Ultrasound Liver and Portal Hypertension Evaluation

PURPOSE:
To evaluate the liver for acute and chronic liver disease and cirrhosis; to interrogate the gallbladder and bile ducts; to screen for hepatocellular carcinoma; and to evaluate for findings of portal hypertension.

SCOPE:
Applies to all studies performed in:

- UT Southwestern William P. Clements Jr. University Hospital, Zale-Lipshy Pavilion, and all University Hospital-based Clinics Imaging Services (UTSW)
- Parkland Health and Hospital System Department of Radiology (PHHS)

ORDERABLE:

- US Liver
- **May be combined with *US Liver Doppler* and/or *US Liver Elastography +/- Fat Quantification* —please see separate Protocol for details**

CHARGEABLES:

- US Abdomen Limited

INDICATIONS:

- Signs or symptoms of liver dysfunction including elevated liver function tests (LFTs);
- Jaundice, elevated bilirubin, or other signs of biliary obstruction;
- Risk factors for chronic liver disease such as viral hepatitis (HBC; HCV; HIV), alcohol abuse, or fatty liver disease;
- History of NAFLD/NASH, MASLD/MASH, hemochromatosis, primary biliary cirrhosis, or primary sclerosing cholangitis;
- Findings of portal hypertension such as thrombocytopenia, ascites, splenomegaly, varices;
- Provided history of or screening for cirrhosis or hepatocellular carcinoma (HCC);
- Abnormal findings on other imaging studies suggesting chronic liver disease/cirrhosis;
- Follow up of known chronic liver disease or hepatic fibrosis.

CONTRAINDICATIONS:

- No absolute contraindications

EQUIPMENT:

- Curvilinear transducer, frequency range of 1-9 MHz that allows for appropriate penetration and resolution depending on patient's body habitus.
- Linear array transducer, frequency range of 7-18 MHz, to evaluate the hepatic capsule.

PATIENT PREPARATION:

- OUTPATIENTS: Patient should be NPO for 6-8 hours prior to study, allowing for distention of gallbladder and decrease in bowel gas.
- ER/INPATIENTS: Fasting not needed given urgency of exam. Follow up imaging may be required if area of interest obscured by bowel gas, gallbladder distention is needed, etc.

EXAMINATION:

GENERAL GUIDELINES:

- A successful examination includes the evaluation of the entire Liver, including parenchymal architecture and capsular contour; screening for focal lesions (eg HCC); Gallbladder and bile ducts; Abdominal cavity for ascites; Spleen size; Main portal vein directionality, velocity, and caliber.
- May be combined with *US Liver Doppler* and/or *US Liver Elastography +/- Fat Quantification* — please see separate protocol for details.

EXAM INITIATION:

- Review any prior imaging, making note of associated abnormalities requiring evaluation.
- Introduce yourself to the patient
- Verify patient identity using patient name and DOB
- Explain test
- Obtain patient history including symptoms. Inquire if the patient has received pain medication. Enter and store data page
- Place patient in supine or left lateral decubitus (LLD) position with arm above head

TECHNICAL CONSIDERATIONS:

- Deep inspiration facilitates imaging of the liver dome and right hepatic lobe in the supine position via subcostal approach.
- In LLD position, the right liver and gallbladder shift towards the midline, improving accessibility for scanning and facilitating intercostal scanning for the posterior liver and dome.
- Cine sweeps allow for better evaluation of focal or indeterminate findings.
- **Doppler:**
    - Optimize color Doppler settings to show optimal flow
        - Adjust scale and gain to maximally fill the vessel of interest without artifact
            - Lighter color in the middle of the vessel lumen
        - Use Power Doppler or Micro Doppler techniques (eg. MFI; MVI; Slow Flow) if suspecting absent flow with color Doppler
    - Optimize spectral Doppler
        - Place time-gate centrally within the center of the vessel of interest
        - Adjust scale to extend spectral waveform to at least 2/3rds of scale (amplitude adequate for interpretation)
        - Reduce aliasing for high flow evaluation
    - As much as possible, utilize angle correction of $\leq 60^{o}$ to measure velocities
        - Angle correction should always be parallel to the vessel wall
        - For certain anatomy, may need to insonate from different approaches to optimize angle
- **Liver:**
    - Liver should be evaluated for focal and/or diffuse abnormalities. Liver echogenicity should be compared with that of the right kidney and pancreas.
    - Cine sweeps, including as much hepatic parenchyma as possible, should be acquired in the transverse and longitudinal orientations.
    - A combination of intercostal and subcostal imaging, supine and LLD, helps ensure all areas of liver are optimally imaged.

- In the absence of ascites, nodular liver surface contour is best seen with a linear array transducer.
- Evaluate the parenchyma adjacent to the gallbladder fossa, fissure for the falciform ligament, and portal bifurcation for areas of focal fat sparing.
- Evaluate the area around the ligamentum teres for a dilated paraumbilical vein in the setting of portal hypertension.
- Evaluation of the hepatic capsule with a higher-resolution linear probe allows for evaluation for capsular nodularity, and allows for an additional evaluation of the underlying parenchyma for coarsening/heterogeneity and nodularity.
- Optimal capsule evaluation includes placing probe in LONG orientation and obtaining a cine clip as the patient inhales and exhales, while keeping the probe stationary—this allows for differentiation of hepatic capsule from abdominal wall.

- **Gallbladder and Bile Ducts**
  - Fasting for 6-8 hours prior to exam will permit adequate distension (not needed for ER or IP exams, although follow-up imaging may be needed if GB distention is desired).
  - Gallbladder and intra/extrahepatic bile ducts should be evaluated for dilatation, wall thickening, and intraluminal findings.
    - Color Doppler may be used to differentiate hepatic arteries and portal veins from dilated intrahepatic bile ducts
  - In addition to supine and LLD imaging, upright or prone imaging of the gallbladder may be necessary to evaluate mobility of sludge and stones or to differentiate them from a polyp.
  - Evaluation for a sonographic Murphy sign requires focal tenderness to transducer compression immediately over the gallbladder fundus, in an unaltered patient, and in the absence of the patient having received pain medication. This should be distinguished from diffuse abdominal tenderness.
  - The common duct should be imaged longitudinally, adjacent to the main portal vein, distinguished from the hepatic artery by color Doppler.
  - The duct should be measured from inner wall to inner wall at the porta hepatis near the crossing of the right hepatic artery. Remainder of the common duct should be evaluated as far distally toward the pancreatic head as possible if common duct measurement is abnormal or for obvious choledochocele variant, with an evaluation for obstructing intraluminal or extrinsic lesions, if possible.
  - Wall thickening and edema should be documented without and with thickness measurements, and without and with color Doppler to assess for wall hyperemia.
  - For suspected cholecystitis, please see US Gallbladder protocol for details regarding hepatic and cystic artery Duplex analysis.

- **Spleen:**
  - Longitudinal measurements: *Length & Width (AKA Thickness)*
  - Transverse measurement: *AP (AKA Height or Trans) - 90 degrees to Long image*
  - Color Doppler evaluation at splenic hilum to document vessel patency, check for varices or evaluate.

        - For splenomegaly, LUQ pain, abnormalities on prior imaging, or if requested by provider, power, and/or microflow may be used to further evaluate splenic perfusion for segmental hypoperfusion/infarction

- **Ascites:**
    - Evaluate RUQ for fluid peripheral to the liver and in the subhepatic space
    - Evaluate LUQ for fluid peripheral to the spleen
    - Evaluate RLQ and LLQ for fluid in the paracolic gutters
    - Evaluate midline pelvis for pelvic free fluid
    - Document the extent and location of any fluid identified
    - Provide stationary cine images to show mobility of debris, if present

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

DOCUMENTATION:

- **Liver**
    - Liver Capsule:
        - With a linear 9, 12, or 18 MHz transducer, include high-resolution images of hepatic capsule and underlying parenchyma for nodularity.
        - Obtain representative images from both left lobe and right lobe (if visualized well), still images (TRV and LONG)
        - CINE CLIP in LONG during a complete breathing cycle (inhalation and exhalation), with probe stationary, from both left lobe and right lobe (if visualized well).
    - Longitudinal images (minimum):
        - LEFT LOBE
            - Left lobe left of midline
            - Left lobe at midline. Include proximal abdominal aorta, celiac /SMA
            - Left lobe with IVC. Include caudate lobe, MPV, and pancreatic head.
            - Left lobe with left portal vein
            - CINE CLIP: from lateral tip to IVC/right of midline
        - RIGHT LOBE
            - Right lobe with gallbladder
            - Right lobe with right kidney
            - Right lobe including right hemi-diaphragm and pleural space
            - Right lobe far lateral
            - CINE CLIP: from midline to lateral most margin, using multiple acoustic windows if necessary.
    - Transverse images (minimum):
        - LEFT LOBE
            - Left lobe dome with hepatic veins
            - Left lobe with left portal vein
            - Left lobe inferior tip
            - CINE CLIP: from dome to inferior most margin
        - RIGHT LOBE
            - Right lobe dome with hepatic veins

- Right lobe with right portal vein
- Right lobe with main portal vein
- Right lobe with gallbladder
- Right lobe with right kidney
- Right lobe near inferior liver tip
- CINE CLIP: from dome to inferior most margin, using multiple acoustic windows if necessary

○ **REPEAT IN LLD: RIGHT LIVER, LONG AND TRANS, STILL IMAGES AND CINE CLIPS**

- A combination of intercostal and subcostal imaging may be necessary to ensure optimal visualization of all areas of liver.

○ Doppler:

- Main portal vein
  - Color Doppler (Dual/Split screen with grayscale)
  - Diameter measurement (inner wall-to-inner wall, on grayscale)
  - Spectral waveform with peak velocity, angle-corrected.
  - *Can refrain from repeating MPV diameter and PSV for US Liver if performed within a Liver Doppler*

- **Gallbladder and Bile Ducts:**
  - ○ Common duct with largest diameter measurement at porta hepatis.
  - ○ Gallbladder:
    - Longitudinal images:
      - Representative images of gallbladder, including the neck, mid body, and fundus
      - Color Doppler of wall if thickened/edematous.
      - CINE CLIP
    - Transverse images:
      - Representative images of gallbladder at neck, mid body, and fundus
      - CINE CLIP
    - *For suspected cholecystitis, please see US Gallbladder protocol for details regarding hepatic and cystic artery Duplex analysis.*

○ **REPEAT IN LLD: GALLBLADDER, LONG AND TRANS, STILL IMAGES AND CINE CLIPS**

- Looking for mobile stones/biliary precipitate (sludge).
- Standing, RLD and/or prone imaging may be needed to differentiate a mobile from impacted gallstone

- **Spleen**
  - ○ Longitudinal images
    - Representative images Including left hemidiaphragm and adjacent pleural space if possible, with cine sweep of any focal abnormality
    - Measurements
      - *Length:* From inferior most tip to highest point along diaphragm (**Red Line**), *crossing through the splenic hilum (arrow).*
      - *Width/Thickness: oriented 90 degrees* relative to longitudinal measurement at the hilum/hilar vessels, calipers placed at greatest thickness (**Green Line**).

- Transverse images:
  - Representative images of the spleen from dome to tip, with cine sweep of any focal abnormality.
  - Measurement
    - *AP/Height/Trans:* (**Blue Line**) measured at level of hilum/hilar vessels, does not have to cross through hilum but calipers placed at greatest width
- Color Doppler evaluation at splenic hilum to document vessel patency, direction of flow; detect varices.
- Splenic Volume**See appendix for examples of accurate spleen measurements.*

- **Ascites:**
  - Transverse images:
    - RLQ; LLQ; Midline pelvis
  - Stationary cine images of mobile debris, if present

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

- **Data Page(s)**

PROCESSING:

- Review examination images and data
- Export all images to PACS
- Document relevant history and any study limitations

REFERENCES:

ACR-AIUM Practice Guideline (Revised 2007)
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.
Assessment of Liver Viscoelasticity by Using Shear Waves Induced by Ultrasound Radiation Force, Radiology 2013.

REVISION HISTORY:

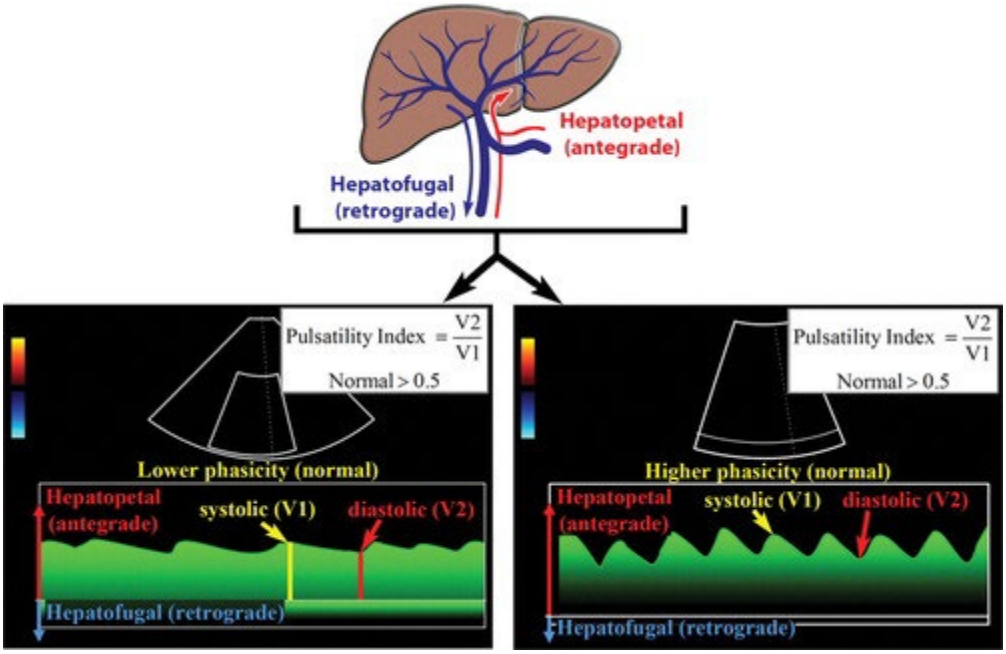
STATUS	NAME & TITLE	DATE	BRIEF SUMMARY
Submission	David Fetzer, MD, Director	11-09-2015	Submitted
Approval	David Fetzer, MD	11-09-2015	Approved
Review	Abhinav Vij, MD	09-24-2018	Reviewed
Revisions	David Fetzer, MD	04-24-2016	Updates to protocol name, corresponding to new templates
	David Fetzer, MD	09-11-2016	New protocol for measuring spleen. Added new size cutoffs.
	David Fetzer, MD	06-17-2017	Included additions and emphasis of obtaining cine sweeps through hepatic parenchyma
	David Fetzer, MD	05-20-2018	Updated details regarding cine sweeps needed through liver
	David Fetzer, MD	09-24-2018	Document reviewed with minor language edits.
	David Fetzer, MD	12-11-2019	Adjusted Documentation section to reflect preferred order of image acquisition. Specified use of LLD imaging
	David Fetzer, MD	02-23-2020	Clarifications regarding cine sweeps needed through liver. Removed liver length measurement
	David Fetzer, MD	05-31-2020	Review for protocol reduction
	David Fetzer, MD	09-09-2020	Added details regarding combining with other liver studies
	David Fetzer, MD	02-10-2021	Reorder liver capsule images to beginning of protocol
	David Fetzer, MD	03-08-2022	Clarified that fasting not needed for IP/ER orders
	David Fetzer, MD	04-24-2023	For suspected cholecystitis, please see US Gallbladder protocol for details regarding hepatic and cystic artery Duplex analysis.
	Skye Smola, RDMS, RVT	09-21-2023	Can refrain from repeating MPV diameter and PSV for US Liver if performed within a Liver Doppler Removed trans spleen superior to inferior images
	Jana Smith, RDMS, RVT	05-01-2025	Added requirement for still images and cine clips in LLD for liver. Added Parkland logo. Revised change history table format. Added images and verbiage for spleen measurement clarification.
	Skye Smola RDMS, RVT; David Fetzer, MD	8/27/2025	Spleen measurements adjusted, “Right” added to liver as LLD clarifier

APPENDIX:

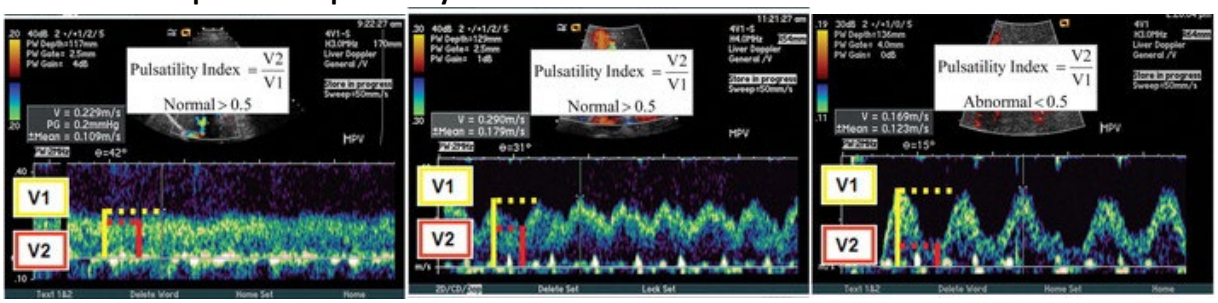
Signs of Portal Hypertension

- Porto-systemic shunts:
  - Patent paraumbilical vein
  - Perisplenic varices
  - Splenorenal shunt
- Hepatic veins:
  - Blunting of the normal triphasic hepatic venous waveforms
- Portal vein:
  - Bi-directional or reverse (hepatofugal) flow
  - Barcelona Criteria:
    - Main portal vein diameter >13 mm
    - Monophasic waveform velocity <16 cm/sec
    - Phasic waveform mean velocity <13 cm/sec

Portal Venous Waveforms:



Assessment of portal vein pulsatility



Causes of Pulsatile Portal Waveform

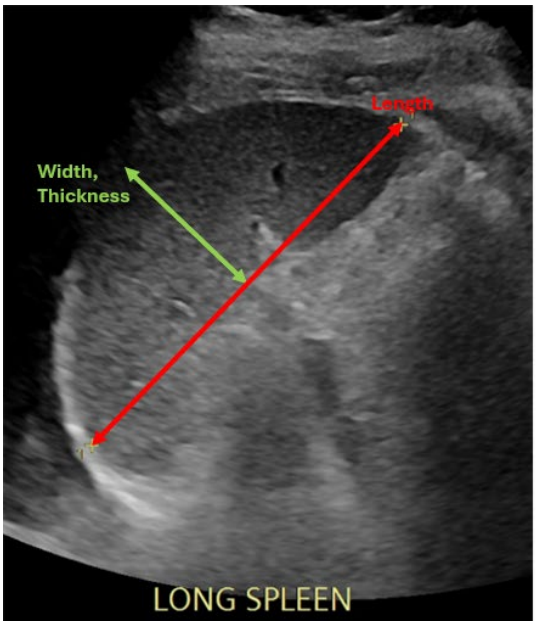
Tricuspid regurgitation
Right-sided CHF
Cirrhosis with vascular arterioportal shunting
Hereditary hemorrhagic telangiectasia–arteriovenous fistulas

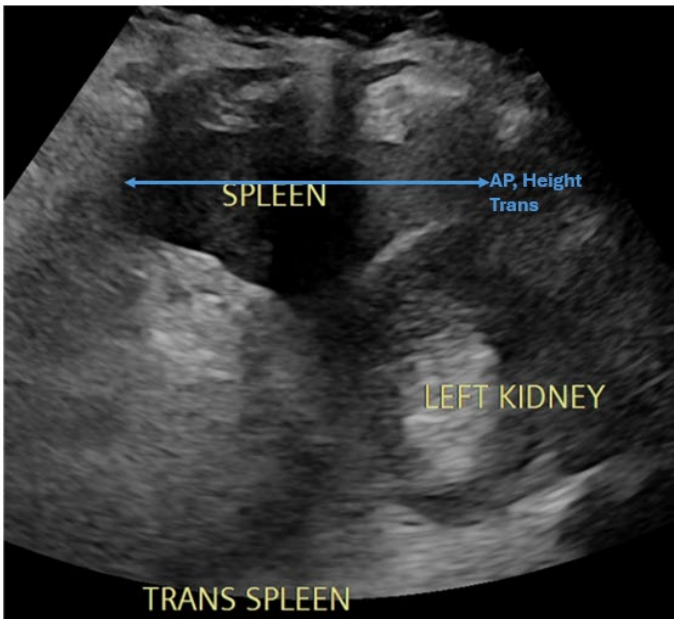
Spleen Measurements

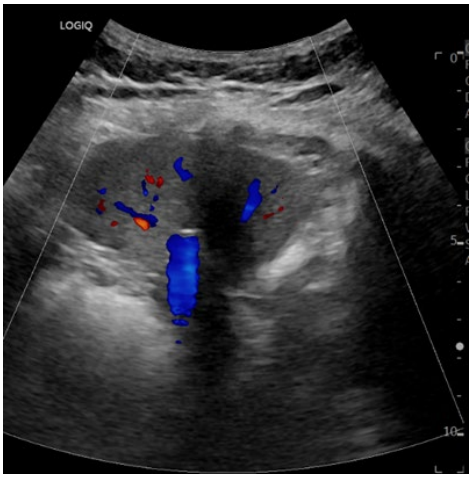
- NORMAL
  - Normal Length: < 12 cm in most patients
  - Normal volumes[+]: 209, SD +/- 76 cc (< 231 cc in women; < 334 cc in men)

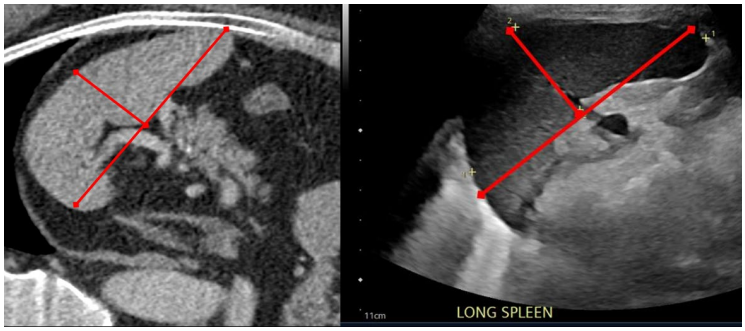
- SPLENOMEGALY
  - Consider splenomegaly ("borderline") when:
    - Length ≥ 12 cm in women; ≥ 13 cm in men –or–
    - Volume[+] > 250 cc in females; > 300 cc in males
  - Definite splenomegaly when:
    - Length ≥ 13 cm in women; ≥ 14 cm in men –or–
    - Volume[+] > 300 cc in females; > 350 cc in males

Additional reference images for Spleen measurements found here.






LOGIQ


LONG SPLEEN


TRANS SPLEEN