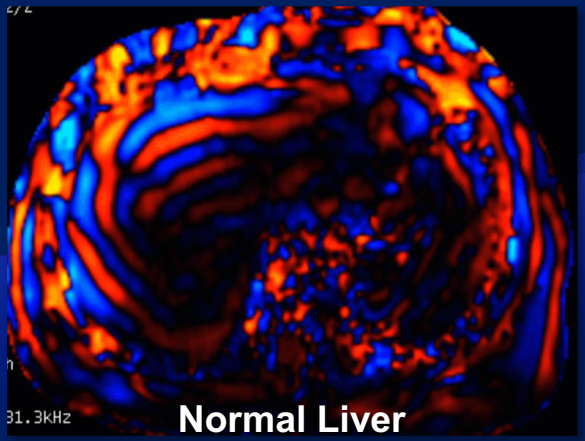

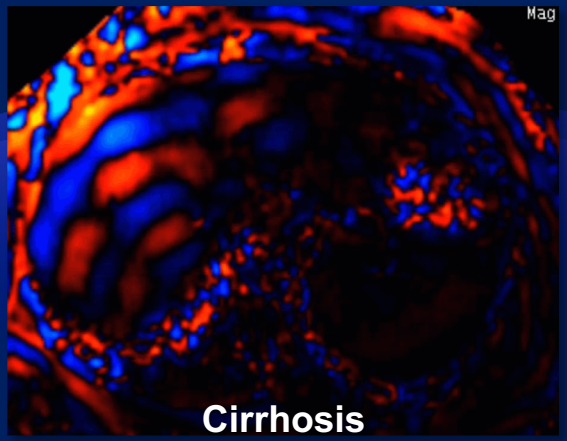

Liver MR Elastography Imaging Technique and Image Interpretation: Pearls and Pitfalls

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Jefferson
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RadioGraphics
Exhibit from the RSNA Annual Meeting

MAYO CLINIC

Background

Liver MR elastography is an imaging technique used to measure liver stiffness for evaluation of fibrosis or cirrhosis. Liver stiffness values are useful for predicting liver fibrosis stages. However, obtaining accurate liver stiffness measurements (LSMs) requires the following:

- IMAGING TECHNIQUE OPTIMIZATION
- QUALITY-CONTROL EVALUATION OF IMAGES
- PROPER ELASTOGRAM INTERPRETATION

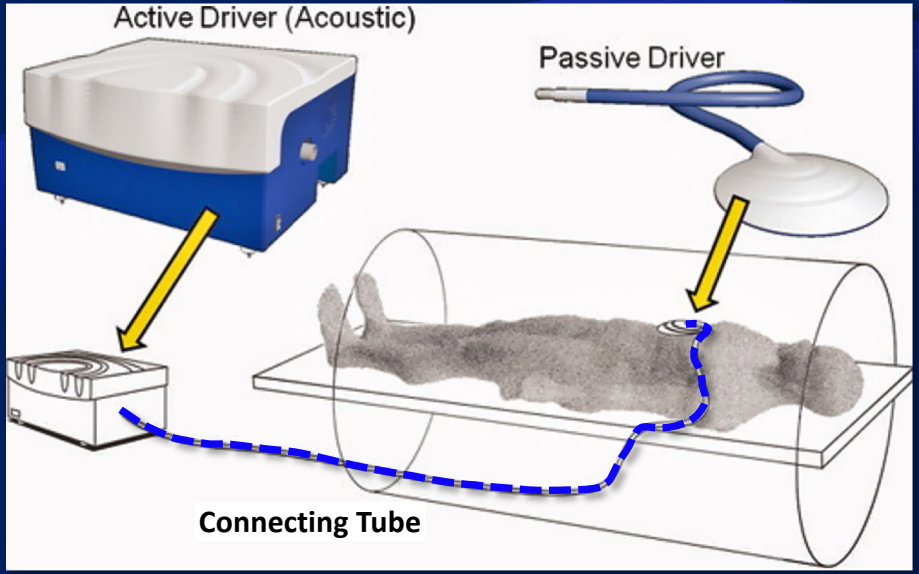
The purpose of this educational presentation is to review the proper technique for performing liver MR elastography, subsequent quality-control evaluation, and liver elastogram interpretation.

Table of Contents

There are four main sections in this presentation:

How MR Elastography is Performed

With MR elastography, an active pneumatic mechanical wave driver is located outside the MRI room.



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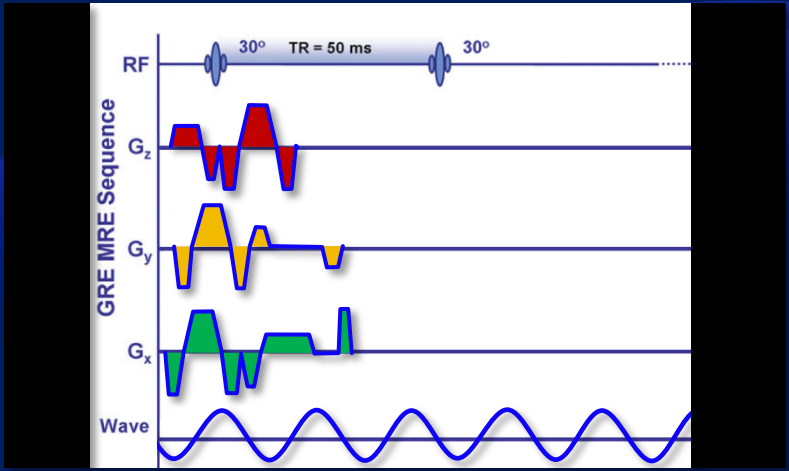
A flexible 25-foot polyvinyl chloride tube connects the active pneumatic driver to a passive driver placed on the abdominal wall over the liver.

The passive driver generates a continuous acoustic vibration that is transmitted through the entire abdomen, including the liver, at a fixed frequency, which is typically set at 60 Hz.

How MR Elastography is Performed



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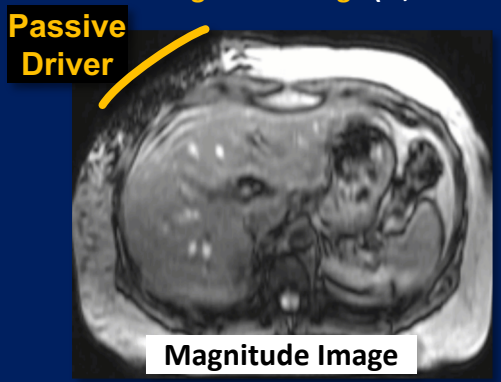
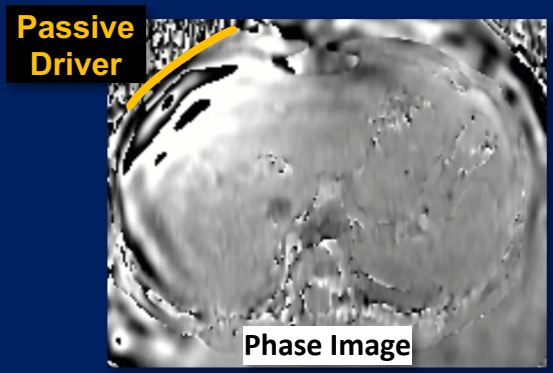
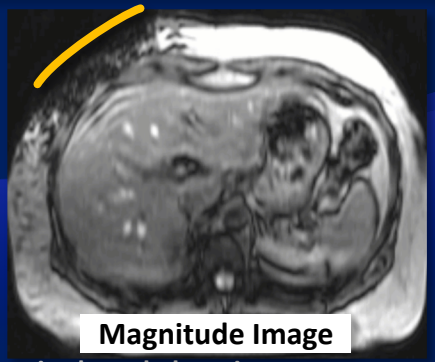
A phase-contrast pulse sequence with motion-encoding gradients synchronized to the mechanical waves created by the passive driver is used to image the micron-level cyclic displacements caused by the propagating waves and create a magnitude image (ie, anatomic image) and phase image (ie, wave motion image).

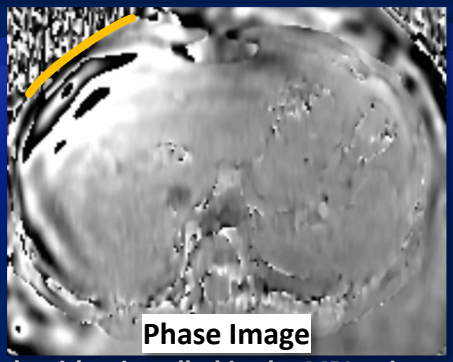




How MR Elastography is Performed

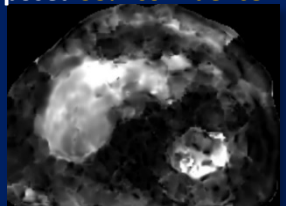


Magnitude Image

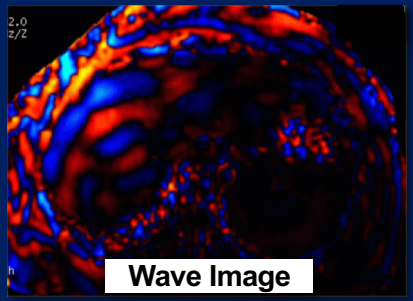


Phase Image

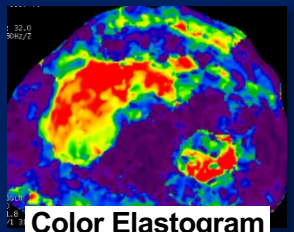
After the magnitude and phase images are created, an inversion algorithm installed in the MRI unit automatically processes these raw data images to create a wave image, and gray-scale and color elastograms, with and without a superimposed 95% confidence map...



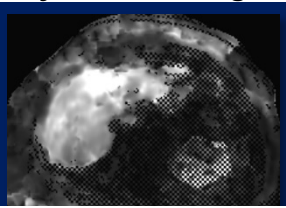
Gray-Scale Elastogram



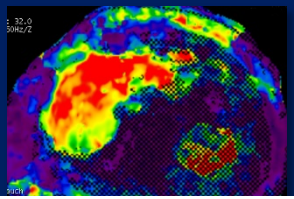
Wave Image



Color Elastogram



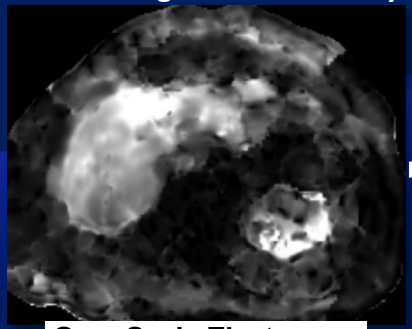
Gray-Scale Elastogram with 95% confidence map



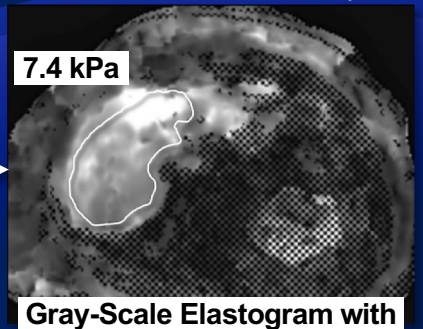
Color Elastogram with 95% confidence map

How MR Elastography is Performed

The gray-scale elastogram is commonly used to make QUANTITATIVE measurements, in kilopascals.

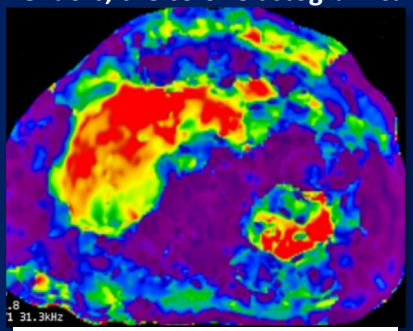


Gray-Scale Elastogram



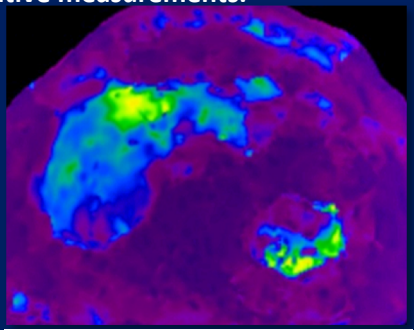
Gray-Scale Elastogram with 95% confidence map

The color elastogram is generally used for QUALITATIVE liver stiffness evaluation; however, with the MRI units from some vendors, the color elastogram can be used for quantitative measurements.



Color Elastogram (0 – 8 kPa)

On the color elastogram, PURPLE & BLUE indicate lower stiffness values and RED & ORANGE indicate higher stiffness



Color Elastogram (0 – 20 kPa)

A 0-20 kPa color elastogram is also created and is useful for appreciating liver stiffness heterogeneity in livers with advanced fibrosis or cirrhosis; however, this image is rarely required for clinical use.

How to Optimize Imaging Technique

Obtaining consistently high-quality elastograms begins with optimizing the imaging technique, which ideally requires addressing six important technical components:

- Patient Preparation
- Passive Driver Placement
- MR Elastogram Section Positioning
- Breathing Technique
- Pulse Sequence Timing
- Pulse Sequence Parameters

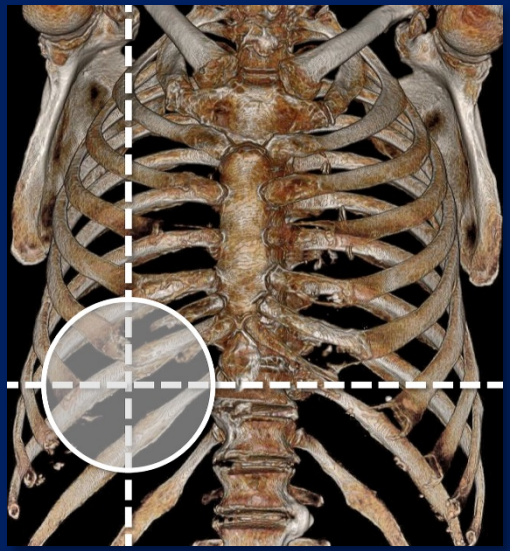
How to Optimize Imaging Technique

Patient Preparation

- Patient fasting for 4-6 hours before the MR elastography examination is recommended, with no sugar-rich drinks during fasting.

Passive Driver Placement

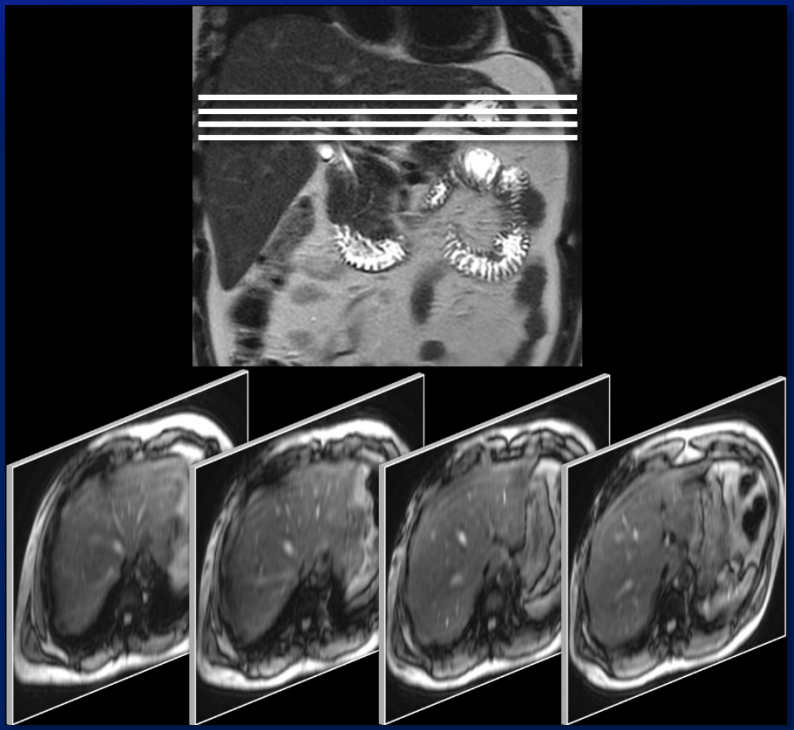
- At *end expiration,* the passive driver needs to be placed *SNUGLY* against the abdominal wall, beneath the torso phased-array surface coil.
- The passive driver should be placed over the right hepatic lobe. The xiphisternum is used for the superior-inferior position, and the right midclavicular line is used for the right-left position.
- **Alternative driver placement:**
  - Over the right lateral abdominal wall for patients with a chest wall deformity or prior surgery or who cannot lie supine
  - Over the largest portion of the liver for patients with hepatic resection or liver malposition



How to Optimize Imaging Technique

MR Elastogram Section Positioning

- In a typical MR elastography examination, four images are obtained and should include the largest portion of the liver and exclude the liver dome.
  - Obtaining images too high over the liver dome can lead to falsely elevated liver stiffness values owing to oblique waves propagating through the liver.
  - Obtaining images too low can create chaotic waves, with inaccurate or nondiagnostic liver stiffness values.

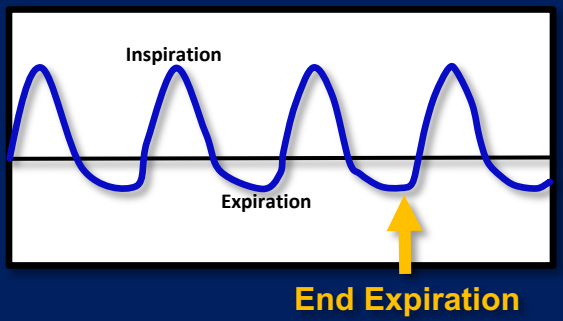


How to Optimize Imaging Technique

Breathing Technique

- The typical two-dimensional gradient-recalled-echo MR elastography pulse sequence is a breath-hold sequence of about 16 seconds and ideally is performed at end expiration to minimize positional changes between individual sections.

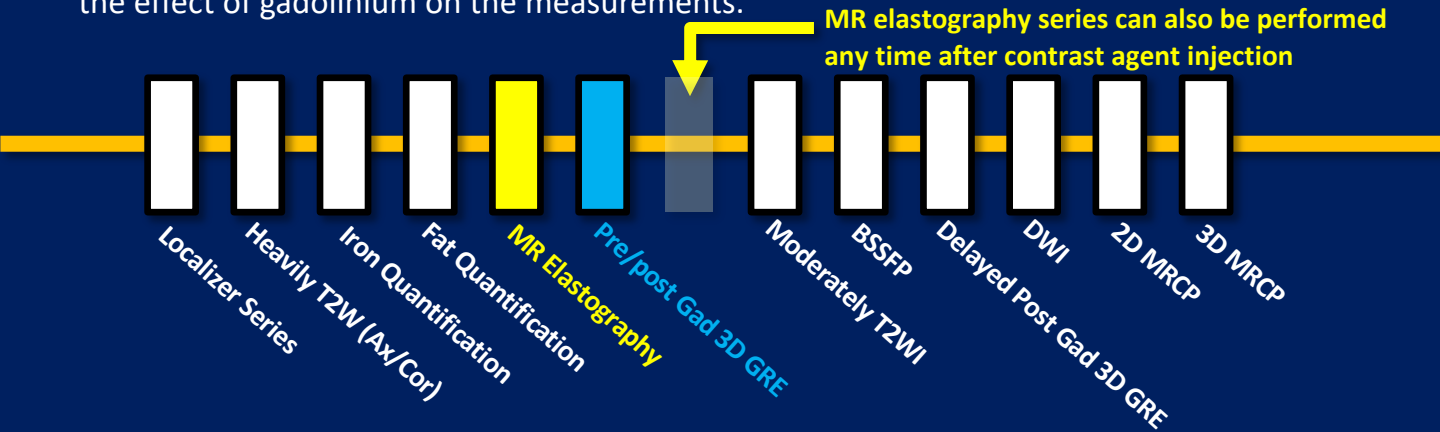
- To best accomplish this, the passive driver needs to be fastened snugly to the abdominal wall when it is applied, with the patient holding his or her breath at end expiration. Then, all subsequent sequences, including the elastogram scout sequence, parallel imaging calibration scan (if required), and elastogram, also should be performed at end expiration to match how and where the driver was applied.



How to Optimize Imaging Technique

Pulse Sequence Timing

- The elastogram series can be performed **before or after injecting gadolinium-based contrast material**.
- The advantage of performing the series **before the injection** is that quality-control issues can be corrected, if they occur, and MR elastography can be repeated before or after the diagnostic portion of the MRI examination, as illustrated below.
- The advantage of performing MR elastography **after the contrast material injection** is increased liver signal intensity, which may result in an elastogram of better quality.
- Note: liver fat and iron quantification still should be performed before the injection to avoid the effect of gadolinium on the measurements.



Ax/Cor = axial and coronal, BSSFP = balanced steady-state free precession, DWI = diffusion-weighted imaging, Gad = gadolinium-based contrast material, GRE= gradient-recalled echo, MRCP = MR cholangiopancreatography, 3D = three-dimensional, 2D = two-dimensional, T2W and T2WI = T2-weighted imaging

How to Optimize Imaging Technique

Pulse Sequence Parameters

- **MR Elastography Imaging Parameters**
  - MR elastography imaging parameters vary among different MRI unit vendors and according to different magnet field strengths. The suggested imaging parameters from many vendors are cited in the RSNA Quantitative Imaging Biomarkers Alliance Profile online document. While the parameters for different magnets vary, the following three common parameters must be understood to improve the reliability of results:
- **Passive Driver Frequency**
  - In routine clinical practice, the passive driver frequency is set at **60 Hz** and should **NOT BE CHANGED** since most LSM references and thresholds for staging liver fibrosis are based on 60 Hz. This is also important for ensuring measurement consistency in follow-up studies.
- **Passive Driver Amplitude (ie, Power Output)**
  - An appropriate passive driver amplitude is **50% for an average-sized patient.** This can be increased or decreased, depending on the patient's size and comfort level (ie, 75% for larger patients, 25% for thin patients).
- **Pulse Sequence Echo Time (TE)**
  - Ideally, the pulse sequence TE should be an **in-phase TE** to minimize the signal loss that occurs with a fatty liver. This is important because when MR elastography hardware is first installed, the default TE may not be set at an in-phase value and thus may need to be changed by an MRI application specialist during or after installation. MR elastography can still be performed at other TEs, but the liver signal intensity may be lower.

RSNA Quantitative Imaging Biomarkers Alliance. MR Elastography of the Liver. Stage 2: Consensus profile. Published May 2, 2018.

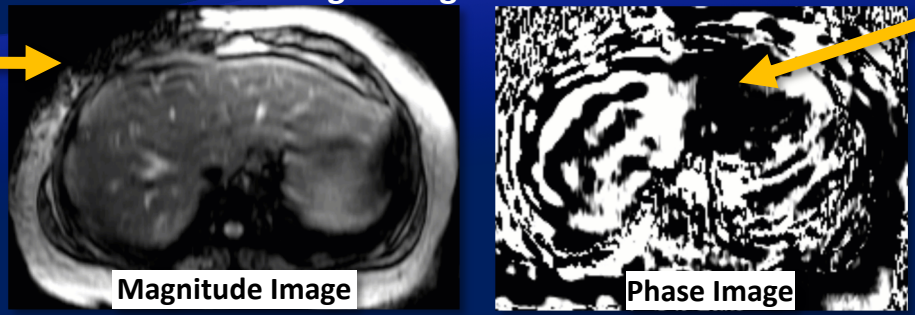
Quality Control

When a liver MR elastography examination is first performed, each study should be immediately evaluated to ensure its quality so that corrective steps, if needed, can be taken before the examination is completed. Both the MR technologist and the radiologist should be able to perform the following quality control evaluation:

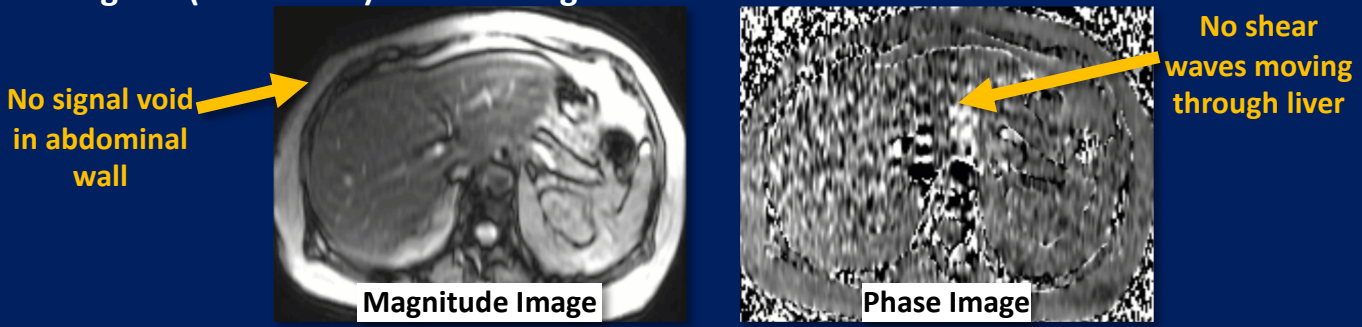
- Review the magnitude images for signal void in the subcutaneous tissues
- Review the phase images for shear waves moving through the liver
- Review the wave images for poor wave propagation, low-amplitude waves, or wave distortion
- Evaluate the quality of the elastogram

Quality Control

The first quality control step is to review the magnitude images for a signal void in the subcutaneous tissues (indicating that the mechanical waves are being applied) and the phase images for shear waves moving through the liver.

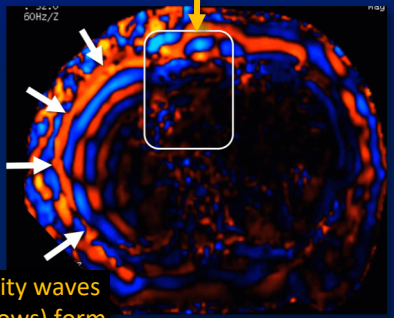


In the example below, the connecting tube between the passive driver and active driver was inadvertently disconnected. This resulted in an absent abdominal wall signal void on the magnitude images and no shear wave propagation on the phase images. The resulting elastogram (not shown) was nondiagnostic.

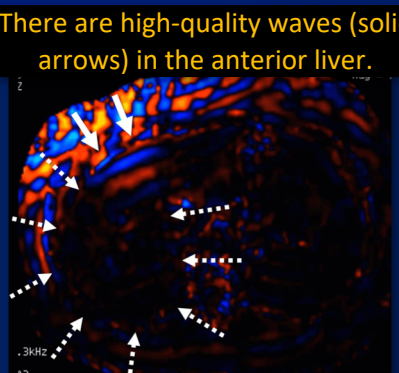


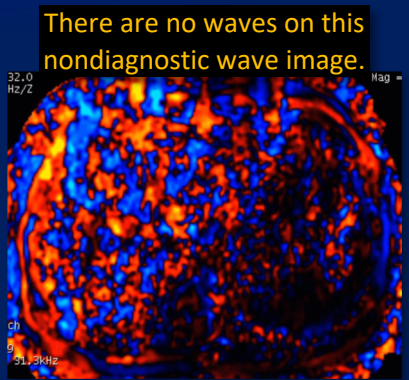
Quality Control

The next quality control step is to review the wave images for areas of poor wave propagation, low-amplitude (darker) waves, or wave distortion.



High-quality waves (white arrows) form parallel to the outer liver surface and travel centrally through the liver. Waves are attenuated centrally by soft normal liver parenchyma.

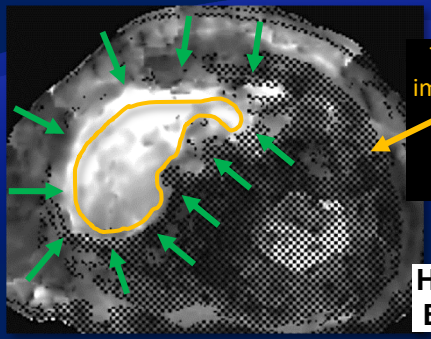




- **Regions of wave distortion may lead to artifactually high or low LSMs.**
- **Low-amplitude (darker) waves have a poor signal-to-noise ratio that is not ideal for postprocessing and may result in low LSMs.**

Quality Control

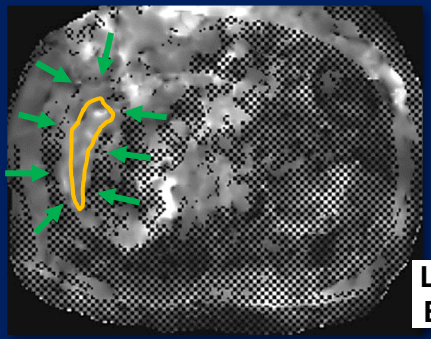
The final quality-control step is to evaluate the elastogram for quality. When performing MR elastography, the goal is to generate elastograms that have a large area of the liver not covered by the 95% confidence map (green arrows) to allow measurements of a large portion of the liver, as in the high-quality elastogram on the right .



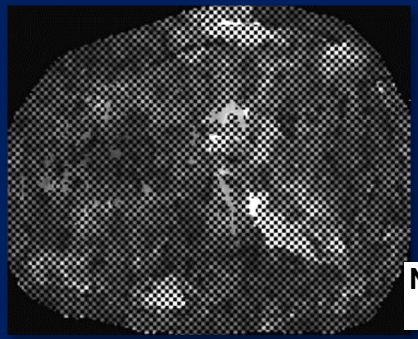
The crosshatching on this image is the 95% confidence map, which should be avoided when obtaining LSMs.

High-Quality Elastogram

On the two elastograms below, only a small portion of the liver can be measured on the low-quality elastogram (LEFT), and no LSM can obtained on the nondiagnostic elastogram (RIGHT) obtained in a different patient. If possible, both of these elastograms should be acquired again to try to improve their quality.



Low-Quality Elastogram

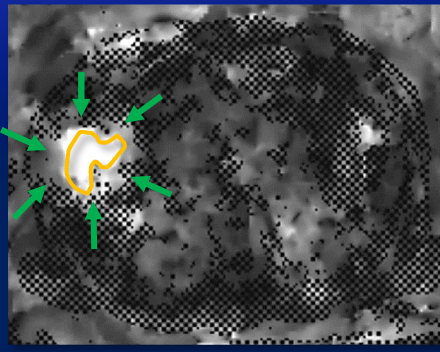


Nondiagnostic Elastogram

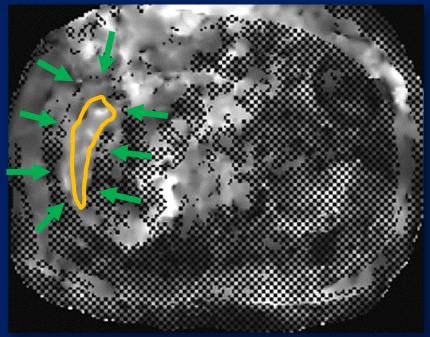
Causes of Low Quality Elastograms

There are MANY POTENTIAL CAUSES of low-quality elastograms:

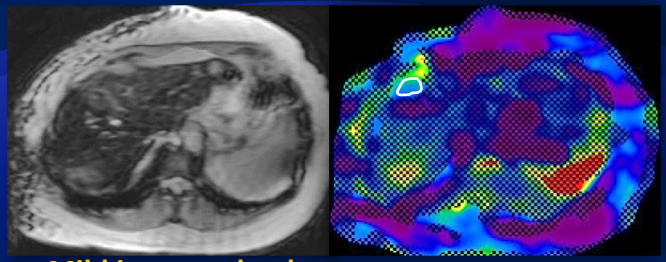
1. Poor shear wave delivery, which may be due to:
   - The passive driver improperly secured onto the abdominal wall because…
     - It became loosened after application or…
     - It was not applied during end expiration
   - The elastogram section location not matching the passive driver location, which may be positioned too high or too low
   - The elastogram section location matching the passive driver location but the section obtained too high or too low
   - Structures such as the lung base or colon interposed over the liver
   - Leakage of the connecting tube connecting the active and passive drivers
2. The active driver power output being set too low or too high



Low-Quality Elastograms

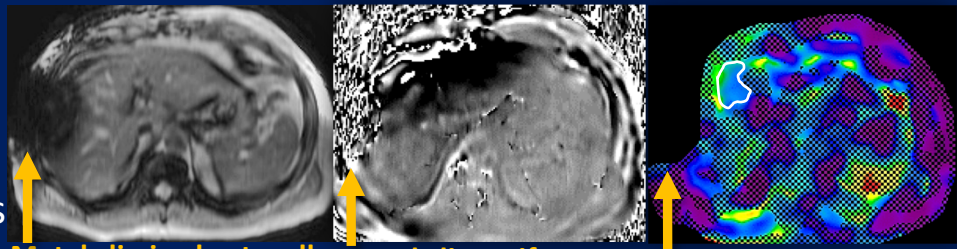


Causes of Low-Quality Elastograms



Mild iron overload

3. Parenchymal causes
   - Unrecognized liver iron overload
   - Hepatic steatosis
     - For this reason, elastography should be performed with an in-phase TE to negate the decrease in liver signal intensity that occurs with hepatic steatosis.
4. Paramagnetic materials in or adjacent to the liver can cause interference
   - Embolization coils
   - TIPS stent
   - Chest wall metal clips



Metal clip in chest wall | Metal clip artifact | Metal clip artifact

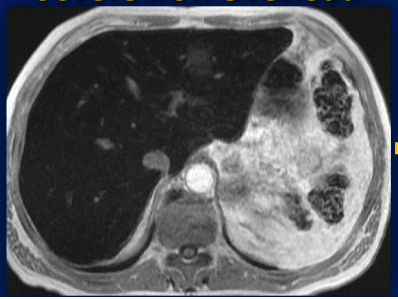
5. Motion artifact
   - Any respiratory motion during elastography, which is a breath-hold sequence, will decrease the quality of the examination.

Causes of Nondiagnostic Elastograms

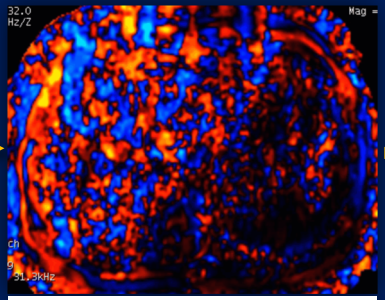
- The three most common causes for a nondiagnostic elastogram:

1. Significant liver iron overload (most common cause)
   - When this occurs, repeating the elastography examination with conventional gradient-echo sequences probably will not correct the problem. More recently available spin-echo sequences, which are not as affected by iron overload, can be used, if available.

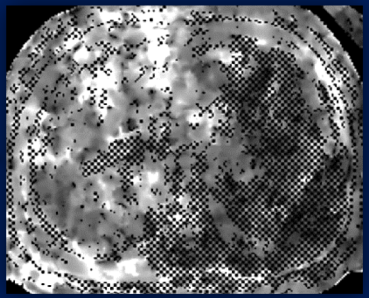
Severe Iron Overload



In-phase dual gradient-echo image in a patient with SEVERE IRON OVERLOAD demonstrates significantly decreased liver signal intensity



There is no wave propagation on this nondiagnostic wave image



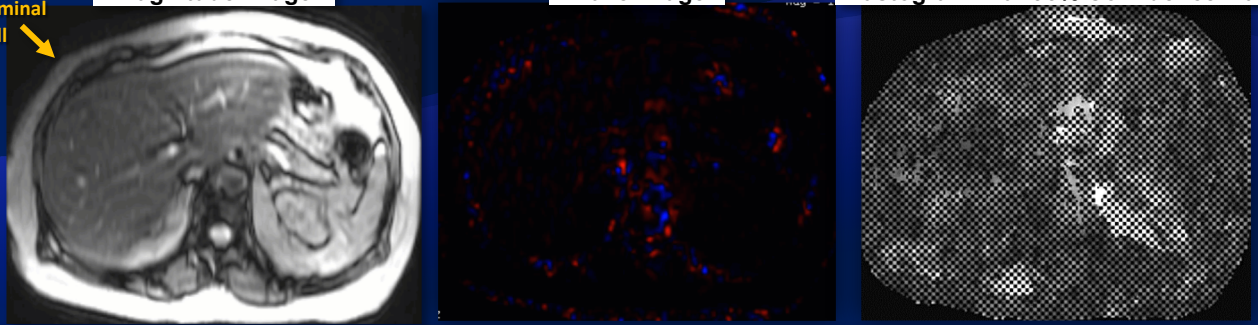
While the 95% confidence map does not completely cover the liver on the elastogram, no valid LSM can be made

2. Nonfunctioning active driver, which may be inadvertently turned off or need to be rebooted.
3. The connecting tube between the active driver and passive driver may be disconnected or kinked, as illustrated in the next slide.

Causes of Nondiagnostic Elastograms

No signal void in abdominal wall

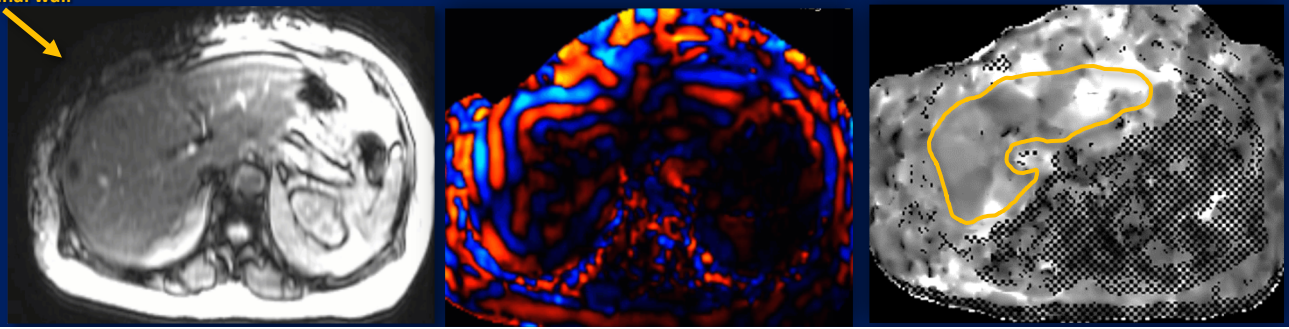
Magnitude Image | Wave Image | Elastogram with 95% Confidence Map



On the magnitude image for this elastogram, there is no subcutaneous (SQ) signal void in the abdominal wall. On the resulting wave image, no waves are present. On the resulting elastogram, the 95% confidence map completely covers the liver, preventing LSM.

The cause for this nondiagnostic elastogram was a disconnected connecting tube between the active driver and passive driver. The tube was reconnected, and the image acquisition repeated:

Signal void in abdominal wall



At repeat elastography, there is a significant SQ abdominal wall signal void on the magnitude image, excellent wave propagation on the wave image, and a high-quality elastogram, on which a significant portion of the liver (gold region of interest) is available for LSM.

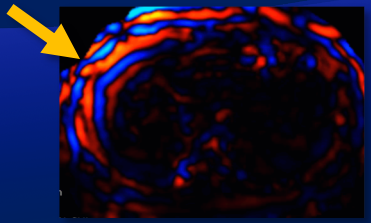
MR Elastogram Interpretation & Reporting

After an elastogram is created, the interpreting radiologist needs to understand how to perform LSMs, potential measurement pitfalls, and how to report examination results. This process is outlined in the next section, which reviews:

- The “Gestalt” Assessment
- How to Obtain LSMs
- Areas to Avoid When Obtaining Measurements
- Causes of Increased Liver Stiffness Mimicking Fibrosis/Cirrhosis
- Reporting Results in the Radiology Report

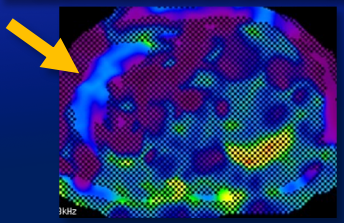
Gestalt Assessment

When interpreting MR elastograms, the first step is to perform a gestalt assessment of the wave images, color elastogram, and gray-scale elastogram to determine if the elastogram is probably normal or if elevated liver stiffness probably is present.



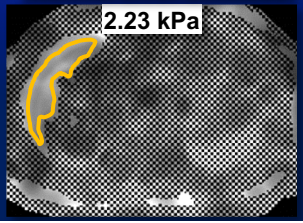
With ***HEALTHY NONFIBROTIC LIVERS***, on the wave images, the waves (arrow) are thinner and darken centrally, as they are attenuated by the soft normal liver parenchyma.

Normal Liver Stiffness

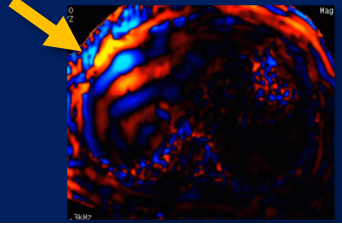


On the color elastogram, portions of the liver not covered by the 95% confidence map (arrow) will be **BLUE** or **PURPLE** owing to lower stiffness values.

Normal Liver Stiffness

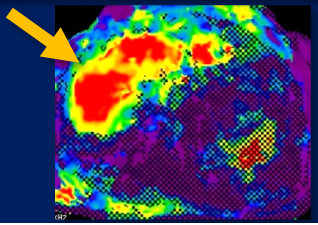


On the gray-scale elastogram, only the liver periphery (outlined) may not be covered by the 95% confidence map. However, this is due to wave attenuation by healthy liver tissue, NOT because of a low-quality elastogram.



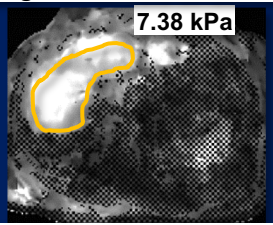
With ***FIBROTIC LIVERS***, on the wave images, the waves are thicker and not attenuated centrally, as they move more quickly through the stiffer liver parenchyma.

Elevated Liver Stiffness



On the color elastogram, the portion of the liver not covered by the 95% confidence map (arrow) will be **RED** or **ORANGE** owing to elevated stiffness values.

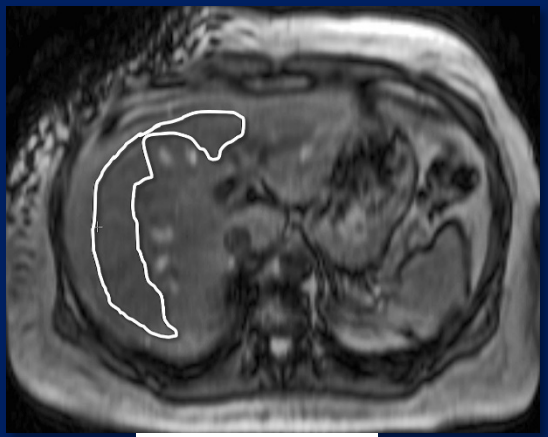
Stage 4 Fibrosis or Cirrhosis



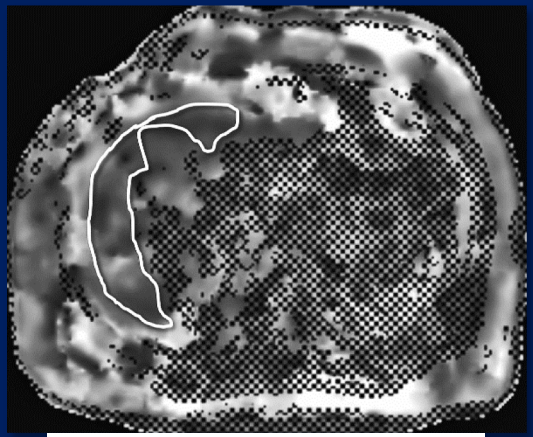
On the gray-scale elastogram, most of the liver is not covered by the 95% confidence map.

How to Obtain LSMs

- The next step in the interpretation process is to correlate the gray-scale elastogram with the magnitude image to determine what portions of the liver are being sampled on the gray-scale elastogram. Note: these two images are created by using the same pulse sequence and from the same acquired data and therefore reflect the same anatomy. LSMs can be performed manually or by using automated software.
- Next, the manual technique for LSM and pearls and pitfalls associated with obtaining measurements are outlined.



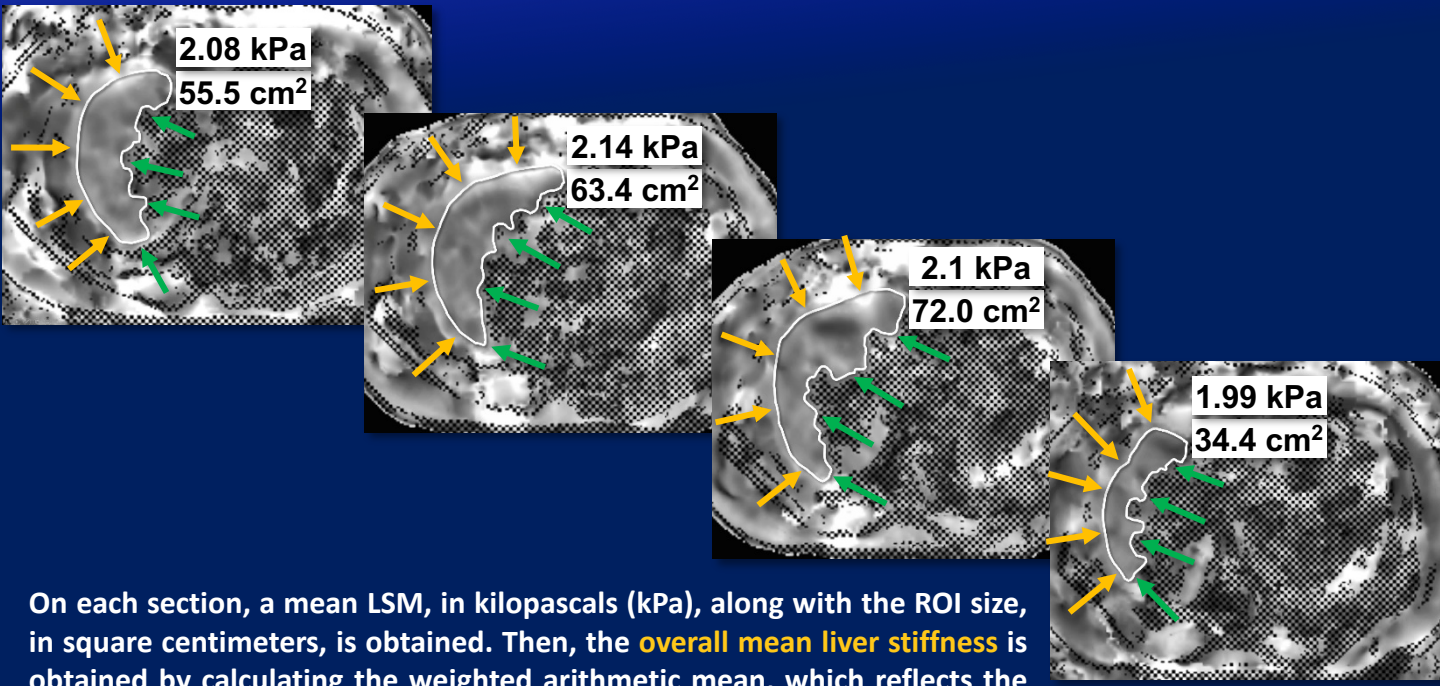
Magnitude Image



Elastogram with 95% Confidence Map

How to Obtain LSMs

The following describes how to obtain LSMs by using a commercially available picture archiving and communication system (PACS) workstation. Using the freehand region of interest (ROI) tool, the LARGEST PORTION OF THE LIVER is drawn on each of the four elastogram sections. The outer margin (gold arrows) should be drawn parallel to the liver margin, 1 cm or greater from the liver edge. The inner margin (green arrows) should exclude the 95% confidence map.

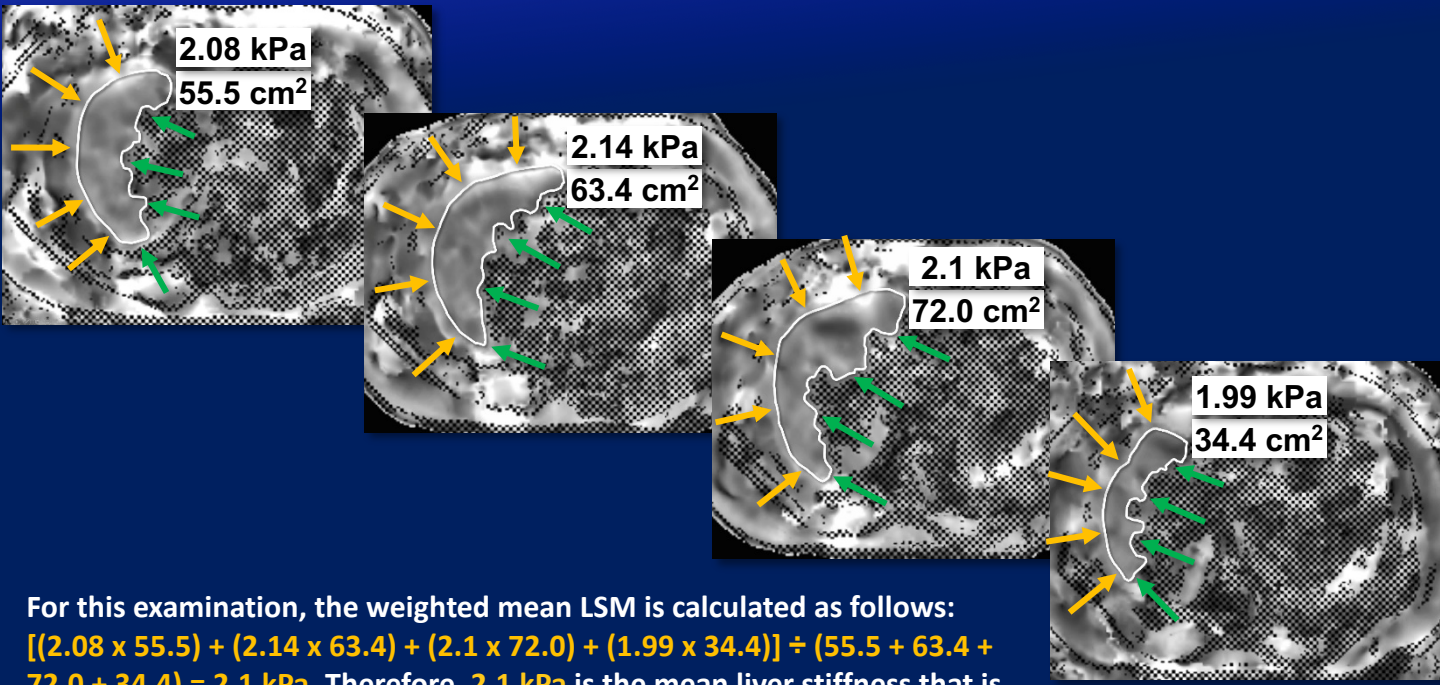


On each section, a mean LSM, in kilopascals (kPa), along with the ROI size, in square centimeters, is obtained. Then, the overall mean liver stiffness is obtained by calculating the weighted arithmetic mean, which reflects the relative contribution of the area of the liver measured in each image.

How to Obtain LSMs

A generic formula for calculating the weighted arithmetic mean (AM_w) of the mean liver stiffness values *(m)* obtained from the ROIs drawn on four sections, with each section having an ROI size of *w* pixels would be:

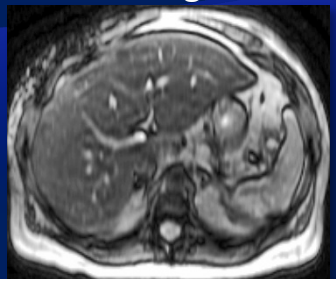
$AM_w = (m_1w_1 + m_2w_2 + m_3w_3 + m_4w_4) \div (w_1 + w_2 + w_3 + w_4)$



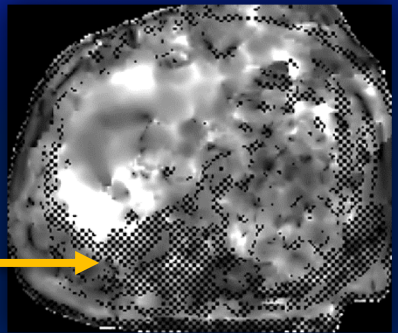
For this examination, the weighted mean LSM is calculated as follows: [(2.08 x 55.5) + (2.14 x 63.4) + (2.1 x 72.0) + (1.99 x 34.4)] ÷ (55.5 + 63.4 + 72.0 + 34.4) = 2.1 kPa. Therefore, 2.1 kPa is the mean liver stiffness that is reported for this examination.

Areas to Avoid When Obtaining Measurements

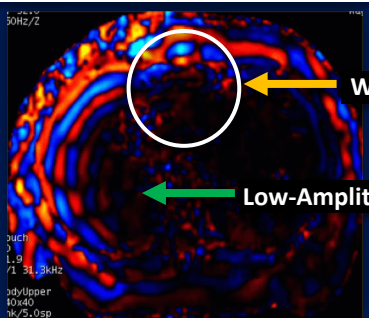
The goal is to sample large portions of the liver on each of the four elastograms. However, for the most accurate LSMs, there are some areas in the liver that should BE EXCLUDED when drawing ROIs. On each of the following images, areas to AVOID include the following…



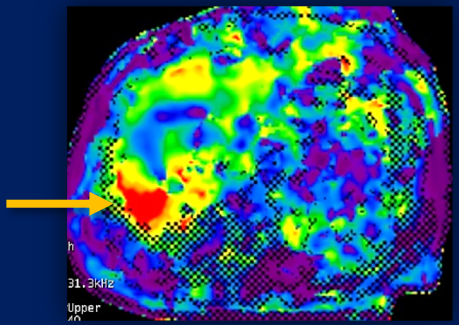
On the ***MAGNITUDE IMAGE***, avoid the liver edge (≥1 cm), nonhepatic tissues, fissures, gallbladder fossa, and large blood vessels. Also avoid the left hepatic lobe unless there is no motion artifact.



On the ***GRAY-SCALE ELASTOGRAM***, avoid the 95% confidence map (arrow).



On the ***WAVE IMAGES***, avoid areas of poor wave propagation, low-amplitude (darker) waves (green arrow), and wave distortion (gold arrow).

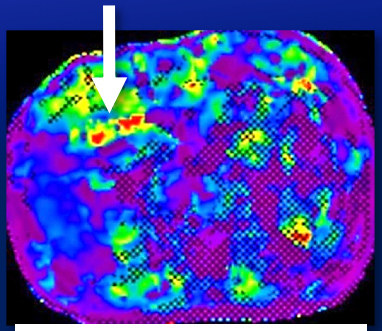


On the ***COLOR ELASTOGRAM***, avoid "HOT SPOTS" (arrow).

Areas to Avoid When Obtaining Measurements

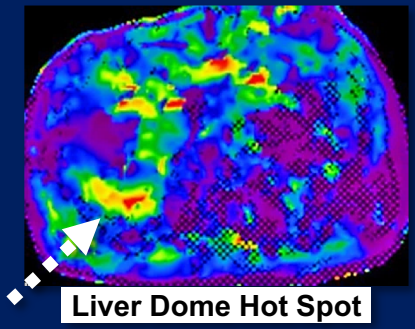
HOT SPOTS

Hot spots are focal areas of elevated liver stiffness that are ARTIFACTUAL and do not reflect the actual liver stiffness. On the color elastogram, hot spots are focal **RED** or **ORANGE** areas in the liver that indicate increased liver stiffness.


Passive Driver Hot Spot

Hot spots may not be obscured by the 95% confidence map. However, hot spots should NOT BE INCLUDED when obtaining LSMs because including these measurements will spuriously increase the mean liver stiffness, potentially making a normal liver appear abnormal or overstaging liver fibrosis.

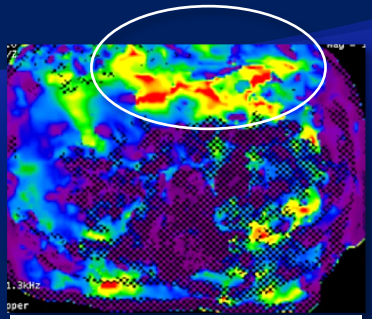
However, many hot spots occur in predictable locations. The two most common locations are just beneath the passive driver (**Passive Driver Hot Spot,** [solid arrow]) and in the liver dome (**Liver Dome Hot Spot**, [dashed arrow]). The **Passive Driver Hot Spot** is probably due to distortion created by the passive driver, and the **Liver Dome Hot Spot**, due to the orientation of waves passing obliquely through the liver dome owing to the liver shape. Hot spots may also be due to random areas of wave distortion.

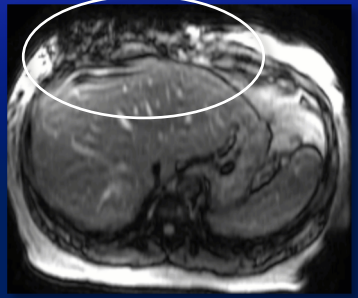

Liver Dome Hot Spot

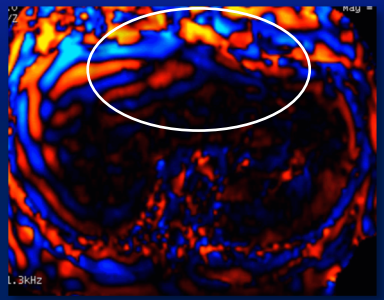
A focal hot spot could also be due to a mass (ie, tumor) in the liver or an area of focal fibrosis, so it is important to correlate the elastogram findings with other MRI pulse sequences.

Areas to Avoid When Obtaining Measurements

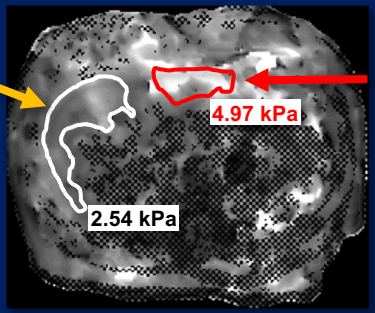
This color elastogram (left image) demonstrates a **Passive Driver Hot Spot** (oval outline) in the anterior left hepatic lobe. The cause is probably excessive or disorganized vibrations in the liver created by the adjacent passive driver (middle image). This results in wave distortion on the wave images (right image).





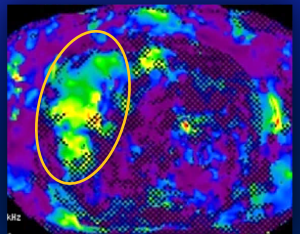


On the corresponding gray-scale elastogram, the portion of the liver outlined above is NOT COVERED by the 95% confidence map. However, this hot spot should **NOT BE INCLUDED** when obtaining LSMs.

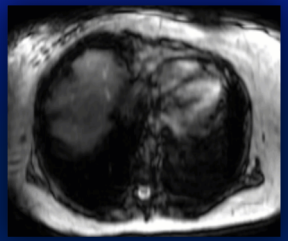


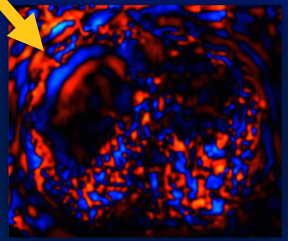
Areas to Avoid When Obtaining Measurements

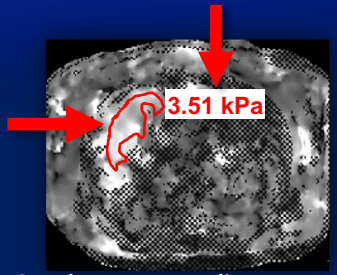
Color elastogram (left image) demonstrates a **Liver Dome Hot Spot**, which occurs when sections are obtained through the liver dome (middle image). This results in an oblique liver imaging plane, causing waves to propagate through the liver obliquely on the wave images (right image), which show artifactually thicker waves that simulate waves caused by liver fibrosis (gold arrow).



Liver Dome Hot Spot

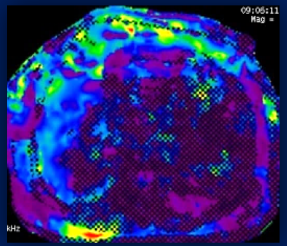


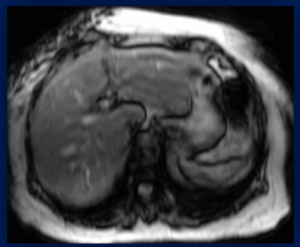


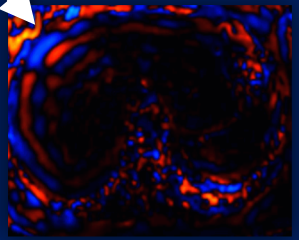


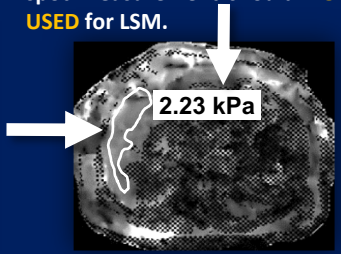
On the corresponding gray-scale elastograms, there is artifactually elevated liver stiffness in the liver dome (red arrows, above), as compared with the mid-liver section (white arrows, below), due to the liver dome hot spot. This hot spot measurement should **NOT BE USED** for LSM.

The images below are from the same study, from a mid-liver section (middle image). There is no hot spot on the color elastogram (left image), and the waves are slightly thinner (arrow, right image) than the waves in the liver dome.



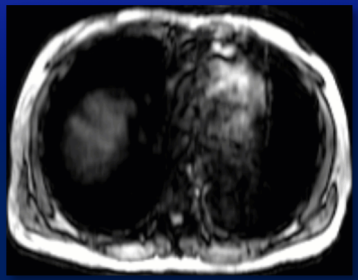


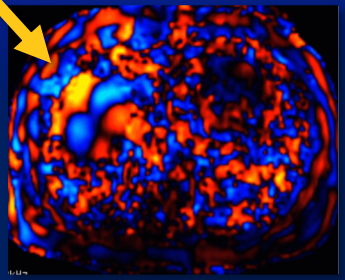


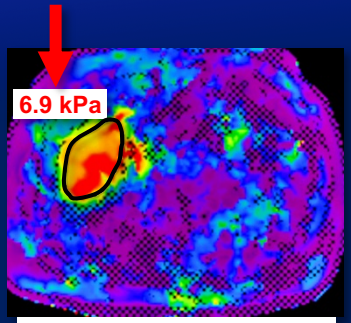


Areas to Avoid When Obtaining Measurements

This is another example of a **Liver Dome Hot Spot** showing a magnitude image that was (incorrectly) obtained even higher in the liver dome than the last case (left image). Wave images (middle image) show artifactually thick oblique waves (gold arrow, middle image) obtained through the liver dome. Color elastogram (right image) shows a hot spot due to oblique waves and a spuriously elevated LSM of 6.9 kPa. This measurement should **NOT BE USED** for LSM.

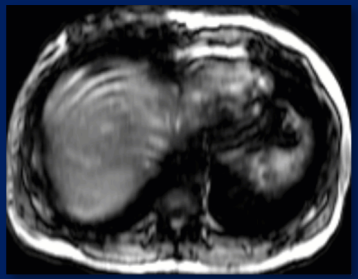


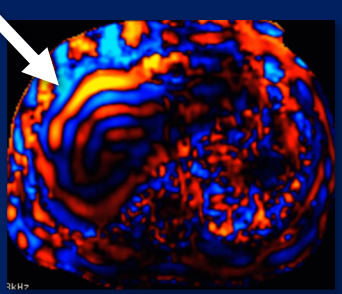


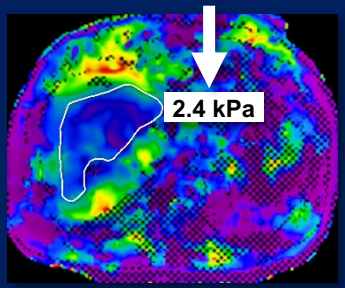


Liver Dome Hot Spot

The images below are from the same study, from a mid-liver section (left image). The waves are significantly thinner than the waves in the liver dome (middle image, arrow), and there is no hot spot on the color elastogram (right image). Note the valid LSM of 2.4 kPa, as compared with the spurious 6.9 kPa LSM in the dome.







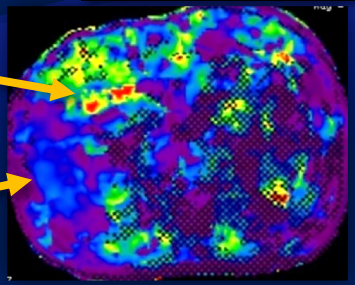
Areas to Avoid When Obtaining Measurements

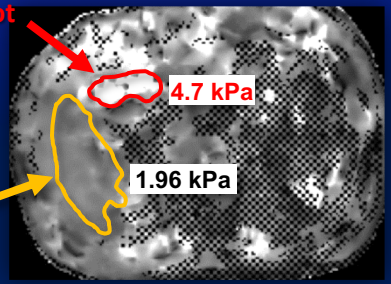
Hot spots are only conspicuous when the liver stiffness is normal or with lower levels of liver fibrosis. With higher levels of fibrosis or cirrhosis, hot spots may be obscured by the stiff liver parenchyma.

Normal Liver Stiffness

Hot spot beneath the passive driver probably due to wave distortion created by the passive driver.

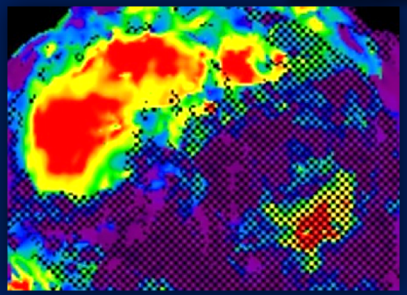
Normal liver stiffness

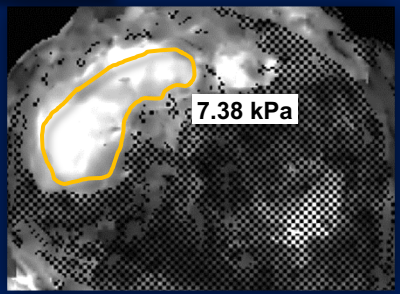




The relatively normal liver stiffness on this elastogram makes the anterior Passive Driver Hot Spot conspicuous.

Elevated Liver Stiffness



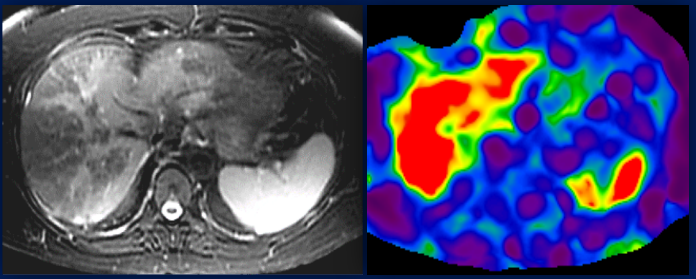


However, when advanced fibrosis or cirrhosis is present, as depicted on this elastogram, hot spots may be inconspicuous compared with the background liver parenchyma.

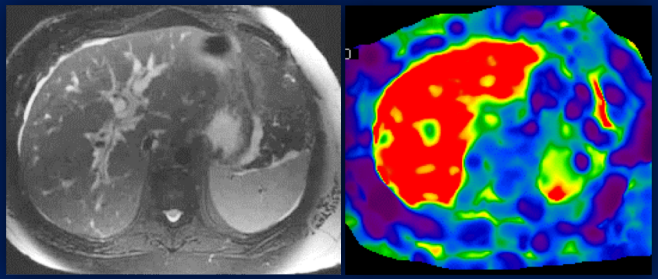
Causes of Increased Liver Stiffness Mimicking Fibrosis or Cirrhosis

The most common causes of increased liver stiffness that are not due to fibrosis or cirrhosis are listed on the next two slides. Since other causes can increase LSMs, the measurements obtained should always be interpreted in conjunction with clinical and laboratory findings for other possible causes of increased liver stiffness.

1. Postprandial
   - Therefore, 4 – 6 hours of fasting is required
2. Acute hepatitis
3. Extrahepatic cholestasis



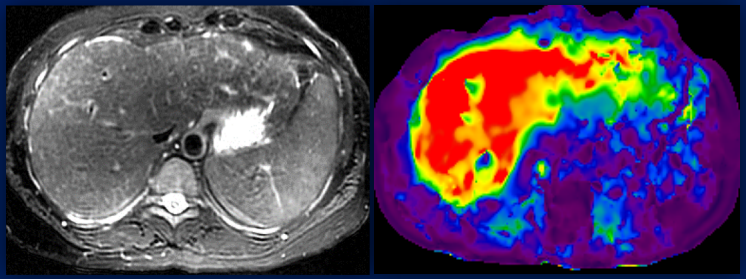
Acute Hepatitis



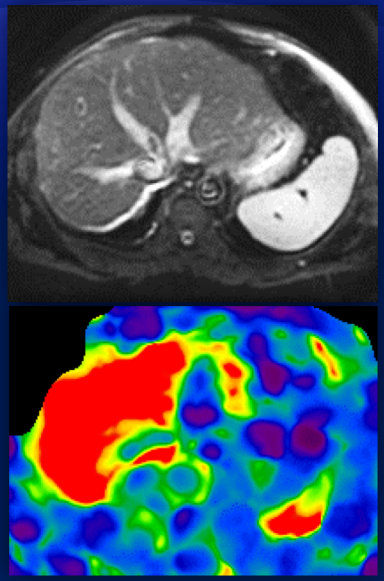
Acute Biliary Obstruction

Causes of Increased Liver Stiffness Mimicking Fibrosis or Cirrhosis

4. Passive hepatic congestion
5. Infiltrative processes



Diffuse Infiltrating Metastatic Carcinoma



Passive Hepatic Congestion-dilated hepatic veins

Finally, as a general rule, most variables will INCREASE LSMs. Therefore, a "normal" measured liver stiffness value is considered acceptable and reliable. Also, hepatic steatosis does not significantly affect LSMs.

Reporting Results in the Radiology Report

- Useful components of an MR elastography radiology report are illustrated in the sample dictation template below and can include:
  - The number of LSMs obtained and the mean liver stiffness.
  - An MR elastography table with fibrosis stage thresholds at a driver frequency of 60 Hz.
  - A caveat indicating that liver stiffness values should be interpreted in conjunction with clinical and laboratory results for other causes of increased liver stiffness.

Mean liver stiffness (weighted mean of [ ]measurements): [ ] kPa

MR elastography estimates of hepatic stiffness (at 60 Hz) correlate with hepatic fibrosis stages as:

<2.5 kPa: Normal

2.5 - 2.9 kPa: Normal or Inflammation

2.9 - 3.5 kPa: Stage 1 to 2 Fibrosis

3.5 - 4 kPa: Stage 2 to 3 Fibrosis

4 - 5 kPa: Stage 3 to 4 Fibrosis

>5 kPa: Stage 4 Fibrosis or Cirrhosis

(These are broad categories and results should be interpreted with clinical and laboratory findings for other possible causes of increased liver stiffness.)

- One of the radiology report impression statements should summarize the elastography component of the study. For example, an impression could be “Mean liver stiffness of 2.6 kPa, consistent with normal or inflammation.”
- A structured report template that can be used as a stand-alone MR elastography template or added to a diagnostic MRI template is available at *https://radreport.org/home/50792*

Venkatesh SK, Ehman RL. Magnetic Resonance Elastography of Liver. Magn Reson Imaging Clin N Am 2014;433–446.

Communication between MR Elastography Technologist and Radiologist

Communication between the MR elastography technologist and radiologist is important for quality control. For example, if a low-quality elastogram is produced, to potentially improve the quality of the current or subsequent MR elastography studies, it is important to know what the contributing factors may have been. For this reason, an MR elastography technologist checklist such as the one shown below can be helpful if it is completed by the technologist performing MR elastography. Using this checklist on a regular basis creates a method of communicating with the interpreting radiologist while also reinforcing the proper MR elastography technique for technologists. The proposed checklist may be useful during the initial stages of implementing liver MR elastography into clinical practice, or it can be used for training new technologists.

MR Elastography Technologist Checklist

1. The passive driver was fastened firmly to the abdominal wall..... Yes ❒ No ❒
2. The passive driver was applied during end-expiration..... Yes ❒ No ❒
3. The calibration scan, localizer scan and MRE were all obtained during end-expiration..... Yes ❒ No ❒
4. Images include the widest portion of liver (excluding dome & inferior tip of right lobe) ..... Yes ❒ No ❒
5. The driver amplitude setting for this scan was: _____%
6. The driver frequency setting was 60 Hz for this scan Yes ❒ No ❒

Technologist MRE QC:

1. The magnitude images show signal loss in the SQ fat just below the passive driver..... Yes ❒ No ❒
2. The phase images show shear waves in the liver..... Yes ❒ No ❒

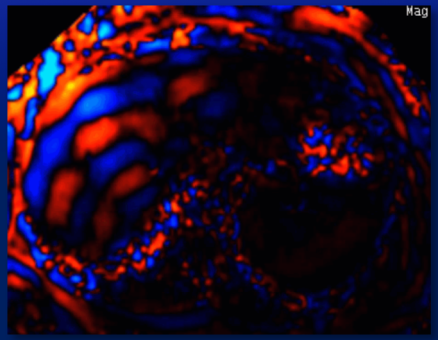
If the MRE needed to be repeated:

1. What was the reason? _____
2. Which radiologist was contacted for input (if applicable)? _____
3. What was changed for the repeat scan? _____

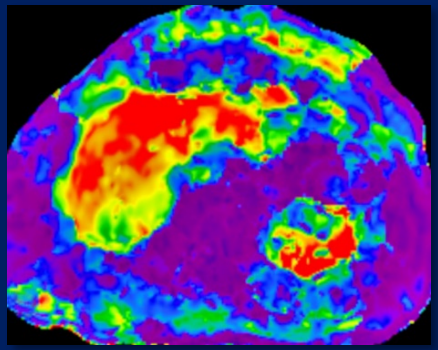
Technologist: _____

Conclusion

- MR elastography is currently the best noninvasive imaging technique available for measuring liver stiffness to evaluate for possible liver fibrosis or cirrhosis. However, obtaining and reporting accurate and reliable LSMs with MR elastography requires an optimal imaging technique, quality control of images, and proper elastogram interpretation and reporting.



- The six most important technical parameters that need to be optimized include:
  - Patient fasting
  - Proper passive driver placement
  - MR elastography section positioning over the largest portion of the liver
  - Obtaining MR elastography–related sequences at end expiration
  - Choosing the best timing of the MR elastography sequence
  - Optimizing several key MR elastography pulse sequence parameters



- Images obtained at MR elastography need to be immediately assessed for quality control by means of magnitude, phase, and wave image review and evaluation of the diagnostic quality of the elastograms.

- The interpreting radiologist needs to understand:
  - The proper method for obtaining LSMs
  - Areas to avoid when obtaining LSMs
  - Conditions other than fibrosis or cirrhosis that can increase liver stiffness
  - How to include elastography results in the radiology report

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