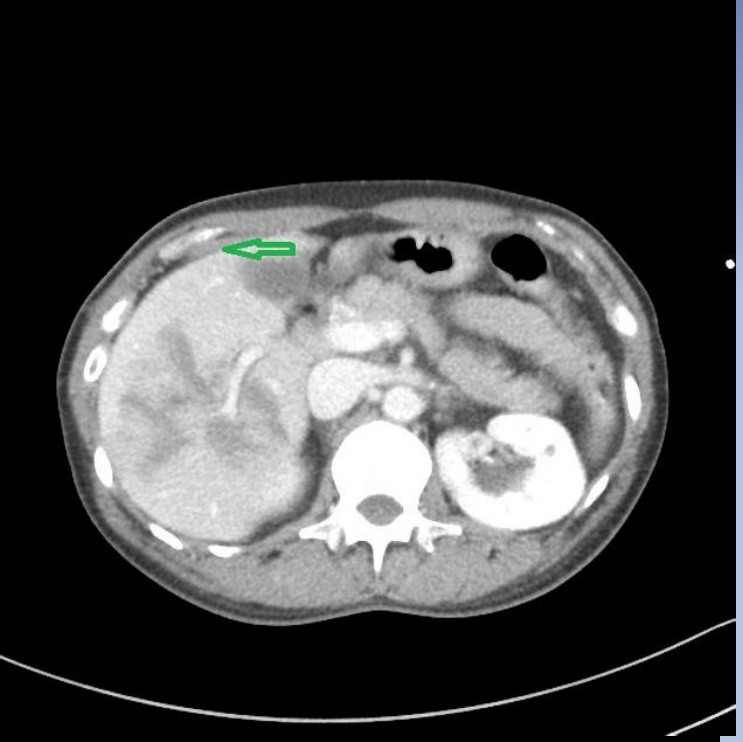
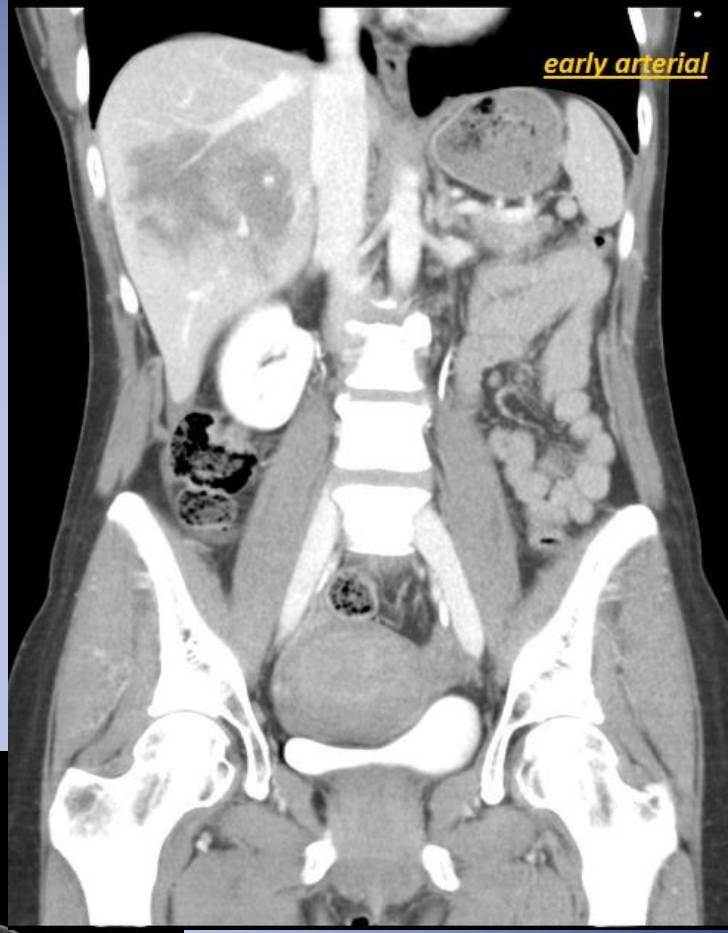
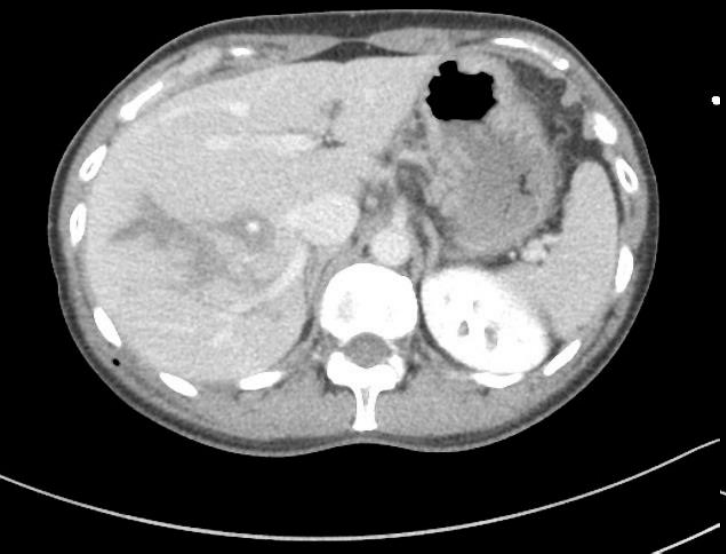
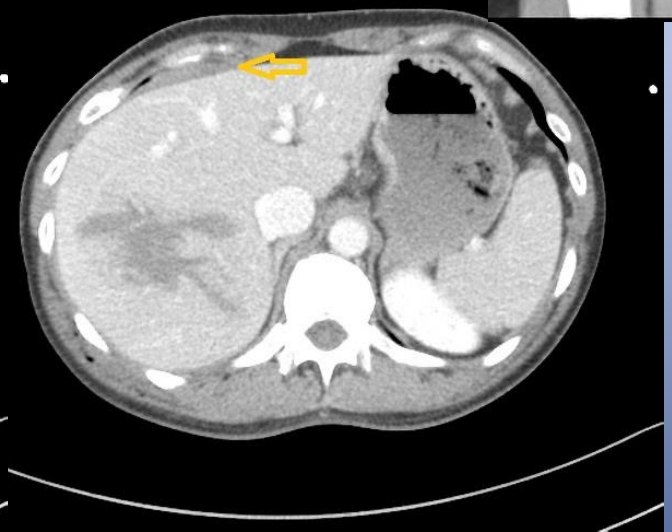




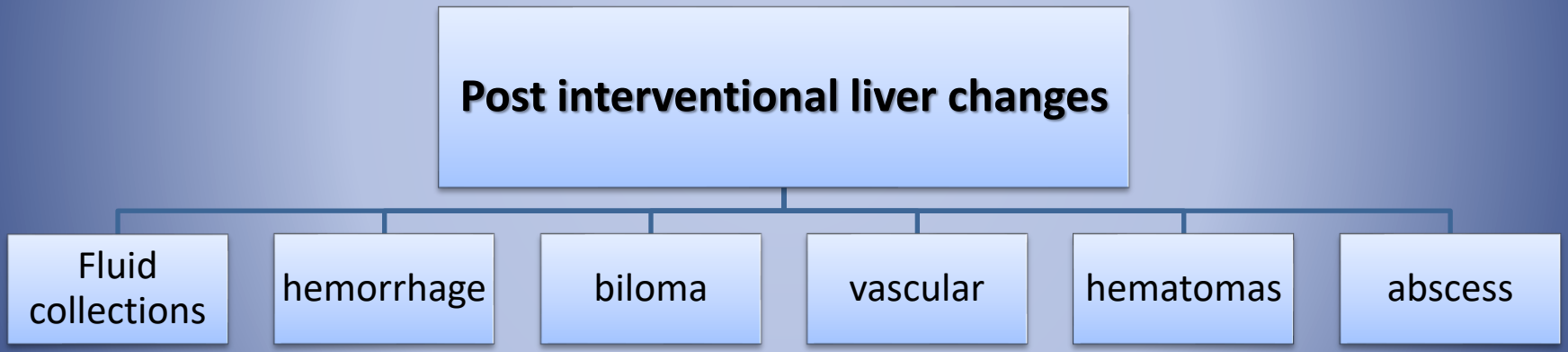
delayed

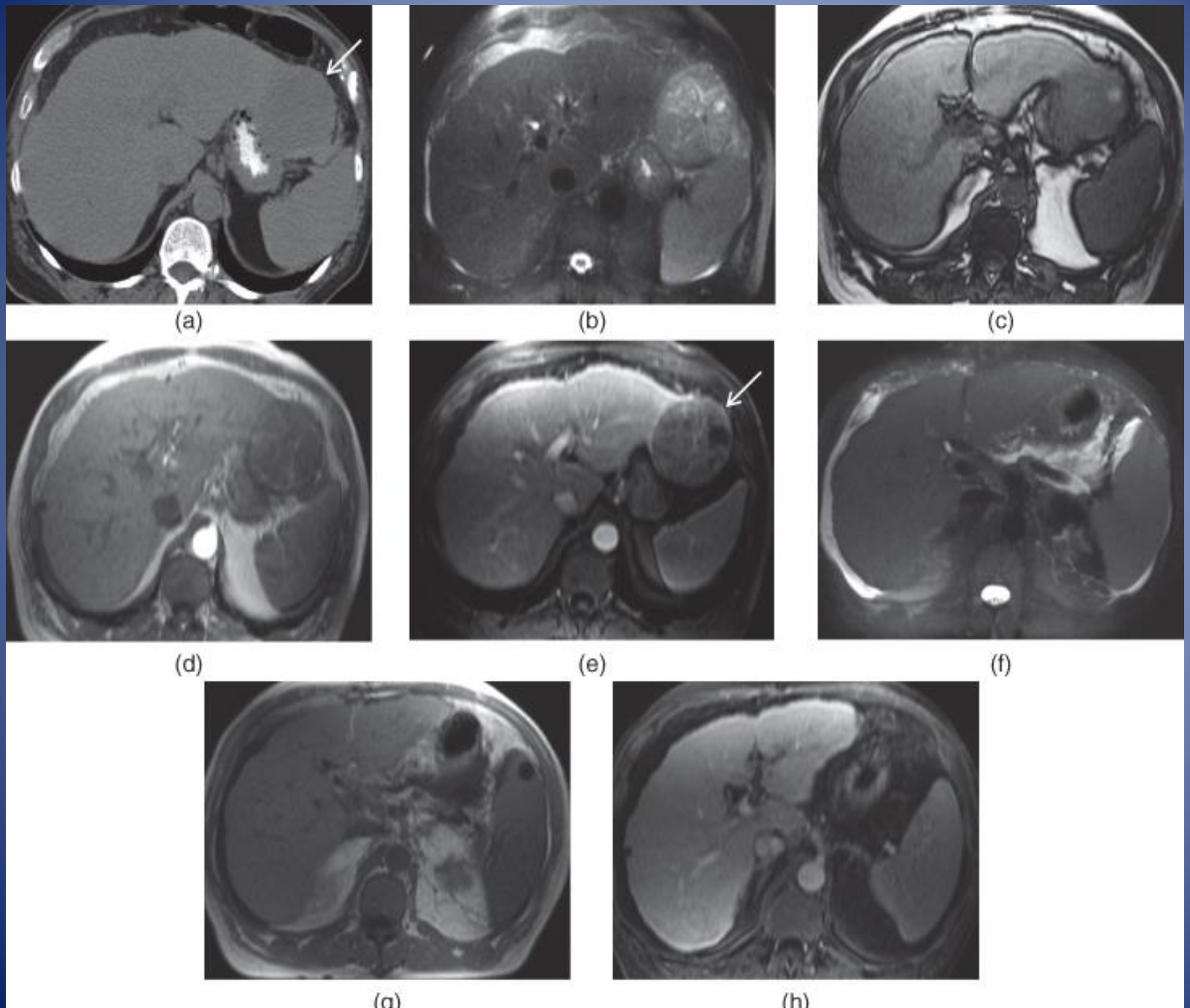




Post treatment changes in the liver

- **Surgical resection**
- Surgical removal with resection negative margins remains the optimal therapy for primary and secondary malignant liver tumors.Wedge resection, segmentectomy, and hepatectomy are the surgical resection techniques
- Wedge resections and resection margins may show low attenuation on precontrast CT images and mildly high signal on T2-weighted and low signal intensity on T1-weighted precontrast MR sequences. A thin rim of enhancement may be seen along the resection margins in the hepatic arterial dominant phase, which fades to isointensity in later phases. In successful complete resection, by 6 months postprocedure negligible enhancement is seen in these resection areas on postcontrast images.
- Resection margin enhancement reflects leaky capillaries (early on), edema, and granulation tissue (>1 month) in the liver parenchyma. These changes are most prominent in the first 3 months after surgery and gradually decrease over the following 6 months.
-


Post interventional liver changes
Fluid collections
hemorrhage
biloma
vascular
hematomas
abscess


(a)
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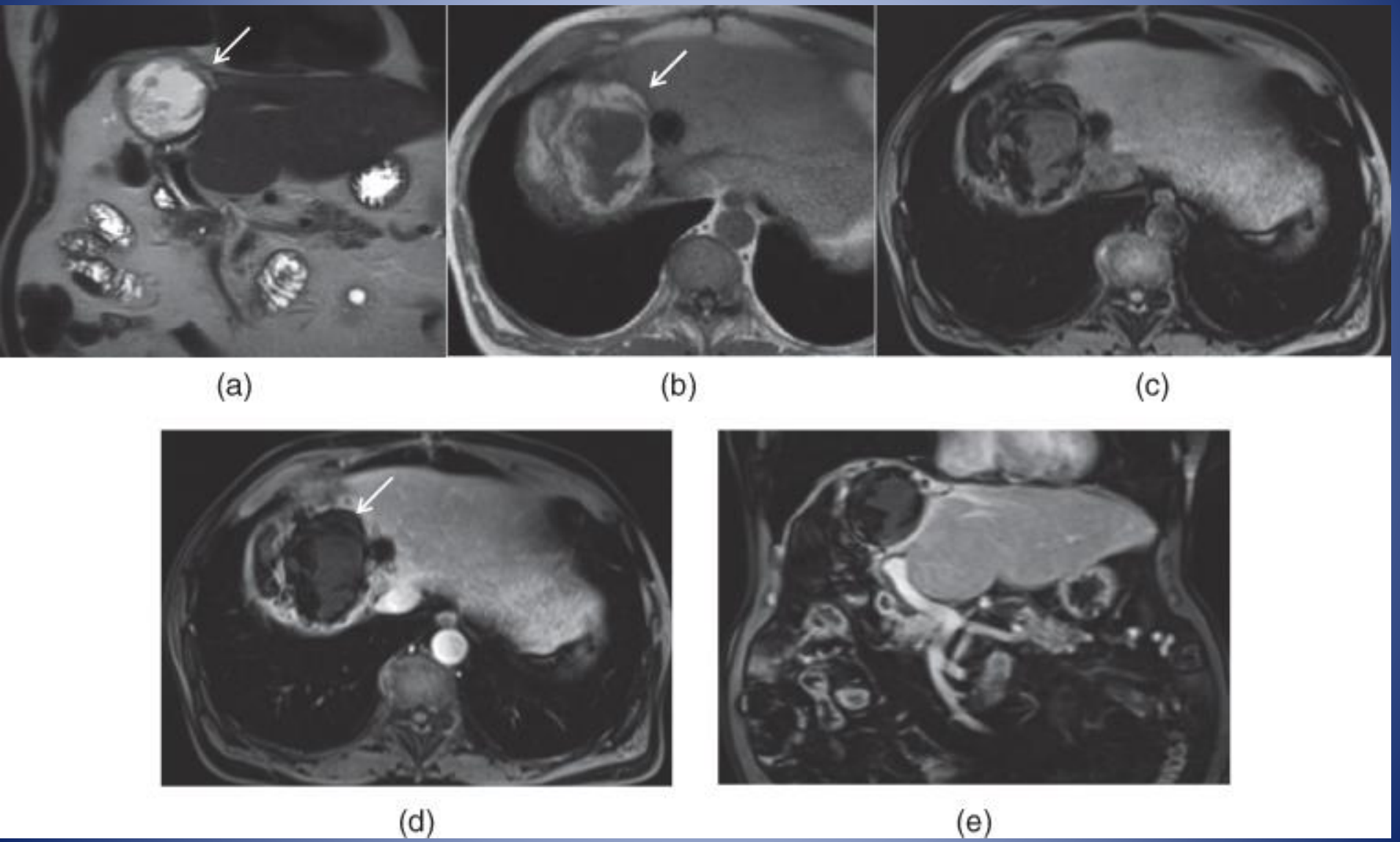
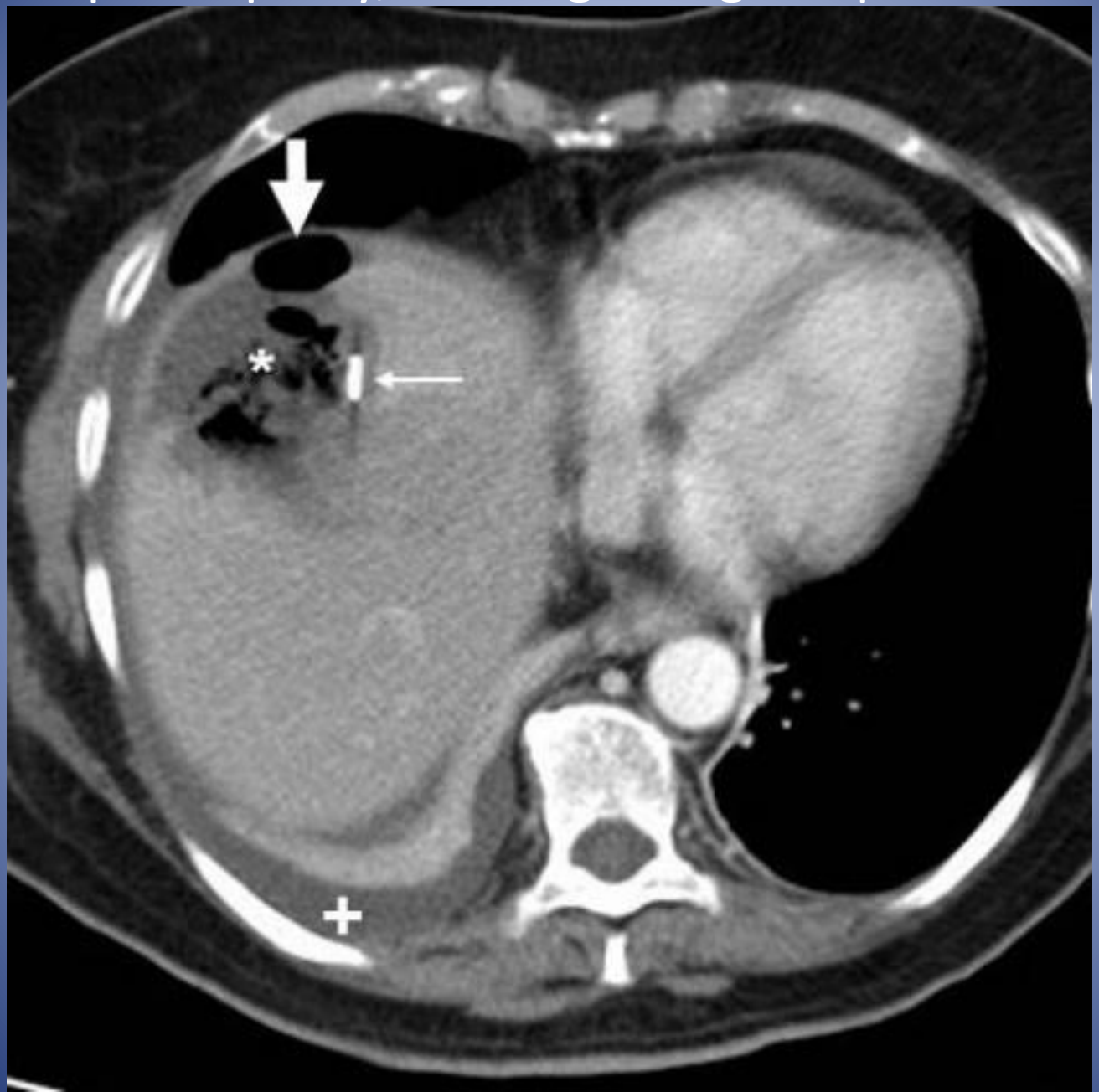
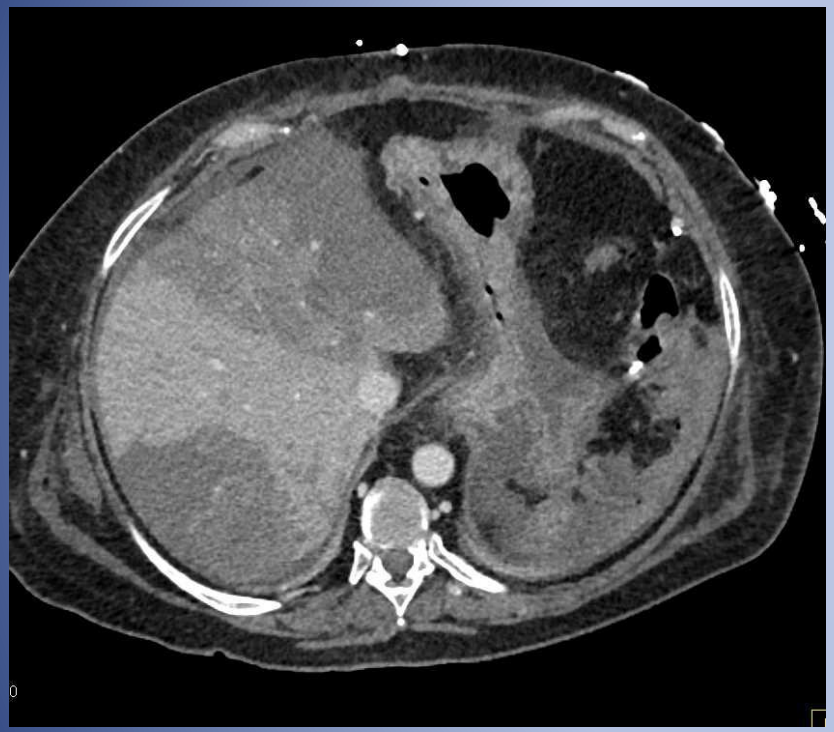
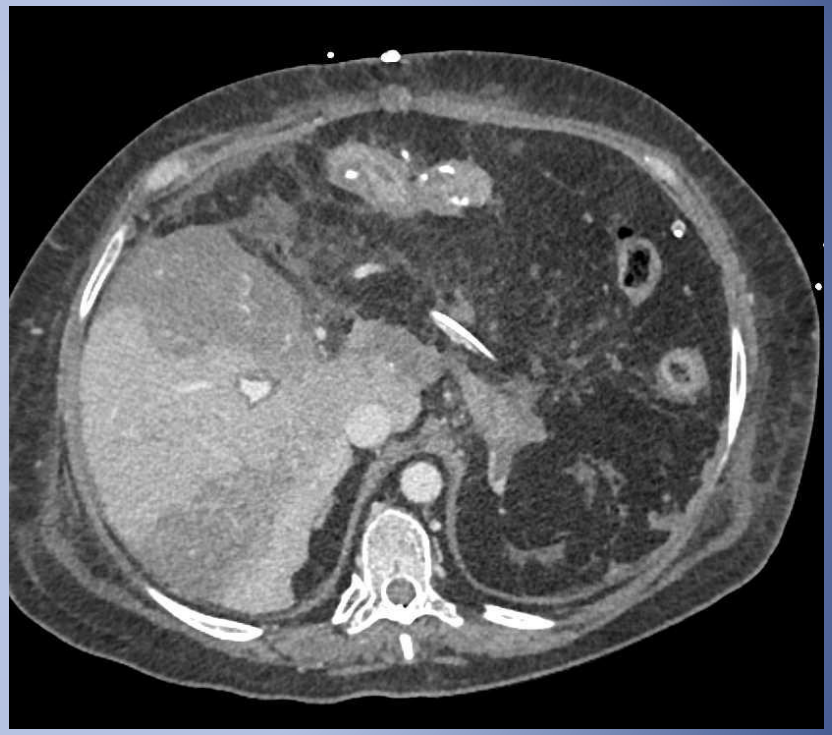

(a)
(b)
(c)
(d)
(e)

5th post op day, folloing wedge hepatic resection

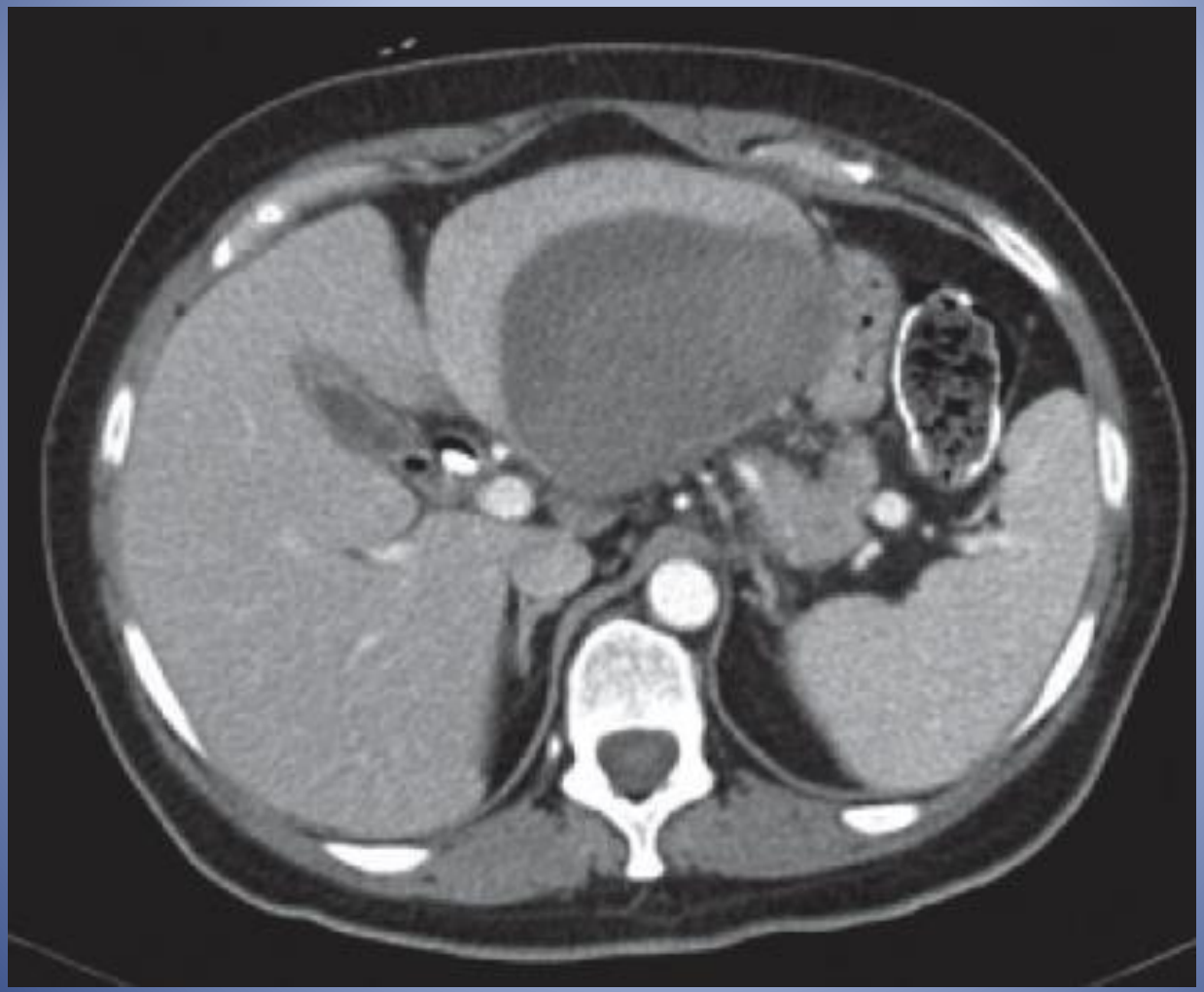


Hepatic infarction





Post ERCP hematoma



- Hyperplasia/hypertrophy of the remaining liver may be appreciated as early as 3 months after surgery. Within 1 year, general enlargement of the remaining liver occurs. After right hepatectomy, hypertrophy of the medial segment may create the appearance of a pseudo right lobe.


THANK YOU