College of Health and Medical Technologies
Department of Radiology Technologies

MAGNETIC RESONANCE IMAGING OF THE LIVER, AND CHOLANGIOPANCREATOGRAPHY

2 nd stage

Lecture 4

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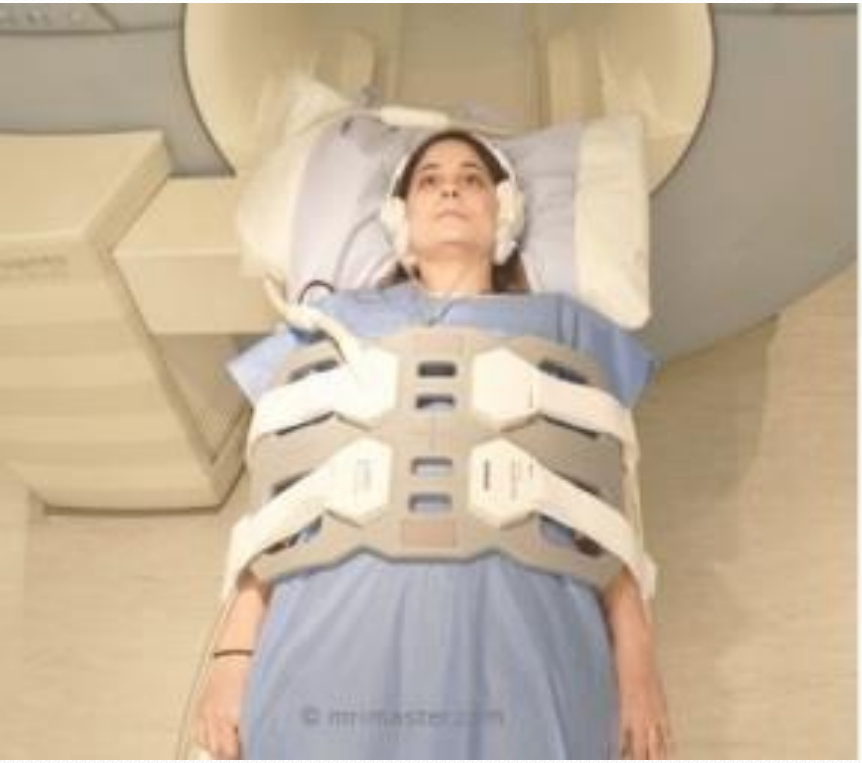
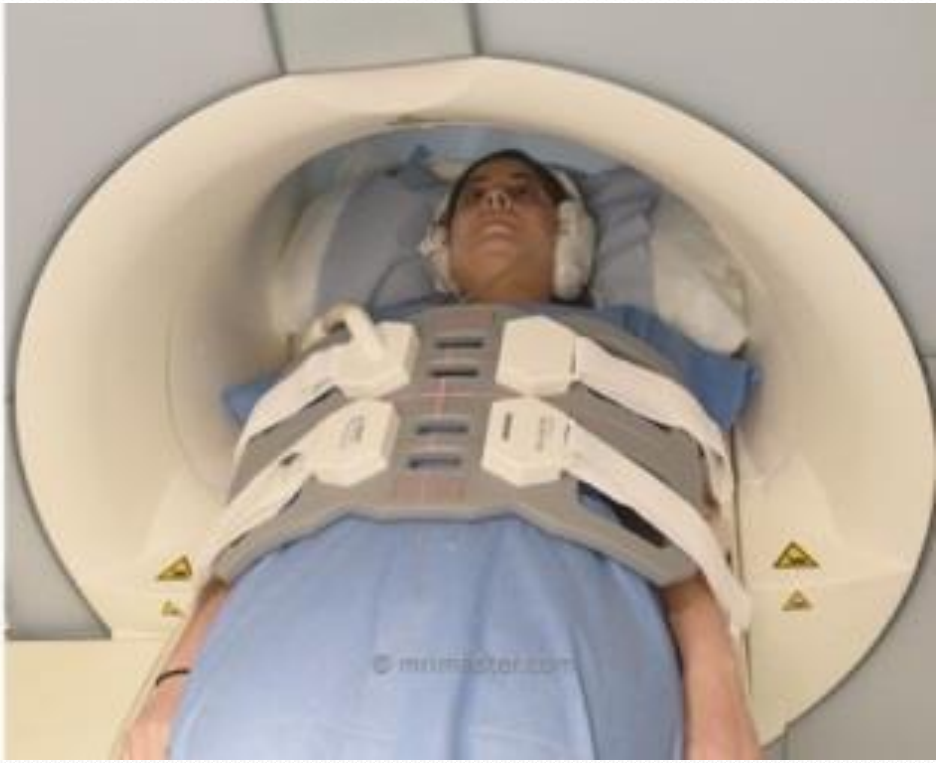
MSc Radiographic Imaging

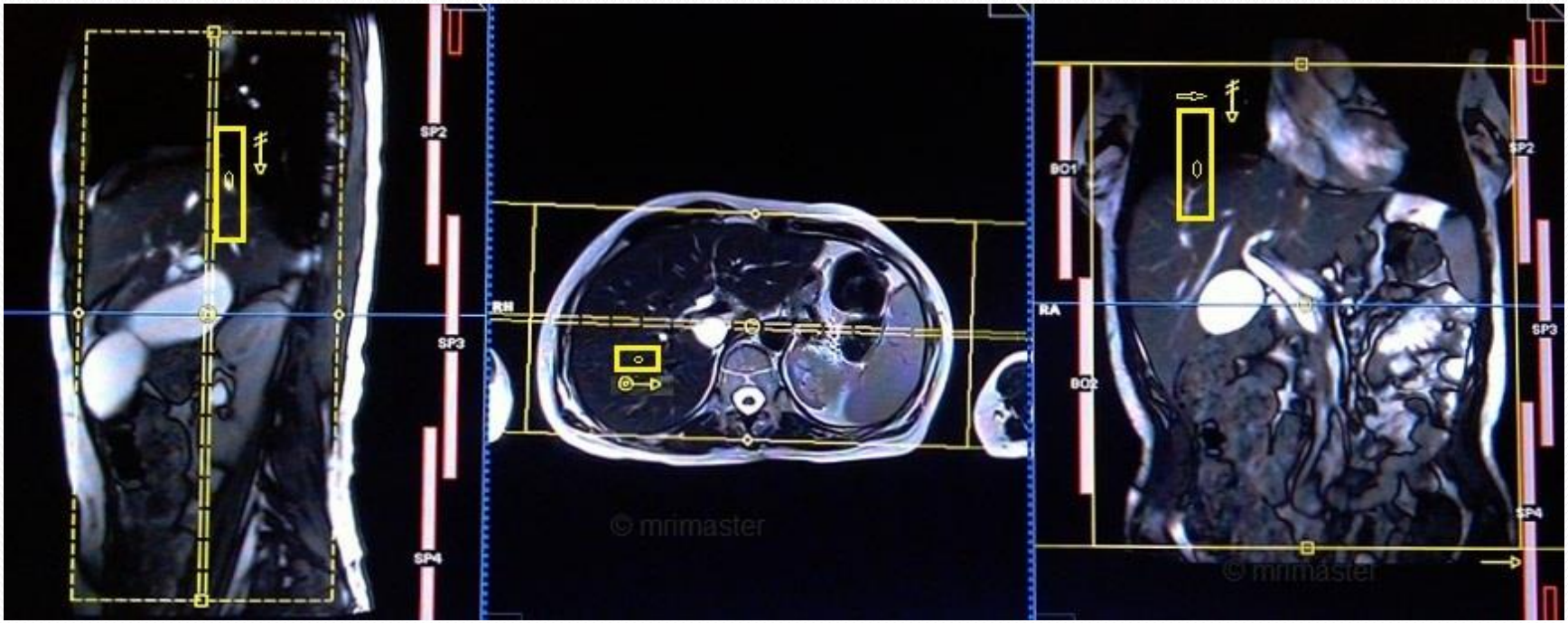
2023

MRI coils of the liver and cholangiopancreatography

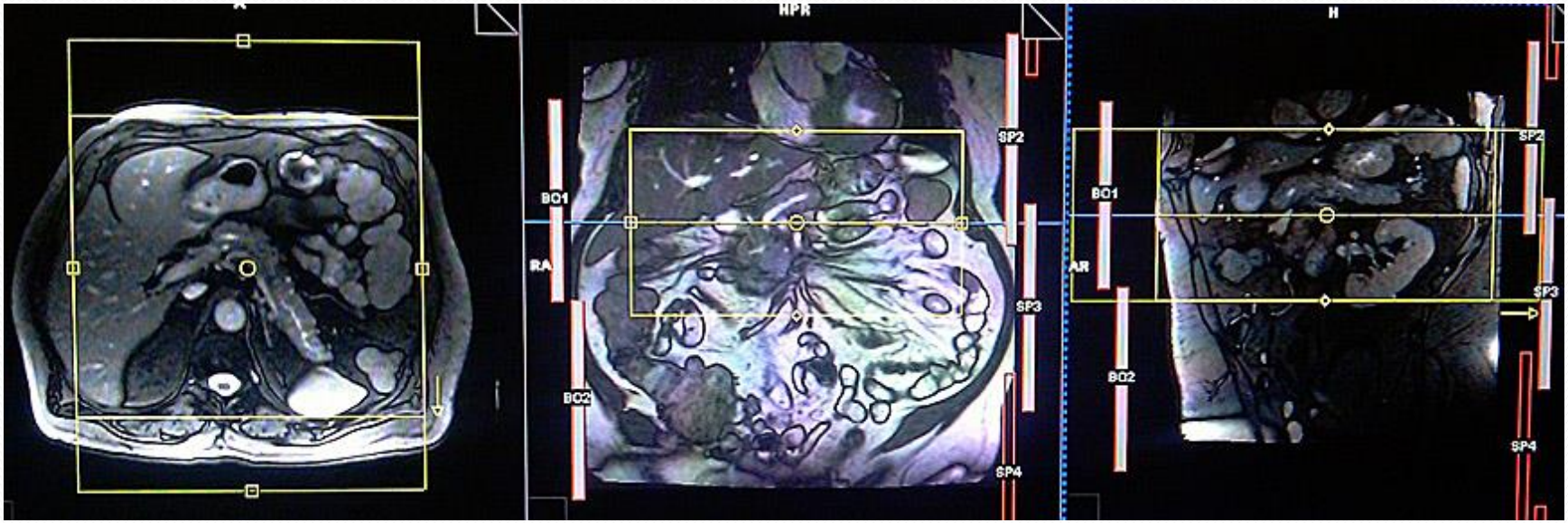




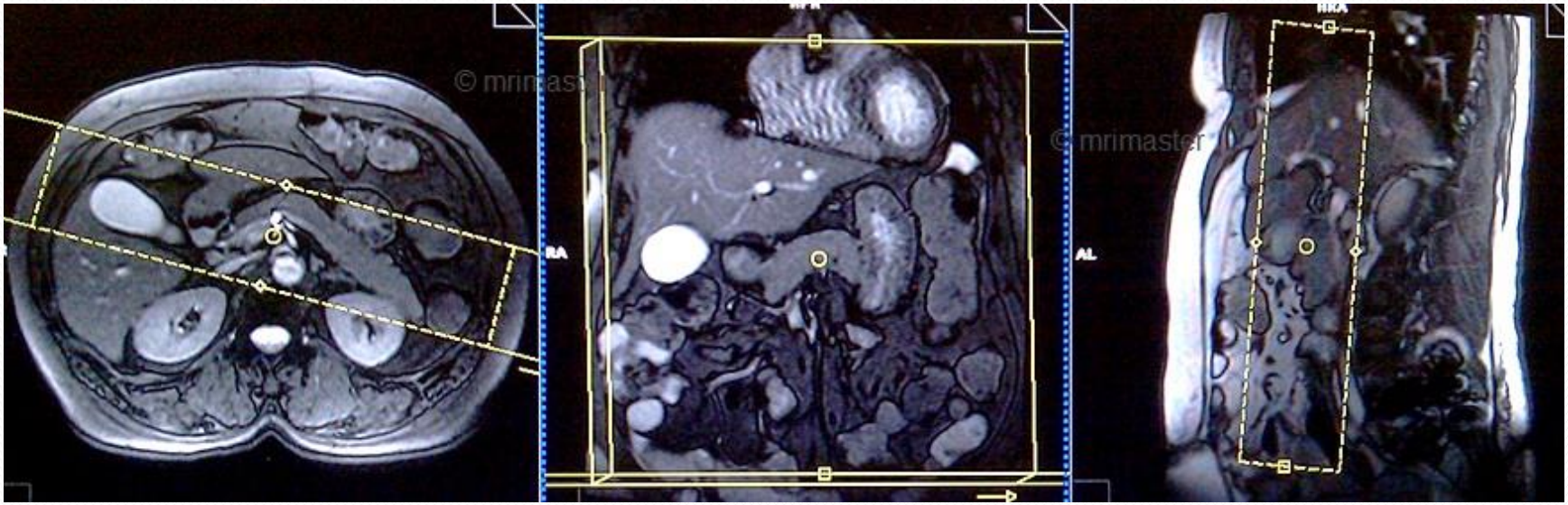
Coronal plane



Axial plane



Sagittal plane



MAGNETIC RESONANCE IMAGING OF THE LIVER

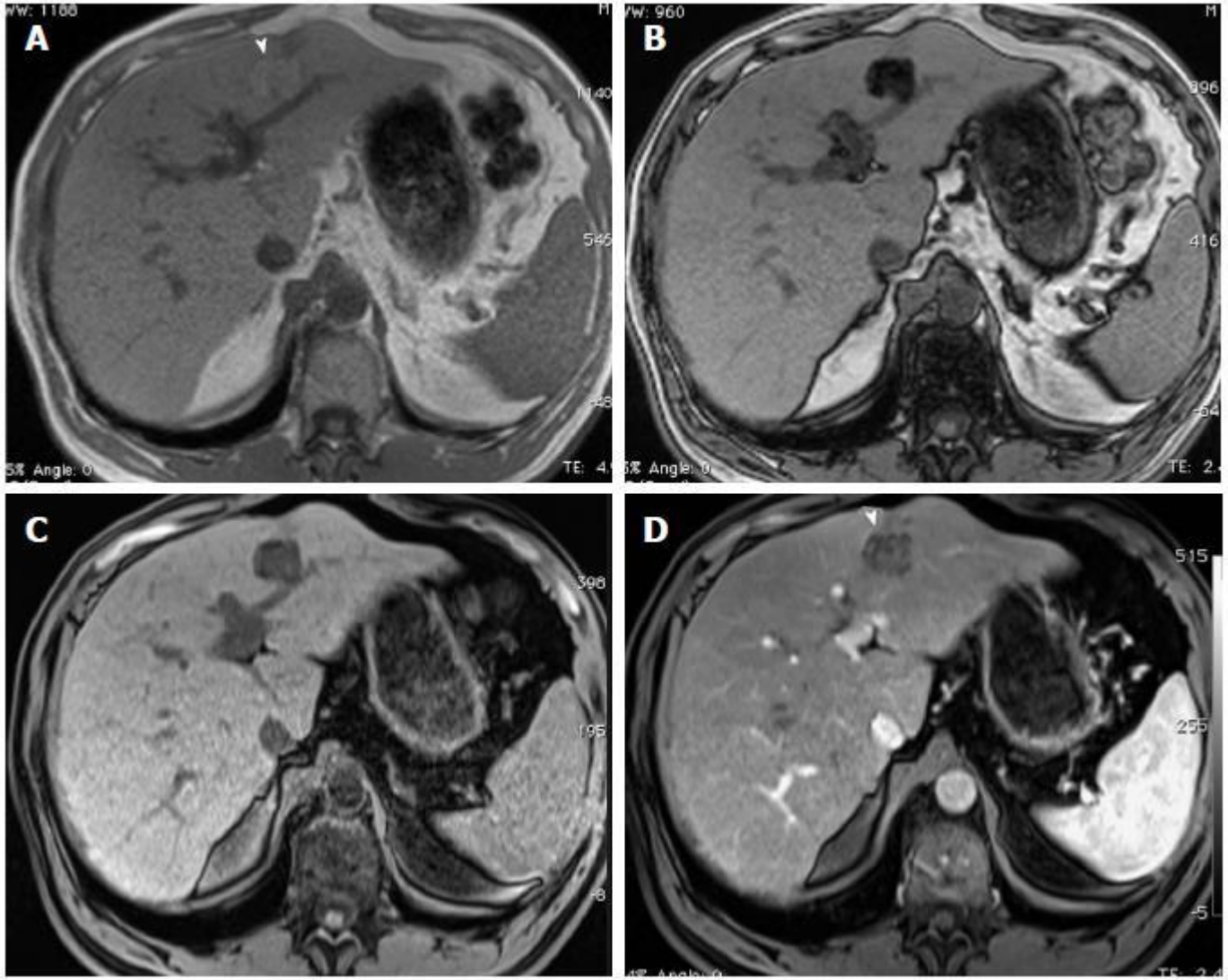
Indications

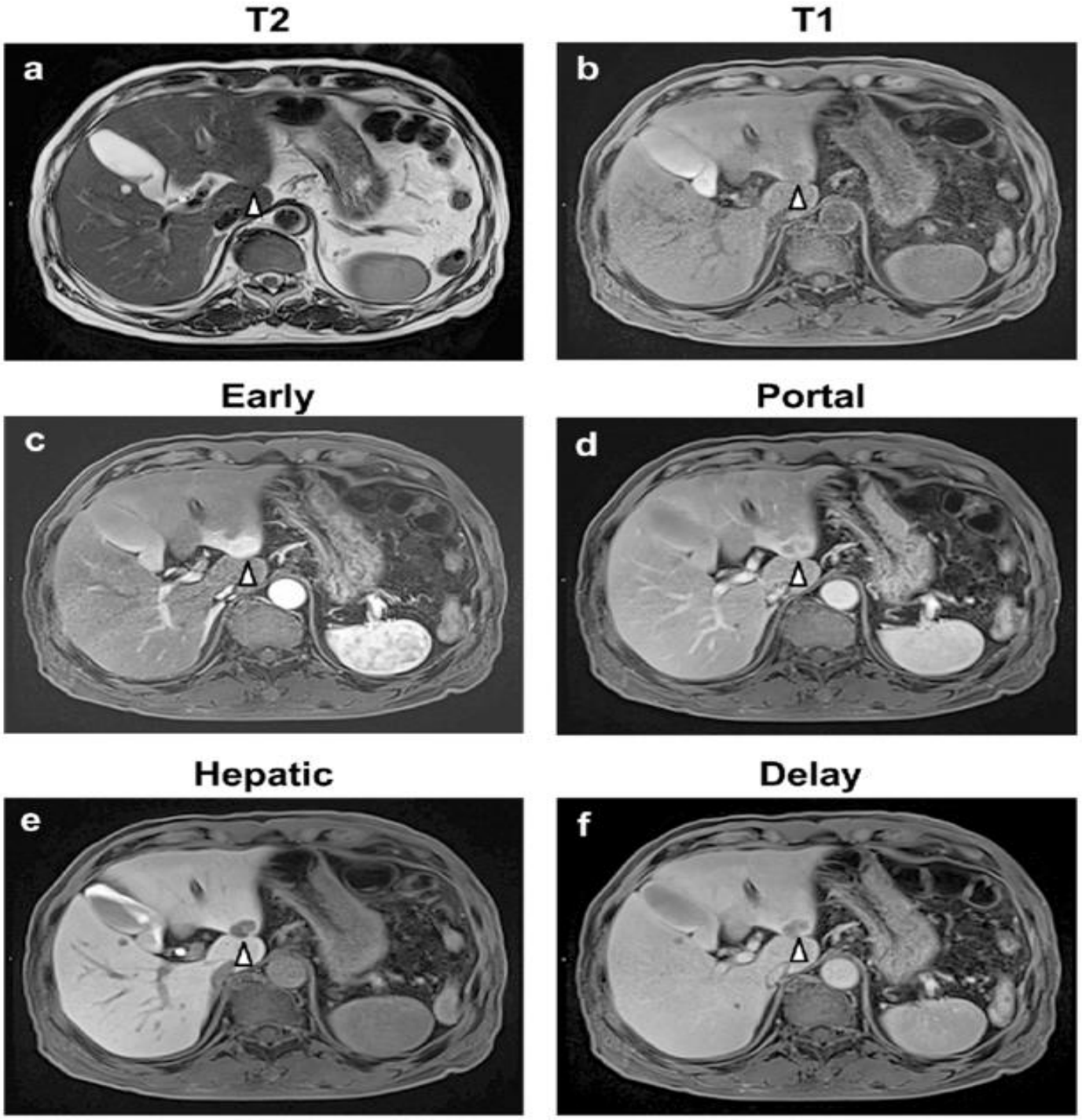
1. Lesion characterization following detection by CT or US. Unenhanced MRI including heavily T2 weighted sequences and DWI can be considered the definitive protocol for detection and characterization of typical cystic and cystic like structures and haemangiomas.1

2. Lesion detection, particularly prior to hepatic resection for hepatic metastatic disease.

Magnetic resonance imaging (MRI) is rapidly emerging as the imaging modality of choice for detection and characterization of liver lesions. There is high specificity with optimal lesion-to-liver contrast and characteristic appearances on differing sequences and after contrast agents. Focal lesions may be identified on most pulse sequences. Most metastases are hypo- to isointense on T1 and iso- to hyperintense on T2-weighted images. However, multiple sequences are usually necessary for confident tissue characterization. The timing, degree and nature of tumour vascularity form the basis for liver lesion characterization based on enhancement properties. Liver metastases may be hypo- or hypervascular.

MAGNETIC RESONANCE IMAGING OF THE LIVER




T2
a
T1
b
Early
c
Portal
d
Hepatic
e
Delay
f

Magnetic Resonance Imaging Pulse Sequences

A minimum field strength of 1.5T is required using a multichannel phased-array coil**. <u>Common pulse sequences are</u>:**

1. T1-weighted spoiled gradient echo (GRE). This has replaced the conventional spin-echo sequence. In and out of phase scans are used to investigate patients with suspected fatty liver.

2. Magnetization-prepared T1-weighted GRE. A further breath-hold technique with very short sequential image acquisition.

3. T1-W GRE fat-suppressed volume acquisition. This sequence can be obtained rapidly following i.v. gadolinium.

4. T2-weighted spin echo (SE). T2-weighted fast spin-echo (FSE;

General Electric) or turbo spin-echo (TSE; Siemens).

Compared with conventional T2-weighted SE images, FSE/TSE images show:

1. Fat with higher signal intensity.

2. Reduced magnetic susceptibility effects which are of advantage in patients with embolization coils, IVC filters, etc., but disadvantageous after injection of superparamagnetic oxide contrast agent.

3. Increased magnetization transfer which may lower signal intensity for solid liver tumours. These sequences may be obtained with fat suppression.

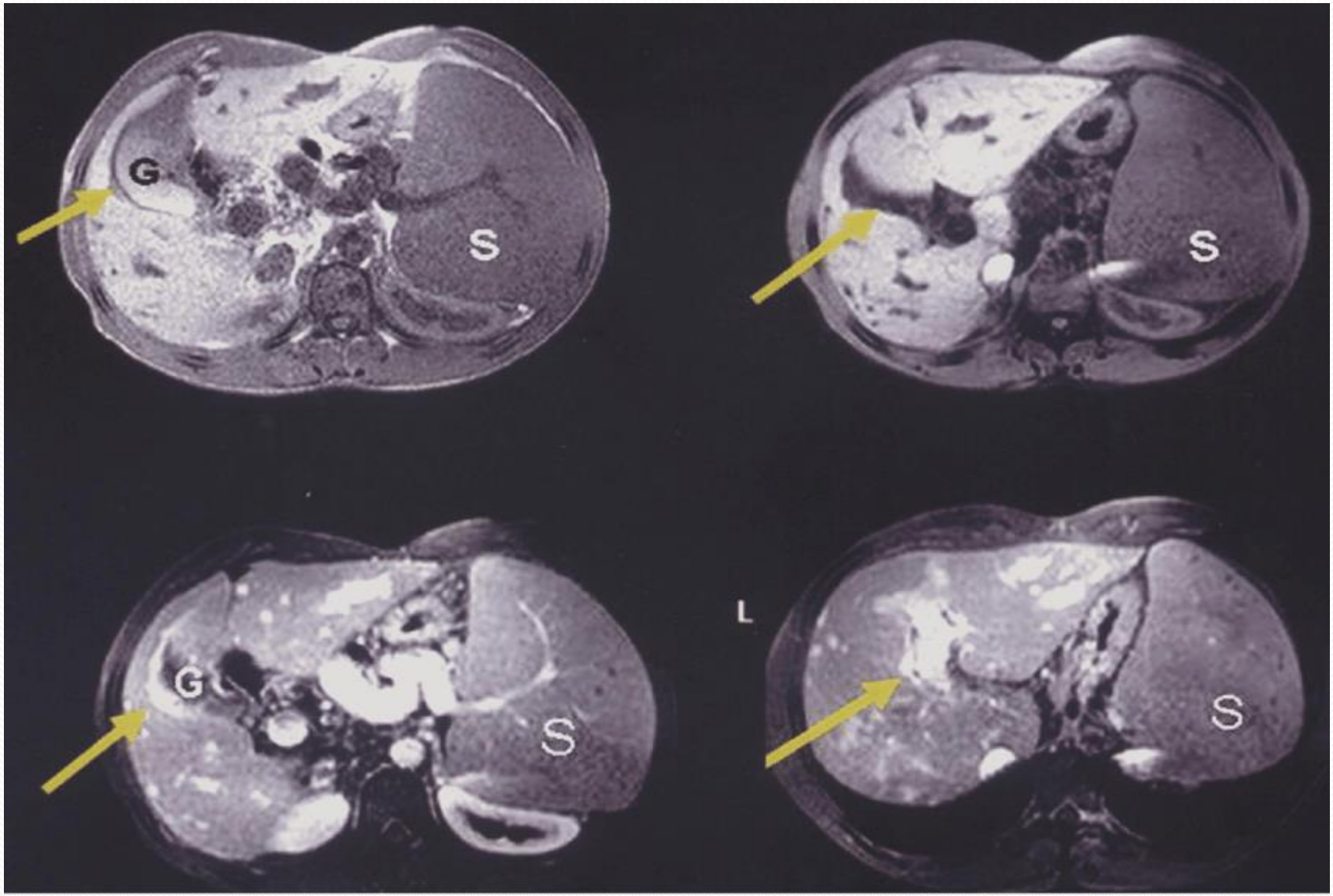
Fat suppression:

1. Decreases the motion artifact from subcutaneous and intraabdominal fat.

2. Increases the dynamic range of the image.

3. Improves signal-to-noise and contrast-to-noise ratios of focal liver lesions.

Fat suppression:



Very heavily T2-weighted sequences can be used to show water content in bile ducts, cysts and some focal lesions. These may be obtained as:

1.Gradient echo breath-hold sequences (e.g. fast imaging with steady-state precession (FISP), fast imaging employing steady state acquisition [FIESTA])

2. Breath-hold very fast spin echo (e.g. half Fourier acquisition single shot turbo spin echo [HASTE])

3. Non-breath-hold respiratory-gated sequences used for magnetic resonance cholangiopancreatography (MRCP)

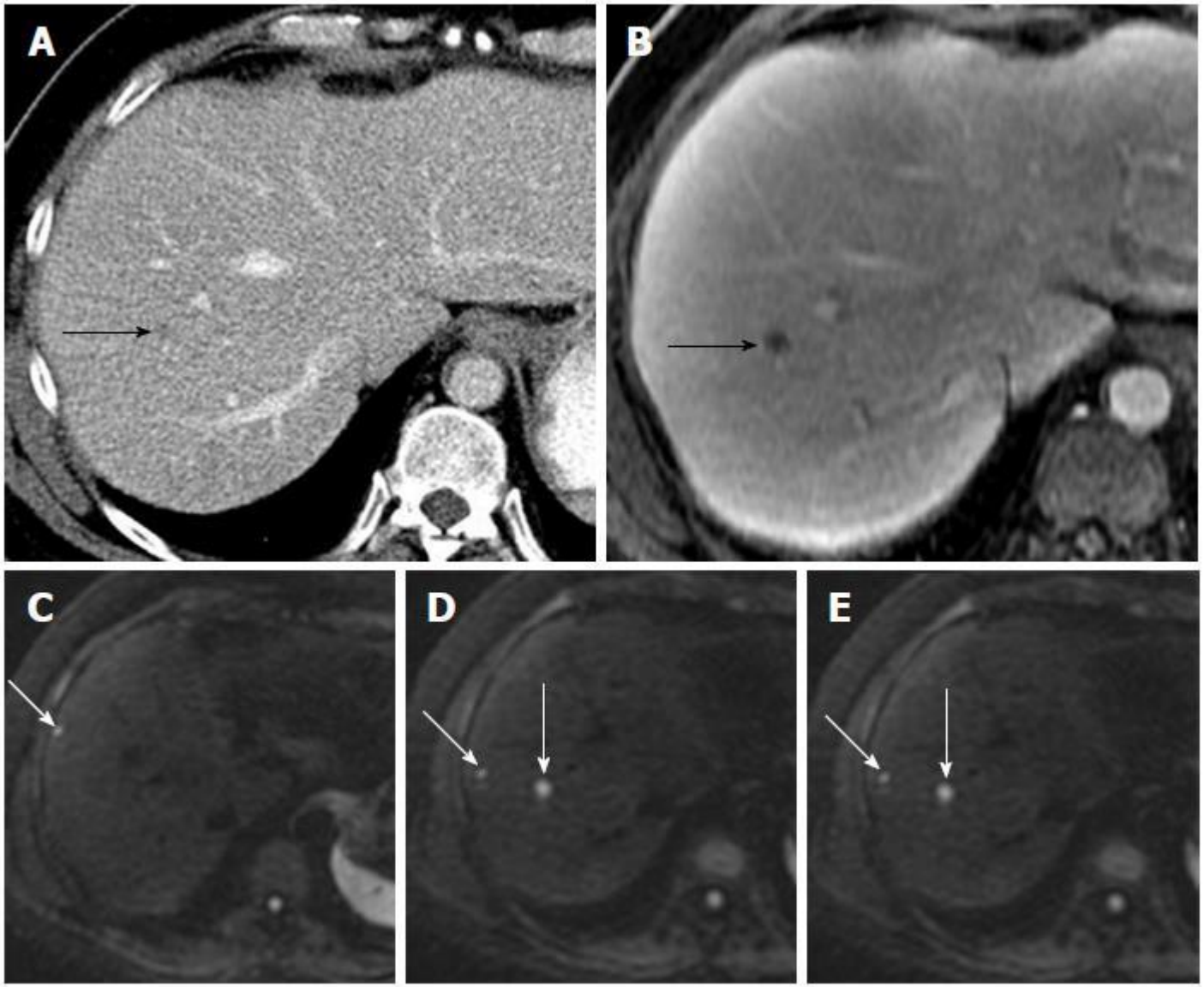
Fat suppression is also used to allow better delineation of fluid containing structures.

Short tau inversion recovery (STIR) also suppresses fat, which has a short T1 relaxation time. Other tissues with short T1 relaxation (haemorrhage, metastases and melanoma) are also suppressed.

Diffusion Weighted Imaging

This very rapidly acquired sequence forms an image based on the microscopic motion of water molecules and provides additional information regarding both lesion detection and characterization.

Diffusion Weighted Imaging



Contrast-enhanced Magnetic Resonance Imaging Liver

Gadolinium-enhanced T1-weighted magnetic resonance imaging

- This probably does not increase sensitivity for focal abnormalities, but may help in tissue characterization. When used in conjunction with spoiled GRE sequences, it is possible to obtain images during the arterial phase (ideal for metastatic disease and hepatocellular carcinoma), portal phase (hypovascular malignancies) and equilibrium phase (cholangiocarcinoma, slow-flow hemangiomas and fibrosis).
- Hepatic arterial phase and FSE T2-weighted sequences are the most sensitive sequences for the detection of hepatic metastases of neuroendocrine tumours.
- Contrast should be administered at a rate of 1–2 mL s–1 followed by a 20 mL saline flush at 1–2 mL s–1 using a power injector. Bolus triggered techniques are recommended for optimized arterial phase.

Liver-specific contrast agents

Standard gadolinium extracellular agents are commonly used for liver MRI as described previously, but other contrast agents have been developed to enhance the distinction between normal liver and lesions, especially malignant lesions. These are mostly used inpatients who are potentially suitable for major liver surgery, e.g. resection or transplantation:

1. Hepato-biliary agents (e.g. Gadoxetic acid [Primovist]; gadobenate dimeglumine [Multihance]) are taken up by normal hepatocytes and excreted by normal liver into the bile. Liver specific contrast agents shorten T1 relaxation times, which results in normal liver showing increased signal on T1 weighted sequences. Metastases, and other lesions not containing normal-functioning hepatocytes, show as a lower signal than the background liver. Lesions containing hepatocytes will enhance to varying extents. High signal contrast can be seen in the bile ducts, which has clinical usefulness.

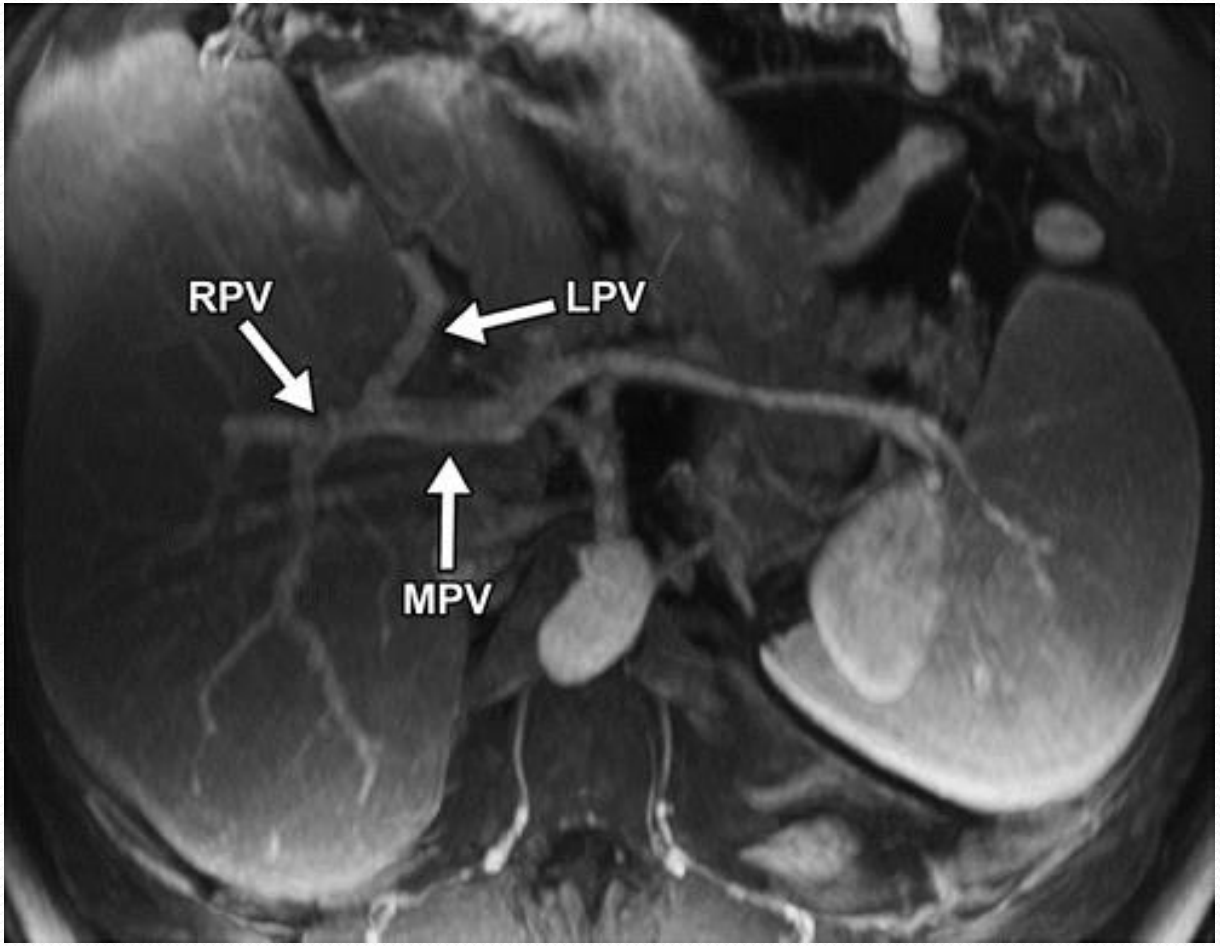
These agents are also excreted by the kidneys.

2. Reticuloendothelial (RE) cell agents (also called super paramagnetic iron oxides, SPIO) are not currently available, as they have been withdrawn from the market for commercial reasons. They are taken up by the RE or Kuppfer cells in normal liver, giving a decrease in signal on T2- and especially T2*-weighted sequences. They can also be used with T1-weighted sequences for characterization. On T2*-weighted images, malignant lesions without RE cells show as higher signal than the background normal liver. Examination with a SPIO agent may be combined with dynamic gadolinium enhancement in order to maximize the detection and characterization of metastases (and benign lesions) in a patient being considered for surgical resection of metastases. The same combination can be used in a patient with cirrhosis to maximize diagnosis and characterization of HCC versus dysplastic or regenerative nodules.

Magnetic resonance angiography

Contrast-enhanced spoiled GRE images may be obtained to give information with respect to the hepatic artery, portal vein and hepatic venous system.

Magnetic resonance angiography



MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY.

Magnetic resonance cholangiopancreatography (MRCP) with 3T scanner provides improved image quality over 1.5T scanners.

Indications:

1. Investigation of obstructive jaundice.
2. Suspected biliary colic/bile duct stones.
3. Suspected chronic pancreatitis.
4. Suspected sclerosing cholangitis.
5. Investigation of jaundice or cholangitis in patients who have. undergone biliary enteric anastomosis.
6. Prior to ERCP/PTC.

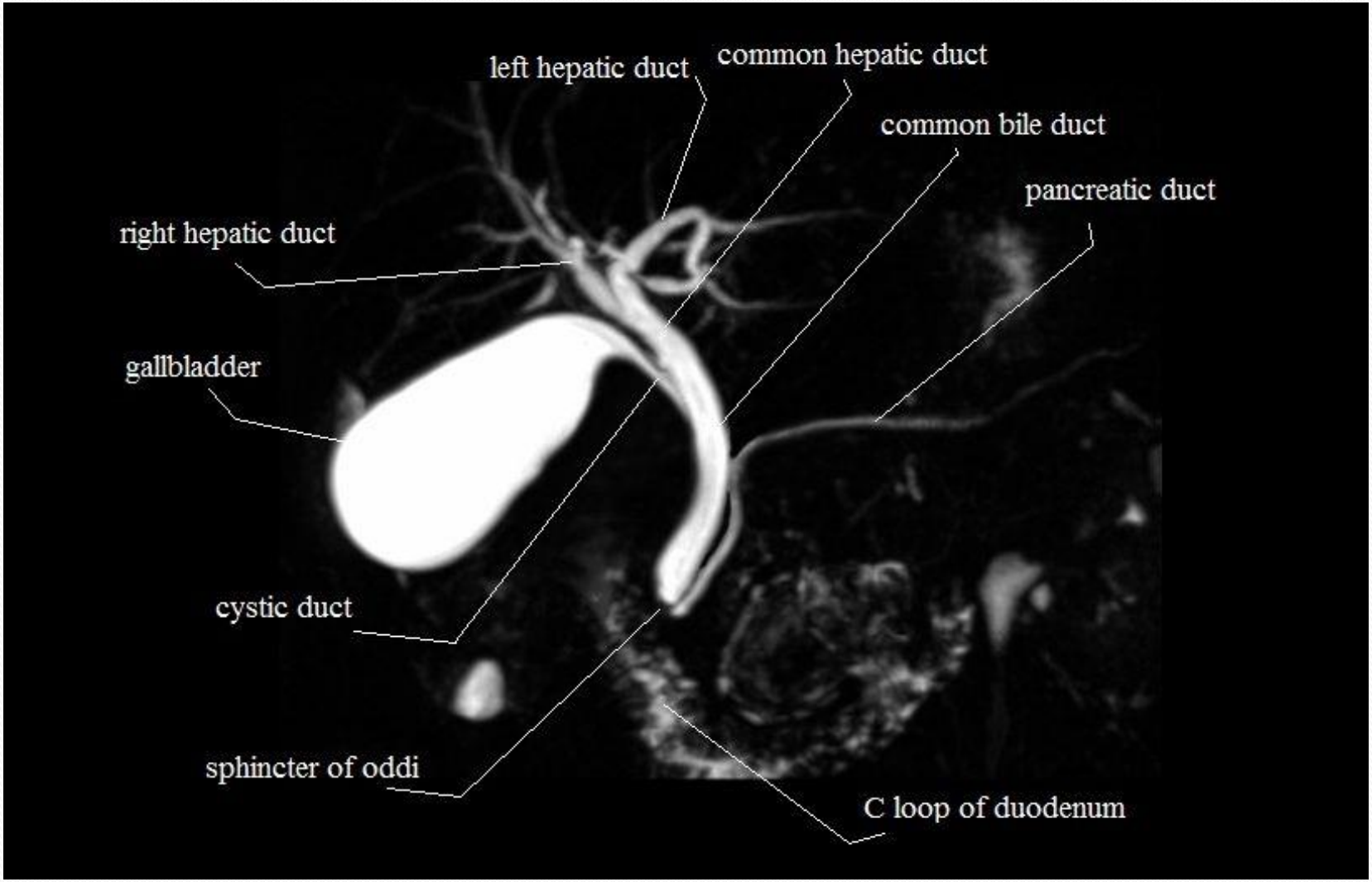
Contraindications:

Those that apply to MRI.

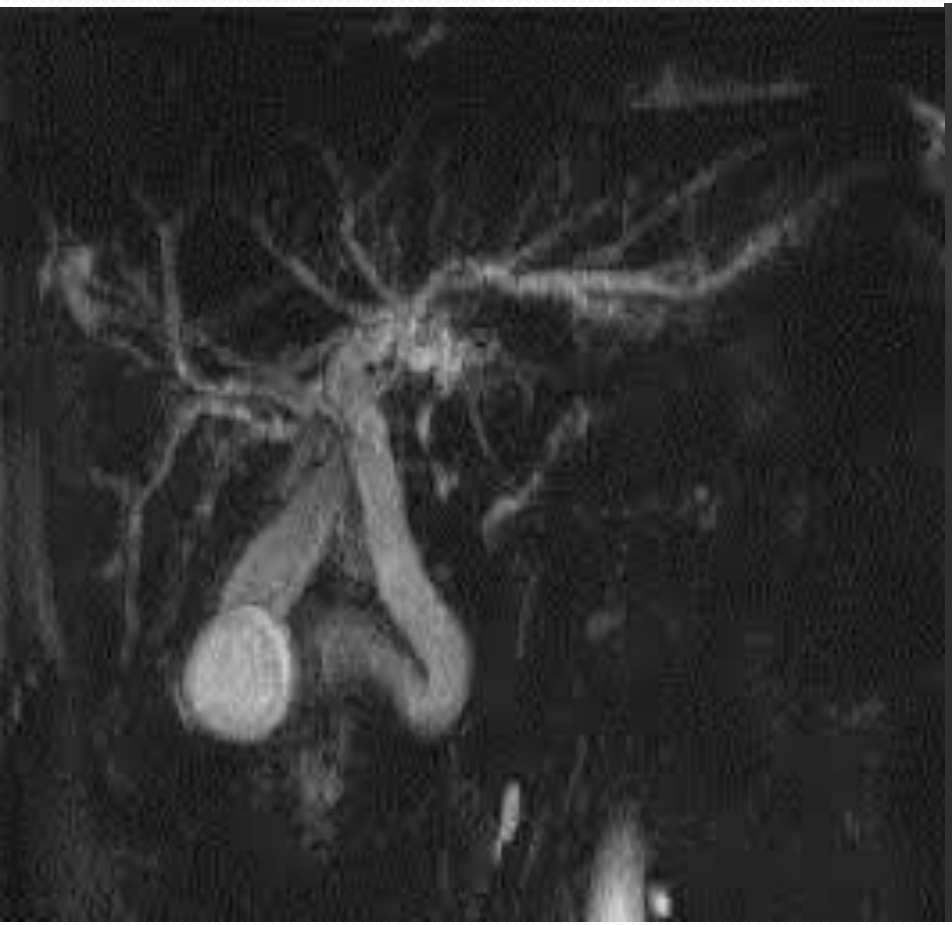
Technique:

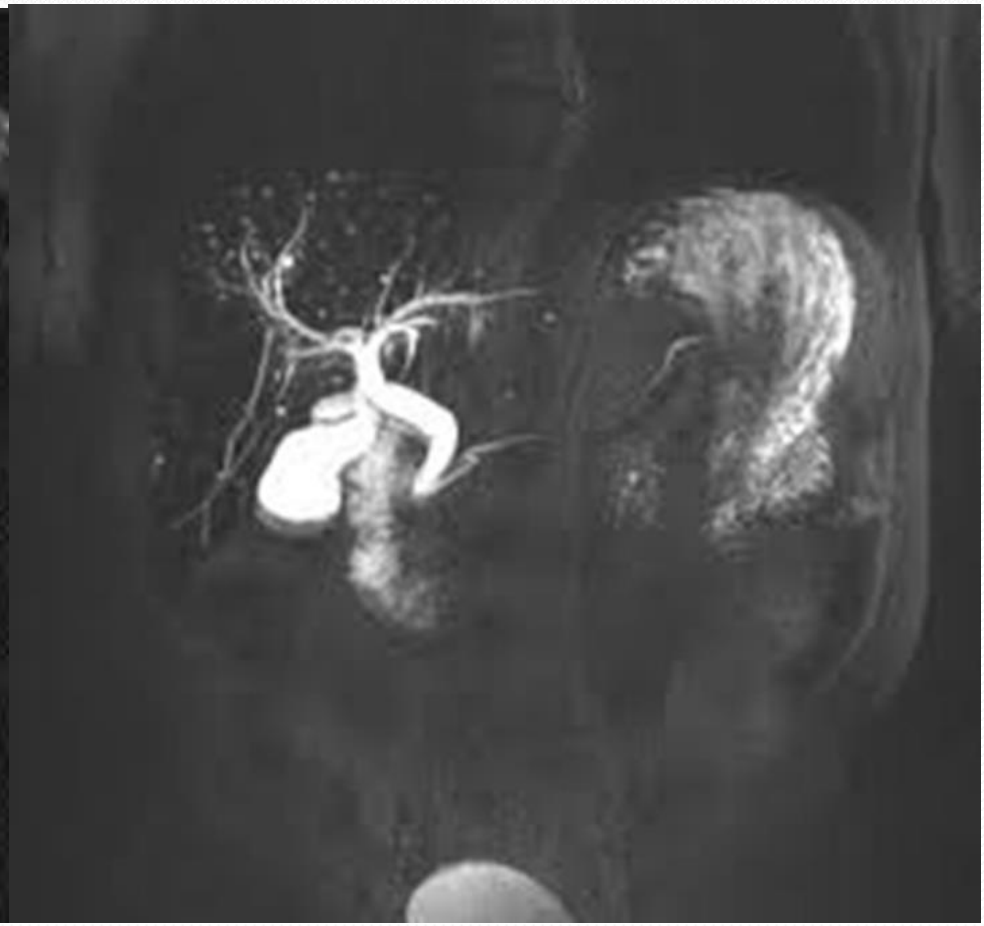
MRCP is a noninvasive technique, which uses heavily T2-weighted images to demonstrate the intra- and extrahepatic biliary tree and pancreatic duct. Most commonly used to demonstrate the presence of stones and the level and cause of obstruction, especially combined with cross-sectional MRI, in cases of tumor or suspected tumour.

MRCP


left hepatic duct
common hepatic duct
common bile duct
pancreatic duct
right hepatic duct
gallbladder
cystic duct
sphincter of oddi
C loop of duodenum

MRCP





Magnetic Resonance Imaging of the Pancreas

Indications

1. Staging of pancreatic tumors.
2. Suspected islet cell tumors.
3. Other indications are similar to CT, although CT is generally preferred because of availability, cost and time implications.

Technique

Sequences are acquired in both axial and coronal oblique planes. The optimal plane depends on the location of the tumour. For pancreatic head tumours, the pancreatic and portal venous phase acquisitions are best acquired initially in an oblique coronal plane followed by axial. The converse is true for tumours of the body and tail:

1. T1-weighted fat-suppressed gradient-echo. Normal pancreas

hyperintense to normal liver.

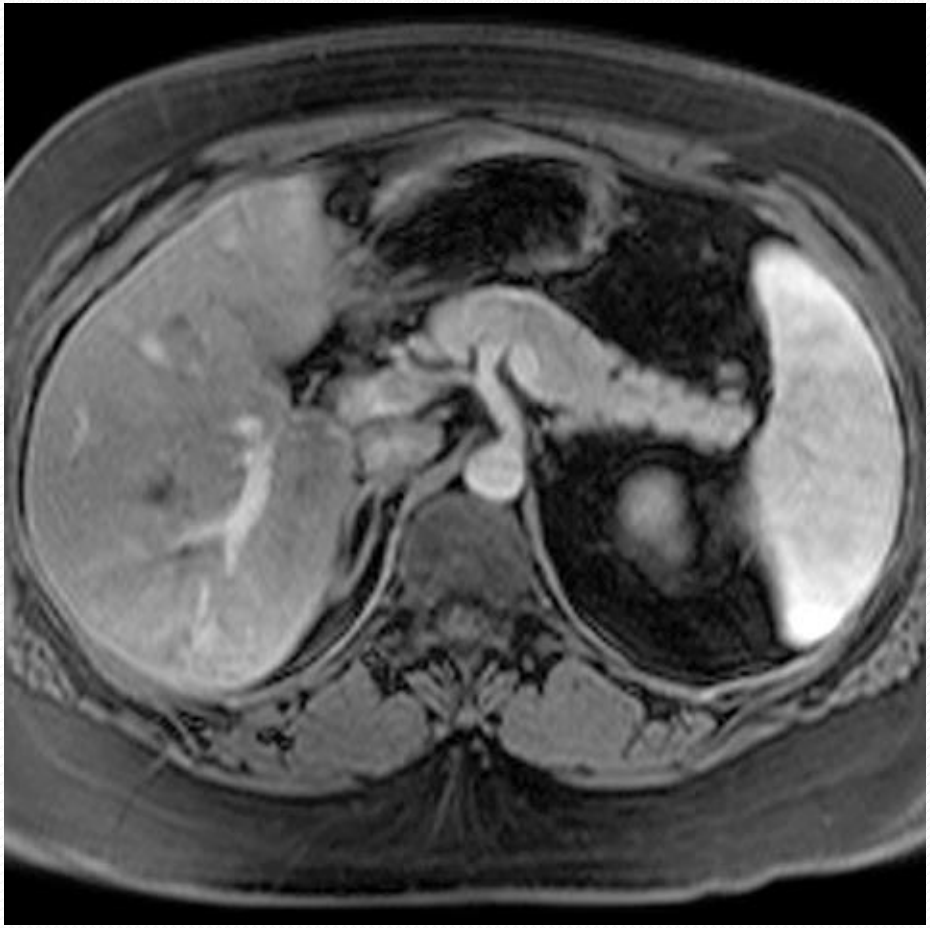
2. T1-weighted spoiled gradient-echo (SPGR, GE Medical Systems; fast low-angle shot [FLASH], Siemens). Normal pancreas isointense to normal liver.

3. T2 weighted turbo-spin echo.

4. Gadolinium-enhanced T1-weighted fat-suppressed spoiled GRE. Images are obtained immediately after the injection of contrast medium, after 45 s, after 90 s and after 10 min. Normal pancreas hyperintense to normal liver and adjacent fat on early images, fading on later images. Bolus triggered techniques are recommended for an optimal arterial phase.

5. The polypeptide hormone secretin may be given slowly i.v. over 1 minute to temporarily distend the pancreatic ducts. This can help better assess pancreatic ductal anomalies and also provide information about the exocrine function of the gland.

MRI of Pancreas



MRI of Pancreas