Ultrasound – Liver Elastography (+/- Spleen Elastography)

PURPOSE:

To evaluate hepatic parenchymal stiffness by shear wave elastography for the detection of fibrosis.
To evaluate spleen parenchymal stiffness in select patients at risk for portal hypertension.

SCOPE:

Applies to all US elastography studies performed in Imaging Services / Radiology

ORDERABLE:

- US Elastography
- Can be performed as a stand-alone code, or performed with *US Liver* (preferred), *US Abdomen Complete*, or *US Abdomen (RUQ)*.

CHARGEABLES:

- CPT code 76981 (Ultrasound, Elastography; Parenchyma [e.g., organ])
- +CPT code 76981 modifier -59 if spleen is included
- Can be charged as a stand-alone examination, or charged with another abdominal examination

INDICATIONS:

- Risk factors for chronic liver disease such as viral hepatitis (HBC; HCV; HIV), alcohol abuse, fatty liver disease (NAFLD/MASLD; NASH/MASH), or other cause of liver fibrosis;
- History of hemochromatosis, primary biliary cirrhosis, or primary sclerosing cholangitis;
- History of chronic heart disease, including history of Fontan;
- Unexplained chronic liver dysfunction such as persistently elevated liver function tests (LFTs);
- Findings or concern for portal hypertension such as ascites, splenomegaly, varices;
- Provided history of, or screening for, cirrhosis;
- Provider comments specifying “Liver Elastography”;
- Abnormal findings on other imaging studies suggesting chronic liver disease/cirrhosis;
- Follow up of know chronic liver disease or hepatic fibrosis.

CONTRAINDICATIONS:

- No absolute contraindications.
- Non-fasting Status; if not NPO, check with Radiologist prior to proceeding*.
    - *Exam may proceed, however if results are abnormal, the patient may have to return for a repeat exam with appropriate preparation.
- Elevated LFTs; if AST/ALT are > 800, check with Radiologist prior to proceeding.
- If spleen is absent, obscured (significant rib, lung or bowel shadow), or too small (<3 cm in thickness), spleen elastography may be deferred. Please document reason in Tech Notes.

EQUIPMENT:

- Philips Epiq with C5-1 transducer, and shear wave ElastPQ and/or ElastQ software package
- -or- Siemens Sequoia, 5C1, DAX, or new 9C2, and Elasto software package (pSWE; 2D SWE)

PATIENT PREPARATION:

- Patient should be NPO for at least 4 hours prior to study.

- May take small amount of water for routine medications.

EXAMINATION:

GENERAL GUIDELINES:

- Liver Elastography can be performed as a standalone exam. However, standard-of-care is to interpret results in context with a *US Abdomen, US RUQ,* or *US Liver* examination. If one of these exams has not been performed at our institution within the last 6 months, the expectation is that an effort will be made to contact the provider for an additional order (*US Liver),* to be performed concurrently.
- This examination includes the successful estimation of liver stiffness with the acquisition of 10 successful measurements within a single liver segment (usually right lobe, segments 5, 7 or 8).

EXAM INITIATION:

- Review prior imaging, risk factors, and LFTs
- Introduce yourself to the patient
- Verify patient identity using patient name and DOB
- Explain test
- Obtain patient history including symptoms. Ensure patient is NPO at least 4 hours. Enter and store data page
- Place patient in supine or semi-decubitus (up to 30 degrees) with right arm above head

TECHNICAL CONSIDERATIONS:

- Always review any prior imaging, making note of abnormalities requiring further evaluation.
- Shear wave elastography is ideally performed in the setting of normal LFTs. Markedly elevated LFTs (eg. AST/ALT 5x normal) may elevate shear wave velocity and artifactually increase fibrosis estimation.
- Shear wave elastography is typically performed with the C5-1 probe, ELASTO preset.
- An intercostal approach into the right lobe is used. Place patient supine or semi-lateral decubitus (up to 30 degrees, supported by pillow) with patient's right arm above head to maximize spacing between ribs.
- **Optimize the B-mode image.** Rotate probe to match the intercostal space for the widest acoustic window. Reduce depth to appropriate image size.
- Ensure probe face is parallel to liver capsule (perpendicular to scan direction).
- Apply only light probe pressure.
- Measurements are taken of liver segments 5, 7, or 8.
- Place ROI sample box within the liver parenchyma, avoiding vessels and bile ducts. Do not measure near the hepatic dome or adjacent to refraction artifact/rib shadow.
- Ask patient to suspend breathing during easy respirations, staying relaxed. **Patient should not take a deep breath in or Valsalva** (this will falsely elevate stiffness measurements).
- **For point shear wave elastography (pSWE; ElastPQ):**
  - ROI should be > 1.5 cm from the hepatic capsule and within 6-8 cm of the skin.
  - **Wait for liver motion to stop. Hold probe steady.** Obtain measurement (Update button) and Acquire image.
  - Stiffness values should display as a shear wave velocity (SWV, in m/s). If "0.00" or "xxx" value is obtained, do not print/acquire. Unfreeze and repeat.

- Some measurements may be obviously too low or too high (eg. < 0.8 m/s; or > 3.0 m/s when all other values may be normal). If 1 or 2 of these values do not correspond with the majority of your other measurements you have collected, you may choose to repeat these measurement.
- In some patients, particularly with diffuse steatosis or several fibrosis/cirrhosis, values may be highly variable—THIS IS AN EXPECTED PHENOMENON. If all measurements are variable, then obtain your 10 measurements and report your findings of high variability. DO NOT THROW OUT ALL "LOW" OR "HIGH" NUMBERS AND FORCE PATIENTS INTO ONE CATEGORY OR ANOTHER.
- Unfreeze after the mandatory 3-second cooling period.
- Repeat measurement in the same area for a total of 10 measurements.

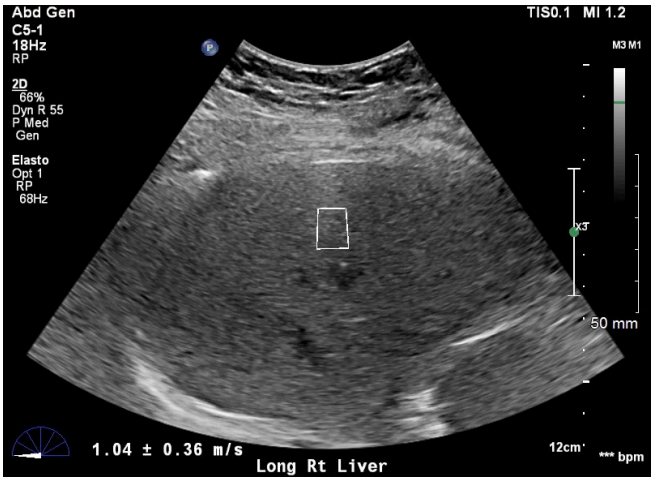
- **For 2D shear wave elastography (2D SWE; ElastQ; EQI):**
  - Measurement box may be placed closer to liver capsule as long as you do not visually see near-field subcapsular reverberation artifact. Move ROI color box down/deeper to just below area of reverberation (see Appendix).
  - **Confidence Map (Philips) and Quality Map (Siemens) should be on.**
  - **During suspended respirations, hold probe steady.**

  - **Philips EPIQ:**
    - **Capture at least 3 cine loops, 8-10 seconds in length each**
    - With cine clip you may scroll/step back through several measurement "refreshes" (frames) and save representative images with measurements, all from one breath hold.
    - Place up to 2 circle ROIs in areas of most representative color on stiffness map:
      - Wait for color pattern to "settle" (usually after 2-3 frames);
      - Then, measure in center of box, in area that changes least over time.
    - **If color map never "settles" and changes dramatically frame-to-frame, repeat. Try different rib space, or reposition patient.**
  - **Siemens Sequoia:**
    - **Capture at least 5 color frames with quality map.**
    - **Place up to 2 measurement ROIs within the color box (usually in the middle)**
  - Reference Confidence/Quality Map, making sure majority of map is green (at least 50%).
    - Place circle ROIs in areas on high confidence/quality (green)
  - Ensure color stiffness map fills in > 50%

If applicable, please see separate *US Liver* and *US Liver Doppler* if also ordered/performed

DOCUMENTATION:

- **Point Shear Wave Elastography (pSWE; ElastPQ):**
  - 10 measurements of shear wave velocity (SWV, in m/s) within the same region of liver tissue;
  - ROI in the liver parenchyma of segments 5, 7 or 8.
  - Avoid taking measurements in or near the liver capsule, heart/diaphragm, large blood vessels or large bile ducts.
  - Do not acquire/save "0.00" or "xxx" values. Unfreeze and repeat measurement.

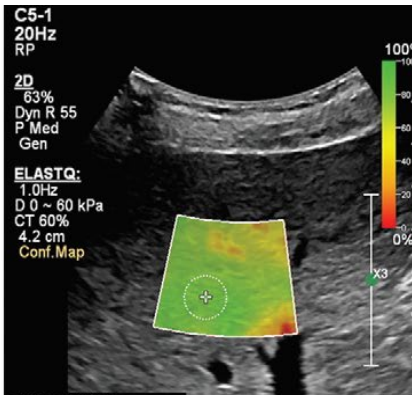


- **2D Elastography (2D SWE; ElastQ; EQI):**
  - **Philips' EPIQ:** Obtain at least 3 cine clips, 8-10 seconds each, with the patient in suspended respiration
    - **Confidence Map ON**
    - **Color map should "settle" after 2-3 frames; then, capture cine loops with 3-5 frames with similar color/pattern.**
  - **Siemens Sequoia:**
    - Obtain at least 5 independent color map measurements
    - Record corresponding Quality Map
  - For each color map refresh, review the grayscale image and stiffness and confidence maps. Place no more than 2 ROIs within each color box following these guidelines:
    - On the **grayscale image**, place ROIs in areas of representative parenchyma. Avoid masses, large vessels, and bile ducts;
    - On **confidence/quality map**, place ROI in areas that are green (high quality/confidence). Refrain from placing ROIs in orange/red areas;
    - On **stiffness map**:
      - Ensure stiffness map fills >50%;
      - Place ROI in areas with the most representative color, in areas that change least over time (usually near center of box);
      - Avoid artifacts (usually in periphery).
  - Acquire the 1) confidence/quality map and 2) stiffness map, with ROIs in place.
  - Obtain a total of 10 ROIs from 5 color map frames.

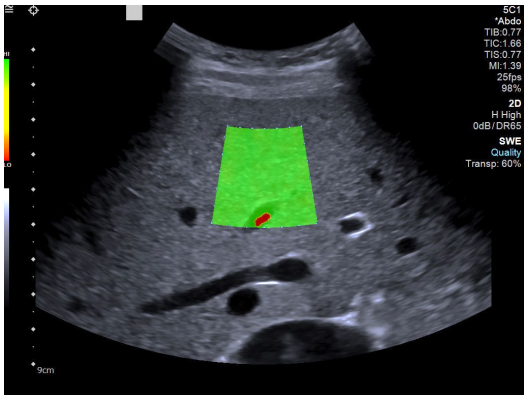
- **Multi-sample Elastography (AutoPoint SWE; Siemens):**
  - Acquire 5 samples
    - For each, change "Site"

- **Spleen Elastography**
  - Perform if requested, or in patients with cardiogenic liver disease (eg. Fontan), known cirrhosis and/or portal hypertension;
  - May defer in patients without these risk factors, without spleen, or spleen too small or obscured which prevents achieving technique requirements;
  - Follow same protocol as for liver elastography (pSWE and 2D SWE, as above);

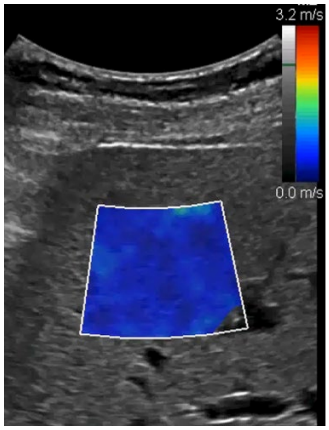
- Acquire 10 measurements for each technique (as above).



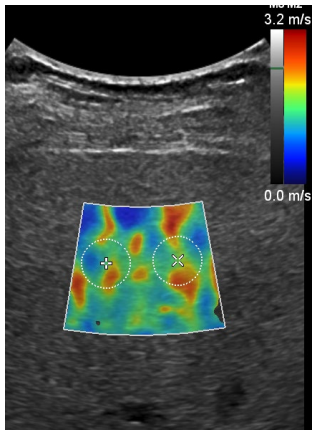
Philips Confidence Map



Siemens Reliability Map



Stiffness Maps (low fibrosis)



(High fibrosis)

If applicable, please see separate *US Liver* and *US Liver Doppler* if also ordered/performed

PROCESSING:

- Review examination images and data
- Export all images to PACS
- Must document relevant history:
  - NPO status
  - If elevated LFTs
  - Any study limitations in Tech Notes

REFERENCES:

ElastPQ Shear Wave Elastography Reference Card for Epiq 7, Philips Healthcare.
Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement, Radiology 2015.
Update to Society of Radiologists in Ultrasound Liver Elastography Consensus Statement, 2020
Assessment of Liver Viscoelasticity by Using Shear Waves Induced by Ultrasound Radiation Force, Radiology 2013.**APPENDIX:**

Cutoff Values based on Updated 2020 SRU Consensus Statement for Liver Stiffness (vendor-neutral):

SWV	Stiffness	Impression	Recommendations
< 1.3 m/s	**< 5 kPa**	Normal (high probably of being normal)	None
< 1.7 m/s	**< 9 kPa**	Low probability (rules out cACLD in absence of other clinical signs)	If concern persists, perform another rule out test
1.7 – 2.1 m/s	**9-13 kPa**	Suggestive of cACLD	If low suspicion, perform rule in test to confirm
> 2.1 m/s	**> 13 kPa**	High probability (rules in cACLD)	Enroll in HCC screening/surveillance program
> 2.4 m/s	**> 17 kPa**	ACLD with concern for clinically significant portal hypertension (CSPH)	HCC + esophageal varices screening

Measurement Reliability (IQR/Median)

Interquartile Range / Median (IQR/M), a quality metric for shear wave elastography

1. Calculate IQR (click link for Calculator)
2. Then divide by Median

IQR/M < 0.15 (15%) supports good precision (when measuring by shear wave speed)

Conversion to Stiffness (kPa):

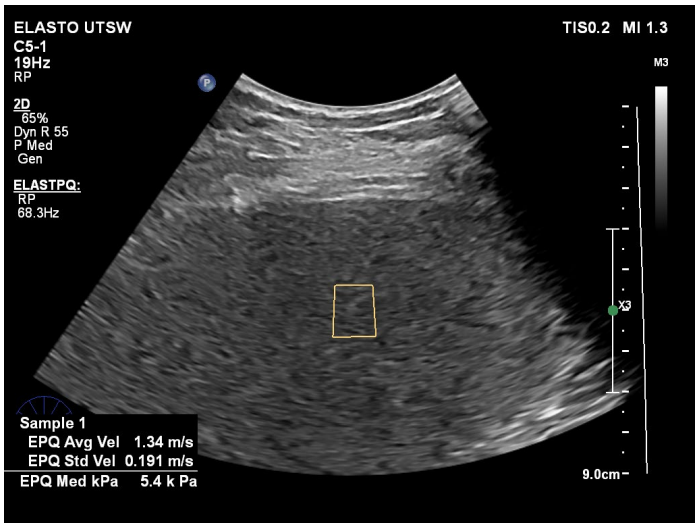
Young's modulus (E) = $V_s^2 * \rho * 3$

where V_s is shear wave velocity, and ρ is density (est as 1)

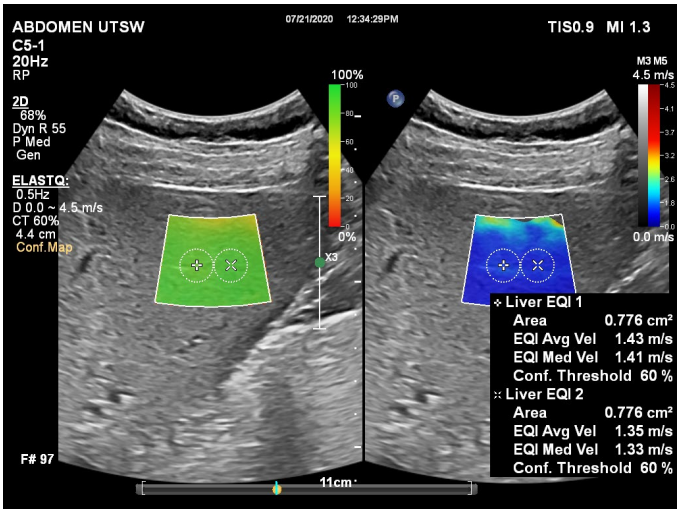
or

$kPa = (SWV)^2 * 3$

Typical Appearance and Report for ElastPQ

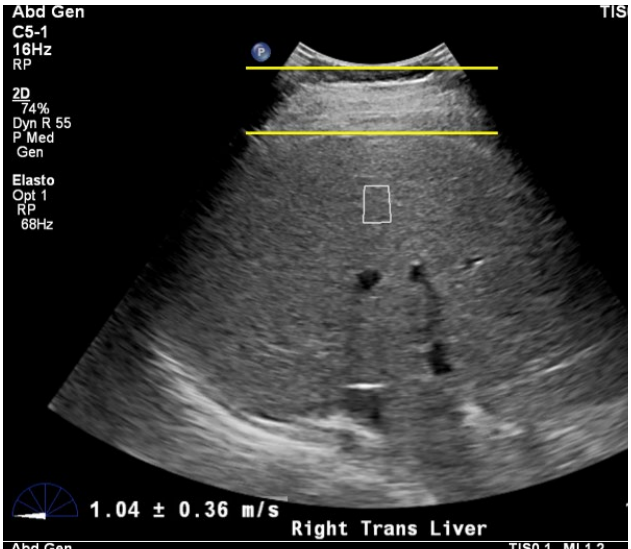


ElastPQ Stiffness Calculations					
EPQ Med Vel	1.21 m/s	EPQ Med	4.37 kPa	EPQ IQR/Med Vel	24 %



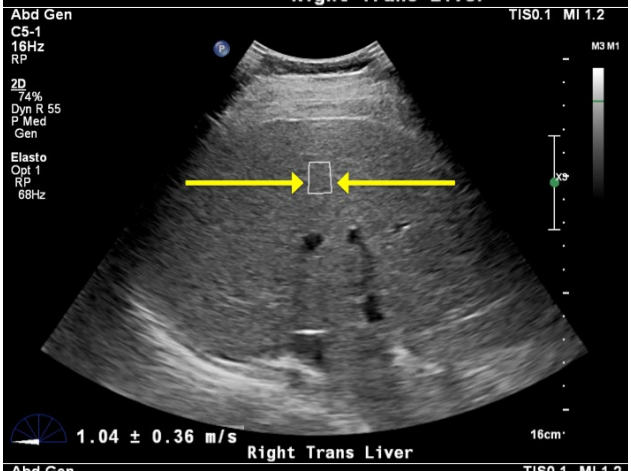
EQI Liver Stiffness Calculations					
Liver EQI Med Vel	1.36 m/s	Liver EQI Med	5.55 kPa	Liver EQI IQR/Med Vel	12 %

Appropriate Measurement Techniques (both pSWE/ElastPQ and 2D SWE/ElastQ Imaging):



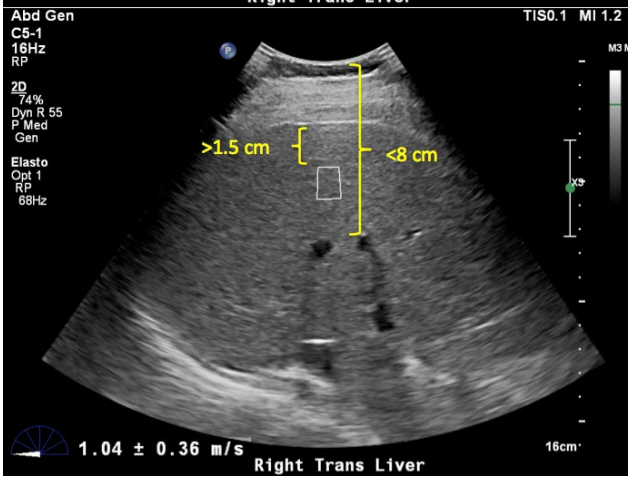
Acoustic Window:

- ✓ Intercostal approach;
- ✓ Probe angled to match rib space to maximize acoustic window;
- ✓ Probe face parallel to the hepatic capsule.



ROI Sample Box Position:

- ✓ Centered within the vector;
- ✓ Away from blood vessels and bile ducts.

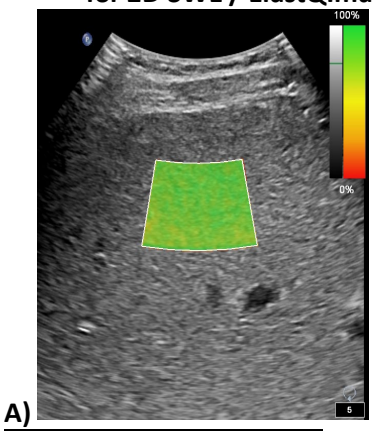


ROI Sample Box Depth:

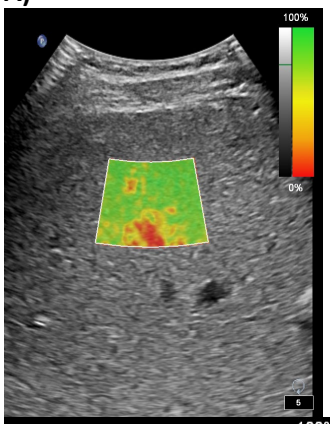
- ✓ > 1.5 cm from hepatic capsule;
- ✓ < 8 cm from skin surface.

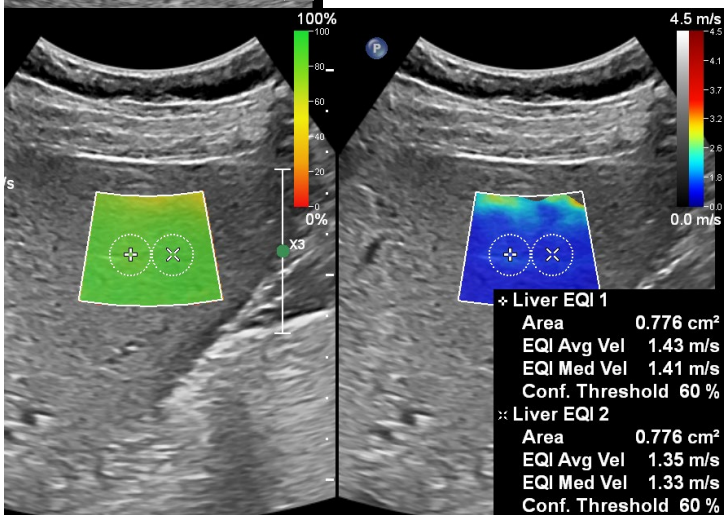
- ✓ For 2DSWE (ElastQ), box may be closer to capsule as long as there is no reverberation artifact

Measurement Technique
for 2D SWE / ElastQImaging (EQI)



A) **B)**





Confidence Maps

Good confidence map (A), primarily green with minimal yellow; no orange or red

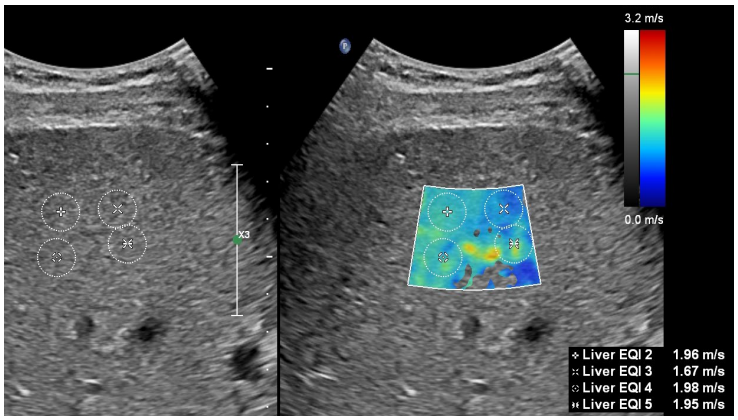
Poor confidence map (B), with large areas of red and orange

Circle ROI Placement

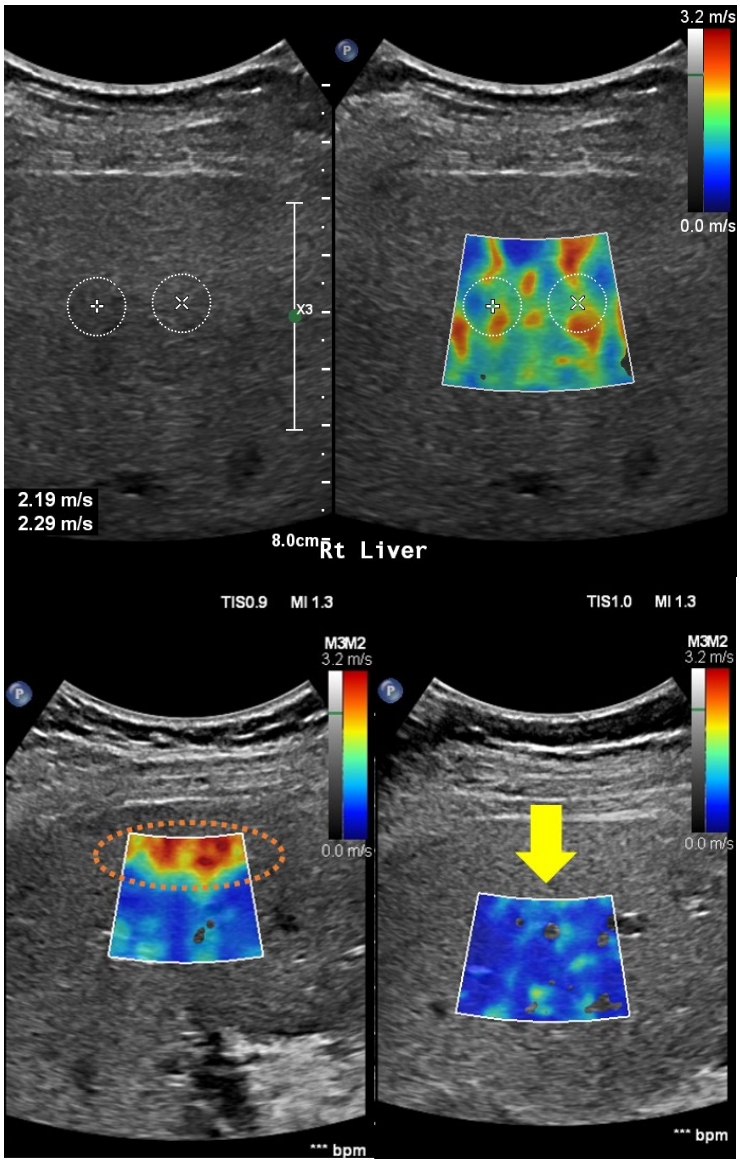
Place 2 ROIs in regions of the most representative color on stiffness map;avoid large vessels, masses, and ducts.

Circle ROI Placement

Avoid areas of “color void” (no color pixels).
If some of your ROI contains blank pixels, it’s ok, these will



not be included in the measurement.
This example shows too many ROIs in one frame.



Circle ROI Placement

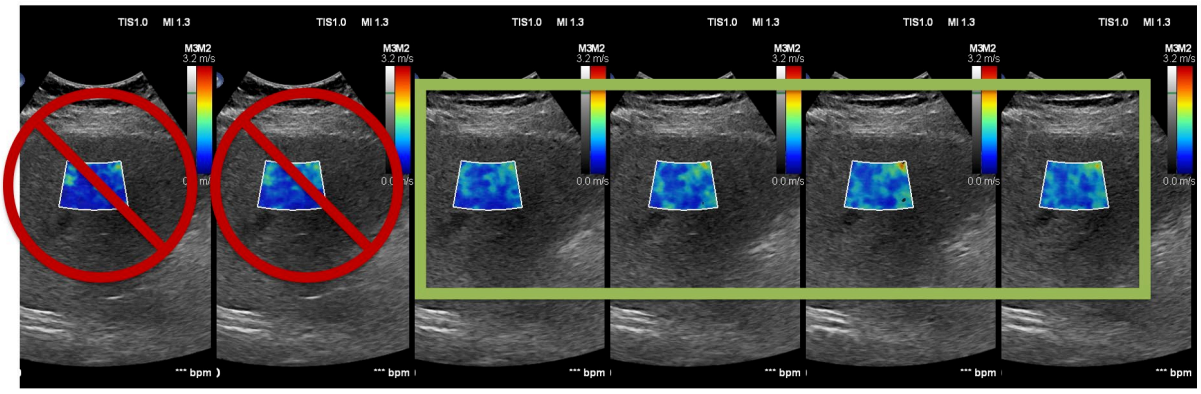
Attempt to place in most representative area. If very heterogeneous, place ROIs evenly distributed throughout color map (as long the pattern is similar frame-to-frame).

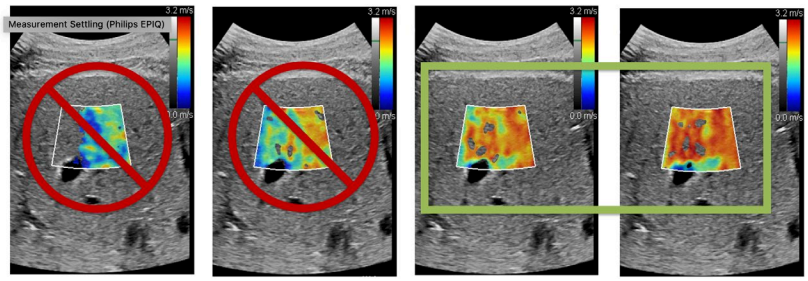
Reverberation Artifact

May move color box closer to liver capsule as long as there is no sub-capsular reverberation artifact (red stripe in near field of box). If so, move box down until just below area of artifact.

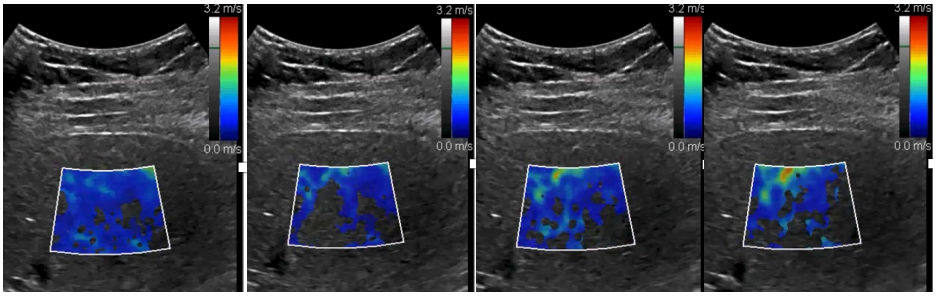
2D SWE for Philips EPIQ (ElastQ / EQI)

Wait for color pattern to "settle" (usually after 2-3 frames). Measure center of box after pattern becomes consisting, with > 50% fill-in for each frame

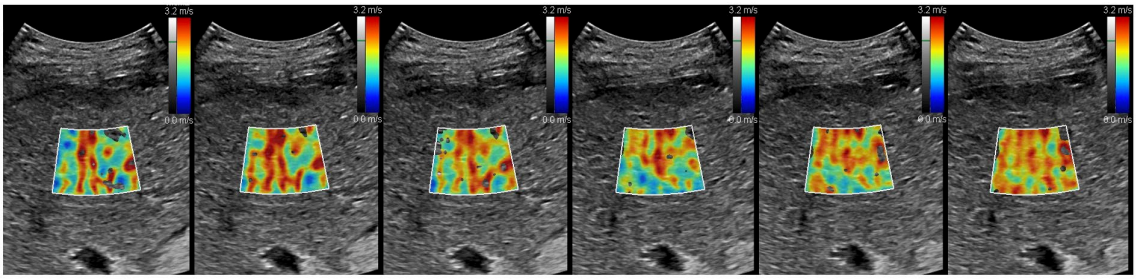




EXAM FAILURE



Cirrhosis will look patchy and heterogeneous, <u>but the same pattern with each frame</u>. If you are getting same pattern over-and-over, ok to measure areas of patchy orange/red.



Inappropriate Measurement Techniques (ElastPQ / pSWE):

ROI Sample Box too close to hepatic capsule.

Correction: move sample box at least 1.5cm from capsule, remaining clear of vessels and bile ducts.

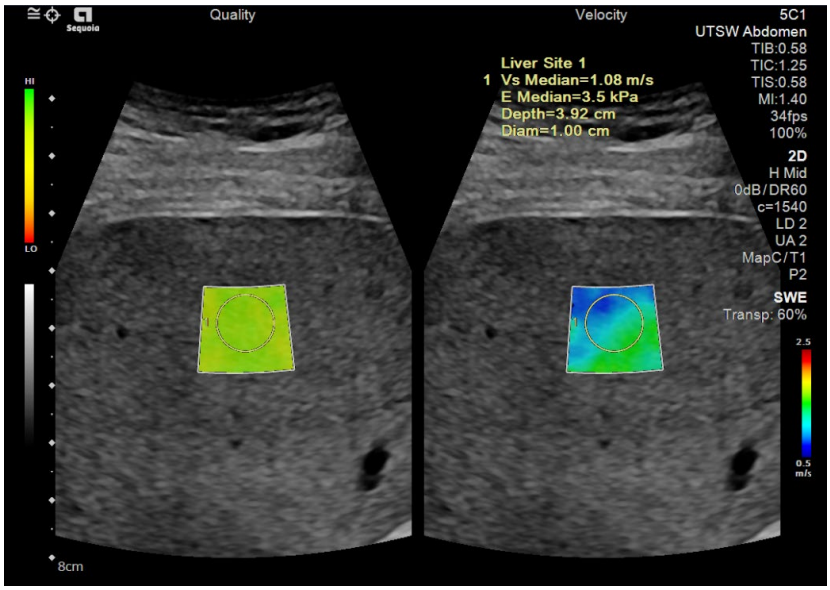
ROI Sample Box too close to rib shadow.

Corrections: angle probe to match rib space (oblique sagittal) to maximize acoustic window.
Move ROI sample box to center of vector.

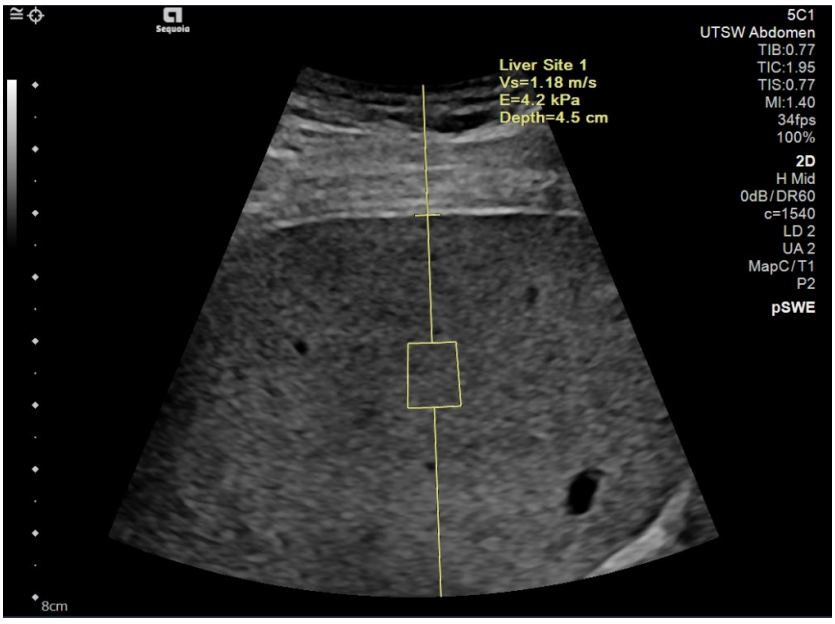
Liver capsule at an acute angle with probe face.
ROI Sample Box too close to hepatic dome.

Corrections: angle probe to match hepatic surface (obtain parallel alignment with liver capsule).
Move ROI Sample Box inferiorly, away from dome.

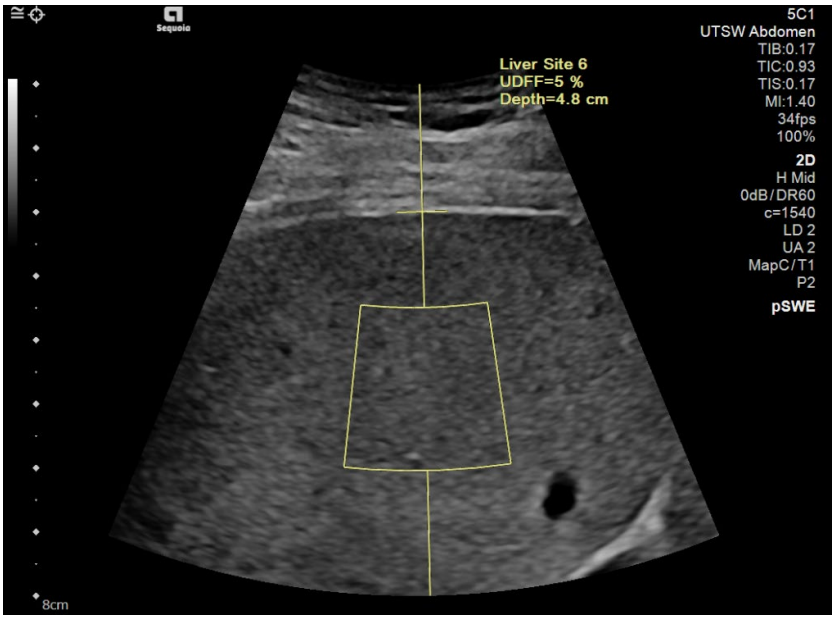
SIEMENS ELASTOGRAPHY:



Siemens image demonstrating SWE with appropriately positioned and color-filled box.



Siemens image demonstrating pSWE with depth indicator for appropriately positioned box.



Siemens image demonstrating correct placement of UDFF sample box with depth indicator.

Spleen Elastography:

SWS	Stiffness	Interpretation
<2.4 m/s	**<17 kPa**	**Normal**
<2.7 m/s	**<22 kPa**	**Rules out clinically-significant portal hypertension (CSPH)**
2.8-3.0 m/s	**23-27 kPa**	**Intermediate risk for CSPH**
>3.1 m/s	**>28 kPa**	**Rules in CSPH**
>3.3 m/s	**>32 kPa**	**CSPH with risk for esophageal varices**
>3.5 m/s	**>36 kPa**	**CSPH with elevated risk for esophageal hemorrhage**

REVISION HISTORY:

SUBMITTED BY:	David T. Fetzer, MD	**Title**	Medical Director
APPROVED BY:	David T. Fetzer, MD	**Title**	Medical Director
APPROVAL DATE:	11-09-2015		
REVIEW DATE(S):	11-14-2018		David Fetzer, MD
REVISION DATE(S):	04-24-2016	**Brief Summary**	
REVISION DATE(S):	12-14-2016	**Brief Summary**	Added information regarding distance to skin, number of measurements needed
REVISION DATE(S):	10-04-2017	**Brief Summary**	Added information regarding ElastQ Imaging
REVISION DATE(S):	08-22-2018		Updated information for ElastQ technique
REVISION DATE(S):	02-06-2019		Updated information regarding documenting NPO status and patient LFTs
REVISION DATE(S):	06-16-2019		Clarified that US Elastography can be performed independent of US Abdomen exam.
	07-10-2020		US Liver must be performed within last 6 months to perform as a stand-alone exam
	7/30/2020		Updates to include Siemens Sequoia, and updates to 2020 SRU Consensus statement
	06/13/2022		Clarified that Confidence/Quality map should always be ON. Emphasized need to check and document NPO status and LFTs
	01/08/2023		Clarified requirements for having a US Liver, US RUQ, or US Abdomen Complete exam performed concurrently or within last 6 months (expected, but not required)
	09/19/2023		Added information for spleen stiffness
	08/27/2024		Updated an error in the image captions
	05/06/2025	Jana Smith, RDMS, RVT	Added Parkland logo. Reformatted appendix. Added Siemens images.