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MR Elastography of Liver

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Disclosure

No financial interest to declare

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Outline

- MR Elastography
- Principle &Technique of MRE of Liver
- Clinical applications of MRE
- MRE in PBC- Mayo experience

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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

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Clinical application of elasticity

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Chronic Liver Disease

Normal

Fibrosis

Cirhosis

Tissue Stiffness

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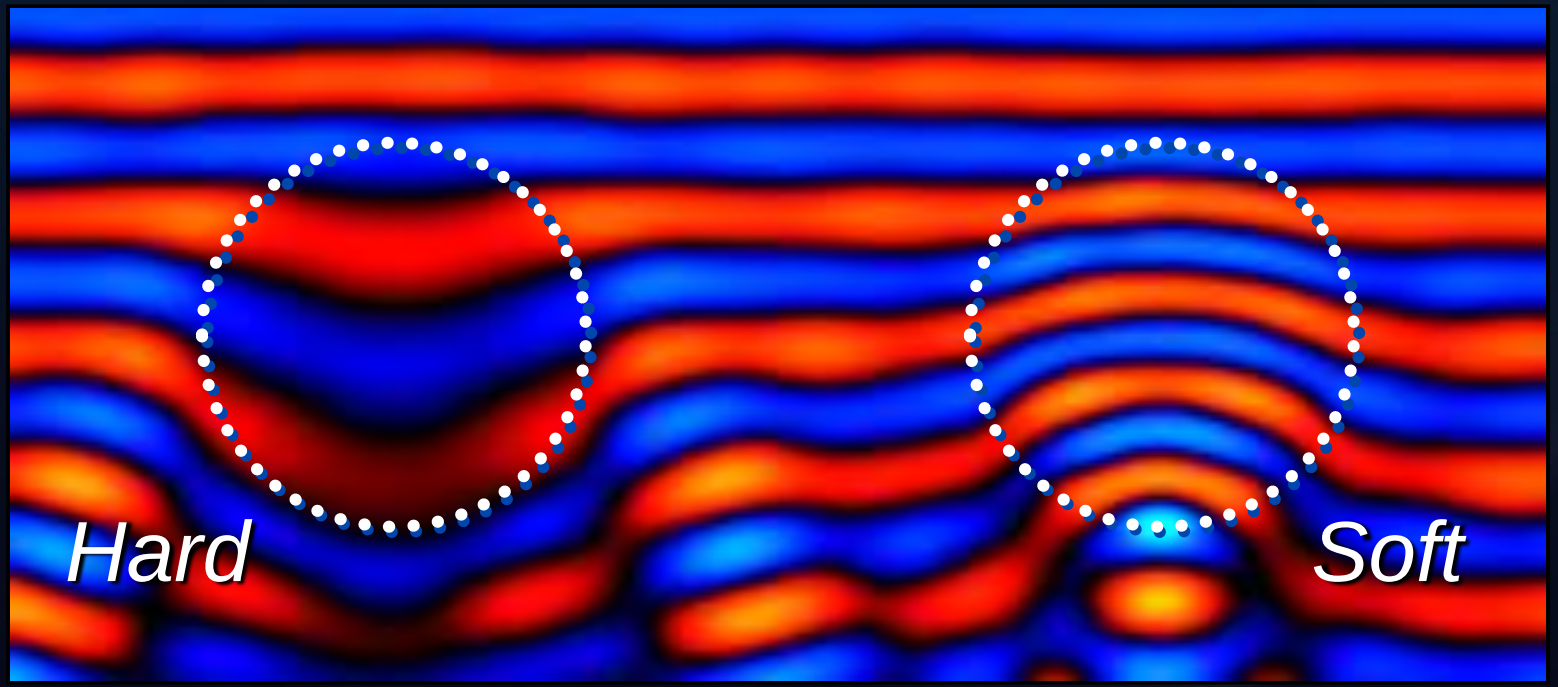
Shear waves to assess stiffness



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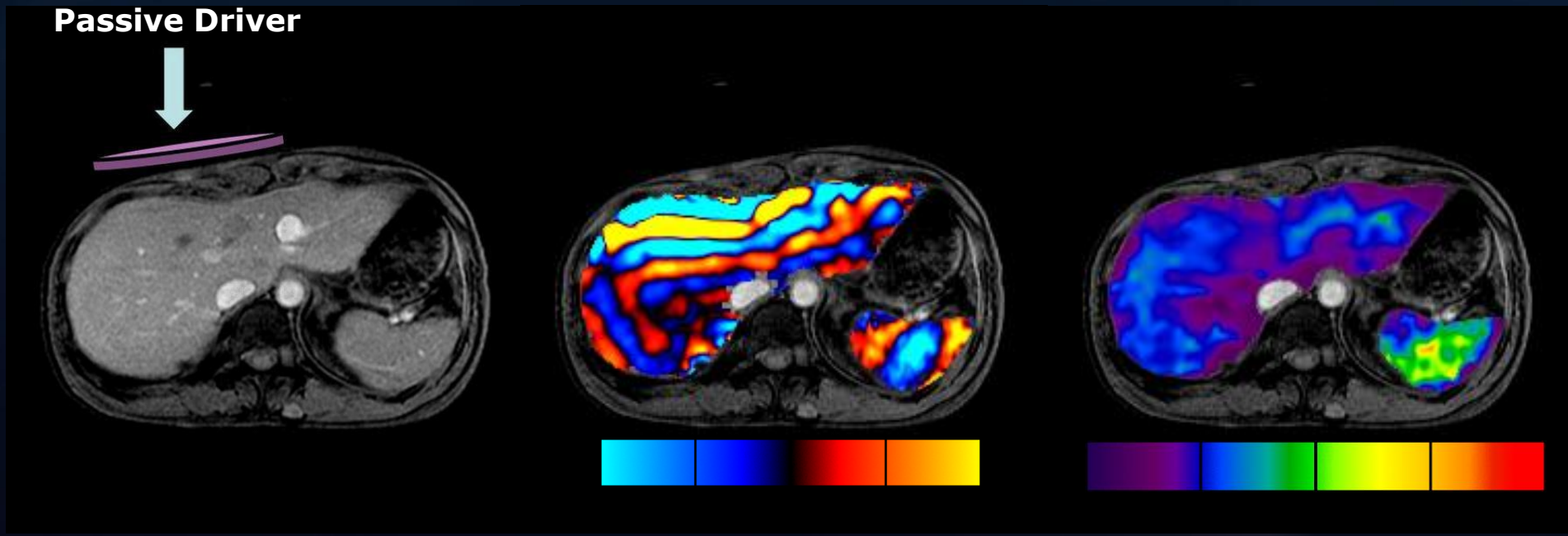
MRE of Liver: Principle

Propagation of Shear waves

MRE sequence

Inversion



Conventional MR Image

Displacement (μm) **Shear stiffness (kPa)**

Wave image → Elastogram

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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

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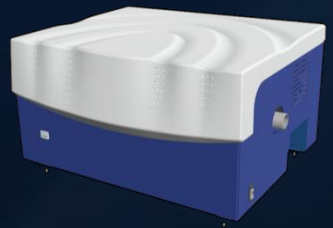
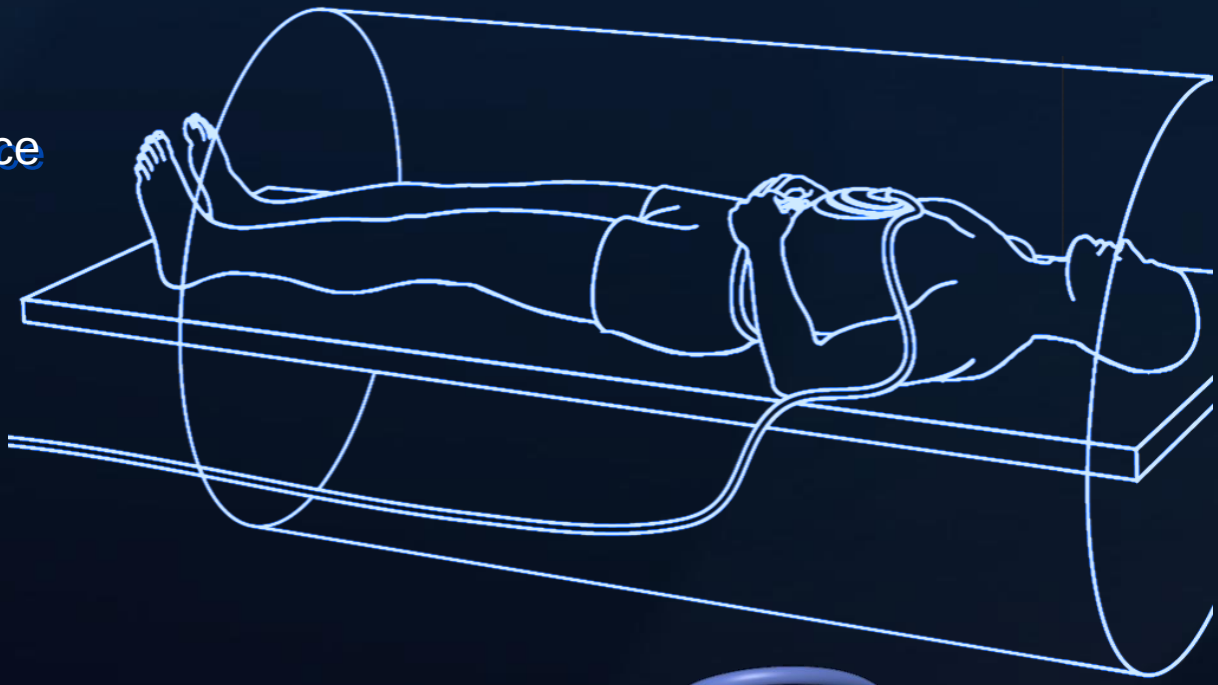
MRE of Liver: Set up



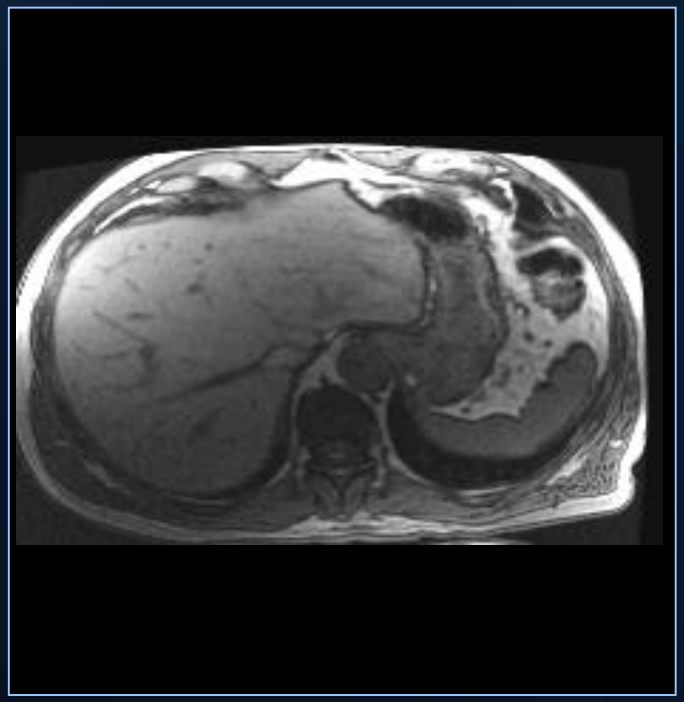
MRE
Vibration Source

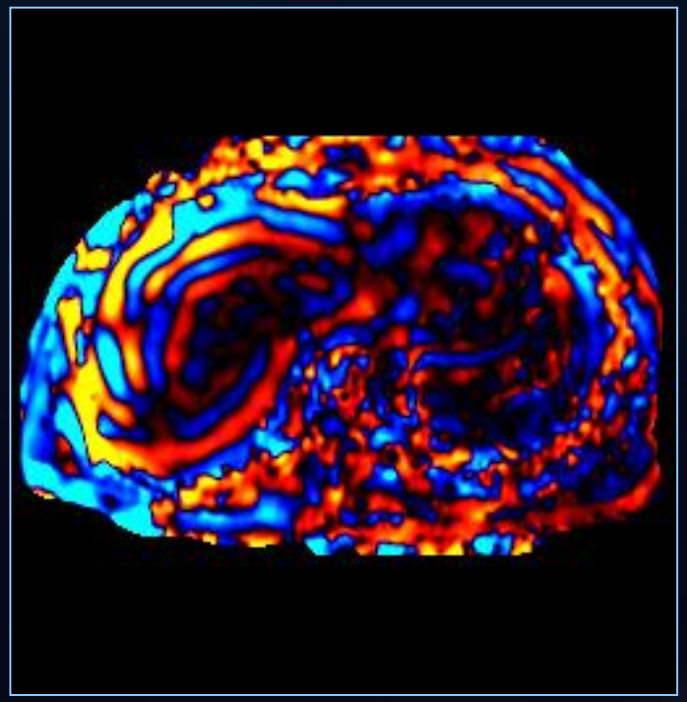


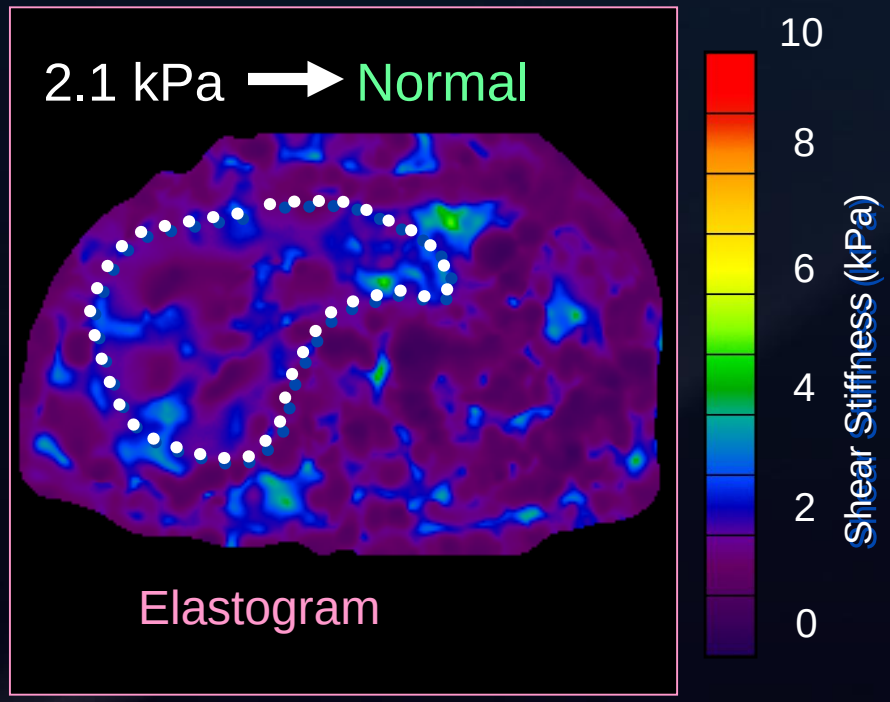
MRE
Abdominal Driver

Conventional MRI exam of Abdomen: ~ 30 - 45 min

MR Elastography: adds ~ 5 min







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Clinical Applications of MRE

- Detection and staging of liver fibrosis
- Assess response to treatment
- Prediction of decompensation

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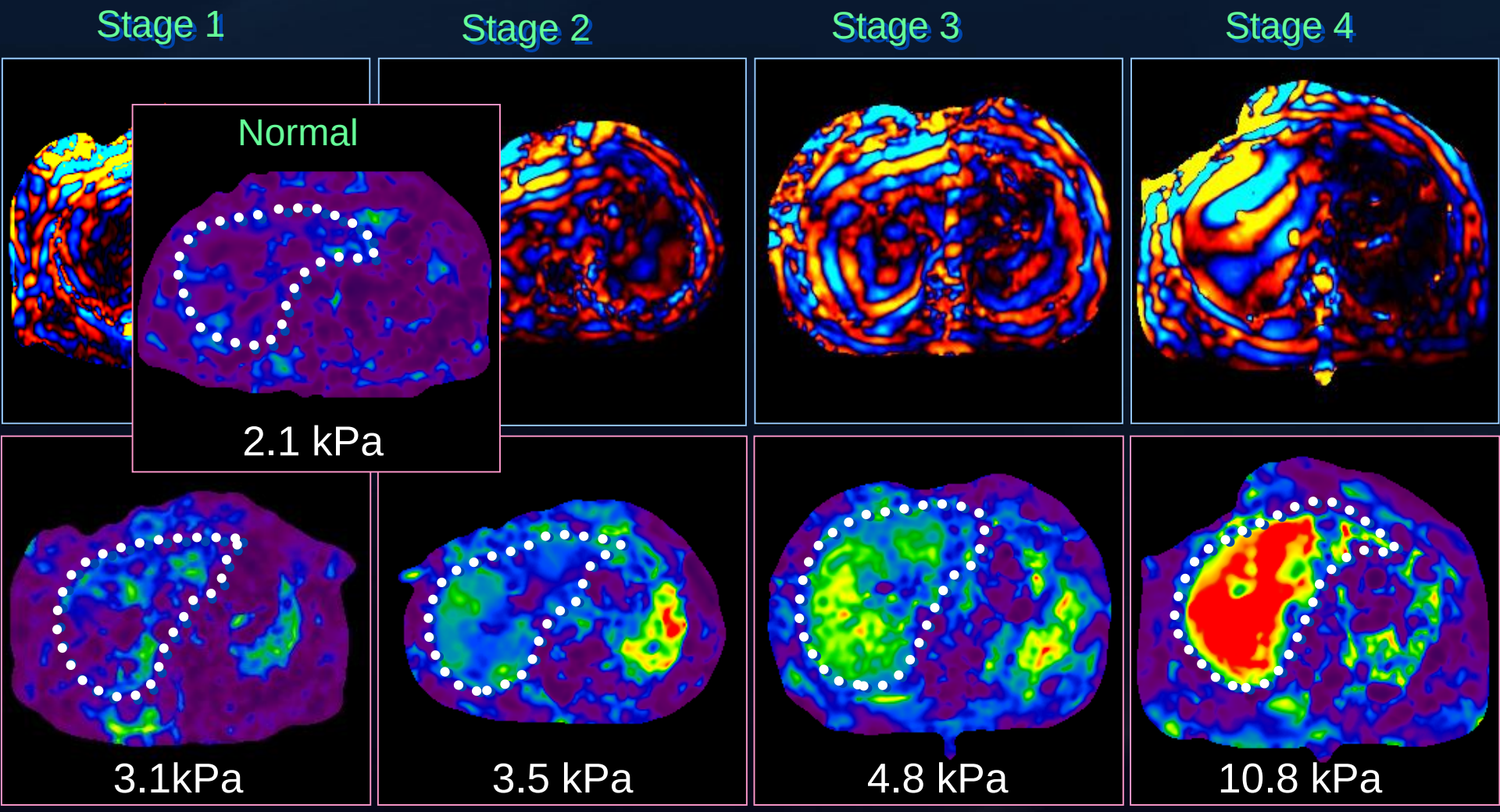
Staging of Liver Fibrosis



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Typical MRE Cut-off Values*

Liver Shear Stiffness (kPa)

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

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Venkatesh SK et al. Radiol Clin North Am 2015

MRE of Liver Experience

Reference	≥ F1	≥ F2	≥ F3	F4
Rouviere et al 2006	1.00	-		
Yin M et al 2007	0.98	0.86	0.92	0.91
Huwart et al 2008	0.96	0.99	0.98	0.99
Asbach et al 2008	0.99			
Huwart et al 2008	0.96	0.99	0.99	1.00
Wang et al 2011	0.92	0.98	0.99	0.95
Kim et al 2011	0.90	0.94	0.98	0.98
Ichikawa et al 2012	0.98	0.98	0.97	0.97
Venkatesh et al 2014	0.99	0.97	0.94	0.94

Rouviere O et al. Radiology 2006; Yin M et al Clin Gastroenterol and Hepatol 2007; Huwart L et al Radiology 2008; Huwart L et al Gastroenterology 2008; Asbach P et al Radioloy 2008; Wang Y et al AJR 2011; Kim et al JMRI 2011; Ichikawa C et al JMRI 2012; Venkatesh SK et al Eur Radiol 2014

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Clinical Gastroenterology and Hepatology 2015;13:440–451

SYSTEMATIC REVIEWS AND META-ANALYSES

Fasiha Kanwal, Section Editor

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/m^2; 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%.

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Prediction of Decompensation

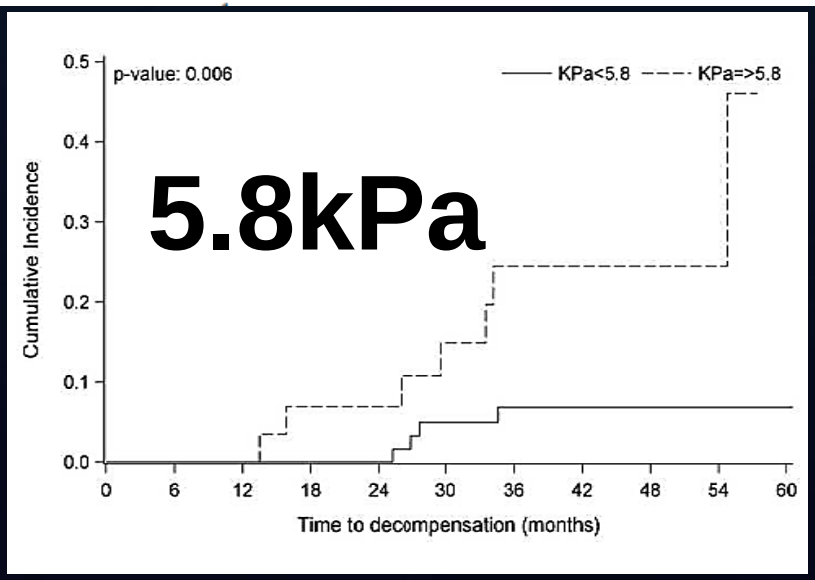
Research Article

CrossMark

EASL EUROPEAN ASSOCIATION FOR THE STUDY OF THE LIVER | JOURNAL OF HEPATOLOGY

Role of magnetic resonance elastography in compensated and decompensated liver disease

Sumeet K. Asrani[1,2], Jayant A. Talwalkar[1,*], Patrick S. Kamath[1], Vijay H. Shah[1], Giovanna Saracino[2], Linda Jennings[2], John B. Gross[1], Sudhakar Venkatesh[3], Richard L. Ehman[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 ⩾5.8kPa as compared to an individual with compensated disease and lower mean LSS values.

J Hepatol. 2014 May;60(5):934-9.

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MRE vs. Other Methods

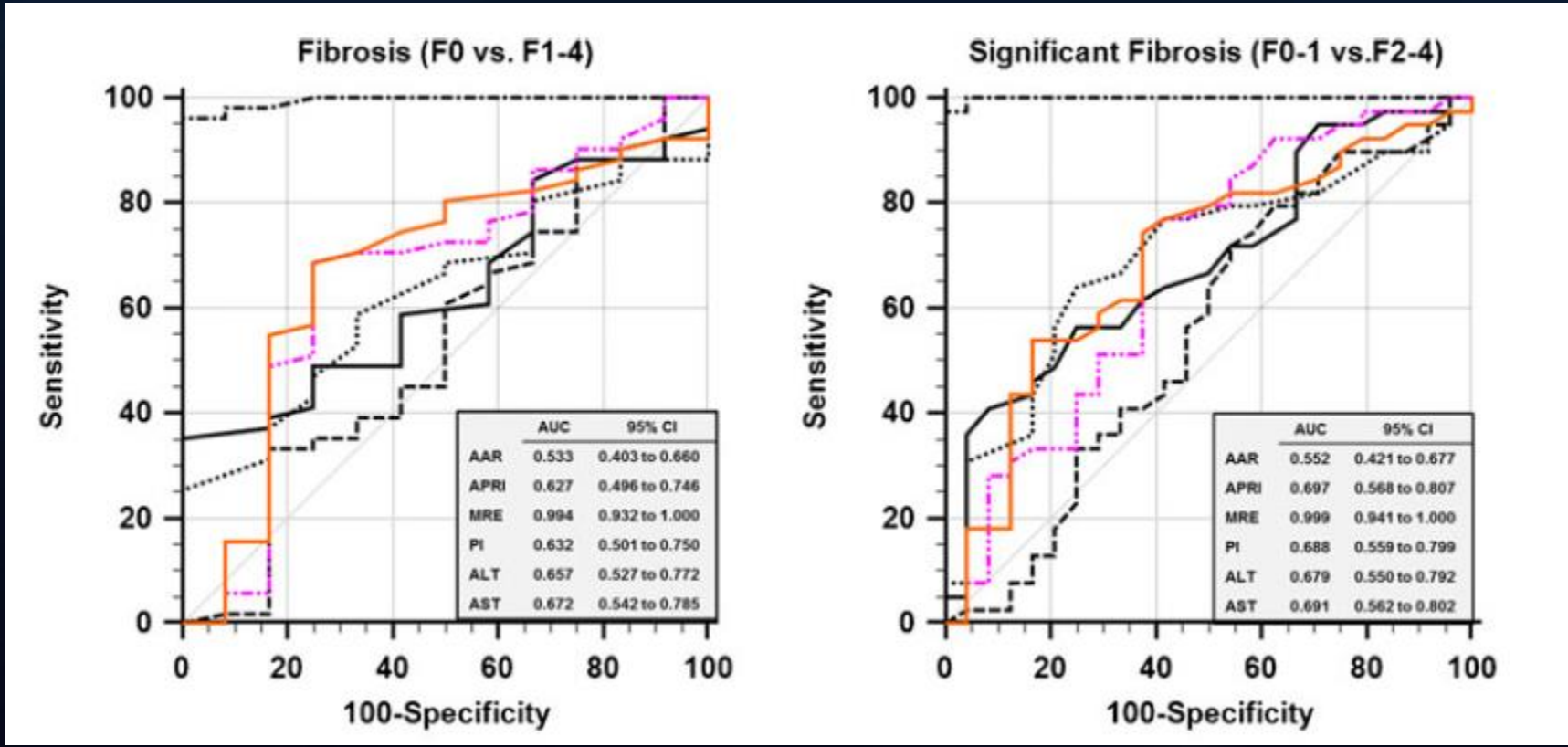
- MRE is proven to superior to
  - Liver function tests
  - Fibroscan
  - Morphological features
  - DWI
  - IVIM
  - Gadoxetate (Eovist) enhanced scans
  - MR Spectroscopy

Huwart et al 2008, Huwart et al 2007, Venkatesh SK et al 2012, Rustogi et al 2010, Venkatesh SK et al 2014, Yoon JH et al 2015, Choi YR et al 2013, Godfrey EM et al 2012

MRE vs. Liver Function Tests

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

63 patients with chronic hepatitis B



Fibrosis **Significant Fibrosis**

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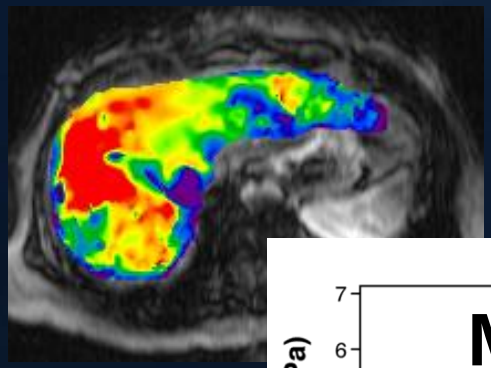
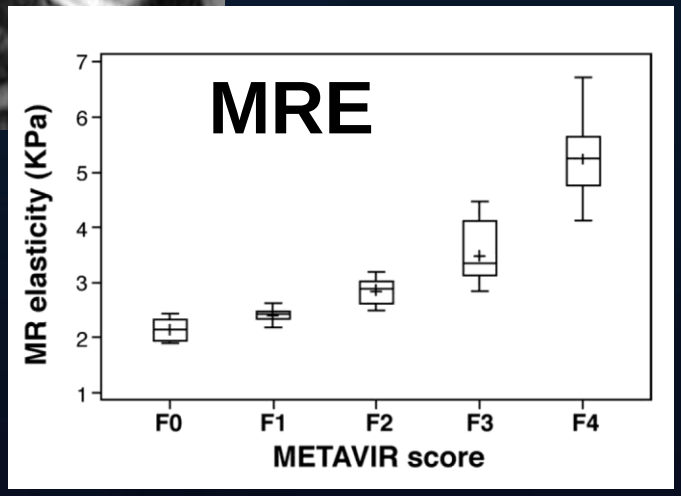
Venkatesh SK et al. European Radiology **2014;24(1):70-8**

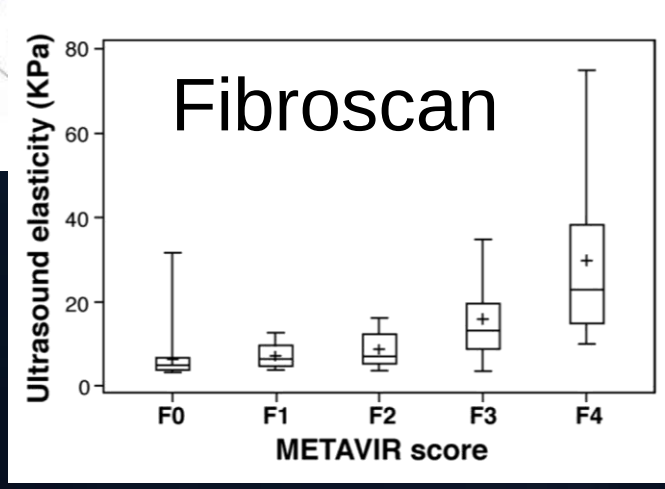
MRE vs. VCTE (Fibroscan)



Entire liver possible



Sample 1/500 of Liver



Reference	≥F1		≥F2		≥F3		F4	
	TE	MRE	TE	MRE	TE	MRE	TE	MRE
Huwart, 2008	**0.80**	**0.96**	**0.84**	**0.99**	0.91	0.98	0.93	0.99
Bohte, 2014			**0.91**	**0.91**	0.89	0.93		
Ichikawa, 2014	**0.87**	**0.97**	**0.87**	**0.98**	0.96	0.98	0.93	0.97

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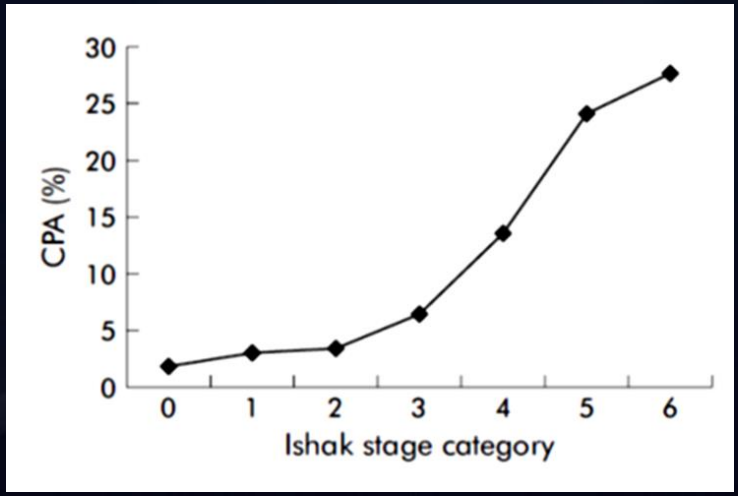
Elastography Meta analysis studies

Reference	Technique	≥F1	≥F2	≥F3	F4
Friedrich-Rust	Fibroscan (TE)		0.84	0.89	0.94
Guo et al.	ARFI	0.82	0.85	0.94	0.94
Wang et al.	MRE	0.95	0.98	0.98	0.99
Guo et al.	MRE	0.94	0.97	0.96	0.97
Singh et al*	MRE	0.84	0.88	0.93	0.92

Excludes normal controls



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Comparison of techniques

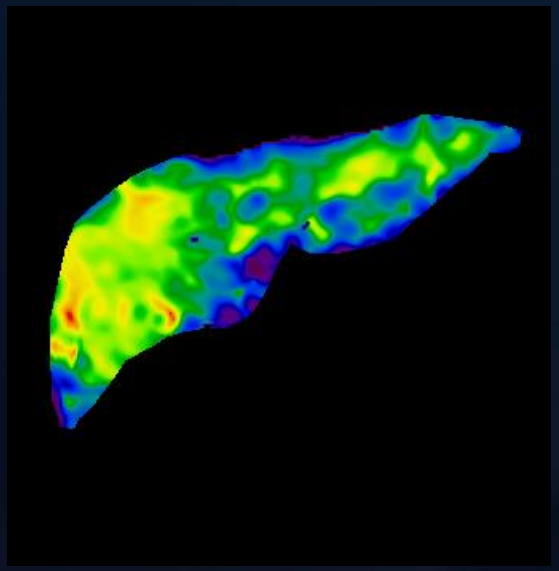
Liver Biopsy

<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

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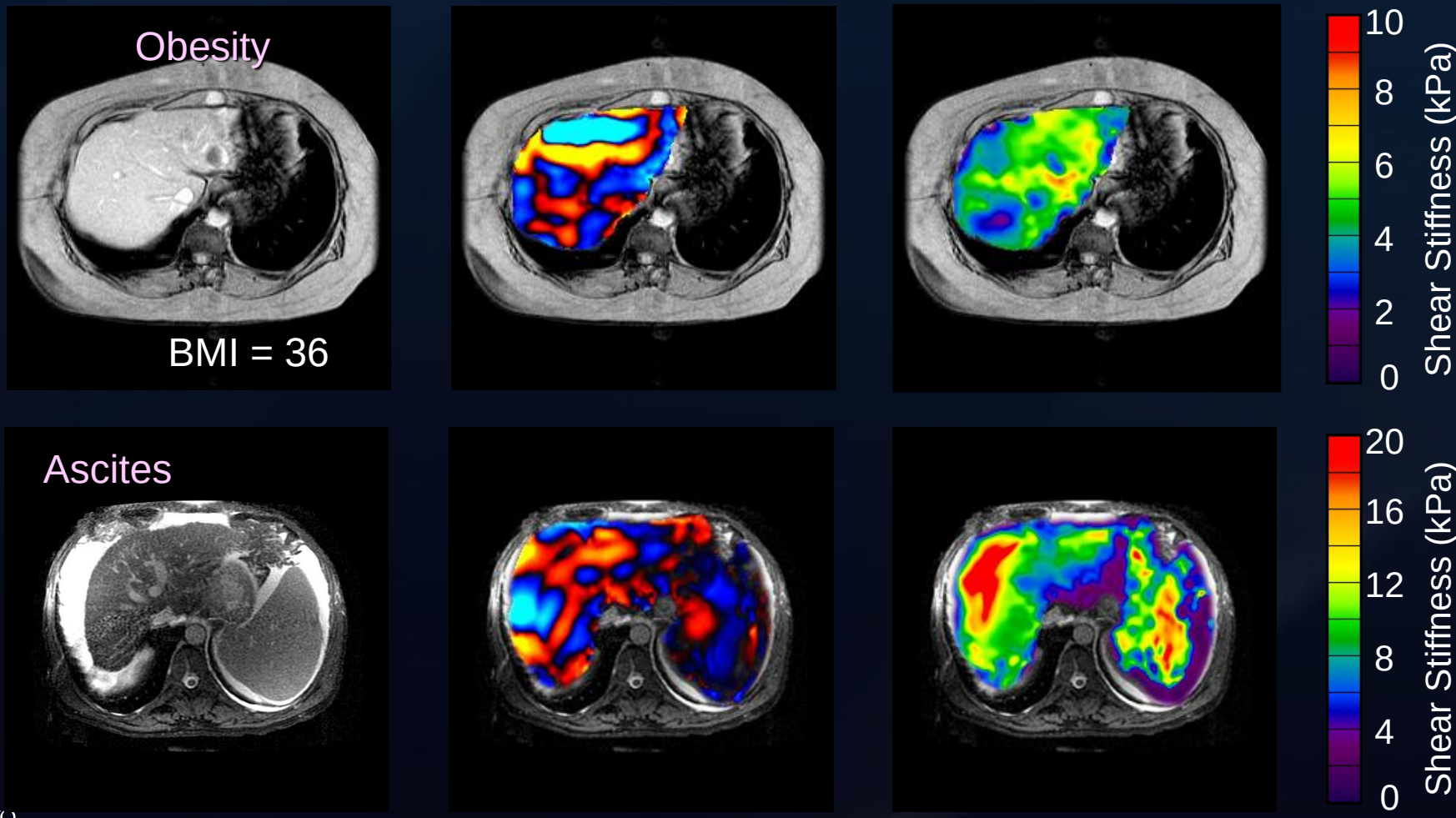
Performance of MR Elastography in Difficult Situations



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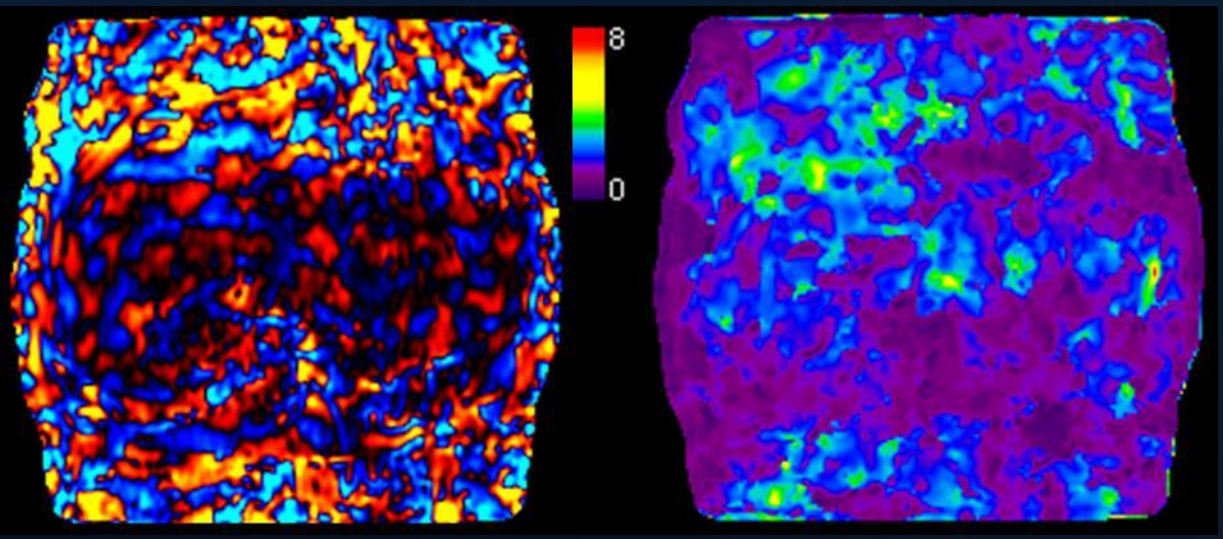
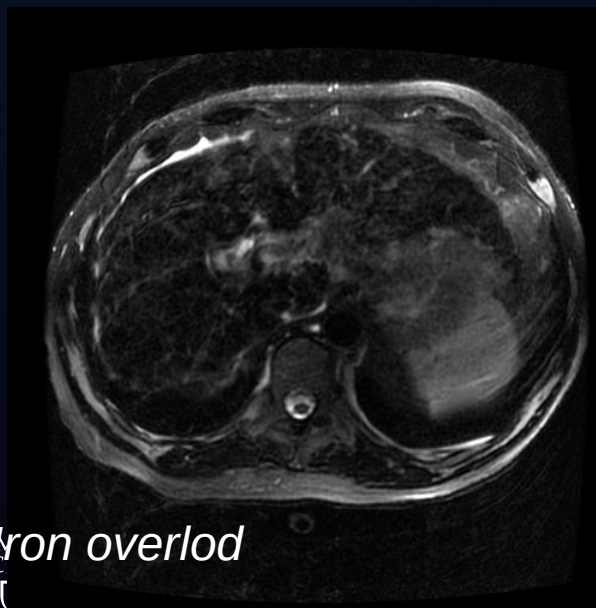
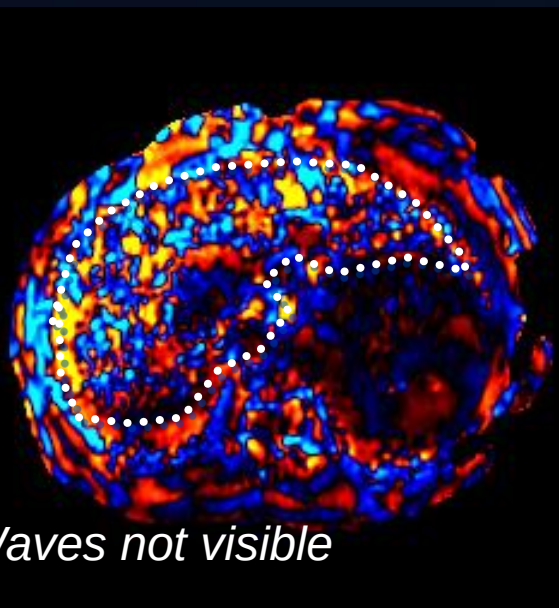
Limitations of MRE

Poor Breath hold

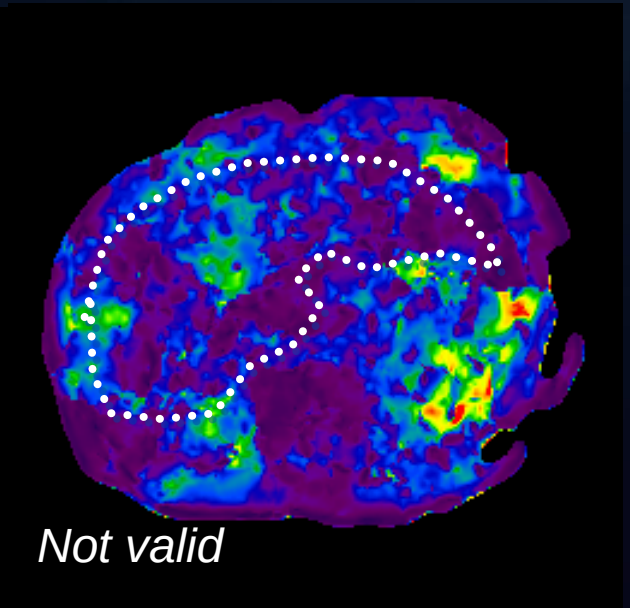




Iron overlod



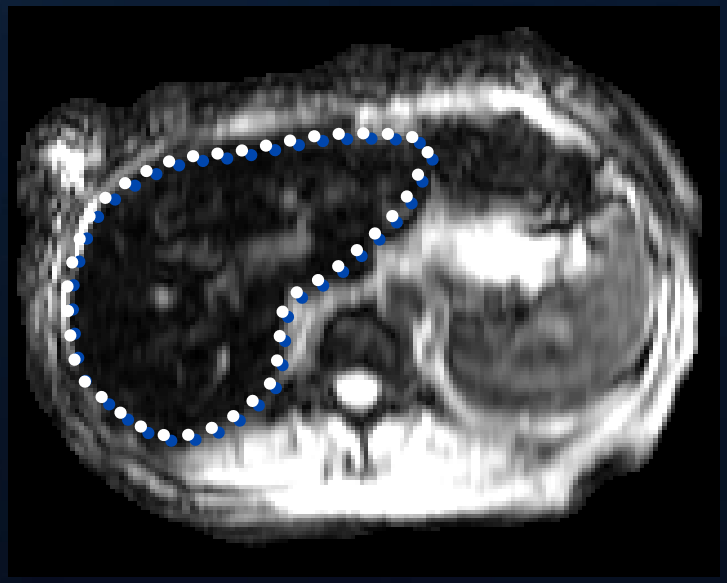
Waves not visible

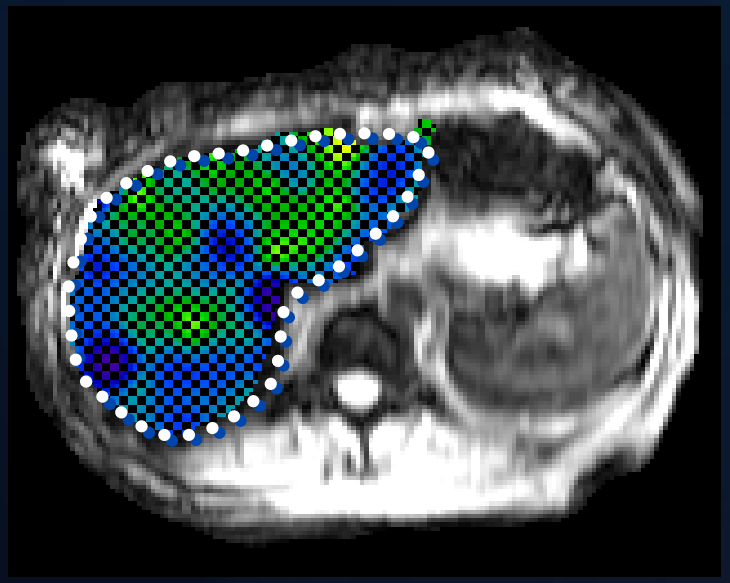


Not valid

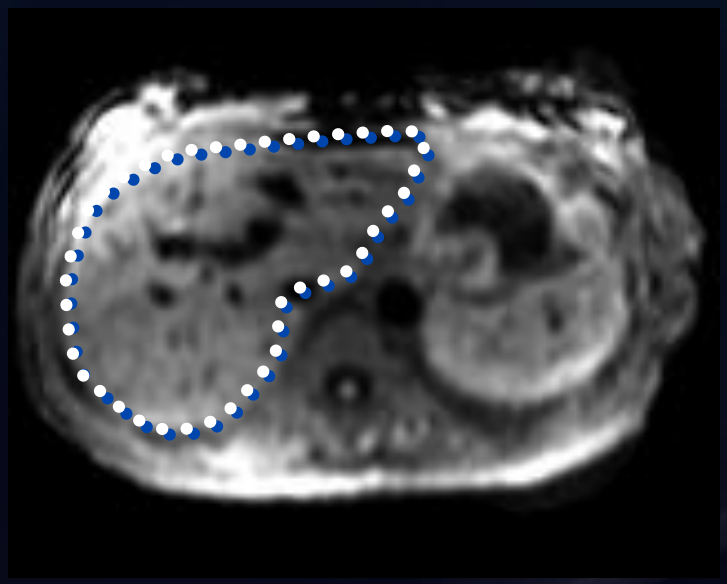
Iron Overload

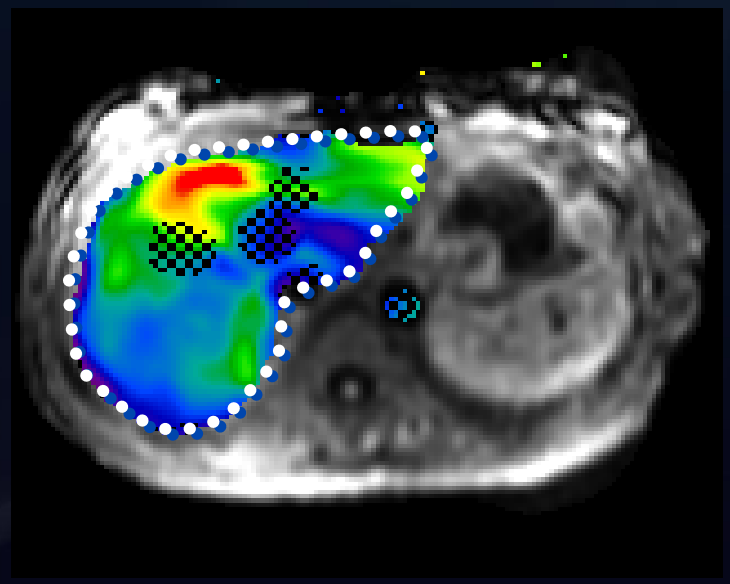
2D
GRE MRE





New
Spin Echo
EPI MRE





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Determinants of Liver Stiffness

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

Always consider clinical setting and data when interpreting MRE

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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**

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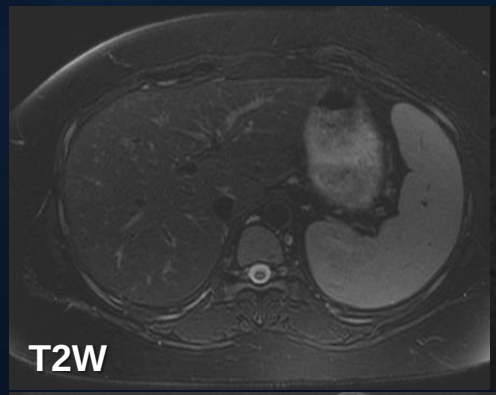
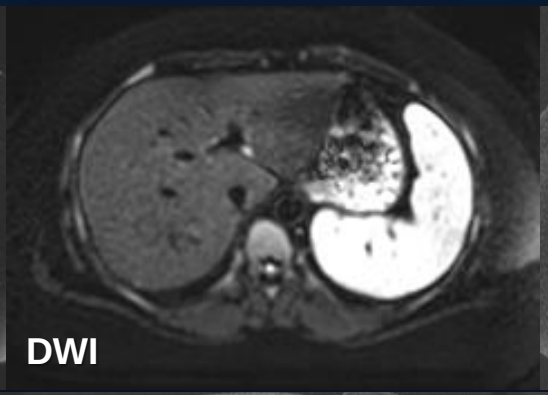
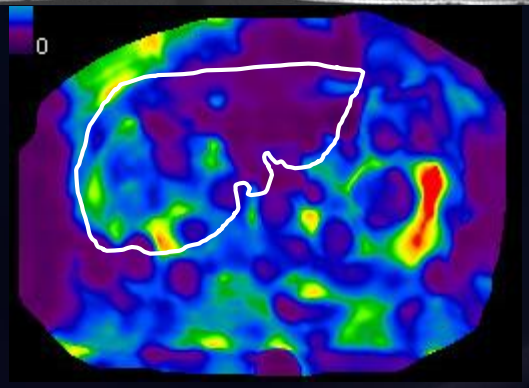
39/F with PBC







LSM 2.4kPa

Liver biopsy- Stage 0-1 fibrosis

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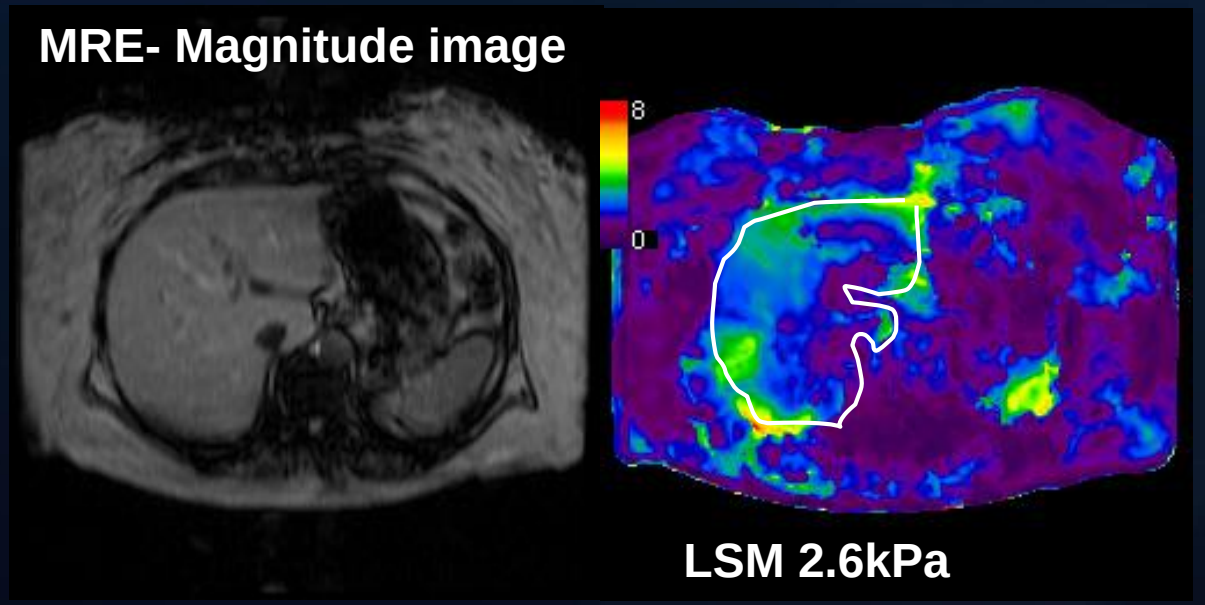
75/F with PBC



Liver biopsy- Stage 1 fibrosis

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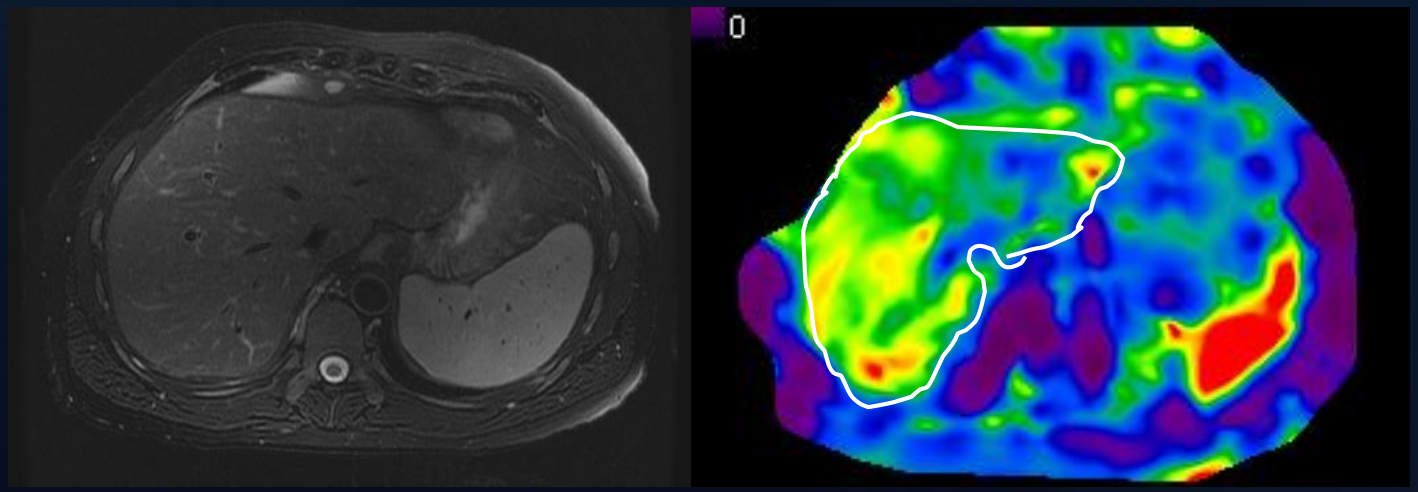
54/M with PBC



LSM 4.3kPa

Liver biopsy- Stage 2-3 fibrosis

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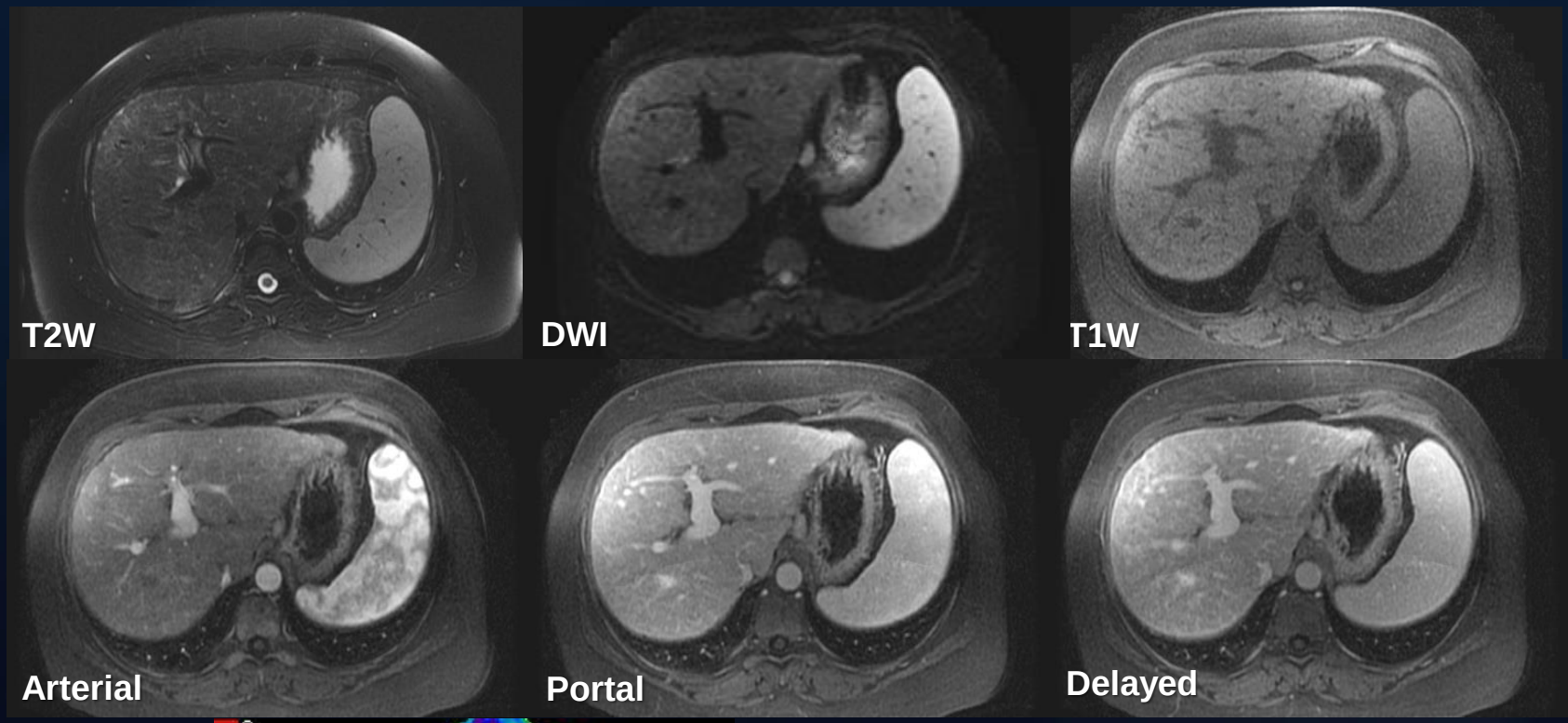
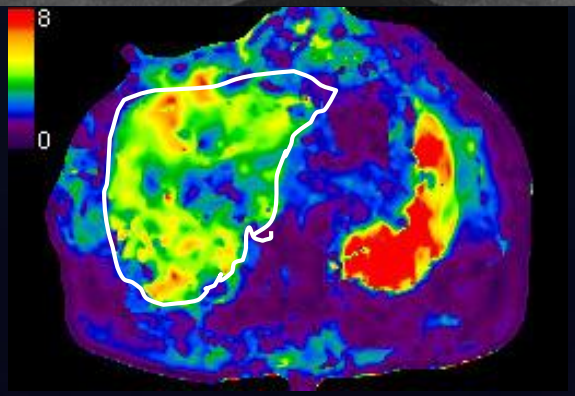
52/F with PBC





LSM 4.9kPa

Liver biopsy: Stage 3-4 fibrosis

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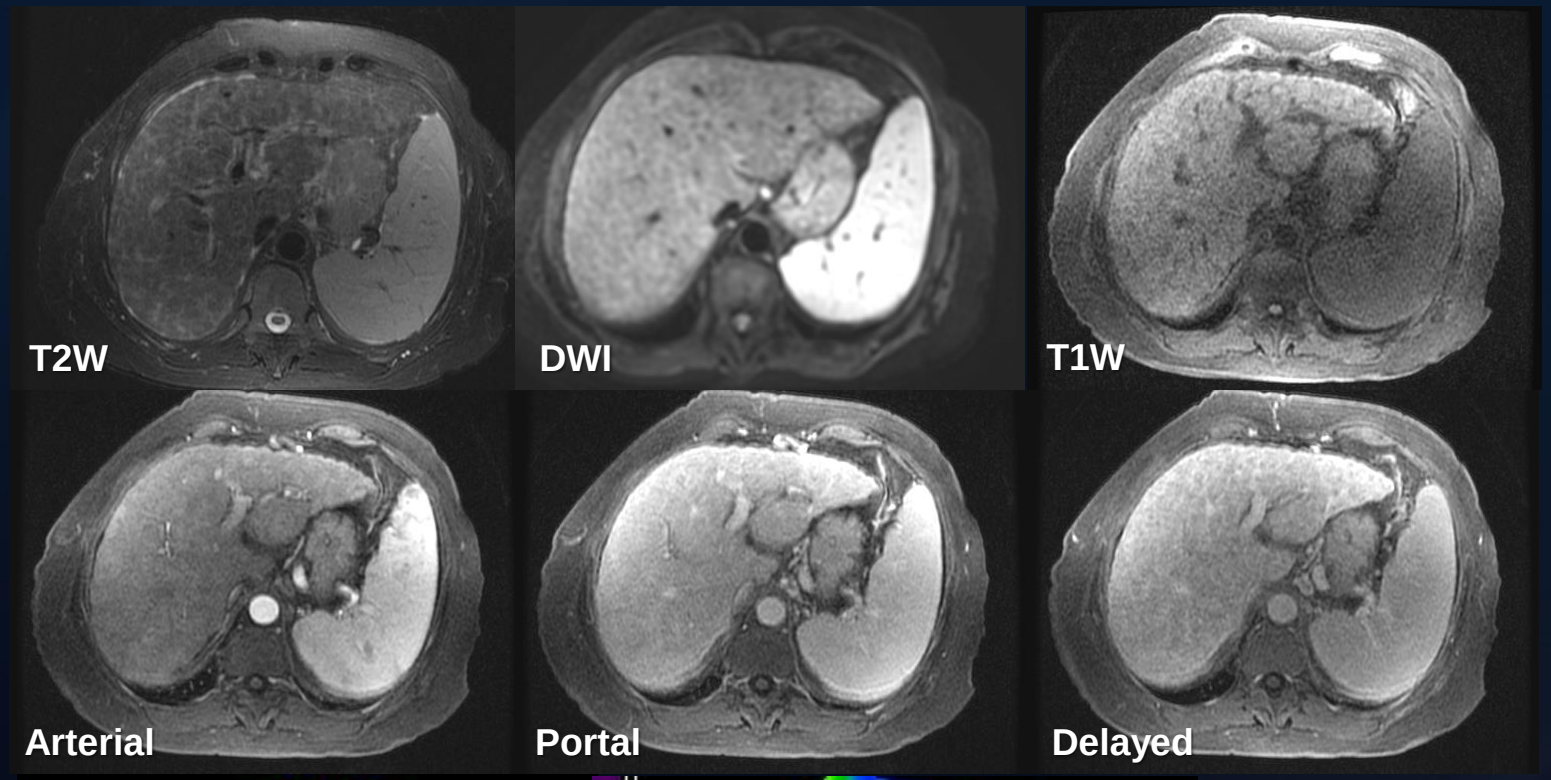
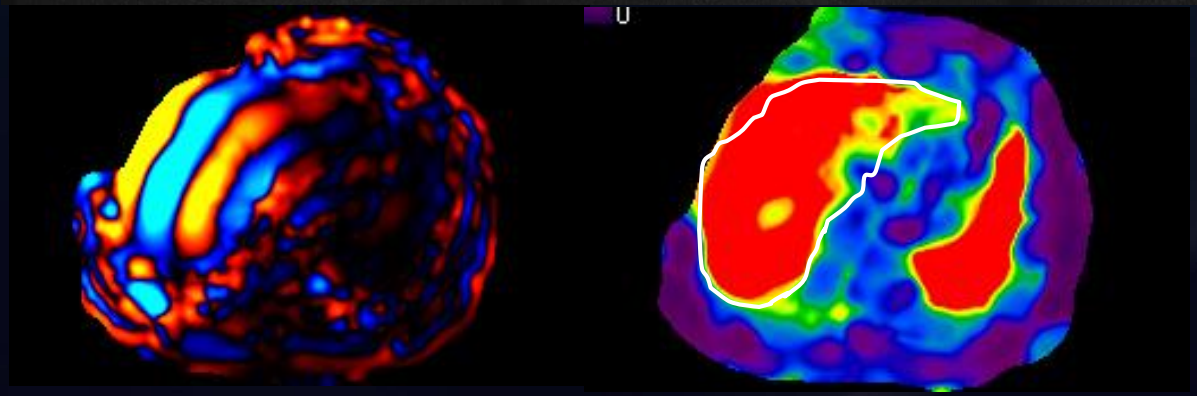
73/F with PBC





LSM 10.8kPa

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Follow up Assessment

73/F with PBC

2015

LSM
5.4kPa

2017

LSM
5.6kPa

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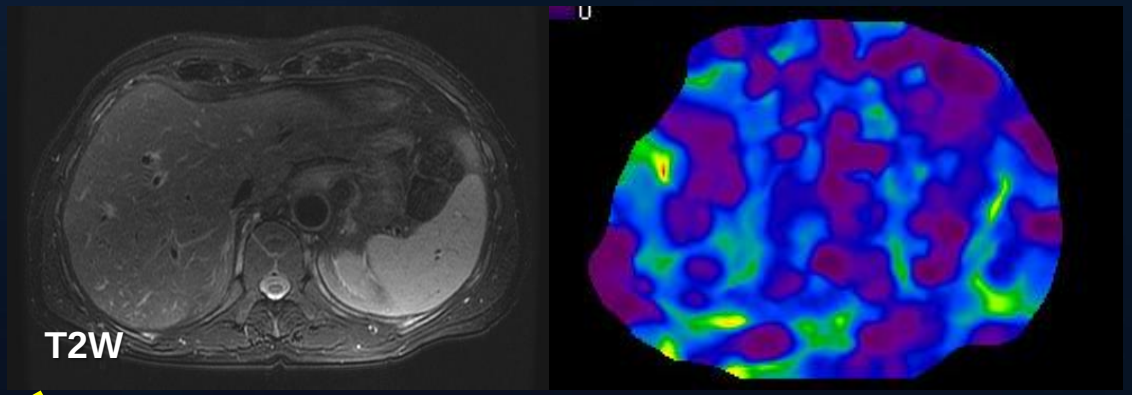
No significant change in the mean stiffness

Follow up Assessment

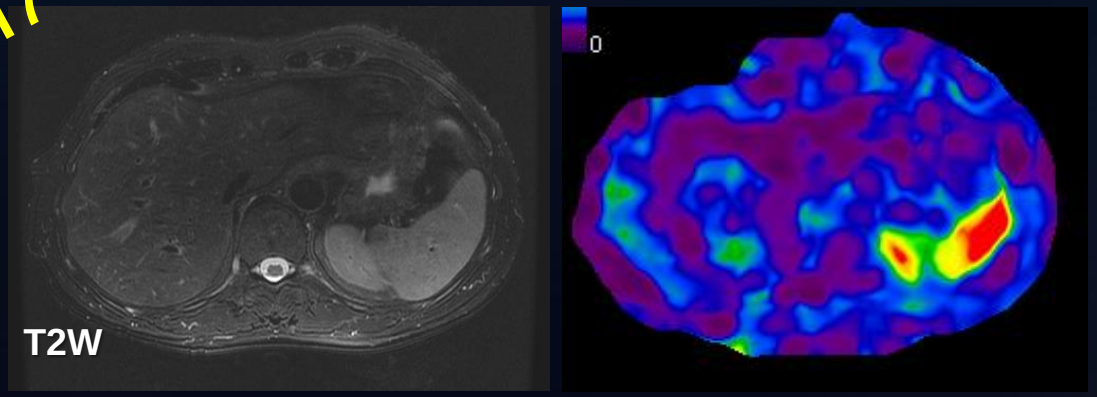
70/M with PBC

2013



LSM 1.8kPa

2017



LSM 1.9kPa

Stable disease

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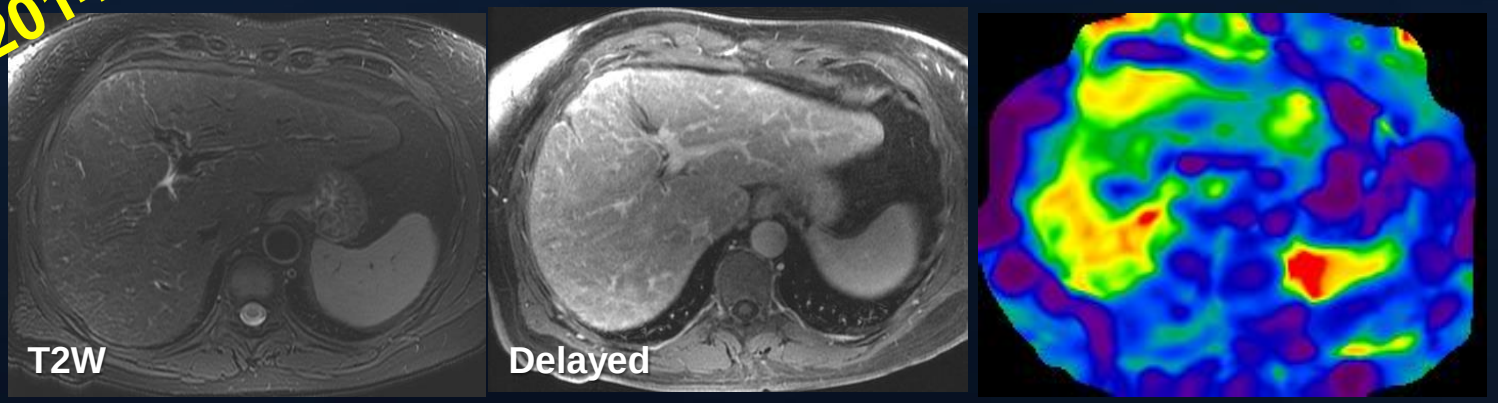
Follow up Assessment

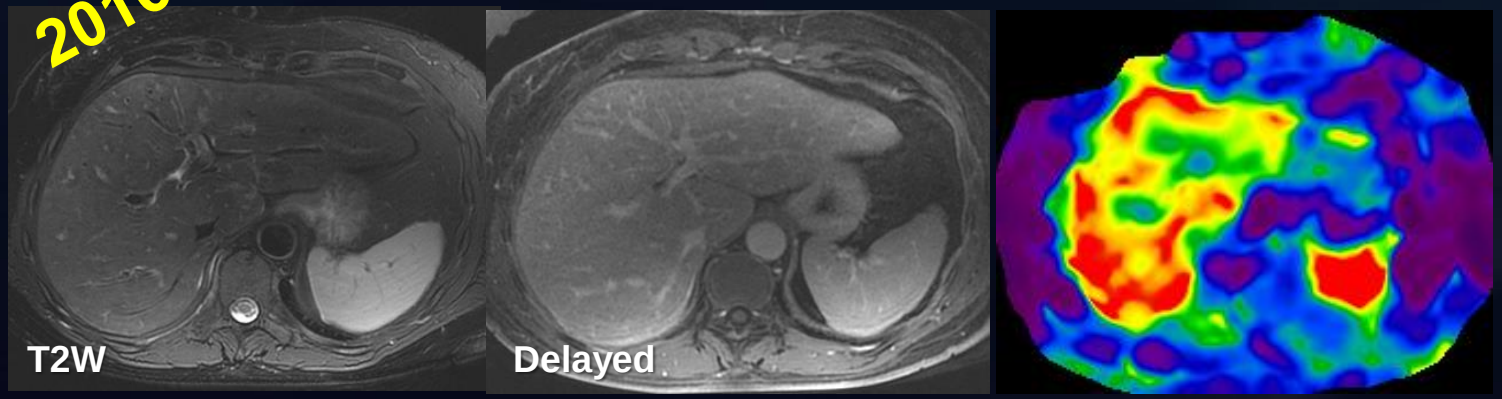
54/F with PBC

2014



LSM
3.4kPa

2016



LSM
5.3kPa

Worsening stiffness- Progression

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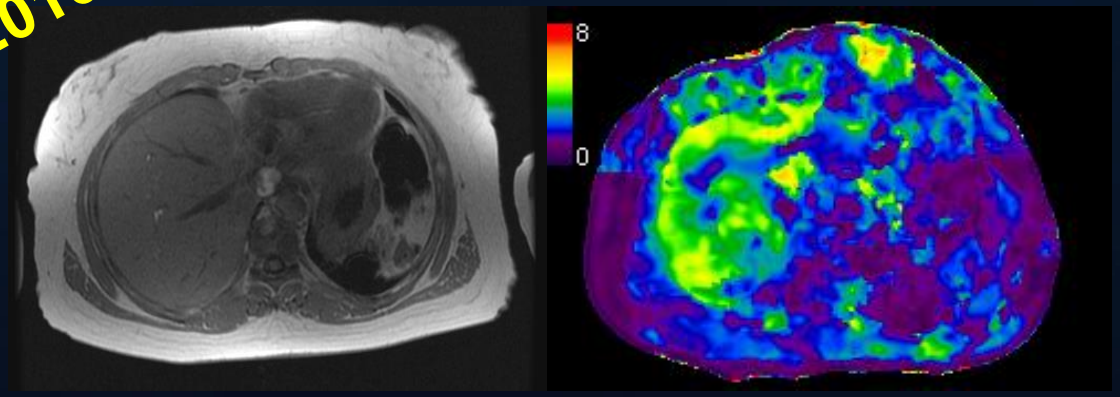
Treatment Assessment

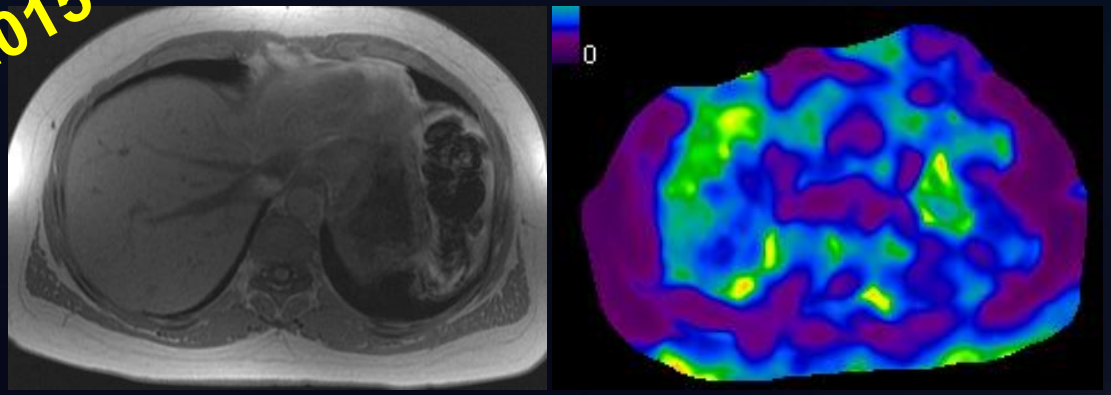
52/F with AMA negative PBC on Ursodiol and Prednisone

2010



LSM 3.5kPa

2015



LSM 2.6kPa

Improvement in the stiffness

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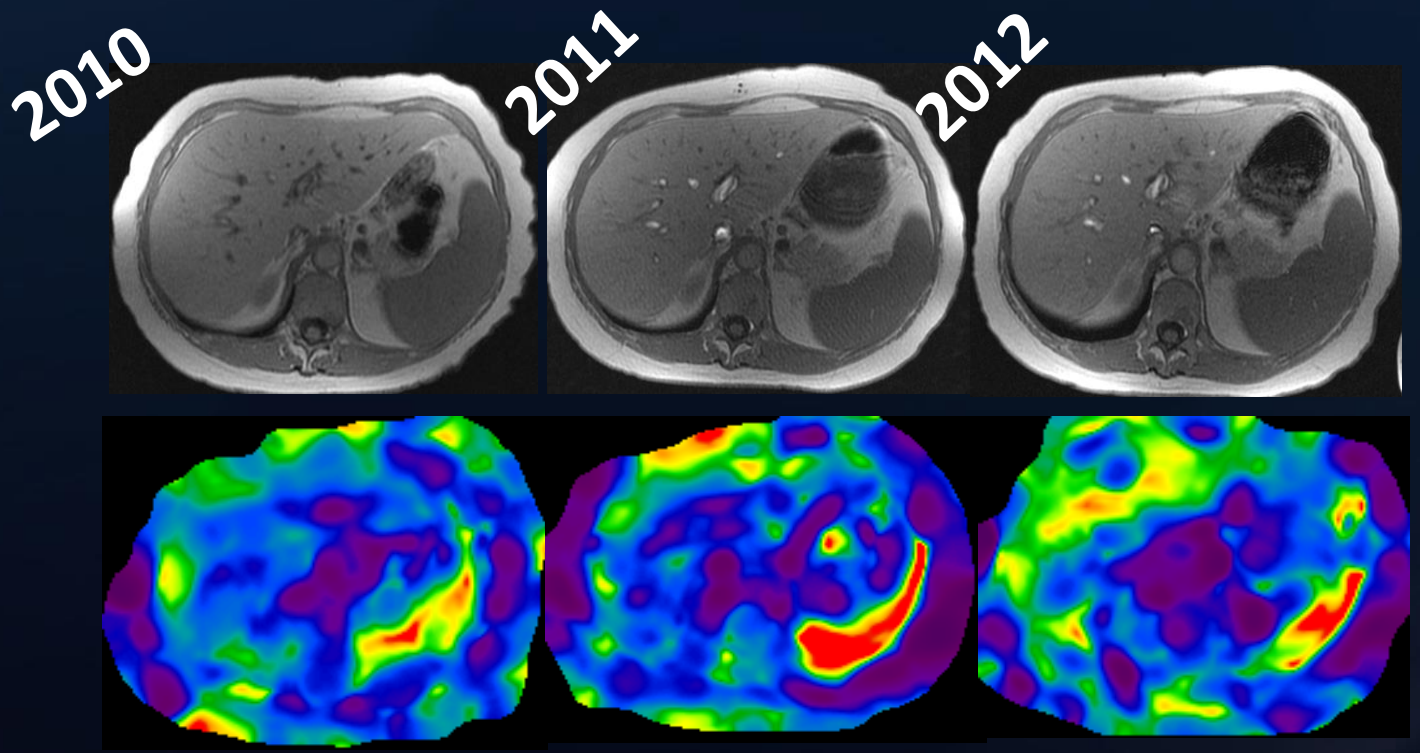
Follow up Assessment

54/F PBC



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

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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**

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Thank you

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