Radiology and imaging the biliary, liver and pancreas

The biliary tract

- **These include:**
- 1. Simple X-ray
- 2. Oral Cholecystography
- 3. Intravenous Cholangiography
- 4. Operative and postoperative Cholangiography
- 5. Percutaneous transhepatic cholangiography (PTC)
- 6. Endoscopic retrograde cholangio pancreatography (ERCP)
- 7. Ultrasound
- 8. Isotope scanning
- 9. Computed tomography (CT)
- 10. Magnetic resonance imaging (MRJ)

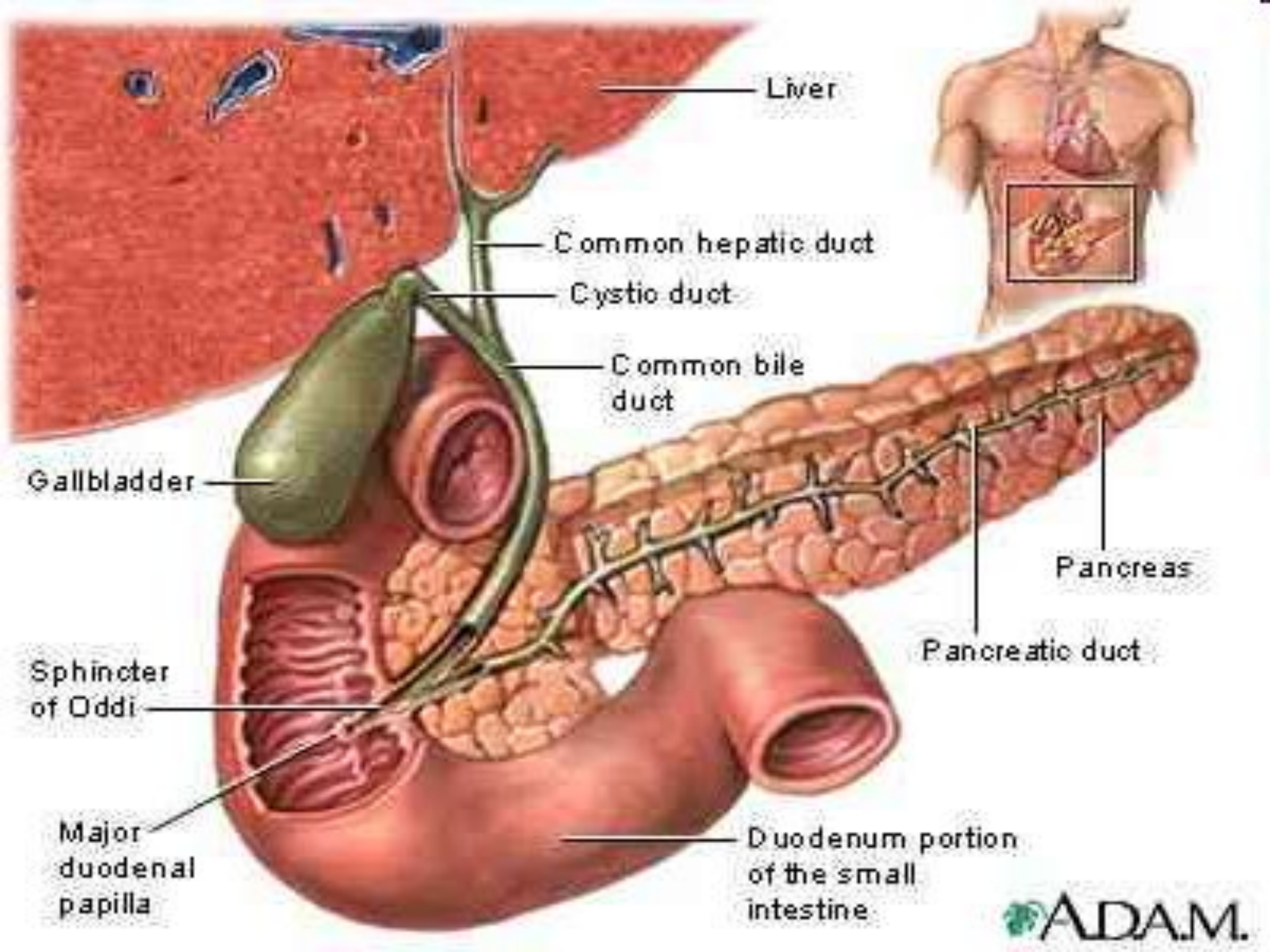
Gall Bladder

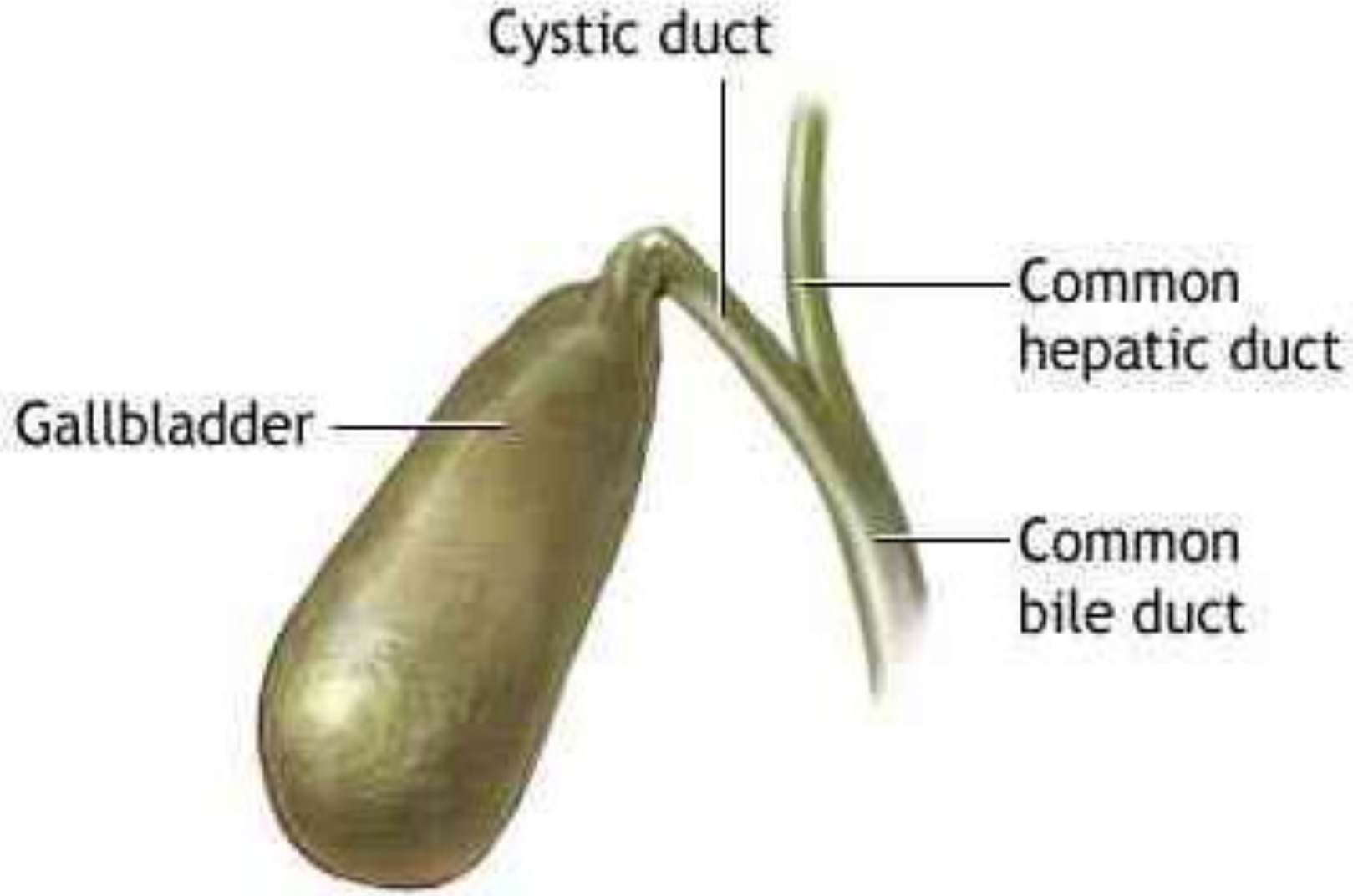
The normal gall bladder is composed of four parts:

- fundus
- body
- infundibulum and
- a neck

- Smooth muscle fibers are found in the wall of the fundus and infundibulum but are completely absent in the body. The liver is constantly secreting thin watery bile which flows into the bile ducts where it is diluted by addition of mucus.

- The gall bladder concentrates this bile and when the pressure in gall bladder falls below that in bile ducts more watery bile runs in. This process continues till the gall bladder is full of concentrated bile. Concentration of bile in gall bladder is carried out by absorption of water. Bilirubin is concentrated about 20 times and cholesterol, bile salts and calcium about 5 to 10 times.


Liver
Common hepatic duct
Cystic duct
Common bile duct
Gallbladder
Pancreas
Pancreatic duct
Sphincter of Oddi
Major duodenal papilla
Duodenum portion of the small intestine
A.D.A.M.


Cystic duct
Common hepatic duct
Gallbladder
Common bile duct

Cholecystitis

Acute Cholecystitis

In acute cholecystitis cholecystography is contraindication because:

- opaque medium may aggravate the inflammation and
- there is failure to concentrate the dye

Only plain x-ray may be of use in revealing opaque calculi.

Chronic cholecystitis

- Chronic cholecystitis may follow acute cholecystitis with or without stones. Chronically inflamed gall bladder is usually distended with mucus, its walls are thickened and its mucosa is thrown into heavy folds. In case where cystic ducts are blocked by stone the gall bladder becomes permanently distended, its wall undergoes atrophy and later on becomes thin sheet of fibrous tissue-like parchment.

Cholecystography

In cholecystography we see the following three points by which we can estimate the biliary function

- i. The rate of filling of gall bladder.

ii. Capability of gall bladder mucosa to concentrate bile as evidenced by the intensity of the shadow.

- iii. The rate of emptying of gall bladder.

Technique

- After a light fat-free dinner the patient is given 3 or 6gm of telepaque; next morning after 12-14 hours supine and erect x-rays are taken.
- Patient is then given fatty meal (egg, butter, etc.) and x-ray is taken after 1 hour. This completes the examination in most cases.

- Occasionally nausea may be complained or mild diarrhea may develop as side reaction. Sensitivity to iodine is a contraindication for the procedure. Use of telepaque is restricted in obstructive jaundice, vomiting and diarrhea.
- Iodine is absorbed from the gastrointestinal tract is secreted by liver. The bile as it comes from the liver ordinarily does not contain enough of the drug to be radio-opaque. The gall bladder receiving the bile does not contain enough of the drug to be radio-opaque. The gall bladder concentrates it by removing water.

- The amount of iodine in bile then becomes sufficient to make it radio-opaque and a dense shadow of gall bladder. To visualize all this mucosa of gall bladder, it must be intact and functioning well. If gall bladder is diseased, as in chronic cholecystitis, the concentrating ability of the mucosa is impaired or lost and gall bladder visualization becomes a failure.

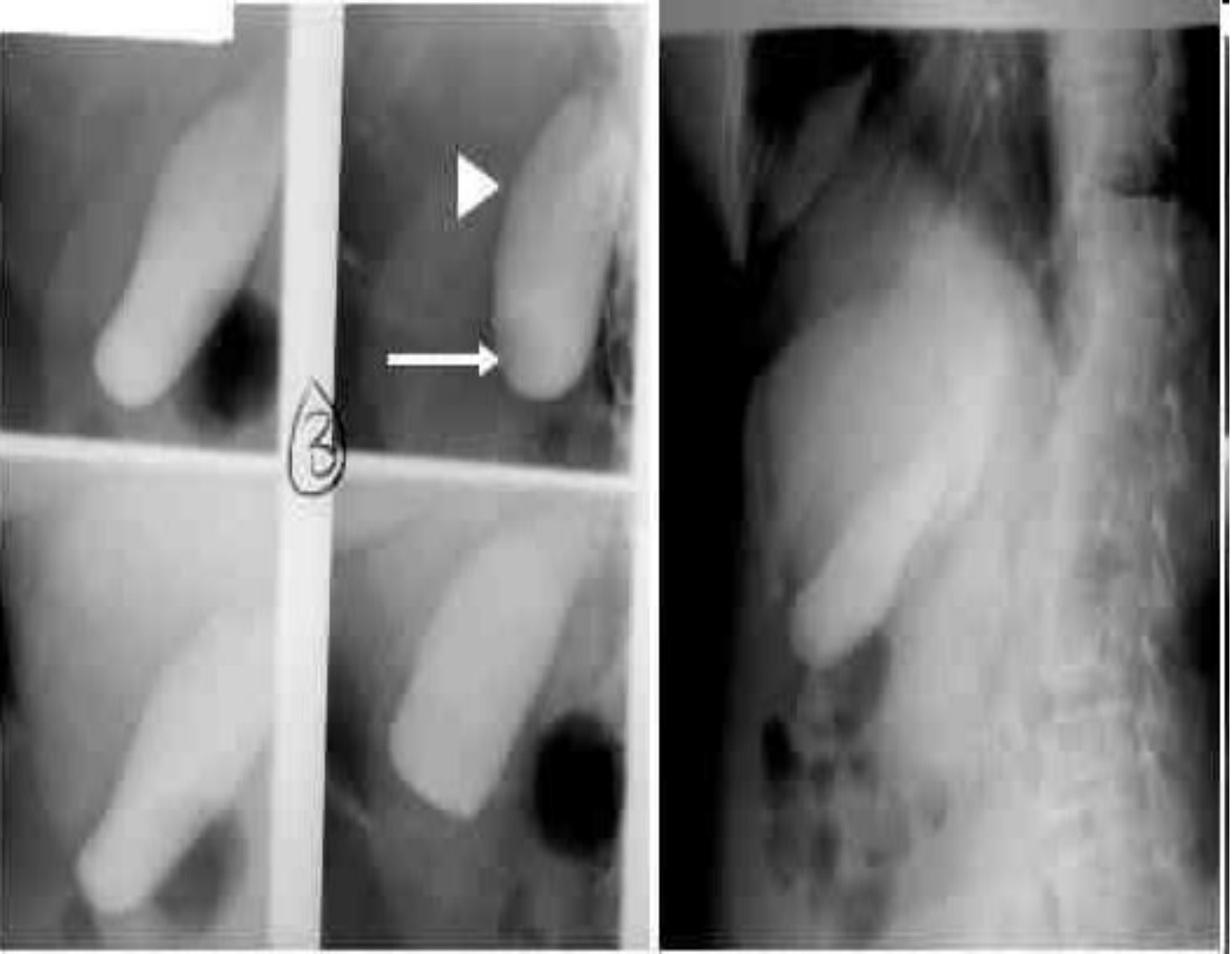
Cause of Non- visualization of Gall Bladder

- The patient could not take drug or could not retain it.
- Obstruction at the cardia or pylorus may prevent the material reaching to small intestine.
- Liver function maybe impaired to the point where a sufficient amount of the material is not secreted. Results are satisfactory if obstructive jaundice is present

- There may be faulty absorption from the intestine
- Obstruction of cystic duct may prevent entrance of bile into the gall bladder.
- Previously removed gall bladder.

Normal Cholecystography

- Gall bladder is visualized with uniform density
- There is no filling defect suggestive of radio-opaque stones
- After fatty meal there is sufficient contraction of gall bladder. Contraction of the gall bladder in response to fatty is the result of production of a hormone known as cholecystokinin by mucous membrane of intestine.
- Absence of contraction of gall bladder after fatty meal is suggestive of cholecystitis.



Non Functioning Gall bladder

- Common cause for non-functioning gall bladder is chronic cholecystitis with stones. Multiple doses of telepaque 3gm each day for 3 or 4 days (after each meal) is advised due to which at times the margins of stone may become opaque and seen.

- When gall bladder is sub normally functional a shadow of the gall bladder is visible but faint. Density may be so low that the presence or absence may not be determined under the conditions and examination may be repeated after giving double dose of telepaque.

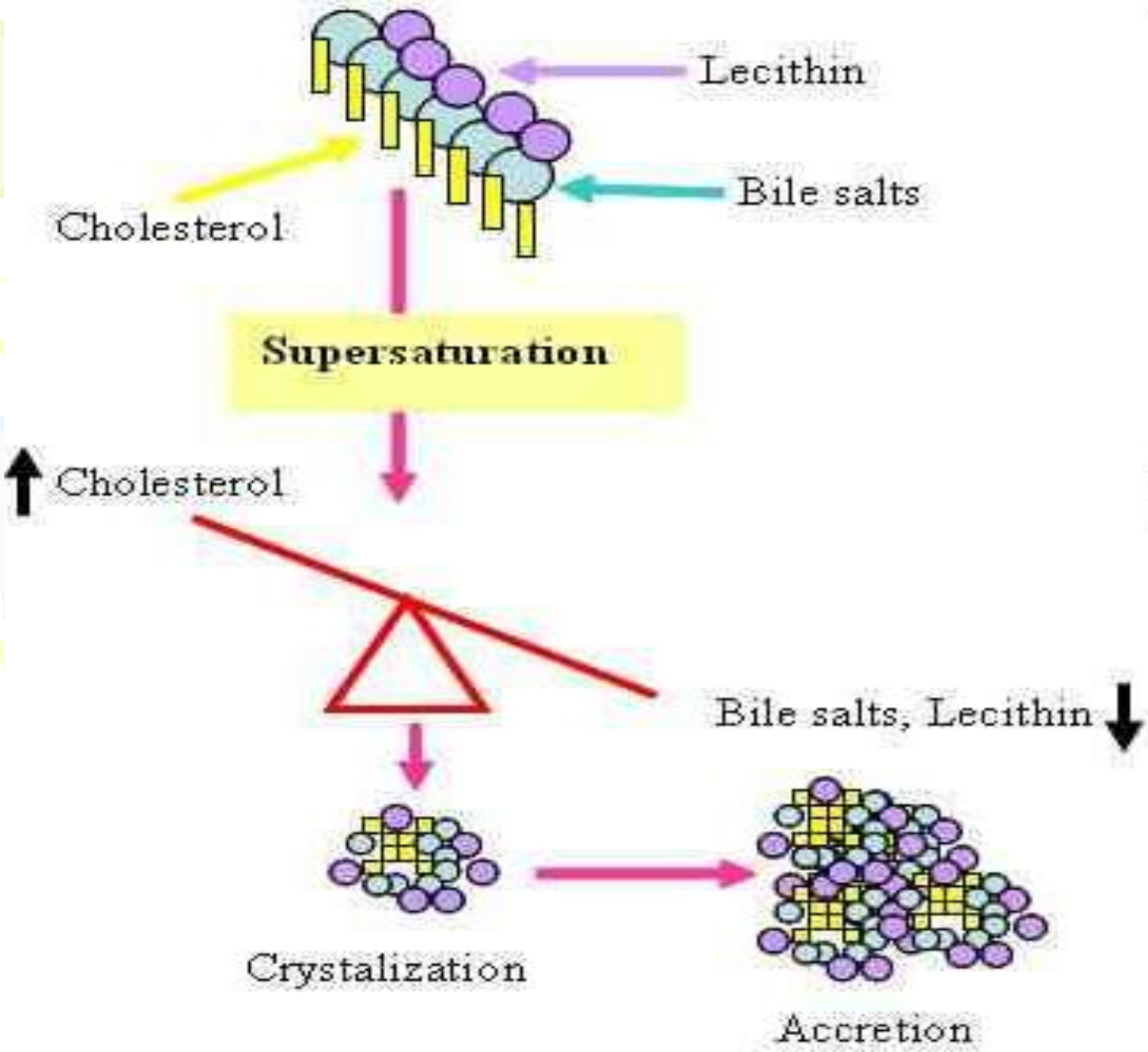
Simple X-ray of the biliary tract

- Opaque gall stones will be readily shown. These vary in type. They may be large laminated structures, which are usually solitary or few in number. On the other hand small calculi may be multiple and numerous. An opaque stone in the cystic or common bile duct can be diagnosed by its position relative to the normal gall-bladder. This is easy if there are also opaque stones in the gall-bladder.

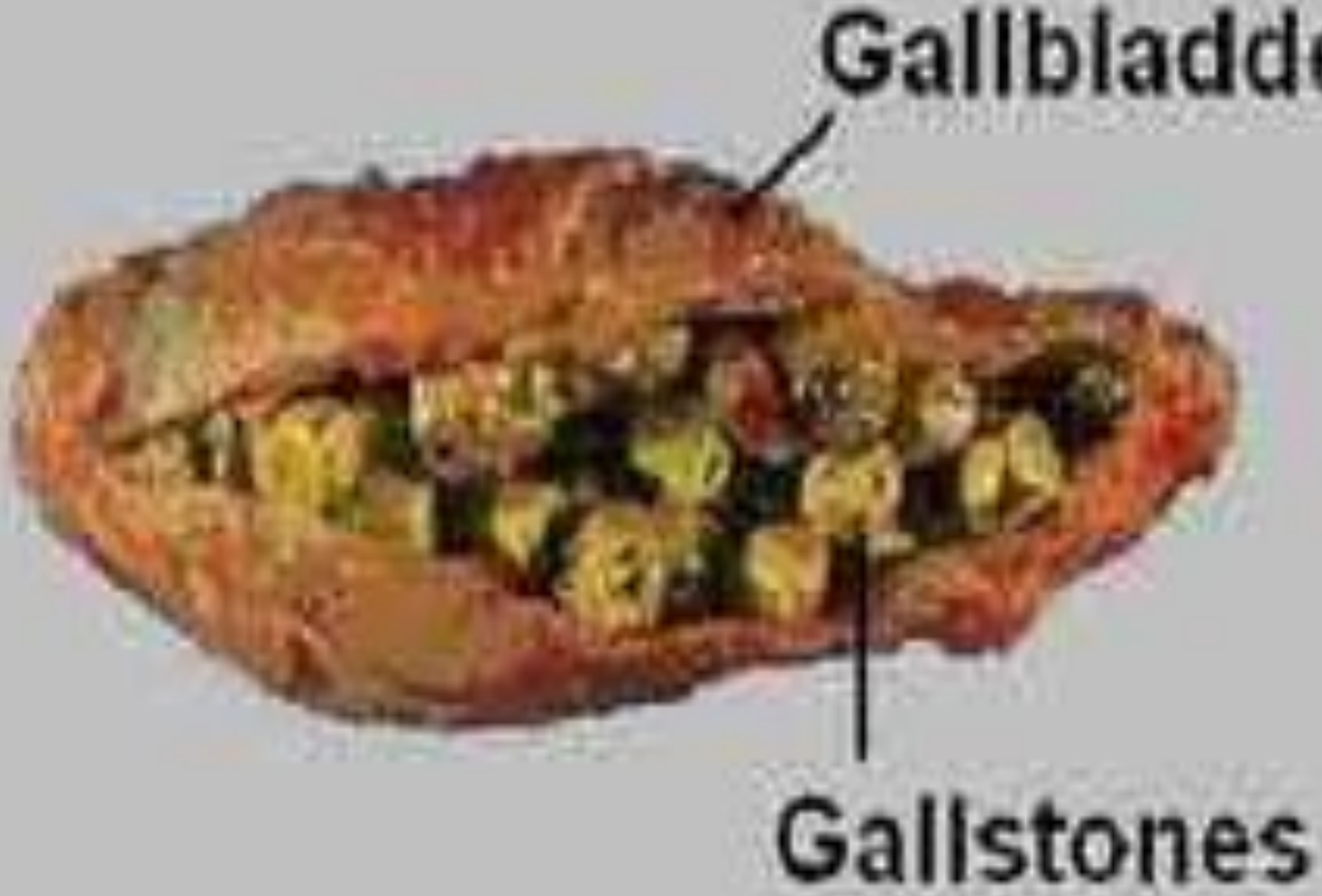
- Non-opaque gall-stones, for instance large cholesterol stones, will not be diagnosed by plain x-rays and will require contrast studies, or ultrasound for their demonstration. Multiple (minute) calculi may form sediment in the gall bladder giving rise to so-called "milky bile". This will outline the whole gall-bladder in the supine patient and will sediment to form a horizontal level in the gall-bladder in the erect film.

Differentiating renal calculus from gall bladder calculus

Gall bladder stones	Renal stones
Mostly lies anterior to the vertebral body (on lateral view)	Mostly lies over the vertebral bodies (on lateral view)
Moves with change in posture	The renal calculus does not show movement on change of posture; however, renal stones may lie anterior to the vertebral body in cases of associated hydronephrosis, where movement of calculus occurs
Multifaceted (centrally lucent)	Centrally opaque


Lecithin
Cholesterol
Bile salts
Supersaturation
Cholesterol
Bile salts, Lecithin
Crystalization
Accretion

Gallstones


Gallbladder
Gallstones

Gas in the biliary tract

- Usually in the hepatic ducts, is only occasionally noted at plain x-ray. This implies either a fistula between the bowel and biliary react, or an incompetent sphincter Oddi. The latter condition may be seen following passage of a large calculus or following operative intervention and exploration.

- It is important to remember that both oral and intravenous cholecystography are unlikely to be successful in the presence of obstructive jaundice. This is because with biliary obstruction the excretion of contrast from the liver is impaired.

Cholesterols [strawberry gall bladder]

- There is diffuse deposition of cholesterol on the mucosa of the gall bladder. The gall bladder shadow appears normal and concentrates normally. When cholesterol deposits measures 2mm or more, they can be detectable. Multiplicity of fixed mural defects is absolutely polyps are extremely rare.

- Cholesterosis are:
- small round translucent defects attached to the gall bladder wall
- these vary in size from 1 to 2mm
- their attachment to the wall is determined by lack of movement in different position

- A cholesterol polyp is not a tumor but consists of small collection of cholesterol crystals. It may form a sessile mass or be attached to the wall by a thin delicate stalk. It has also been called "lipid gall bladder" or "strawberry gall bladder" because of the gross appearance of multiple tiny collections of cholesterol on the surface of reddened mucosa resembling strawberry seeds.

Universal Medical Imaging Group

Multiple Gallbladder Polyps

www.universalmedicalimaging.com

Calcification of walls of Gall Bladder

- This is a rare condition. It cannot occur without existing fibrosis and therefore is a sequel to a chronic cholecystitis. It is known as porcelain gall bladder. Calcium is laid down symmetrically and the usual ovoid outline of the gall bladder is visible. Calcified gall bladder either completely fails to concentrate the contrast medium of does it feebly and slowly.

Milk of Calcium Gall Bladder

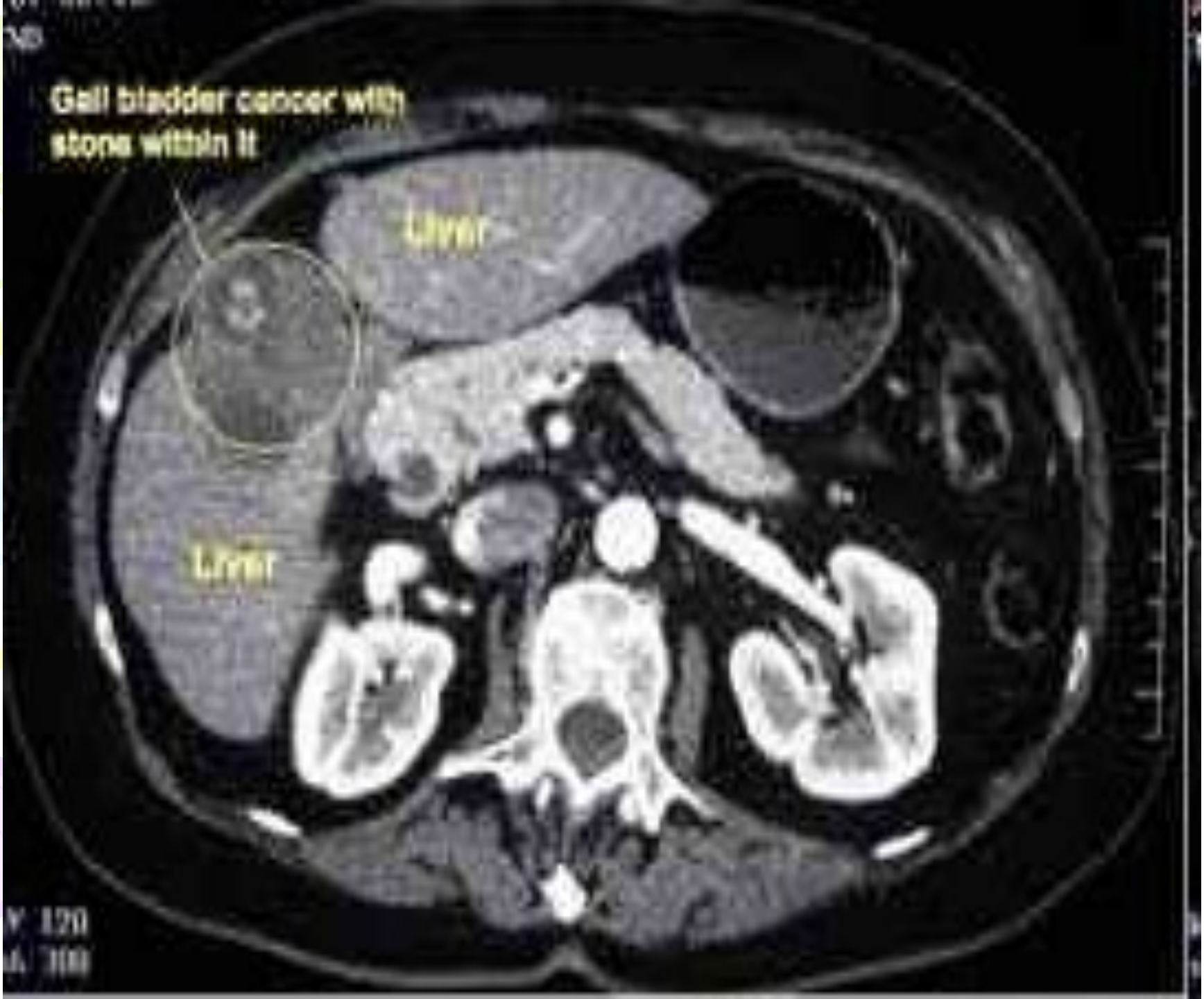
- Milk of calcium bile is a condition in which the gall bladder becomes filled with an accumulation of bile containing a high percentage of calcium carbonate due to which gall bladder is visualized in pain abdomen film without administering telepaque to the patient. It follows obstruction of cystic duct.

Tumors of Gall Bladder

- Small papillomas are most frequent. These are seen as small translucent defects usually on the lateral walls of the gall bladder. Their average size is about 0.5cm and not longer than 1cm. They are found in multiple. Gall bladders concentrate the dye well. These are fixed and never changes position. In the filled gall bladder these resembles stones or small pocket of duodenum gas.

- Adenoma of gall bladder is rear. It looks like single small semi -circular or circular translucent defect in the fundus of a well defined gall bladder. It never alters its position and it is best seen when gall bladder has evacuated half of its content.


Gallbladder cancer


Gall bladder cancer with
stone within it
Liver
Liver

Percutaneous Cholangiography

- Indications are:
- • To differentiate between obstructive and non obstructive jaundice.
- • To determine the presence and site of carcinoma of billiary system.
- • To demonstrate the number of calculi in billiary system.
- • To decompress the billiary tree prior to surgery. The procedure is restricted to patients schedule for surgery and it is performed an hour or two before it.

Contraindications are:

- Hemorrhagic diathesis
- Vitamin K resistant hypoprothrombinemia
- Febrile cholangitis

Interpretation of Percutaneous Cholangiography

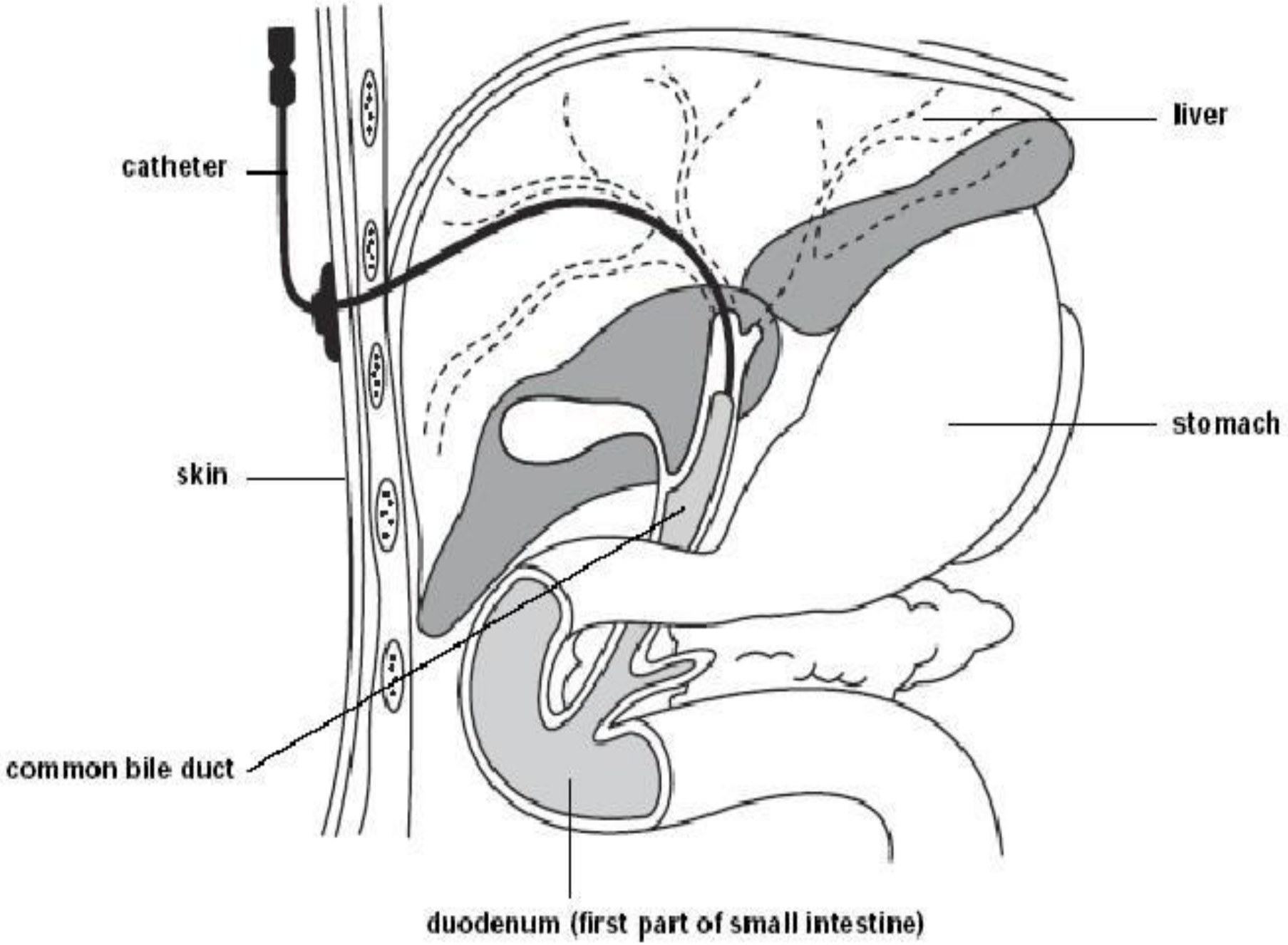
- Calculi producing filling defects.
- Obstructed duct is usually due to calculi.
- Smooth narrowness of a short segment indicates stricture.
- Rigid and irregular duct indicates carcinoma

- • Dilatation of duct with an uneven and ragged obstruction pattern indicates carcinoma in the ampulla of pancreas.

- • Smooth, flat, shallow obstruction with dilation of the duct indicates carcinoma.

- • Tortuous and marked dilatations of ducts indicate pancreatic carcinoma obstruction and may be rounded, bulbous, tapered or notched.

- • Detection of metastasis


catheter
liver
stomach
skin
common bile duct
duodenum (first part of small intestine)

The same duct, following removal of the stone through the

drainage catheter

Ultrasound

- This view is widely used as the preliminary examination in suspected gall bladder or billiary tract diseases and has the added advantage that the liver and pancreas can be assessed at the same examination. It is highly accurate in the diagnosis of gall stones including the non-opaque stones visible at the simple radiography.

- Gall stones characteristically produce high density echoes and cast acoustic shadows appearing dark bands.

- Ultrasound will also demonstrate the dilated intra hepatic ducts or common bile duct and thus will help to differentiate obstructive from non-obstructive jaundice.

normal


LONG OE DECUB

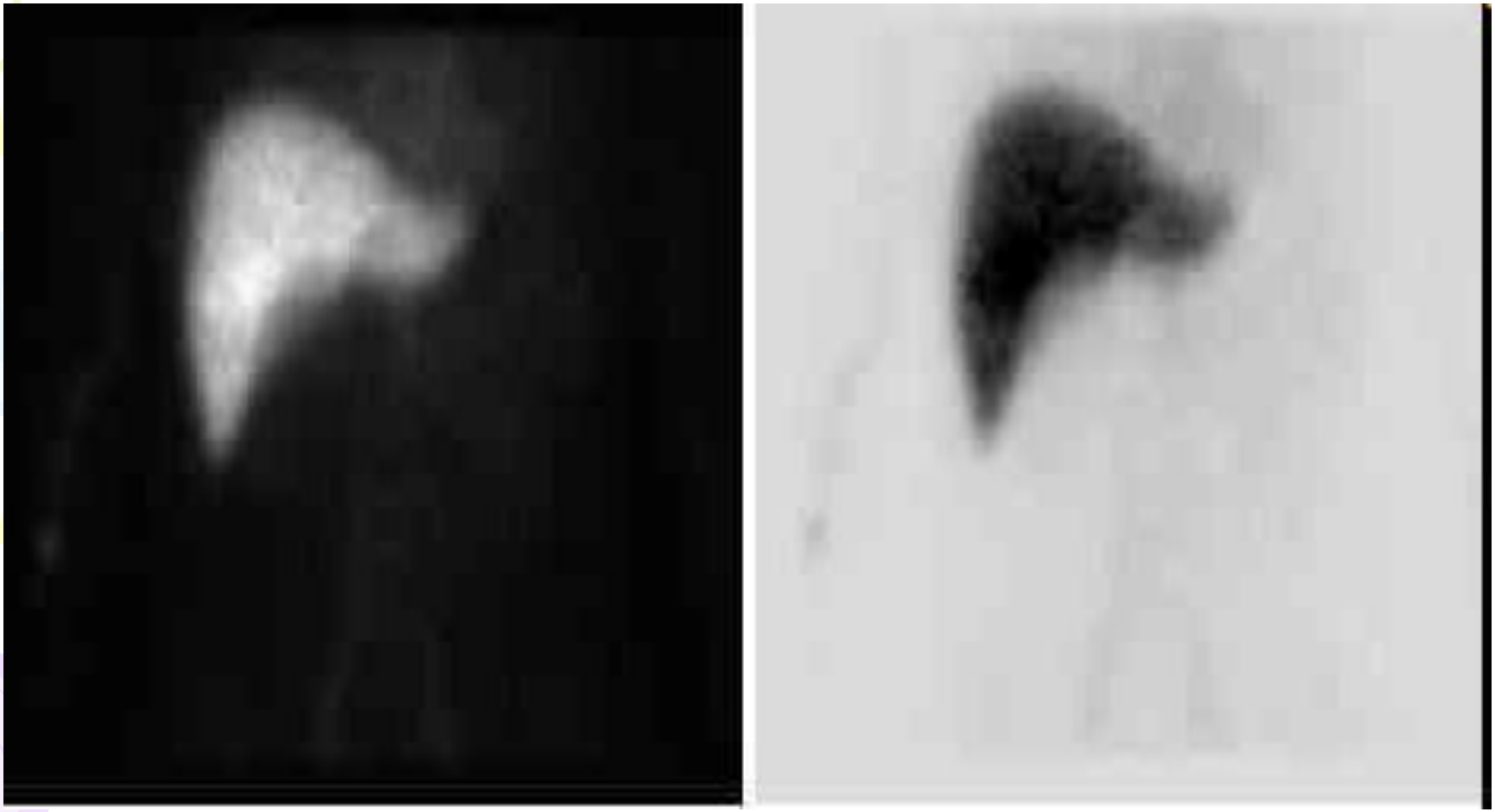
stones

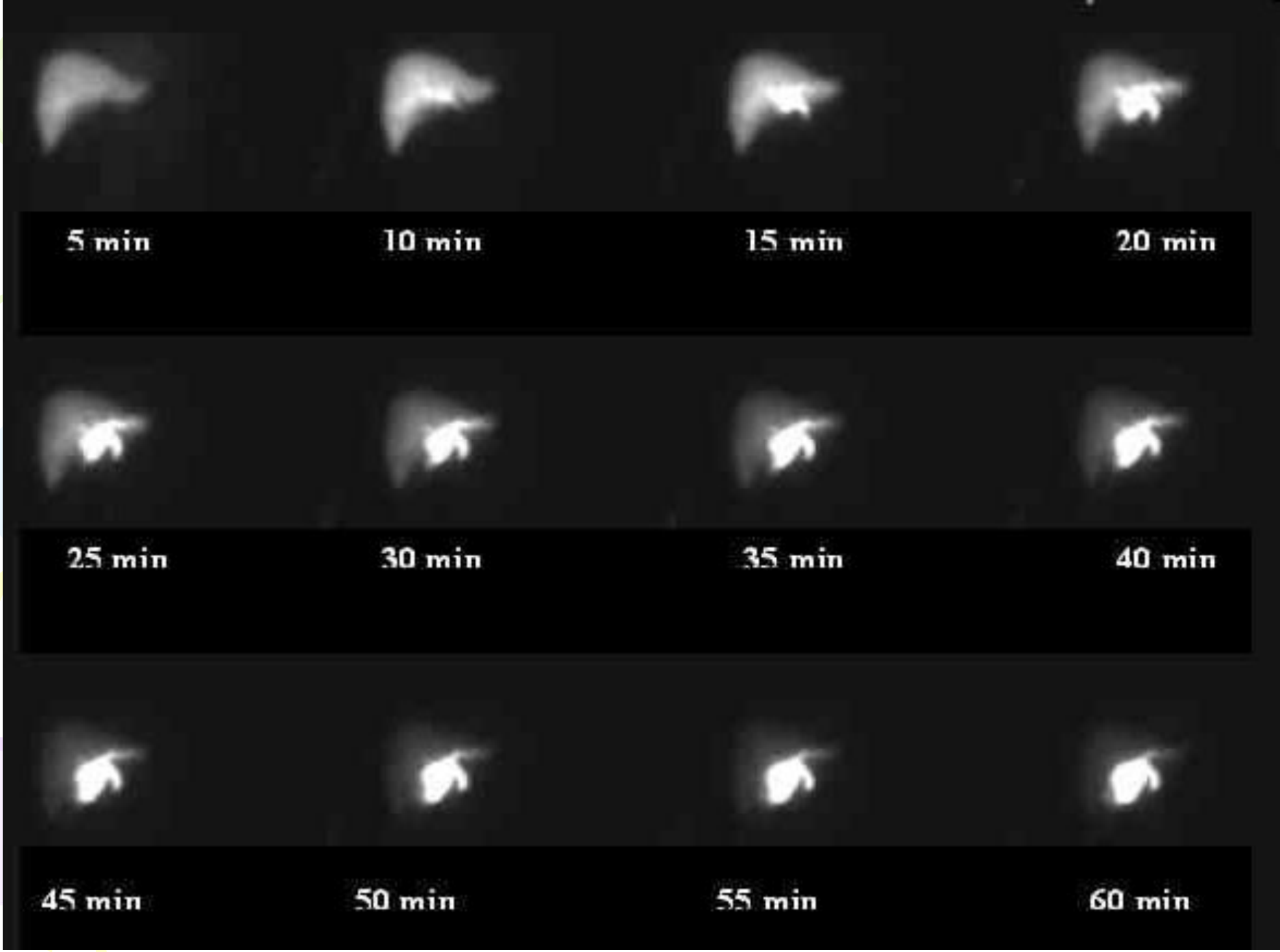
Isotope scanning

- 99 Tc HIDA (a derivative of iminodiacetic acid (IDA)) is a drug which is concentrated by the hepatocytes and excreted in the bile. Serial gamma camera pictures taken at 10 minutes interval after administration show the normal gall bladder and billiary tract at 30 min and drainage into the gut at 60 min. In billiary obstruction, there is no evidence of gut activity even on delayed films at 24 hr.

- NIDA is also a most valuable screening test for acute cholecystitis when the gall bladder will fail to fill despite the gut activity. Similar appearances are seen if the cystic duct or Hartmann's pouch are obstructed by calculi.

normal




5 min
10 min
15 min
20 min
25 min
30 min
35 min
40 min
45 min
50 min
55 min
60 min

Operative and post – operative cholangiography

- It is well known that in calculous billiary diseases cholecystectomy alone will leave a proportion of patients with residual stones in the billiary ducts. On the other hand the exploration of the ducts adds considerably to the risk of the operation and many miss stones which are free to move about in the ducts or are soft consistency ("putty stones").

- Many surgeons now perform operative cholangiography as a routine at operations for billiary stones.

- A small tube is inserted into the cystic duct and the bile ducts are filled with contrast medium. Films are obtained and examined during the operation and should demonstrate most removal calculi in the ducts.

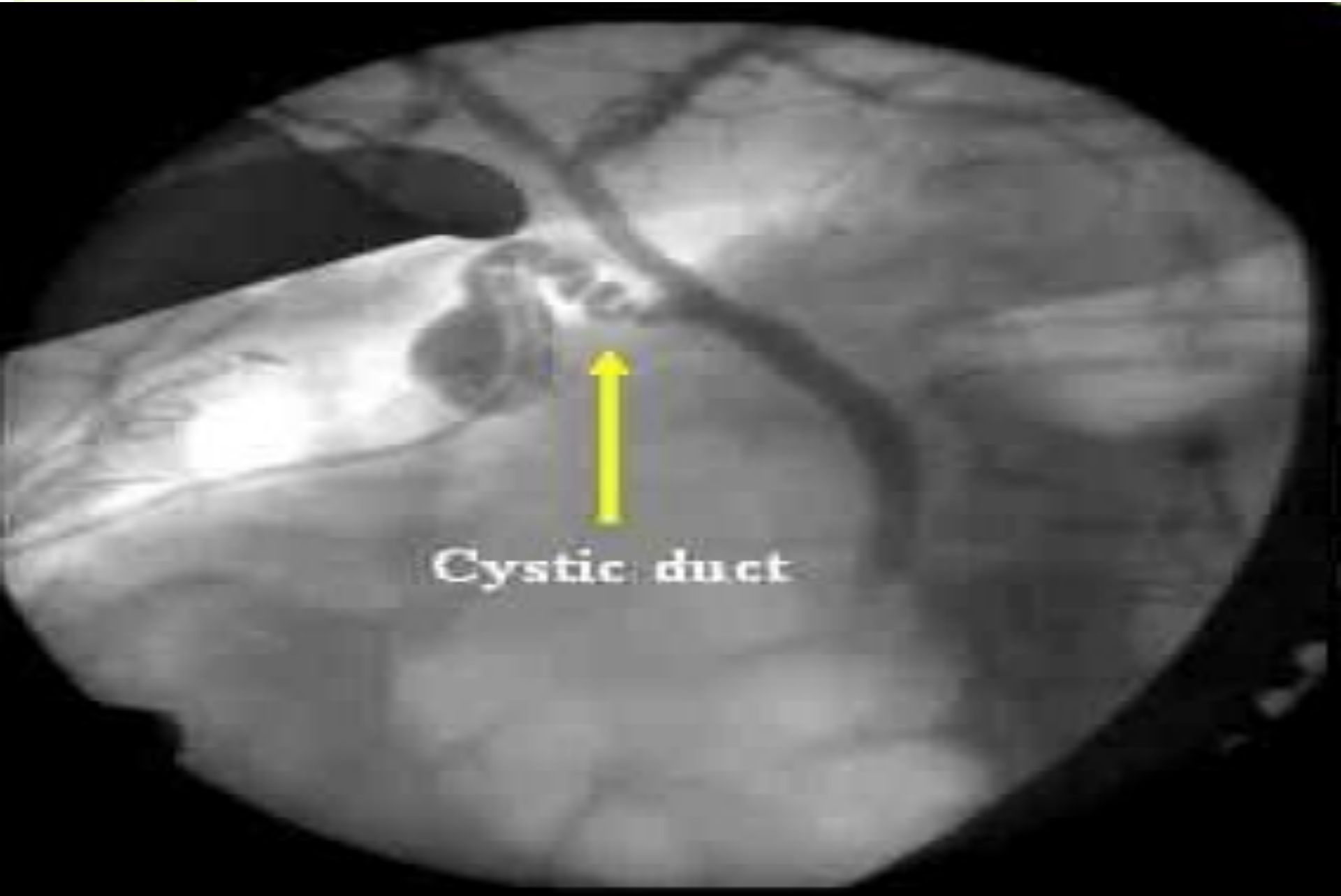
Operative cholangiography

- **Operative cholangiography**, if skillfully performed, adds little to the operative time and will ensure against leaving stones in the duct which may require a second operation. The best results are obtained when there is direct co - operation between surgeon and radiologist and apparatus permitting serial film is used. The possibility of artefact due to gas bubbles must be borne in mind and guarded against.

Post - operative cholangiography

- **Post - operative cholangiography** is carried out in the immediate post operative period by injecting the T tube drain in the common bile duct with contrast medium. This method will also show residual calculi which have been missed at the operation. These can be removed with a catheter with a catheter Snare passed through the T tube tract under image intensifier control.

Operative and T-tube cholangiogram



post operative study

Endoscopic retrograde cholangio pancreatography (ERCP)

- Under radiological control, the ampulla of Vater is cannulated and the common bile duct or the pancreatic duct can be entered. Contrast medium can then be injected and the biliary ducts or the pancreatic ducts can be shown.

- Biliary obstruction due to stone or neoplasm can be visualized or alternatively a normal biliary tree may be shown.

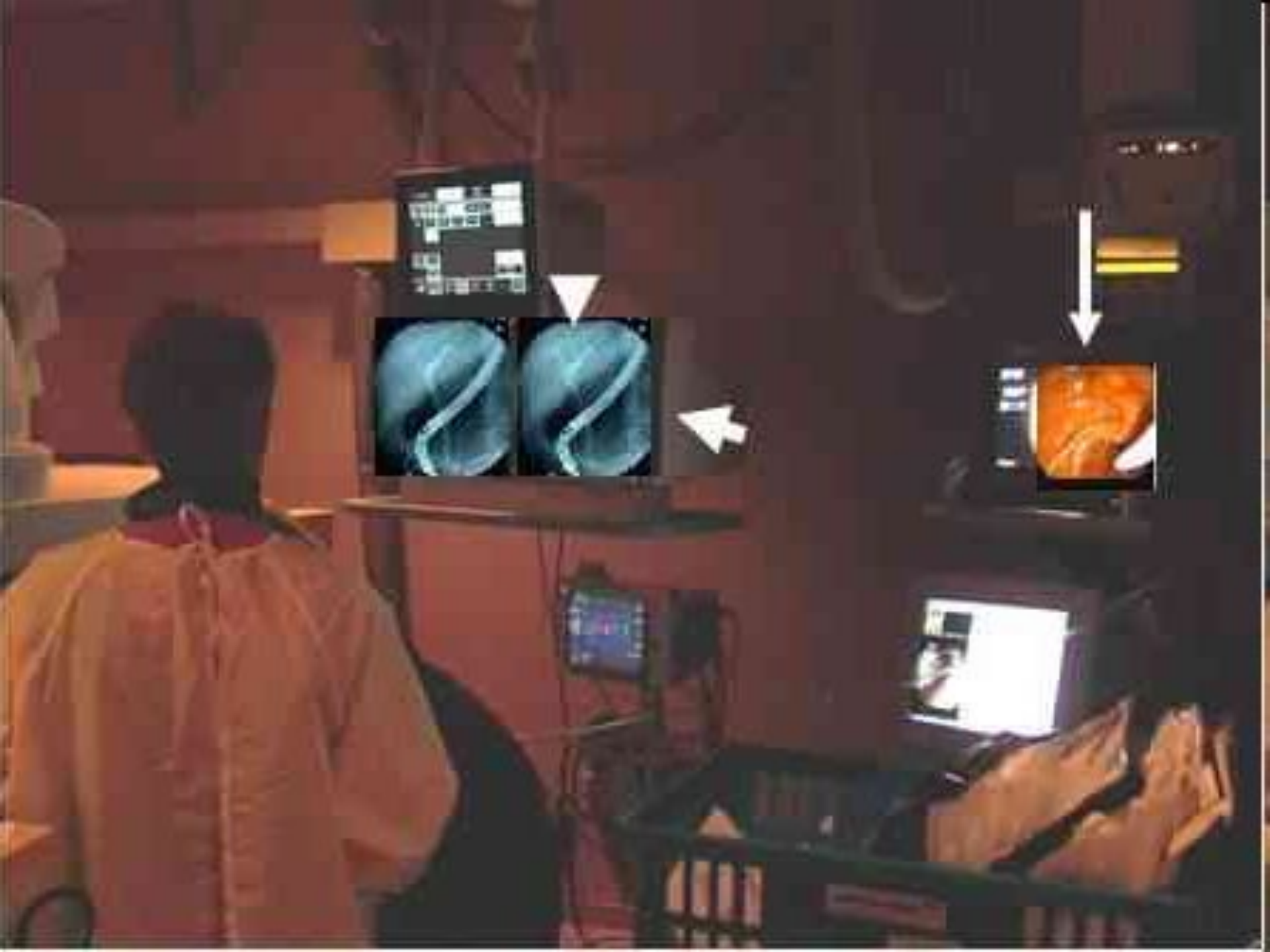
- In skilled hands this is probably the method of choice for the investigation of obstructive jaundice.

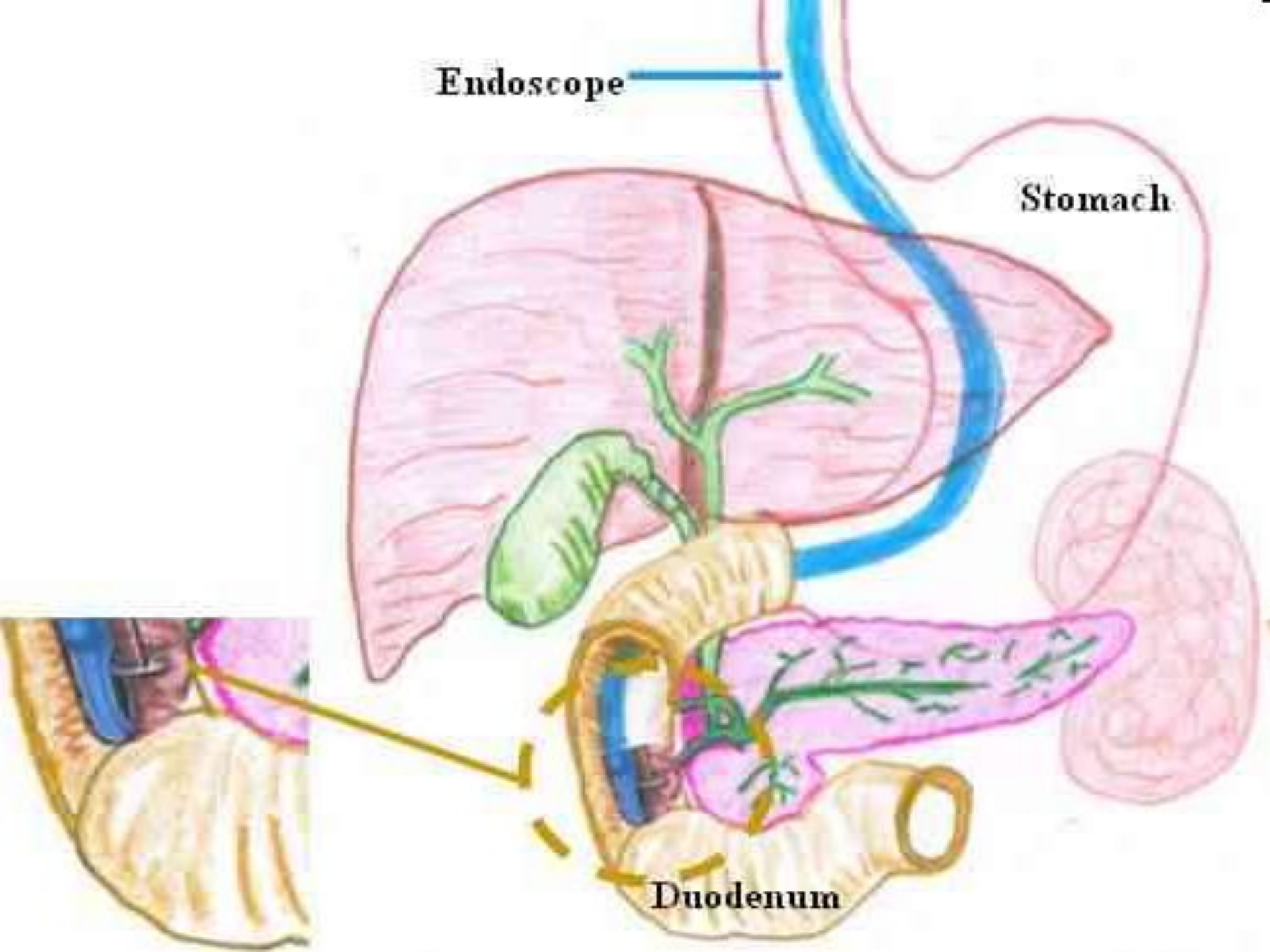
- It is also of great value in the investigation of the pancreatic diseases.

- Not only can the pancreatic duct be injected and shown to be normal, abnormal or obstructed but pancreatic juice can be directly collected and analyzed.

- For this examination the patient is usually fasting and lightly sedated. A side viewing duodenoscope or other fibre - scope is passed to the duodenum. The ampulla of Vater is identified and a small Teflon catheter is passed from the endoscope into the apex of the papilla under visual control.

endoscope

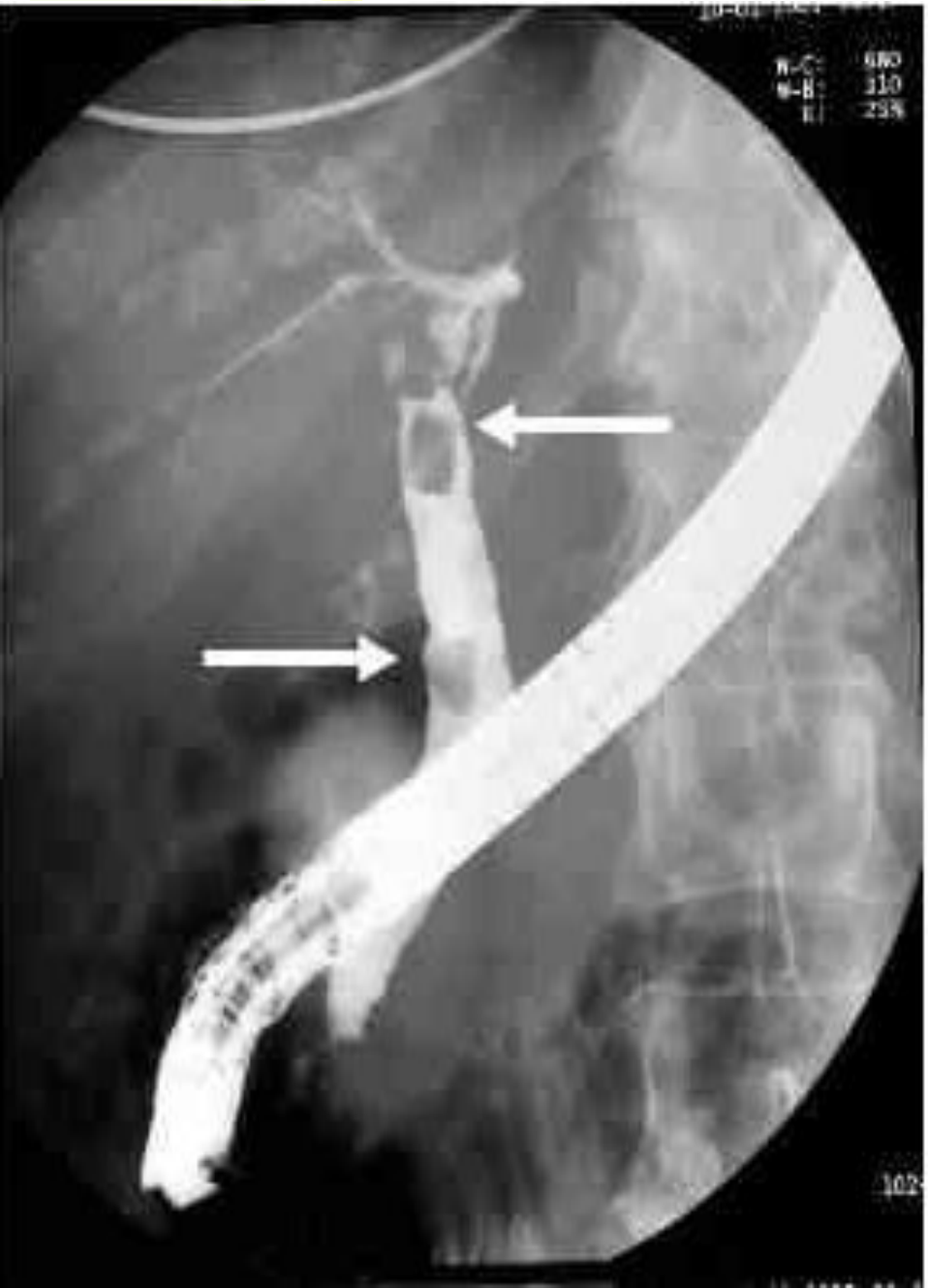



Endoscope
Stomach
Duodenum


Left Hepatic duct
Common Hepatic duct
Cystic Duct
Common Bile Duct

Stricture of the cystic duct

stones



The Liver

- The main indication or the investigation of the liver by imaging are the diagnosis or excision of tumors, primary or secondary, of cysts and of inflammatory lesions. Other indications are the investigation of hepatomegaly, of cirrhosis, and of portal hypertension.

The techniques available include:

- Simple X ray
- Ultra sound
- CT
- Isotope scanning
- MRI
- Hepatic angiography
- Splenic and arterial portography

- **Simple X ray** provides little information apart from the confirming enlargement of the liver and showing the occasional calcified lesion as hydatid cysts.

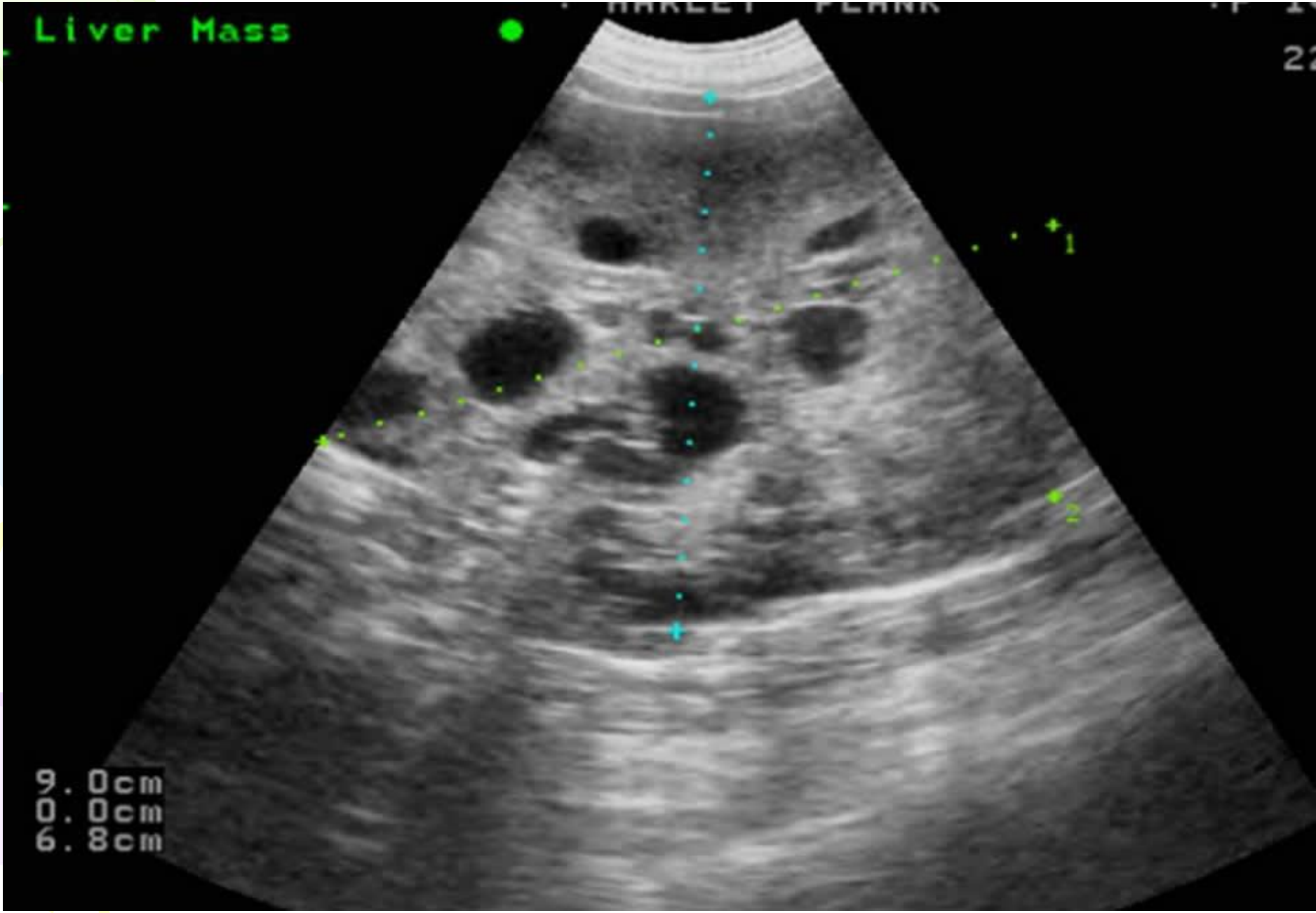
- **Ultrasound**
- Ultrasound is widely used in the investigation of the liver and biliary system.

Indications are:

- the liver cysts
- abscess
- Hematomas
- and neoplasm both primary and secondary are readily identified

- Tumors usually show as rounded areas with diminished echoes.
- Cysts are completely transonic.
- As already noted above dilated bile ducts are indefinable and are characteristic of obstructive jaundice.
- The gall bladder and gall stones are readily shown.

tumor



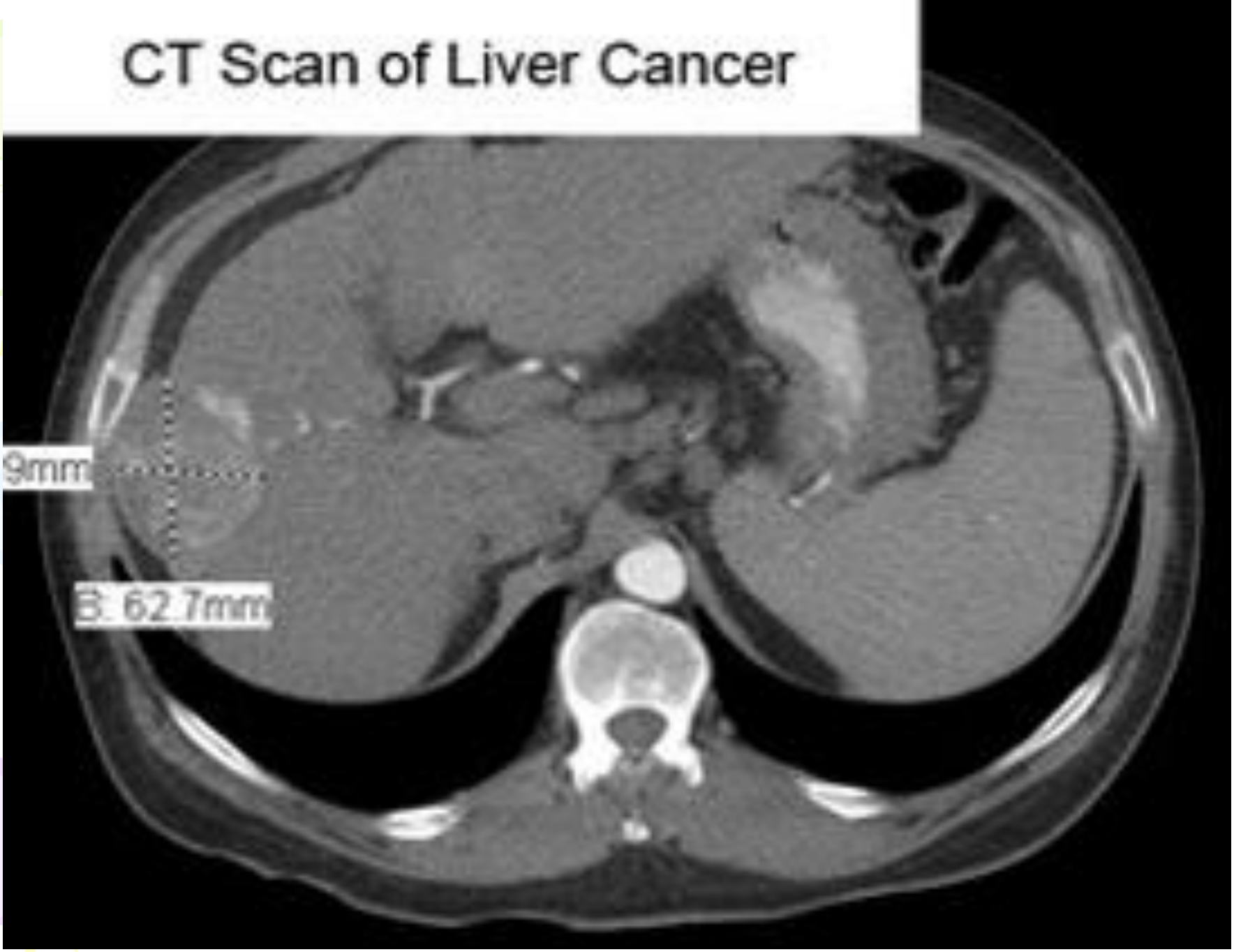

Abdomen
Liver cyst (zoom)

CT scanning

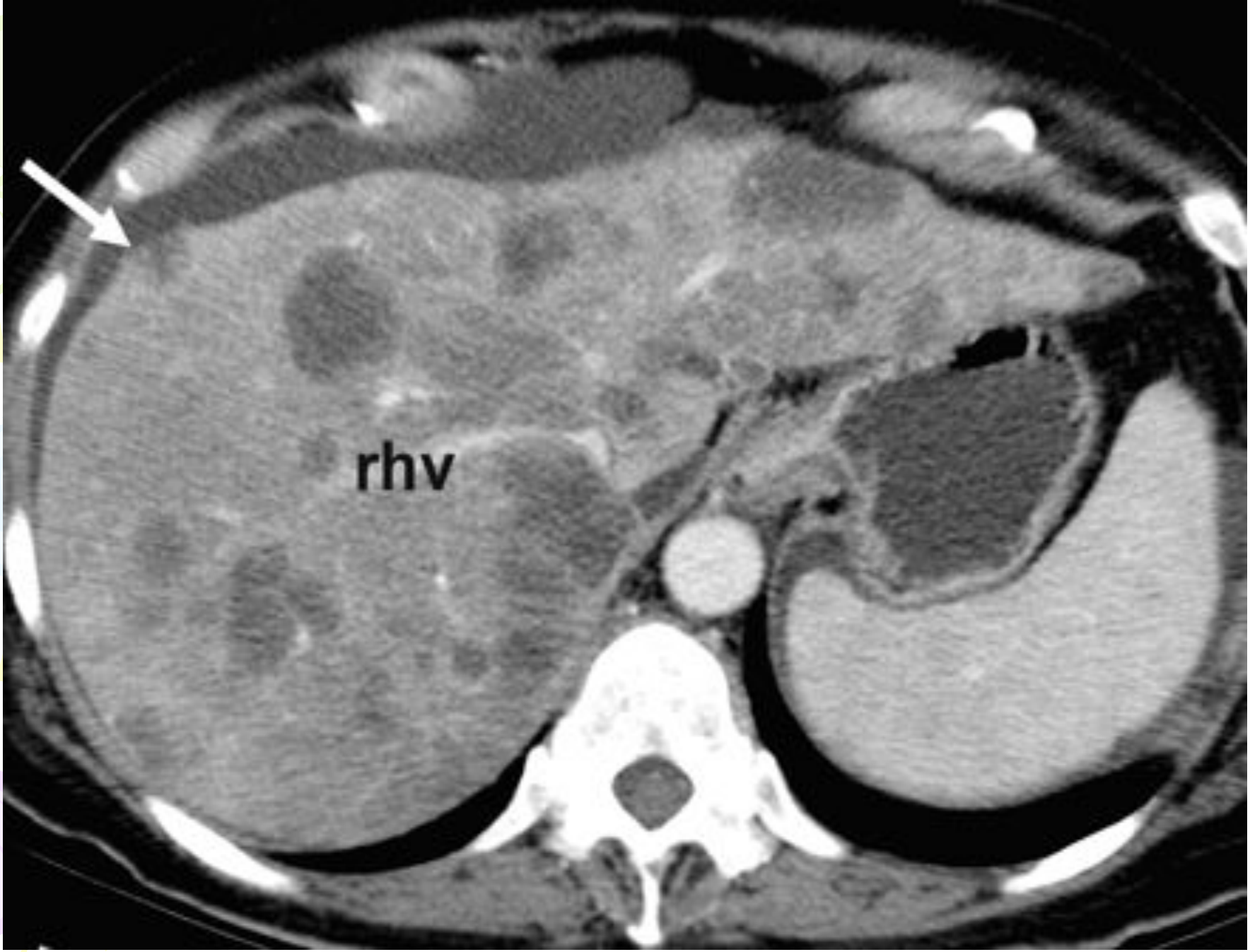
- CT shows the liver in axial sections with high resolution.
- Primary and secondary neoplasm can be demonstrated and differentiated from the cysts.
- Adjacent organs are also shown on the scans including abdominal nodes thus making CT invaluable in the staging of tumors.
- Contrast enhancement following IV injection is frequently under taken to highlight focal lesions. Dynamic scans involving rapid serial images after contrast injections may assist in diagnosing vascular lesions such as haemangiomas and some tumors.

cyst

CT Scan of Liver Cancer

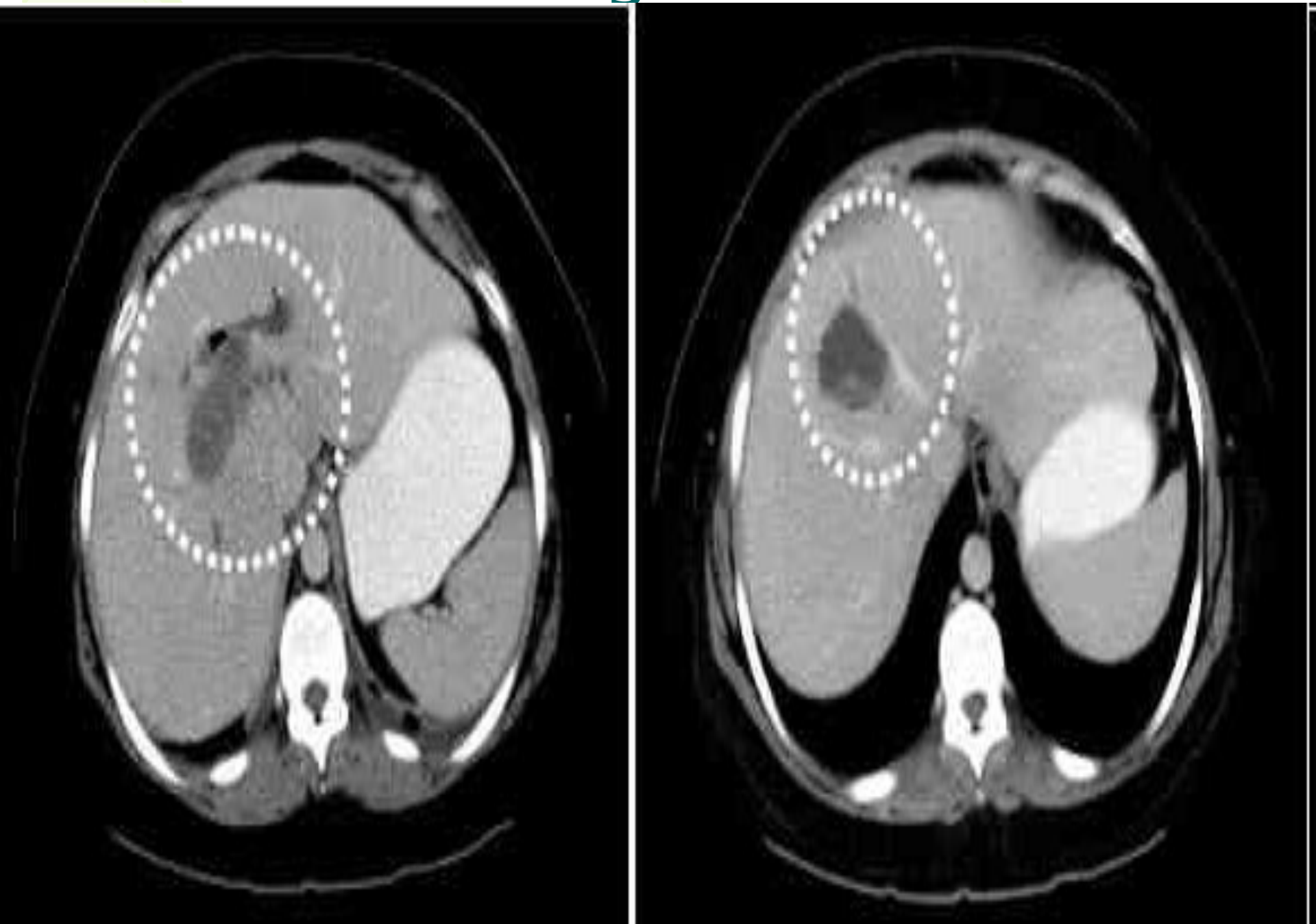


mts


rhv

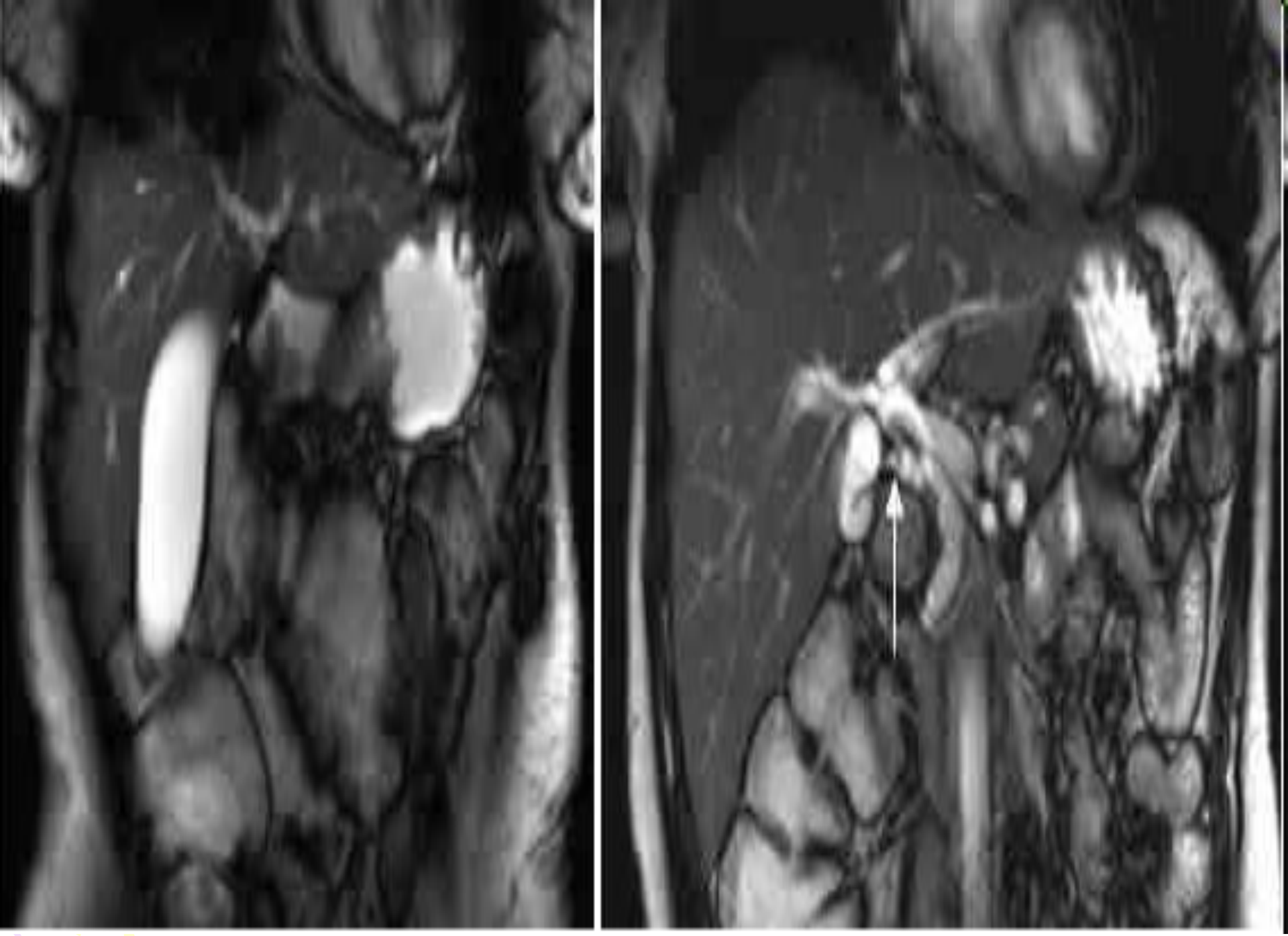
stone

Necrotic gall bladder



MRI

- MRI is similar to CT in the accuracy of showing focal lesions in the liver. It has the advantage of easy imaging in the coronal and sagittal planes but is still relatively more costly than CT.



3-D image

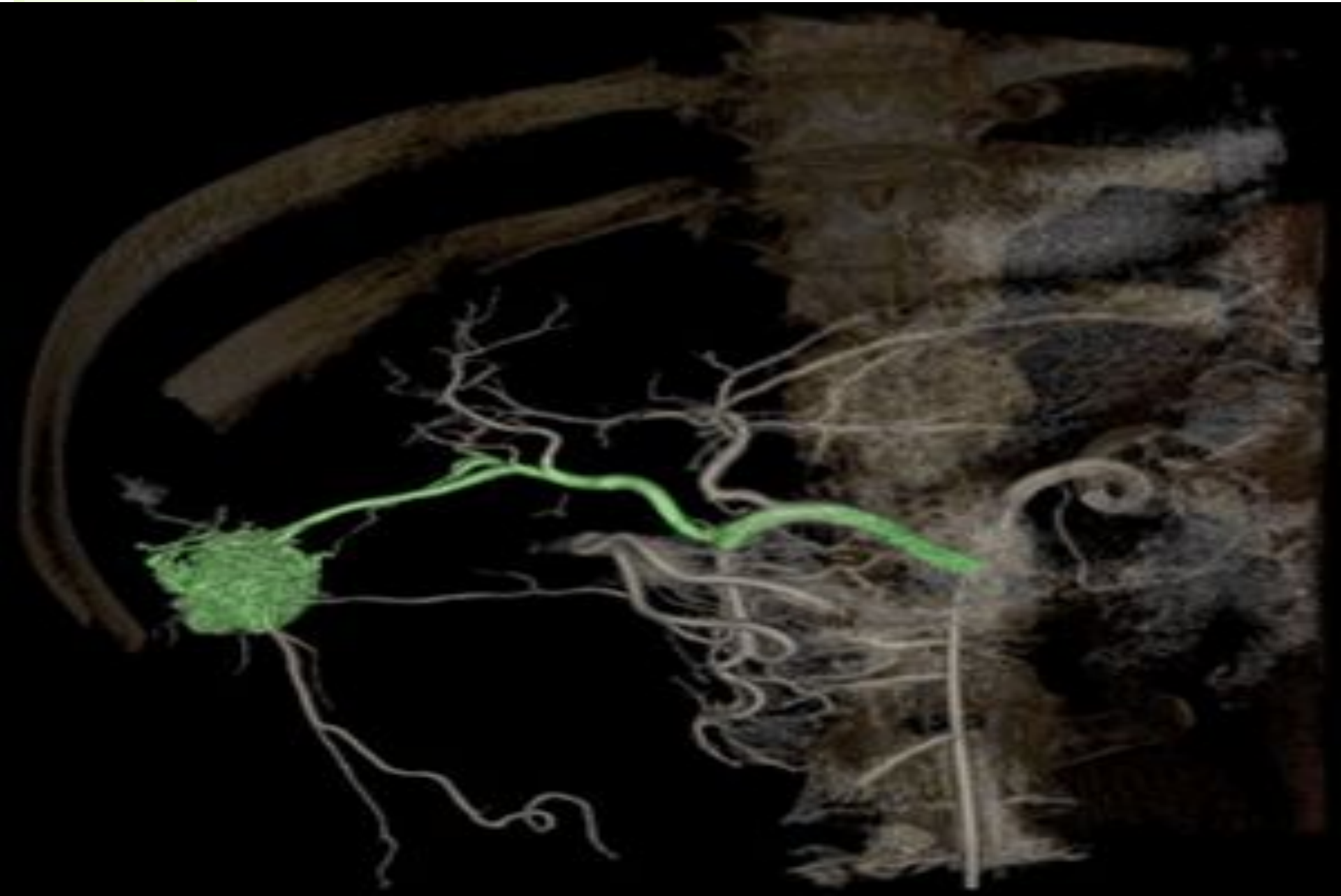
Angiography

- *Hepatic angiography* is performed by percutaneous transfemoral catheterization of the coeliac axis or superselective catheterization of the hepatic artery followed by injection of a bolus of a contrast medium.

- The technique uses:

- for the diagnosis of tumors
- angiomas
- aneurysms
- and other vascular lesions
- for the transcatheter embolisation of vascular lesions as well as tumor
- for the treatment of tumors by local chemotherapy drug infusion

liver tumor during embolizations




Nml

hemangioma

Isotope scanning

- The study is usually performed 15-30 minutes after injection with radiopharmaceutical substent since 10-15 min are required for complete clearing of the colloid from the blood stream in the normal object

- Following are the indications of liver imaging:

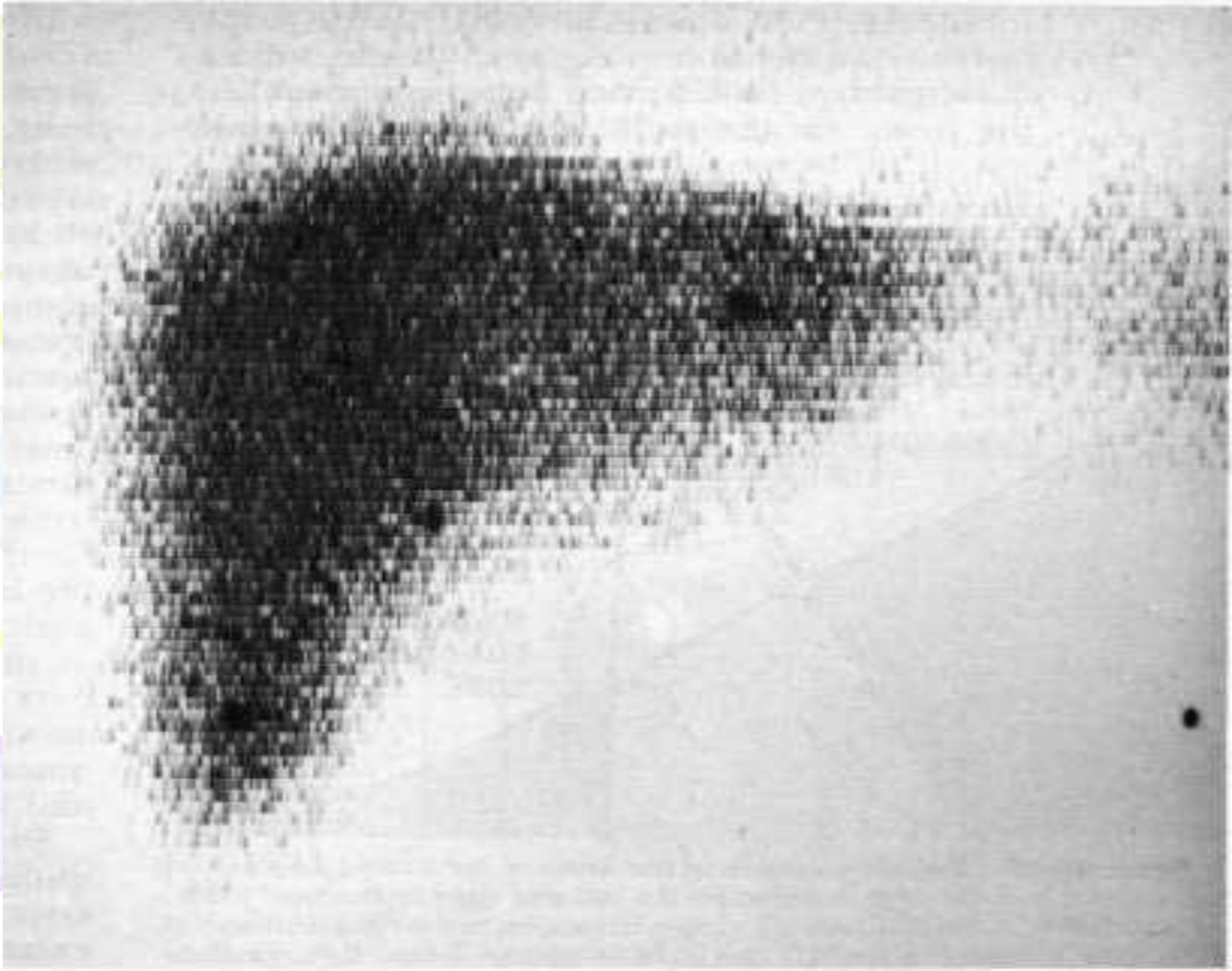
- Evaluation of the liver size, shape and position.

- Evaluation of the abdominal masses.

- Detection: abscess, hematoma, tumor and cyst.

- Pre and post treatment evaluation of the hepatic metastases.

- Evaluate diffuse hepatic disease such as cirrhosis, hepatitis or metabolic disease.



CHOICE OF EXAMINATION IN BILIARY AND LIVER DISEASE

- ***Suspected liver masses (tumors, primary or secondary, cysts or abscess)*** should be examined in the 1st place by isotope scanning or ultrasound. Both these methods will usually demonstrate liver masses quite well. Ultrasound has the advantage that it will differentiate cysts and abscess from solid masses.

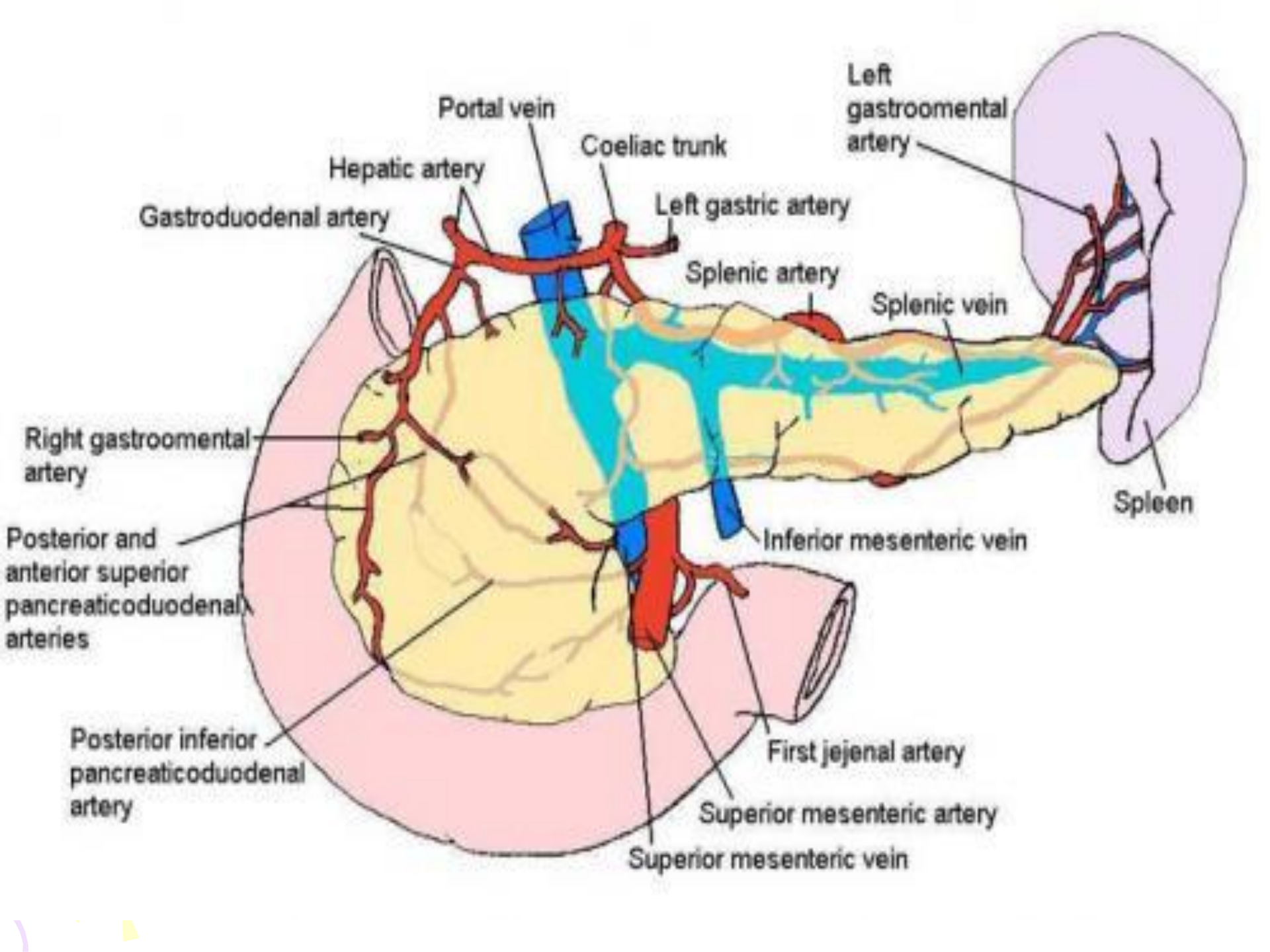
- CT and MRI will also perform this function but are more expansive investigations and

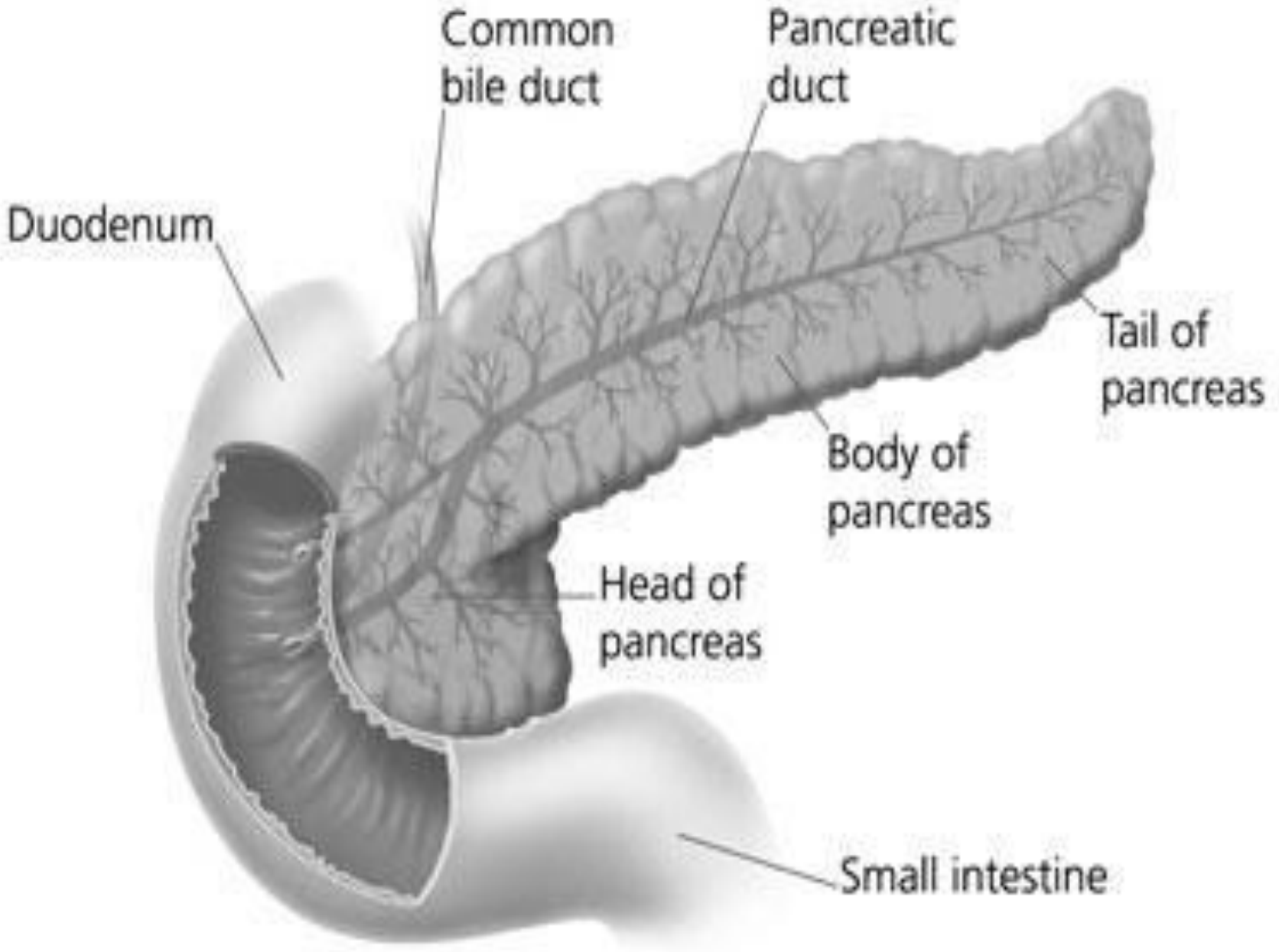
- CT involves radiation. They are used for more precise diagnosis; as a prelude to surgery; and for tumor staging.

- ***In suspected obstructive jaundice,*** ultrasound is the primary investigation of choice, though biliary isotope scanning will show moderately dilated ducts, as will CT. Transhepatic cholangiography or ERCP may be required to define the point of obstruction, and percutaneous biliary drainage may be used in treatment.

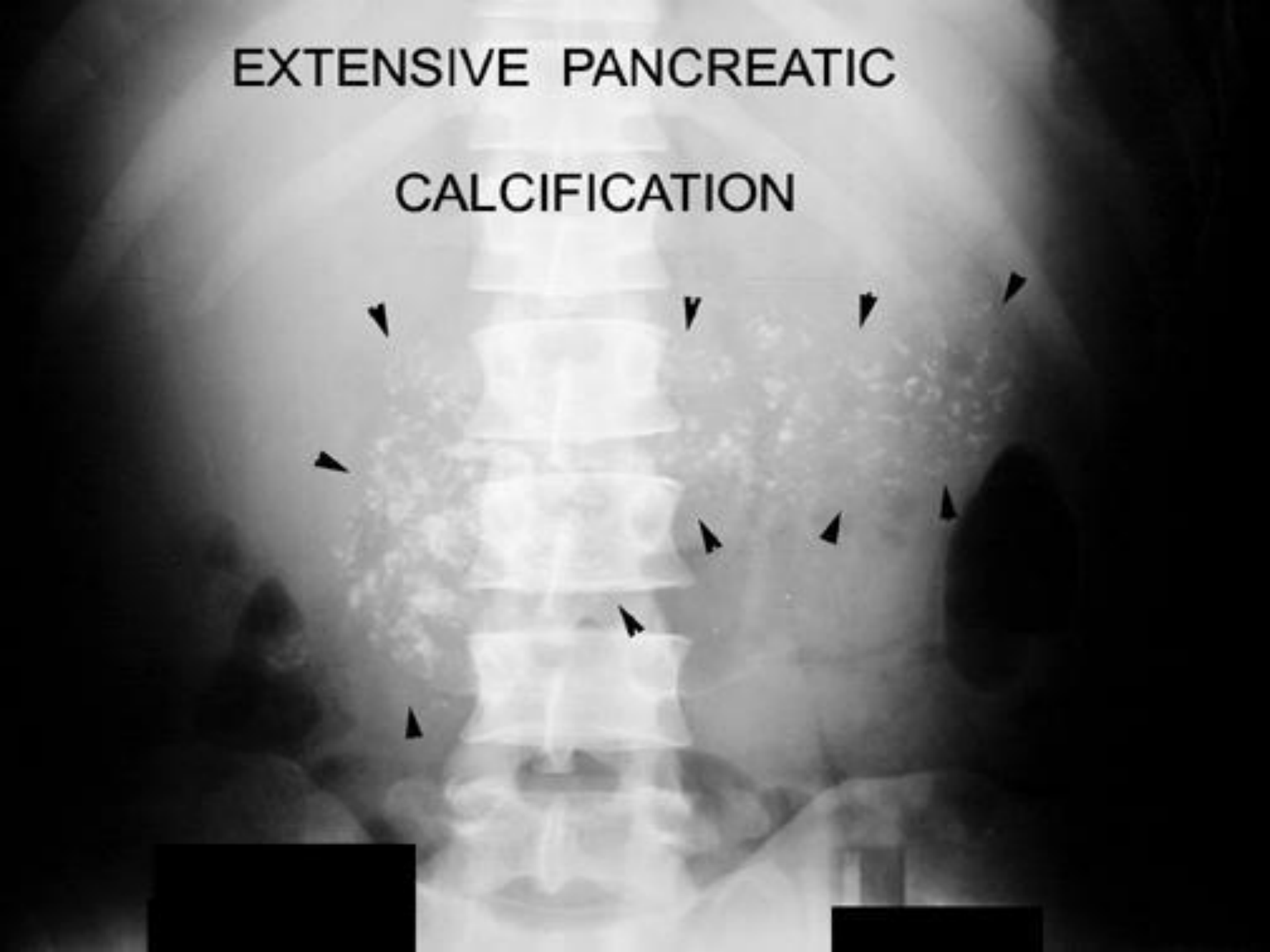
PANCREAS

- Pancreas lies in the posterior abdominal wall in the epigastrium and left hypochondrium. Head is surrounded on three sides by duodenal ring and prepyloric areas of stomach. Head is covered anteriorly by distal end of the stomach, duodenum and transverse colon.


Left gastroomental artery
Portal vein
Coeliac trunk
Hepatic artery
Gastroduodenal artery
Left gastric artery
Splenic artery
Splenic vein
Right gastroomental artery
Spleen
Posterior and anterior superior pancreaticoduodenal arteries
Inferior mesenteric vein
Posterior inferior pancreaticoduodenal artery
First jejenal artery
Superior mesenteric artery
Superior mesenteric vein


Common bile duct
Pancreatic duct
Duodenum
Tail of pancreas
Body of pancreas
Head of pancreas
Small intestine

- **Simple X ray** will occasionally show extensive nodules of calcification in the pancreas associated with chronic pancreatitis but is otherwise little help.


EXTENSIVE PANCREATIC
CALCIFICATION

- **Barium studies** will show:
- distortion of the duodenal loop by masses in the head of the pancreas
- large pancreatic masses or cysts may displace the stomach.

- **Ultrasound:** the normal pancreas may be partly obscured by bowel gas but when well seen appears as 1 to 3 cm diameter band arching over the aorta at the level of superior mesenteric artery and of slightly higher echogenicity than normal liver.

- In acute pancreatitis, the whole organ is enlarged and edematous appearing more transonic than normal.

- Abscess and cysts appear as well defined rounded transonic areas.

- Tumors appear as local masses enlarging the pancreas.

Rupture of **pancreas**

CT scan

- **CT** is now the method most widely used for the demonstration of the pancreatic morphology.

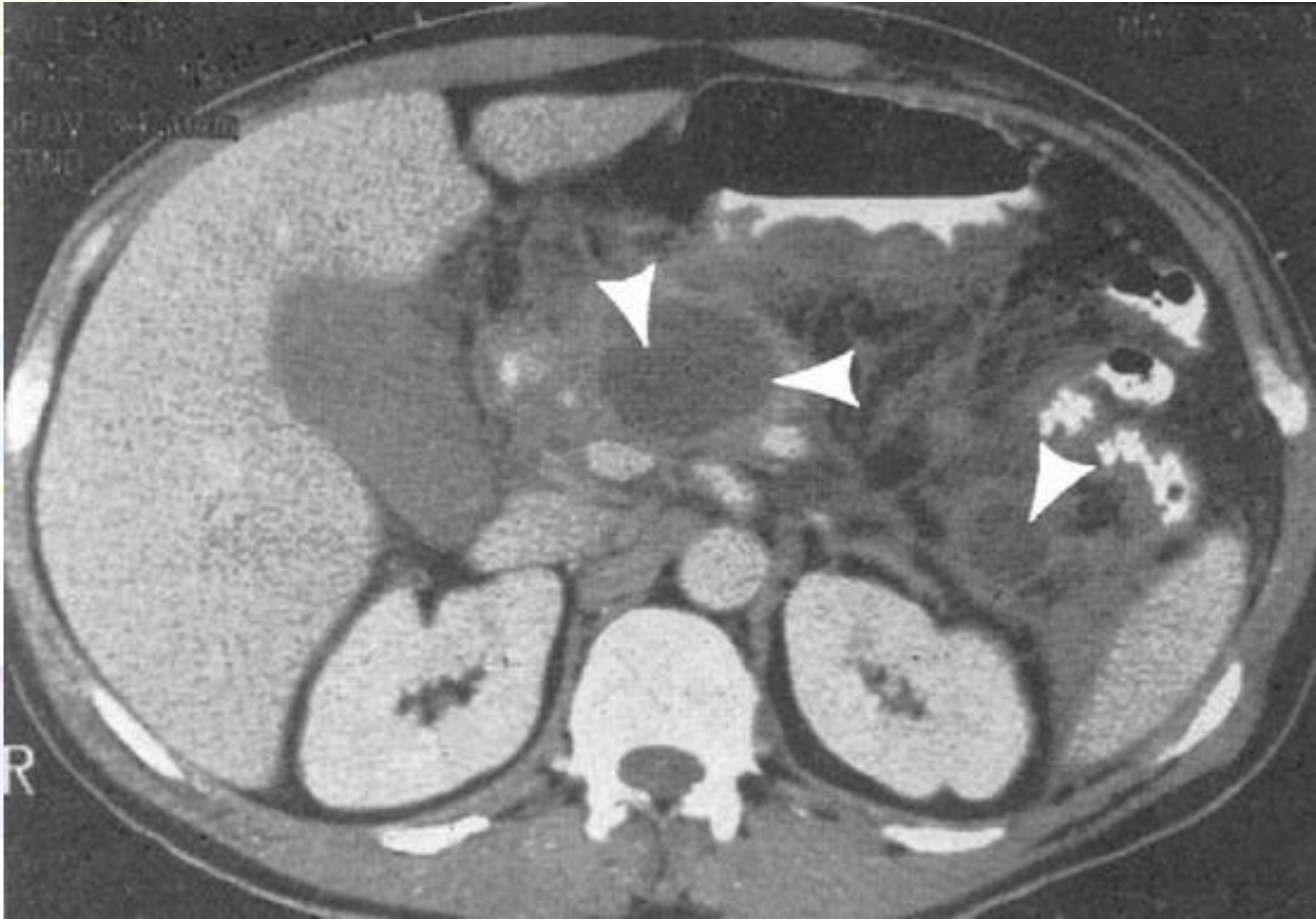
- The pancreas and its relationships to the adjacent organs are clearly identified.
- Cysts and mass lesions greater than 2 cm in diameter are easily identified.

- Small tumors such as islet cell adenomas are more difficult to diagnose.

- Acute pancreatitis may be clearly demonstrated at CT as diffuse swelling and edema of the whole organ, though some cases, particularly in first 24 hours, will not show diagnostic appearances.

- Dilation and irregularity of the main pancreatic duct can also be seen at CT.

cyst



MRI

- MRI can also show the pancreas well but has no advantage over CT, which is much cheaper and more readily available.

ERCP

- **ERCP** is the method of choice for demonstrating the pancreatic duct and its obstruction or stenosis by calculi or tumor. The bile ducts can be demonstrated by at the same time and variety of diagnostic and therapeutic procedures performed.

- These include:

- 1. Stone extraction from pancreatic and bile ducts
- 2. Sphincterectomy
- 3. Biopsy of ampulla
- 4. Cytology of pancreatic juice
- 5. Balloon dilation of benign structures
- 6. Biliary stem insertion.
- 7. Pancreatic cyst drainage

Choice of examination

- CT is probably the best method for speedy demonstration of the pancreas. The normal pancreas is usually well shown as are masses and cysts. Small tumors whether carcinomas or islet cell adenomas are more difficult to define.

- Ultrasound in skilled hands is almost reliable, but is to some extent operator dependent.

- Isotope scanning is less reliable than CT or ultrasound and is no longer used for pancreatic lesions. Neither CT nor ultrasound will differentiate an inflammatory pancreatic mass from a tumor lesion.

- However fine needle biopsy guided by CT or ultrasound will permit a definitive diagnosis.