

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 abdominal ultrasound studies for liver disease performed in Imaging Services / Radiology

ORDERABLE:

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

CHARGEABLES:

- US Abdomen Limited

INDICATIONS:

- Signs or symptoms of liver dysfunction including elevated liver function tests (LTFs);
- 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, hemochromatosis, primary biliary cirrhosis, or primary sclerosing cholangitis;
- Findings of portal hypertension such as 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 4-6 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:

- 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*—please see separate protocol for details.

EXAM INITIATION:

- Introduce yourself to the patient
- Verify patient identity using patient name and DOB
- Explain test
- Obtain patient history including symptoms. Enter and store data page
- Place patient in supine or left lateral decubitus (LLD) position with arm above head.

TECHNICAL CONSIDERATIONS:

- Review any prior imaging, making note of associated abnormalities requiring evaluation.
- Deep inspiration facilitates imaging of the liver dome and right hepatic lobe in the supine position via subcostal approach.
- In LLD position, the liver and gallbladder shift towards the midline, improving accessibility for scanning and facilitating intercostal scanning for the posterior liver.
- Liberal use of cine sweeps allows 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 if suspecting absent flow with color Doppler
 - Optimize spectral Doppler
 - Place time-gate centrally within the vessel of interest
 - Adjust scale to extend spectral waveform (amplitude adequate for interpretation)
 - Reduce aliasing for high flow evaluation
 - As much as possible, utilize angle correction of $\leq 60^\circ$ to measure velocities
 - Angle correction should always be parallel to the vessel wall
 - For certain anatomy, may need to try 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 orientation for both lobes from dome to inferior most margin, and longitudinal sweeps of both lobes from left lateral tip through IVC (left lobe), and midline to right lateral margin (right lobe) preferably from a subcostal approach.
 - 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 fatty 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 4-6 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/or 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 choledochoceles 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 Size**
 - Deep inspiration facilitates imaging of the spleen.
 - Longitudinal spleen measurement: taken from inferior most tip to highest point along diaphragm, *crossing through the splenic hilum*.
 - Transverse measurements: *oriented 90 degrees* relative to longitudinal measurement, calipers placed at greatest thickness and width at the same level.
 - Evaluate for splenic vein varices with color Doppler evaluation of splenic hilum.
- **Ascites Check**
 - 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 both 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 adjacent pleural space
 - Right lobe far lateral
 - CINE CLIP: from midline to lateral most margin, using multiple acoustic windows if necessary.
 - Transverse images (minimum):
 - Dome with hepatic veins. Include entire right and left lobe (on separate images as needed)
 - LEFT LOBE
 - Left lobe dome
 - Left lobe with left portal vein
 - Left lobe inferior tip
 - CINE CLIP: from dome to inferior most margin
 - RIGHT LOBE
 - Right lobe dome
 - Right lobe with right portal vein
 - Right lobe with main portal vein
 - Right lobe with gallbladder

- Right lobe with right kidney
- Right lobe near liver tip
- CINE CLIP: from dome to inferior most margin, using multiple acoustic windows if necessary
- 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 IMAGES IN LLD
 - Gallbladder, long and transverse, looking for mobile stones/biliary precipitate (sludge).
 - Standing or even RLD or prone imaging may be needed to differentiate a mobile from impacted gallstone
 - Repeat TRV images of hepatic dome
 - Repeat Long images of right lateral margin of right lobe
 - Repeat any images of areas not seen well supine
- **Spleen**
 - Transverse images
 - Longitudinal images
 - Color Doppler evaluation at splenic hilum to document vessel patency, direction of flow; detect varices.
 - Longitudinal spleen measurement: from inferior most tip to highest point along diaphragm, *crossing through the splenic hilum*.
 - Transverse measurements: *oriented 90 degrees* relative to longitudinal measurement, calipers placed at greatest thickness. Width measured transverse to longitudinal measurements at same position.
 - Splenic Volume
- **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
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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.

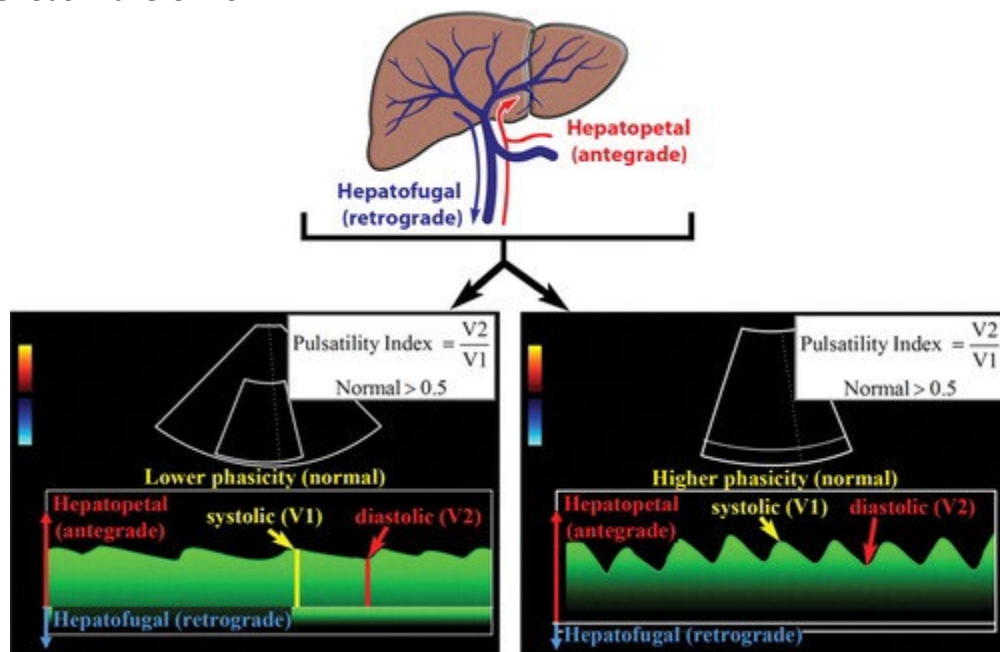
Assessment of Liver Viscoelasticity by Using Shear Waves Induced by Ultrasound Radiation Force, Radiology 2013.

APPENDIX:

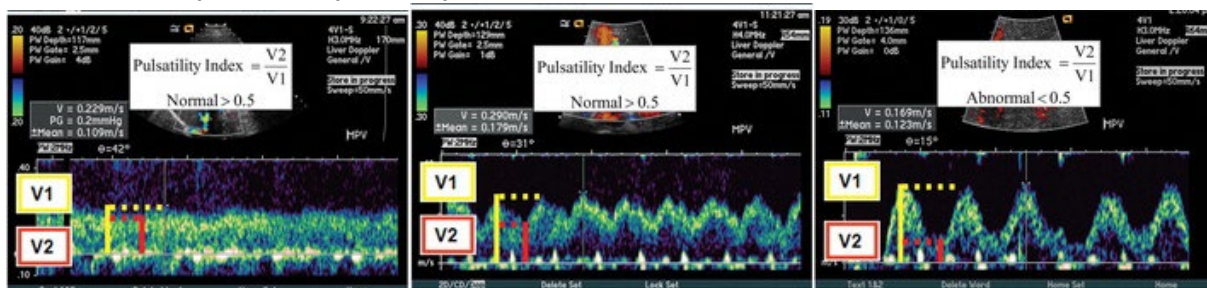
Signs of Portal Hypertension

- 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

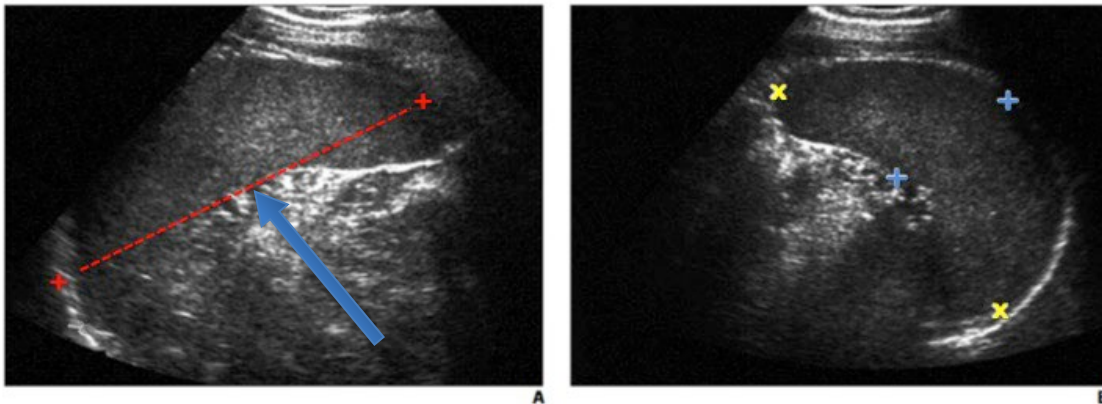


Causes of Pulsatile Portal Waveform

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

Splenomegaly:

- Longitudinal spleen measurement, from inferior most tip to highest point along diaphragm (+), crossing through the splenic hilum (arrow).
- Transverse measurements: oriented 90 degrees relative to longitudinal measurement, calipers placed at greatest thickness (X). Width (+) measured transverse to longitudinal measurements at same position.



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 \geq 12 cm in women; \geq 13 cm in men –or–

Volume⁺ > 250 cc in females; > 300 cc in males

Definite splenomegaly when:

Length \geq 13 cm in women; \geq 14 cm in men –or–

Volume⁺ > 300 cc in females; > 350 cc in males

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):	09-24-2018		Abhinav Vij, MD
REVISION DATE(S):	04-24-2016	Brief Summary	Updates to protocol name, corresponding to new templates
REVISION DATE(S):	09-11-2016	Brief Summary	New protocol for measuring spleen. Added new size cutoffs.
	06-17-2017	Brief Summary	Included additions and emphasis of obtaining cine sweeps through hepatic parenchyma
	05-20-2018	Brief Summary	Updated details regarding cine sweeps needed through liver
	09-24-2018	Brief Summary	Document reviewed with minor language edits.
	12-11-2019	Brief Summary	Adjusted Documentation section to reflect preferred order of image acquisition. Specified use of LLD imaging
	02-23-2020	Brief Summary	Clarifications regarding cine sweeps needed through liver. Removed liver length measurement
	05-31-2020	Brief Summary	Review for protocol reduction
	09-09-2020	Brief Summary	Added details regarding combining with other liver studies
	02-10-2021	Brief Summary	Reorder liver capsule images to beginning of protocol
	03-08-2022		Clarified that fasting not needed for IP/ER orders
	4-24-23		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