

Radiologic Approach to Fatty Liver

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Classification of Hepatic Steatosis

1

Histopathological Basis

Simple Steatosis (NAFL): Fat accumulation >5% of hepatocytes without inflammation

Steatohepatitis (NASH): Steatosis with lobular inflammation and hepatocyte injury

Fibrosis/Cirrhosis: Progressive fibrotic replacement of hepatic parenchyma

2

Etiological Classification

Fatty liver is broadly divided into two major categories:

Alcoholic Liver Disease (ALD) — related to chronic alcohol consumption

Non-Alcoholic Fatty Liver Disease (NAFLD) — associated with metabolic syndrome

Secondary Causes — drugs, total parenteral nutrition, pregnancy, viral hepatitis

3

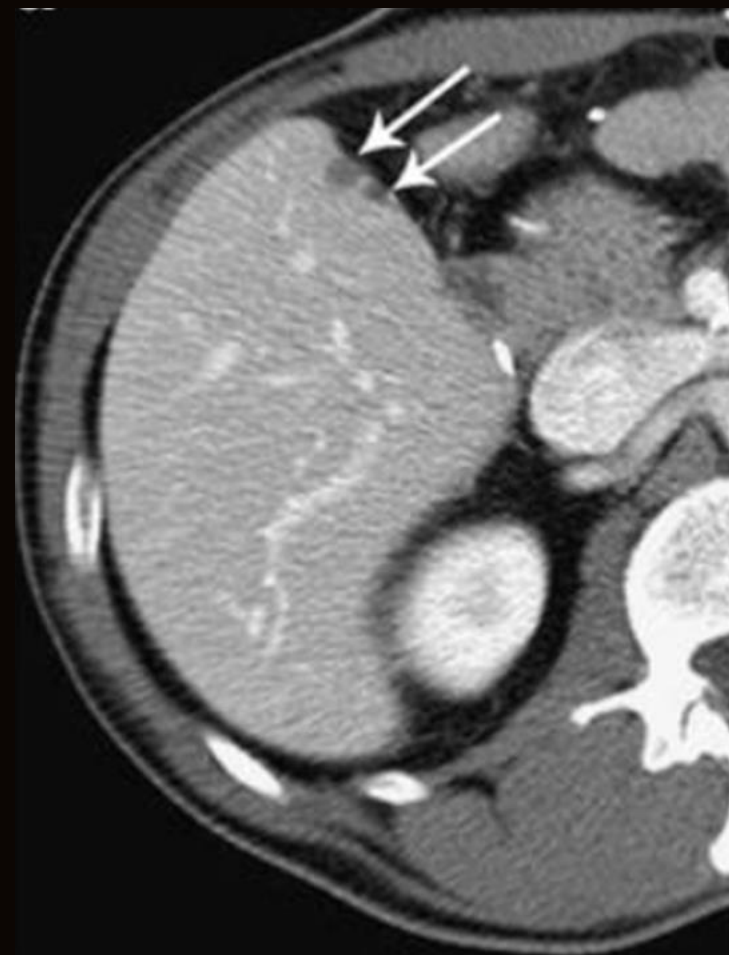
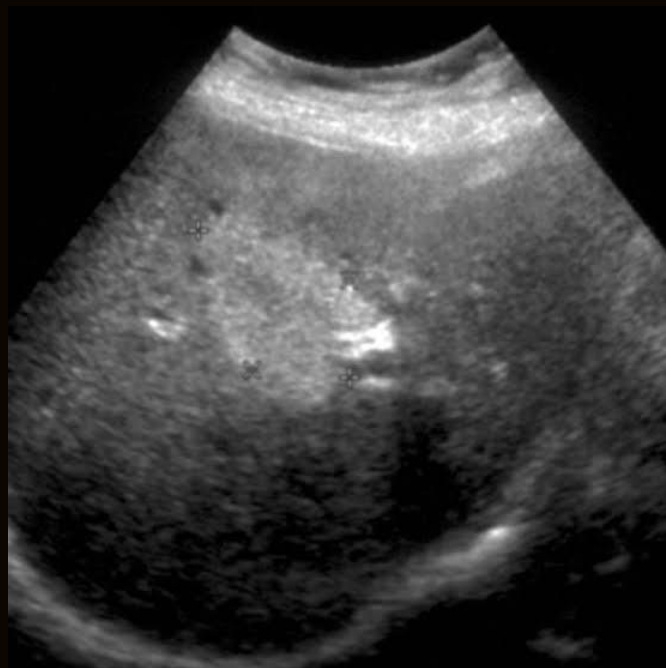
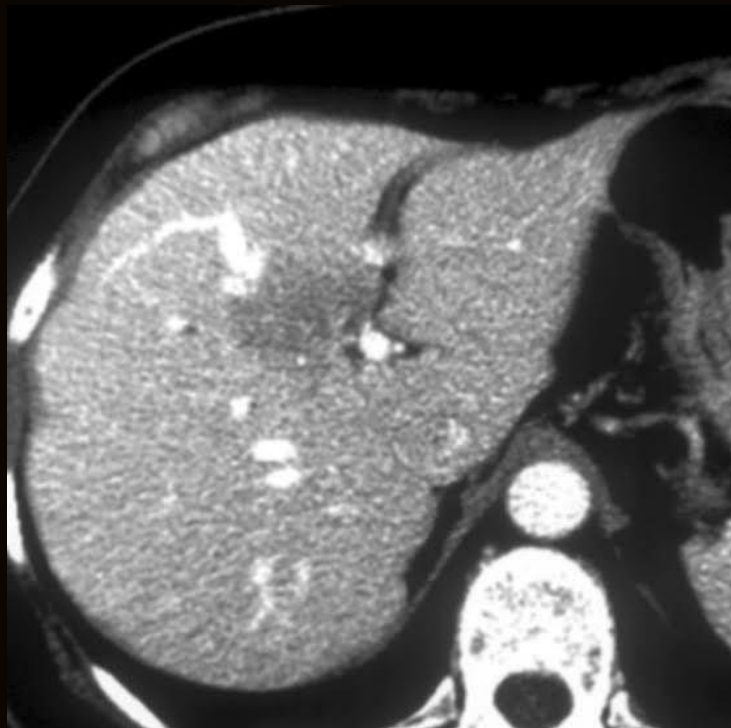
Distribution Patterns

Fat deposition may be diffuse (uniform throughout the liver)

focal (isolated segments or lobes)

multifocal

Atypical distributions can mimic focal lesions and must be recognized to avoid misdiagnosis on imaging.



Grading of Fatty Liver

Histological grading (Brunt/SAF score) remains the gold standard for staging steatosis. Imaging-based grading correlates with histological findings and allows non-invasive quantification across modalities.

Grade 1 — Mild

5–33% hepatocyte fat involvement; subtle imaging changes

Grade 2 — Moderate

33–66% hepatocyte involvement; clear imaging signal changes across modalities

Grade 3 — Severe

>66% hepatocyte involvement; marked imaging findings with reduced liver attenuation/signal

Imaging-Based Fat Fraction Thresholds



5%

Steatosis Threshold
Minimum hepatic fat fraction defining steatosis on MRI



33%

Moderate Steatosis
Fat fraction indicative of Grade 2 disease; reliable detection by CT and MRI



66%

Severe Steatosis
Grade 3 threshold; reliably detected on ultrasound, CT, and all MRI sequences

Sonographic Assessment of Fatty Liver

Ultrasound is the first-line screening modality for hepatic steatosis due to its wide availability, low cost, and lack of ionizing radiation. Sensitivity ranges from 60–94% for moderate-to-severe steatosis but falls significantly for mild disease.

1

B-Mode Features

Increased hepatic echogenicity ("bright liver"), hepatorenal contrast difference, posterior acoustic attenuation, and poor diaphragm visualization

2

Elastography

Shear-wave and transient elastography (FibroScan®) quantify liver stiffness as a surrogate for fibrosis; CAP score estimates steatosis grade non-invasively

3

Limitations

Operator-dependent; limited in obese patients; cannot reliably detect mild steatosis (<20% fat) or differentiate simple steatosis from NASH

Key Ultrasound Sign: The hepatorenal index (HRI) — comparing liver to right renal cortex echogenicity — provides semi-quantitative assessment of steatosis severity and improves grading reproducibility.



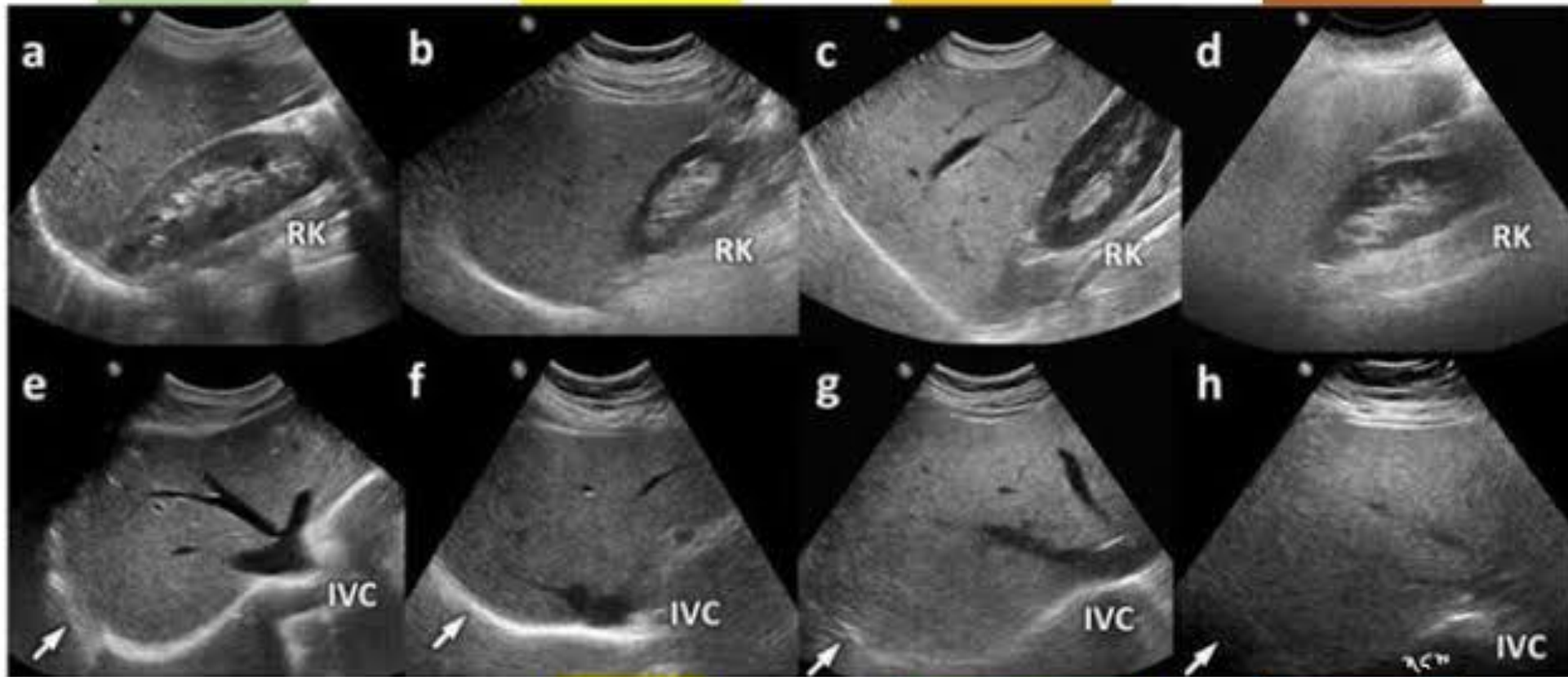


Normal

Grade 1

Grade 2

Grade 3



Mild

Moderate

Severe

Grade 0 - NORMAL

- ❖ Normal liver echotexture
- ❖ Echogenicity $\leq$ renal cortex / spleen
- ❖ Clear visualization of :
 - Portal vein walls
 - Diaphragm
- ❖ No posterior acoustic attenuation



Grade 1 – Mild steatosis

- ❖ Slightly increased liver echogenicity
- ❖ Liver brighter than renal cortex / spleen
- ❖ Normal visualization of :
 - Portal vein walls
 - Diaphragm
- ❖ No or minimal posterior beam attenuation



Grade 2 – Moderate steatosis

- ❖ Moderately increased liver echogenicity
- ❖ impaired visualization of :
 - Portal vein walls
 - Diaphragm
- ❖ Mild posterior acoustic attenuation
- ❖ Reduced visualization of liver parenchyma



Grade 3 – Moderate steatosis

- ❖ Markedly increased echogenicity (bright liver)
- ❖ Poor or absent visualization of :
 - Portal vein walls
 - Diaphragm
- ❖ Significant posterior acoustic attenuation
- ❖ Poor visualization of liver parenchyma



DDX:

Overweight or obesity

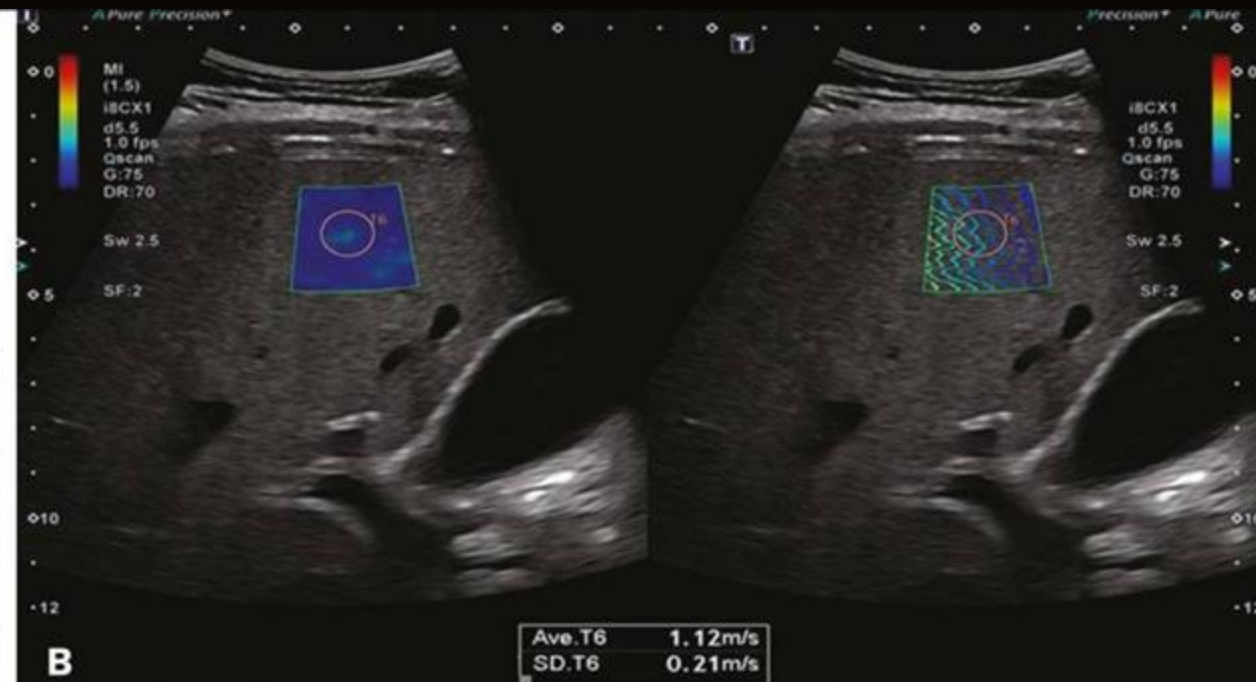
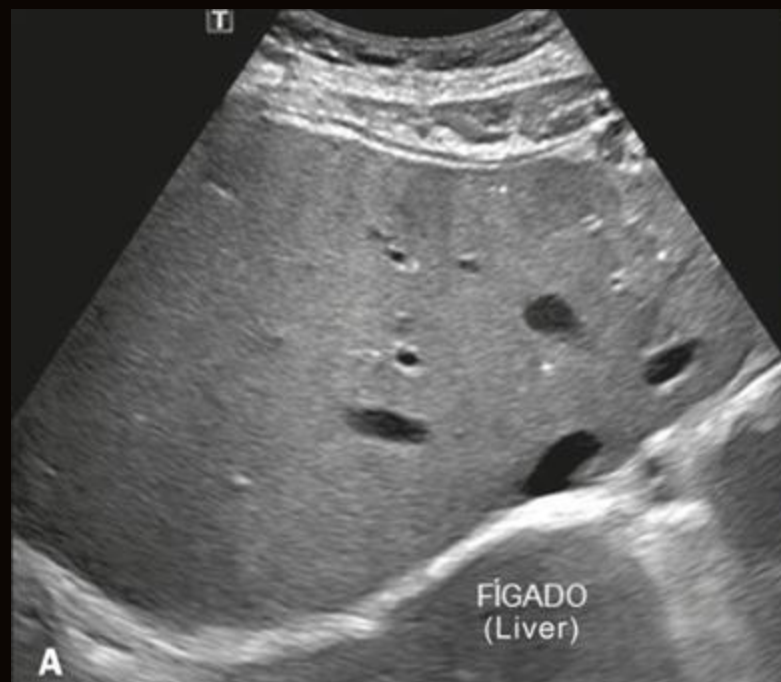
Hypertension

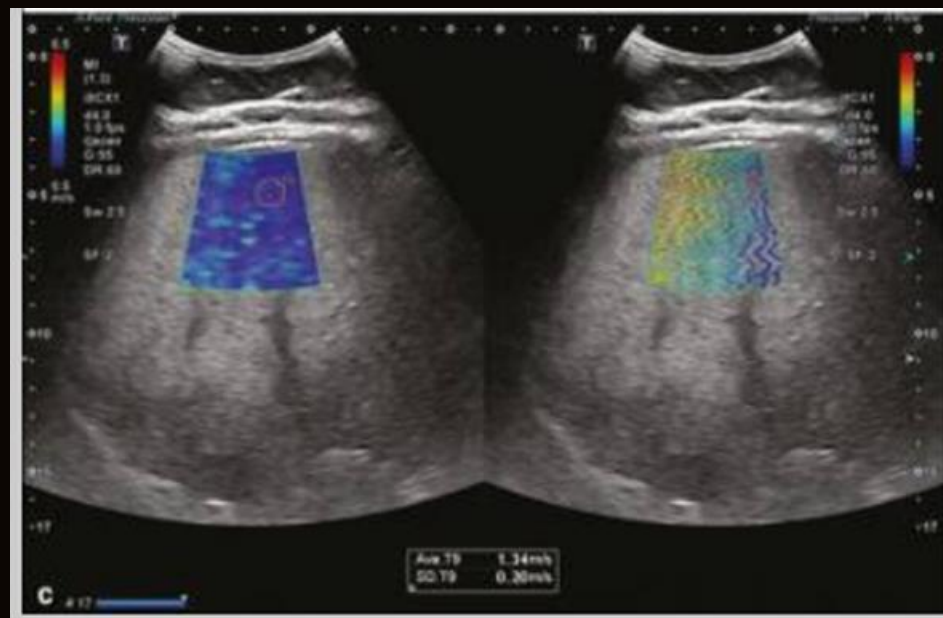
Impaired glucose metabolism

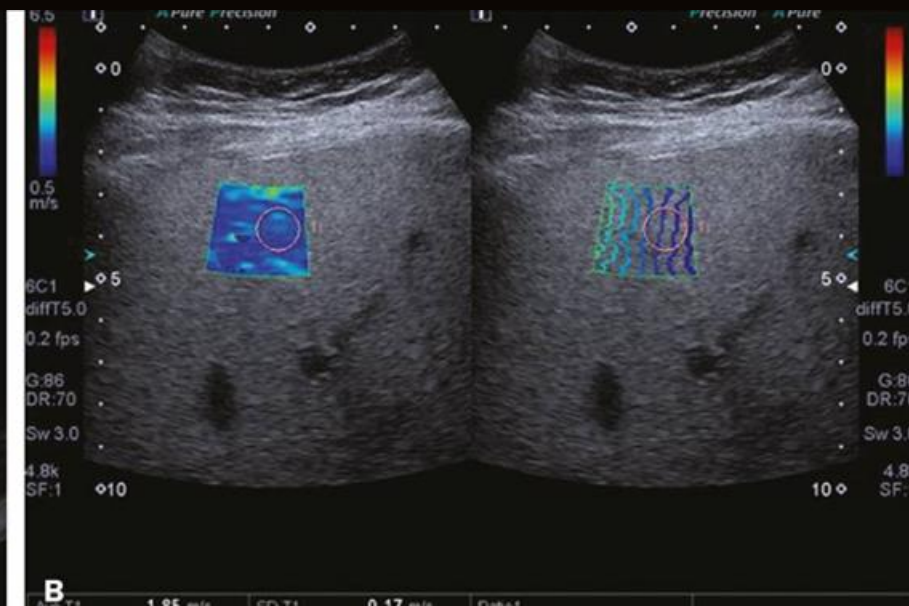
Low HDL cholesterol

Hypertriglyceridemia

FibroScan
shear wave







<5 kPa / <1.3 m/s: likely normal

<9 kPa / <1.7 m/s: rules out advanced chronic liver disease if clinical signs are absent

9-13 kPa / 1.7-2.1 m/s: likely chronic liver disease but needs independent confirmation

>13 kPa / >2.1 m/s: suggests advanced chronic liver disease

>17 kPa / >2.4 m/s: suggests significant portal hypertension

Pitfalls and artifacts

False positive elevated values of liver elastography can be seen in many conditions

- acute hepatitis
- AST/ALT values >5x of normal
- obstructive cholestasis
- liver congestion (hepatic outflow tract obstruction)
- post-prandial status
- intense exertion

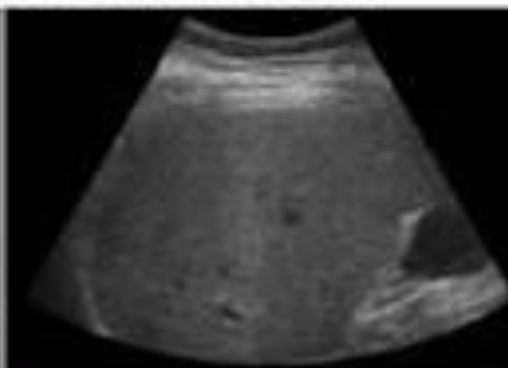
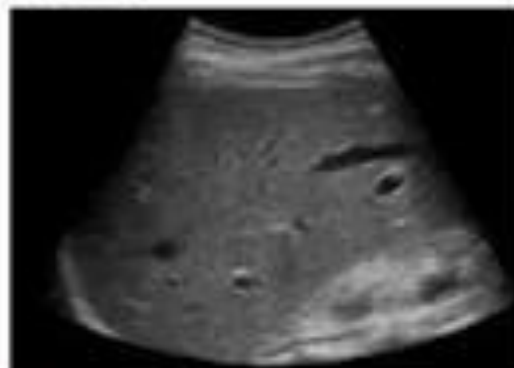
Normal
liver

Mild fatty
liver (NAFLD)

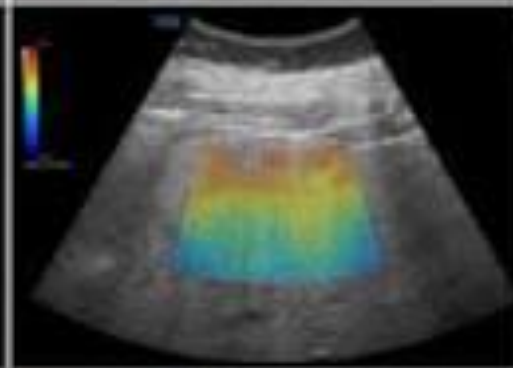
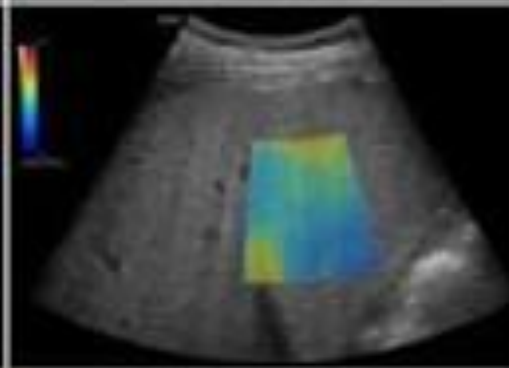
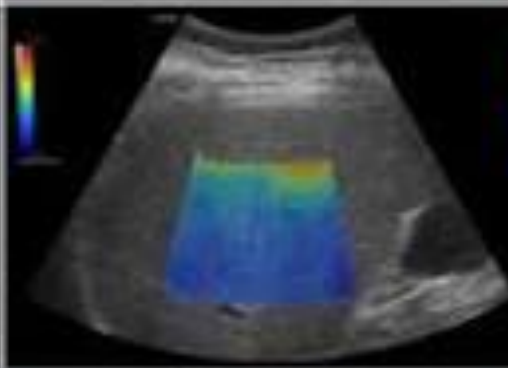
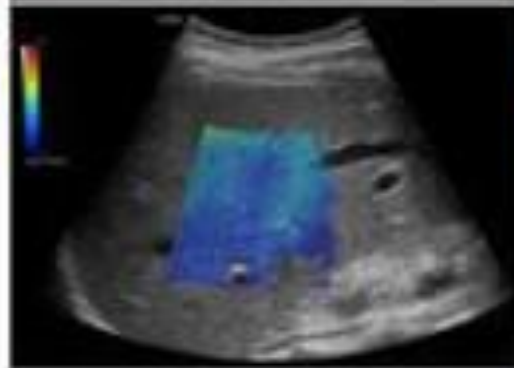
Moderate fatty
liver (NAFLD)

Severe fatty
liver (NAFLD)

Reference
image
B-Mode



Reference
image
Attenuation
Map



Reference
image
Quality Map



CT Evaluation of Fatty Liver

Computed tomography provides objective, reproducible attenuation measurements of the liver. While it lacks the sensitivity of MRI for mild steatosis, CT is widely used due to its availability and quantitative capability using Hounsfield units (HU).

Unenhanced CT

Liver attenuation < 48 HU or liver-to-spleen ratio < 0.9 indicates steatosis. Normally liver HU $>$ spleen HU.

Diagnostic Thresholds

Liver HU $<$ spleen HU: moderate-severe steatosis

Liver-spleen difference < -10 HU: reliable steatosis diagnosis

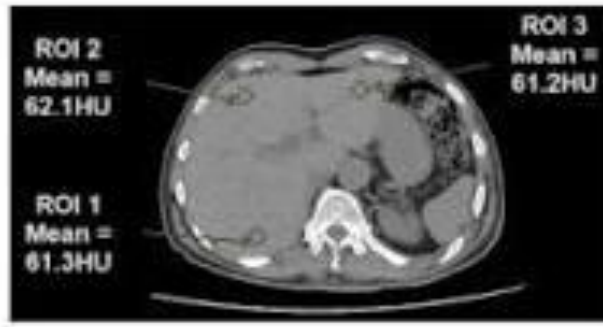
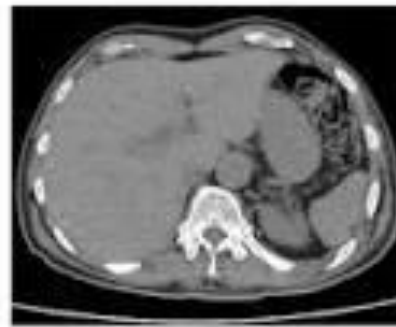
Focal Fat Deposition

Focal low-attenuation areas without mass effect, no vessel displacement; perivascular and periligamentous distribution common.

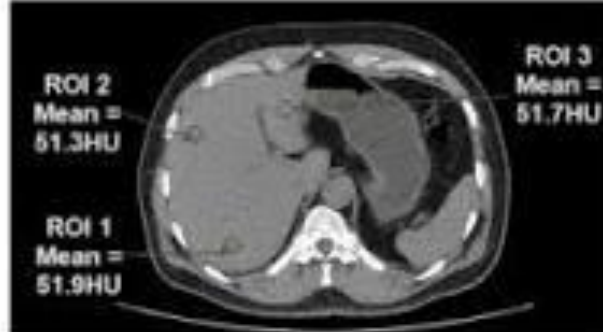
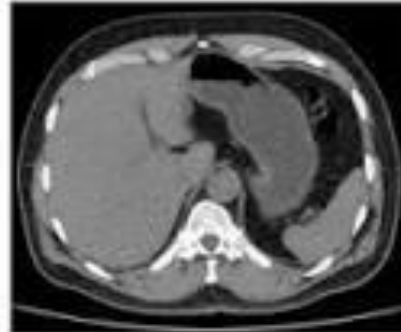
Focal Fat Sparing

Pseudolesion appearance in a diffusely fatty liver; typical locations near gallbladder fossa and falciform ligament.

Grade-0
(Normal liver)



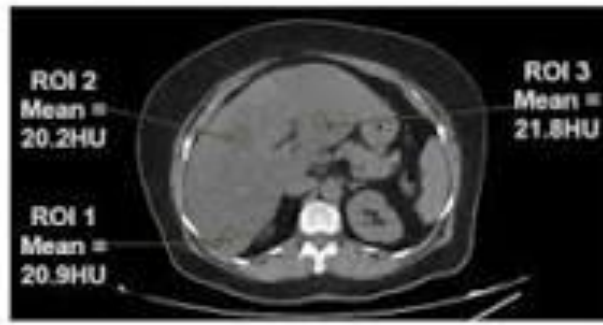
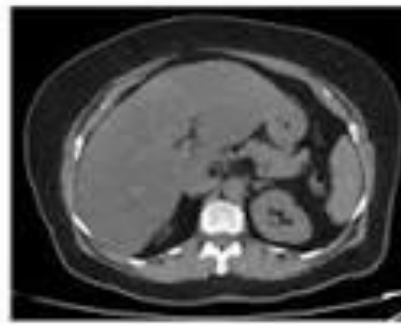
Grade-1
(Mild)



Grade-2
(Moderate)



Grade-3
(Severe)



MRI of Fatty Liver

MRI is the most sensitive and specific non-invasive modality for hepatic fat quantification. Proton Density Fat Fraction (MRI-PDFF) is the current reference standard for non-invasive steatosis grading, with excellent correlation to liver biopsy across all grades of steatosis.

Chemical Shift Imaging (CSI)

In-phase and out-of-phase (opposed-phase) T1-weighted sequences detect intracellular fat via signal dropout on out-of-phase images. Qualitative and semi-quantitative technique.

CSI Interpretation

Signal Drop: Signal intensity loss on opposed-phase relative to in-phase confirms intracellular fat

SII Ratio: Signal Intensity Index >20% indicates significant steatosis

Limitation: Cannot distinguish fat from iron co-deposition without additional sequences

MRI-PDFF (Proton Density Fat Fraction)

Multi-echo Dixon-based technique providing voxel-wise fat fraction maps across the entire liver. Highly reproducible across vendors and field strengths.

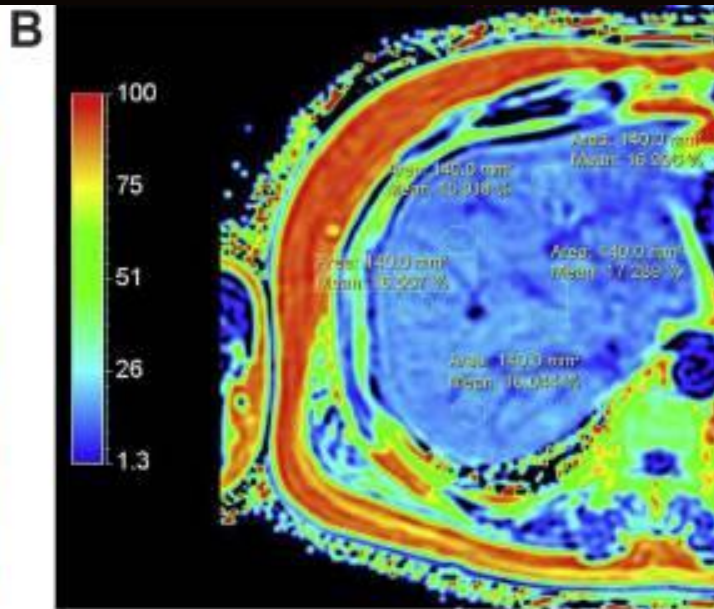
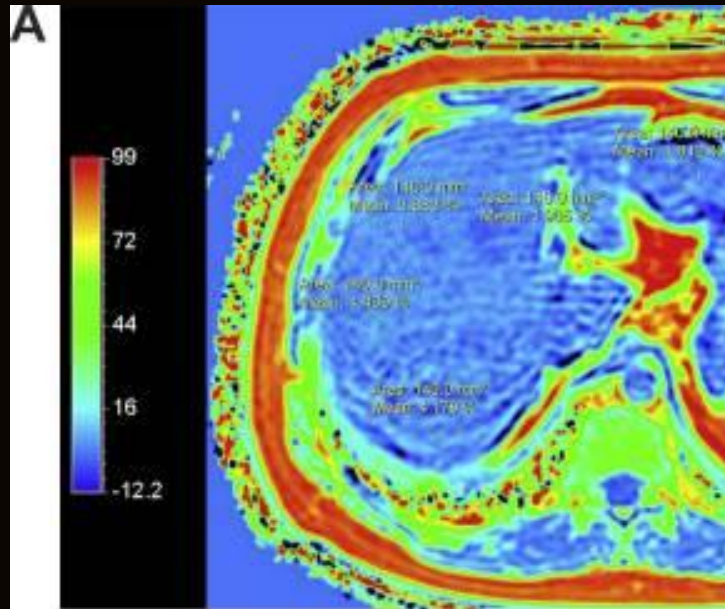
PDFF Thresholds

Grade 1 (Mild): PDFF 5–17%; subtle but measurable fat accumulation

Grade 2 (Moderate): PDFF 17–22%; reliable detection with high confidence

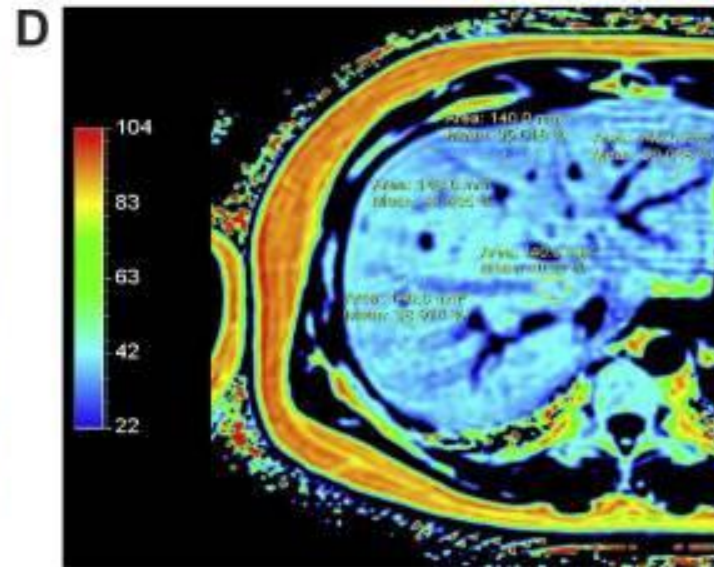
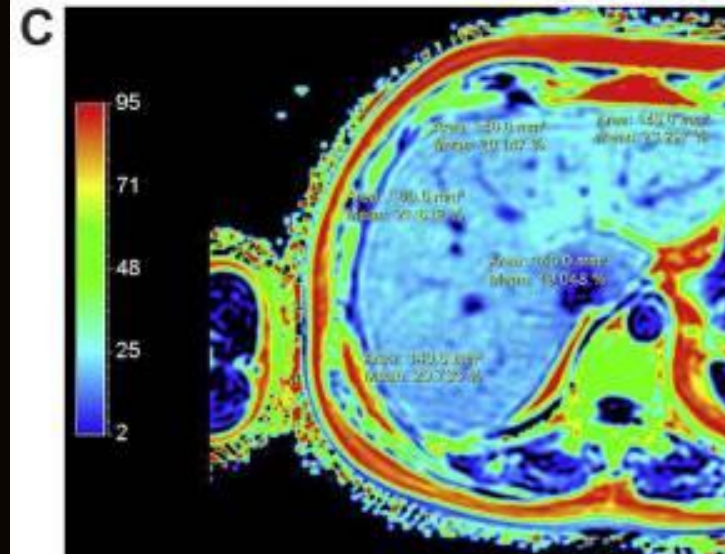
Grade 3 (Severe): PDFF >22%; robust detection across all sequences

(A) MRI-PDFF showing normal liver (PDFF value < 6.5%).



(B) MRI-PDFF showing Grade I fatty liver (PDFF value > 6.5 and < 17.4%).

(C) MRI-PDFF showing Grade II fatty liver (PDFF value > 17.4 and < 22.1%).



(D) MRI-PDFF showing Grade III fatty liver (PDFF value > 22.1%).

Nuclear medicine

Tc-99m sulfur colloid

uptake is reduced in fatty liver ⁵

reduced hepatic uptake relative to the spleen (reversal of normal liver:spleen uptake ratio)

focal fatty area can simulate a hepatic mass ⁷

Xenon-133: accurate quantitative non-invasive assessment of hepatic steatosis ⁸

FDG-PET: (Fludeoxyglucose) liver uptake is not altered by the presence of steatosis

Pitfalls & Differential Considerations

Accurate radiologic interpretation of fatty liver requires awareness of imaging pitfalls, pseudolesions, and overlapping conditions that may mimic or obscure hepatic steatosis across all modalities.

Focal & Atypical Fat Patterns

Focal steatosis: May mimic a hypodense mass on CT — absent mass effect is key.

Focal sparing: Pseudolesion in diffuse steatosis near the gallbladder or ligaments.

Perivascular sparing: Seen near aberrant venous drainage (third inflow).

Subdiaphragmatic fat: Periligamentous location mimics focal lesion on ultrasound

Overlapping & Confounding Conditions

Hepatic iron overload: Reduces T2* signal, confounds MRI fat quantification — R2* correction required.

Hepatocellular carcinoma: Can contain fat; history of cirrhosis and enhancement pattern distinguish.

HCC in fatty liver: Requires multiphasic contrast imaging for confident characterization.

Drug-induced steatosis: Amiodarone, steroids, tamoxifen — clinical correlation essential.

Multimodality Imaging — Key Takeaways

Each imaging modality offers distinct advantages in evaluation of hepatic steatosis. A structured approach guides the selection of the appropriate modality based on clinical context, disease severity, and available resources.

- **Ultrasound — First-Line Screening**

Cost-effective, widely available, and radiation-free. Best for moderate-to-severe steatosis; CAP via FibroScan adds semi-quantitative grading capability in clinical practice.

- **CT — Objective Quantification**

Liver-to-spleen HU ratio provides a reproducible, quantitative assessment. Particularly valuable when CT is performed for other indications — steatosis grading is an important incidental finding.

- **MRI-PDFF — Reference Standard**

proton density fat fraction

از توجه شما سپاسگزارم

