Liver MRI Elastography: A Practical Overview

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INTRODUCTION

The incidence of chronic liver disease is increasing, with liver fibrosis as a common outcome. While biopsy remains the histopathologic reference standard, current clinical guidelines mandate initial non-invasive risk stratification. Magnetic Resonance Elastography (MRE) serves as the non-invasive gold standard, utilizing mechanical shear wave propagation to accurately quantify hepatic stiffness.

PROCEDURE AND IMAGING FINDINGS

MRE uses an external driver to transmit low-frequency vibrations to the liver. Phase-contrast sequences capture the resulting shear waves, which an inversion algorithm converts into quantitative elastograms measuring shear stiffness in kilopascals (kPa). Images are acquired during an end-expiration breath-hold.

MRI Scanner:

- GE, Siemens or Philips - 1,5T or 3.0T

Driver system:

- Active driver: producing sound waves, outside of the room

- Passive driver: rigid, secured on the patient with strap

1. Patient Preparation:

Patients fast for 4 hours prior to the examination (postprandial state increases stiffness) and hold their breath at end-expiration to ensure consistent slice positioning.

2. Positioning of Passive Driver:

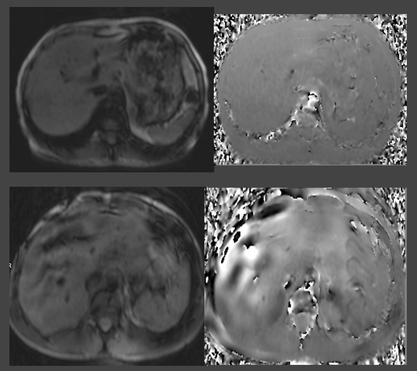
The passive driver is placed over the right hepatic lobe, typically using the xiphoid process and right midclavicular line for positioning.

3. MRE Sequences and Slice Positioning:

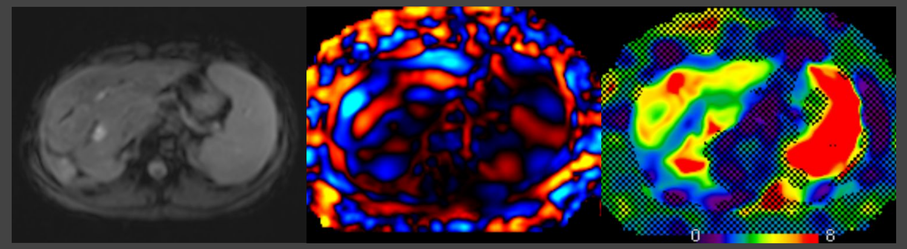
The standard gradient-recalled echo (GRE) sequence yields high-resolution stiffness maps but is highly susceptible to T2* signal dropout, leading to acquisition failure in patients with hepatic iron overload. Spin-echo echo-planar imaging (SE-EPI) mitigates this iron sensitivity and reduces respiratory motion through faster acquisition, but it is prone to geometric distortion and offers lower spatial resolution. The active driver frequency is standardized at 60 Hz.

Four axial slices are positioned to cover the largest liver surface area at the portal bifurcation, avoiding the liver dome and inferior liver tip.

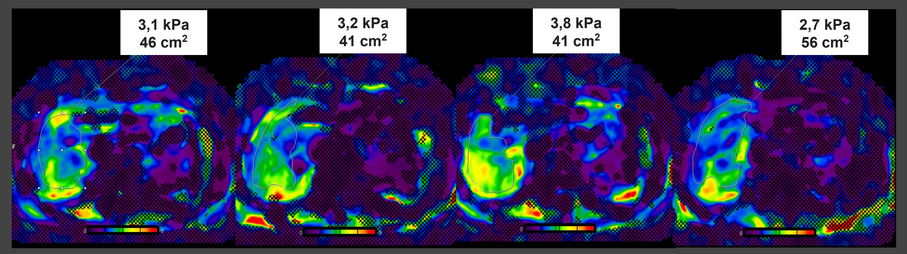
a) Position of passive driver.



b) Magnitude images with appropriate subcutaneous signal void in the bottom picture.



c) Magnitude, wave and elastogram images of a successful MRE.



d)The weighted mean for this example would be 3,15 kPa, which would be reported as mild fibrosis (F1).

4. MRE Images and quality control:

Magnitude Images: Provide a conventional anatomic reference to assess background signal quality, identify potential artifacts like iron overload, and guide the accurate placement of measurement regions of interest (ROIs) away from large vessels or liver margins.

Wave Images: Display the physical propagation of the mechanical shear waves through the hepatic parenchyma, allowing visual confirmation of adequate wave amplitude, continuous wave progression and sufficient liver penetration.

Elastogram Images: Serve as quantitative, color-coded maps generated by an inversion algorithm that translate the underlying wave propagation data into measurable tissue stiffness values expressed in kilopascals (kPa).

Quality control involves reviewing magnitude images for signal voids, wave images for wave propagation, and elastograms for diagnostic quality.

5. MRE Analysis and Measurements: Images (magnitude, wave, color elastograms) are reviewed, and stiffness is measured in kilopascals (kPa) using free hand region of interest (ROI) on the elastogram map, excluding areas prone to artifacts.

Weighted arithmetic mean is calculated of the mean liver stiffness values obtained from the ROIs drawn on four sections, with each section having an ROI size of w pixels would be:

$$AM = (m1w1 + m2w2 + m3w3 + m4w4) / (w1 + w2 + w3 + w4)$$

SAR/LI-RADS universal fibrosis thresholds (for all etiologies, 2024 consensus):

Normal < 2.5; Normal or Inflammation 2.5 – 2.9; Stage 1 or higher (F1+) ≥ 3.0; Stage 2 or higher (F2+) ≥ 3.5; Stage 3 or higher (F3+) ≥ 4.0; Stage 4 (Cirrhosis, F4) ≥ 5.0

CONCLUSION

MR liver elastography provides a highly reliable and reproducible quantitative assessment of liver fibrosis. Its high diagnostic accuracy is essential for non-invasively managing, risk-stratifying, and longitudinally monitoring patients with chronic liver disease.

REFERENCES AND FURTHER READING

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