MR Elastography of Liver

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Disclosure

No financial interest to declare
Outline

• MR Elastography
• Principle & Technique of MRE of Liver
• Clinical applications of MRE
• MRE in PBC - Mayo experience
Magnetic Resonance Elastography (MRE)

- MRI + Elastography

Elastography - method for direct imaging of mechanical (viscoelastic) property of tissues

MRE - provides quantifiable parameters for measuring mechanical property of tissue

Tissue elasticity (stiffness)
Tissue Elasticity
Clinical application of elasticity
Chronic Liver Disease

Normal → Fibrosis → Cirrhosis

Tissue Stiffness
Shear waves to assess stiffness

Hard

Soft
MRE of Liver: Principle

Propagation of Shear waves

Conventional MR Image

MRE sequence

Displacement (µm) Shear stiffness (kPa)

Wave image → Elastogram

Inversion
Preparing for liver MRE

- Suitable for MRI
  - No contraindications
  - No devices susceptible to magnetic field
- Fit in the MRI scanner (60-70cm bore)
- Fasting 4 - 6 hours
  - Post prandial increase in stiffness
  - No high sugar drink/soda/pop during fasting
  - Same prep during follow up
MRE of Liver: Set up

MRE
Vibration Source

MRE
Abdominal Driver
Conventional MRI exam of Abdomen: 
~ 30 - 45 min

MR Elastography: 
adds ~ 5 min
Clinical Applications of MRE

• Detection and staging of liver fibrosis
• Assess response to treatment
• Prediction of decompensation
Staging of Liver Fibrosis

Stage 1: 2.1 kPa
Stage 2: 3.1 kPa
Stage 3: 4.8 kPa
Stage 4: 10.8 kPa
Liver Shear Stiffness (kPa)

* Based on clinical experience, histological correlation, and feedback from Gastroenterologists and Hepatologists

## MRE of Liver Experience

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<tr>
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Diagnostic Performance of Magnetic Resonance Elastography in Staging Liver Fibrosis: A Systematic Review and Meta-analysis of Individual Participant Data

Siddharth Singh,* Sudhakar K. Venkatesh,† Zhen Wang,§ Frank H. Miller,‖ Utaroh Motosugi,¶ Russell N. Low,# Tarek Hassanein,** Patrick Asbach,†† Edmund M. Godfrey, §§ Meng Yin,‡ Jun Chen,¶ Andrew P. Keaveny,¶¶ Mellena Bridges,¶¶¶ Anneloes Bohte,## Mohammad Hassan Murad,§ David J. Lomas, §§ Jayant A. Talwalkar,* and Richard L. Ehman‡

**12 studies, 697 patients**

**Etiology:** HBV (11.6%), HCV (47.1%), NAFLD (16.5%), alcoholic liver disease (3.0%), autoimmune hepatitis (4.6%), cholestatic liver diseases (5.9%), and miscellaneous (11.3%)

**RESULTS:** We analyzed data from 12 retrospective studies, comprising 697 patients (mean age, 55 ± 13 y; 59.4% male; mean BMI, 26.9 ± 6.7 kg/m²; 92.1% with <1 year interval between MRE and biopsy; and 47.1% with hepatitis C). Overall, 19.5%, 19.4%, 15.5%, 15.9%, and 29.7% patients had stage 0, 1, 2, 3, and 4 fibrosis, respectively. The mean area under the receiver-operating curve values (and 95% confidence intervals) for the diagnosis of any (≥stage 1), significant (≥stage 2), advanced fibrosis (≥stage 3), and cirrhosis, were as follows: 0.84 (0.76–0.92), 0.88 (0.84–0.91), 0.93 (0.90–0.95), and 0.92 (0.90–0.94), respectively. A similar diagnostic performance was observed in stratified analysis based on sex, obesity, and etiology of CLD. The overall rate of failure of MRE was 4.3%.
The hazard of hepatic decompensation was **4.96 (95% CI 1.4-17.0, p=0.019)** for a subject with compensated disease and mean LSS value $\geq 5.8$ kPa as compared to an individual with compensated disease and lower mean LSS values.
MRE vs. Other Methods

• MRE is proven to superior to
  • Liver function tests
  • Fibroscan
  • Morphological features
  • DWI
  • IVIM
  • Gadoxetate (Eovist) enhanced scans
  • MR Spectroscopy

MRE vs. Liver Function Tests

MRE versus AAR, APRI, PI, ALT and AST values

63 patients with chronic hepatitis B

Fibrosis

Significant Fibrosis

Venkatesh SK et al. European Radiology 2014;24(1):70-8
### MRE vs. VCTE (Fibroscan)

**Entire liver possible**

<table>
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<tr>
<th>Reference</th>
<th>≥F1 TE</th>
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Elastography Meta analysis studies

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Excludes normal controls
Comparison of techniques

Liver Biopsy
- <1 mm x 10-25 mm
- 1/50,000 of Liver

Fibroscan
- 10 mm x 40 mm
- 1/500 of Liver

MR Elastography
- Potentially whole Liver
Performance of MR Elastography in Difficult Situations

- **Obesity**
  - BMI = 36

- **Ascites**

Shear Stiffness (kPa)

Scale: 0 to 20
Limitations of MRE

- Poor Breath hold
- Waves not visible
- Iron overload
- Not valid
Iron Overload

2D GRE MRE

New Spin Echo EPI MRE
Determinants of Liver Stiffness

- Fibrosis
- Inflammation
- Acute biliary obstruction
- Portal pressure
- Venous congestion
- Infiltrative processes

Always consider clinical setting and data when interpreting MRE
MRE in PBC

• Clinical experience at Mayo Clinic

• Other elastography methods
  • Floreani A et al Dig Liver Dis 2011
  • Coprechot C et al. Hepatology 2012
    • VCTE useful in PBC
    • Over 5 year period
      • Liver stiffness is stable in most non cirrhotics
      • Significantly increases in cirrhosis
    • Progression of cirrhosis → poor outcome
  • Zhang HC et al world J Gastroenterol 2016
    • ARFI is useful in evaluation of PBC
39/F with PBC

Liver biopsy - Stage 0-1 fibrosis

LSM 2.4kPa
75/F with PBC

Liver biopsy - Stage 1 fibrosis

MRE - Magnitude image

LSM 2.6kPa
54/M with PBC

Liver biopsy - Stage 2-3 fibrosis

LSM 4.3kPa
52/F with PBC

Liver biopsy: Stage 3-4 fibrosis

LSM 4.9kPa
73/F with PBC

LSM 10.8kPa
Follow up Assessment

73/F with PBC

No significant change in the mean stiffness
Follow up Assessment

70/M with PBC

2013

T2W

LSM 1.8kPa

2017

T2W

LSM 1.9kPa

Stable disease
Follow up Assessment

54/F with PBC

2014
T2W
Delayed

LSM 3.4kPa

2016
T2W
Delayed

LSM 5.3kPa

Worsening stiffness - Progression
Treatment Assessment

52/F with AMA negative PBC on Ursodiol and Prednisone

2010

LSM 3.5kPa

2015

LSM 2.6kPa

Improvement in the stiffness
Follow up Assessment

54/F  PBC

MRE can detect fibrosis even in the absence of morphological changes in the liver.
Summary

• **MRE of Liver**
  • Robust, reliable and reproducible technique for evaluation of liver stiffness.
  • Most accurate test for detection of fibrosis
  • Clinical follow up for progression/regression
  • Assessment of therapeutic response

• **Role of MRE in PBC**
  • Likely useful in evaluation of fibrosis
  • Role in assessment of treatment is promising
Thank you

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