HEPATIC DOPPLER ULTRASOUND EXAMINATION

POLICY: Hepatic Doppler Ultrasound will be performed with an order from a physician or other qualified clinical practitioner. The examination will be supervised and interpreted by a radiologist or other licensed practitioner who is qualified by reason of training to understand the normal anatomy and pathophysiology of the liver and its blood supply, and integration of ultrasound with other imaging techniques to optimize the probability of detecting disease.

PURPOSE: To assess the anatomy of the liver, evaluate the portal venous, hepatic arterial, and hepatic venous systems, and document normal and abnormal structures and blood flow therein.

INDICATIONS: Hepatic Doppler Ultrasound is indicated for patients with signs, symptoms, and/or laboratory evidence of disease involving the abdomen, liver, portal venous system, spleen, and coagulation mechanism. This examination is intended to complement conventional imaging (e.g. abdominal ultrasound, abdominal CT, abdominal MRI) of the upper abdomen by focusing primarily on the vascular supply of the liver. Patients who are at risk for diseases of the hepatic arterial or venous systems, or may be donors for liver transplant are candidates for Hepatic Doppler Ultrasound.

PATIENT PREPARATION: Outpatients should be fasting for a minimum of eight hours prior to the exam. Non urgent inpatients should be fasting for at least six hours if possible. Emergency Room and acute patients can be examined without fasting. Patients should be instructed to take prescribed oral medication on their normal schedule with small sips of water. The preparation for patients receiving diabetic medication (oral or injectable) must be approved by the radiologist or nurse.

PROCEDURE: The examination involves a combination of conventional gray scale, real-time imaging of upper abdominal organs plus color and spectral (pulsed) Doppler examination of the hepatic vasculature. Each organ and vessel should be imaged in its entirety (e.g. long and transverse views) before imaging the next organ. When any measurement is performed, an image should be captured with and without measurements. The order of organ imaging will be (minimal number of images in parenthesis):

B-MODE IMAGING:
• liver (13 images, 4 cines)
• gallbladder (3 images, 1 cine)
• biliary system (3 images)
• spleen (4 images)

COLOR AND SPECTRAL DOPPLER:
• portal venous system (12 images)
• hepatic arteries (6 images)
• hepatic veins (6 images)
• inferior vena cava (2 images)
• splenic vein (4 images)
• superior mesenteric vein (2 images)
**B-MODE IMAGING**

- Gray scale, real-time images are intended to demonstrate the hepatic size, echogenicity relative to the spleen and right kidney, contour, and any focal abnormalities. Images of the spleen shall demonstrate its size, texture, and any focal abnormalities. The peritoneal recesses of the upper abdomen included in images of the liver and spleen can be assessed for ascites and/or pleural effusions. The examination can be performed in supine or decubitus positions, with respiration suspended at a level that optimizes images of the desired anatomy. With the exception of surface images of the liver, a curved array (or sector) transducer should be employed to image the abdominal organs.

**LIVER:**

The anterior subcostal approach should be employed when it feasible to do so. An intercostal approach can be used as an alternate or supplementary window when necessary.

- **Minimal stored images should include:**

  - three sagittal views of the liver to the right of the porta hepatis, labeled *Liver Long*; one image will include the maximal cephalocaudad length of the right lobe measured from the diaphragm to its inferior tip in a parasagittal plane; one image should also include the right kidney to allow comparison of the relative echogenicity of the two organs
  - one sagittal view of the liver to include the main portal vein in the porta hepatis, labeled *Liver Long*
  - one sagittal view of the medial segment of the left lobe to include the inferior vena cava and caudate, labeled *Liver IVC Long*
  - one sagittal view of the lateral segment of the left lobe, labeled *Liver Long*;
  - two transverse views of the left lobe to include the left lateral contour of the liver, the left portal vein and the fissure of the ligamentum teres, labeled *Liver Trans*
  - one transverse view of the liver to include the venous confluence of the hepatic veins and the inferior vena cava, labeled *Liver Trans*
  - one transverse view of the liver to include the main portal vein with the maximal diameter measured, labeled *Liver Trans*
  - three transverse views of the right lobe to demonstrate representative views of the superior, middle, and inferior one thirds of the right lobe, including its lateral and posterior contours, labeled *Liver transverse*; images will include the dome, right hepatic vein and right portal vein
  - one sagittal cine of the entire right lobe of the liver, from the lateral right margin through the porta hepatis, labeled *Liver Long Rt-Lt*
  - one transverse cine of the entire right lobe of the liver, from the dome through the inferior margin, labeled *Liver Trans Sup-Inf*
  - one sagittal cine of the entire left lobe of the liver, from the porta hepatis through the lateral left margin, labeled *Liver Long Rt-Lt*
  - one transverse cine of the entire left lobe of the liver, from the superior margin through the inferior margin, labeled *Liver Trans Sup-Inf*
  - one image of the surface contour of the liver, obtained using linear transducer, labeled *Liver Surface Contour*
BILIARY SYSTEM:
The gallbladder should be examined to consider stones, wall thickness and irregularities, pericholecystic structures, and tenderness to palpation with the ultrasound transducer (Murphy's Sign).
The gallbladder must be examined with the patient in at least two different positions to assess the mobility of intraluminal objects (e.g. gallstones). In the presence of gallstones, multiple positions should be employed in order to differentiate mobile gallstones from gallstones lodged in the neck of the gallbladder.
The intrahepatic branches of the bile ducts should be investigated in each lobe of the liver, and the extrahepatic segment of the bile duct examined through its entire course from the porta hepatis to the sphincter of Oddi, searching for enlargement or intraluminal objects (e.g. stones).

• Minimal stored images should include:
  • two longitudinal views of the gallbladder with the patient in a position that optimizes visualization of the gallbladder, labeled GB Long; images should include the neck and fundus of the gallbladder, as well as the gallbladder wall
  • one longitudinal cine of the gallbladder, labeled GB Long
  • one longitudinal view of the gallbladder with the patient in a different position (e.g. exaggerated left lateral decubitus, upright, prone/kneeling) focused on the most dependent segment of the gallbladder, labeled GB LLD (or Upright, Prone, etc.)
  • one transverse view with the patient in a position that optimizes visualization of the body of the gallbladder, labeled GB Trans
  • two views of the extrahepatic bile duct at the point of its maximal luminal diameter, labeled Bile Duct; color Doppler may be utilized to isolate the bile duct from surrounding vessels; images should include a measured maximal diameter

SPLEEN:
Images should include a calculated volume measurement of the spleen obtained using three orthogonal dimensions: maximal length, height (perpendicular to the length) and width.

• Minimal stored images of the spleen should include:
  • two longitudinal views, labeled Spleen Long; images will include the maximal length measurement and height (perpendicular to the length); the left kidney will also be included to allow comparison of the relative echogenicity of the two organs
  • one view orthogonal to the long axis view with the maximal width measured, labeled Spleen Trans

COLOR AND SPECTRAL DOPPLER
• Doppler examination (color and spectral) is intended to display the flow direction, velocity, and cyclical variation of blood entering and exiting the liver. Evaluation of portal venous flow requires individual investigation of its main contributing sources (splenic vein and superior mesenteric vein [SMV]) and intrahepatic branches (right and left). Intra and extrahepatic portosystemic shunts should be sought and documented. Color and spectral Doppler examination should be performed in suspended tidal inspiration (not maximal inspiration or Valsava) with the patient supine or left posterior oblique position. A curved array transducer with frequency optimized for body habitus should be primarily employed; a high frequency linear array transducer may be required to image vessels close to the body wall (e.g.
paraumbilical veins or surface hepatic collaterals). If an individual vessel cannot be visualized or accurately investigated (e.g. the right hepatic artery cannot be identified), a gray scale image (without color or spectral Doppler) with the appropriate label shall be included in the documentation.

PORTAL VENOUS SYSTEM

- **Minimal stored images:**
  - one color Doppler image of the proximal splenic vein near its origin at the spleen, labeled *splenic vein prox*
  - one color/spectral Doppler image of the proximal splenic vein near its origin at the spleen, labeled *splenic vein prox*
  - one color Doppler image of the distal splenic vein near its confluence with the SMV, labeled *splenic vein dist*
  - one color/spectral Doppler image of the distal splenic vein near its confluence with the SMV, labeled *splenic vein dist*
  - one color Doppler image of the superior mesenteric vein near its confluence with the splenic vein, labeled *SMV*
  - one color/spectral Doppler image of the superior mesenteric vein near its confluence with the splenic vein, labeled *SMV*
  - one color Doppler image of the main portal vein (half the distance between intrahepatic branching and the confluence of the splenic vein and SMV), labeled *MPV*
  - one color/spectral Doppler image of the main portal vein, labeled *MPV*; maximal flow velocity, minimal flow velocity, time average velocity and pulsatility index shall be documented on the image
  - one color Doppler image of the right branch of the portal vein to include its origin from the main portal vein labeled *Rt PV*
• one color/spectral Doppler image of the right branch of the portal vein to include its origin from the main portal vein labeled *Rt PV*
• one color Doppler image of the left branch of the portal vein near its origin from the main portal vein labeled *Lt PV*
• one color/spectral Doppler image of the left branch of the portal vein near its origin from the main portal vein labeled *Lt PV*

**HEPATIC ARTERY**
• Minimal stored images:
  • one color Doppler image of the common/proper hepatic artery, labeled *Com/Prop Hep A*
  • one color/spectral Doppler image of the common/proper hepatic artery, labeled *Com/Prop Hep A*; the peak systolic flow velocity, maximum diastolic flow velocity, and resistive index shall be documented on the image
  • one color Doppler image of the right hepatic artery, labeled *Rt Hep A*
  • one color/spectral Doppler image of the right hepatic artery, labeled *Rt Hep A*; the peak systolic flow velocity, maximum diastolic flow velocity, and resistive index shall be documented on the image
  • one color Doppler image of the left hepatic artery, labeled *Lt Hep A*
  • one color/spectral Doppler image of the left hepatic artery, labeled *Lt Hep A*; the peak systolic flow velocity, maximum diastolic flow velocity, and resistive index shall be documented on the image

**HEPATIC VEINS AND INFERIOR VENA CAVA**
• Minimal stored images:
  • one transverse color Doppler image of the confluence of the right, middle, and left hepatic veins with the inferior vena cava, labeled *Hep V*
  • one color Doppler image of the right hepatic vein, labeled *Rt Hep V*
  • one color/spectral Doppler image of the right hepatic vein, labeled *Rt Hep V*; the Doppler gate should be positioned 2-3 cm from the confluence of the hepatic vein and IVC
  • one color Doppler image of the middle hepatic vein, labeled *Mid Hep V*
  • one color/spectral Doppler image of the middle hepatic vein, labeled *Mid Hep V*; the Doppler gate should be positioned 2-3 cm from the confluence of the hepatic vein and IVC
  • one color Doppler image of the left hepatic vein, labeled *Lt Hep V*
  • one color/spectral Doppler image of the left hepatic vein, labeled *Lt Hep V*; the Doppler gate should be positioned 2-3 cm from the confluence of the hepatic vein and IVC
  • one longitudinal color Doppler image of the intrahepatic segment of the inferior vena cava, labeled *IVC*
  • one longitudinal color/spectral Doppler image of the intrahepatic segment of the inferior vena cava, labeled *IVC*

**PATHOLOGIC CONDITIONS**: When pathologic processes are detected during the course of the examination, extra images are necessary to characterize the abnormality. The following is a description of commonly encountered
abnormalities, or conditions that should be considered during the examination and the minimum additional stored images expected for each circumstance. The list is not intended to be comprehensive, and sonographers are expected to apply their knowledge of pathophysiology to provide clear images of the abnormalities they encounter.

Hepatic Mass: Focal hepatic abnormalities or masses encountered in the course of Hepatic Doppler Ultrasound require documentation of their size in three dimensions, position in the liver (lobe and segment), margins, and internal architecture. If more than one focal abnormality or mass with similar ultrasound characteristics is encountered, the largest lesion in each lobe shall be documented. When focal abnormalities or masses of significantly different character (e.g. one cystic and one solid) are encountered, both (all) shall be documented.

Portal venous hypertension (PVH): Patients with PVH may be asymptomatic or present with symptoms such as abdominal pain, distention, jaundice, or variceal bleeding. Doppler findings of mild PVH may be subtle (enlarged main portal vein, altered portal vein pulsatility), but hallmarks include hepatofugal flow in the main portal vein, splenomegaly, and ascites. When PVH is suspected, portosystemic venous collaterals should be actively sought. Utilizing ultrasound, the most commonly recognized collaterals include paraumbilical veins originating from the left portal vein and coursing towards the umbilicus, an enlarged coronary vein arising from the main portal vein and coursing towards the gastroesophageal junction, and splenorenal collaterals as they enter the left renal vein. Color and spectral Doppler documentation of portosystemic collaterals with appropriate labels, is necessary when identified.

Transjugular Intrahepatic Portosystemic Shunt (TIPS): Patients with symptomatic portal venous hypertension may be treated with TIPS, a radiologic interventional technique that places a metallic stent between an intrahepatic portal vein and hepatic vein. TIPS are subject to complications such as thrombosis and pseudointimal hyperplasia that obstruct their flow. Hepatic Doppler Ultrasound is the primary diagnostic tool for evaluation of shunt patency. In addition to the complete Hepatic Doppler Ultrasound, patients undergoing an initial TIPS evaluation shall receive supplementary investigation of the shunt to include: color Doppler of the entire length of the shunt, color/spectral Doppler of the portal vein end, mid-segment, and hepatic vein end of the shunt. Spectral images shall include the maximal shunt velocity and time averaged velocity. Special attention should be directed to small, high velocity jets in or near the shunt indicating focal stenoses. Patients who have at least one complete Hepatic Doppler Ultrasound evaluation of their TIPS may be imaged at subsequent examinations with a limited protocol (e.g. limited gray scale imaging) that addresses the specific clinical issues.

Liver Transplant: Liver transplants for end stage liver disease are cadaver (whole liver allograft) or living related donor. Both can be complicated by
mechanical and nonmechanical problems in the acute or chronic setting. Hepatic Doppler Ultrasound plays a limited role in diagnosis of nonmechanical complications (rejection, infection). Mechanical complication, primarily related to the connection of the donor liver to the host's IVC, portal vein, hepatic artery, and bile duct are investigated with Hepatic Doppler Ultrasound, but require careful investigation of the surgical anastomoses for accurate diagnosis. Bile duct leak or stricture is the problem most commonly encountered following transplant and requires image documentation of the intrahepatic and extrahepatic bile ducts. Complications of the IVC and portal vein anastomoses are usually related to post operative thrombosis or stricture. Hepatic artery anastomoses can be complicated by thrombosis, stenosis, or pseudoaneurysm.

Budd-Chiari Syndrome: The Budd-Chiari syndrome results from thrombotic or nonthrombotic obstruction of one or more hepatic veins, resulting in abdominal pain, hepatomegaly, and ascites. Absent flow in hepatics vein and intrahepatic and subcapsular venous-to-venous shunts are the hallmarks and best documented with color Doppler. The inferior vena cava may or may not be involved.

REFERENCES: