LIVER TRANSPLANT DOPPLER ULTRASOUND PROTOCOL

BILLING CODE TO BE USED:

ULIVLD – This is a combined charge of UABDL and UORGDC

ULIVCD to be used if a Complete Abdomen ultrasound is performed. This is combined charge of UABDC and UORGDC

PATIENT PREP: No Prep

****THIS STUDY INCLUDES COLOR AND SPECTRAL DOPPLER OF PORTAL VEINS, HEPATIC ARTERIES, HEPATIC VEINS & IVC. TO BE USED FOR POST LIVER TRANSPLANT EVALUATIONS, INCLUDING SPLIT LIVER TRANSPLANT EVALUATIONS.****

***For repeat exams on INPATIENTS within 72 hours, and it is not the routine POD 1,4,7 or 10 exam:

- A limited evaluation of the liver parenchyma, vasculature, bile ducts and assessment for new fluid collections is acceptable.
- State in the report that kidney, spleen, pancreas were "not evaluated."
- Billing code remains ULIVLD.

**If a patient is coming in for pain, document within the indication section what the current status of pain is. For instance, how long the patient has had pain, if it's getting worse or better, and where exactly the pain is. Always take an image where the patient is hurting the most, labeled as area of pain. When describing the pain, write "per patient, …" in the indication. Example: Per the patient, his pain is now in the RUQ and getting worse.

**"Not well seen" to be stated if structure is not able to be completely evaluated. Include the reason why in relevant section of the report.

**Any masses, cysts, stones or abnormalities should be measured in three dimensions and have a 2D picture and a color image documented. MFI should be routinely used to evaluate perfusion and low flow structures as needed. Measure the 2 largest or most worrisome masses/cysts in any given structure and comment on the presence of additional if relevant.

**Cine clips to be added as needed for any abnormality seen.

IMAGES TO OBTAIN

ASSESS FOR FLUID COLLECTIONS

- Document any fluid collections, hematomas and/or masses in two dimensions, with and without color doppler images.

ASSESS FOR COLLATERALS

- Color image documenting any collaterals or varies if present in periportal area, LUQ, epigastric region, or the presence of a recanalized umbilical vein. If collaterals are seen, the splenic vein velocity and direction of flow should be documented.

PANCREAS

Transverse images:

- Pancreas head, body, and tail.
- Pancreatic head showing porto-splenic confluence.
- Pancreatic body showing splenic vein
- Document and measure pancreatic duct if visible.

Sagittal images:

- Pancreatic head, body, and tail.

Take image of "Pancreas Area" if not well seen.

LEFT LIVER - ***subcostal/epigastric approach***

Sagittal images:

- Left lobe with left portal vein and ligamentum teres.
- Left lobe with hepatic vein
- Cine clip sweeping through LHL in sagittal from medial to lateral

Transverse images:

- Left lobe visualizing dome of liver
- Left hepatic vein confluence into IVC with and without color
- Left lobe at left portal vein with and without color assessing for thrombus and direction of flow
- Cine clip sweeping through LHL in transverse from superior to inferior

CAUDATE LIVER - ***subcostal/epigastric approach***

- Sagittal image of the caudate lobe.
- Transverse image of the caudate lobe.

RIGHT LIVER - ***subcostal or intercostal approach***

Transverse images:

- Right lobe to visualize dome of liver
- Right and middle hepatic veins confluence into IVC with and without color
- Right lobe at right portal vein with and without color assessing for thrombus and direction of flow
- Right lobe and right kidney
- Cine clip sweeping through RHL in transverse from superior to inferior

Sagittal images:

- Right hemidiaphragm to assess for pleural effusions and ringdown.
- Right lobe and right portal vein
- Main interlobar fissure with CHD and MPV
- Right lobe showing echotexture between liver and right kidney.
- Right lobe and right kidney documenting approximate liver size. Measurement of length of the liver is not needed unless requested.
- Cine clip sweeping through RHL in sagittal from medial to lateral

NOTE: If lateral edge or dome of liver is not seen in its entirety with patient in supine position, turn patient in LLD or raise head of bed and repeat RHL cine clips to visualize better.

MAIN PORTAL VEIN -

- 2D image through MPV evaluating for thrombus and narrowing
- Color image of MPV showing anastomosis, patency and direction of flow

BILE DUCTS -

- Sagittal image of CBD and CHD with measurements at the level of the porta hepatis. Color doppler should be used to distinguish ducts from vessels.
- If dilated, follow CBD as distal as possible to look for stones/mass and measure as distal as possible as well.
- Document and measure any intrahepatic bile duct dilatation with 2D and color imaging.
- Document presence of pneumobilia if seen
- Document biliary stent if present.

RIGHT KIDNEY not needed for LHL only split liver transplants

- Sagittal image of right kidney in medial, middle, and lateral views.
- Sagittal measurement of right kidney.
- Transverse images of superior, mid, inferior right kidney.
- Demonstrate calculi, hydronephrosis or pelviectasis with a color image of the renal pelvis if present.
- **IF RENAL STONES ARE PRESENT:**
    - Measure renal stones in one largest dimension.
    - Demonstrate acoustic shadowing if possible.
    - Image with color to look for twinkle (can still be a stone if no twinkle shows).
- **IF HYDRONEPHROSIS, PELVIECTASIS, OR DILATED URETER PRESENT:**
    - Patient should void bladder and images should be taken to reassess degree of dilation with 2D and color images.

SPLEEN

- Sagittal and transverse images through spleen
- Sagittal length measurement of spleen
- Color Doppler image of any abnormality.

LOWER QUADRANTS:

- Document RLQ and LLQ to check for ascites.

COLOR & SPECTRAL DOPPLER IMAGES TO OBTAIN

SWEEP SPEED should be set to SLOW (36cm/s) on the Philips machines and 2 or 3 on the GE machines.
You will be asked to repeat images if this is not the case. It is critical for comparison to priors to have the settings consistent.

PORTAL VEINS - LPV, RPV, MPV ***VELOCITY with angle correction***

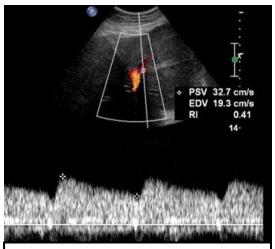
- Color images of MPV, Right PV and Left PV showing direction of flow
- Direction of flow should be hepatopetal, towards the liver.
- The waveform should be continuous, monophasic flow.
- Some velocity variation from respiration is expected, measure where waveform is most consistent.
- Mild undulation or phasicity in the waveform is normal and can be seen especially if the patient is thin or has eaten a large meal recently.
- A pulsatile portal vein is defined as one that has >50% variation in velocities between the minimum and maximum velocity within the waveform. This can be seen with right heart failure, tricuspid regurge, HV and PV fistula, PHTN, malignant tumor invasion, and cirrhosis
- Normal diameter of MPV is 13-16mm. Some difference in caliber between the donor and recipient portal vein is normal.
- Normal RPV and LPV velocity is >10cm/s, less than 10cm/s or reversal of flow indicates portal hypertension.
- Normal MPV velocity is >30 cm/s
    - 30-50 cm/s: Expected velocity
    - 70-100 cm/s : Recommended to watch on follow up exams
    - >100 cm/s: Increased suspicion for stenosis or thrombus
    - >150 cm/s: Concerning for stenosis or thrombus.
- If increased velocity over 100 cm/s or color aliasing is seen within the MPV, evaluate vessel further for velocity at these areas-
    - At anastomosis (or area of color aliasing)
    - Pre anastomosis (or area of color aliasing)
    - Post anastomosis (or area of color aliasing)
    - Color and 2D images of the anastomosis
    - Measure any area of suspected narrowing.

A velocity gradient of >3 and turbulent flow post area of concern suggests stenosis.

- Velocity should always be measured with angle correction.

HEPATIC ARTERY - LHA, RHA, PHA *RESISTIVE INDEX with angle correction*

- Measurement of RI with angle correction, showing a linear segment of the artery.
- Normal RI range is 0.5 -0.8
- Immediately post op, a transient increase in RI is not unusual and should resolve after 48-72 hours.
- The upstroke should be sharp and rapid, with continuous diastolic flow. Normal upstroke acceleration time is <0.08 seconds
- Tardus parvus is defined as a delayed upstroke and a decreased RI of less than 0.5. If a tardus parvus waveform is seen, evaluate the PHA anastomosis carefully looking for color aliasing and increased velocity on spectral doppler. This indicates a stenosis may be present.



Example of tardus parvus waveform. Delayed upstroke, increased diastolic flow, decreased RI <0.5

- A velocity of >250cm/s in the PHA is considered elevated. If velocities greater than >200cm/s are seen, evaluate the vessel further at these areas:
    - At area of color aliasing
    - Pre area of color aliasing
    - Post area of color aliasing

HEPATIC VEINS– LHV, RHV, MHV *WAVEFORM ONLY*

- Document waveform and assess for phasicity.
- Sample should be taken within 2 cm from IVC
- LHV can often be difficult to separate from artifact from heart motion, it is okay to come farther out into liver if needed to eliminate doppler artifact.
- Velocity is not needed except for:
    - In the presence of hepatic vein stent.
    - In cases where color flow is seen aliasing
    - A narrowing is suspected
- Phasicity of the hepatic veins should be assessed during normal respiration. Deep inspiration may dampen hepatic flow. If necessary, use suspended/mid respiration or shallow breathing.
- **SPLIT LIVER TX:** If the MHV is present, it often runs along the free edge of the liver and has been reconstructed. It is also sometimes referred to a Segment 5 hepatic vein. Be sure you are not evaluating a branch of the RHV or LHV instead of the MHV itself. Look at priors and surgical notes in order to know its course and evaluate it completely. Because of the reconstruction done of the vessel, it can often clot, so special attention is needed.

FOR MONOPHASIC HEPATIC VEINS:

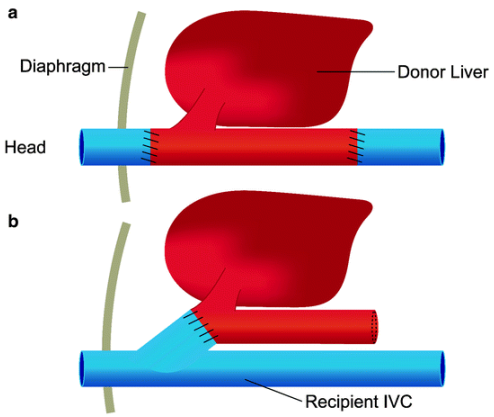
- If monophasic waveforms are seen, use LLD positioning to reassess. This can sometimes be positional and due to compression, not stenosis.
- If monophasic waveform persists in a **single vessel** after change in position, this vein should be further evaluated for stenosis in that hepatic vein and its confluence with IVC. Images to obtain:
    - Waveform and velocity near IVC or area of color aliasing
    - Color and 2D images of the hepatic vein's confluence with IVC
    - Measure any area of suspected narrowing.
- If monophasic waveform persists after change in position in **all 3 hepatic veins**, the IVC should be further evaluated for stenosis of the anastomosis:
    - Waveform and velocity of any area of color aliasing in area of anastomosis.
    - Waveform and velocity of IVC in an area before or after color aliasing to evaluate for any difference
    - Color and 2D images IVC in transverse and sagittal
    - 2D transverse cine clip of IVC to show any change in size near anastomosis
    - Measure any area of suspected narrowing.

INFERIOR VENA CAVA – IVC *VELOCITY*

- Sagittal color image of IVC at anastomosis
- Velocity of IVC at the anastomosis (see proper technique below)
- Waveform should be triphasic.
- Some variation in velocity from respiration is normal.
- If a patient is 20+ years post transplant, always check old notes and images to see what type of anastomosis the patient has. Do not rely solely on the last time they were scanned. We sample the IVC differently depending on the type.

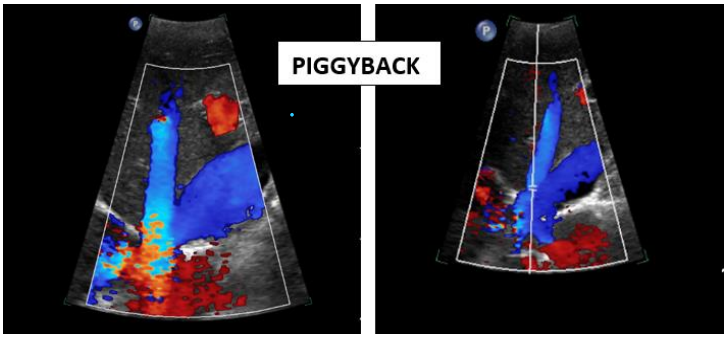
TYPES OF IVC ANASTOMOSES:

- End-to-End anastomosis *(Image a)* –
  - Most common surgical technique before 2003
  - Recipient IVC was severed completely and the donor IVC was inserted in its place.
- IVC- Piggyback anastomosis *(Image b)* –
  - Most common surgical technique after 2003
  - Donor IVC was patched into an opening made in anterior wall of recipient IVC. The rest of the recipient IVC is left intact.
  - Less invasive with less complications and better outcomes.



PIGGYBACK ANASTOMOSIS:

- Velocity should be measured at the anastomosis along the anterior wall of the IVC, not in the donor IVC lumen itself.
- The sample should be taken just past where the hepatic veins dump in and where aliasing can be seen, but also being careful to not actually be in the hepatic vein.
- Angle correction is not needed since the flow is going straight down into the IVC at that location and is in line with the angle of the spectral doppler already.

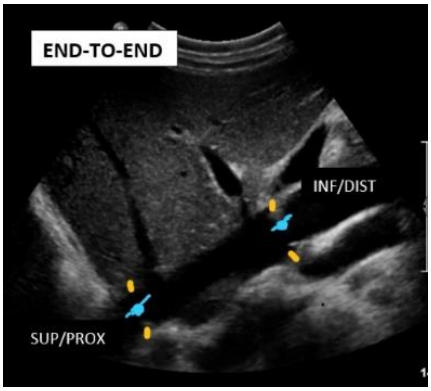


SPLIT LIVER TX ANASTOMOSIS:

- Velocity should be measured the same way piggybacks are evaluated at the anastomosis along the anterior wall of the IVC, not in the donor IVC lumen itself.

END-TO-END ANASTOMOSIS:

- Velocities should be measured at BOTH the superior and inferior anastomoses.
- Sample should be placed within the lumen of the IVC.
- Angle correction should be used.
- The superior anastomosis is typically higher velocity than the inferior anastomosis, but if the velocity is greater than 3 times the inferior anastomosis, a narrowing or stenosis may be present and should be evaluated further.



SPLENIC VEIN –*VELOCITY with angle correction*

- Velocity and direction of flow to be obtained if evidence of PHTN or collaterals are seen.

LIVER TRANSPLANT ULTRASOUND IMAGE LIST

IMAGE	MODE
Assess for fluid collections	Color, 2D+
Assess for collaterals	Color, 2D+
Panc Trans H/B/T	2D
Panc Sag H/B/T	2D
Panc Duct if dilated	*2D +*
Left Liver Sag (at portal vein)	2D
Left Liver Sag (at hepatic vein)	2D
Left Liver Sag M-L	Cine
Caudate Liver Sag	2D
Caudate Liver Trans	2D
Left Liver Trans (at hepatic vein)	2D
Left Liver Trans (at portal vein)	2D
Left Liver Trans S-I	Cine
LPV *without color*	2D
LPV *w/ color*	Color
LPV *velocity w angle correction*	Spectral cm/s
LHA *RI w angle correction*	Spectral RI
LHV *waveform*	Spectral
Right Liver Trans (at dome)	2D
Right Liver Trans (at hepatic veins)	2D
Right Liver Trans (at portal vein)	2D
Right Liver Trans (at RK)	2D
Right Liver Trans S-I	Cine
Right Liver Sag/Rt Chest	2D
Right Liver Sag (at portal vein)	2D
Right Liver Sag (at main lobal fissure)	2D
Right Liver Sag / RK	2D
Right Liver Sag L-M	Cine
CHD w/measurement and color	Color+
CBD w/measurement and color	Color+

IMAGE	MODE
MPV *without color*	2D
MPV *w/ color*	Color
MPV *velocity w angle correction*	Spectral cm/s
PHA *RI w angle correction*	Spectral RI
RPV *without color*	2D
RPV *w/ color*	Color
RPV *velocity w angle correction*	Spectral cm/s
RHA *RI w angle correction*	Spectral RI
MHV *waveform*	Spectral
RHV *waveform*	Spectral
IVC *velocity at piggyback anastomosis*	Spectral cm/s
IVC end-to-end anastomosis:	
Superior IVC velocity at anast	*Spectral cm/s*
Inferior IVC velocity at anast	*Spectral cm/s*
Right Kidney Sag Mid	2D
Right Kidney Sag Mid w/ measurement	2D +
Right Kidney Sag Med	2D
Right Kidney Sag Lat	2D
Right Kidney Trans Sup	2D
Right Kidney Trans Mid	2D
Right Kidney Trans Inf	2D
Spleen Sag x2	2D x2
Spleen Sag w/ measurement	2D +
Spleen Trans	2D
Splenic Vein if collaterals or evidence or PHTN seen	*Spectral cm/s*
RLQ/LLQ	2D

LIVER TRANSPLANT ULTRASOUND PROTOCOL HISTORY

	Date	Changes made	By whom
Updated	08/14/20		Becky Marion
Updated	03/03/22	-Added Split liver requirements -Added IVC Piggyback vs End-to-end -Added respiration note on HVs -Added if aliasing comments in MPV -Added tardus parvus comments for HA	03/03/22 Protocol Meeting Attendees (Dighe, Lee, Kolokythas) (Document updated by Renee Betit Fitz)
Approved	03/14/22		Manjiri Dighe
Updated	10/13/22	Changed ~~For repeat exams within 24 hours, limited doppler evaluation of all the vessels, bile duct and assessment for fluid collections is acceptable.~~ New: For repeat exams on INPATIENTS within 72 hours, and it is not the routine POD 1,4,7 or 10 exam, limited evaluation of the liver vasculature and bile ducts and assessment for new fluid collections is acceptable. State in the report that Kidney, Spleen, Pancreas were "Not evaluated". If it is ordered as a POD 1,4,7, or 10 exam, or if it has been longer than 72 hours (3days) since we looked at everything, do the full exam.	Manjiri Dighe Lena Sibulesky
Added	10/27/22	Cine clips of RHL & LHL in TRV & Sag	Renee Betit Fitzgerald
Added	4/15/2024	Image lists	Renee Betit Fitzgerald
Reviewed	6/27/2024	-Added: assess for collaterals -Changed: RK not required for Split liver left lobe only. -Added: HA velocity and tardus parvus info -Added: PV velocity info -Added: monophasic HV info -Added: additional IVC info -Added: Splenic vein velocity if evidence of PHTN or collaterals are seen	Protocol Meeting Attendees: Manjiri Dighe, Shaun Bornemeier, Dalene Edden, Renee Betit Fitzgerald, Becky Marion