Liver Imaging: Pearls for the Gastroenterologist

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SIMA
SUBSPECIALIZED IMAGING GROUP

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Nothing to disclose

Objectives

- Overview of LI-RADS
- Indications, strengths, weaknesses of US, CT, MRI in liver disease
- Review cases of liver pathology
- Be aware of state-of-the-art new imaging options for liver imaging

Outline

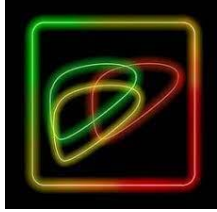
- LI-RADS
  - US
  - CT/MRI
- Cases
- Hepatobiliary contrast (Eovist)
- Advances in liver imaging

LI-RADS (liver reporting and data system)

LI-RADS

- 2006, UCSD
- Reports
  - “Indeterminate”, “equivocal”, “supicious”, “HCC should be considered”, “worrisome for HCC”, “may represent HCC”, “possibly representing HCC”, “HCC not excluded”, “can’t exclude cancer”, “unclear relevance”, “uncertain significance”, “clinical correlation recommended”
  - Ambiguous and not actionable reports
- V1.0 – 2011
- V2018 last
  - LI-RADS supported by AASLD
- >250 contributors, >30 institutions, >30 countries

LI-RADS



- System for standardized imaging for liver cancer
- Standardizes
  - Terminology
  - Technique
  - Interpretation
  - Reporting
  - Data collection
- Algorithms
    - US LI-RADS – surveillance of HCC
    - CEUS LI-RADS – diagnosis of HCC
    - CT/MRI LI-RADS –diagnosis and staging of HCC
    - CT/MRI tx response LI-RADS – assessing response of HCC to LRT
    - In development…
      - CEUS tx response
      - Sistemic tx response
- Improved communication, patient care, education and research
- Multidisciplinary consortium
- Dynamic

LI-RADS v2018 manual

LI-RADS: Four imaging algorithms

- Screening and surveillance algorithm
  - US
- Diagnosis
  - CT
  - MRI
  - CEUS
- Treatment response assessment
  - CT
  - MRI
  - CEUS

US for liver evaluation

Ultrasound for liver evaluation

Advantages

Not expensive

“Accessible”

No radiation

Limitations

Operator dependent

Limited reproducibility

Pts with large body habitus and uncooperative

Limited acoustic window

Reduced beam penetration

Parenchymal heterogeneity

Ultrasound for liver evaluation

US LI-RADS® v2017 CORE

Screening or surveillance US in patient at high risk for HCC

US category

US-1	Negative
US-2	Subthreshold
US-3	Positive

Category	Concept	Definition
US-1 Negative	No US evidence of HCC	No observation **OR** Only definitely benign observation(s)
US-2 Subthreshold	Observation(s) detected that may warrant short-term US surveillance	Observation(s) < 10 mm in diameter, not definitely benign
US-3 Positive	Observation(s) detected that may warrant multiphase contrast-enhanced imaging	Observation(s) ≥ 10 mm in diameter, not definitely benign **OR** New thrombus in vein

US visualization score

A	No or minimal limitations
B	Moderate limitations
C	Severe limitations

Score	Concept	Examples
A. No or minimal limitations	Limitations if any are unlikely to meaningfully affect sensitivity	Liver homogeneous or minimally heterogeneous Minimal beam attenuation or shadowing Liver visualized in near entirety
B. Moderate limitations	Limitations may obscure small masses	Liver moderately heterogeneous Moderate beam attenuation or shadowing Some portions of liver or diaphragm not visualized
C. Severe limitations	Limitations significantly lower sensitivity for focal liver lesions	Liver severely heterogeneous Severe beam attenuation or shadowing Majority (>50%) of liver not visualized Majority (>50%) of diaphragm not visualized

LI-RADS v2018 manual

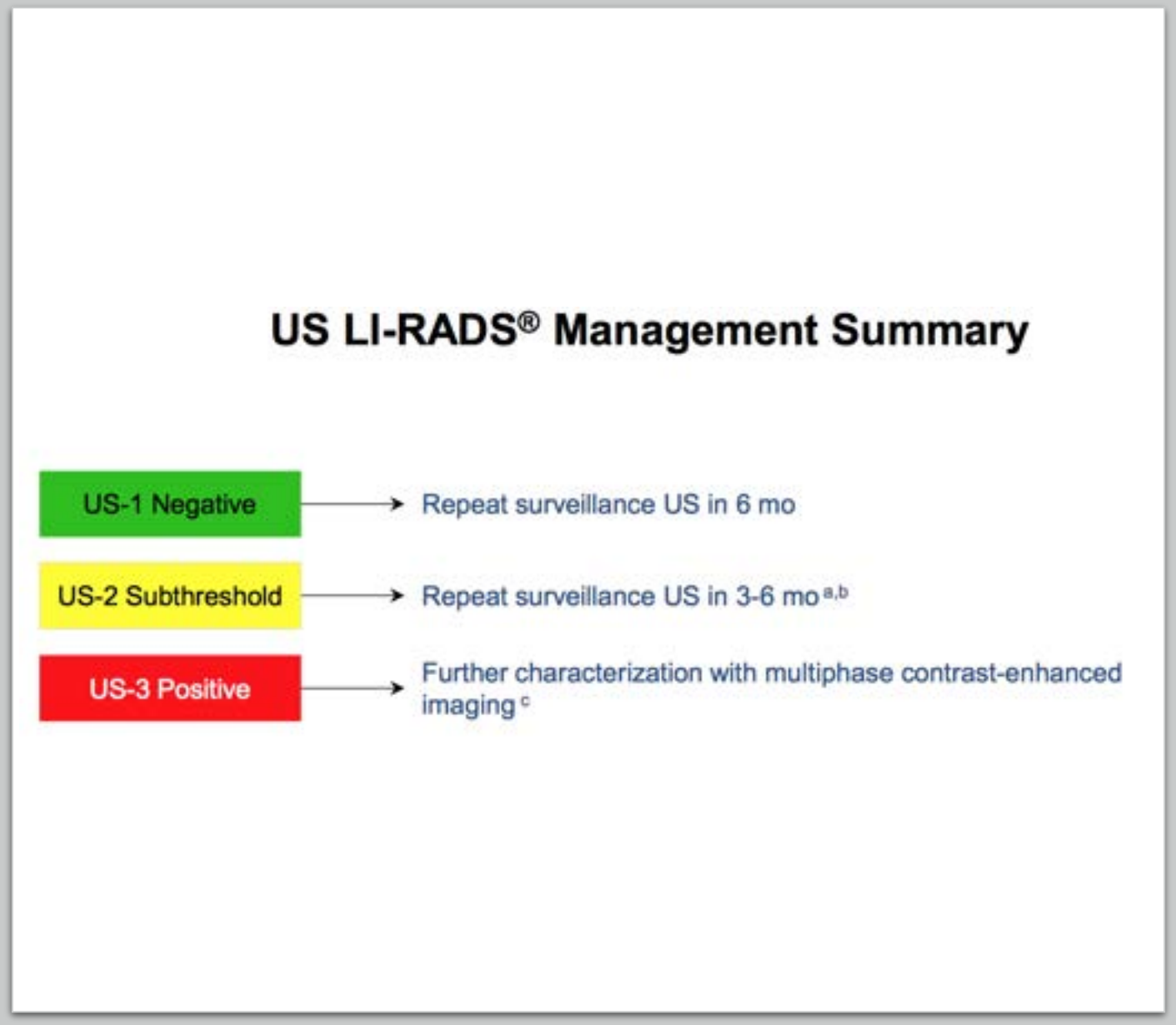
Ultrasound

US LI-RADS® Recommended US Views

Longitudinal images	
Recommended views	Left lobe: • left of midline • at midline; include proximal abdominal aorta, celiac artery, and SMA • with IVC; include caudate lobe, MPV, and pancreatic head • with left portal vein Right lobe: • with gallbladder • with right kidney • including right hemidiaphragm and adjacent pleural space • far lateral Main portal vein; include grayscale and color Doppler Common bile duct at porta hepatis; include diameter measurement
Optional views	Color Doppler of the right and left portal veins, and hepatic veins Spectral Doppler of main portal vein to assess waveform, velocity, and flow direction
Transverse images	
Recommended views	Dome with hepatic veins; include entire right and left lobe with medial and lateral liver edges (on separate images as needed) Left lobe: • with left portal vein • falciform ligament to evaluate for the presence of patent paraumbilical vein Main portal vein bifurcation Right lobe: • with right portal vein • with main portal vein • with gallbladder • with right kidney • near liver tip
Optional views	Color Doppler view of additional vascular structures
Cine loops	
Recommended views	—
Optional views	Longitudinal and transverse cine sweeps of left and right lobes, including as much hepatic parenchyma as possible

LI-RADS v2018 manual

Ultrasound



LI-RADS v2018 manual

CT and MRI for liver evaluation

CT/MRI for liver evaluation

CT

Temporal resolution

Fast study

Widely available

MRI

Contrast resolution

Artifacts

- Breathing
- Peristalsis
- Ascites

Long study

Expensive

- Insurances

CT/MR LI-RADS v2018 Technical Recommendations

CT

Recommended equipment	• Multidetector CT with ≥ 8 detector rows
Required images	• Arterial phase (late arterial phase strongly preferred) • Portal venous phase • Delayed phase
Suggested images	• Precontrast, if patient has had locoregional treatment • Multiplanar reformations

LI-RADS® v2018
CT/MRI Core

CT/MR LI-RADS v2018 Technical Recommendations

MRI with extracellular contrast agents or gadobenate dimeglumine

Recommended equipment	• 1.5T or 3T • Torso phased-array coil

Required images	• Unenhanced T1-weighted OP and IP imaging
	• T2-weighted imaging (fat suppression per institutional preference)
	• Multiphase T1-weighted imaging
	  • Precontrast imaging
	  • Arterial phase (late arterial phase strongly preferred)
	  • Portal venous phase
	  • Delayed phase

Suggested or optional images	• Diffusion-weighted imaging • Subtraction imaging • Multiplanar acquisition • 1- to 3-hr hepatobiliary phase with gadobenate dimeglumine (same sequence type as for multiphase, may use higher flip angle to increase T1 contrast)

CT/MR LI-RADS v2018 Technical Recommendations

MRI with gadoxetate disodium

Recommended equipment	• 1.5T or 3T • Torso phased-array coil

Required images	• Unenhanced T1-weighted OP and IP imaging
	• T2-weighted imaging (fat suppression per institutional preference)
	• Multiphase T1-weighted imaging
	  • Precontrast imaging
	  • Arterial phase (late arterial phase strongly preferred)
	  • Portal venous phase
	  • Transitional phase (2 to 5 minutes after injection)
	  • Hepatobiliary phase (same sequence type as for earlier phases, may use higher flip angle to increase T1 contrast)

Suggested or optional images	• Diffusion-weighted imaging • Subtraction imaging • Multiplanar acquisitions

CT/MRI
LI-RADS

CT/MRI LI-RADS® v2018

✓

Apply in patients at high risk for HCC, namely those with:

- Cirrhosis **OR**
- Chronic hepatitis B viral infection **OR**
- Current or prior HCC

Including adult liver transplant candidates and recipients posttransplant

✗

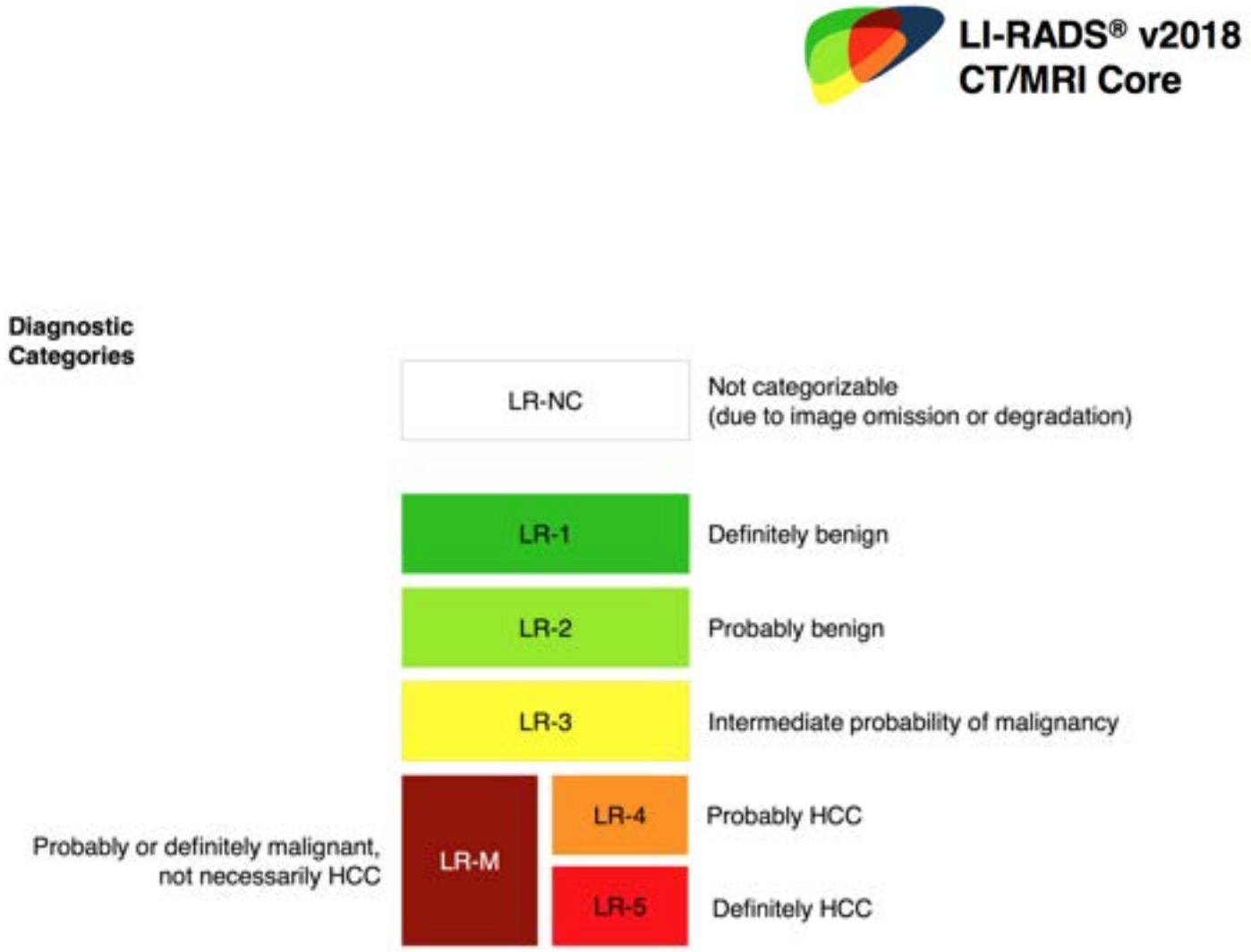
Do not apply in patients:

- Without the above risk factors
- < 18 years old
- With cirrhosis due to congenital hepatic fibrosis
- With cirrhosis due to a vascular disorder such as hereditary hemorrhagic telangiectasia, Budd-Chiari syndrome, chronic portal vein occlusion, cardiac congestion, or diffuse nodular regenerative hyperplasia

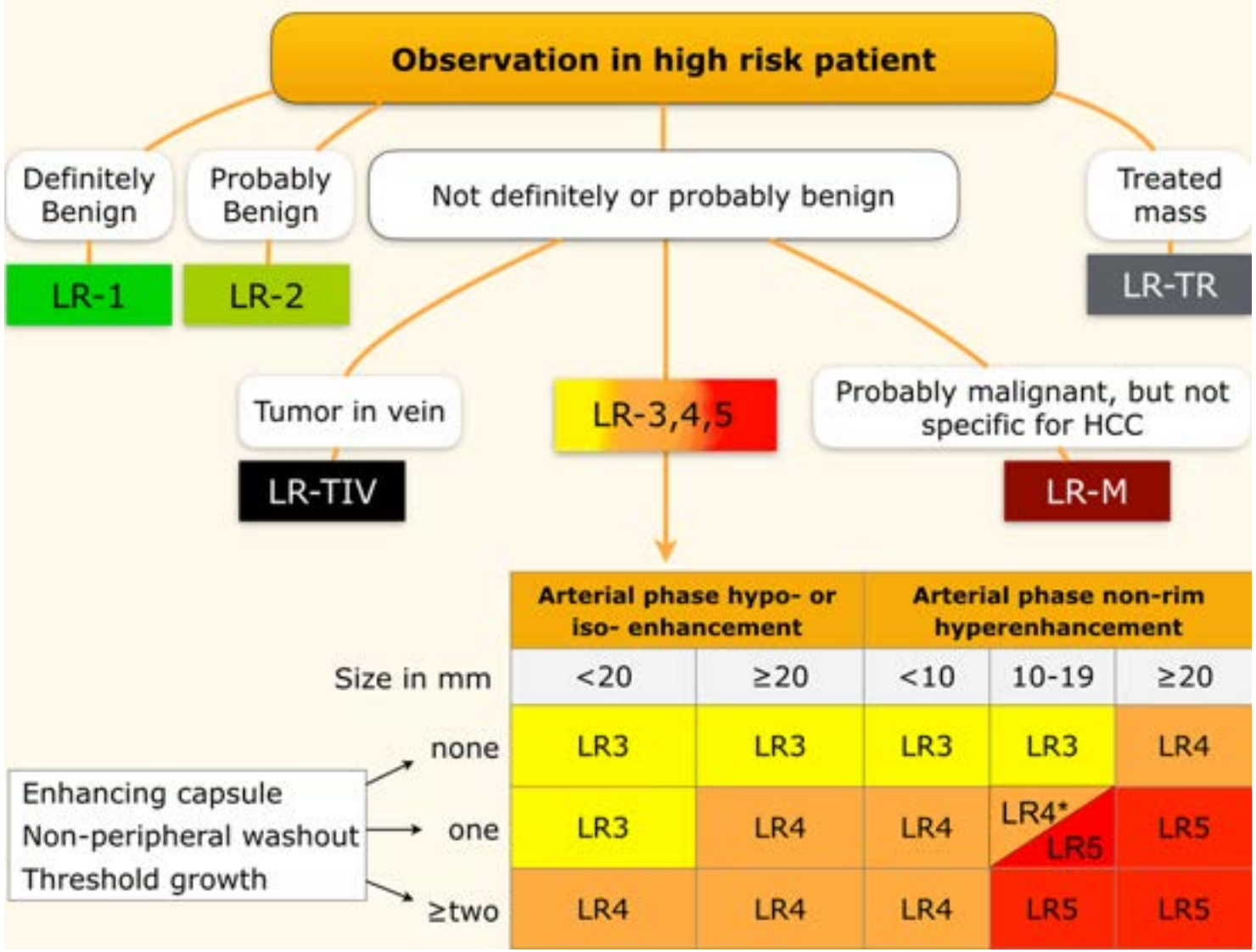
LI-RADS® v2018
CT/MRI Core

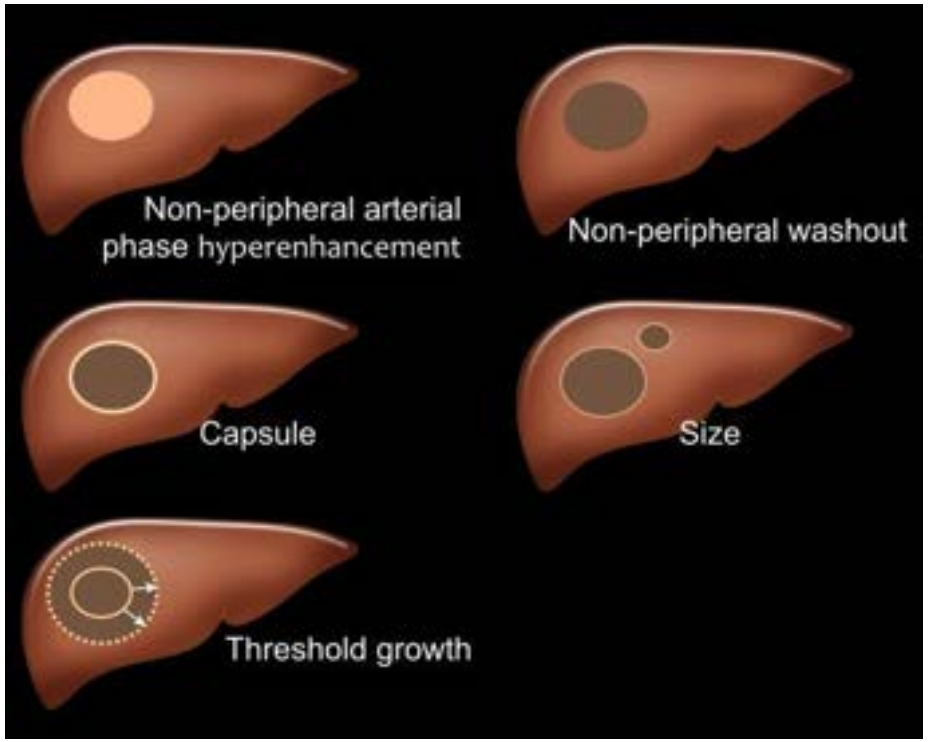
LI-RADS

- Observations: distinctive when compared to background liver
- 8 diagnostic categories



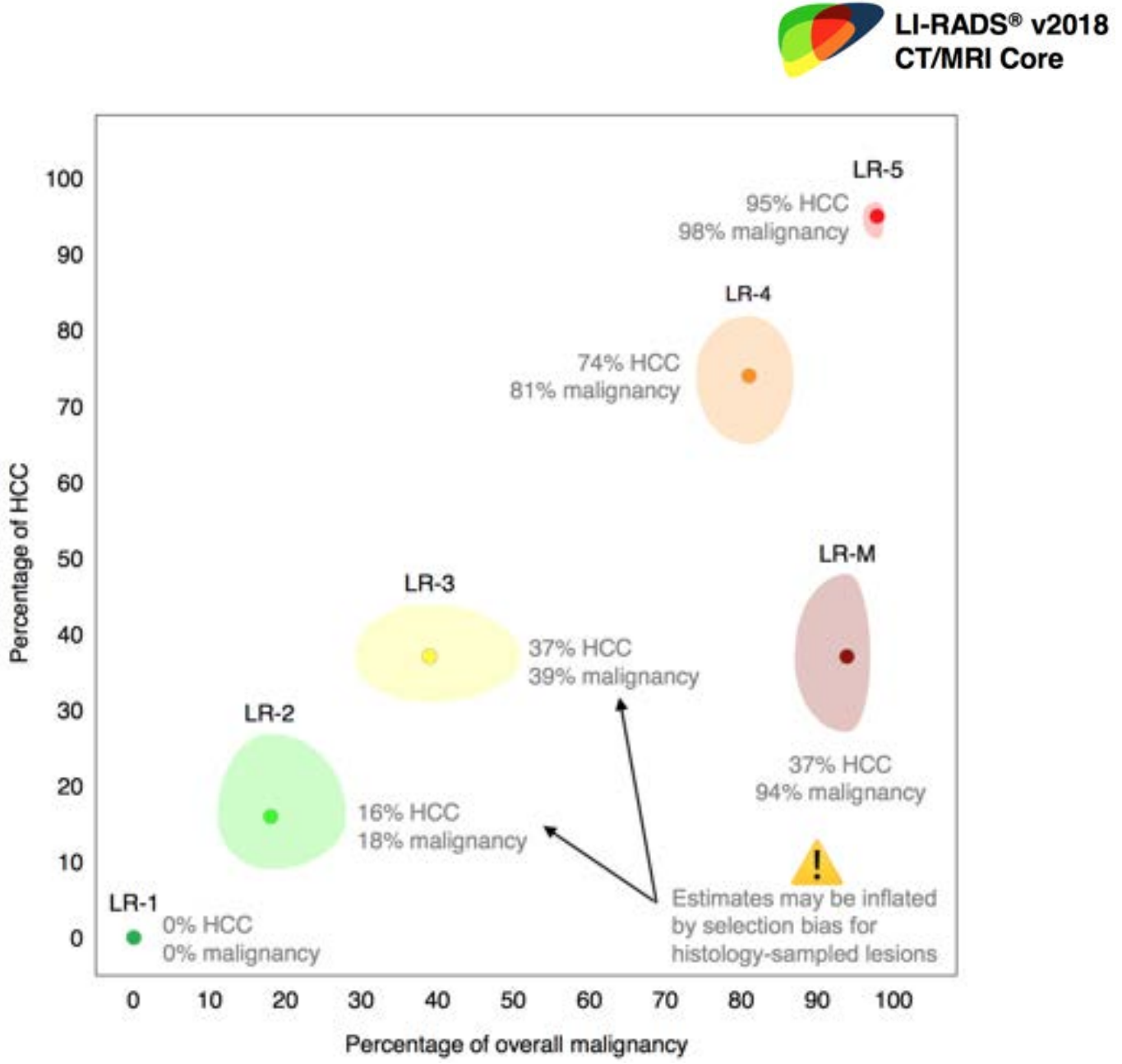
LI-RADS


Observation in high risk patient
Definitely Benign
Probably Benign
Not definitely or probably benign
Treated mass
LR-1
LR-2
LR-TR
Tumor in vein
LR-3,4,5
Probably malignant, but not specific for HCC
LR-TIV
LR-M
Arterial phase hypo- or iso- enhancement
Arterial phase non-rim hyperenhancement
Size in mm
<20
≥20
<10
10-19
≥20
Enhancing capsule
Non-peripheral washout
Threshold growth
none
one
≥two
LR3
LR3
LR3
LR3
LR4
LR3
LR4
LR4
LR4* LR5
LR5
LR4
LR4
LR4
LR5
LR5


Non-peripheral arterial phase hyperenhancement
Non-peripheral washout
Capsule
Size
Threshold growth

LI-RADS

- LR-3: 31% HCC
- LR-4: 64% HCC
- LR-5: 95% HCC
- LR-M: 99% malignant
  - 33% HCC
  - 65% other malignancy
  - 1% benign

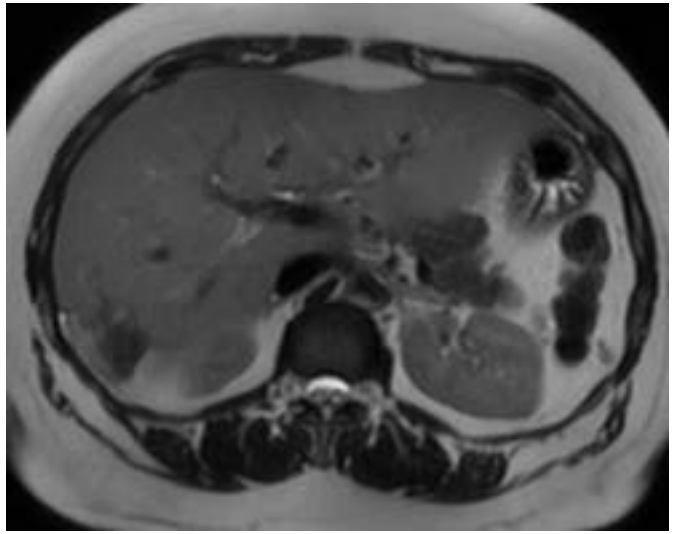
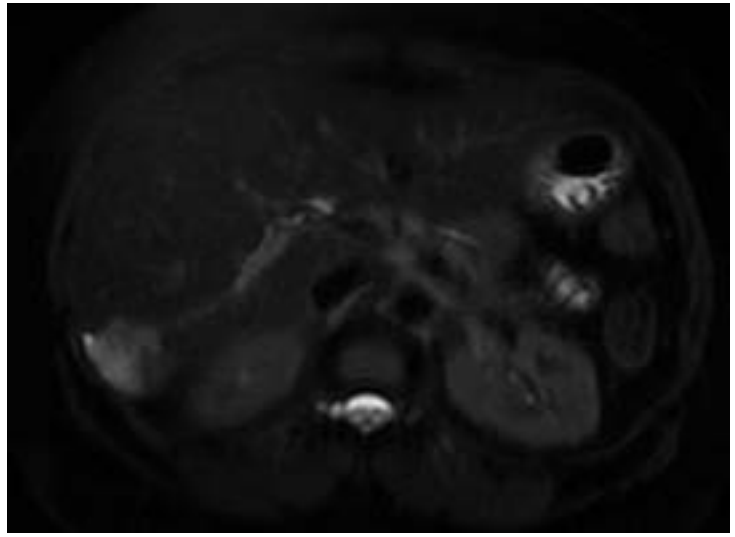
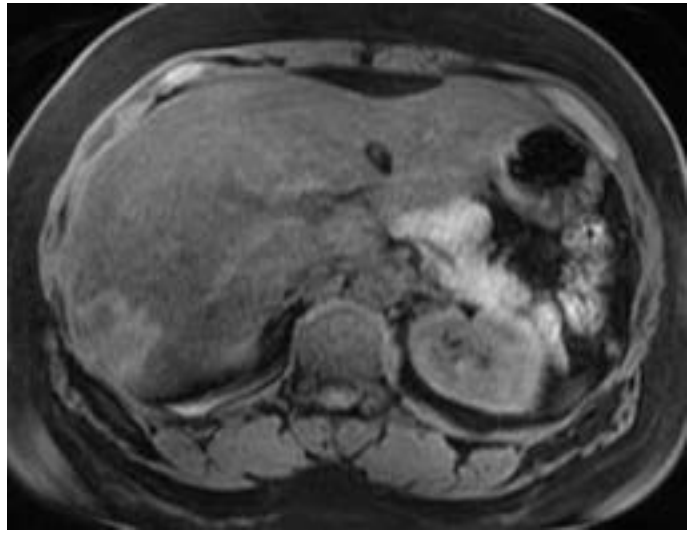
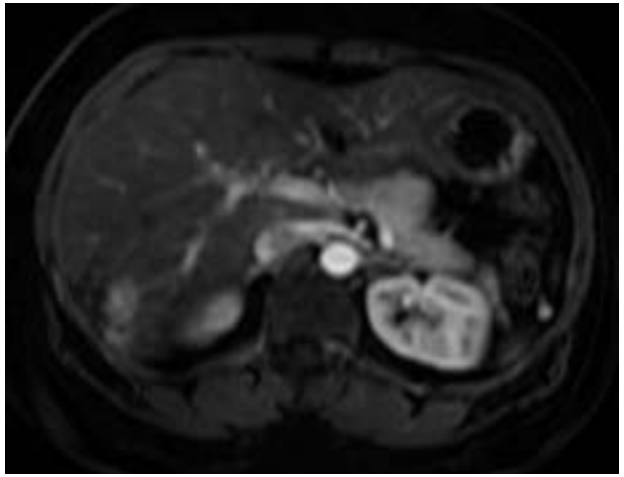
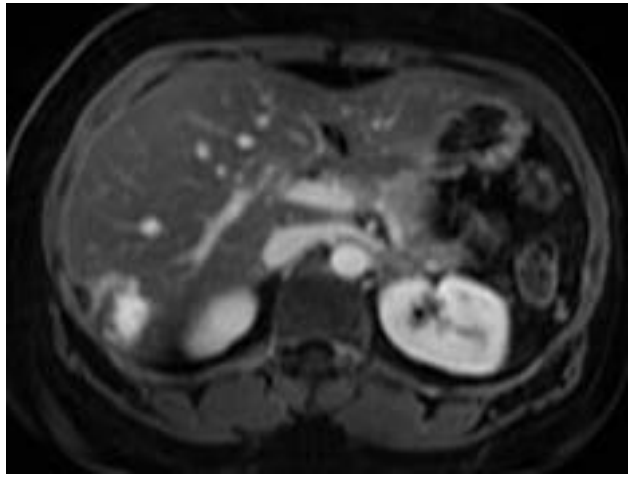
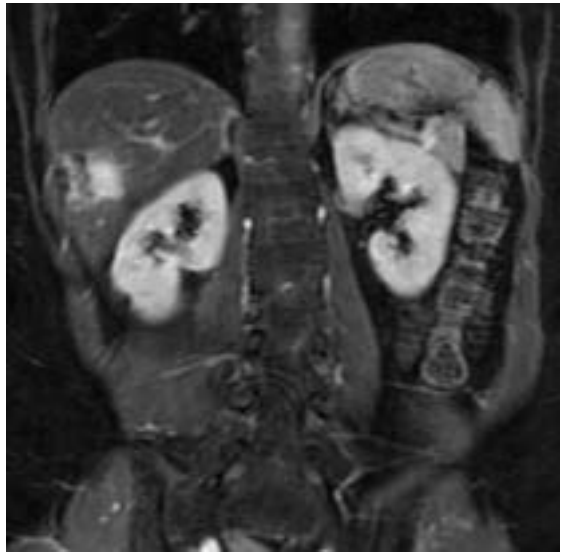
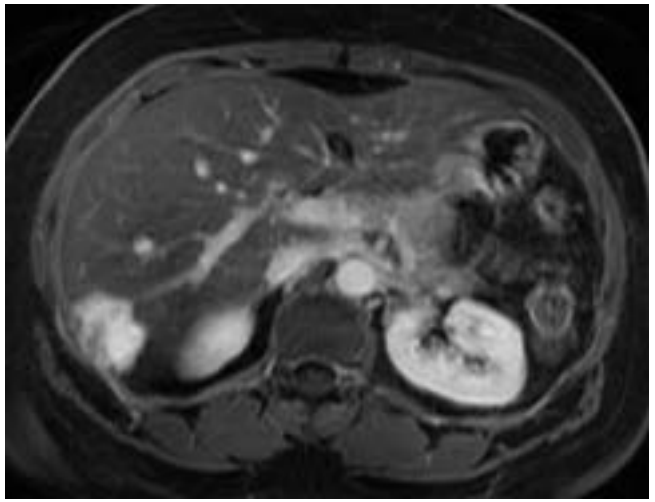


Cases

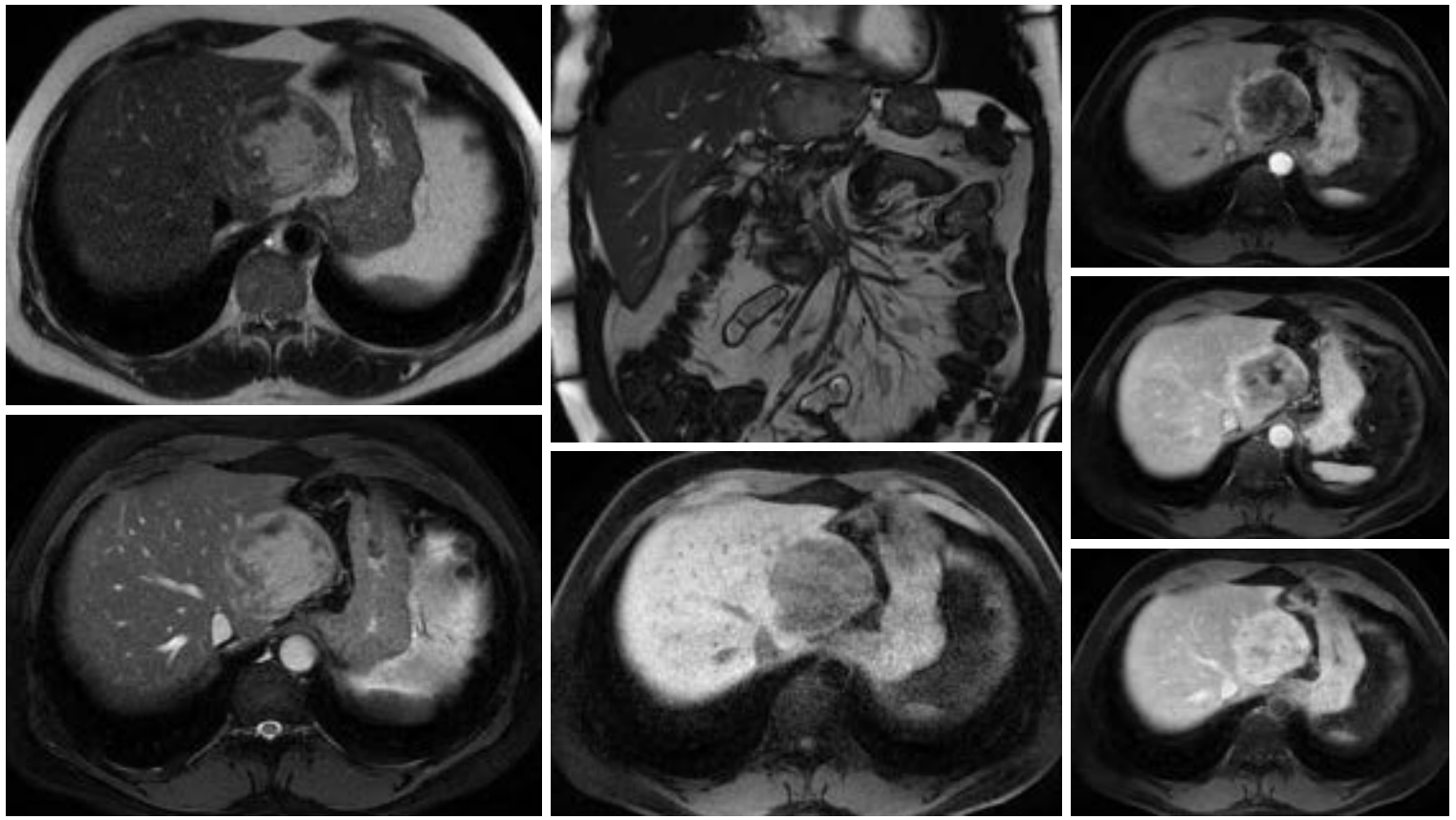
LR-1

- Cysts
- Hemangiomas
- Focal fat
- Arterioportal shunt
- Siderotic nodules
- Hypertrophic pseudomass

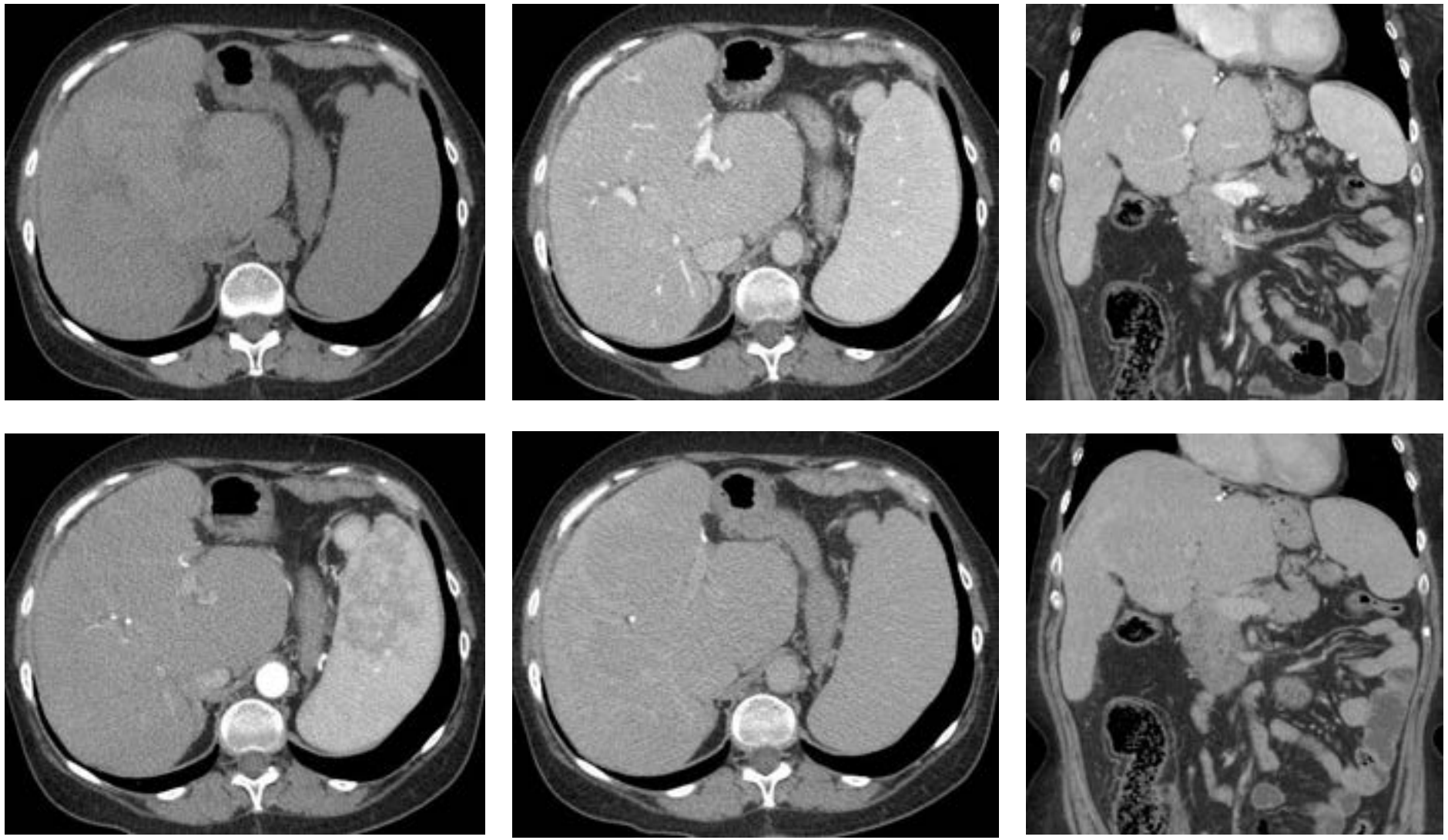
Hemangioma; LR-1

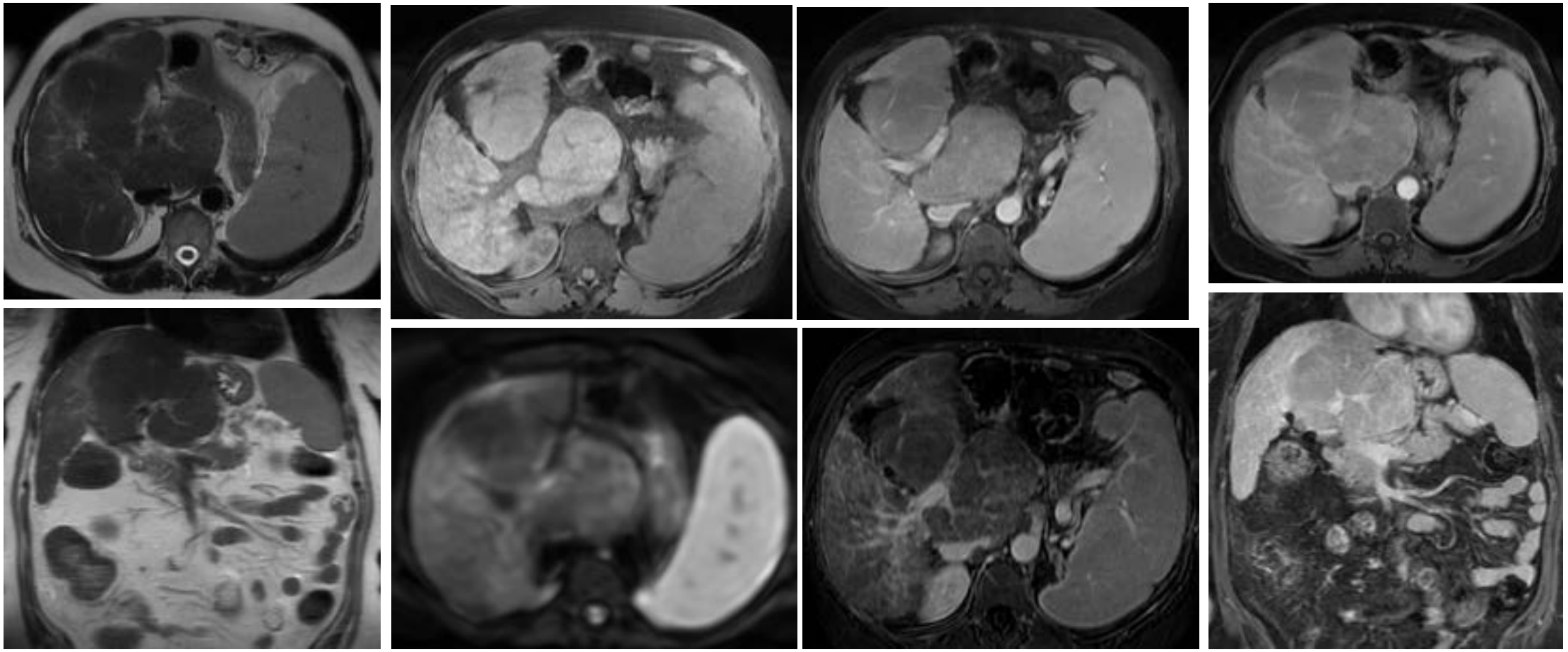
Hemangioma;
LR-1



LR-1: Hypertrophic pseudomass - CT



LR-1: Hypertrophic pseudomass - MRI



LR-2

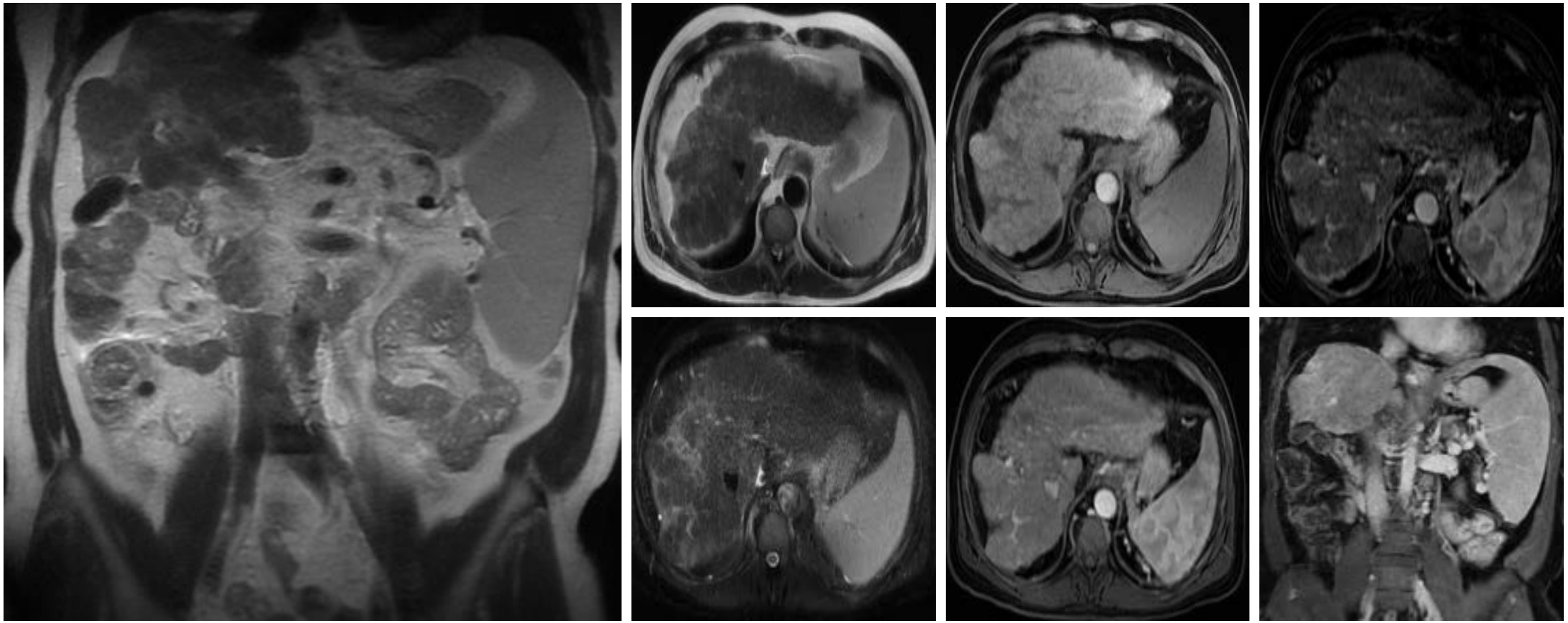
Discrete siderotic nodule

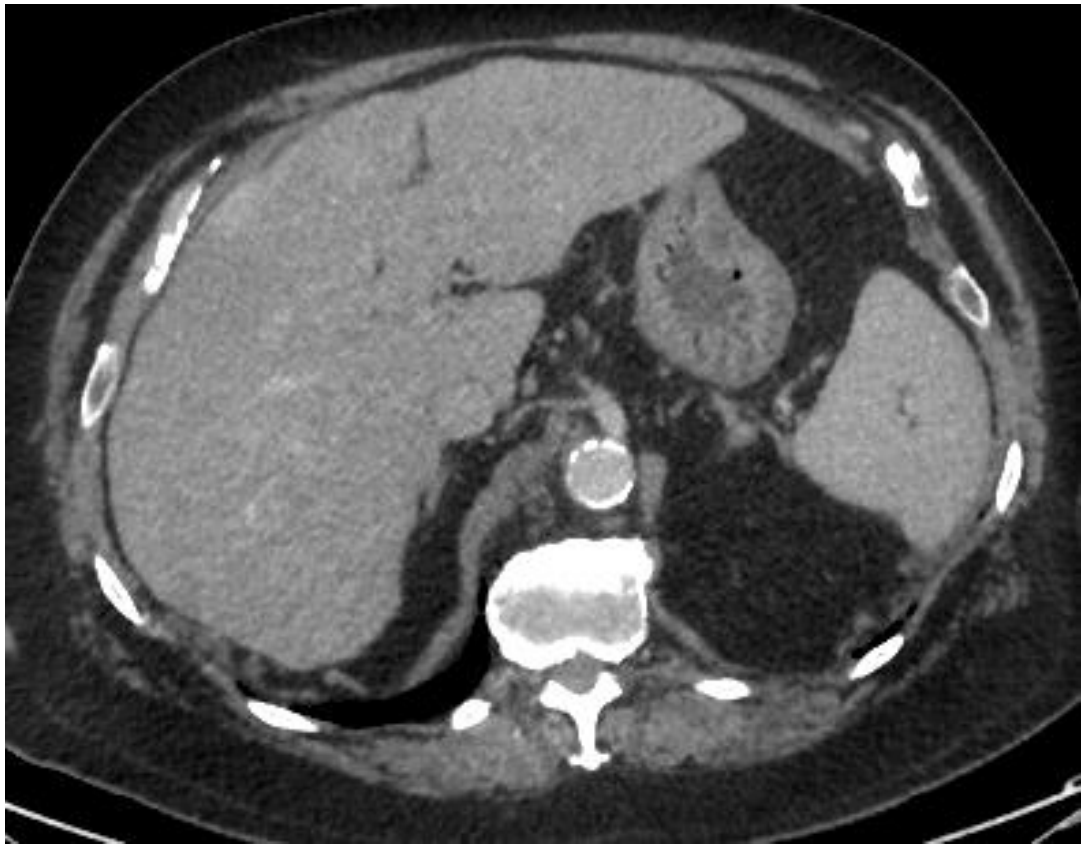
Confluent hepatic fibrosis

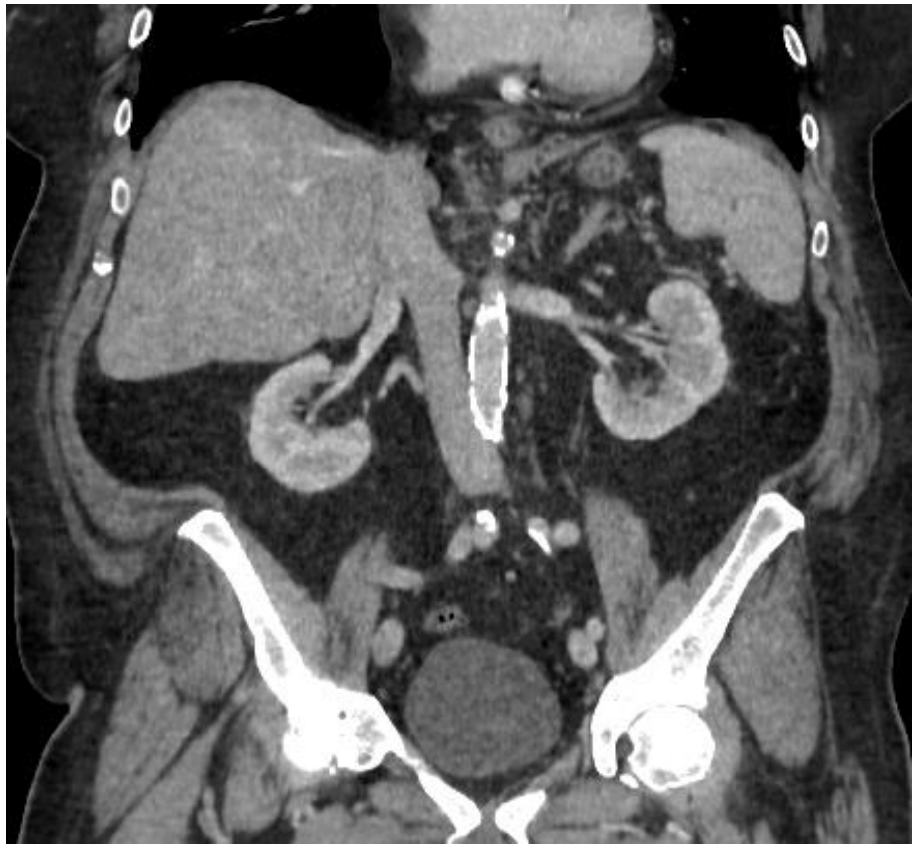



LR-2 - Confluent Hepatic Fibrosis

LR-2 - Confluent Hepatic Fibrosis

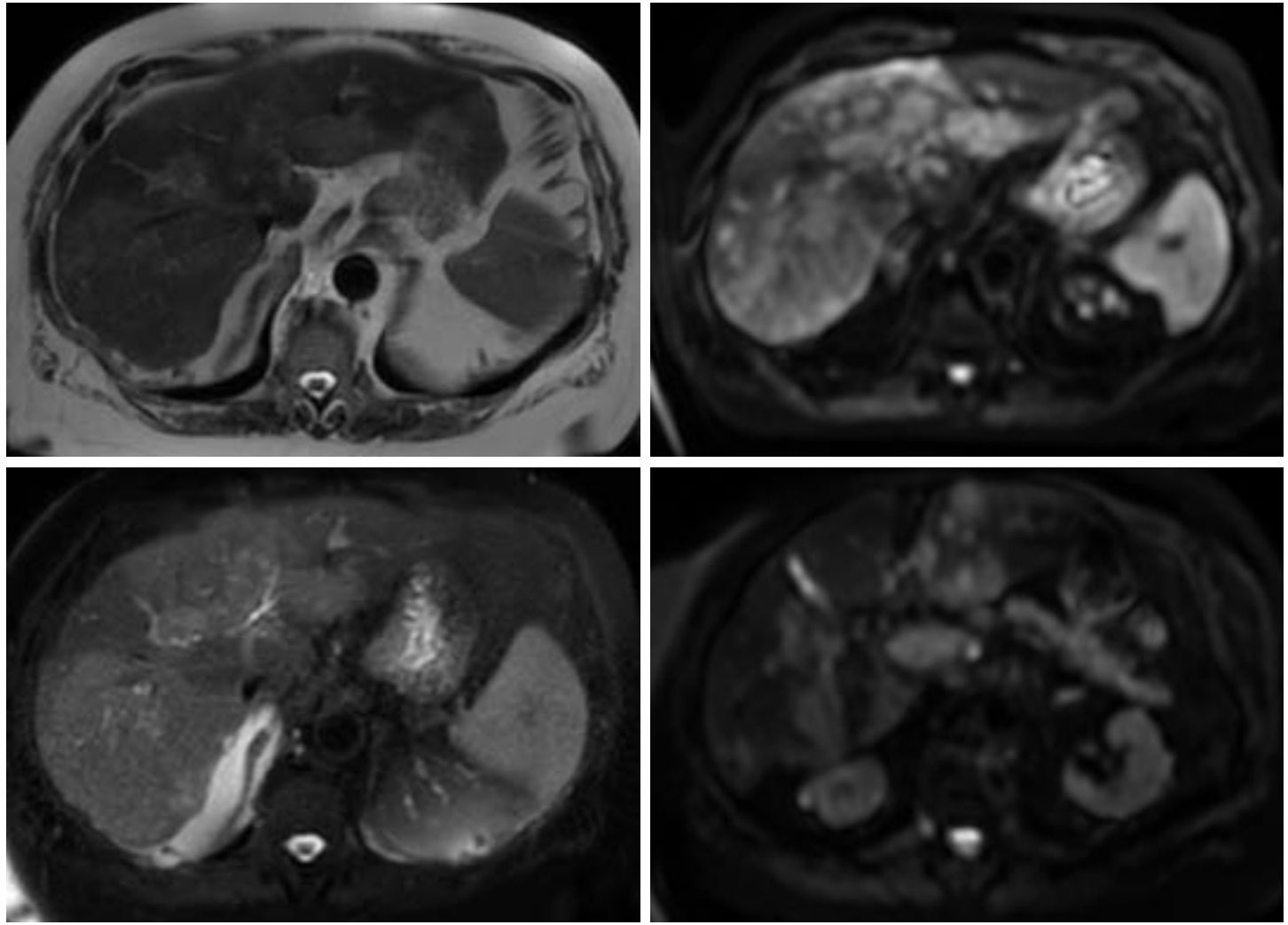




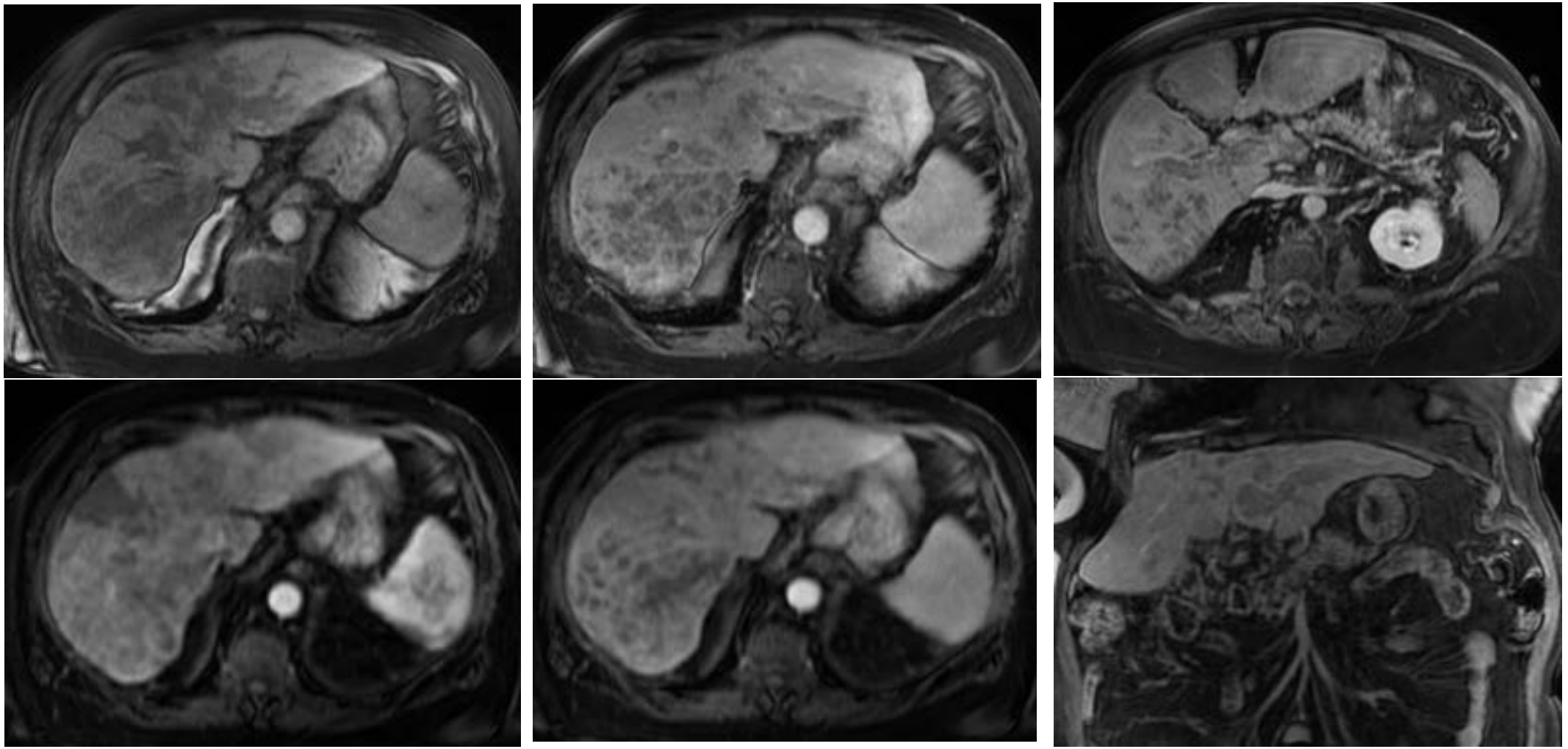


Cirrhotic liver, “heterogeneous enhancement”

LR-TIV



LR-TIV



LR-3

CT/MRI Diagnostic Table

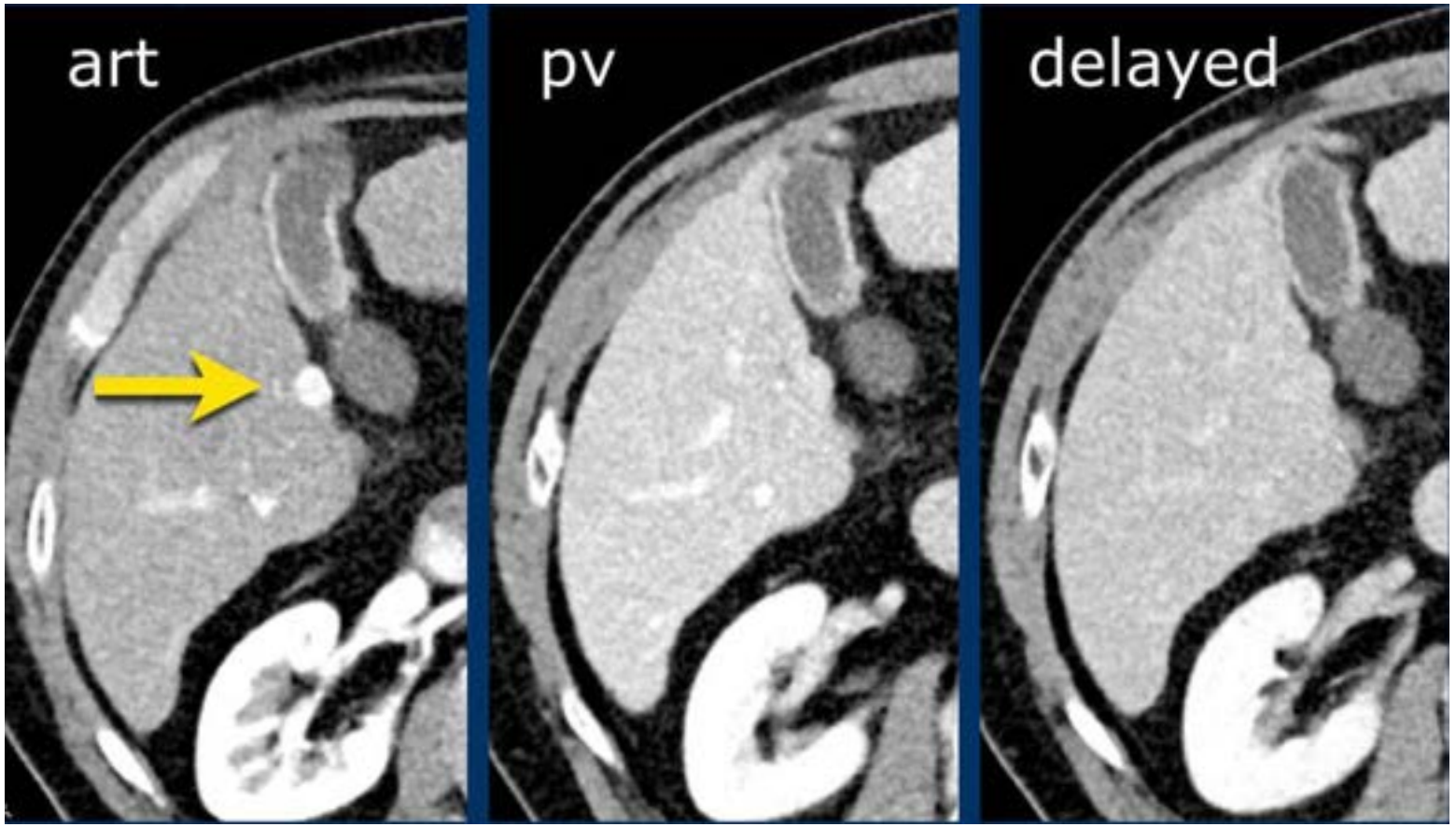
Arterial phase hyperenhancement (APHE)		No APHE		Nonrim APHE		
Observation size (mm)		< 20	≥ 20	< 10	10-19	≥ 20
Count additional major features: • Enhancing "capsule" • Nonperipheral "washout" • Threshold growth	None	LR-3	LR-3	LR-3	LR-3	LR-4
	One	LR-3	LR-4	LR-4	LR-4 / LR-5	LR-5
	≥ Two	LR-4	LR-4	LR-4	LR-5	LR-5

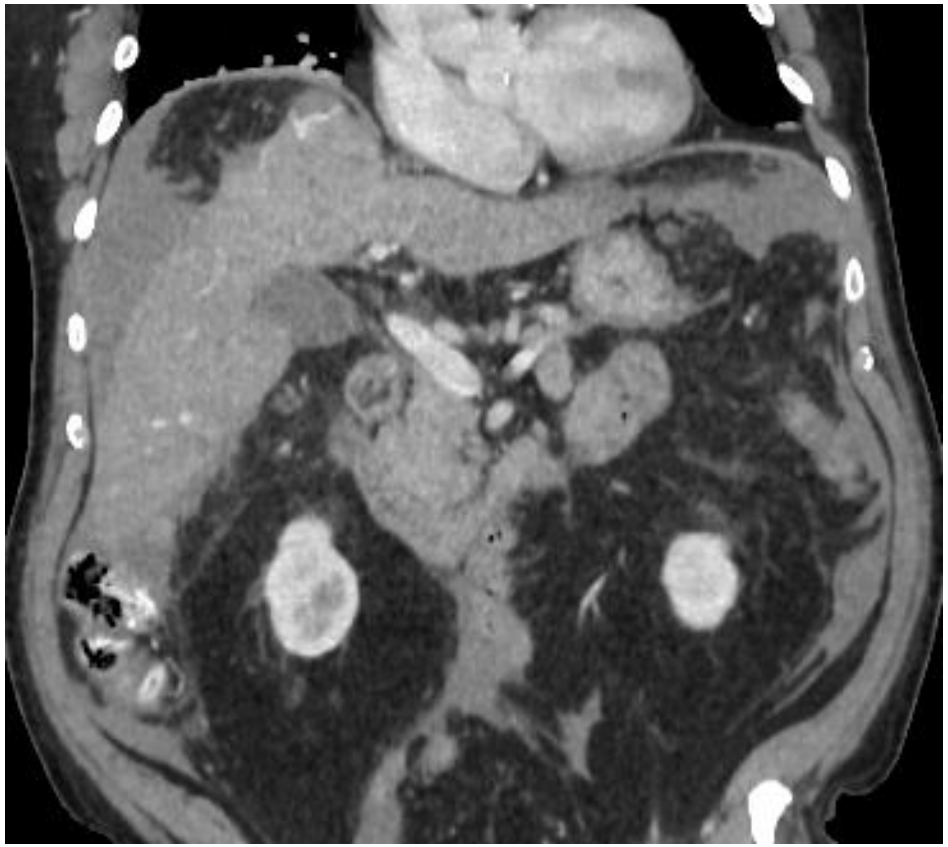
LR-4 / LR-5

Observations in this cell are categorized based on one additional major feature:
- LR-4 – if enhancing "capsule"
- LR-5 – if nonperipheral "washout" **OR** threshold growth

If unsure about the presence of any major feature: characterize that feature as absent

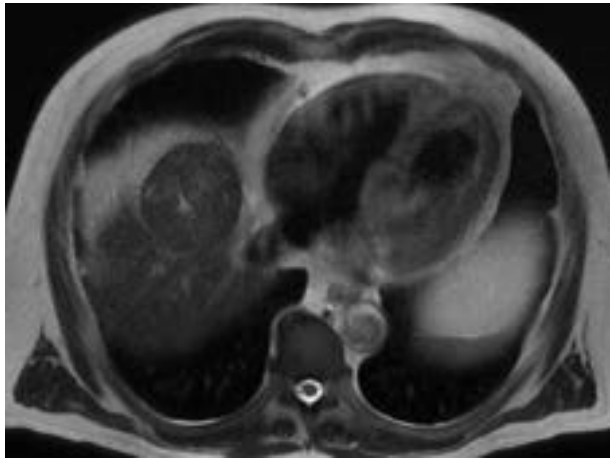
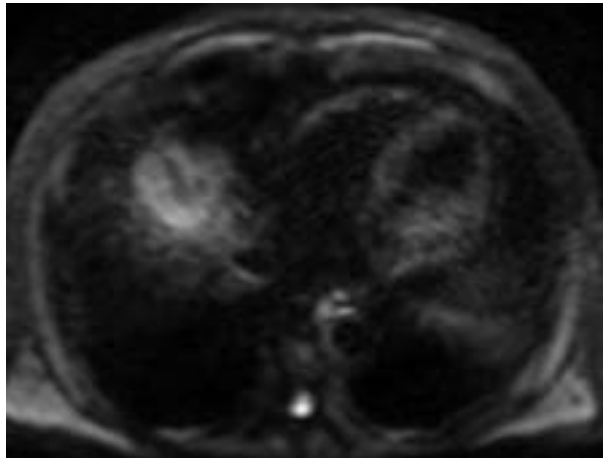
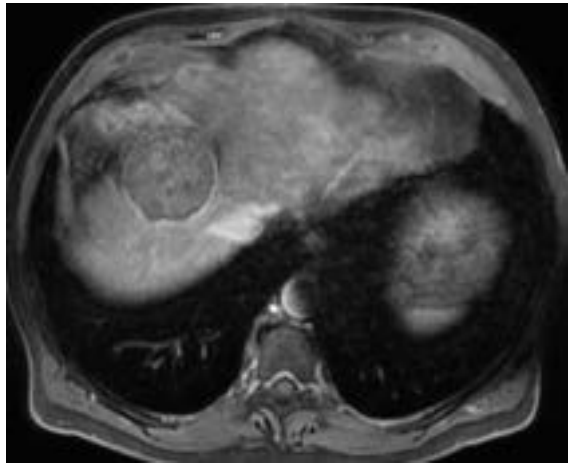
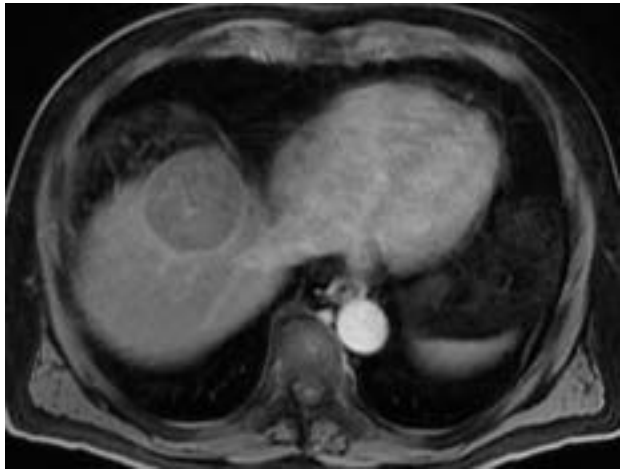
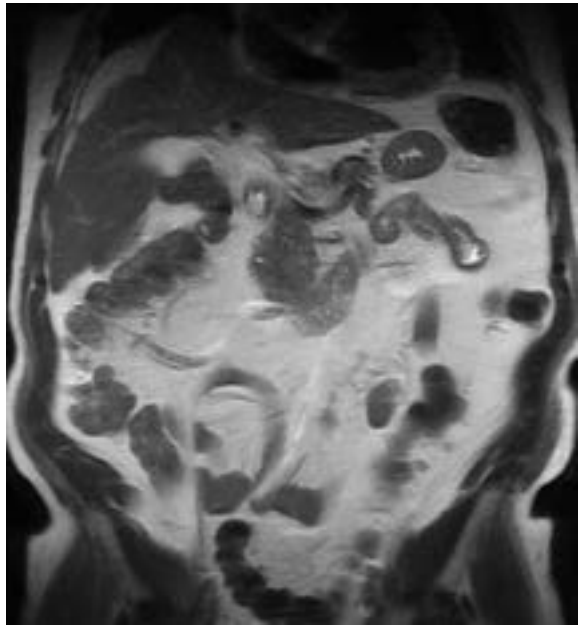
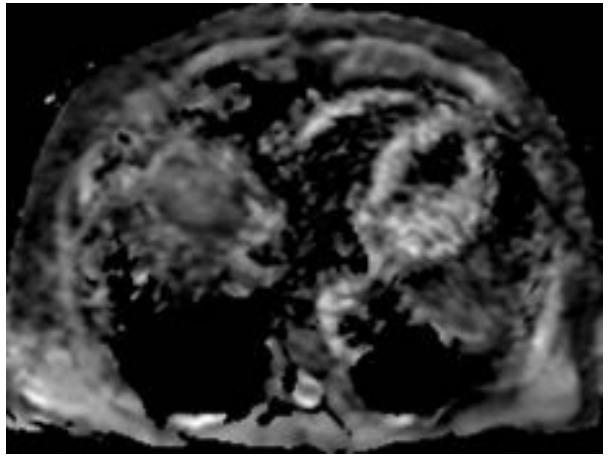
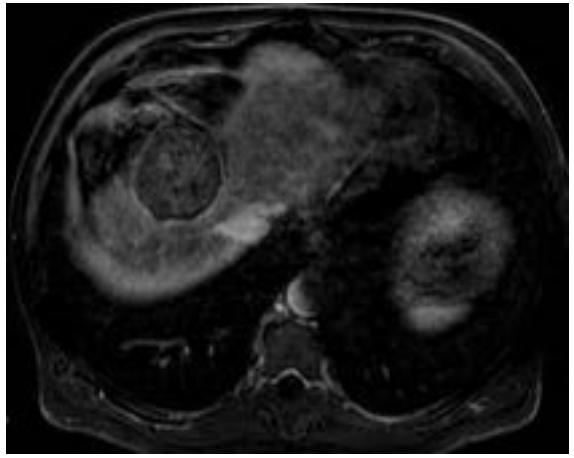
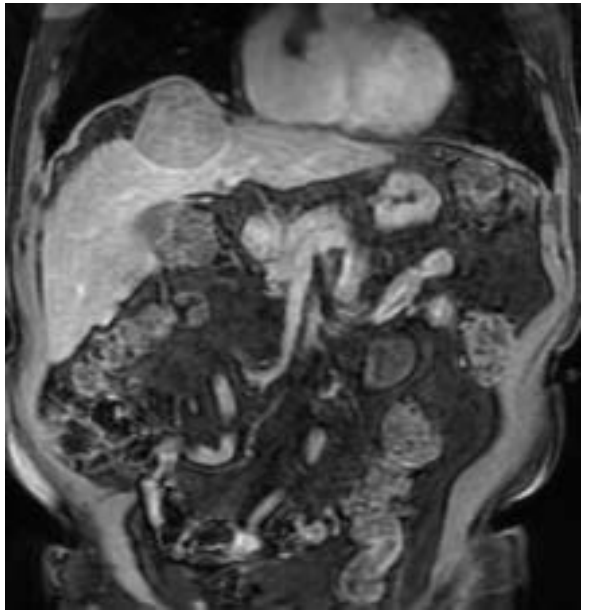
LR-3



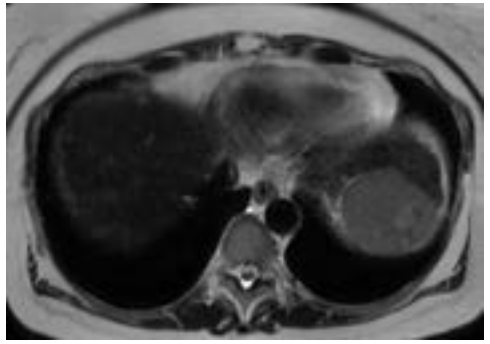
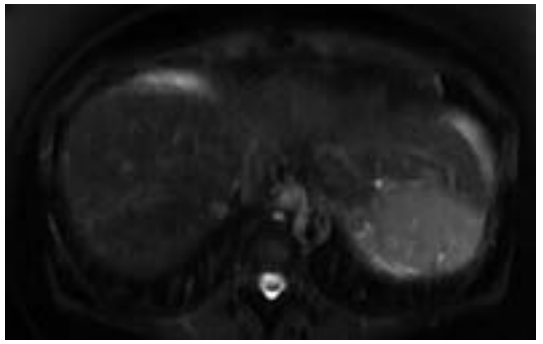
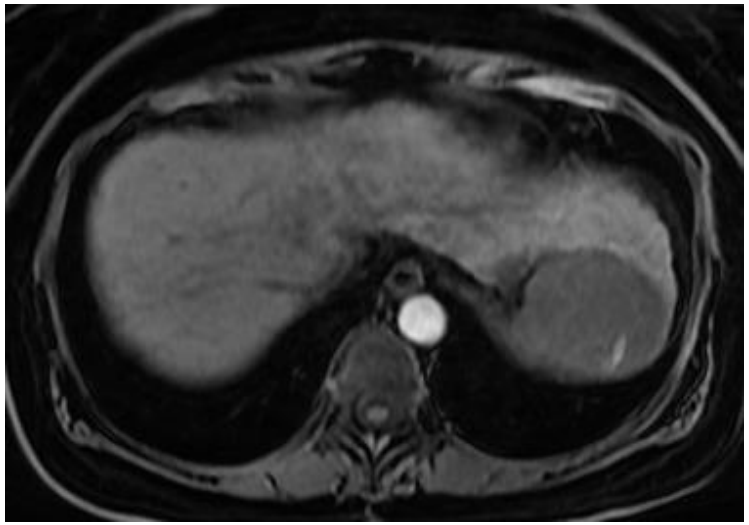
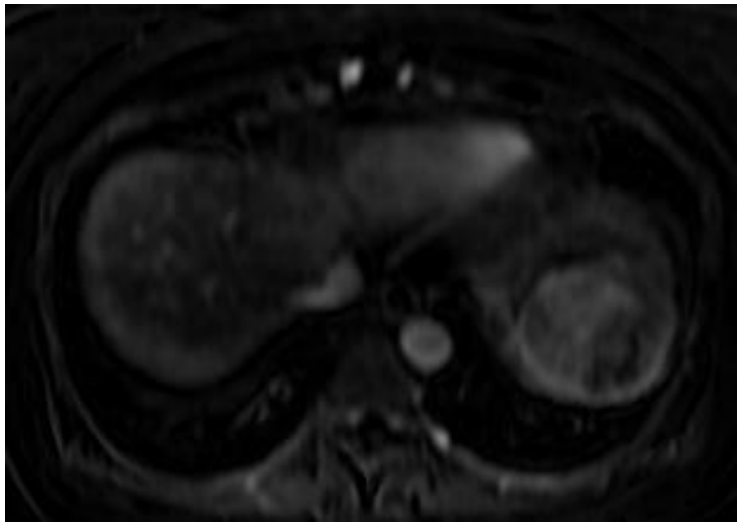
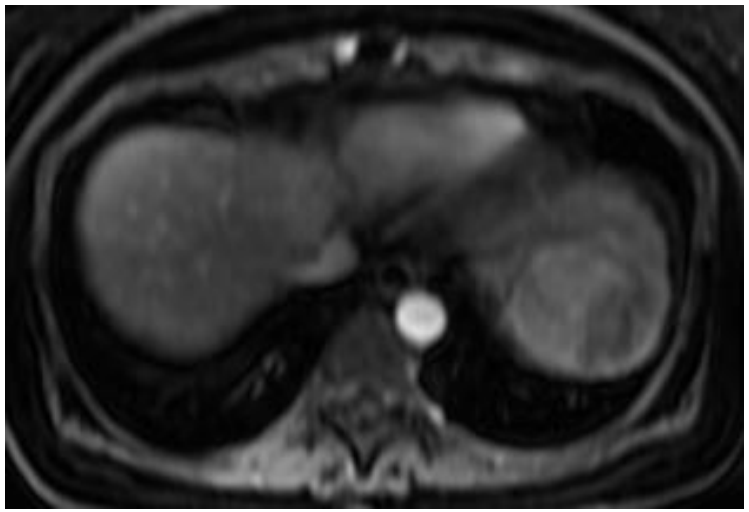
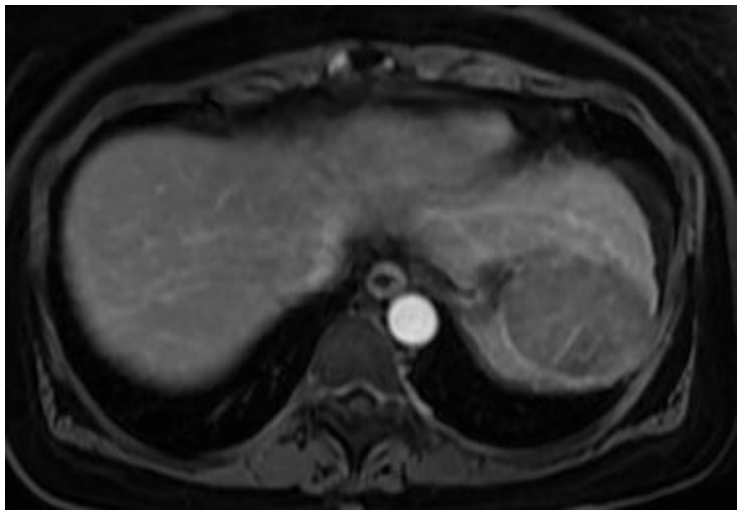
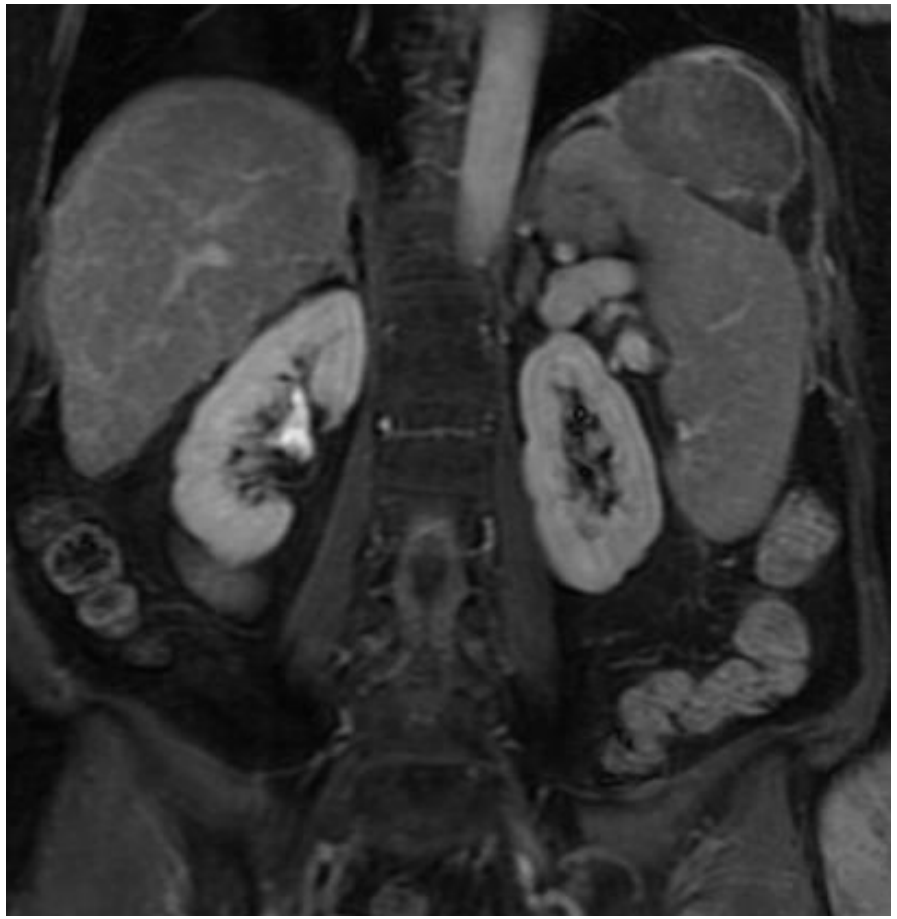


“Liver mass”

HCC; LR-5

HCC; LR-5

LI-RADS-M

- Probably or definitely malignant, not HCC specific (1/3 are HCC)
  - Bx is needed to establish a diagnosis
  - Targetoid DCE, TP, HBP, DWI
    - Rim APHE
    - Peripheral washout
    - Delayed central enhancement
  - Marked DWI restriction
  - Necrotic, infiltrative
    - No TIV
  - Bile duct dilation
  - Capsular retraction
  - One feature is enough to categorize LI-RADS-M

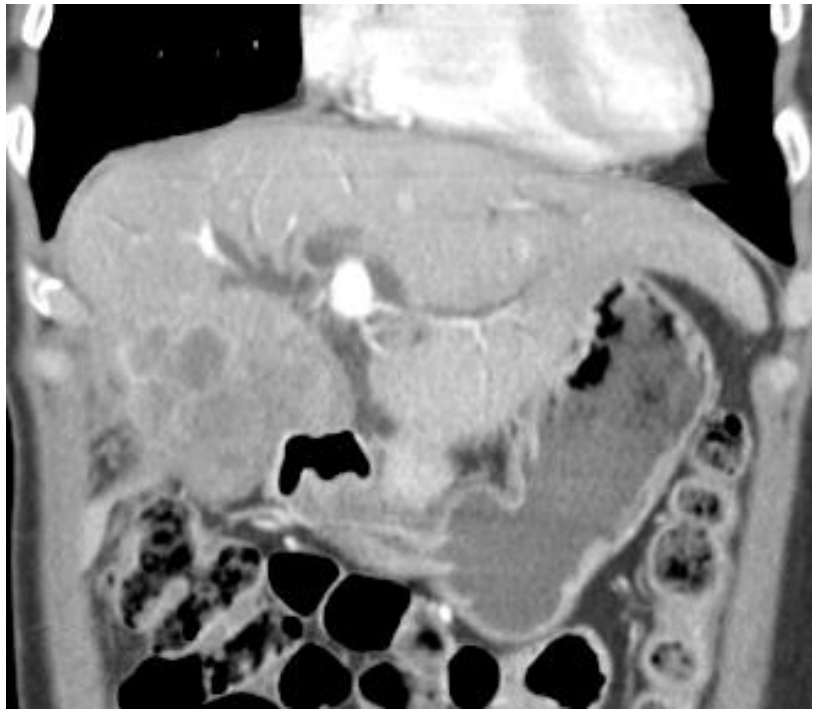
LI-RADS® v2018
CT/MRI Core

LI-RADS-M

- Probably or definitely malignant, not HCC specific
  - Cholangiocarcinoma
  - cHCC-CCA
  - Atypical HCC
  - Metastatic disease
  - Lymphoma, Sarcoma
  - Sclerosed hemangioma

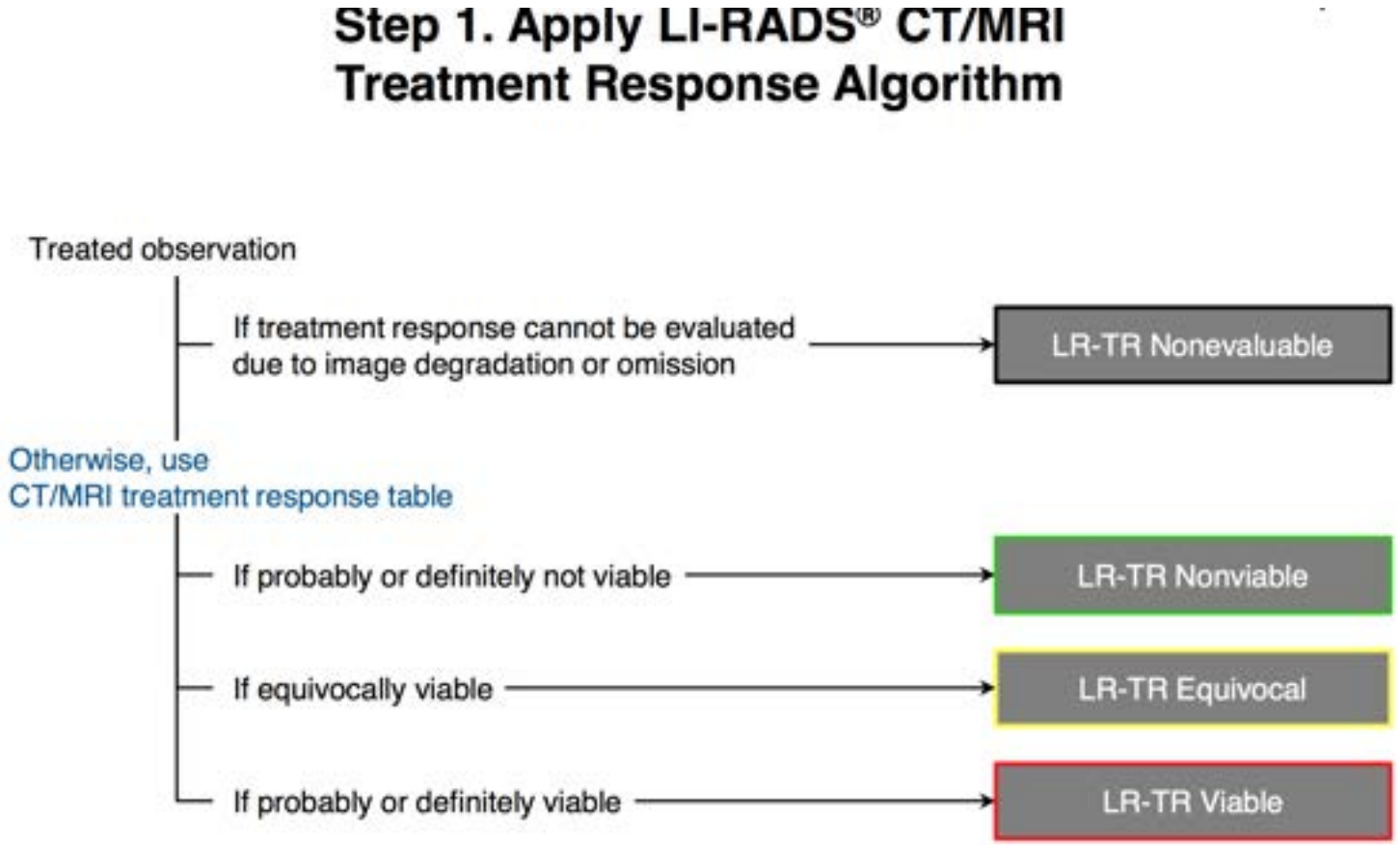
LI-RADS® v2018
CT/MRI Core

LR-M

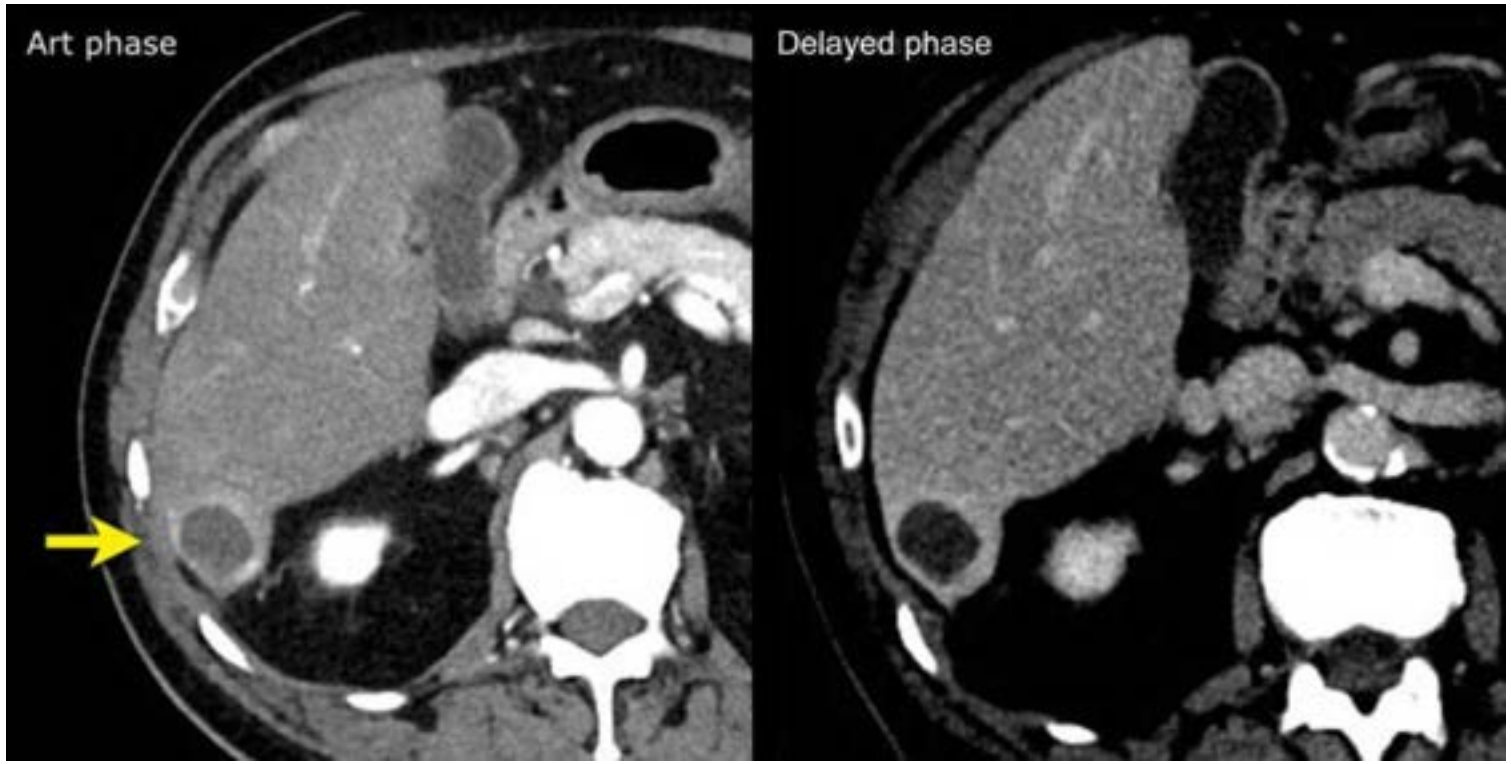


LI-RADS® v2018
CT/MRI Core

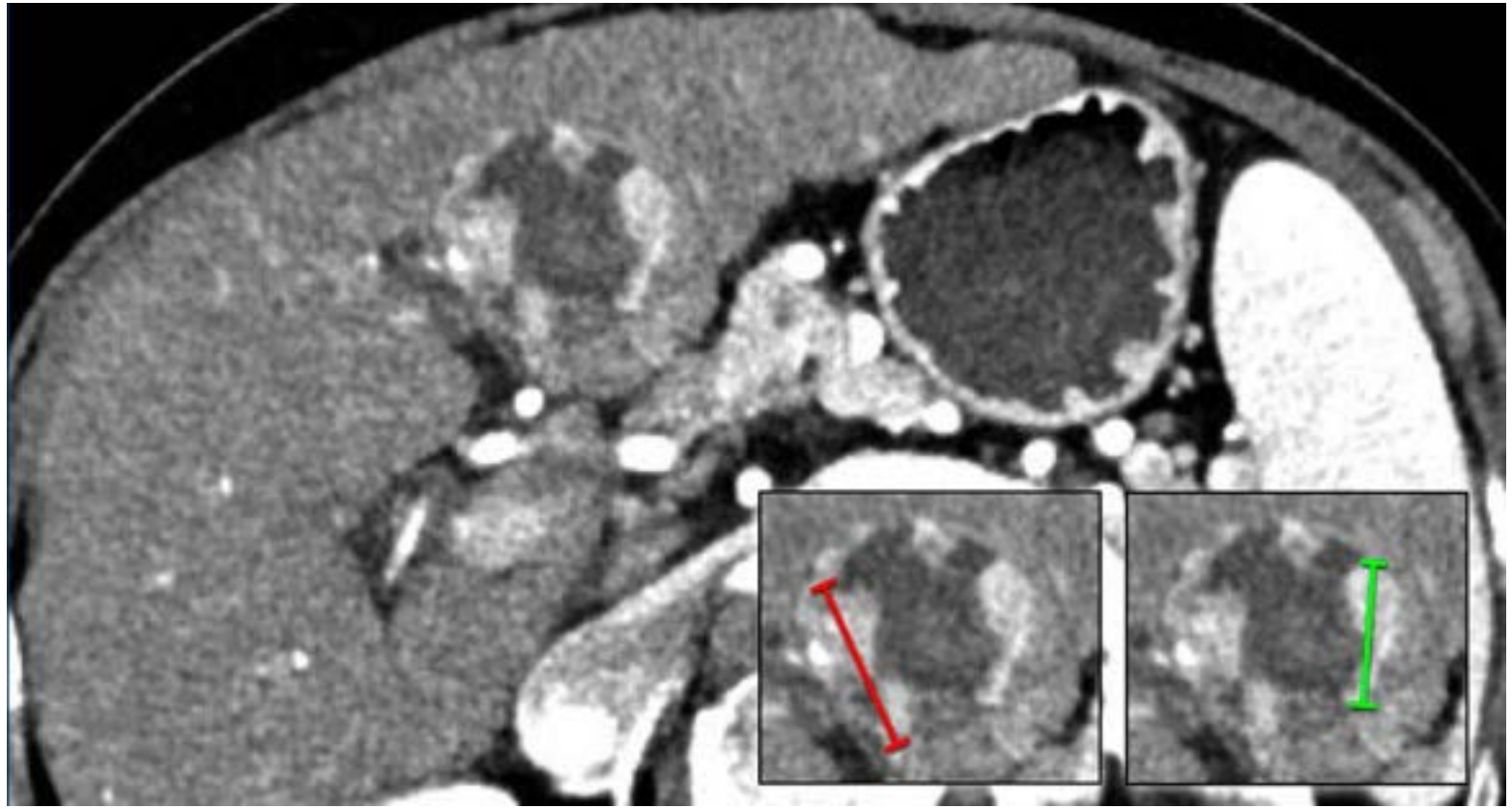
LI-RADS



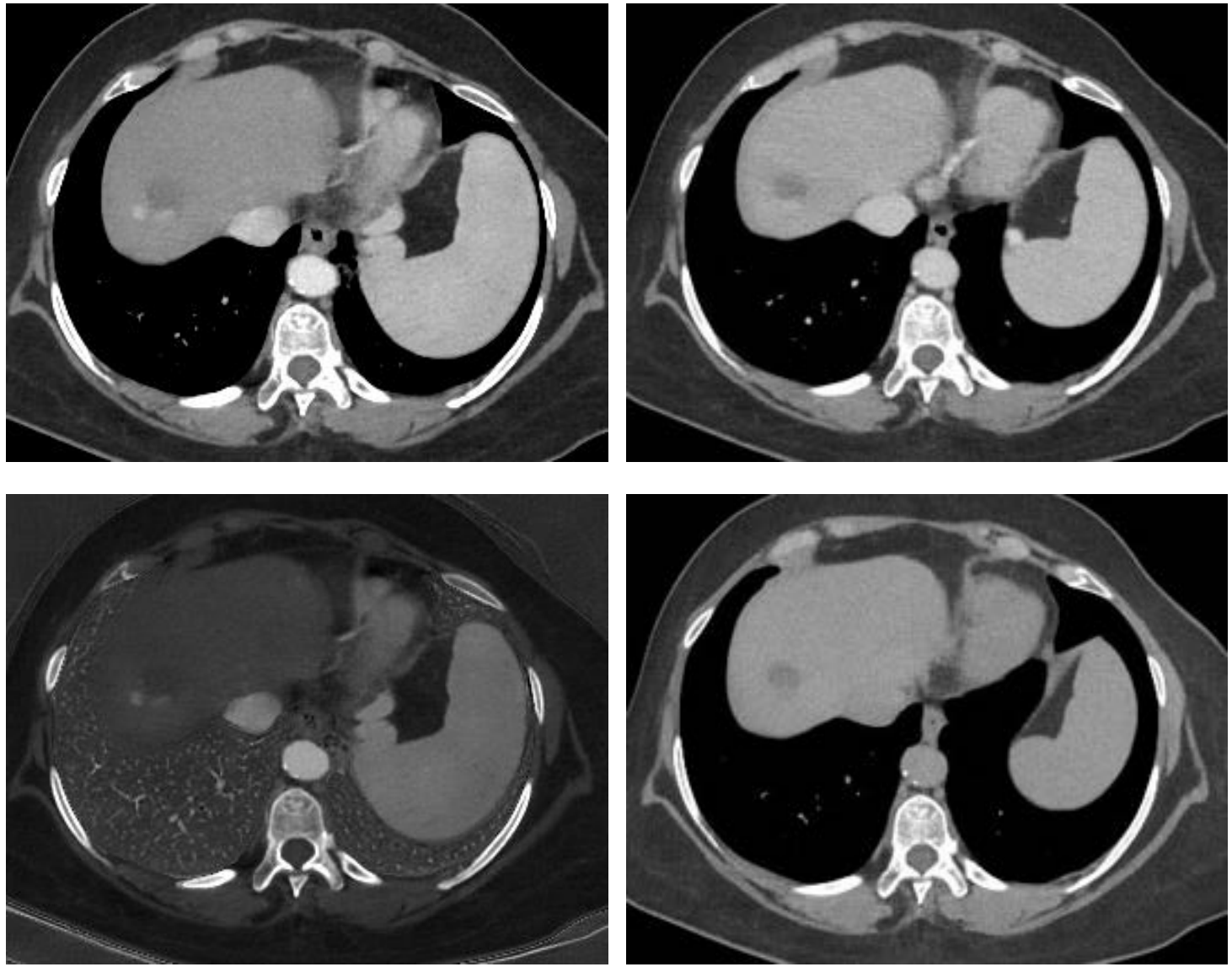
LR-TR nonviable



LR-TR viable



LR-TR viable



Hepatobiliary contrast (Eovist)

Eovist (Gadoxetate Disodium, Gd-EOB-DTPA)

- Hepatobiliary (hepatocyte-specific) Gd agent
- Uptake requires cellular transporters in functioning hepatocytes
- Focal nodular hyperplasia (FNH)
- HCC
  - 85% - no uptake
  - 15% - uptake (nodule-in-nodule, int septations, int defects, hypo rim)
- HBP hypointensity is not specific for HCC
  - Dysplastic nodule, cyst, hemangioma, mets, iCCa, cHCC-CCA

Suh et al. AJR 2011
Tamada et al. Hepatol Res 2017
Yamamoto et al. AJR 2013
Ichikawa et al. Liver Cancer 2015

Eovist (Gadoxetate Disodium, Gd-EOB-DTPA)

- Eovist in cirrhotic patients
  - Advantages
    - Improved sens for HCC
    - May detect small/early HCCs
    - Predictor of tumor differentiation and improved survival
    - Improved spec for HCC

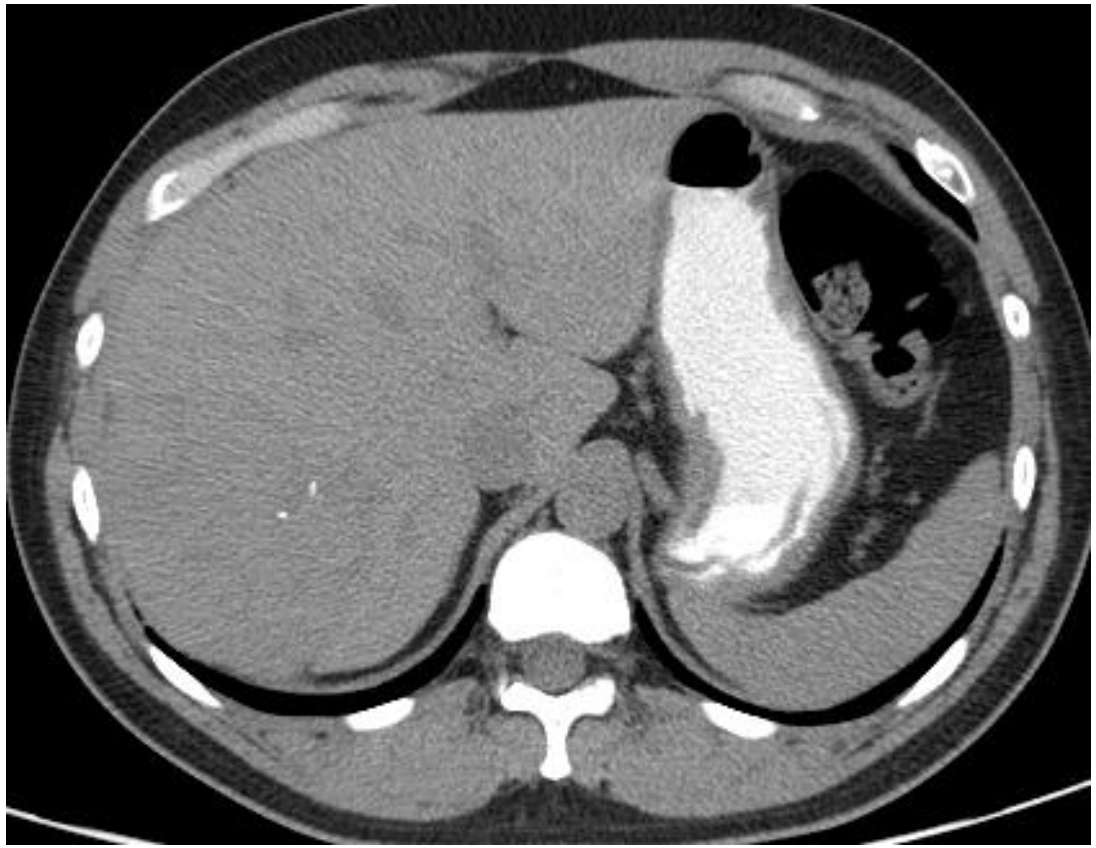
Suh et al. AJR 2011
Tamada et al. Hepatol Res 2017
Yamamoto et al. AJR 2013
Ichikawa et al. Liver Cancer 2015

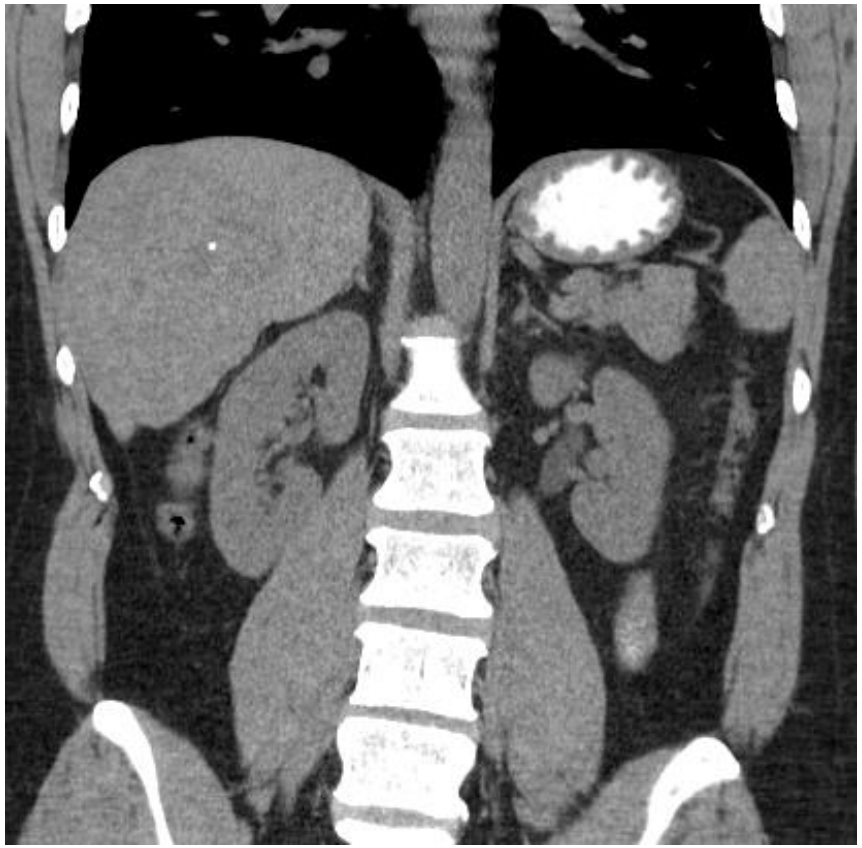
Eovist (Gadoxetate Disodium, Gd-EOB-DTPA)

- Eovist in cirrhotic patients
  - Pitfalls
    - Transient severe motion in art phase
    - Mistiming of art phase
    - Washout only in PV phase
    - Require assessment of HBP for adequacy for interpretation
      - TP and HBP onset can be delayed in cirrhosis (poor liver function)
      - Liver iron
      - Severe steatosis
      - Confluent fibrosis

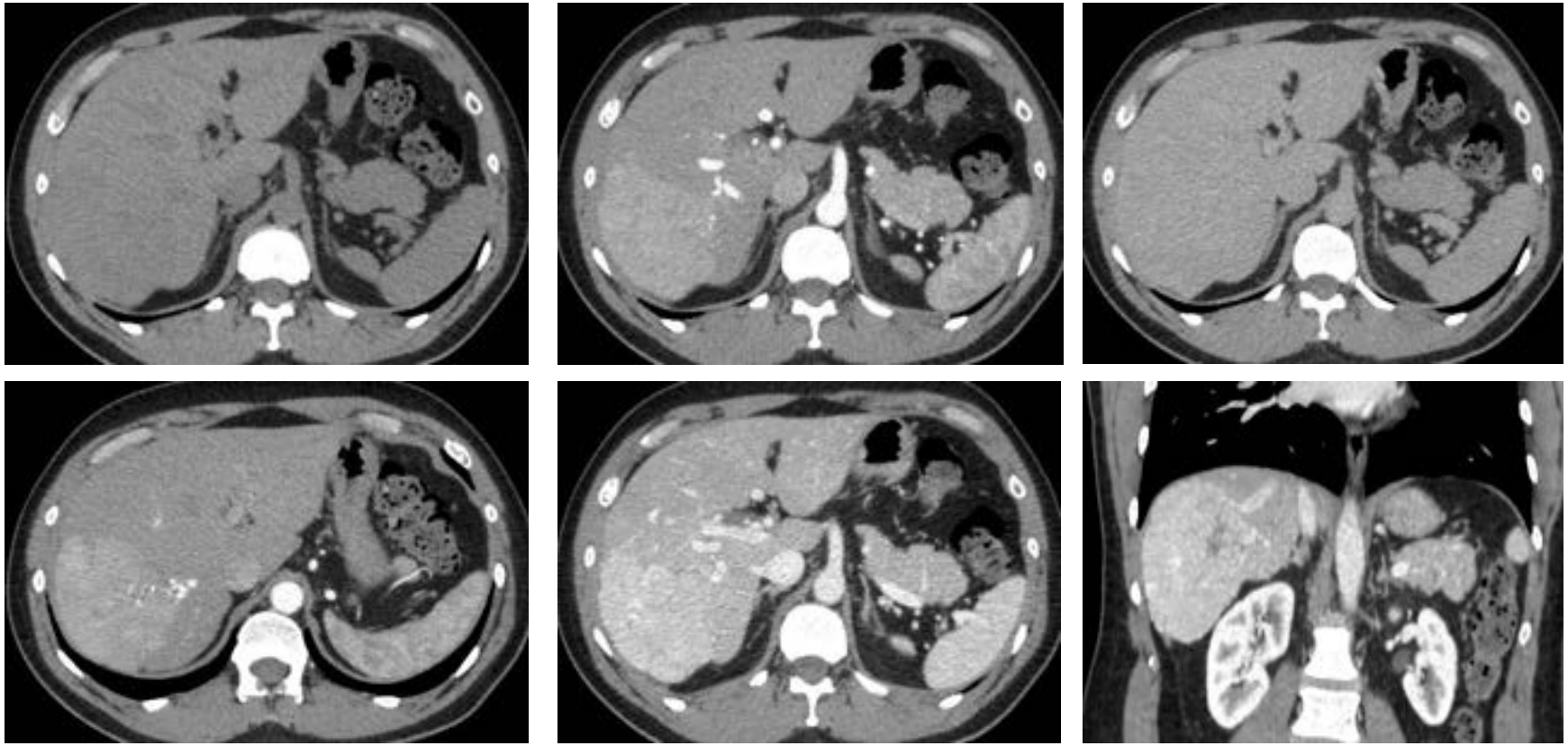
Suh et al. AJR 2011
Tamada et al. Hepatol Res 2017
Yamamoto et al. AJR 2013
Ichikawa et al. Liver Cancer 2015

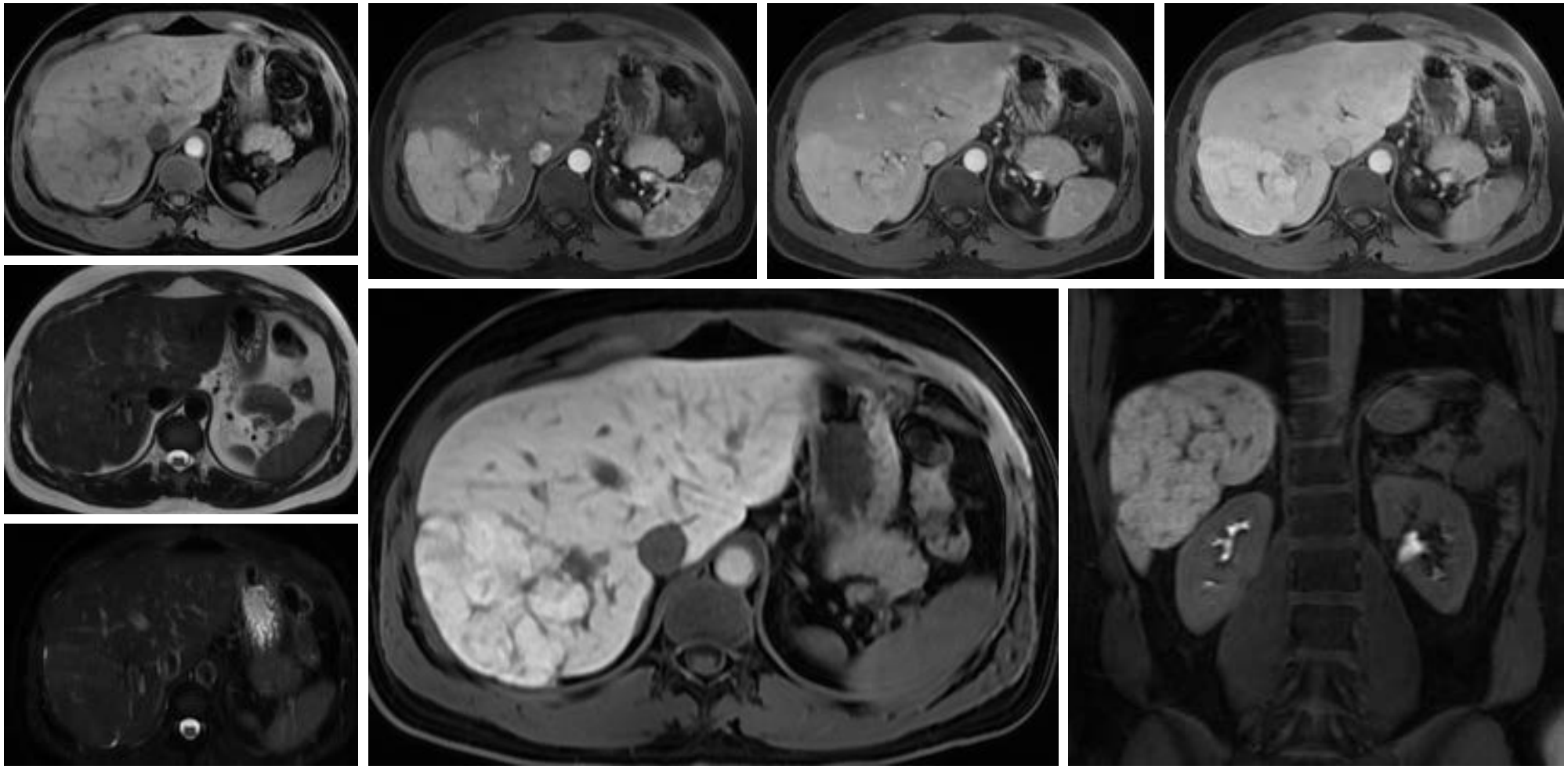
“Hepatic Mass”





“Hepatic mass”





Focal Nodular Hyperplasia (FNH)

Advances in Liver Imaging

State-of-the-art new liver imaging in DLD

- Quantitative (MR hepatogram)
  - MRI-PDFF for fat
  - R2* mapping for iron
  - Elastography for fibrosis
- Fast
- “Accessible”
- Accurate and low risk

SLD: MASLD/MASH/MetALD

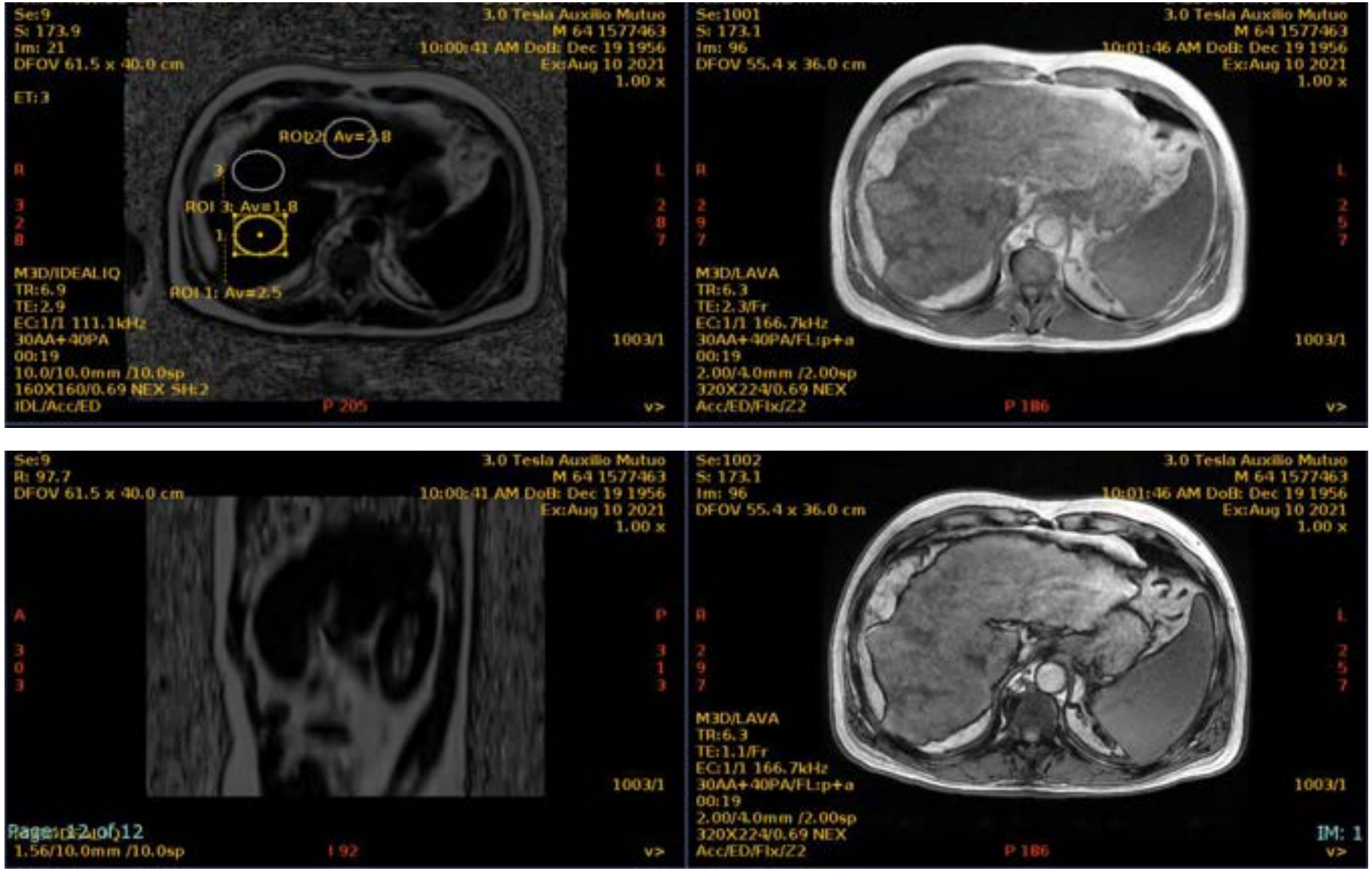
MRI (conventional)

- Loss of SI on dual echo opposed-phase compared to in-phase images
  - Qualitative

MRI-PDFF

- Quantitative

MRI-PDFF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Ex:Aug 10 2021
1.00 x
ROI 2: Av=2.8
ROI 3: Av=1.8
ROI 1: Av=2.5
M3D/IDEALIQ
TR:6.9
TE:2.9
EC:1/1 111.1kHz
30AA+40PA
00:19
10.0/10.0mm /10.0sp
160X160/0.69 NEX SH:2
IDL/Acc/ED
P 205
1003/1
v>
Se:1001
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Im: 96
DFOV 55.4 x 36.0 cm
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M3D/LAVA
TR:6.3
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30AA+40PA/FL:p+a
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2.00/4.0mm /2.00sp
320X224/0.69 NEX
Acc/ED/Fix/Z2
P 186
1003/1
v>
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R: 97.7
DFOV 61.5 x 40.0 cm
3.0 Tesla Auxilio Mutuo
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1.56/10.0mm /10.0sp
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1003/1
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Im: 96
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2.00/4.0mm /2.00sp
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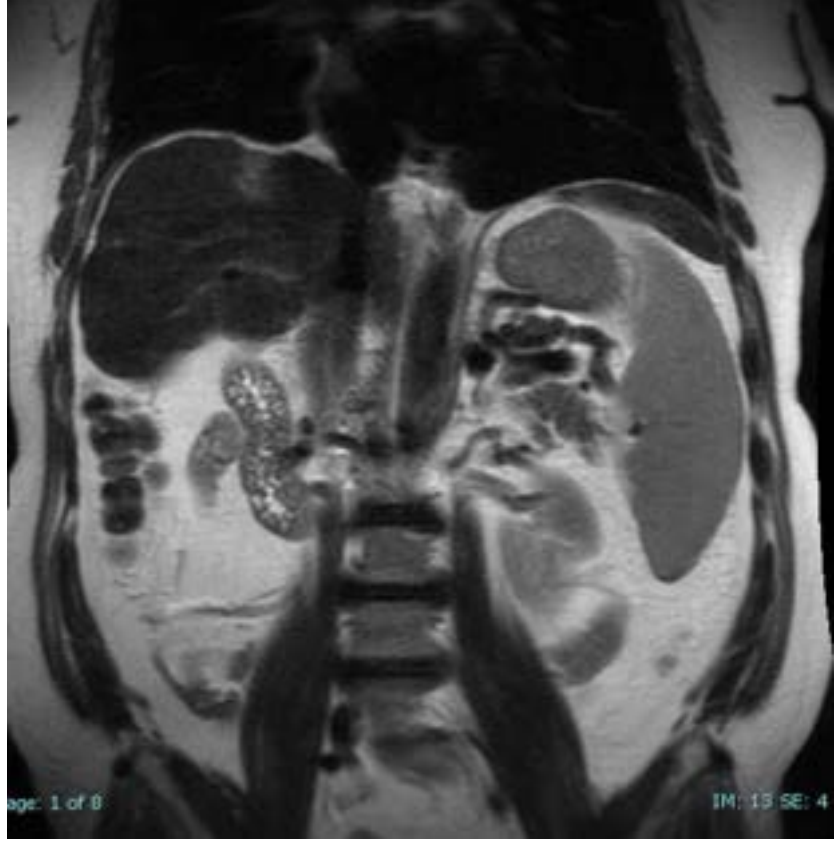
Acc/ED/Fix/Z2
P 186
1003/1
IM: 1
v>

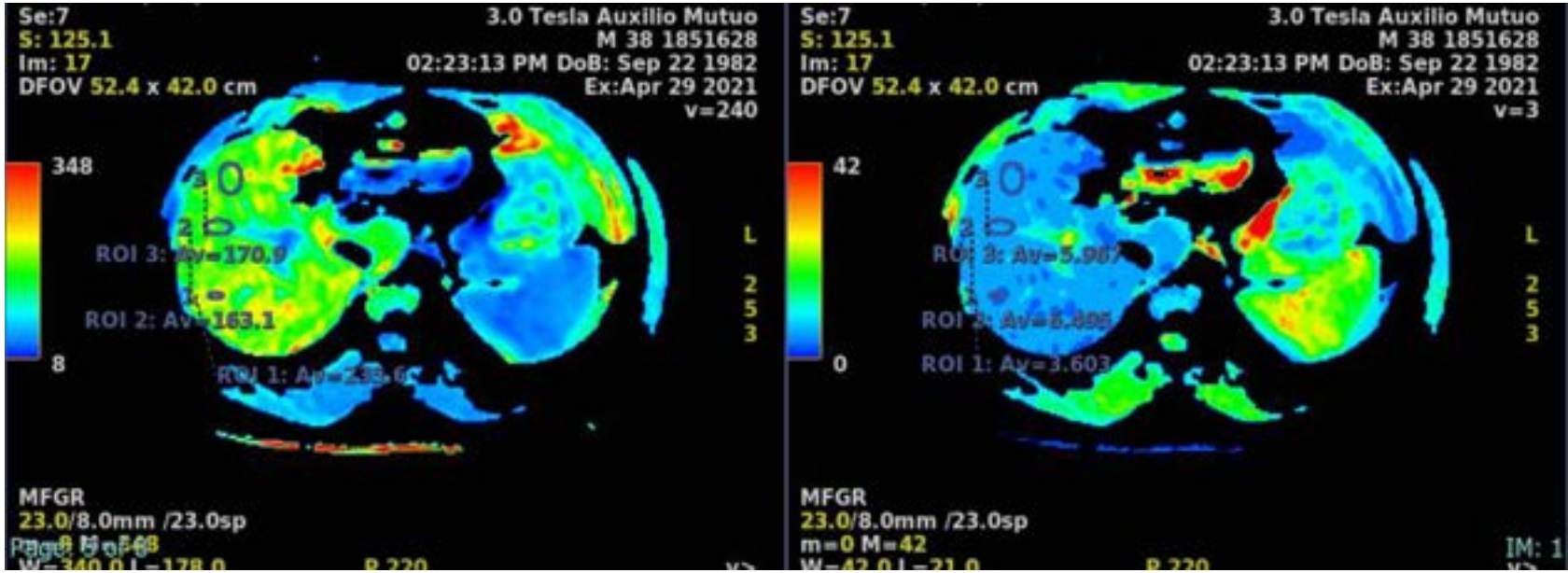
Liver Iron

- Deposition excess in hepatocytes and/or kupffer cells
- As Fe increases, R2* increases
- Liver iron concentration in mg/g dry
- As good or better than liver biopsy
- Detect and quantify iron overload
    - Follow patients on chelation therapy



Hemochromatosis, CLD

R2* mapping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Ex:Apr 29 2021
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8
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ROI 2: Av=163.1
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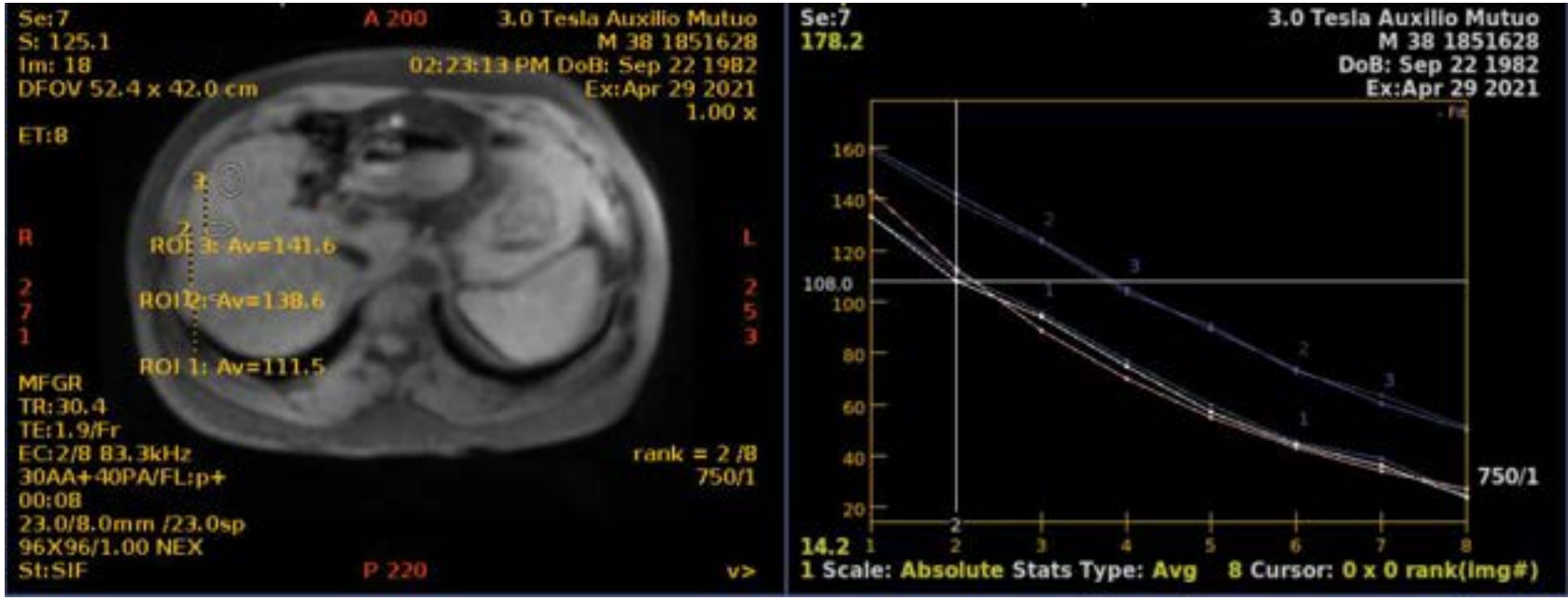
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1.00 x
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ROI 1: Av=111.5
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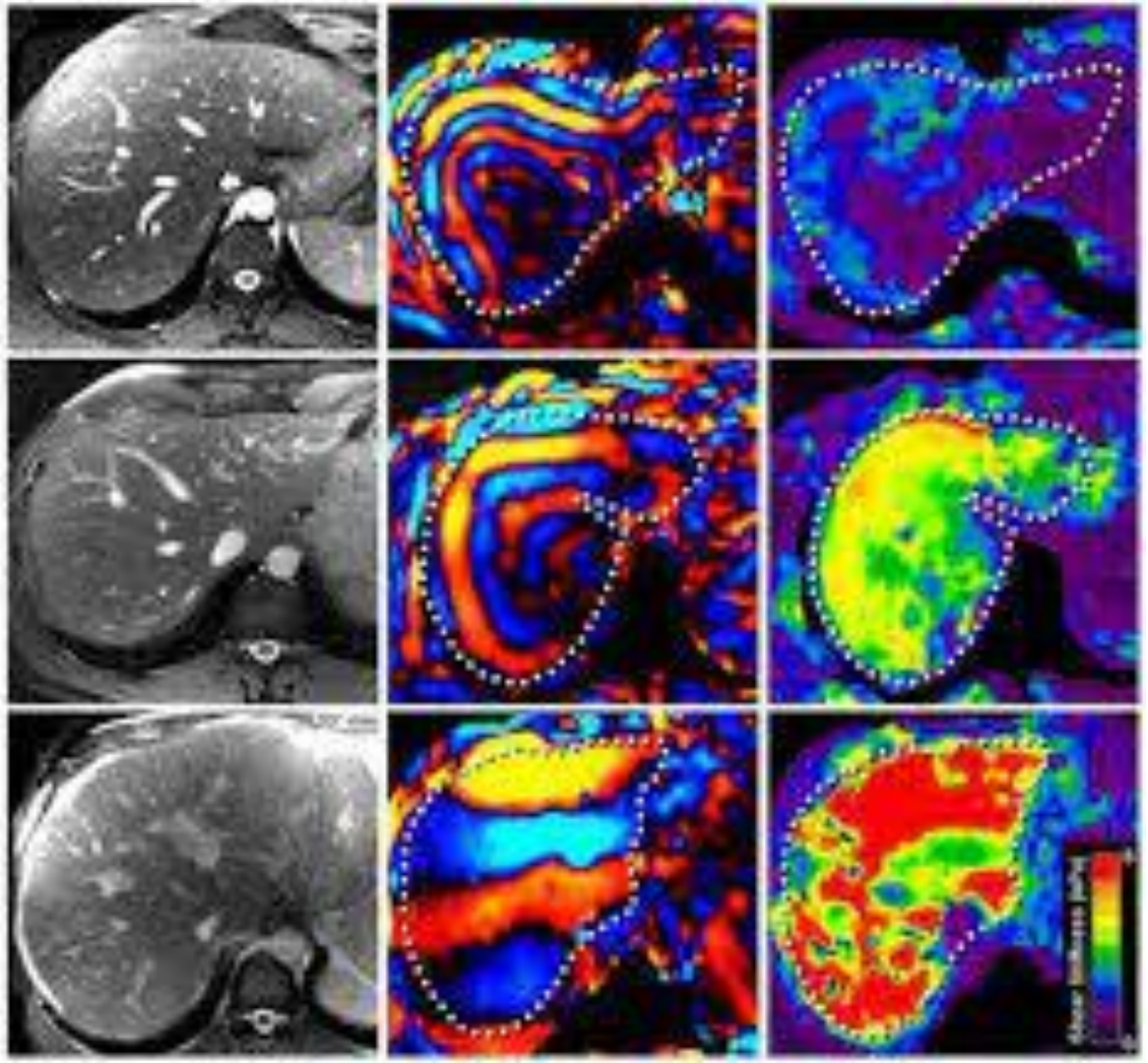
96X96/1.00 NEX
St:SIF
rank = 2 /8
750/1
P 220
v>
Se:7
178.2
3.0 Tesla Auxilio Mutuo
M 38 1851628
DoB: Sep 22 1982
Ex:Apr 29 2021
160
140
120
108.0
100
80
60
40
20
750/1
14.2
1 Scale: Absolute Stats Type: Avg
8 Cursor: 0 x 0 rank(Img#)

Elastography

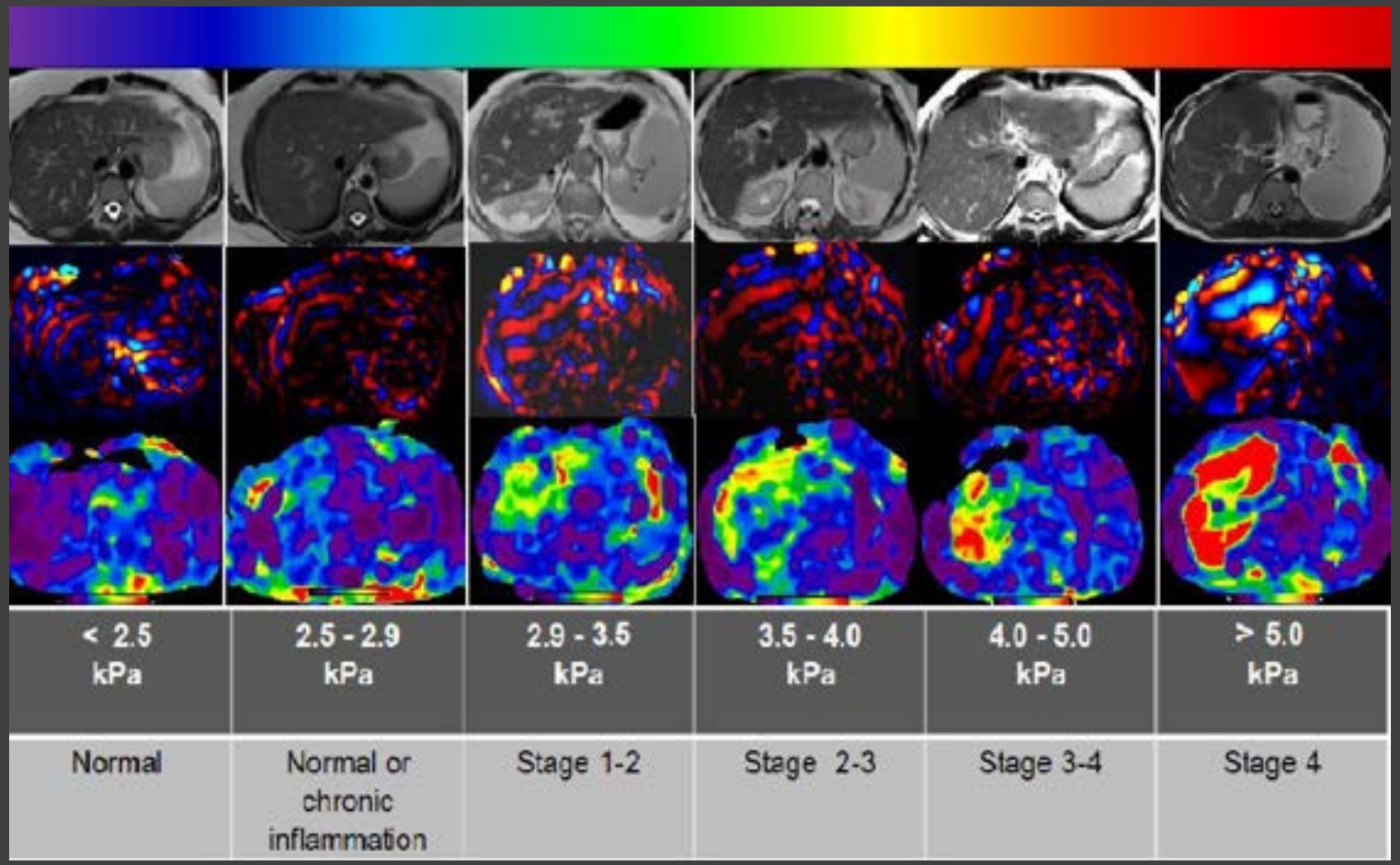
- US (strain and shear wave)
  - Elastogram of small ROI
  - Potentially impacted by obesity
  - Poor for early fibrosis (stage 1 vs. stage 2)
  - Ok for stage 2 and up
  - Excellent for detecting Stage 4
- MRI
  - Elastogram of entire liver

MR elastography

- US vs, MR elastography
  - MRE more accurate, especially at lower stages



Chen 2017, Park 2017, Imajo 2016, Chou 2017, Cui 2016

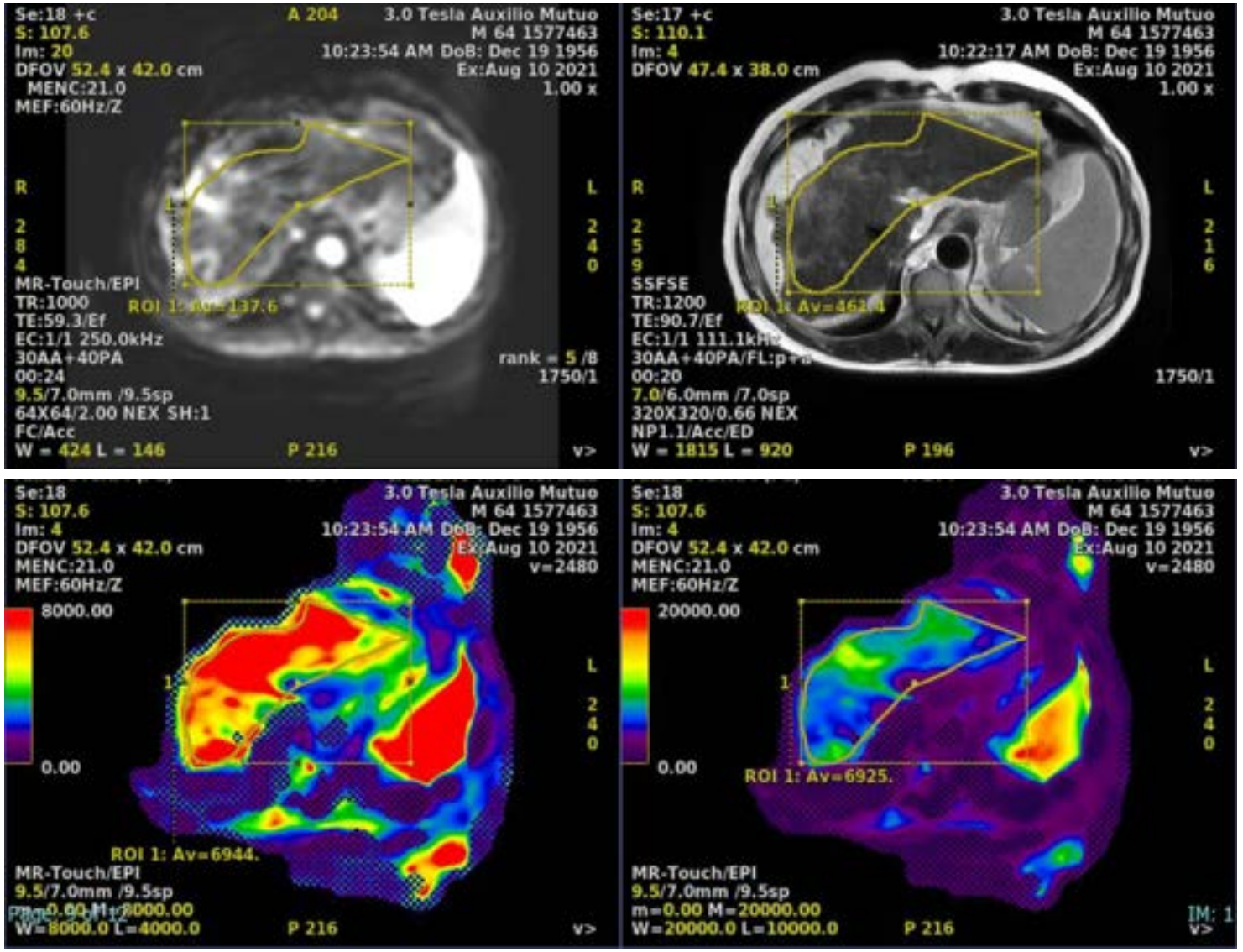


< 2.5 kPa	2.5 - 2.9 kPa	2.9 - 3.5 kPa	3.5 - 4.0 kPa	4.0 - 5.0 kPa	> 5.0 kPa
Normal	Normal or chronic inflammation	Stage 1-2	Stage 2-3	Stage 3-4	Stage 4

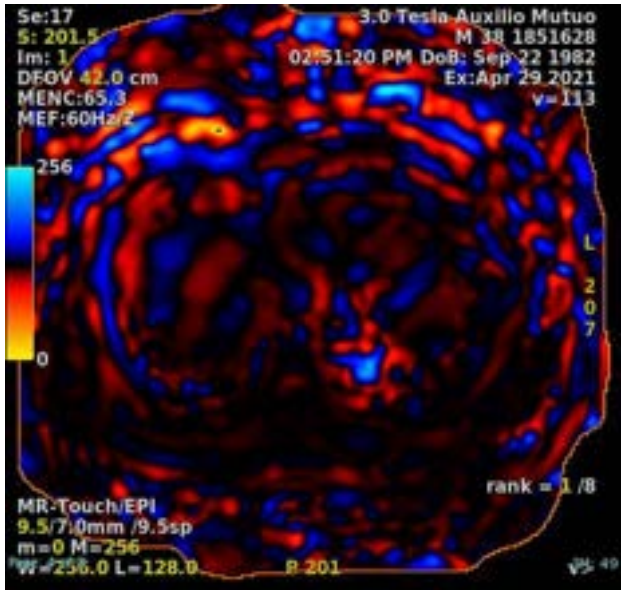
MR elastography

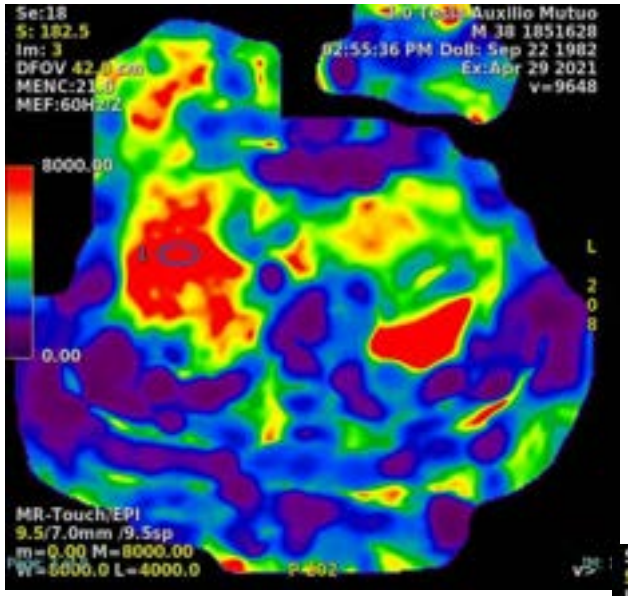
Chen 2017, Park 2017, Imajo 2016, Chou 2017, Cui 2016

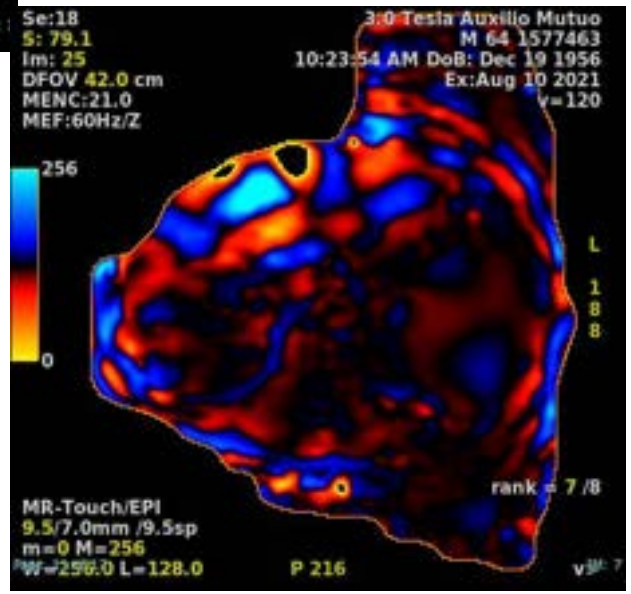
MRE - Confluent Hepatic Fibrosis

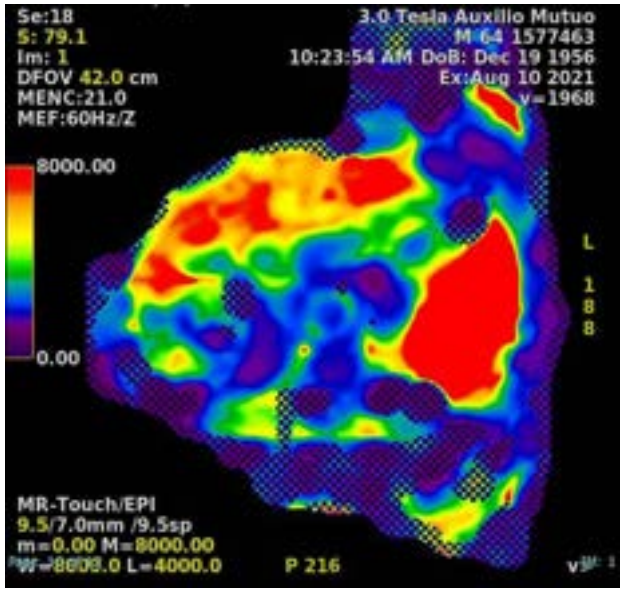


MR elastography



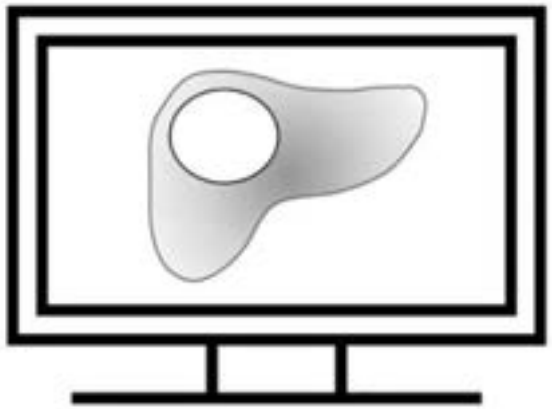






Multidisciplinary team approach

Multidisciplinary Liver Tumor Board



Take home points

Contrast-enhanced CT and MRI play key role in evaluation of the liver in pts at high risk for HCC

- Diagnosis, treatment response

Adequate liver protocol CT/MRI

LI-RADS

Imaging advances in liver imaging

Multidisciplinary approach

Reference

- https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/LI-RADS/CT-MRI-LI-RADS-v2018

Thanks...

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