Imaging and Doppler of Portal Hypertension

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Objectives:

Review the normal hepatic Doppler flow profiles

Recognize the hemodynamic changes of portal hypertension

Recognize the common and unusual pathways of porto-systemic shunting

Hepatic artery

- Normal waveform
- Brisk upstroke in systole
- RI ≥ 60-70%
- Diastolic velocity <20 cm/sec

Portal vein

- Relatively uniform velocity.
- Some periodicity OK, but not too much.
- Velocity just under 20 cm/sec in a fasting patient

Nothing to disclose relevant to this presentation.
Portal flow basically percolates through the liver.

**The liver vascular index**
- Relates portal vein velocity to hepatic artery velocity

- PV velocity near arterial end diastolic velocity

**Outflow**
The Hepatic Veins

**Caudate Veins**

**Hepatic vein laminar flow dynamics**
Hepatic Vein Flow Dynamics

Venous waveform terminology
• Pulsatility
• Periodicity
• Phasicity

Normal hepatic blood flow
• 25% of cardiac output
• 1.5 Liters per minute
• Portal inflow 2/3; arterial inflow 1/3
• 90% of Oxygen via Hepatic Artery
• The Artery supplies the disease process.

The Diseased Liver

The altered liver vascular index
• Initially reported to be highly sensitive and specific for diagnosis of Hepatocellular Carcinoma (HCC)
• Many other causes

Altered porta-hepatis hemodynamics

- Diffuse hepatocellular disorder
  - Hepatitis – viral, chemical, alcoholic
- Focal lesions
  - Lymphoma
  - Metastatic disease
  - Hepatitis
  - Etc.
  - Non-specific
  - It’s not really compensatory

How do you report this liver?

Verifies the “starry sky” liver as abnormal

With just the right degree of liver disease main PV flow may be relatively stagnant.

Don’t call it thrombosed.

Valsalva maneuver then release can flip PV flow from fugal to petal.

Good trick to avoid thrombosis overcall.

Nomenclature

- Reversed portal flow is hepatofugal
- Normal portal flow is hepatopetal
  - Not – hepatopedal
- As in: centrifugal force / centripetal force

The degree of main PV flow reversal correlates with the severity of the liver disease.

Except in the presence of a paraumbilical vein
Increased Periodicity of Portal vein flow

1. May be due to hyperdynamic hepatic arterial inflow
   - Capillary leak
   - AV Fistula

2. May be secondary to increased venous retropulsation with cardiac disease
   - TR (large pressure waves forcing back into the liver)

Altered porta-hepatis hemodynamics

• Liver disease
• AV fistula

Portal hypertension

• Increased pressure gradient between the portal vein and the IVC above 6 mmHg
• >6 mmHg <12 mmHg (clinically silent)
• >12 mmHg (clinically evident)

Hepatic Venous Outflow Obstruction

Increased Periodicity of Portal vein flow

Hepatic Vascular Anatomy

Portal Triad
Hepatic Vascular Anatomy

Portal Triad

Resistance to the outflow from the Portal Vein Results in Portal Hypertension

Classifications of portal hypertension

- Pre-sinusoidal
- Sinusoidal
- Post-sinusoidal

Pre-sinusoidal

- Extrahepatic
  - Portal vein obstruction
  - compression
  - occlusion
  - Arterio-portal fistula
- Intrahepatic
  - Fibrosis
  - Wilson disease
  - Sarcoid
  - Parasites
Sinusoidal
- Cirrhosis
- Laennec
- Hepatitis
- Sclerosing cholangitis

Post-sinusoidal - Budd Chiari Syndrome
- Hepatic vein thrombosis
- Hepatic venous outflow obstruction
  - Cardiac
  - Pulmonary

Hepato-cellular disease presentation depends on its severity
- Elevated Liver Enzymes
- Ultrasound is usually the 1st imaging test
- You should perform (request) Doppler because imaging itself is often negative.

With Hepato-cellular disease...
- Portal flow decreases
- Arterial flow increases (early in the disease process)

Reversed Portal flow
Eventually the disease worsens to the point that even Hepatic Artery flow encounters resistance.
- It finds a path with less resistance …
  - The portal vein
  - The end result is…
  - Hepatofugal flow

Where is this blood coming from?
Imaging findings of portal hypertension

- Portal vein enlargement
- Decreased or reversed flow
- Varices

Portosystemic pathways

- Gastroplenic (short gastric)
- Left gastric
- Recanalized umbilical vein
- Splenorenal
- Mesenteric
- Retroperitoneal
- Hemorrhoidal

Identification and mapping of varices ...

- Helps avoid surgical complications
- Helps in planning transplant surgery
- Helps in planning TIPS

3D CT angiography of portal hypertension

- Imaging during early arterial, late arterial and portal venous phases (3 min delayed)
- Augment perception of the entire collateral pathway
- 3D reformatting with subtraction
  - (the old SSD way)
42 y/o liver transplant candidate
- Short Gastric Varix

55 y/o liver transplant candidate
- Both Short and Left Gastric Varices

Liver transplant recipient
- Left Gastric Varix
- Collateral steal syndrome
Esophageal varix

Left Gastric Varix

The Ultrasound window to the....

Left gastric varix  Short gastric varix

Recanalized paraumbilical vein

When flow arrives at the umbilicus, it is still not back to the systemic circulation
Recanalized umbilical vein
Drainage pathways
- Caput Medusa
- Inferior epigastric to external iliac
- Superficial circumflex iliac vein
- Substernal veins
- Anywhere it can

Caput Medusa

But a Caput Medusa is rarely seen

Rec. Umbilical to Right Inferior Epigastric Varix
Funny things can happen at the umbilicus.

32 y/o prisoner with an umbilical hernia

DO NOT biopsy this!
Varices may complicate the surgical approach to underlying pathology

52 y/o female with LLQ pain, fever, elevated white count
- Clinical diagnosis - diverticulitis
- Past medical history
  - Liver disease
  - Portal hypertension - Apparently resolved

Pericholecystic varices
- Rare
- Commonly associated with portal vein thrombosis

What do you think of the Portal Vein?
Spleno-renal varices are rarely direct

They often involve the gonadal vein.

… or a mesenteric vein

… or an adrenal vein

Spleno-renal-mesenteric collateral pathways can be very convoluted

Spleno-external-iliac collateral (via the panus)
... or the collateral pathway can be very direct

IMV to IVC via a Lumbar Vein

39 y/o female with pelvic mass on physical exam

IMV to Left Gonadal Vein

IMV to hemorrhoidal varix

PC VIPR
Phase Contrast Vastly Under-sampled Isotropic Projection Imaging

- Novel '4D MR Flow' technique developed at UW Madison
- Currently very computer intensive, but improving

MR PC VIPR
- Helical flow in the Portal Vein

Normal Variant

MR PC VIPR
- Portal Vein Thrombosis
- Reversed Lt PV
- Reversed SMV
Conclusions

Portal Hypertension

- Variceal pathways can be just about anywhere
- Pre-transplant shunt identification is critical to transplant survival
- An unsuspected varix can ruin a good surgeon’s day

Conclusions

Portal hypertension (cont.)

- The Caput Medusae is only present in a small percentage of recanalized paraumbilical varices
- When you think you have a cystic mass - don’t forget to turn on the Doppler
Thank you