Ultrasound – Liver Elastography

**PURPOSE:**
To evaluate hepatic parenchymal stiffness by shear wave elastography for the detection of fibrosis.

**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])
- 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; NASH), or other cause of liver fibrosis;
- History of hemochromatosis, primary biliary cirrhosis, or primary sclerosing cholangitis;
- Unexplained chronic liver dysfunction such as persistently elevated liver function tests (LFTs);
- Findings of portal hypertension such as ascites, splenomegaly, varices;
- Provided history of, or screening for, cirrhosis or hepatocellular carcinoma (HCC);
- 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

**EQUIPMENT:**
- Philips Epiq7 or Epiq5 with C5-1 transducer, and shear wave ElastPQ and/or ElastQ software package
- -or- Siemens Sequoia, 5C1 transducer, and Elasto software package (pSWE; 2D SWE)

**PATIENT PREPARATION:**
- Patient should be NPO for at least 4 hours prior to study.

**EXAMINATION:**
**GENERAL GUIDELINES:**
Liver Elastography can be performed as a standalone exam. However, a *US Abdomen, US RUQ*, or *US Liver* must have been performed at our institution within the last 6 months. Otherwise, a *US Liver* must be ordered and 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. Ensure patient is NPO at least 4 hours
- Obtain patient history including symptoms. 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 (e.g., AST/ALT 5x normal) may elevate shear wave velocity and artifactually increase fibrosis estimation.
- Shear wave elastography is 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.
- Rotate probe to match the intercostal space for the widest acoustic window.
- 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 (e.g., < 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, then you may choose to repeat the 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 to just below area of reverberation (see Appendix).
- 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)
- Check confidence map, making sure majority of map is green (at least 50%).
- 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, blood vessels or 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
    - Color map should “settle” after 2-3 frames, and then you should capture 3-5 frames with similar color/pattern.
  - Siemens Sequoia: Obtain at least 5 color map measurements
For each color map refresh, review the grayscale image and stiffness and confidence maps. Place up to 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 quality/confidence map, place ROI in areas that are green (high confidence). Refrain from placing ROIs in areas that are orange or red on confidence map;
- On stiffness map, place ROI in areas with the most representative color:
  - In areas that change least over time (usually near center of box)
  - Ensure stiffness map fills >50%

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.

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
- Document relevant history, NPO status, LFTs, and any study limitations in Tech Notes
REFERENCES:
ElastPQ Shear Wave Elastography Reference Card for Epiq 7, Philips Healthcare.
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 2020 SRU Consensus Statement (vendor-neutral):

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

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

Conversion to Stiffness (kPa):
Young’s modulus (E) = $V_s^2 \cdot \rho \cdot 3$
where $V_s$ is shear wave velocity, and $\rho$ is density (est as 1)
or
$$kPa = (SWV)^2 \cdot 3$$
Typical Appearance and Report for ElastPQ

**ElastPQ Stiffness Calculations**

| EPQ Med Vel | 1.24 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 / ElastQ Imaging (EQI)

**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.
  (this example shows too many ROIs in one frame)

**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
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, but the same pattern with each frame. 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.
<table>
<thead>
<tr>
<th>REVISION DATE(S):</th>
<th>Brief Summary</th>
<th>Added information regarding distance to skin, number of measurements needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-04-2017</td>
<td>Brief Summary</td>
<td>Added information regarding ElastQ Imaging</td>
</tr>
<tr>
<td>08-22-2018</td>
<td>Brief Summary</td>
<td>Updated information for ElastQ technique</td>
</tr>
<tr>
<td>02-06-2019</td>
<td>Brief Summary</td>
<td>Updated information regarding documenting NPO status and patient LFTs</td>
</tr>
<tr>
<td>06-16-2019</td>
<td>Brief Summary</td>
<td>Clarified that US Elastography can be performed independent of US Abdomen exam.</td>
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<tr>
<td>07-10-2020</td>
<td>Brief Summary</td>
<td>US Liver must be performed within last 6 months to perform as a stand-alone exam</td>
</tr>
<tr>
<td>7/30/2020</td>
<td>Brief Summary</td>
<td>Updates to include Siemens Sequoia, and updates to 2020 SRU Consensus statement</td>
</tr>
</tbody>
</table>