

**Ultrasound – Liver Doppler Protocol**

**PURPOSE:**

To evaluate the hepatic vasculature for patency, directional flow, and evidence of portal hypertension.

**SCOPE:**

Applies to all ultrasound abdominal Doppler studies performed in Imaging Services / Radiology

**ORDERABLE:**

- US Doppler Liver (perform this protocol only)
- May be combined with *US Liver* and/or *US Liver Elastography*—please see separate Protocol for details
- For order US Liver Transplant and Doppler, see dedicated *US Liver Transplant* protocol

**INDICATIONS:**

- Signs or symptoms of vascular insufficiency or venous thrombosis attributable to the liver (examples: ascites, varices, splenomegaly, acute liver failure)
- Known liver disease (cirrhosis or other) with suspected portal hypertension
- Known hepatic artery stenosis; follow up to angioplasty and/or stent
- Abnormal findings on other imaging studies
- Follow up known hepatic vascular issue and/or portal hypertension
- For Liver Transplant, see dedicated US Liver Transplant protocol

**CONTRAINDICATIONS:**

- No absolute contraindications
- Exam may be compromised by bandages, fresh surgical incisions, bowel gas, obesity.

**EQUIPMENT:**

- Curvilinear transducer with a frequency range of 1-9 MHz that allows for appropriate penetration and resolution depending on patient's body habitus

**PATIENT PREPARATION:**

- None

**EXAMINATION:**

**GENERAL GUIDELINES:**

A complete examination includes evaluation of the hepatic veins, portal veins, splenic vein, superior mesenteric vein, hepatic artery, inferior vena cava (IVC), TIPS (if present), and additional image acquisition protocols based on orderable (above)

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

**EXAM INITIATION:**

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

## TECHNICAL CONSIDERATIONS:

- Always review any prior imaging, making note of abnormalities or other findings requiring further evaluation.
- Review clinical and surgical history, making note of relevant findings
- Note any variations in technique or technical limitations
- In LLD position, the liver shifts towards the midline improving accessibility for scanning
- Optimize gain and display setting with respect to depth, dynamic range, and focal zones on grey scale imaging first
- Optimize color Doppler setting to show optimal flow
  - Adjust scale and gain to maximally fill the vessel of interest without artifact
    - Light color in the middle of the vessel lumen, darker toward periphery, showing laminar flow
  - Use Power Doppler if suspect 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
- Evaluate hepatic artery and main portal vein using angle corrected spectral Doppler
- Evaluate hepatic vein phasicity during suspended respiration or shallow breathing
  - Deep inspiration may dampen hepatic venous flow
- Evaluate the area around the ligamentum teres for a dilated patent paraumbilical vein
  - If present, document image including flow direction
- Evaluate for other upper abdominal varices particularly along the gastrohepatic ligament, near the splenic hilum, and near the renal hilum
  - If present, document image
- Assess the perihepatic area for fluid collections; if a fluid collection is visualized, document and measure; evaluate with and without color.
- If a TIPS is present, survey the entire TIPS – see *US Liver TIPS* protocol
- If applicable, please see separate *US Liver Doppler* and *US Liver Elastography* if also ordered/performed

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## IMAGE DOCUMENTATION:

Anatomy	Grey Scale	Color Doppler	Waveform	*PV	RI	SAT
Splenic vein: hilum	x	x	x			
Splenic vein: mid	x	x	x			
Splenic vein: confluence	x	x	x			
Superior mesenteric vein: central	x	x	x			
Hepatic artery: proper	x	x	x	x	x	
Portal vein: main	x	x	x	x		
Portal vein: right	x	x	x			
Portal vein: left	x	x	x			
Hepatic vein: right	x	x	x			
Hepatic vein: middle	x	x	x			
Hepatic vein: left	x	x	x			
IVC	x	x	x			
^TIPS: portal vein end	x	x	x	x		
^TIPS: mid	x	x	x	x		
^TIPS: hepatic vein/IVC end	x	x	x	x		
Data page with measurements						
* If there is no phasic waveform, then measure peak velocity						
^ If present or if visible (review <i>US Liver TIPS</i> Protocol for details)						
For Liver Transplant, see dedicated US Liver Transplant protocol.						

## PROCESSING:

- Review examination data
- Export and review all images in PACS
- Confirm data transmission in Imorgon (where available)
- Note any study limitations (in Tech Study Note or paper communication, per local workflow)

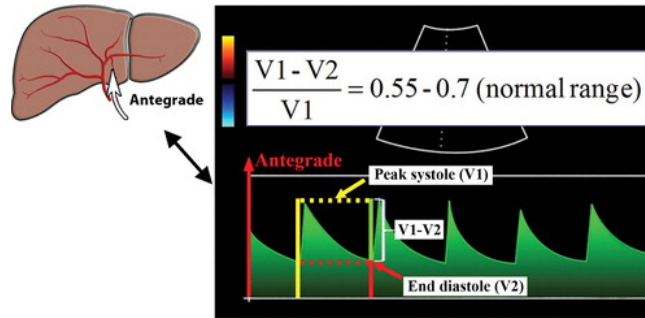
## REFERENCES:

- ACR-AIUM Practice Guideline (Revised 2007)
- ICAVL Guidelines (Updated 8/2012)
- Radiology (2011) 260(3): 884-891
- Radiographics (2011) 31(1): 161-189

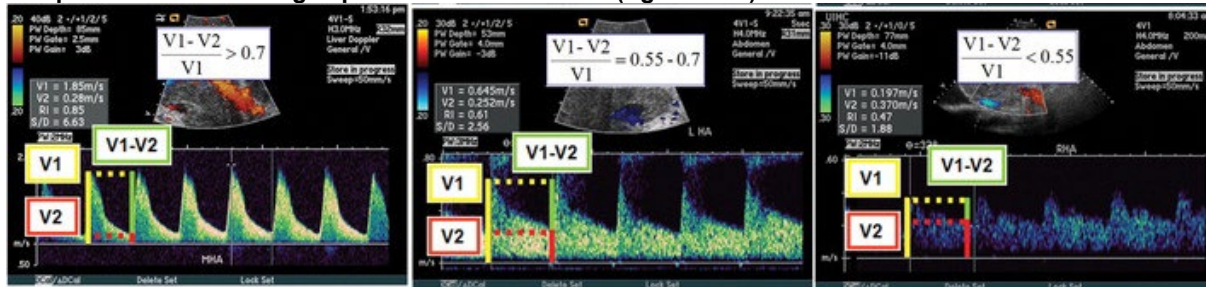
**APPENDIX:**

- Hepatic artery
  - RI 0.55-0.70 normal range; abnormal elevation  $\geq 0.80$ 
    - Elevated (nonspecific) = postprandial, elderly, diffuse peripheral microvascular compression or disease (chronic hepatocellular disease or cirrhosis), hepatic venous congestion
    - Low = proximal stenosis, distal vascular shunt, cirrhosis with portal HTN and shunts, Osler-Weber-Rendu with AV fistulas
  - PSV  $\sim 100$  cm/sec
  
- Portal hypertension
  - Reversal of flow (hepatofugal)
  - Barcelona Criteria
    - Main portal vein diameter  $>13$  mm
    - Monophasic waveform velocity  $<16$  cm/sec
    - Phasic waveform mean velocity  $<13$  cm/sec
  
- Normal TIPS velocity is 90-190 cm/sec
  - Suspect stenosis if
    - Portal vein velocity change from baseline     $\downarrow >40$  cm/sec     $\uparrow >60$  cm/sec
    - TIPS velocity (if no baseline)                     $<90$  cm/sec                     $>190$  cm/sec
    - Portal vein velocity (if no baseline)             $<30$  cm/sec

**Normal Arterial Waveforms:**



**Spectrum of increasing hepatic arterial resistance (right to left).**



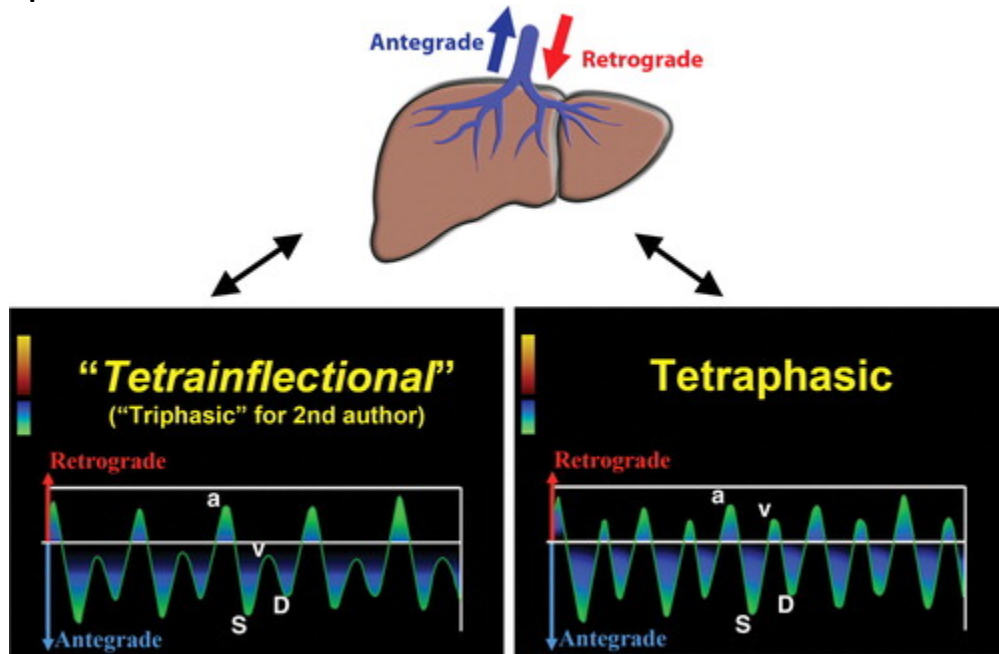
**Causes of Elevated Hepatic Arterial Resistance (RI > 0.7)**

- Pathologic (microvascular compression or disease)
  - Chronic hepatocellular disease (including cirrhosis)
  - Hepatic venous congestion
    - Acute congestion → diffuse peripheral vasoconstriction
    - Chronic congestion → fibrosis with diffuse peripheral compression (cardiac cirrhosis)
  - Transplant rejection (any stage)
  - Any other disease that causes diffuse compression or narrowing of peripheral arterioles
- Physiologic
  - Postprandial state
  - Advanced patient age

**Causes of Decreased Hepatic Arterial Resistance (RI < 0.55)**

- Proximal arterial narrowing
  - Transplant stenosis (anastomosis)
  - Atherosclerotic disease (celiac or hepatic)
  - Arcuate ligament syndrome (relatively less common than transplant stenosis or atherosclerotic disease)
- Distal (peripheral) vascular shunts (arteriovenous or arterioportal fistulas)
  - Cirrhosis with portal hypertension
  - Posttraumatic or iatrogenic causes
  - Hereditary hemorrhagic telangiectasia (Osler-Weber-Rendu syndrome)

Normal Hepatic Waveforms:



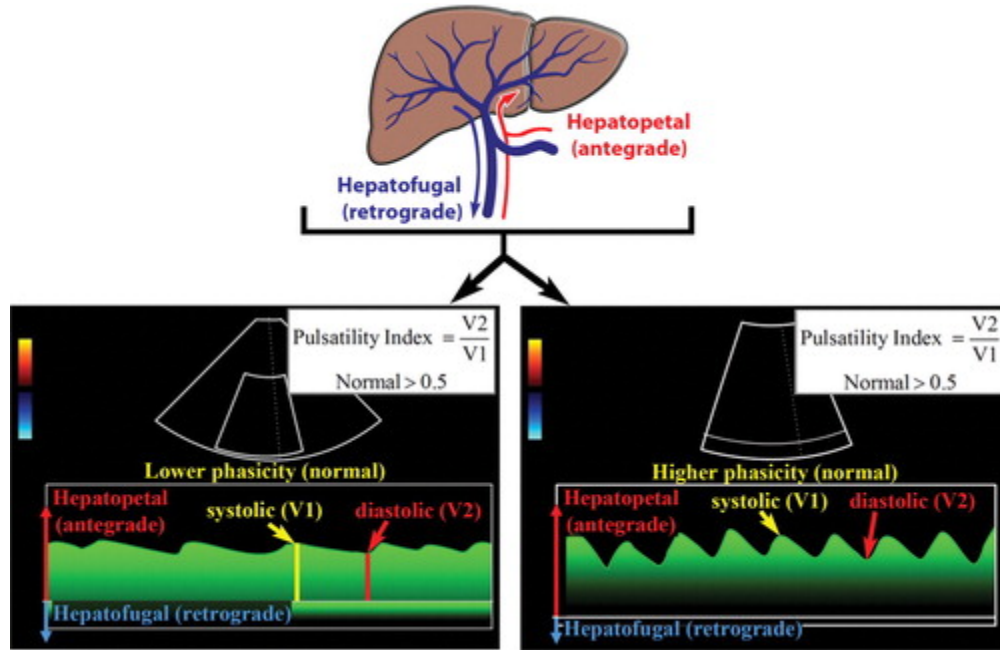
**Causes of Pulsatile Hepatic Venous Waveform**

- Tricuspid regurgitation
  - Decreased or reversed S wave
  - Tall a and v waves
- Right-sided CHF
  - Maintained S wave/D wave relationship
  - Tall a and v waves

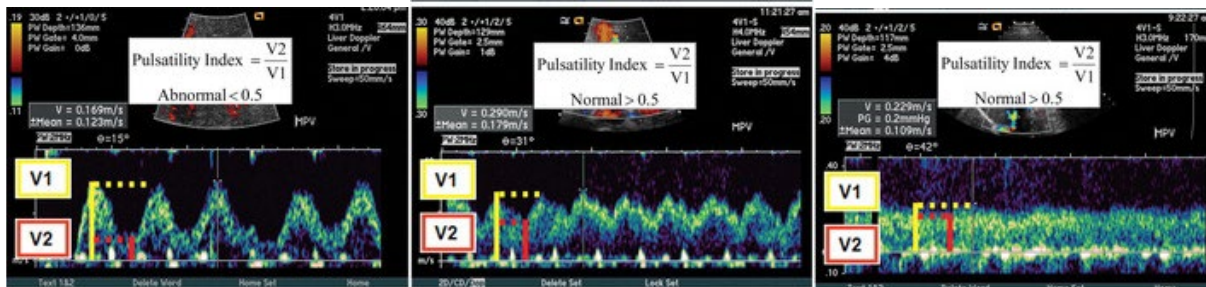
**Causes of Decreased Hepatic Venous Phasicity**

- Cirrhosis
- Hepatic vein thrombosis (Budd-Chiari syndrome)
- Hepatic veno-occlusive disease
- Hepatic venous outflow obstruction from any cause

Normal Portal Veins:



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

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## Transplant liver

- Relevant anastomosis for each vessel should be specifically interrogated, if evident sonographically
- Determine if the patient underwent a caval interposition technique, in which case both proximal and distal anastomoses should be interrogated, or a piggy back, in which case there will be a blind-ending oversewn end of the donor vena cava—thrombus may form in this structure. A velocity gradient  $\geq 3$  and turbulent flow may indicate a significant stenosis.
- The portal vein anastomosis can frequently be identified as an area of subtle narrowing. A velocity gradient  $\geq 3$  and turbulent flow may indicate a significant stenosis.
- Hepatic artery:
  - RI 0.55-0.70 normal range; abnormal elevation  $\geq 0.80$
  - In the immediate post-transplant period, transient elevation in RIs is not unexpected and should resolve over the subsequent 48-72 hours.
  - Tardus parvus waveform:
    - SAT  $>0.07$  msec AND PSV  $>48$  cm/sec (69% sensitive, 99.1% specific)
    - Absence of tardus parvus waveform has a high NPV for stricture, dissection, or thrombosis

## REVISION HISTORY:

<b>SUBMITTED BY:</b>	David T. Fetzer, MD	<b>Title</b>	Medical Director
<b>APPROVED BY:</b>	David T. Fetzer, MD	<b>Title</b>	Medical Director
<b>APPROVAL DATE:</b>	11-09-2015		
<b>REVIEW DATE(S):</b>	09-24-2018		Abhinav Vij, MD
<b>REVISION DATE(S):</b>	04-24-2016	<b>Brief Summary</b>	Updates to protocol name, corresponding to new templates
	04-17-2017	<b>Brief Summary</b>	Included details for liver transplant
	06-19-2017	<b>Brief Summary</b>	Changes to list of relevant orders to reflect consolidation of EPIC orderables
	04-11-2018	<b>Brief Summary</b>	Removed references to Liver Transplant, directing reader to dedicated US Liver Transplant protocol
	09-24-2018	<b>Brief Summary</b>	Minor Language Edits
	12-11-2019	<b>Brief Summary</b>	Routine formatting updates
	02-12-2020	<b>Brief Summary</b>	Removed SAT from HA
	09-09-2020	<b>Brief Summary</b>	Clarified combining with other liver exams