Maastricht UMC+

Imaging of the liver

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Imaging modalities for evaluation of the liver:

- CT
- MRI
- Ultrasound

Imaging modalities for the liver:

- CT
- MRI
- ~~Ultrasound~~

Ultrasound

- specificity in detecting liver metastases is poor
- overall false-negative rate is 50%

Reasons:

- observer experience

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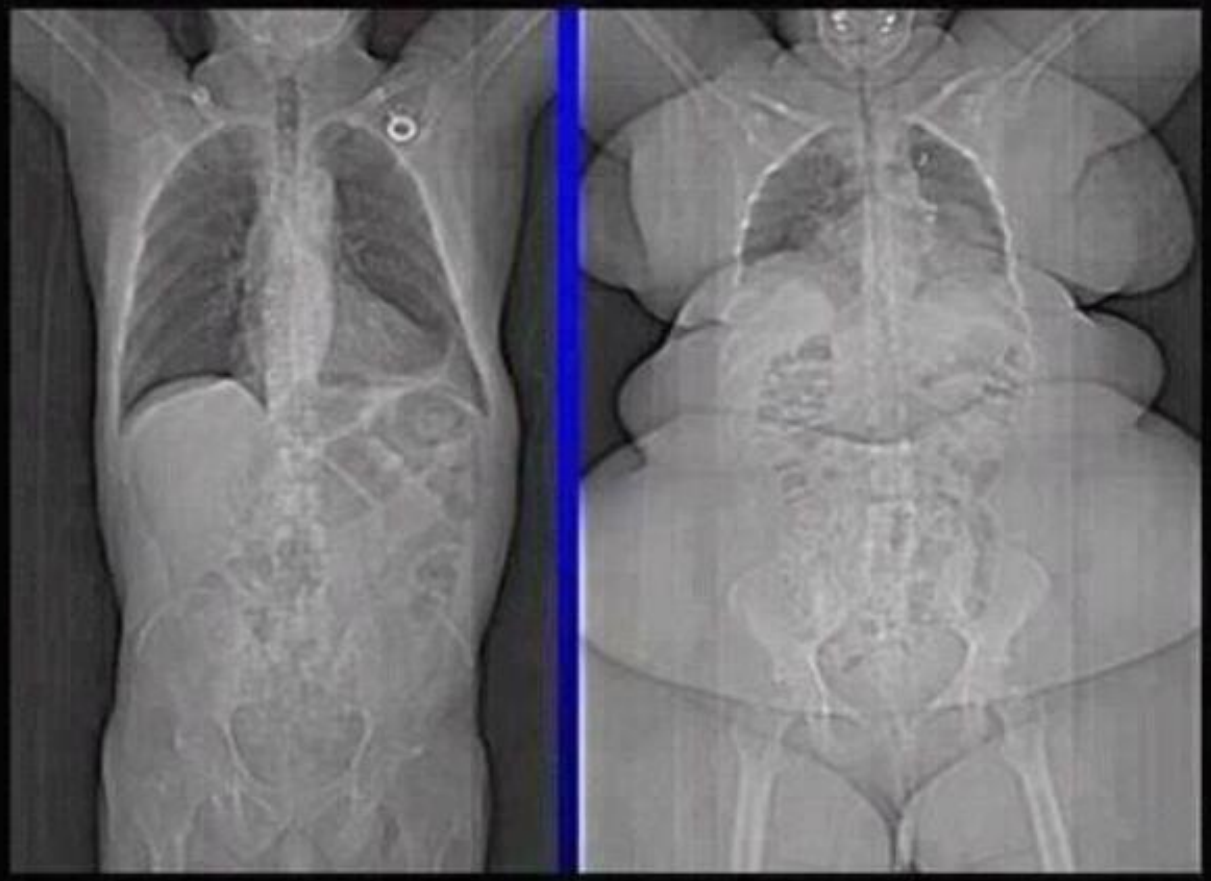
- physical build of patient

MYTH:
'I AM JUST BIG BONED'



YOUR EXCUSE IS INVALID

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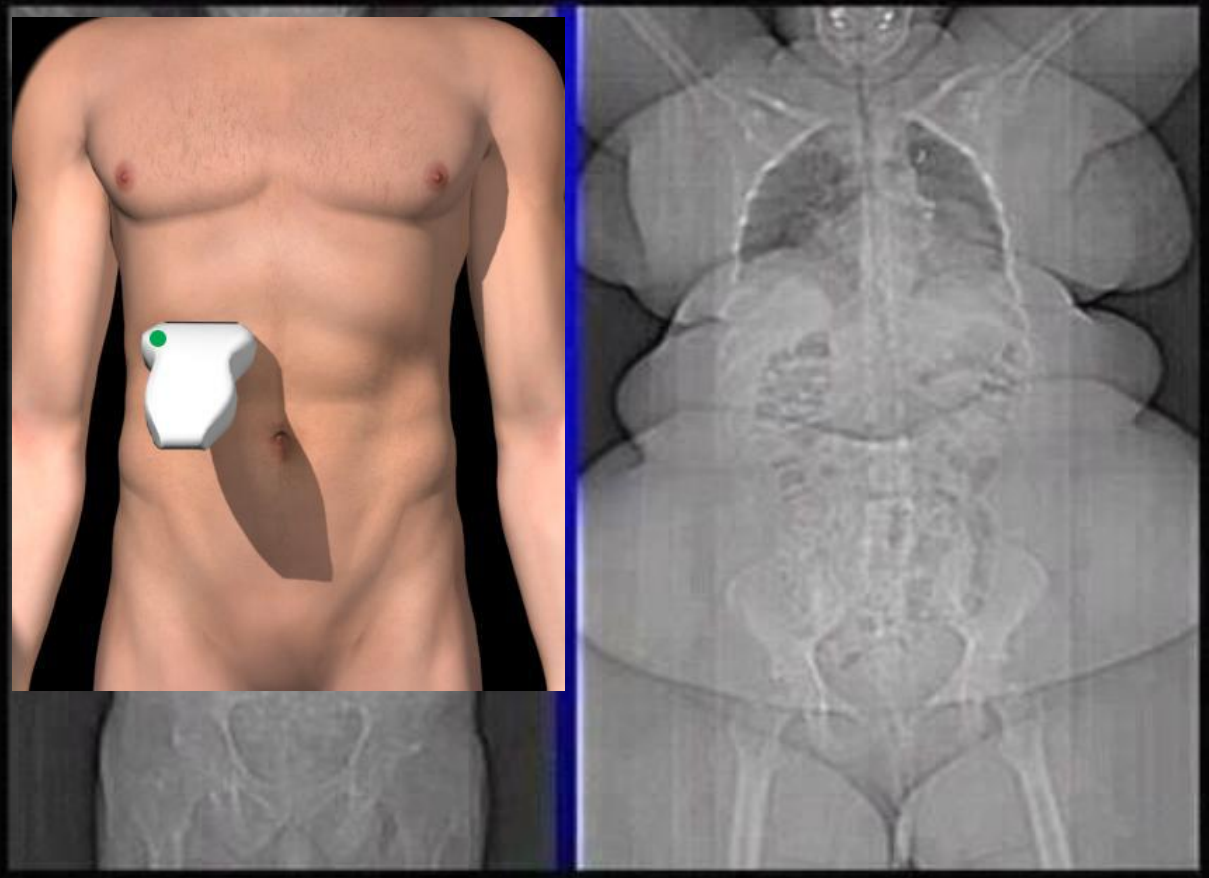

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Ultrasound

- sound attenuation increases with fat thickness and transducer frequency

Ultrasound

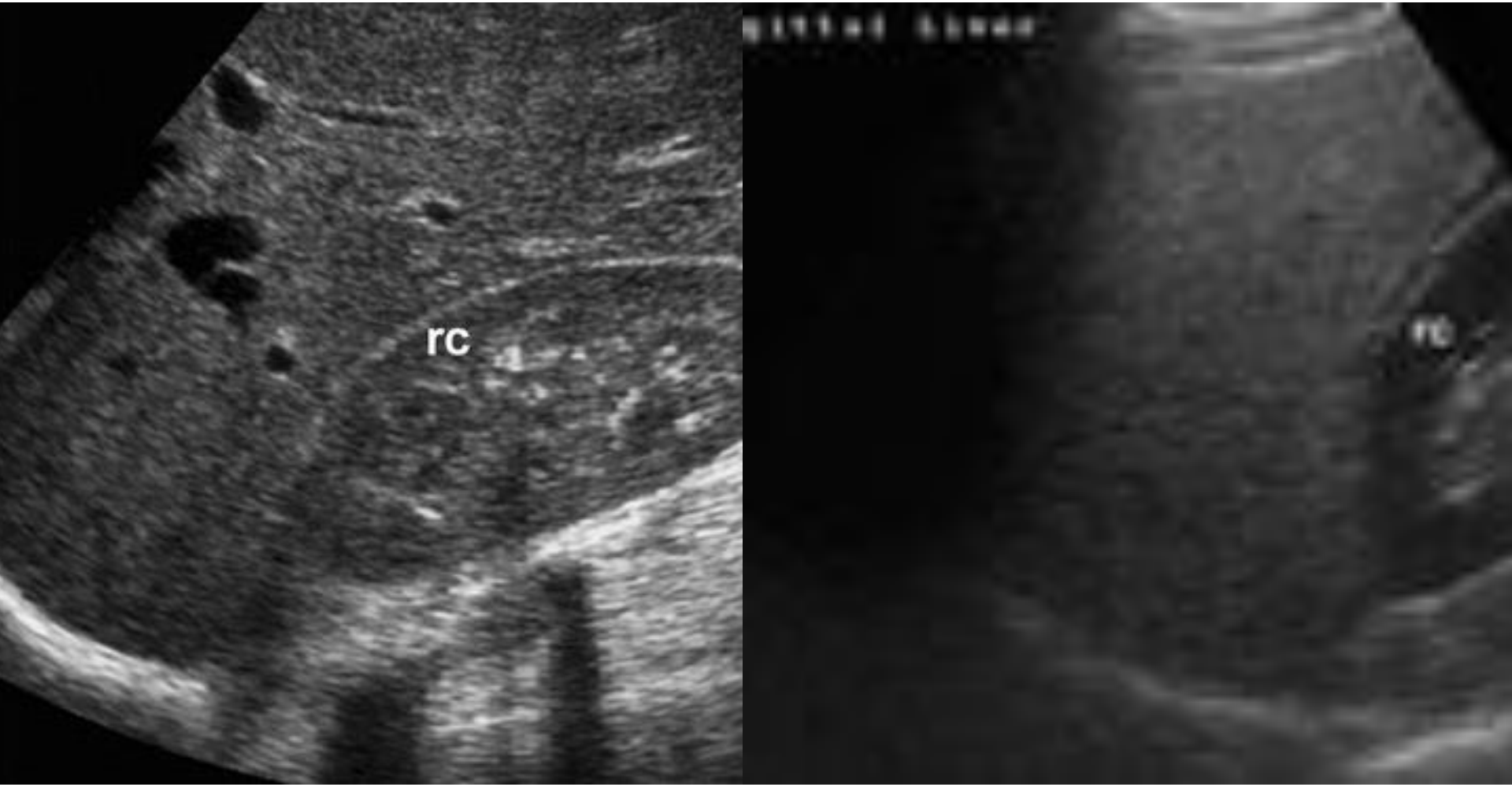
- sound attenuation increases with fat thickness and transducer frequency
- the sound wave produced by a 7-MHz transducer is attenuated **50%** after traveling through **1 cm** of fat

Ultrasound

- in an obese patient with 8 cm of subcutaneous fat, **94%** of the original sound wave is attenuated before it reaches the peritoneal cavity

Reasons:

- observer experience
- physical build of patient
- diffuse parenchymal disease
    - storage
    - (vascular)
    - (inflammatory)



Fatty Liver: Imaging Patterns and Pitfalls
RadioGraphics 2006; 26:1637–1653

CT

- ionizing radiation

CT

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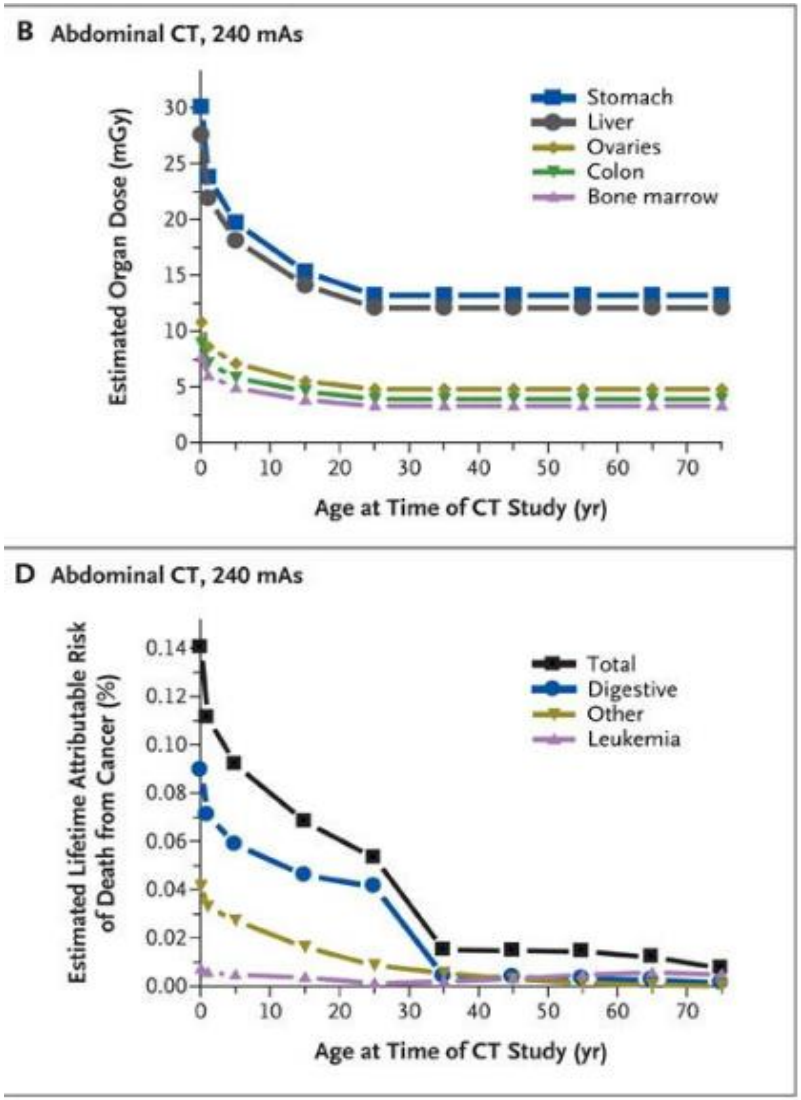
- estimated that about **0.4%** of all cancers in the US may be attributable to the radiation from CT studies

Brenner et al. N Engl J Med 2007; 357:2277-2284

CT

- ionizing radiation
- estimated that about 0.4% of all cancers in the US may be attributable to the radiation from CT studies
- by adjusting for current CT use, this estimate might now be in the range of **1.5 to 2.0%**

Brenner et al. N Engl J Med 2007; 357:2277-2284



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MRI

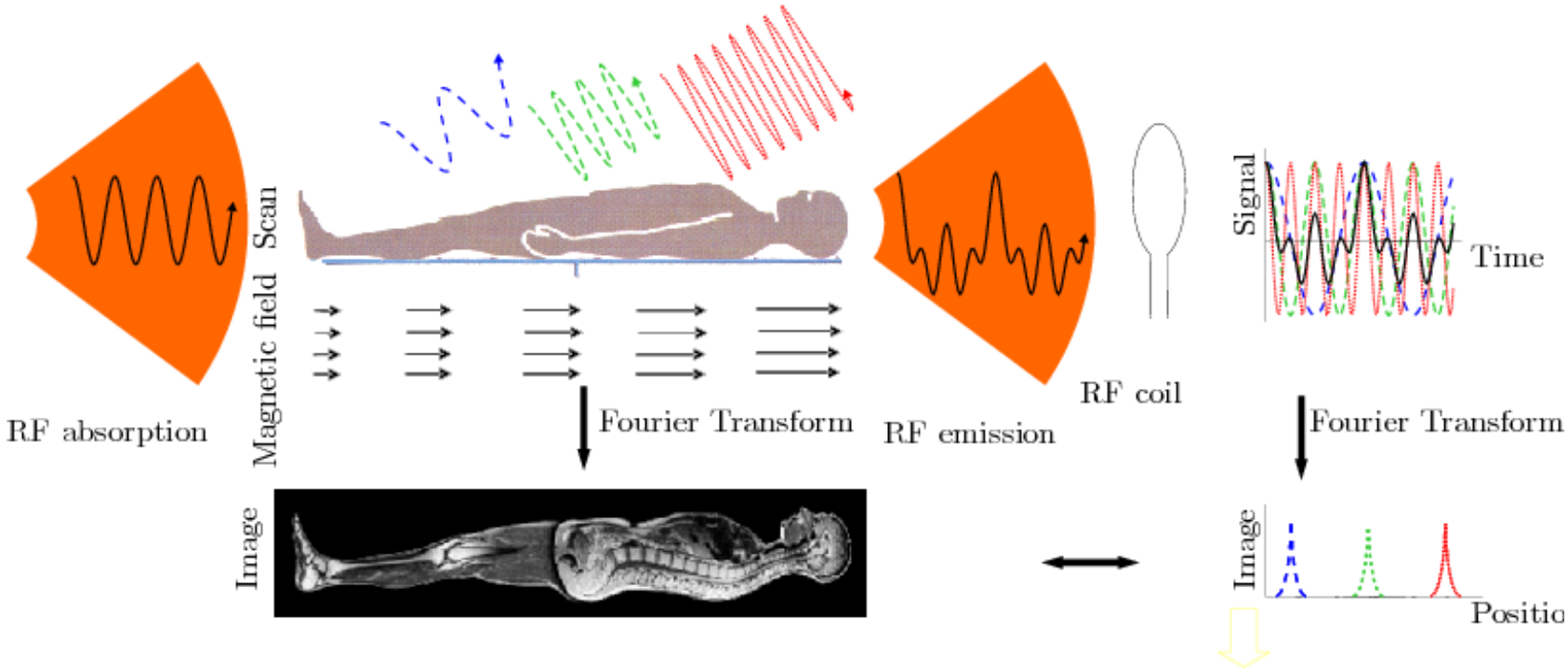
- magnetic resonance imaging

MRI

- magnetic resonance imaging
- no ionizing radiation

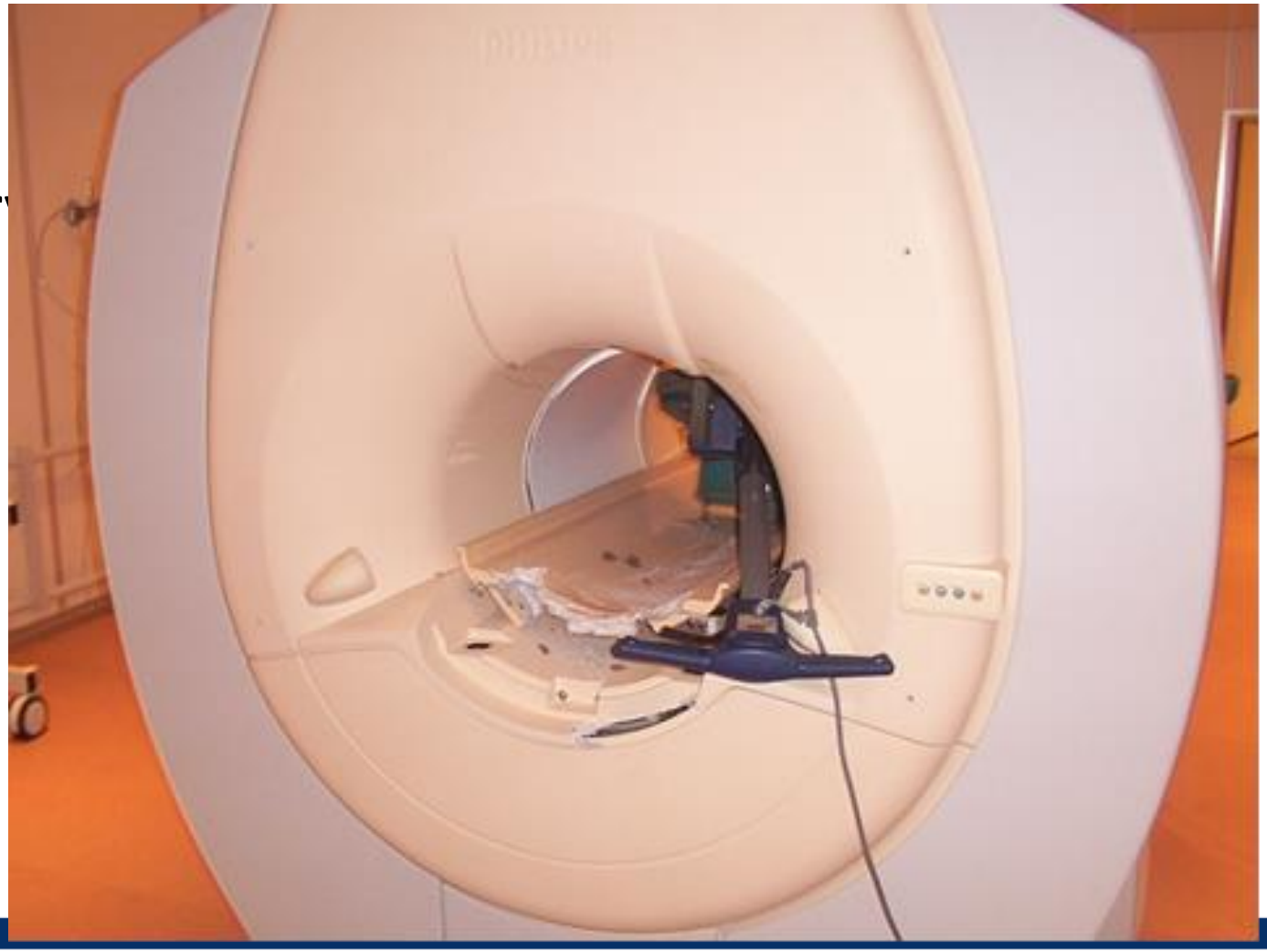
MRI

- uses the magnetic properties of the hydrogen nucleus present in water molecules (thus in all body tissues)
- nuclei behave like compass needles that are partially aligned by a strong magnetic field in the scanner
- the nuclei can be rotated using radio waves
- subsequently oscillate in the magnetic field while returning to equilibrium
- produce their own rotating magnetic fields that a scanner detects and uses to create an image


RF absorption
Magnetic field
Scan
Fourier Transform
Image
RF emission
RF coil
Signal
Time
Fourier Transform
Image
Positio

MRI

- ver



Suspected liver metastases:

- CT imaging method of choice
- better evaluation of the involvement of extrahepatic tissues, including bones, bowel, lymph nodes, and mesentery
- diffuse liver disease and fatty infiltration limit the sensitivity in lesion detection

MRI for preoperative evaluation of liver lesions

- high sensitivity for detection of small lesions
- ability to characterize small lesions
- tissue characterization with T1 and T2
- high spatial resolution
- high sensitivity for contrast enhancement

LIVER MRI PROTOCOL
(Liver cirrhosis surveillance protocol)

- SCOUT
- AXIAL T1 in/opposed phase 6 mm
- CORONAL T2-HASTE 4 mm
- AXIAL T2-HASTE 4 mm
- AXIAL STIR 6 mm
- AXIAL DWI 6 mm (b 50,400,1000)
- AXIAL VIBE 3 mm (5 MEASUREMENTS)
  - Basal
  - →Care bolus
  - Arterial phase
  - Portal phase
  - Venous phase
  - Equilibrium phase

T1 and T2-weighted sequences

T1- fat is white

- highlights high fat content structures
- helpful in defining anatomy

T2- water is white

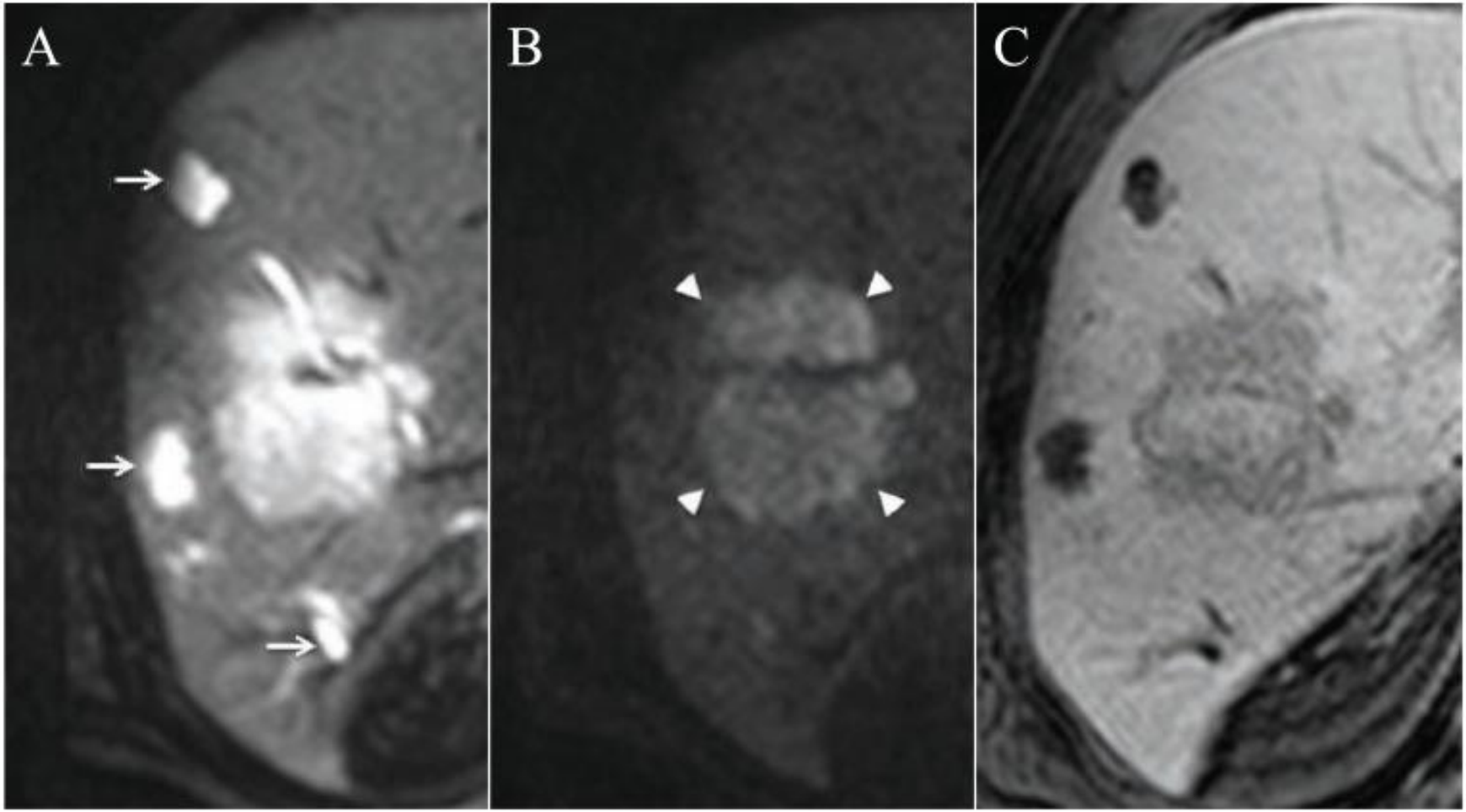
- highlights water content and areas of inflammation

T1 and T2

- most benign tumors are bright on T2w imaging
- malignant lesions are slightly hyperintense
- most lesions hypo-intense on T1

Diffusion Weighted Imaging (DWI)

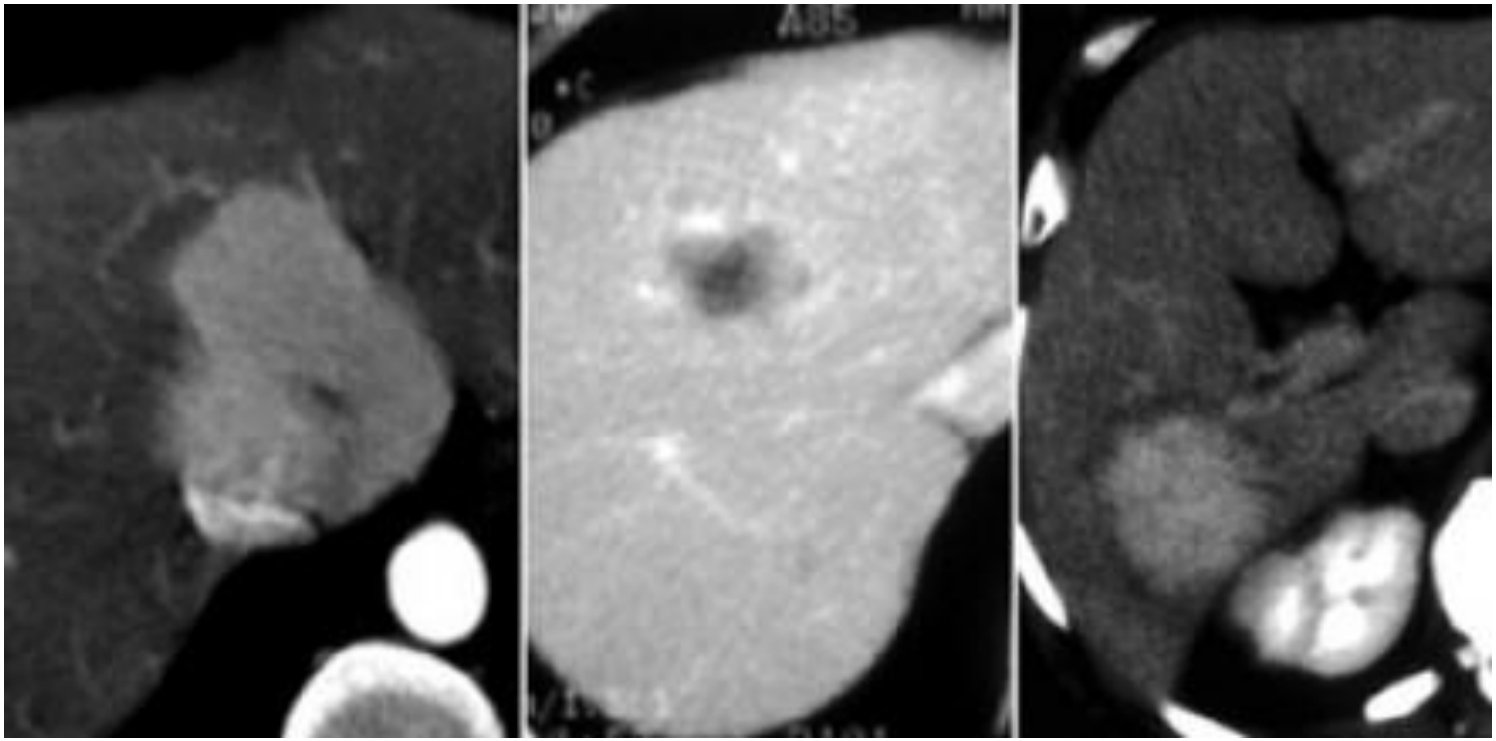
- reliable method to detect liver metastases
- sensitivity of 87% and specificity of 97%
- multidetector CT sens 53% and spec 78%


A
B
C

Contrast-enhanced MRI

- native phase
- late arterial phase
- portal venous phase
- equilibrium phase

- the conspicuity of a liver lesion depends on the attenuation difference between the lesion and the normal liver
- dual blood supply to the liver (80% by the portal vein and 20% by the hepatic artery)
- all liver tumors get 100% of their blood supply from the hepatic artery, so when they enhance it will be in the arterial phase



Detection of a lesion depends on difference in attenuation between liver and lesion.
LEFT: Arterial phase showing hypervascular FNH
MIDDLE: Portal venous phase showing hypovascular metastasis
RIGHT: equilibrium phase showing relatively dense cholangiocarcinoma

Arterial phase

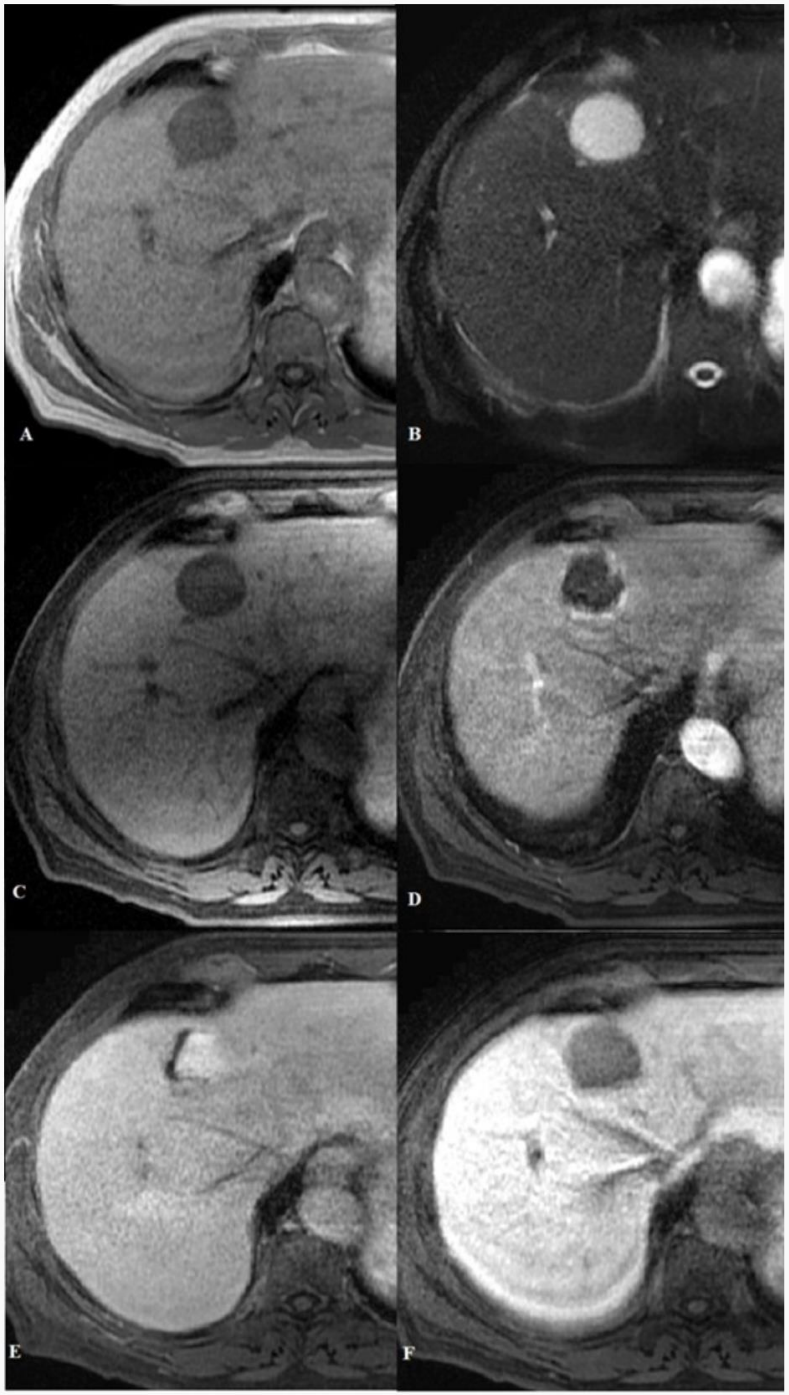
- 35 sec after contrast injection (late arterial phase)
- hypervascular tumors will enhance via the hepatic artery, when normal liver parenchyma does not yet enhance, because contrast is not yet in the portal venous system
- visible as hyperdense lesions in a relatively hypodense liver
- when the surrounding liver parenchyma starts to enhance in the portal venous phase, these hypervascular lesion may become obscured

Hypervascular lesions

Benign	Malignant
FNH	HCC
Adenoma	Hypervascular Metastases: Breast
Hemangioma	Sarcomas
	Neuroendocrine
	Renal Cell
	Melanoma

Hemangioma

- cavernous hemangioma is the most common hepatic tumor, incidence 20%
- well delineated
- hypointense as blood on T1w images
- clearly hyperintense on T2w images
- peripheral and nodular enhancement in early phases
- progressive centripetal filling in late and delayed phases
- SI is similar to blood


A
B
C
D
E
F

Hepatocellular adenomas

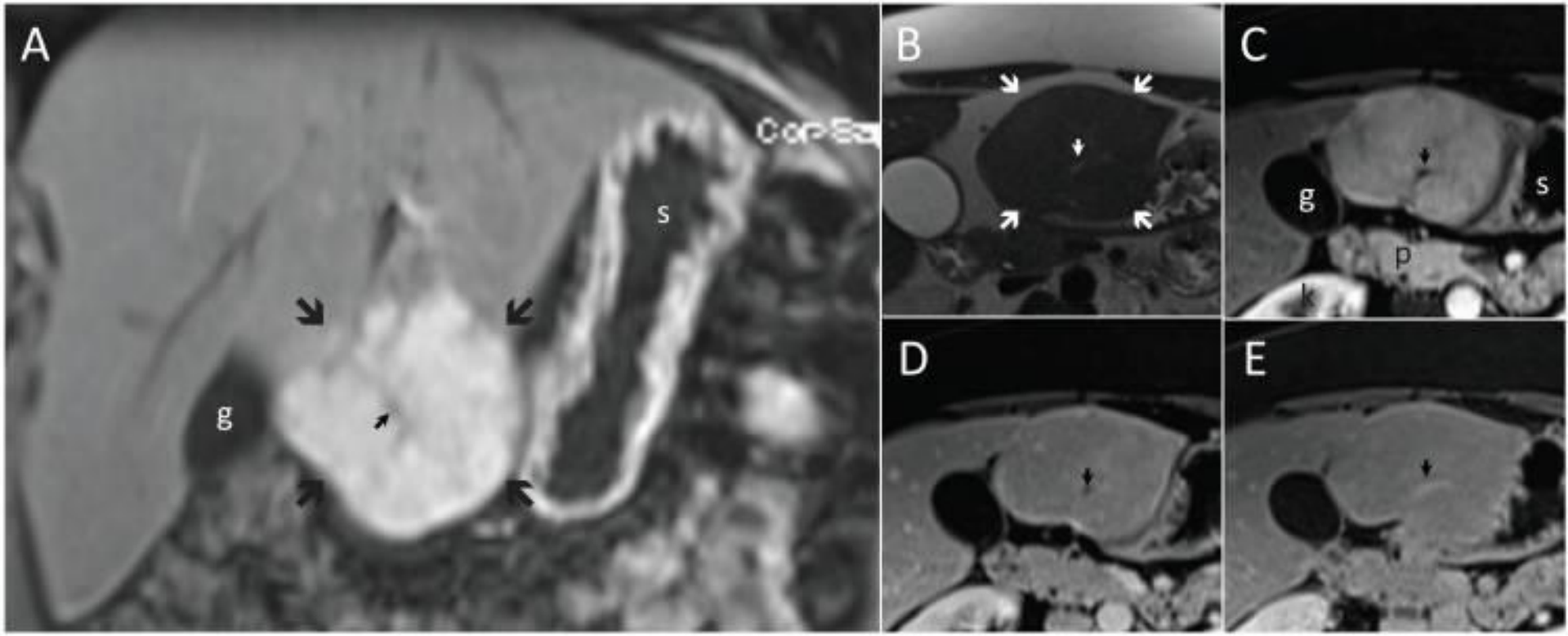
- 80 % solitary
- large, well circumscribed encapsulated tumors
- sheets of hepatocytes without bile ducts or portal areas
- most frequent liver tumor in young females taking oral contraceptives

Hepatocellular adenomas

- heterogeneous (prone to central necrosis and hemorrhage because the vascular supply is limited to the surface of the tumor)
- hyperintense or isointense on T1, mildly hyperintense on T2
- often fatty component (50%)
- most are hypervascular in the arterial phase
- peripheral rim observed in approx 1/3
- shows gadolinium enhancement, which represents compressed normal liver around the tumor

Focal Nodular Hyperplasia (FNH)

Etiology	Congenital vascular malformation or vascular injury
Morphology	Usually lobulated/well circumscribed No capsule Central fibrous scar with large vessels feeding the lesion
Enhancement	Hyperenhancing Arterial Phase in 100% Enhances Homogeneously in 95% Central scar enhances in equilibrium phase - Large Lesions 60 - 70% - Small lesions 30 - 35%



Typical focal nodular hyperplasia; it is slightly hyperintense to the liver on T2 (**B**) and enhances richly on T1 in the arterial phase (**A** and **C**) followed by isointensity in the delayed phases (**D** and **E**).
Note the central scar (small arrow), which is hyperintense on T2 (**B**) and hypointense on T1 in arterial (**A** and **C**) and portal venous (**D**) phases, whereas hyperintense after 5 minutes (**E**).

Table 4. DDx Hypervascular Liver Metastasis
"MR. CT Craves Peanut Butter"
Melanoma
Renal Cell
Choriocarcinoma
Thyroid
Carcinoid
Pancreas
Breast

- hypervascular metastases are best imaged during the arterial phase and enhance diffusely
- small flash fill hemangiomas may have a similar appearance to hypervascular metastases
- hemangiomas will typically remain enhanced on portal venous phase imaging whereas metastases will washout

portal venous phase

- about 75 seconds after injection
- hypovascular tumors are detected, when the normal liver parenchyma enhances maximally
- visible as hypodense lesions in a relatively hyperdense liver
- if you do not seen enhancement of the hepatic veins, you are too early

Hypovascular lesions

- most liver metastases including lung, GI tract, pancreas, breast, bladder, and lymphoma
- may demonstrate peripheral enhancement during the arterial phase
- meticulous inspection of the ring should establish discontinuous globular enhancement similar in attenuation to the arterial blood pool before making the diagnosis of hemangioma

equilibrium phase

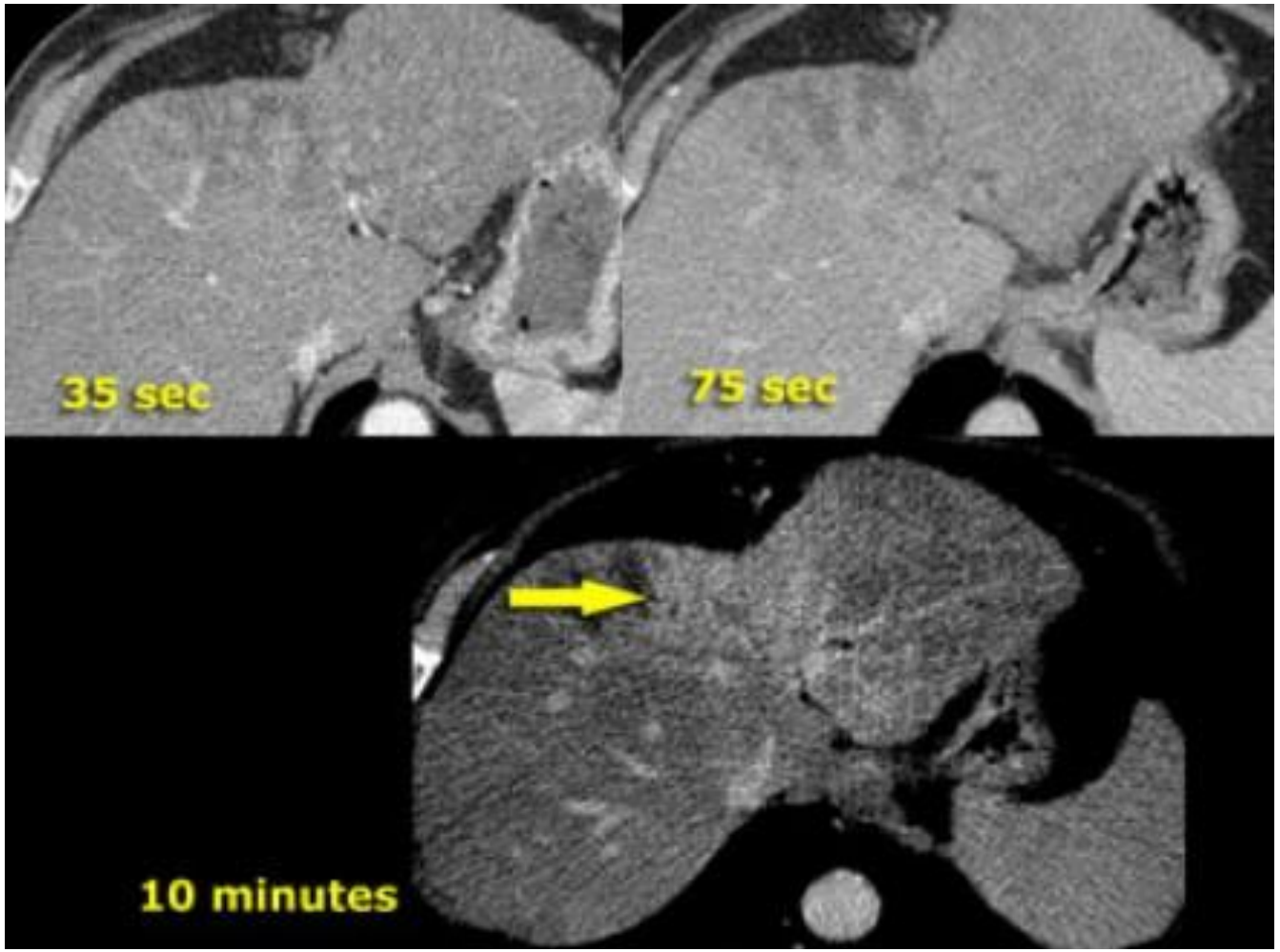
- tumors become visible, that either loose their contrast slower than normal liver, or wash out their contrast faster than normal liver parenchyma
- either relatively hyperdense or hypodense to the normal liver

Value of Equilbrium Phase

Tumoral wash out	Vascular tumors
Retention of contrast in blood pool	Hemangioma
Retention of contrast in fibrous tissue	Capsule around HCC Cholangiocarcinoma when fibrous Central fibrous scar (FNH)

equilibrium phase

- fibrous tissue that is well organized and dense is very slow to let iodine or gadolinium in
- once contrast gets in, it is equally slow to get back out in the equilibrium phase
- when the normal liver parenchyma washes out, the fibrous components of a tumor will look brighter than the background liver tissue



cholangiocarcinoma

Conclusion:

- CT and MRI are valuable techniques for evaluation of liver lesions
- MRI is more sensitive and specific for small lesions

Thank you for your attention

References:

MR Imaging of Hypervascular Liver Masses: A Review of Current Techniques. Silva AC et al, RadioGraphics 2009

the Radiology Assistant http://www.radiologyassistant.nl

MRI of focal liver lesions. Albion N, Curr Med Imaging Rev. 2012