

Mesenteric Ischemia

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No disclosures

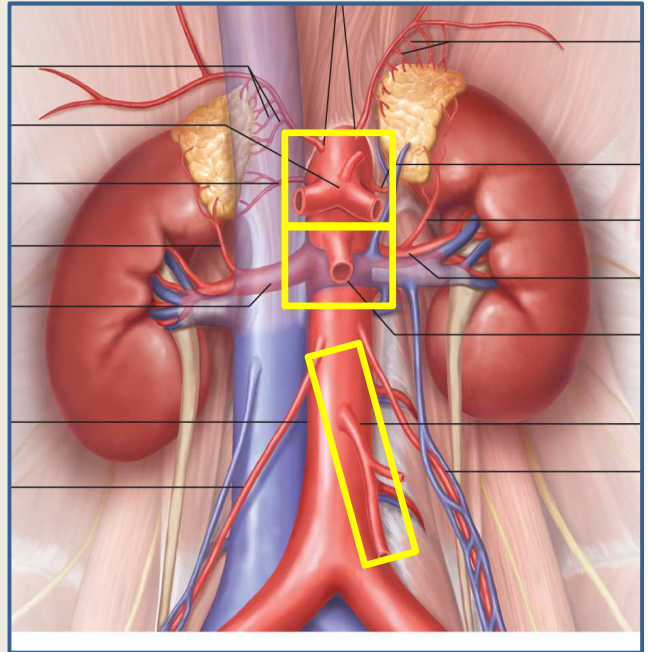
Objectives

- Review normal mesenteric arterial and venous vascularity.
- Discuss normal mesenteric arterial doppler waveforms.
- Discuss acute and chronic mesenteric ischemia.
- Discuss patient preparation and exam techniques.
- Review best practices for optimizing doppler waveforms.
- Discuss compensatory flow and collateral pathways in the presence of mesenteric ischemia.
- Discuss abnormal mesenteric doppler waveforms and diagnostic criteria for mesenteric stenosis.
- Discuss post intervention follow-up
- Discuss median arcuate ligament compression and aneurysms.

Normal Anatomy and Doppler Waveforms

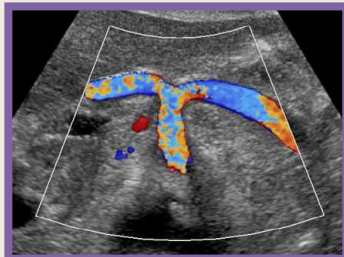
Anatomy Overview

- Celiac Axis/Trunk/Artery
- Superior Mesenteric Artery
- Inferior Mesenteric Artery
- Mesenteric Veins
- Portal System



Celiac Axis

- Supply the organs of the foregut ie, liver, stomach, pancreas, GB, spleen & duodenum
- Three branches: left gastric, splenic and hepatic artery
- “SEAGULL or DOVE SIGN”

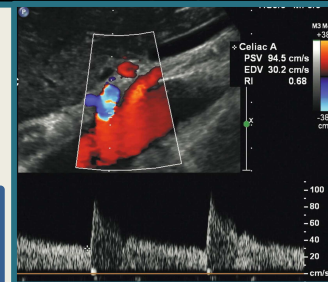
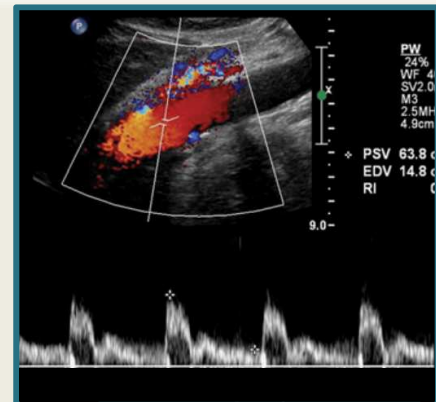


Sonography: Celiac Axis



Doppler Waveform: Aorta & Celiac Axis

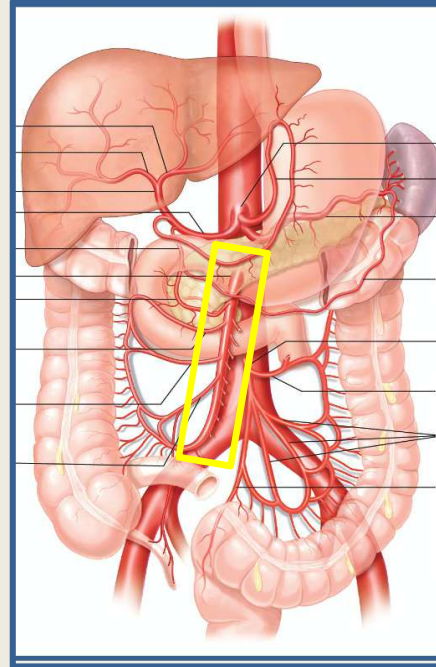
- Proximal aorta, celiac, common hepatic, and splenic arteries demonstrate **low-resistance flow patterns**.
- Sharp systolic upstroke
- Continuous forward flow throughout the cardiac cycle.
- High O₂ demands of organs/vascular bed
- Similar to low resistance waveforms seen in renal arteries and internal carotids
- Waveform does not change post prandial (unlike SMA).
- **About 100 cm/sec**



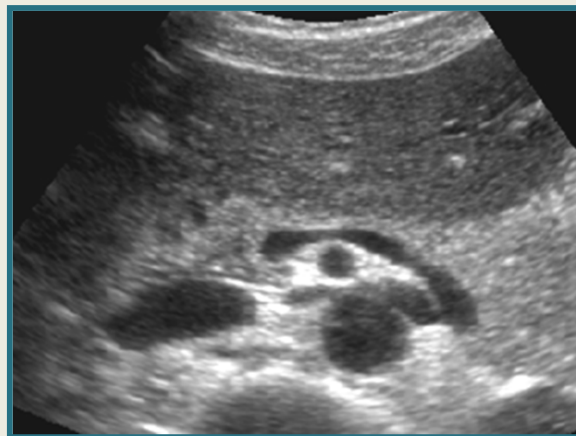
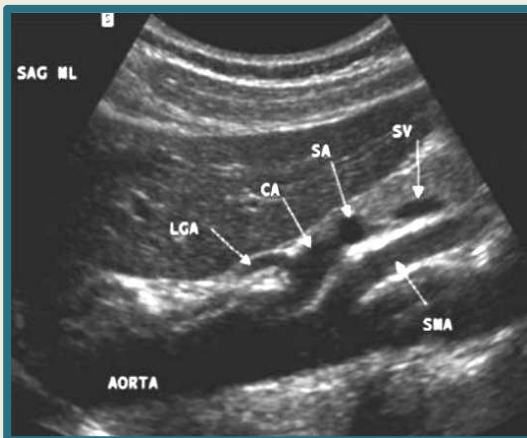
Normal to see **spectral broadening** in small to medium size vessels.

Superior Mesenteric Artery

- Artery of the midgut, supplies majority of small intestines, except superior portion of the duodenum.
- Supplies the cecum, ascending and most of the transverse colon.

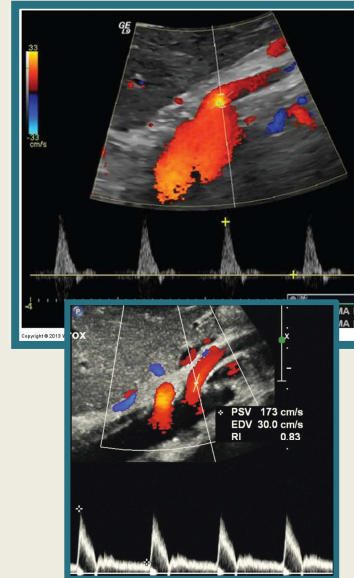


Sonography: Superior Mesenteric Artery



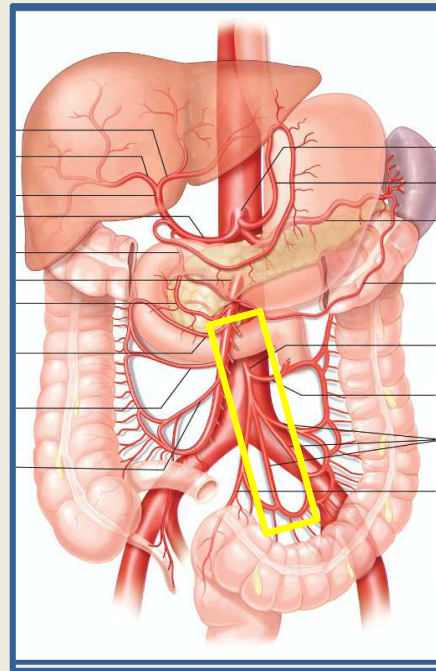
Doppler Waveform: Superior Mesenteric Artery

- *Fasting* SMA demonstrates **high-resistance**
- *Postprandial* SMA demonstrates **low-resistance** flow patterns.
- Sharp systolic upstroke
- **PSV About 115 cm/sec**
- **Range of 95-140 cm/sec**



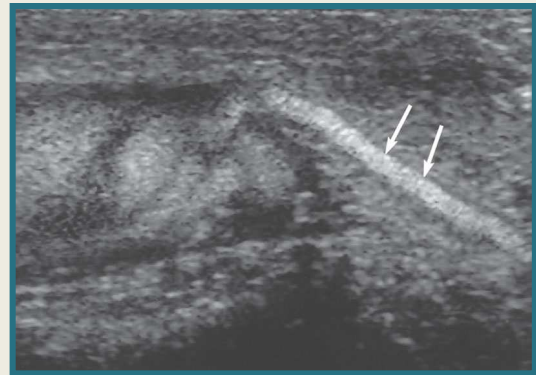
Inferior Mesenteric Artery

- Courses to left to supply blood to descending colon, sigmoid colon and rectum.



Sonography: IMA Branches

- Difficult to visualize due to overlying bowel gas.
- Most easily identified in transverse plane
- Use aortic bifurcation as landmark
- A sagittal oblique approach towards the left



Courtesy. Wolters Kluwers Health

Doppler Waveform: Inferior Mesenteric Artery

- Doppler waveform resembles fasting SMA (high-resistance)
- Typically does not change after eating
- PSV About 141 cm/sec
- Range of 90-190 cm/sec



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Summary: Normal doppler findings

- Celiac artery
Normal Waveform
 - Sharp systolic upstroke
 - Low-resistance flow pattern
 - PSV About 100 cm/sec

- SMA
Normal Waveform
 - Sharp systolic upstroke and clear systolic window
 - High-resistance flow pattern (in fasting patient)
 - PSV About 115 cm/sec
 - Range of 90-190 cm/sec

- IMA
Normal Waveform sharp upstroke; high resistance
 - PSV About 141 cm/sec
 - Range of 90-190 cm/sec

Velocities in mesenteric vessels correspond to aorta (1 to 1 ratio)

Reference: Pellerito

Doppler Settings

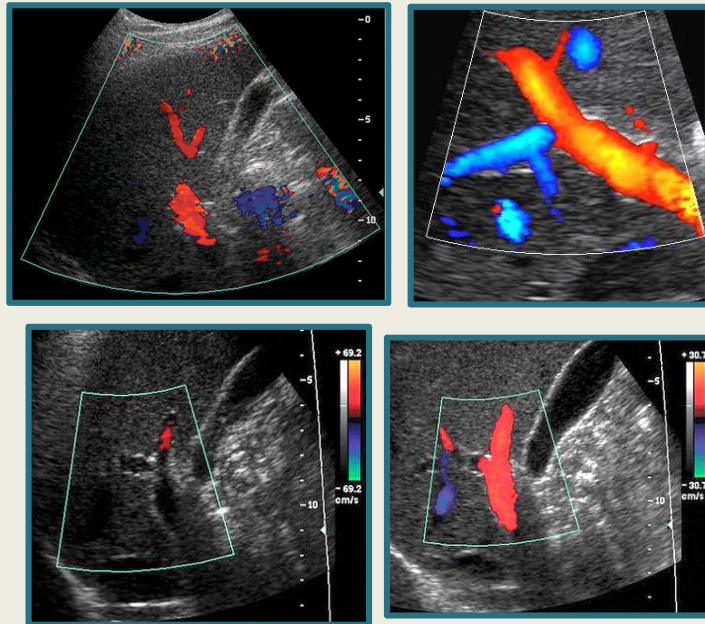
Doppler Settings

Set for high velocities in the abdomen

- Least depth as possible
- Zoom

Color Doppler Settings

- Small color box
- Color Scale / PRF
- Color Gain*

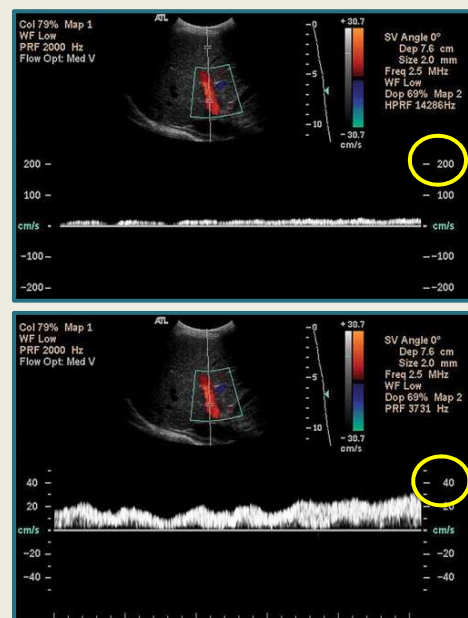
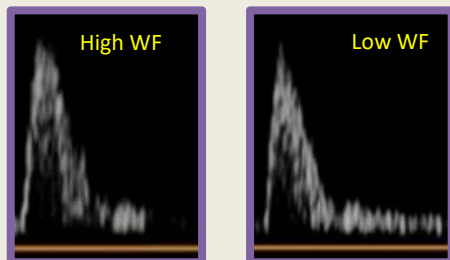


Doppler Settings

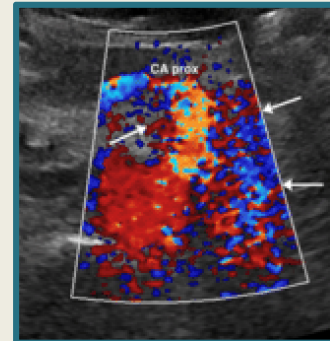
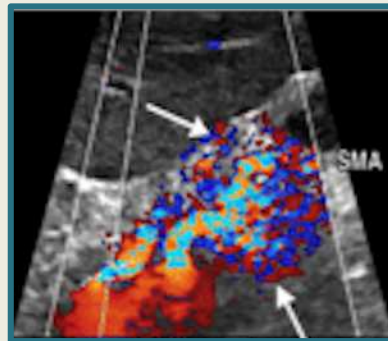
Spectral Doppler Settings

- Higher velocities
- Large Sample Volume
- Low wall filter

Appreciate low velocities in end diastole



Color Bruit & Color Aliasing



Revzin, Margarita & Pellerito, John & Nezami, Nariman & Moshiri, Mariam. (2020). Abdominal Radiology

Anatomical Variants

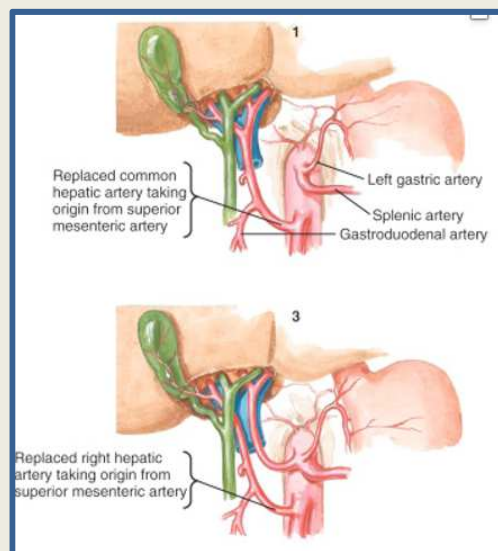
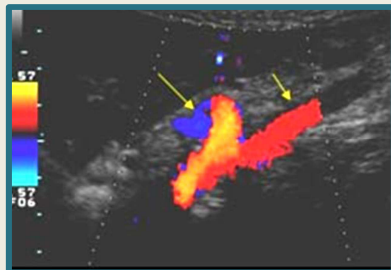
- Replaced right hepatic artery (12%)

Commonly originate SMA

- Replaced common hepatic artery

Also typically arises from SMA

- Common origin of celiac and SMA (celiacomesenteric artery)



Mesenteric Ischemia

Acute Mesenteric Ischemia

- Life threatening surgical emergency
- Arteriogram, CT or MRI for diagnosis (not sonography)
- Embolic occlusion or stenosis /occlusion of artery with existing chronic disease
- Often occurs distally (not well seen on sonography)
- Bowel necrosis and high mortality rate.

Clinical Presentation:

Acute pain “pain out of proportion to physical findings.”

Abdominal Distention

Fever

Dehydration

Acidosis (due to ischemia of the tissue)

Chronic Mesenteric Ischemia

- Most common reason mesenteric duplex exam.
- More common in women **65 average age**
- Postprandial pain (30-40 mins)
- Nausea
- Bloating
- Weight loss
- Diarrhea
- Fear of food
- Presence of abdominal **BRUIT**
- Collateral flow (GDA, arc of Riolan and marginal arteries)
- **Two of three mesenteric vessels**

The Study

Patient Preparation

- Patient to fast NPO after midnight. 12 is better to reduce scatter and attenuation from bowel gas.
- No smoking or chewing gum or eating to prevent bowel gas.
- Diagnostic criteria established for fasting vessels
 - **SMA changes dramatically after eating**
 - *Changes from high-resistance flow pattern to low-resistance flow pattern*

Post prandial studies are not needed. Stenosis can be identified fasting and post prandial.

Documentation

- **Doppler waveforms from following vessels**
 - Proximal aorta
 - Celiac artery origin (ostia) & proximal
 - SMA origin (ostia) & proximal
 - Inferior mesenteric artery (IMA)
 - Splenic and hepatic arteries (when needed)
 - *Distal portions are not seen well. Ok, since stenosis is most often at the ostia and proximal part.*

Scanning Technique

- Begin just below xiphoid process in transverse to identify proximal aorta.
- Sagittal and transverse views
- Doppler sample should be “walked” through required vessels.
- Peak systolic volume (PSV) and end-diastolic volume (EDV) should be recorded in all vessel segments.
- Angles of **60 degrees or less** must always be used.
- **Poststenotic turbulence** should be recorded as well.

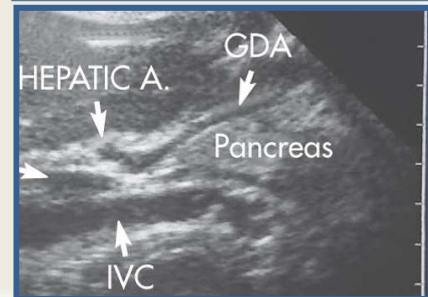
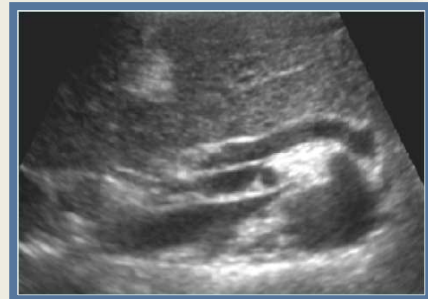
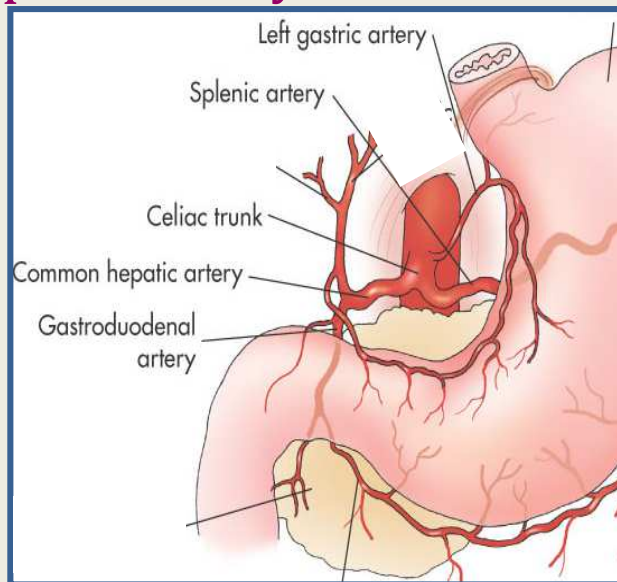
Breathing:

Vessel angles change quickly.

Often better to have the patient stop breathing versus holding breath

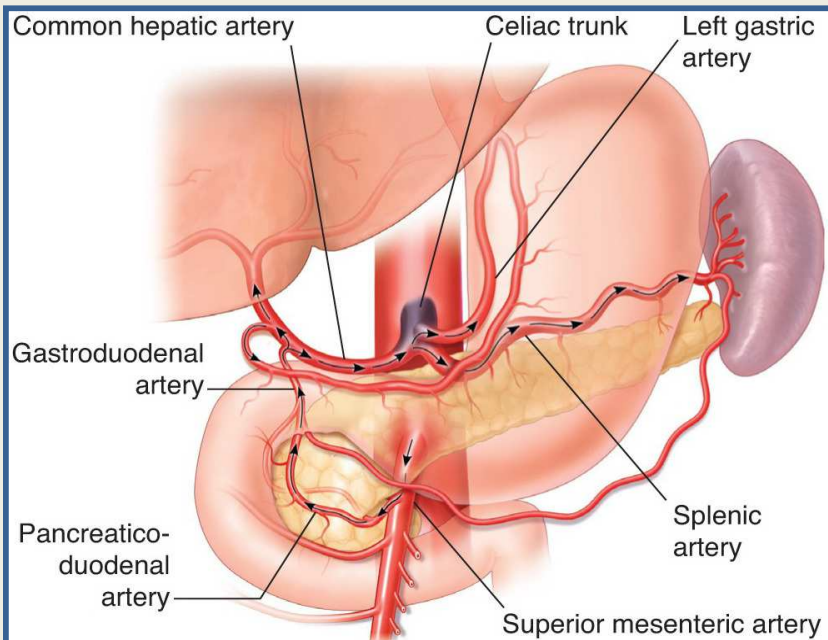
Collateral Flow in the Presence of Mesenteric Ischemia

Hepatic Artery & Gastroduodenal Arteries



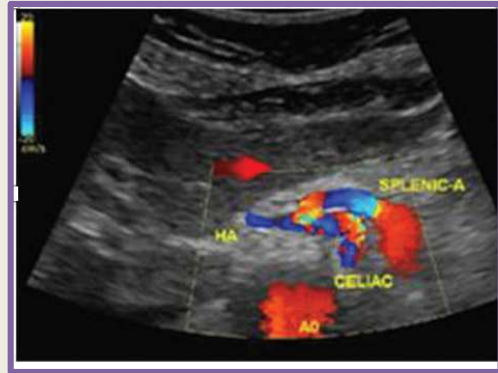
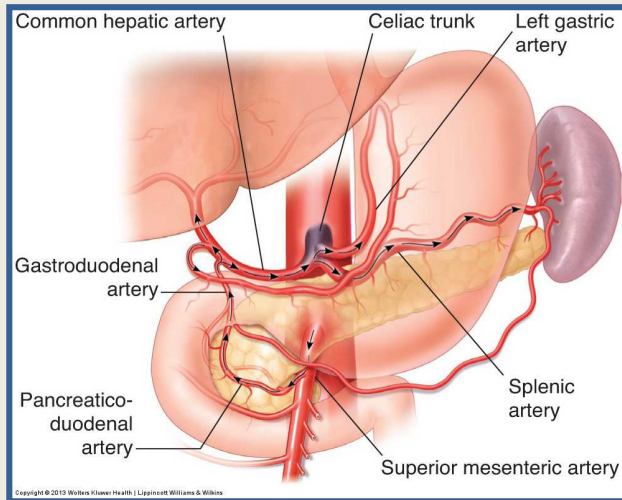
Occluded Celiac

SMA divert blood through the gastroduodenal artery toward the liver and spleen. Retrograde flow in the common hepatic artery fills the splenic artery.



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Compensatory Flow



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Compensatory Flow

- **Elevated velocities** may be noted in normal vessels when they are acting as collaterals.
 - Mesenteric system has extensive collateral network.
- **True stenosis** usually demonstrates
 - Increased flow
 - Poststenotic turbulence/spectral broadening
- Compensatory flow has **little spectral broadening and no stenotic profile** (change before, in, and after stenosis).
- Prominent IMA suggests SMA occlusion with collateralization through meandering mesenteric artery.

Collateral Flow

These pathways can allow sufficient circulation in the presence of atherosclerotic disease.

- **Pancreaticoduodenal Arcade**

Bridge celiac and superior mesenteric artery (SMA)

- **Arc of Riolan (meandering mesenteric artery of Moskowitz)**

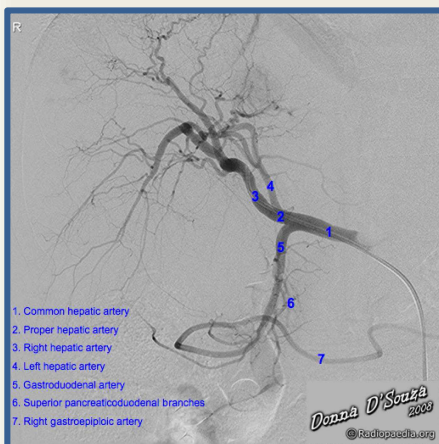
Bridges inferior and superior mesenteric arteries (**more proximal**)

- **Marginal Artery of Drummond**

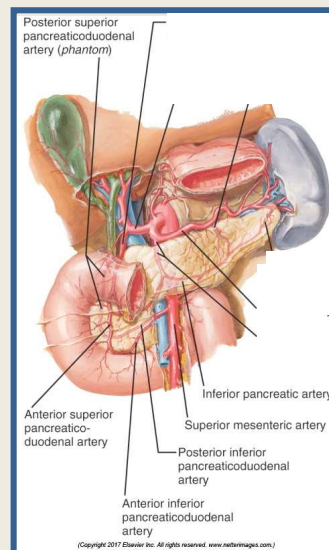
Bridges inferior and superior mesenteric arteries (**more distal**)

- **Collaterals between internal iliac arteries and inferior mesenteric artery**

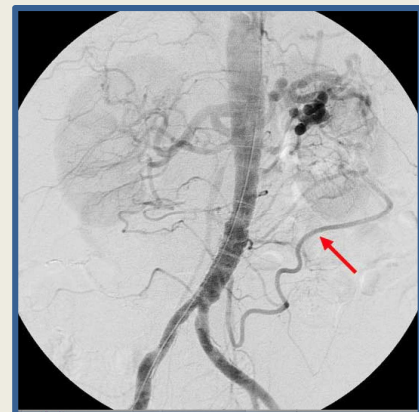
Pancreaticoduodenal Arcade



Case courtesy of Donna D'Souza,
Radiopaedia.org, rID: 36182



Arc of Riolan



Case courtesy of Donna D'Souza,
Radiopaedia.org, rID: 36156

Increase in PSV is seen in IMV in the presence of occluded celiac & sma.

Diagnostic Criteria

Mesenteric Ischemia Diagnostic Criteria

Peak Systolic Velocity* (most accurate)
End Diastolic Velocity
Aortic Mesenteric Ratio ≥ 3.5

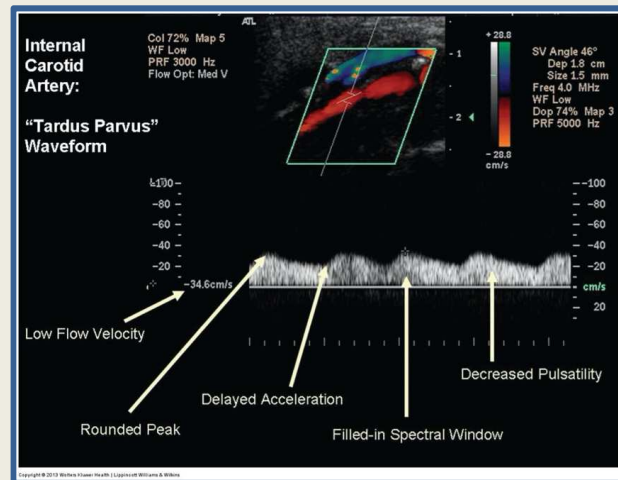
Two Vessel Disease

Celiac artery	Superior Mesenteric Artery	Inferior Mesenteric Artery
70% Stenosis	70% Stenosis	50% Stenosis
PSV ≥ 200 cm/s consistent EDV ≥ 55 cm/s consistent with $\geq 50\%$ stenosis	PSV ≥ 275 cm/s consistent EDV ≥ 45 cm/s consistent with $\geq 50\%$ stenosis*	PSV > 200 cm/s EDV ≥ 45 cm/s consistent with $\geq 50\%$ stenosis

Attempts should be made to document post stenotic turbulence and distal waveform changes should be documented to confirm presence of stenosis.

Reference: Moneta & Pellerito

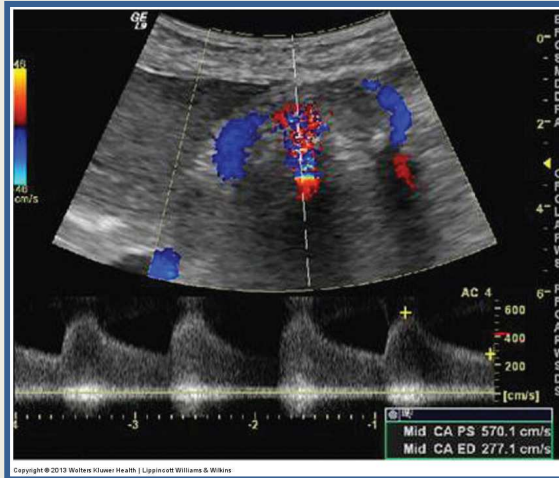
Distal to a stenosis Dampened / Tardus Parvus



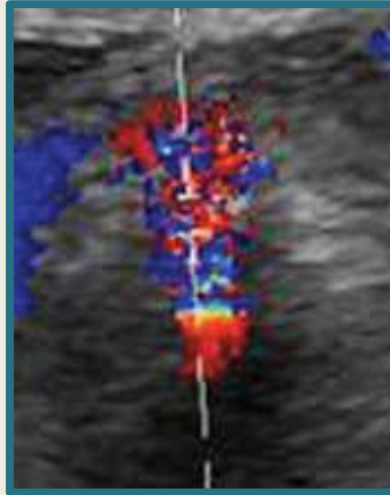
Courtesy, Wolters Kluwer Health

Cases

Stenosis: Celiac Axis



At the stenosis: High Velocity
/Spectral Broadening

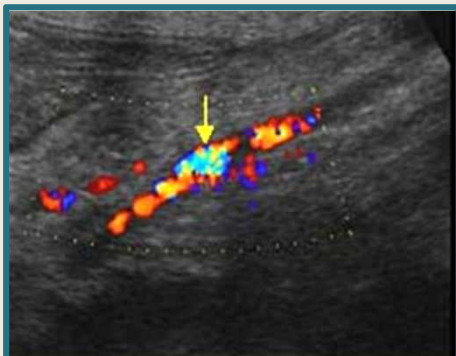


Color Bruit

Color Aliasing

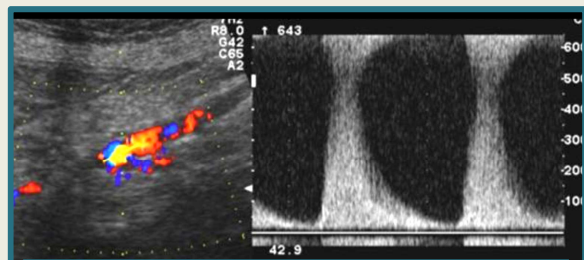
Reference: Ultrasoundcases.info

Stenosis: SMA

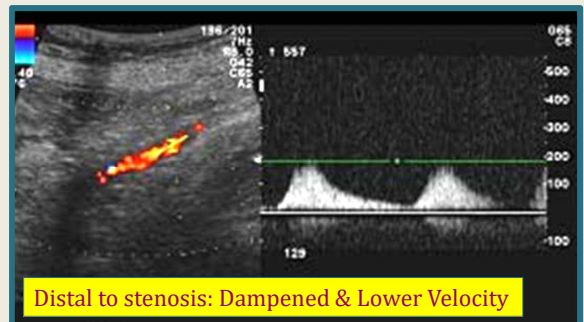


Color Aliasing

Reference: Ultrasoundcases.info

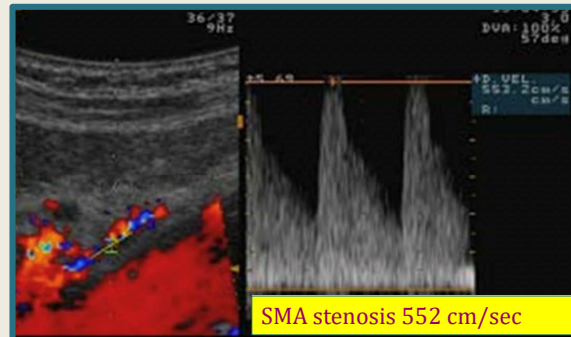
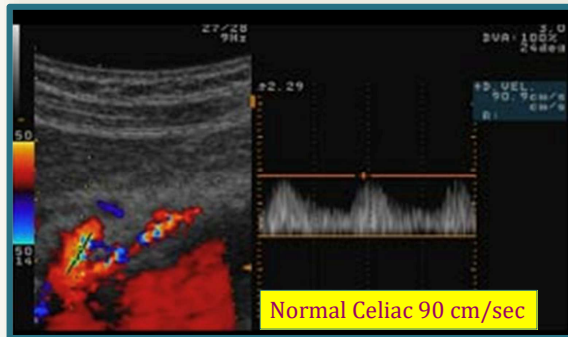


At the stenosis: High Velocity /Spectral Broadening



Distal to stenosis: Dampened & Lower Velocity

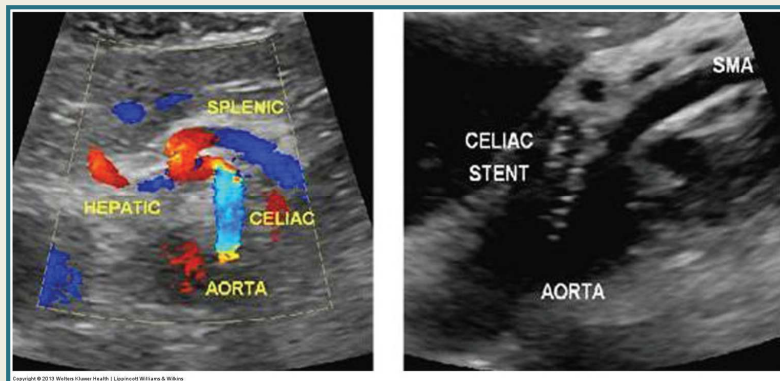
Normal Celiac, SMA stenosis



Reference: Ultrasoundcases.info

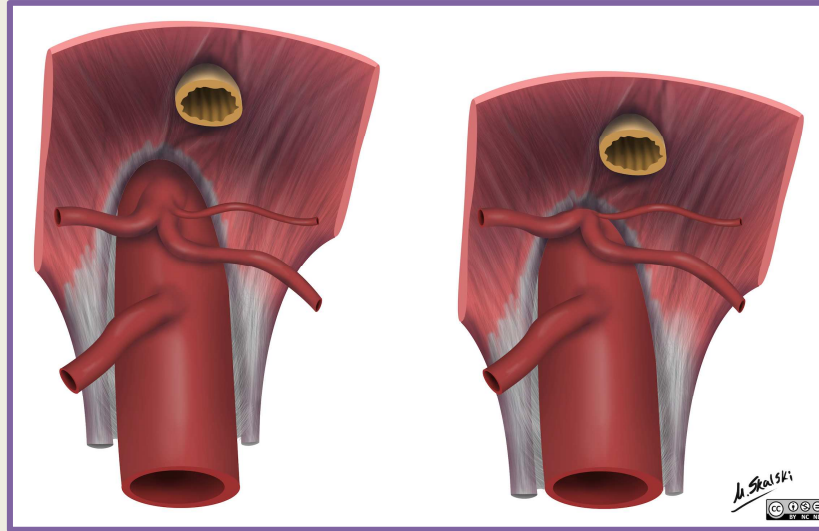
Stent

- Identify with grayscale
Open surgical approach versus endovascular
- Symptoms and restenosis is more common in endovascular group.



Courtesy. Wolters Kluwers Health

Median Arcuate Ligament Syndrome



Case courtesy of Matt Skalski, Radiopaedia.org, rID: 36837

Median Arcuate Ligament Syndrome

- Celiac artery compression & Dunbar syndrome
 - Compression occurs during exhalation
 - Compression relieved by inhalation (diaphragm descends)
- Rare compression / narrowing of the celiac trunk by the diaphragmatic crura.
- Controversy: high prevalence of narrowing in asymptomatic patients
- Treatment: surgical decompression
- More common in females (4:1)
- Average age 30-50 years old
- Common in thin patients

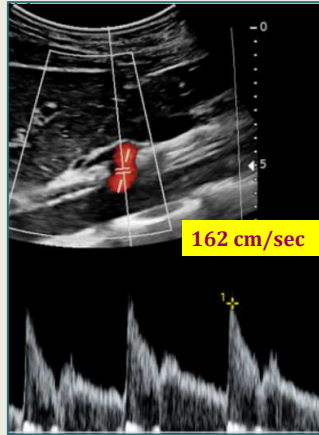
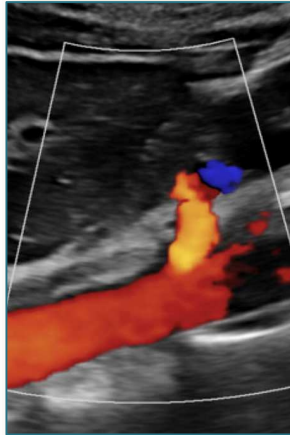
Clinical presentation

- Postprandial pain
 - relieved by standing position
 - aggravated by supine position
- Nausea/vomiting
- Weight loss

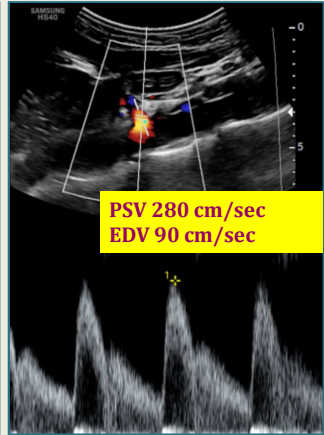
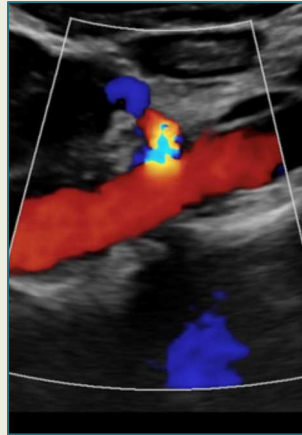
Case courtesy of Matt Skalski, Radiopaedia.org, rID: 36837

Median Arcuate Ligament Syndrome

Inspiration



Expiration



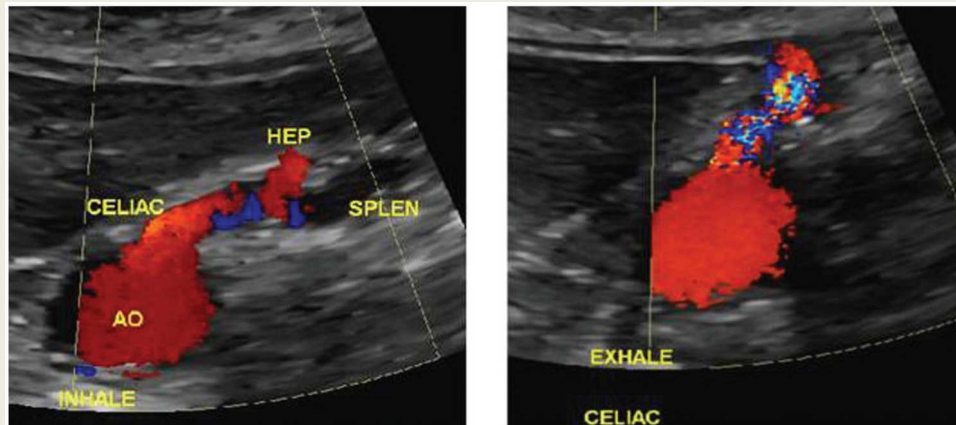
Case courtesy of Dr Ali Basim, Radiopaedia.org, rID: 98954

Median Arcuate Ligament Syndrome



Case courtesy of Dr Ali Basim, Radiopaedia.org, rID: 98954

Median Arcuate Ligament Compression Syndrome



Courtesy. Wolters Kluwers Health

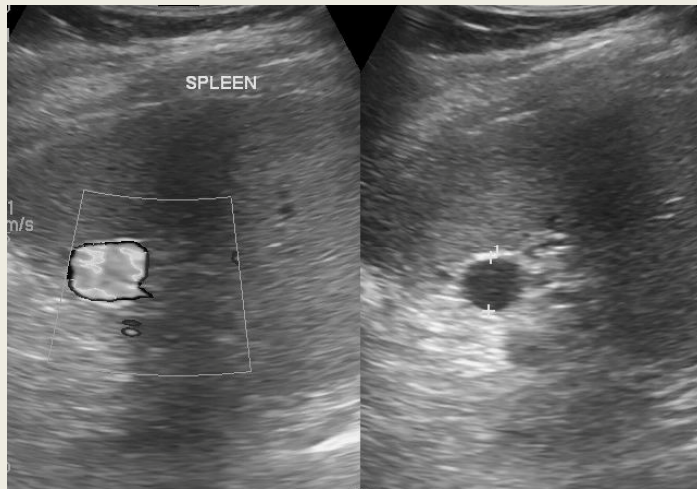
Aneurysm

- Visceral artery aneurysms are rare.
 - Most identified incidentally
- Of those that occur, most occur in **splenic artery**.
 - Women are more affected than men.
 - Causes include medial degeneration due to arterial fibrodysplasia, portal hypertension, and repeated pregnancies.
 - Rupture can be catastrophic. 4x more common to rupture in men.



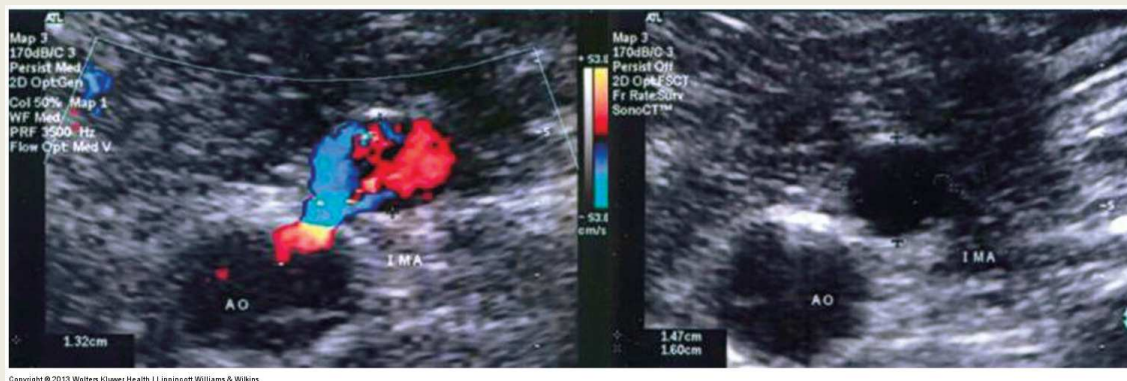
Case courtesy of Maulik S Patel,
Radiopaedia.org, rID: 9926

Aneurysm Splenic Artery



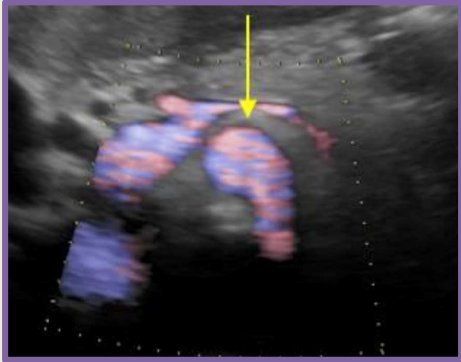
Case courtesy of Maulik S Patel, Radiopaedia.org, rID: 9926

Aneurysm IMA

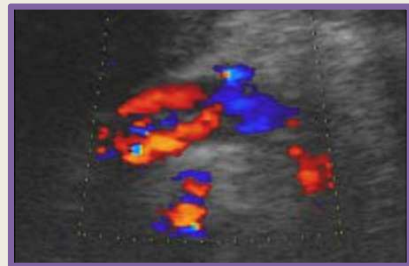
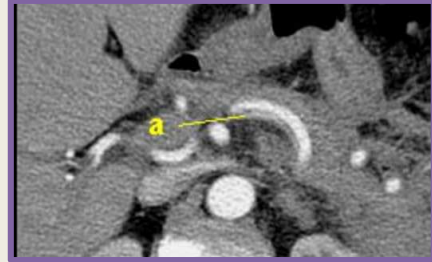


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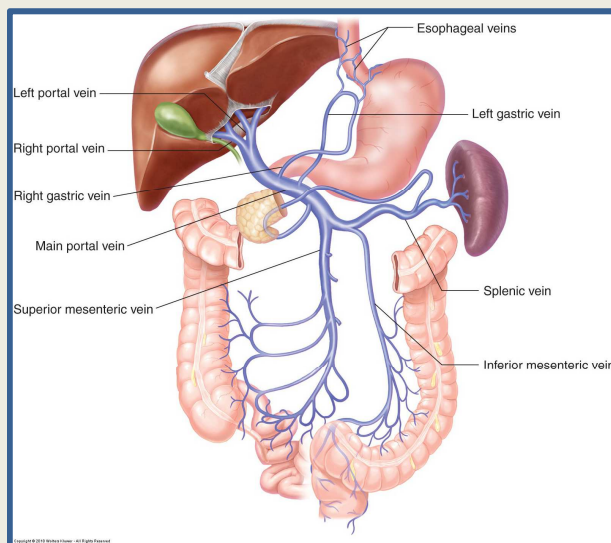
Aneurysm Celiac Axis



Splenic Artery Dissection

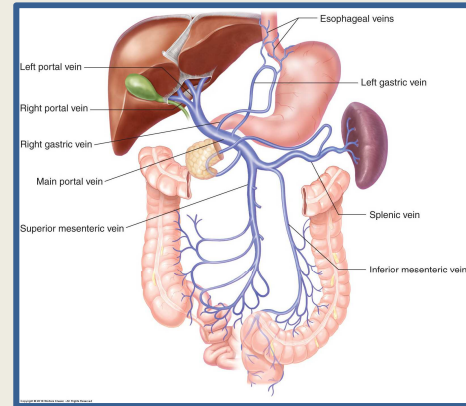


Mesenteric & Portal Venous System

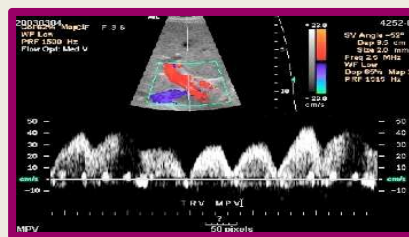
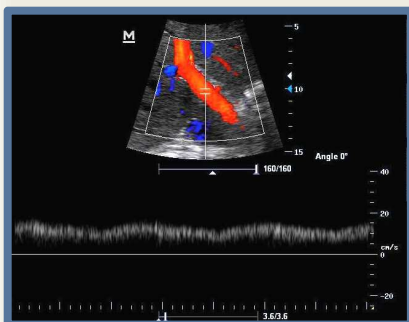


Mesenteric & Portal Venous System

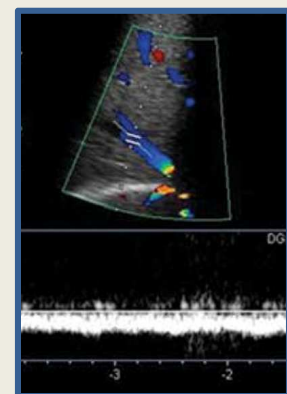
- Bowel & spleen
- 15-30 cm/sec
- Portal flow is hepatopedal
- Phasic / Laminar flow respiratory variation
- Flow increases post prandially and when supine
- Pulsatile flow seen with sided heart failure
- Dampened / continuous flow with liver disease



Normal and Abnormal Mesenteric and Portal flow patterns

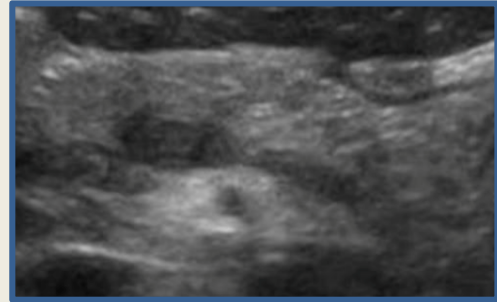
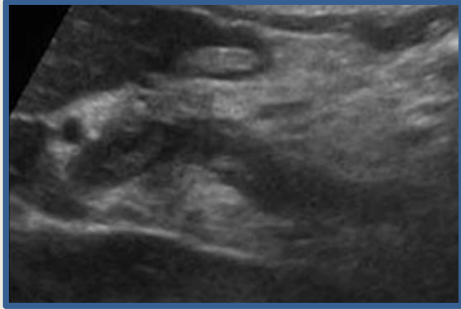


Pulsatility with Rt sided heart failure



Flat / Monophasic waveforms seen in liver disease in hepatic and portal veins

Mesenteric Disease and Venous Thrombosis



Reference: Ultrasoundcases.info

THANK YOU!