Liver imaging
the revolution

Valérie Vilgrain
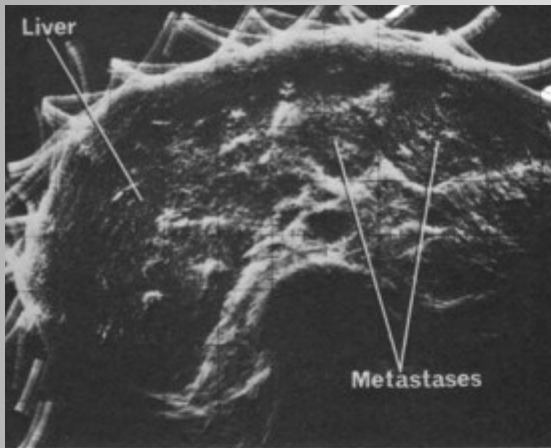### *Hôpital Beaujon, Paris, France*
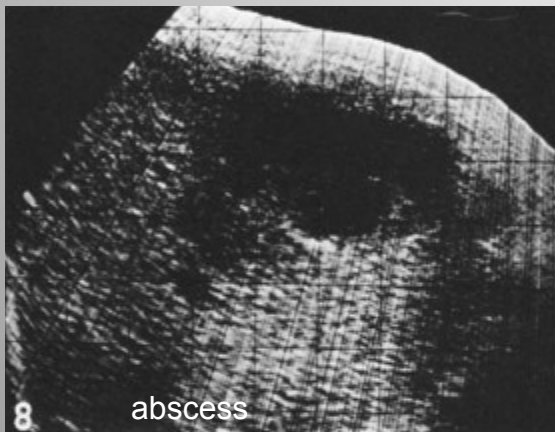
At the Beginning of the story

Radiology in the 1970s
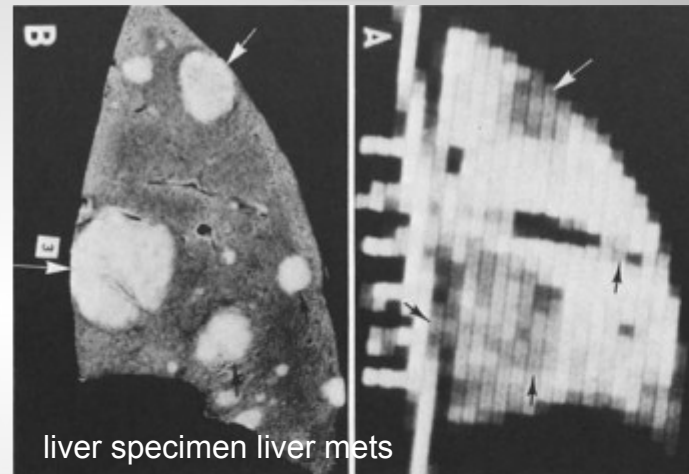
US

CT

Liver
Metastases

Garrett Radiology 1976

liver specimen liver mets

Philips Radiology 1975

8 abscess

Taylor Radiology 1976

L
C M. 9-13-76 302041 U+19
D hepatic cyst
L
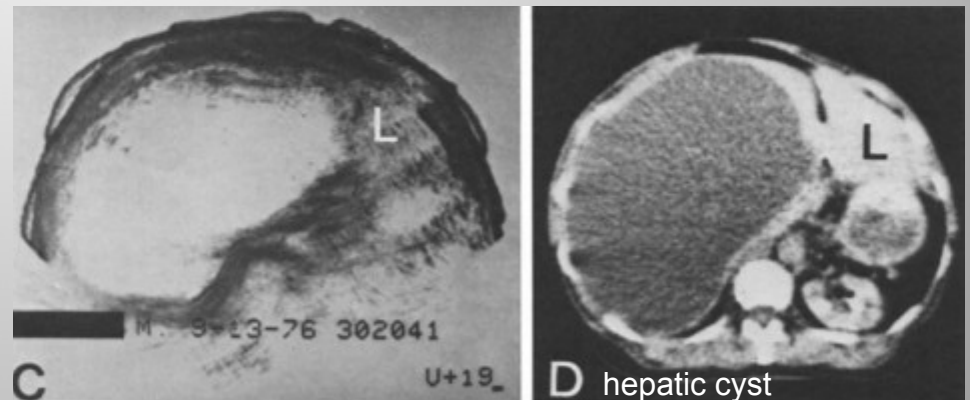
Bryan Radiology 1977

Radiology in the 1980s

MRI

Nuclear magnetic resonance imaging of the liver and pancreas

THE RADIOLOGICAL SOCIETY of North America

Peter L. Davis, M.D.
Albert A. Moss, M.D.
Henry I. Goldberg, M.D.
David D. Stark, M.D.
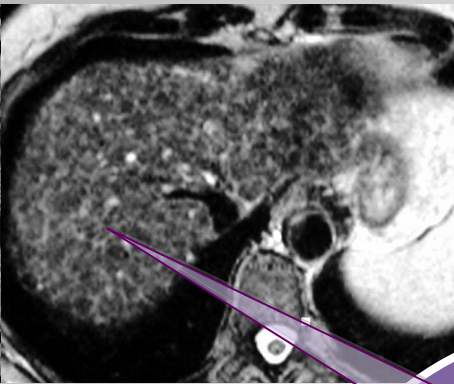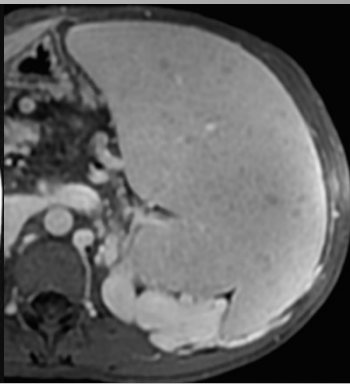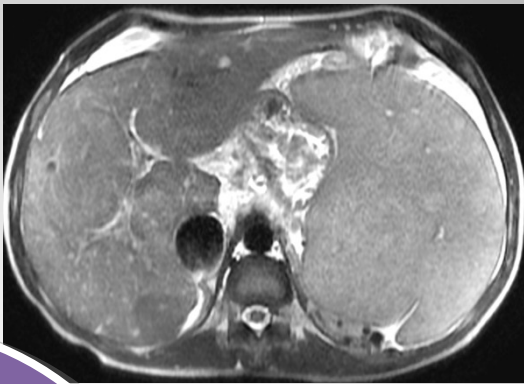Alexander R. Margulis, M.D.

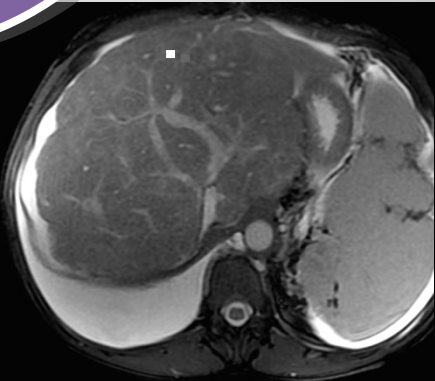*Radiology 1984*

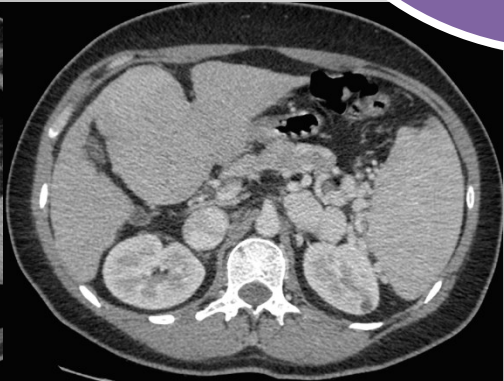Liver mets

Chronic liver disease
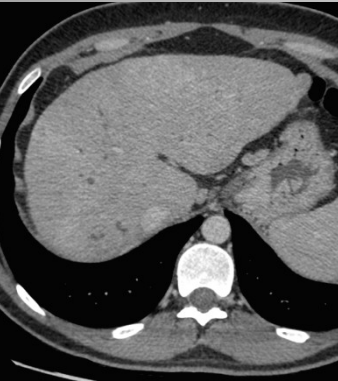*Tumor detection*
Tumor characterization
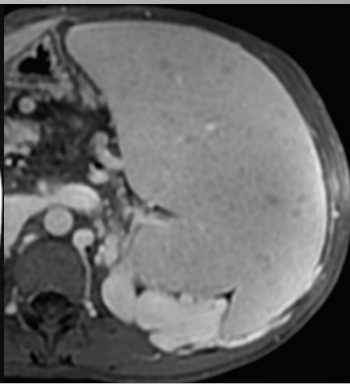*Tumor response*

Morphological imaging

Chronic liver disease

Cirrhosis

Non cirrhotic:
Portal cavernoma
Budd-Chiari
Biliary

Chronic liver disease
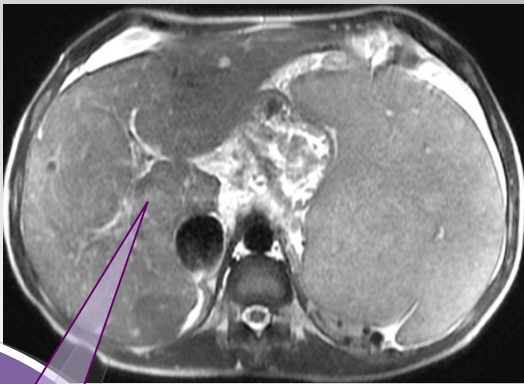
Cirrhosis
Non cirrhotic:
Portal cavernoma
Budd-Chiari
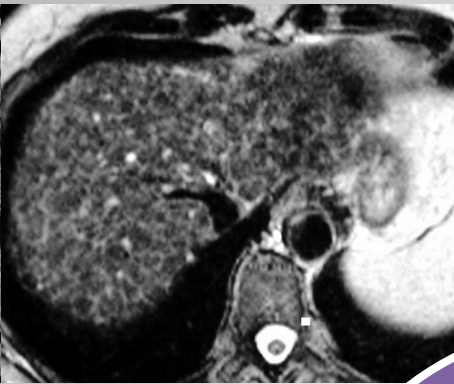Biliary

Chronic liver disease
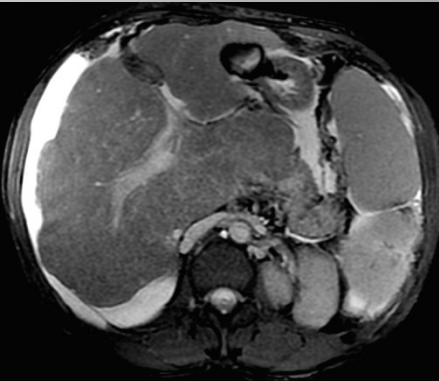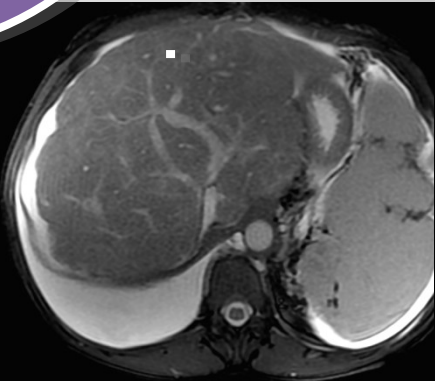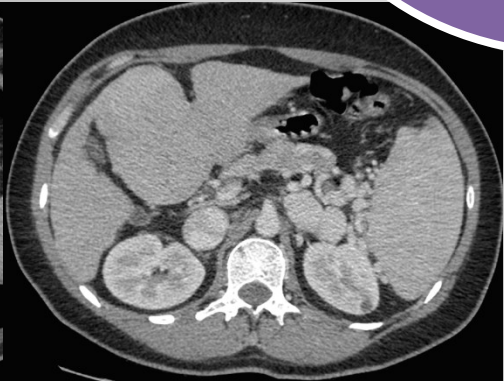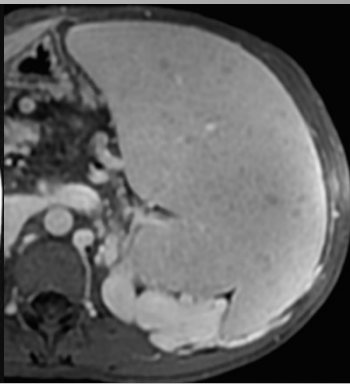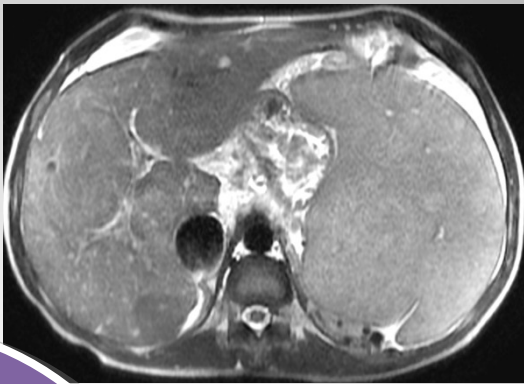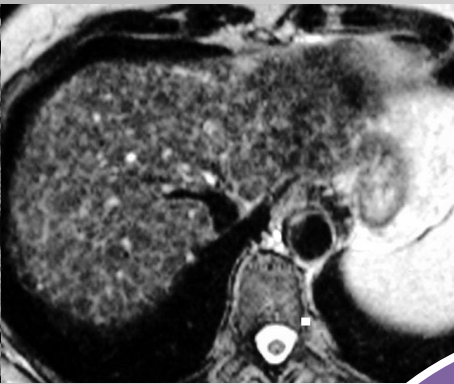

Cirrhosis
Non cirrhotic:
Portal cavernoma
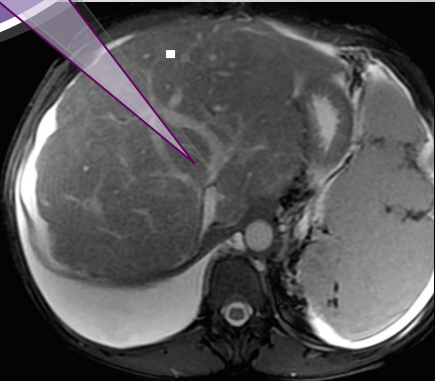Budd-Chiari
Biliary

Chronic liver disease

Cirrhosis
Non cirrhotic:
Portal cavernoma
Budd-Chiari
Biliary

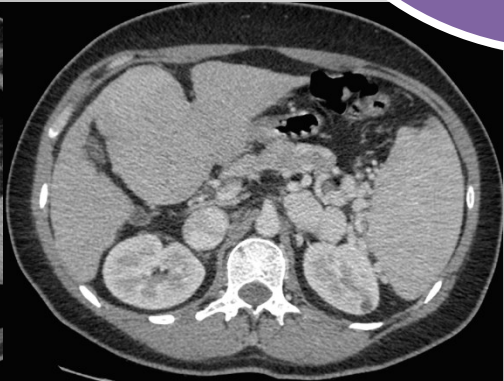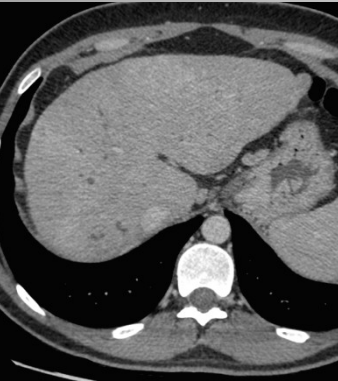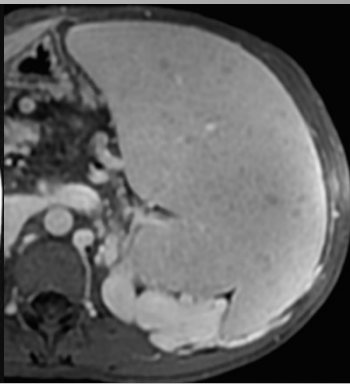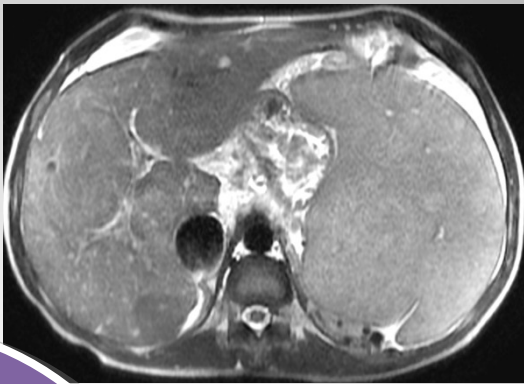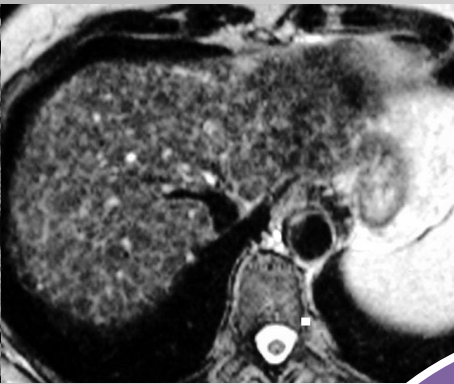# Tumor screening
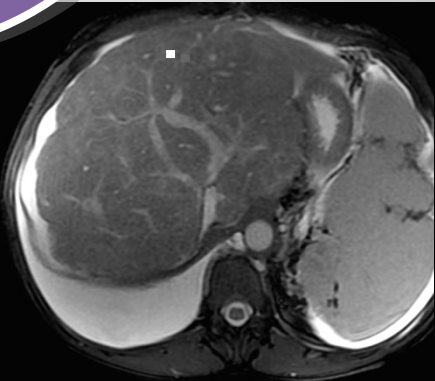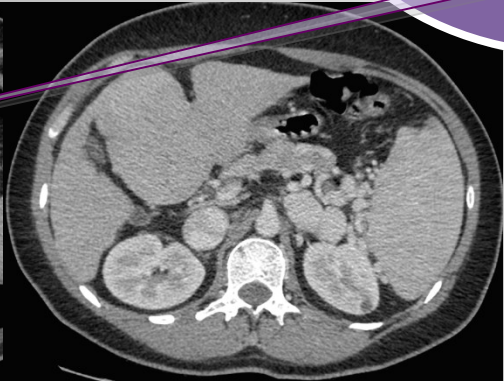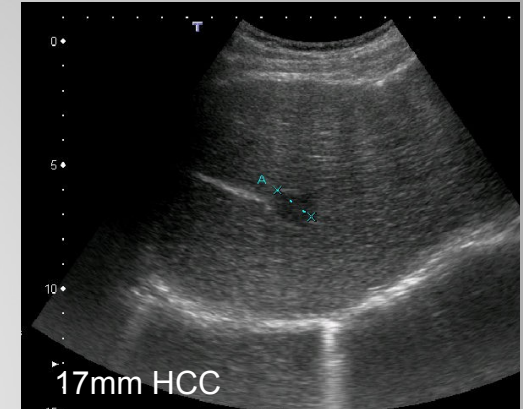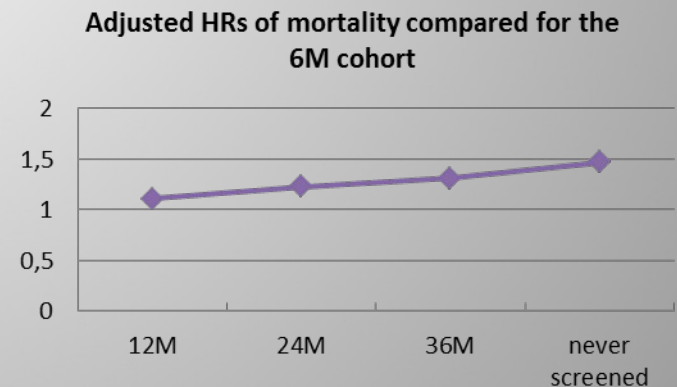
- ## What are the clinical needs?
  - Impact on patient management
  - Impact on patient survival

- ## Which patients
  - High risk patients: chronic liver disease (HCC)

- ## Which imaging technique?
  - Widely performed
  - Non invasive US

17mm HCC

Adjusted HRs of mortality compared for the 6M cohort

Liver tumor staging

- What are the clinical needs?

  - Impact on patient management

  - Impact on patient survival

- Which patients

  - Oncologic patients

  - Surgical resection (colorectal liver metastases)

Maarten Christian Niekel, MSc
Shandra Bipat, PhD
Jaap Stoker, MD, PhD

2010

Diagnostic Imaging of Colorectal Liver Metastases with CT, MR Imaging, FDG PET, and/or FDG PET/CT: A Meta-Analysis of Prospective Studies Including Patients Who Have Not Previously Undergone Treatment[1]

Radiology

Conclusion: MR imaging is the preferred first-line modality for evaluating colorectal liver metastases in patients who have not previously undergone therapy. FDG PET can be used as the second-line modality. The role of FDG PET/CT is not yet clear owing to the small number of studies.

Liver tumor staging
liver metastases

Conventional **DW-MR** **HB contrast agents**

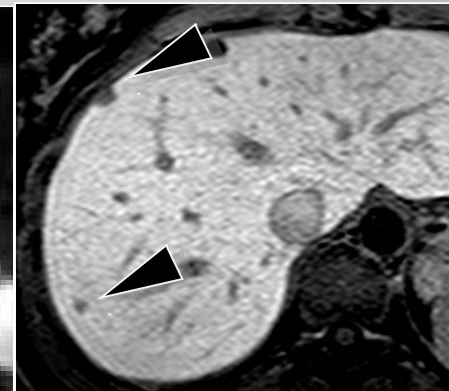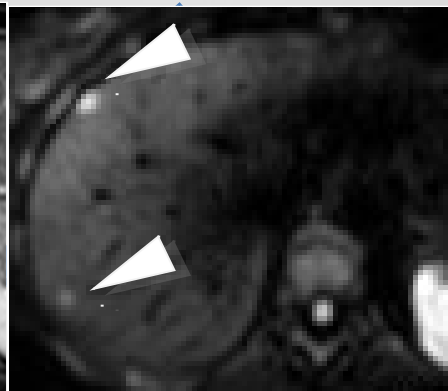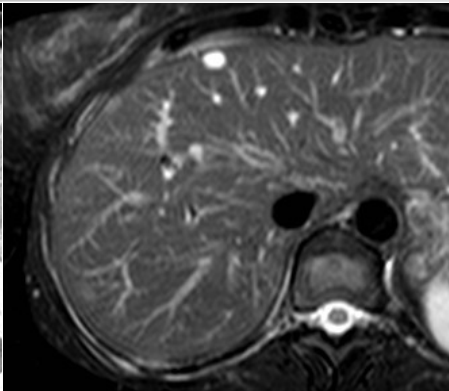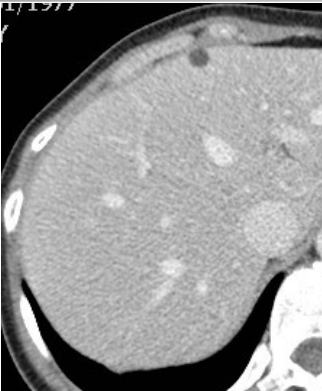T1, T2
Lesion enhancement

Restricted
diffusion

Hypointensity on
HB phase

Liver tumor staging
liver metastases

- ## Meta-analysis on liver mets

  - ## 39 articles (1989 patients, 3854 liver metastases)

MR	Sensitivity (%)
diffusion	87.1%
HB phase using Gadoxetic acid	90.6%
both	95.5%

Higher sensitivity with combined DW and HB phase
Only colorectal liver mets
Liver mets < 1 cm
Neoadjuvant chemotherapy
Histopathology alone as reference method

Translation in clinical practice ?

Vilgrain, Europ Radiol 2016

Liver tumor staging
liver metastases

VALUE study: 360 patients with suspected colorectal cancer liver metastases who had either

gadoxetic acid enhanced MRI

MRI with extracellular contrast medium

or contrast-enhanced CT

as a first-line imaging method in patients

	Gadoxetic A MR	Regular MR	CT
Further imaging	0%	17%	39.3%
Diagnostic confidence	98.3%	85.7%	65.2%
Surgical changes	28%	32%	47%

Zech, Br J Surgery 2014

Tumor characterization

- What are the clinical needs?
    - Impact on patient management in all patients

| **Incidental lesions** | **Oncologic pts** | **Chronic liver diseases** |

Mostly benign f/U?

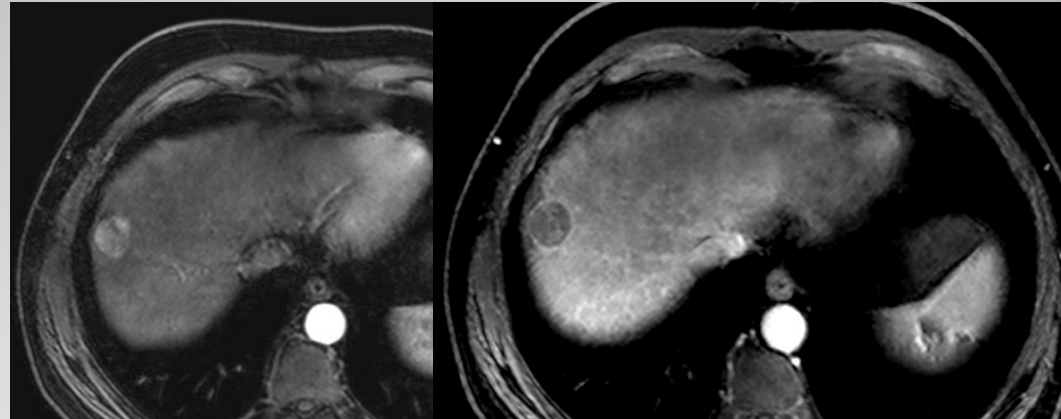*Rarely malignant*

Mostly liver mets
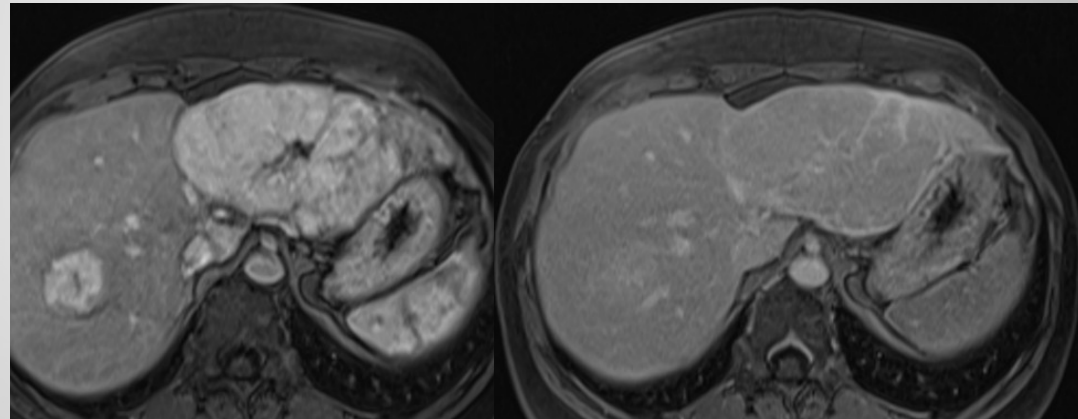
some benign 50% <2cm

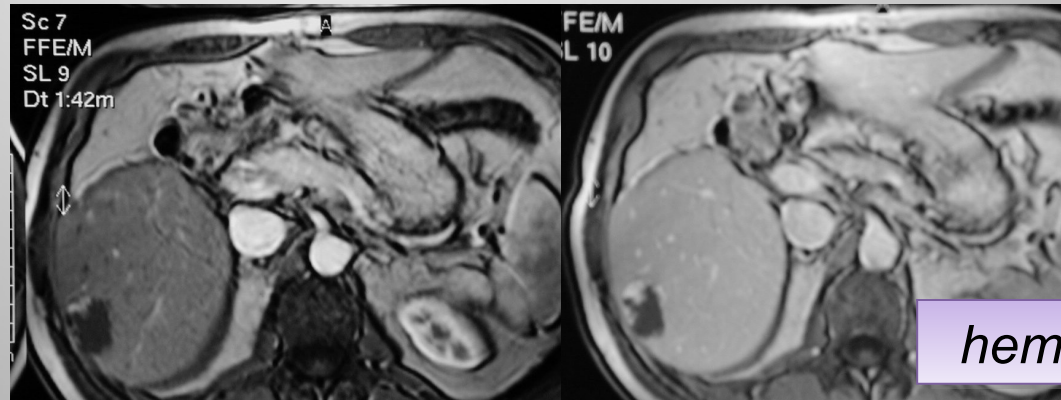*HCC*

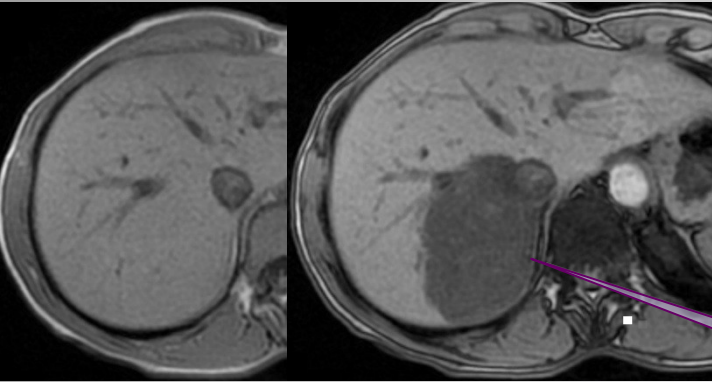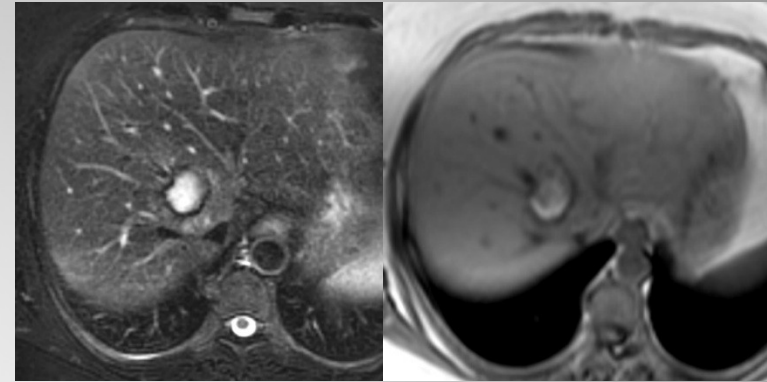*Benign nodules*

Hemangioma
FNH
Adenoma

Tumor characterization
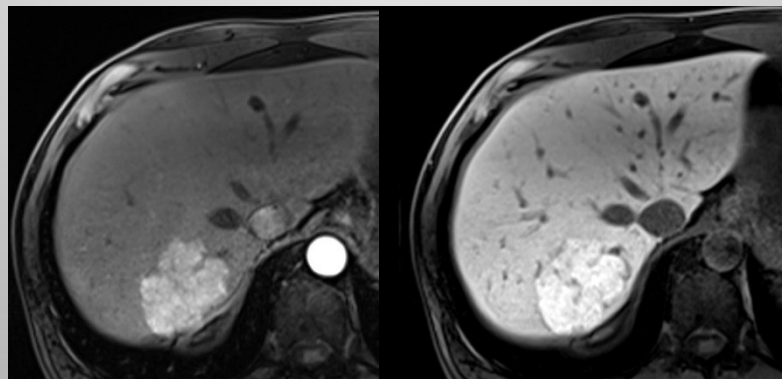
Lesion enhancement

CT
MRI
CEUS
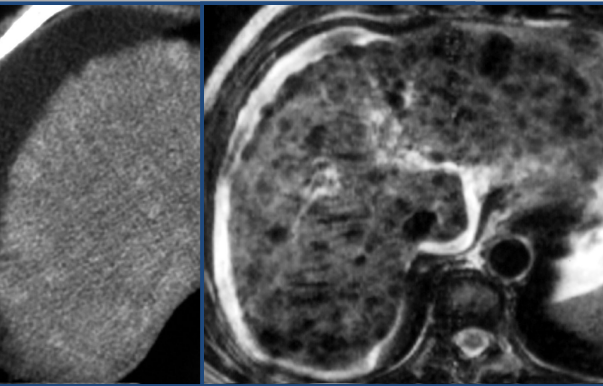
HCC

FNH

hemangioma

Tumor characterization

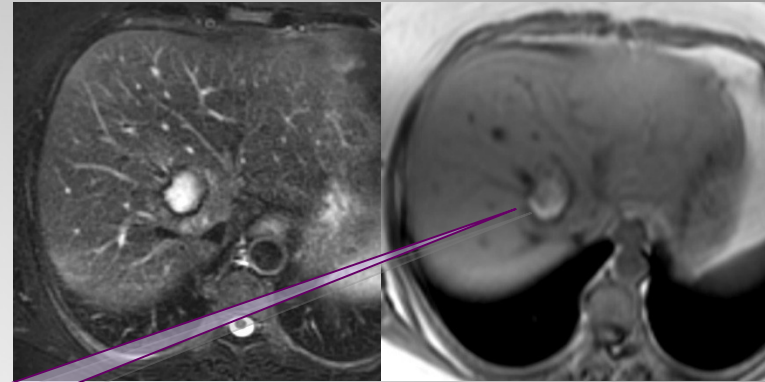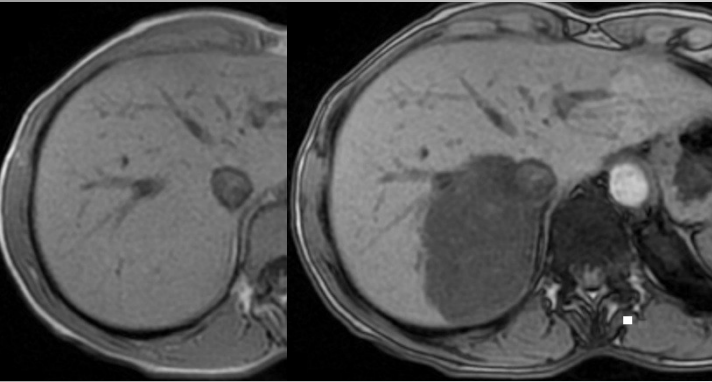

Fat
Hemorrhage
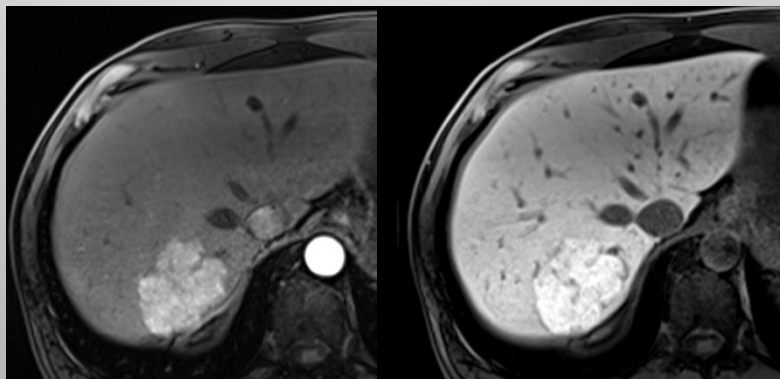Iron
Highly cellular
Hepatocellular

Tumor characterization

Fat
Hemorrhage
Iron
Highly cellular
Hepatocellular

Tumor characterization

Fat
Hemorrhage
Iron
Highly cellular
Hepatocellular

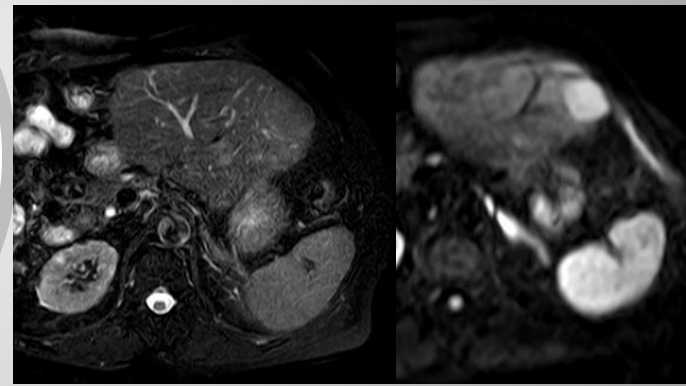# Tumor characterization

Fat
Hemorrhage
Iron
Highly cellular
Hepatocellular
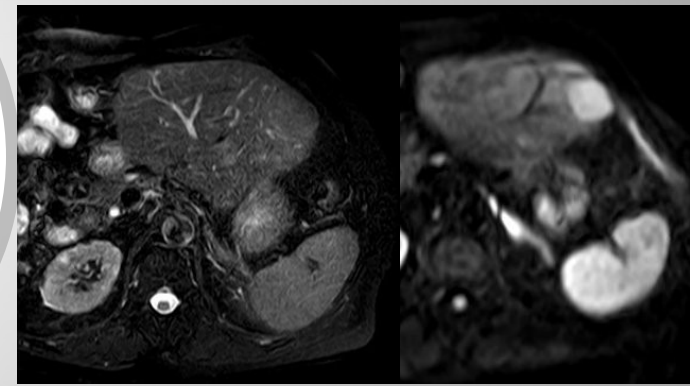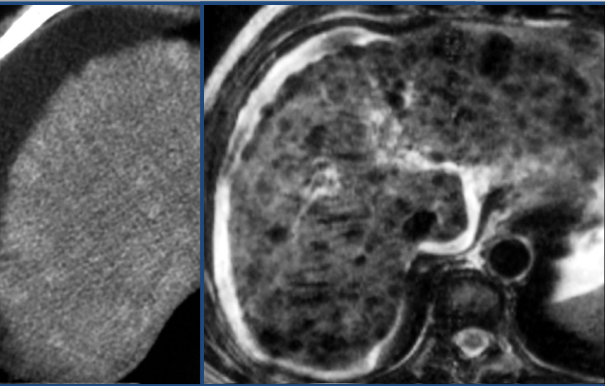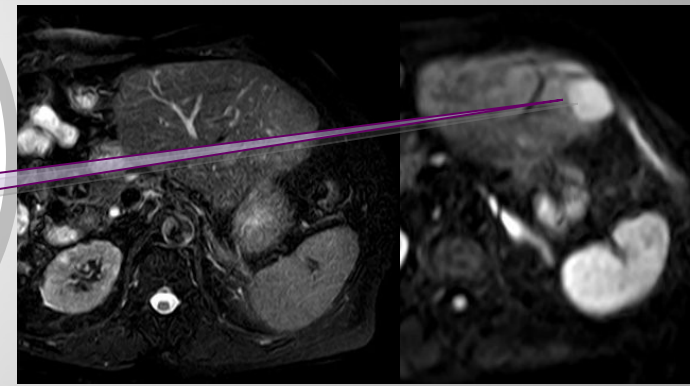
Tumor characterization
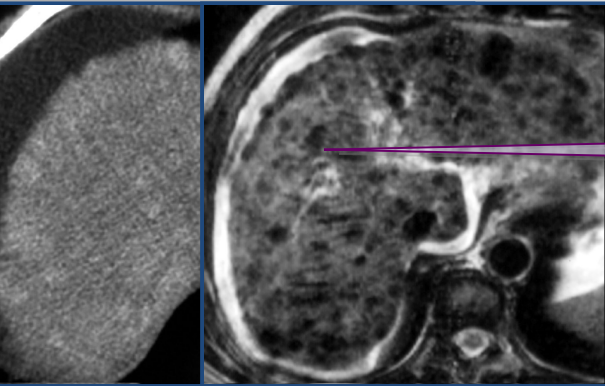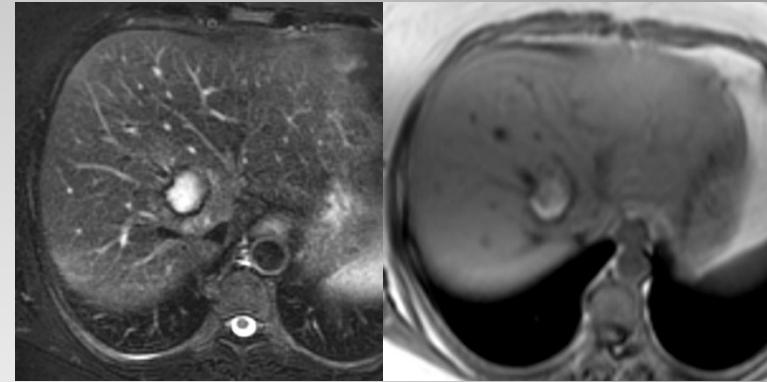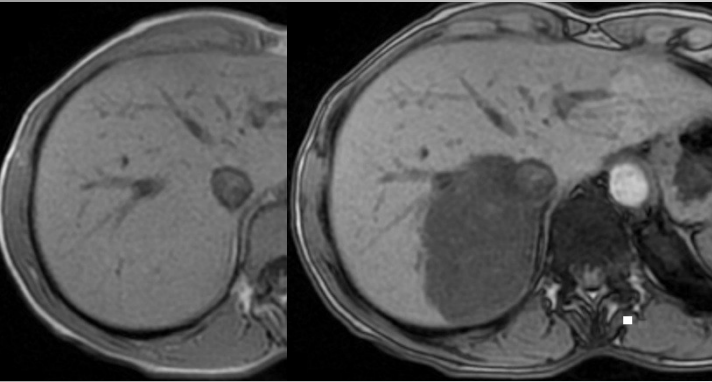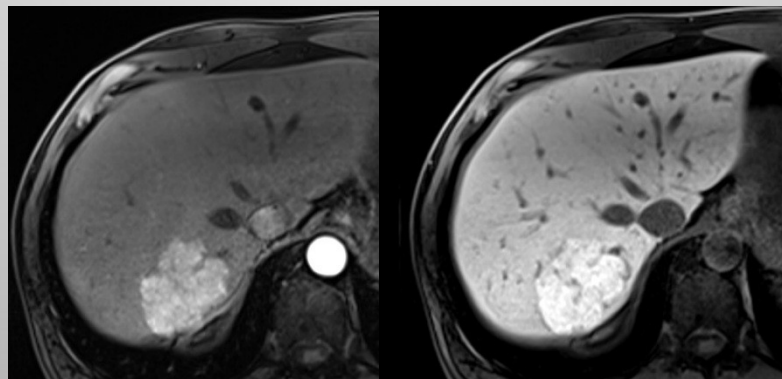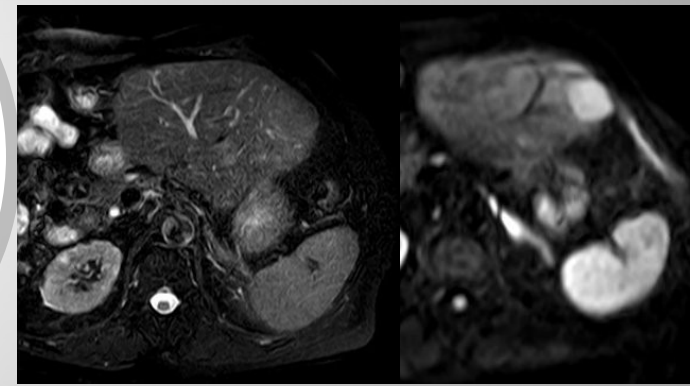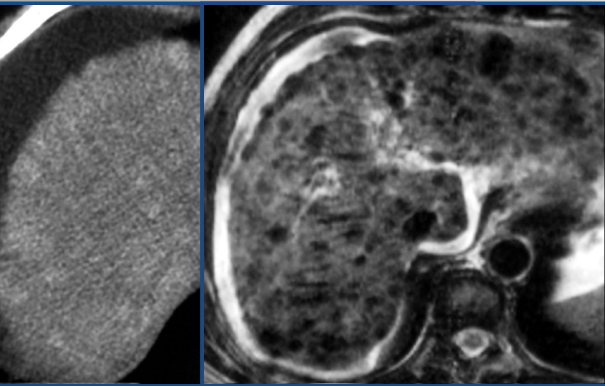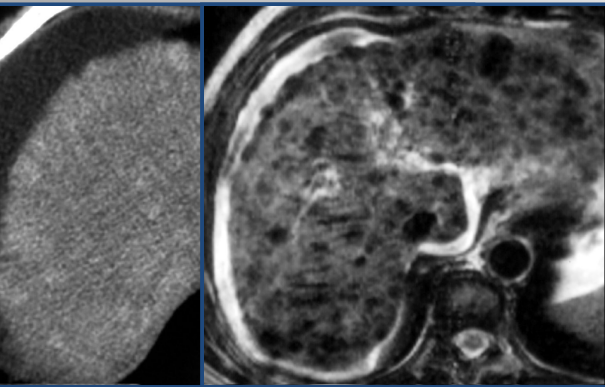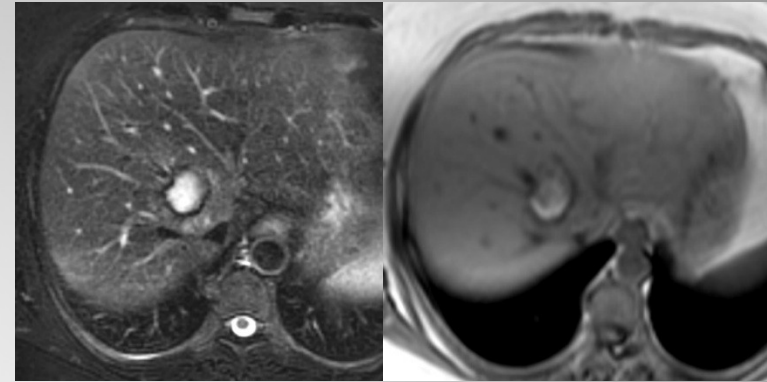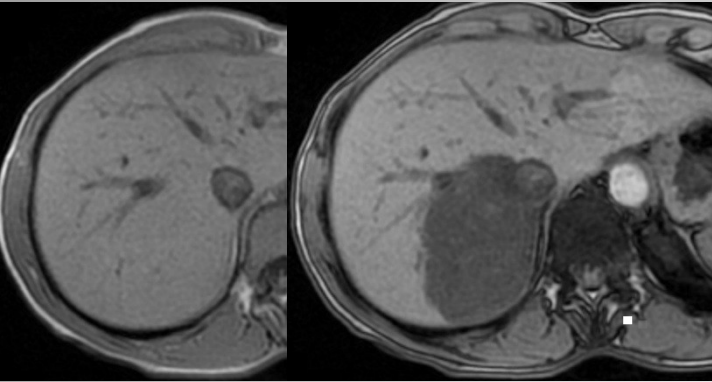

Fat
Hemorrhage
Iron
Highly cellular
Hepatocellular
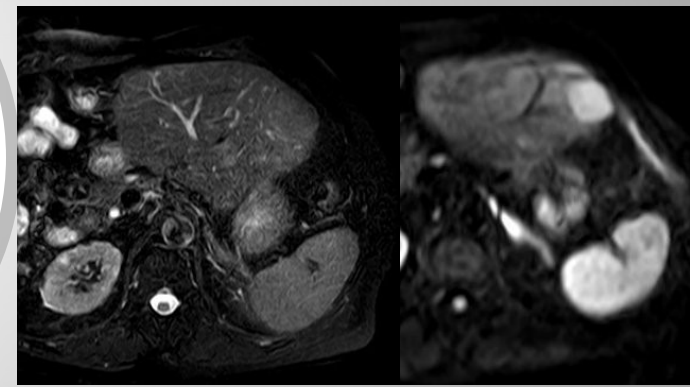
MRI
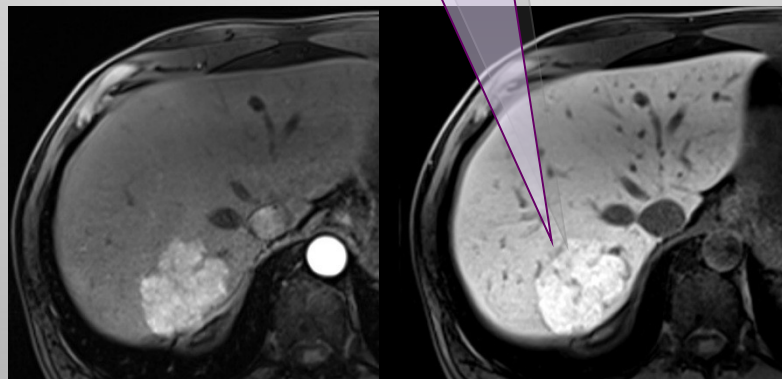
Tumor response
RECIST criteria

Complete response
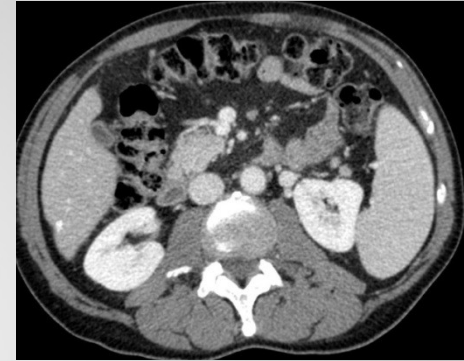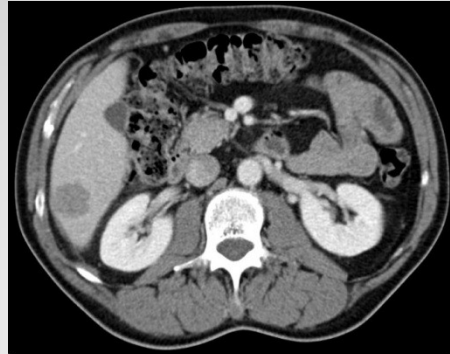
Partial response
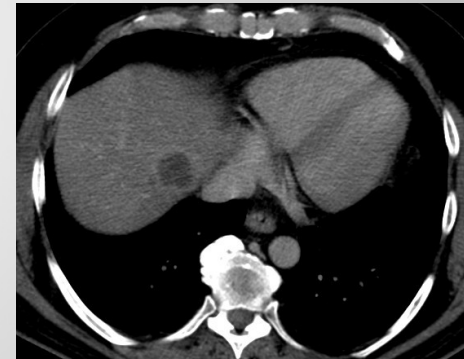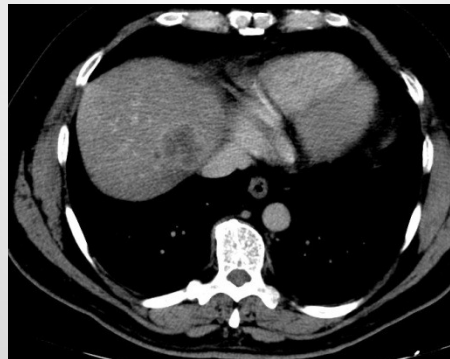
Progression

Can we push the morphological imaging forward?

- Probably marginally

- The revolution is elsewhere

Quantitative imaging
Multiparametric imaging
Multimodal approach
3D assessment
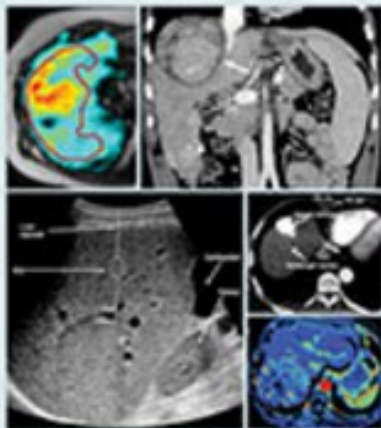
Radiology Select

■ hepatocellular tumors

■ DW-MR

■ Quantitative imaging

■ hepatobiliary MR agents

■ interventional

quantitative imaging

Quantitative imaging
the big four

- Liver volume

- Fat quantification

- Iron quantification

- Liver stiffness

Murray Djokovic   Nadal   Federer

Widely used

Highly reproducible

Validated

Clinical impact

Quantitative imaging
liver volume
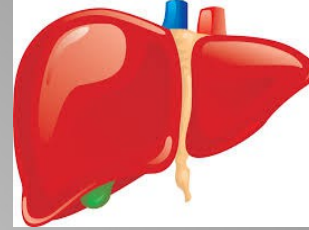
- **Entire liver**
  - Prognostic factor in fulminant hepatic failure

- **Future remnant liver**
  - critical predictor of perioperative outcomes major liver resection
  - Indicates portal vein embolization

pre-PVE   664 CC³

1 mo Post-PVE   1007 CC³

After Rt. hepatectomy   1539 CC³
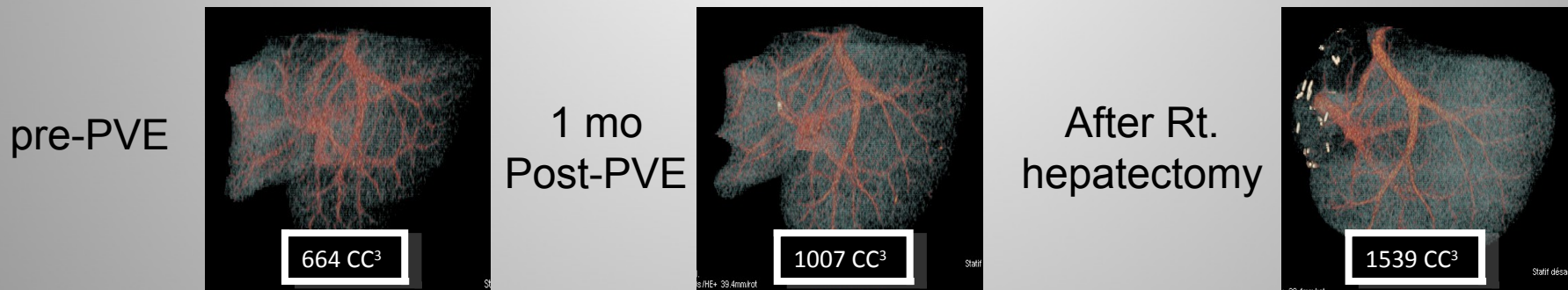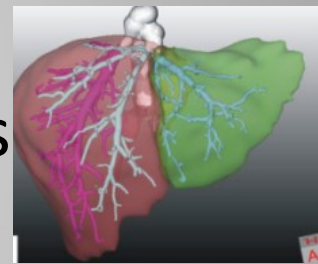
- **Tumor volume**

Quantitative imaging
fat
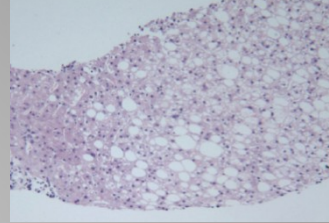
- NAFLD is the most frequent cause for referral for chronic liver disease and an increasing cause of HCC

- In patients undergoing liver resection, NAFLD increases the risk of postop complications and death

- In liver transplantation, presence of steatosis in the graft increases the risk of graft failure

Berzigotti, J Hepatol 2014

Quantitative imaging
fat with MRI
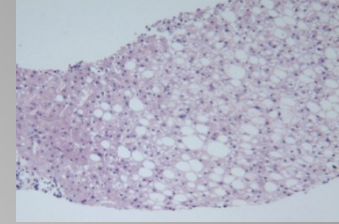
- MR spectroscopy
  - direct measure of the chemical composition of tissue

- chemical-shift techniques (T1 GE)
  - *in-phase/out-of-phase* (Dixon in 1984)
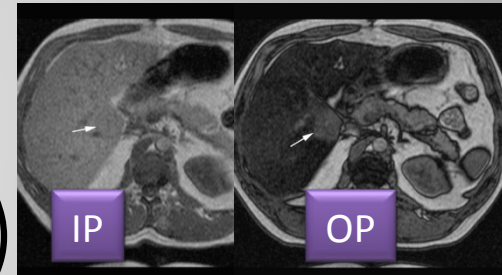
  - *Current Dixon-type sequences*: Decomposition of
    an   o
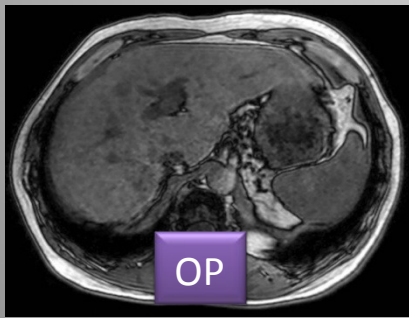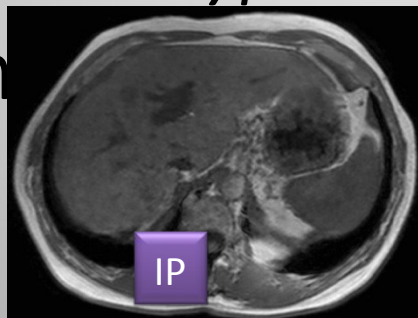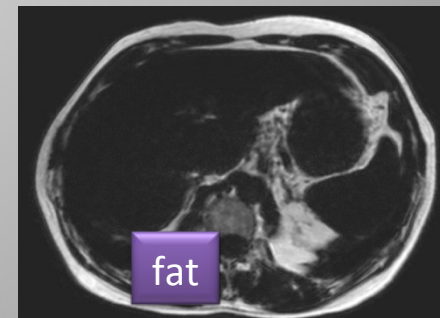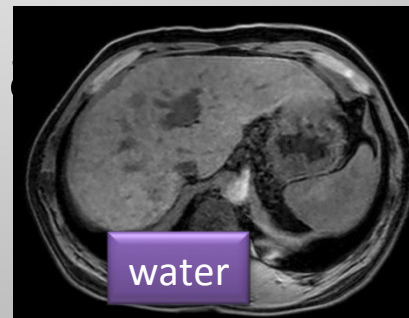
Fat-water separation sequences for quantification

Steatosis
Mild iron overload

PDFF 29%

T2*: 12 ms
25μmol/g

$$PDFF = \frac{\rho_f}{\rho_w + \rho_f}$$

No steatosis
Mild iron overload

PDFF 7%

T2*: 5 ms
52μmol/g

Zone : 13,38 cm²

Zone : 19,54 cm²
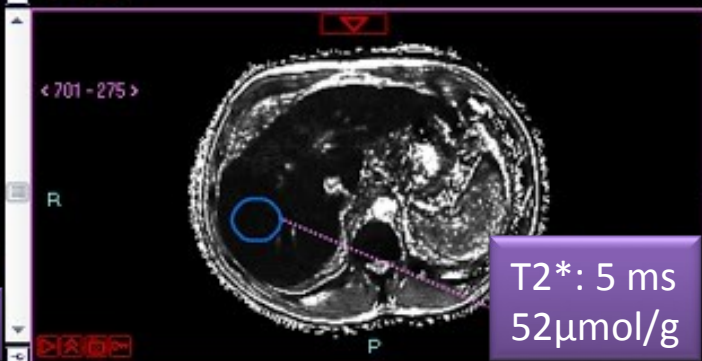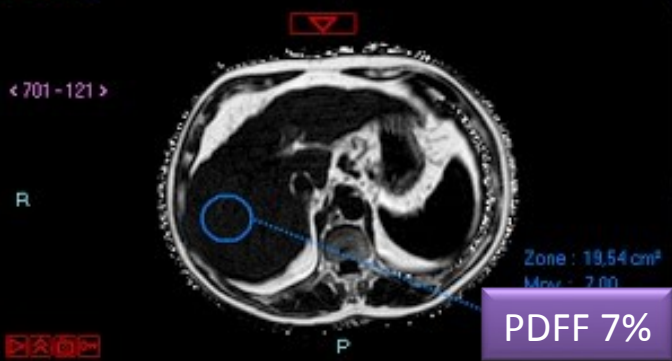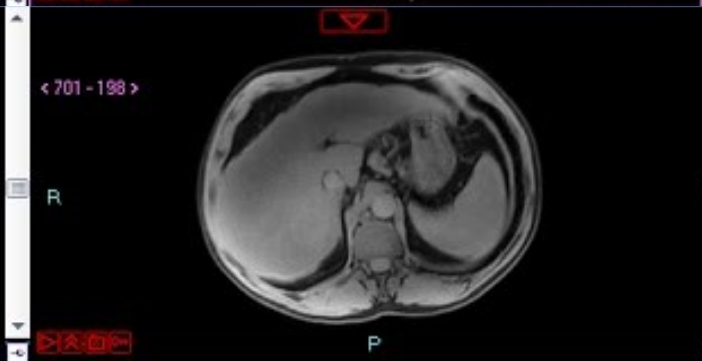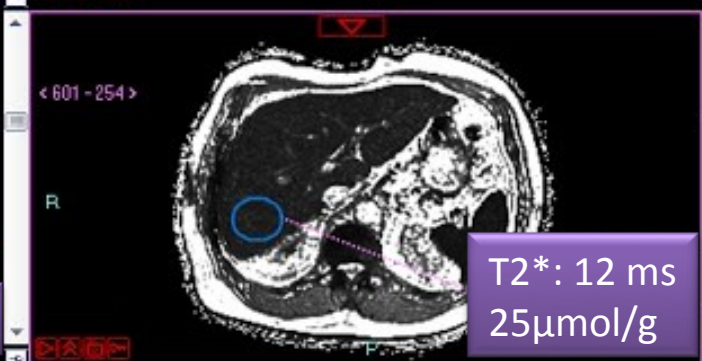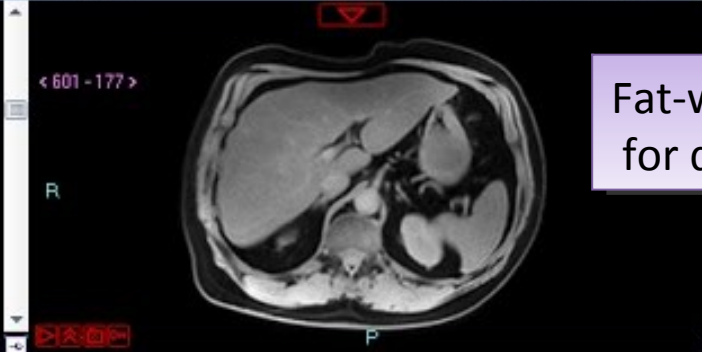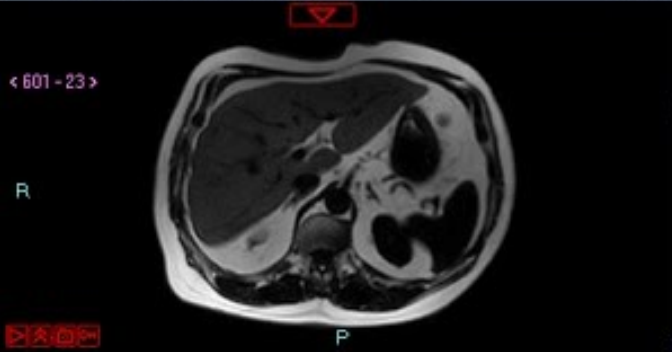
Quantitative imaging
liver stiffness

Increased stiffness correlates with the amount of fibrosis

- Treatment planning in chronic viral hepatitis depends on the degree of fibrosis

- In patients undergoing liver resection, marked fibrosis and cirrhosis increase the risk of postop complications and death

- Liver and spleen stiffness are correlated to the degree of portal hypertension

Quantitative imaging
liver stiffness

- Ultrasound

  - Transient Elastography (TE)

  - Integrated onto conventional US

    - Acoustic Radiation Force Impulse (ARFI)

    - ShearWave™ Elastogra
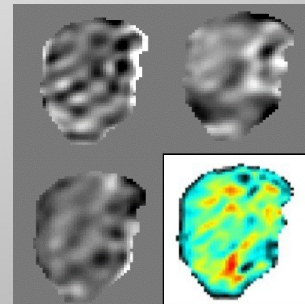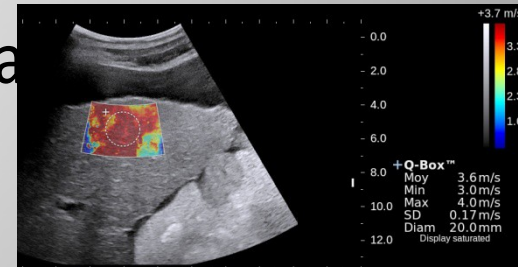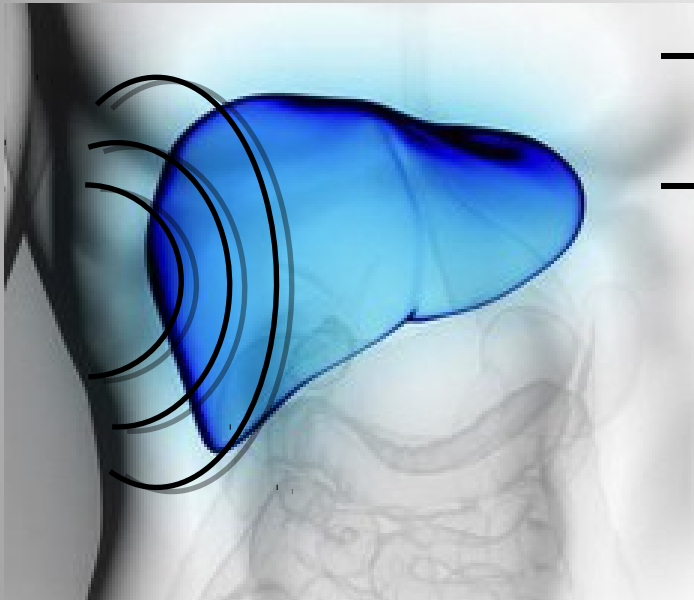
- MR imaging

	Fibroscan	Ultrasound	MRI
availability	+++	+++	+
dimension	1D	2D	3D
performance	++	+++	+++
Other data	steatosis	All US	All MRI
limitations	Ascites, obesity	few	few

2014

OPEN ACCESS Freely available online

PLOS ONE

Liver Stiffness by Transient Elastography Predicts Liver-Related Complications and Mortality in Patients with Chronic Liver Disease

Jack X. Q. Pang[1,2], Scott Zimmer[3], Sophia Niu[3], Pam Crotty[1], Jenna Tracey[1], Faruq Pradhan[1], Abdel Aziz M. Shaheen[1], Carla S. Coffin[1], Steven J. Heitman[1,2], Gilaad G. Kaplan[1,2], Mark G. Swain[1], Robert P. Myers[1,2*]

2015

HEPATOLOGY
Official Journal of the American Association for the Study of Liver Diseases

Increased Risk of Hepatocellular Carcinoma in Chronic Hepatitis B Patients With Transient Elastography–Defined Subclinical Cirrhosis

Mi Na Kim,[1] Seung Up Kim,[1,2] Beom Kyung Kim,[1,2] Jun Yong Park,[1,2] Do Young Kim,[1,2] Sang Hoon Ahn,[1,2,5] Ki Jun Song,[3] Young Nyun Park,[4] and Kwang-Hyub Han[1,2,5]
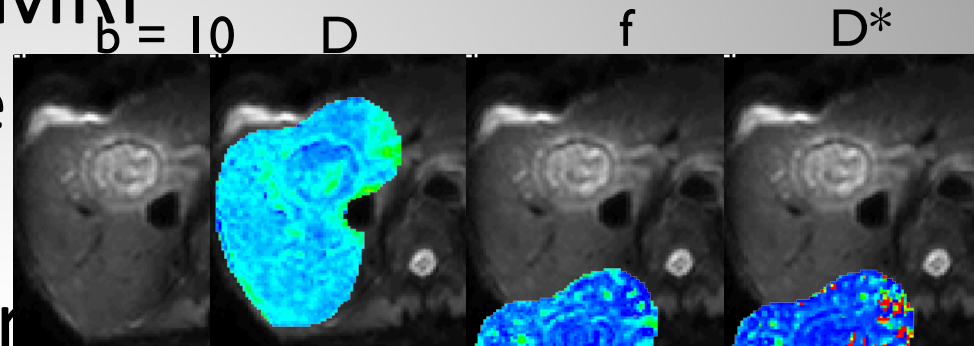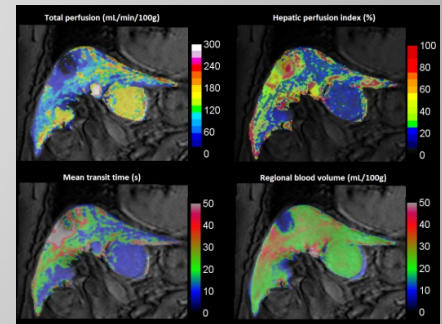
Quantitative imaging
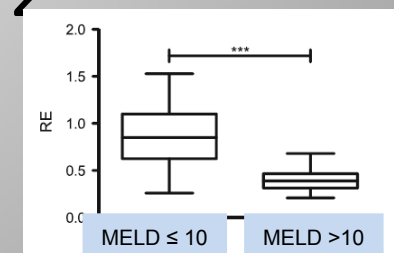## other

- Diffusion-weighted MRI
  - ADC, IVIM technique

- Perfusion parameters
  - Blood flow, blood volume...

- Fingerprinting
  - Simultaneous measure of T1 and T2

- Liver function: gadoxetic acid

Saito, JMRI 2012   Vellion, Europ Radiol 2014

Conclusion

- Liver imaging is everyday morphological and multimodal

- The role of imaging biomarkers is increasing but few are validated

- Tomorrow imaging will be quantitative and multiscale: Radiomics

- Artificial Intelligence in Imaging is the next revolution and will change the practice