Abdominal Doppler Case Studies

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Disclosures

Educational consultant for Aegle Medical

Lectures for Philips Medical

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Objectives

1. Discuss the effects of color velocity scale (PRF) on the image.
2. Describe how portal vein is affected by liver disease.
3. Discuss how kidney disease influences renal artery flow.

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The Challenge of **Abdominal Doppler**

Vessels are at different levels in the body	• HV is shallow, MPV is deep
Need to Doppler both arteries and veins in a study	• MRA and MRV
Vessels move with respiration	
Sonographer needs to constantly adjust the Doppler controls during the study	• One “setting fits all” does not work

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Common Reasons

Portal Vein	Renal Artery
• Hypertension • Thrombosis	• Stenosis • Amount of diastolic flow • Resistive Index (RI)

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Case 1

2 months post liver transplant

Increased LFTs

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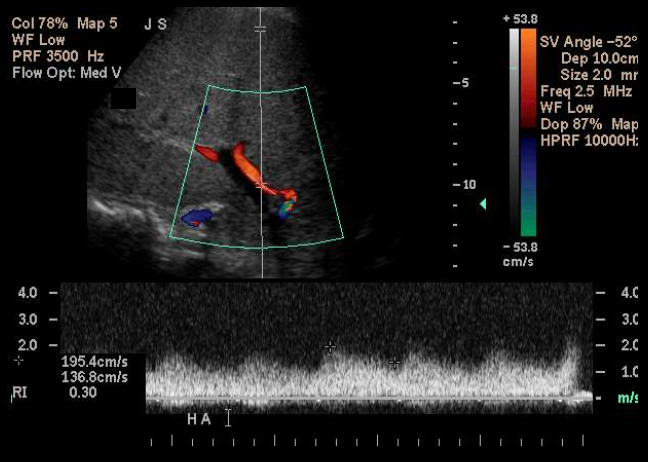
Why is there no flow in the portal vein?

- Portal vein thrombosis
- Color gain too low
- Color velocity scale too high
- Color velocity scale too low



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Why is there no flow in the portal vein?

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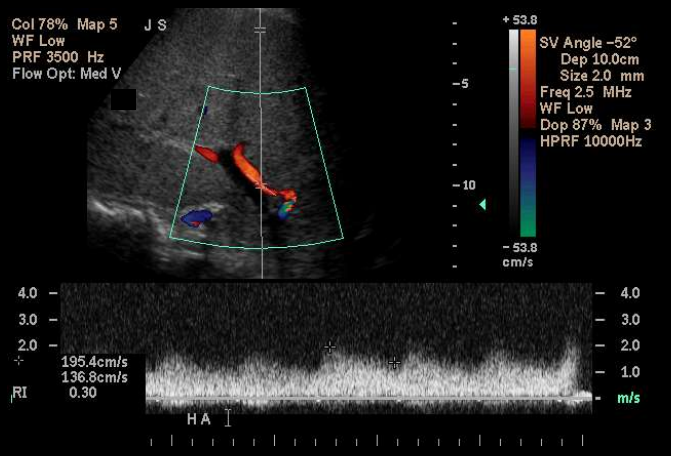
- Color velocity scale too low



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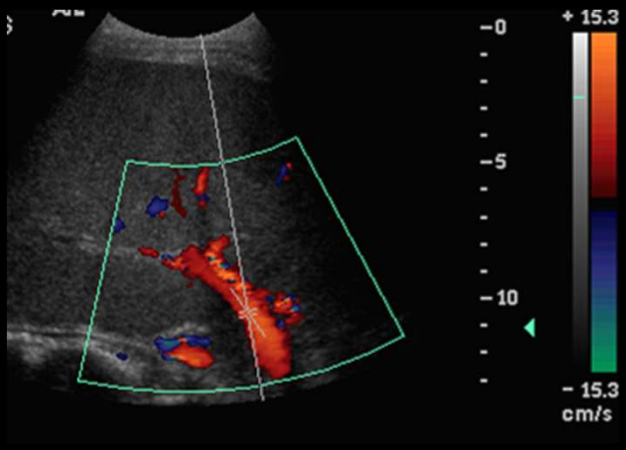
Why is there no flow in the portal vein?

Color velocity scale too high

- Increased to 53 cm/sec to eliminate aliasing in hepatic artery
- Eliminated flow in portal vein



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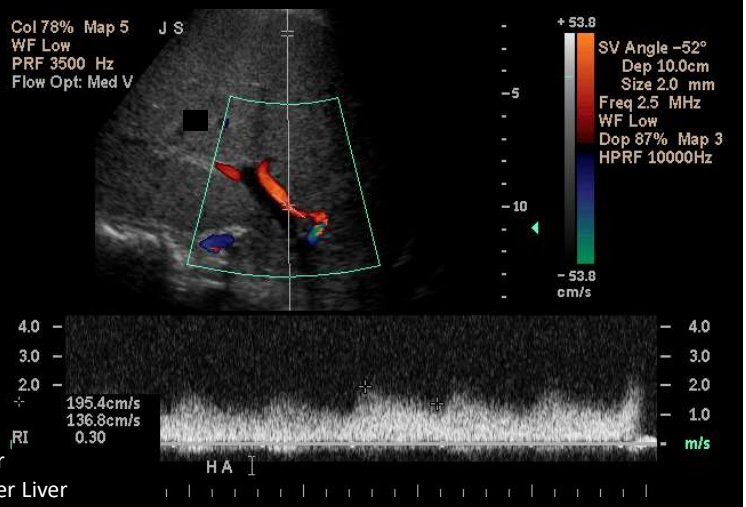
HAS US Criteria

- Prolonged systolic acceleration time
- Low RI <0.55
- Elevated systolic velocity >2 m/s



Ángeles G, Rosa G, Annalisa B, Concepción B. Doppler Ultrasound Findings in the Hepatic Artery Shortly After Liver Transplantation
American Journal of Roentgenology 2009 193:1, 128-135

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Case 2

- Patient with alcoholic cirrhosis
- Ascites

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Why is there no flow in the portal vein?

- Portal vein thrombosis
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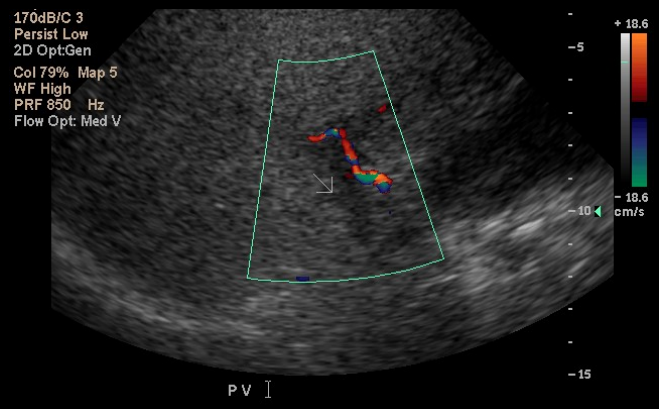
- Color velocity scale too high



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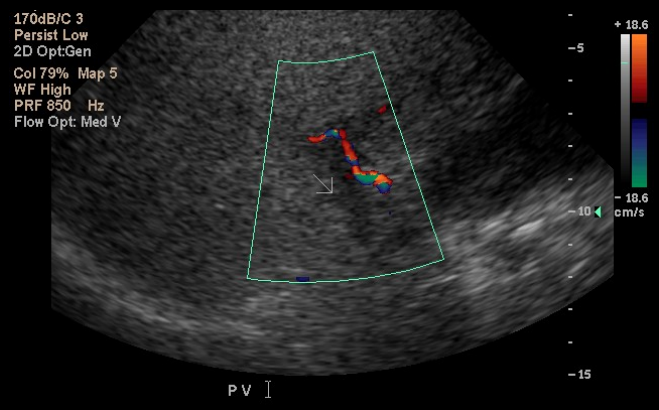
Why is there no flow in the portal vein?

- Portal vein thrombosis
- Color gain too low
- **Color velocity scale too high**



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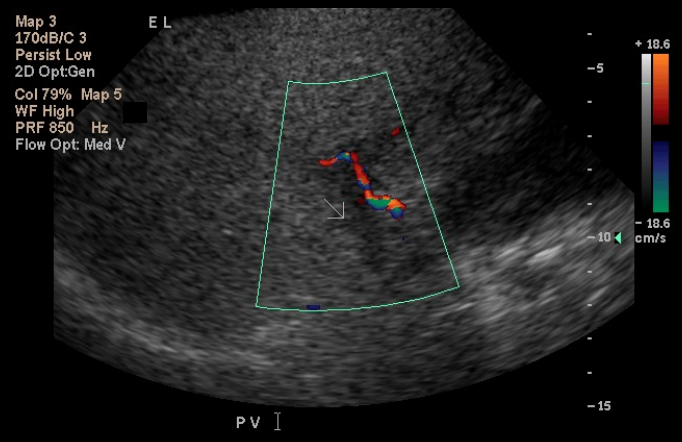
Why isn't this PVT?

- Cirrhotic liver
- Portal Vein filled in with echoes
- CVS is 18.6 cm/sec



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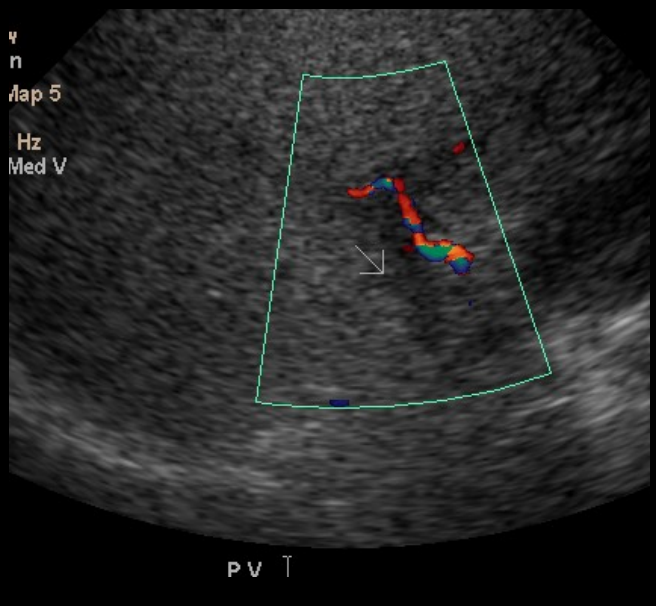
What sign suggests that this is not PVT?



- Hepatic artery is aliasing
- Hepatic artery is normal in size

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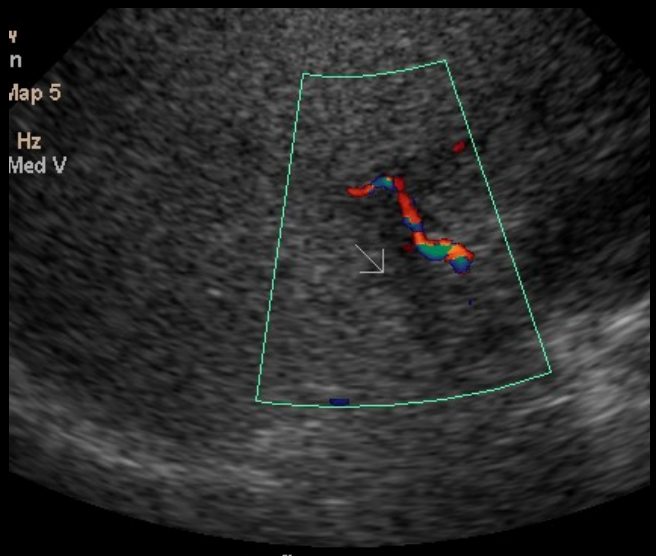
What sign suggests that this is not PVT?



Hepatic artery is aliasing

Hepatic artery is normal in size

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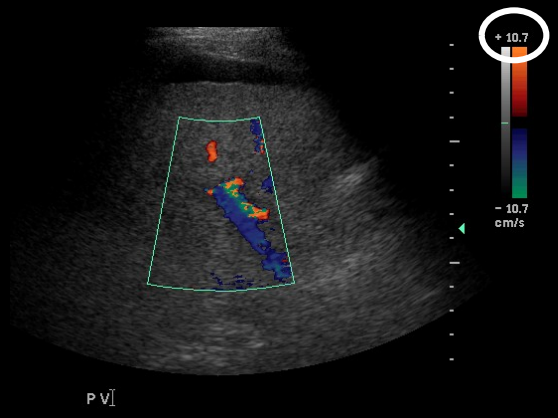
Rest of the Story

Portal Vein Hypertension

Color Velocity Scale

- Decreased to 10.7 cm /sec
- Hepatic artery now aliasing
- Can see flow in portal vein
  - Which is reversed



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Color Velocity Scale

- 10 - 20 cm/sec for venous flow
- 20-30 cm/sec for arterial flow
- Decrease values for low cardiac output or slow flow states
- Increase values as needed for normal, increased cardiac output or elevated flow states

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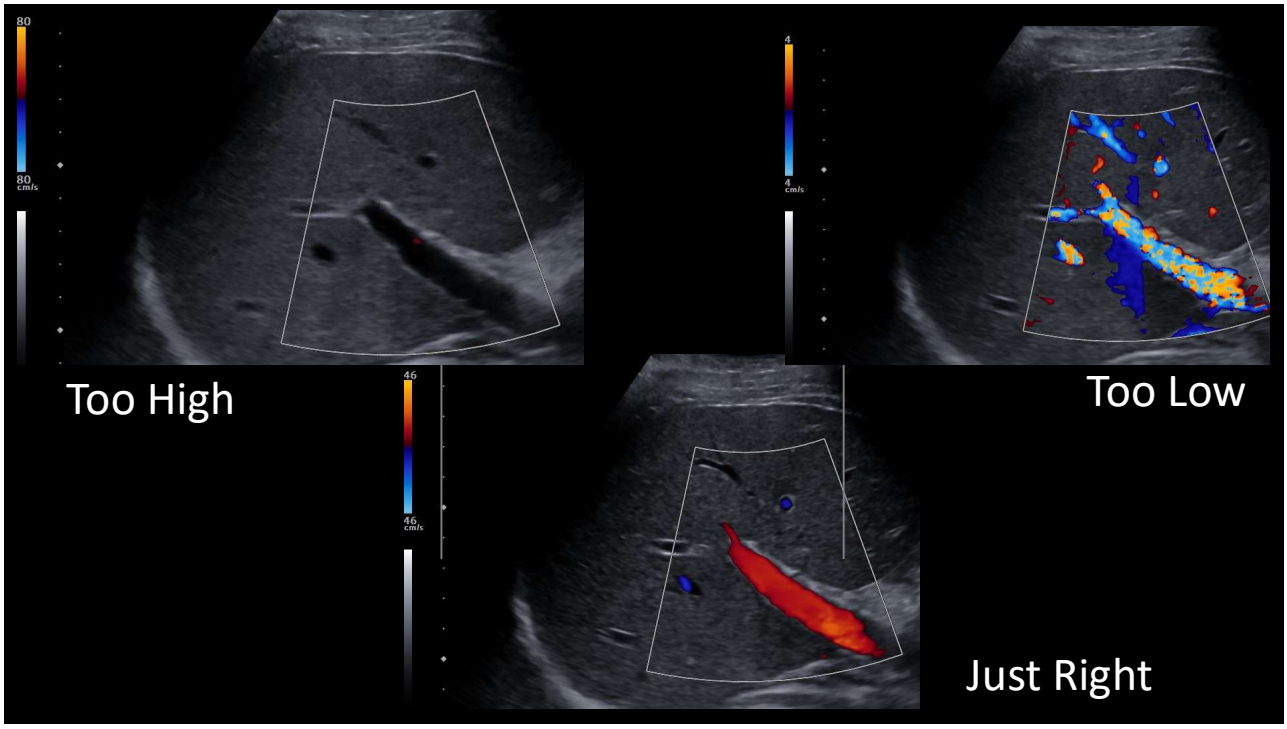

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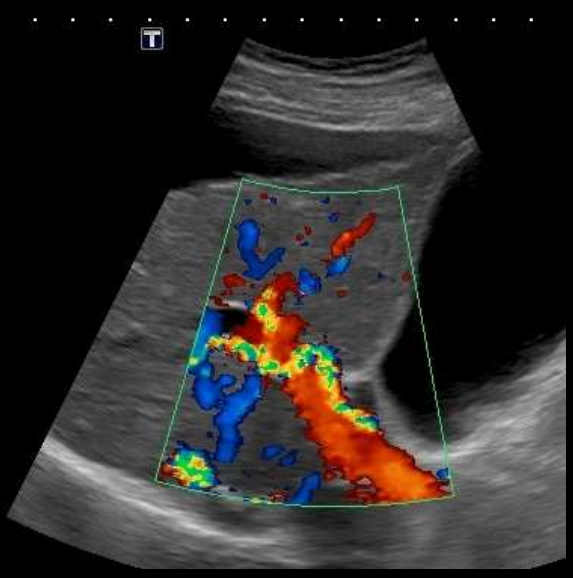
Corkscrew Hepatic Artery

Liver shrinks and portal blood flow is reduced causing hepatic arteries to increase in flow to compensate and become dilated and coiled



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Corkscrew Hepatic Artery

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Case 3

- History alcoholic cirrhosis
- Ascites
- GI bleeding
- Splenomegaly

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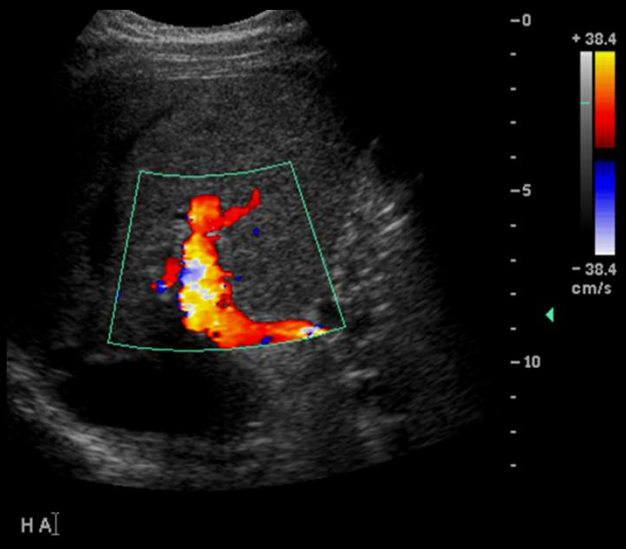
? Normal Portal Vein



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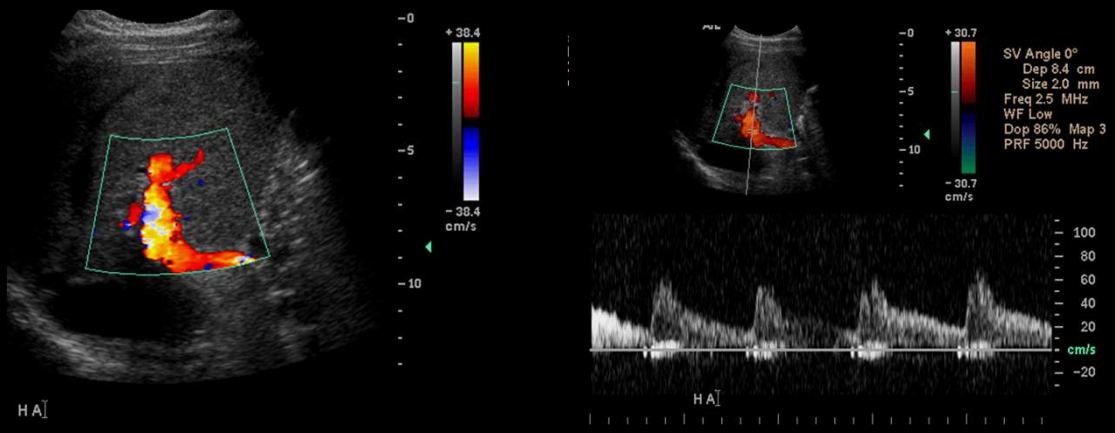
HA compensating for missing PV flow



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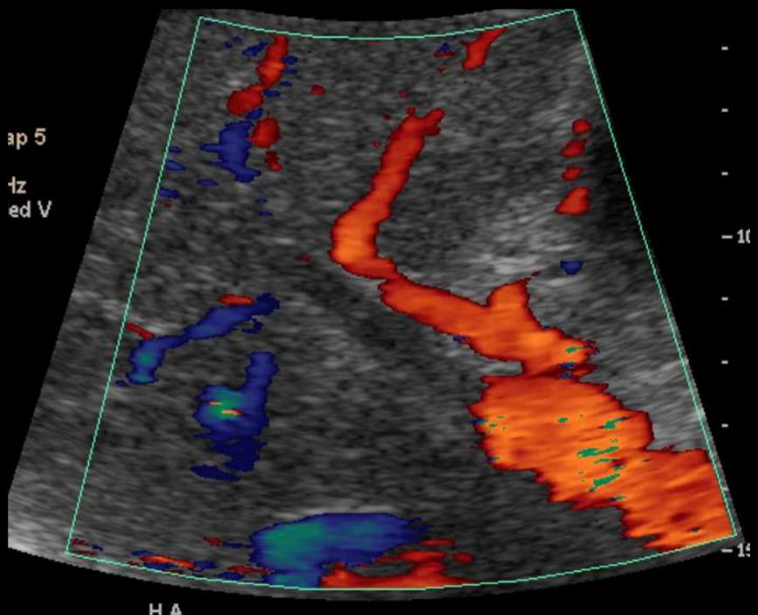
HA enlarging due to PVT as it increases its input



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Portal Vein Thrombosis

Cirrhosis
- Alcoholic most common
- Biliary

Tumor invasion
- Hepatocellular carcinoma (HCC)
- Metastatic

Intraperitoneal inflammation
- Pancreatitis
- Appendicitis

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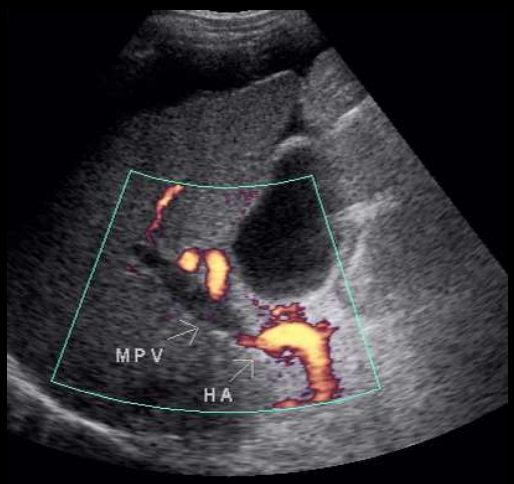
Sonographic Signs of Portal Vein Thrombosis

Acute stage
- Enlarged vein filled with echoes
- Lack of flow by color or power Doppler
- Corkscrew artery

Chronic stage
- Hepatic Artery enlarges
  - Look for two vessels with color Doppler
  - If only one seen, Doppler vessel to determine which one



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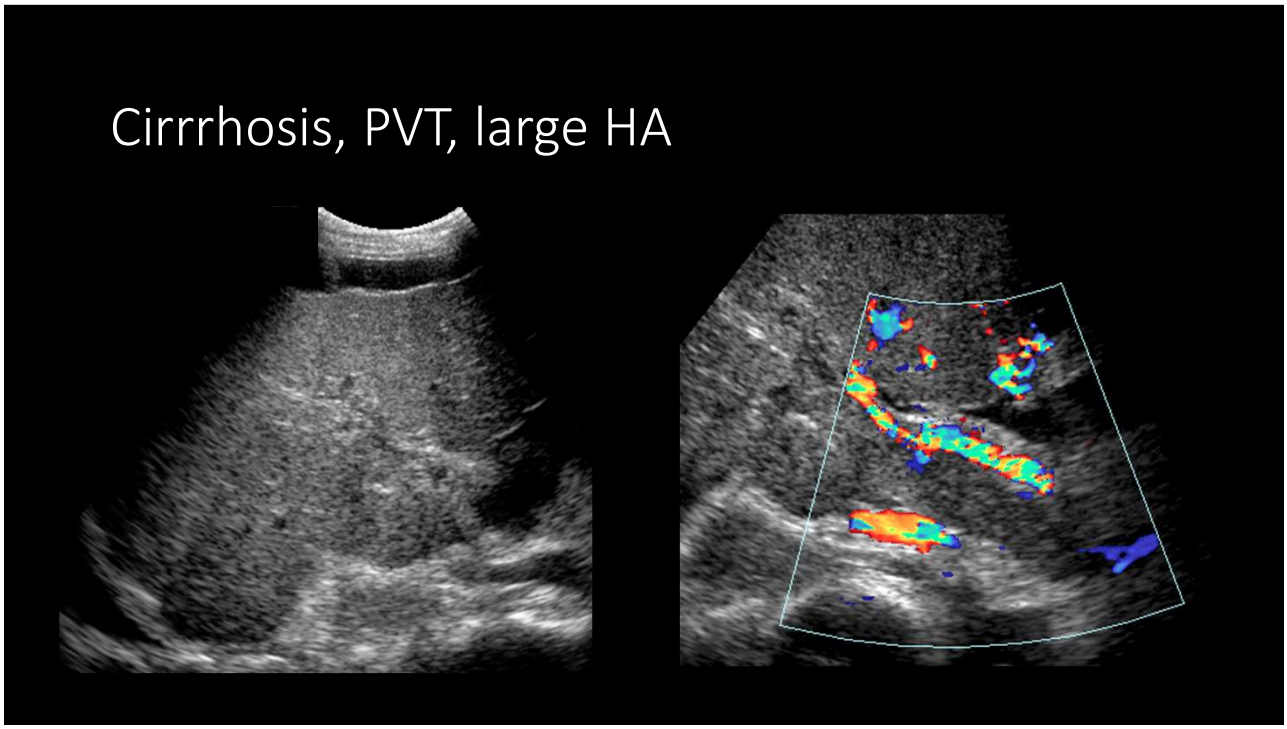

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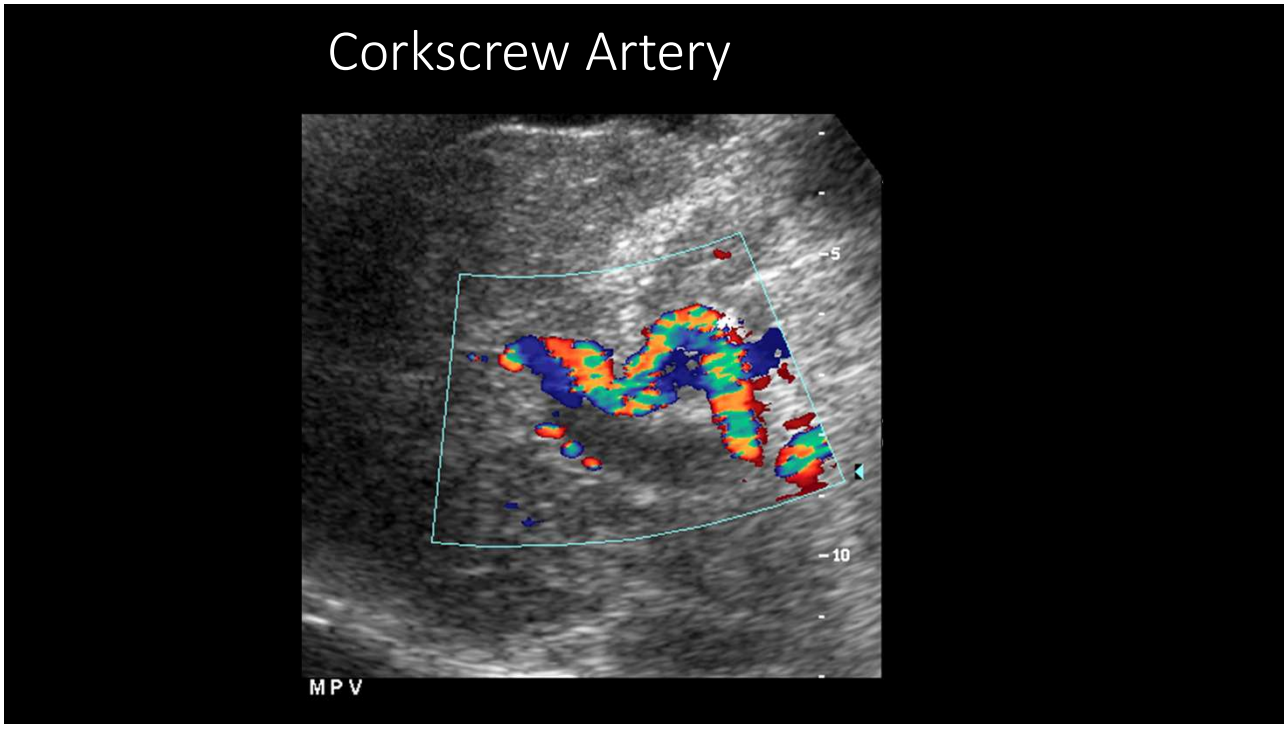

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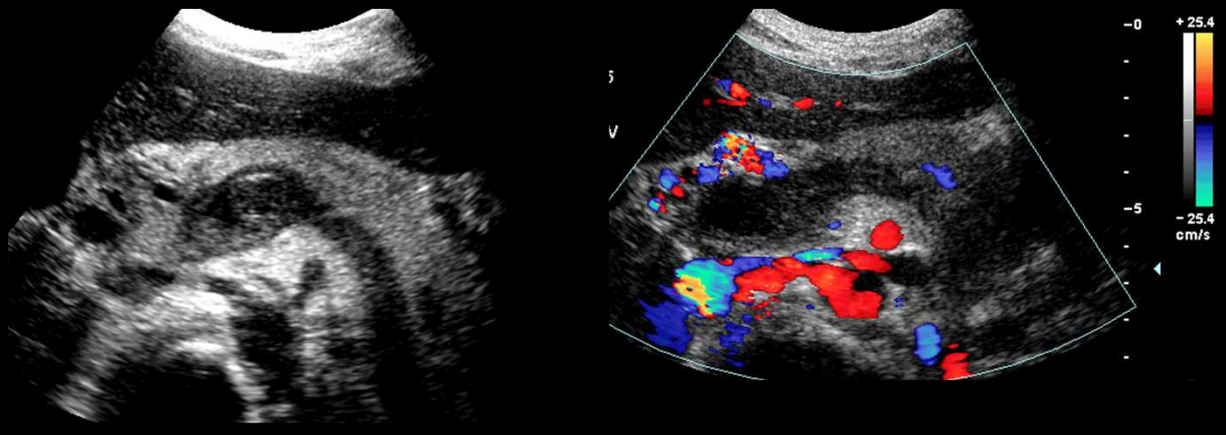
Check for Extension Into Splenic Vein



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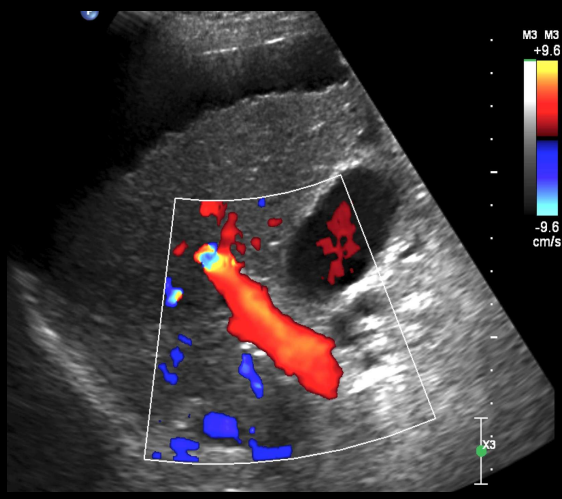
Incidental Finding: Why is there aliasing in the portal vein?

- CVS too low
- Color gain is too high
- Portal vein narrowing
- That's the patient's hemodynamics



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Incidental Finding:
Why is there aliasing in the portal vein?

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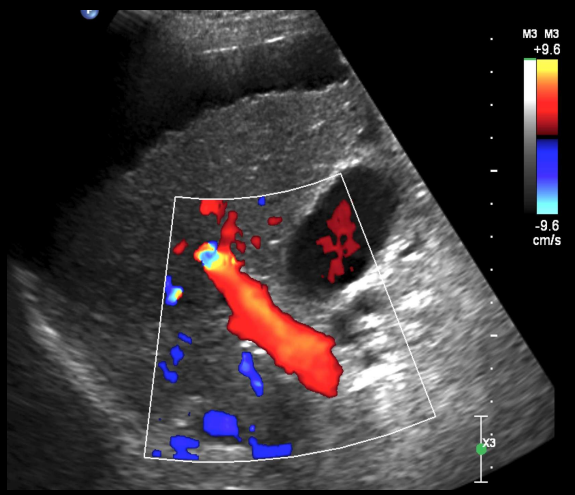
- Color gain is too high
- **Portal vein narrowing**
- That's the patient's hemodynamics



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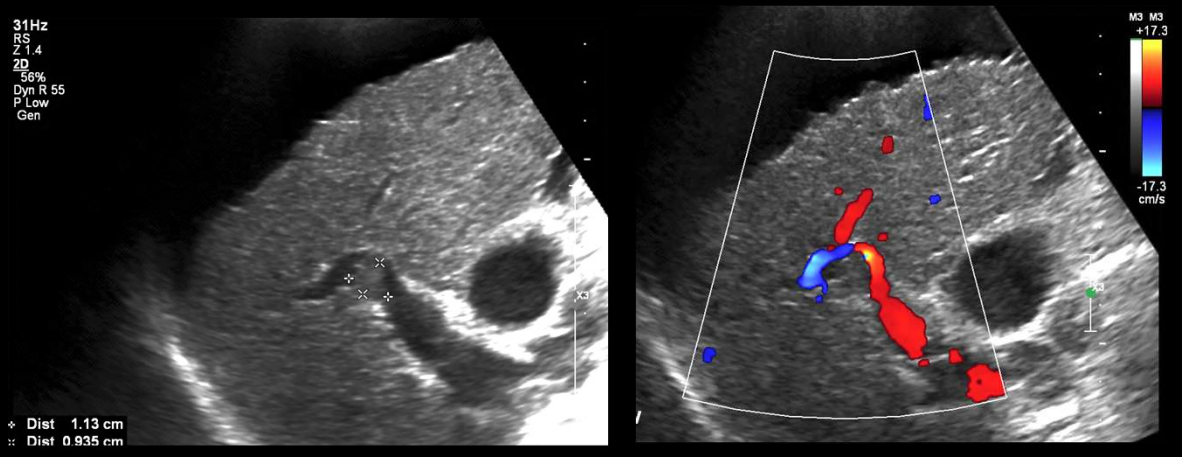
Narrowing due to clot causing a "stenosis".
Sometimes color Doppler can overwrite pathology.



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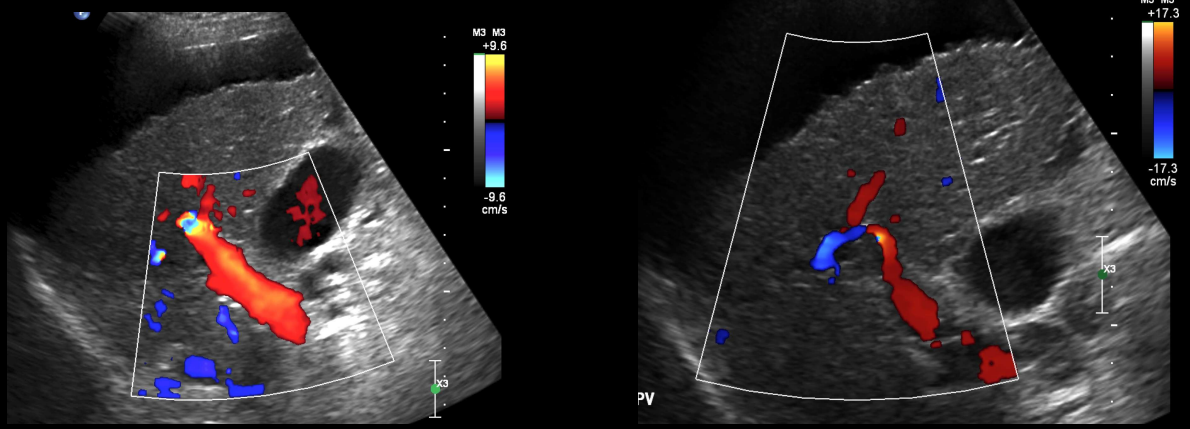
CVS increased from 9.6 - 17.3 cm/sec



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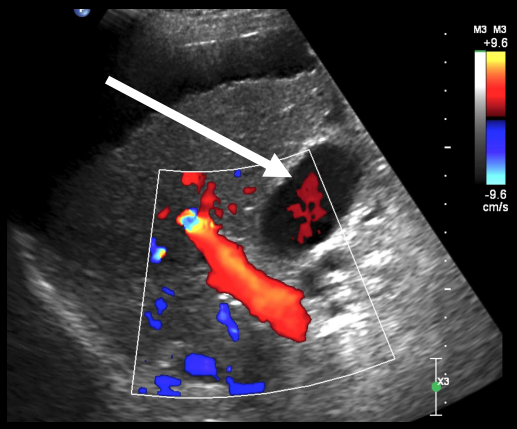
Why is there color inside the GB?



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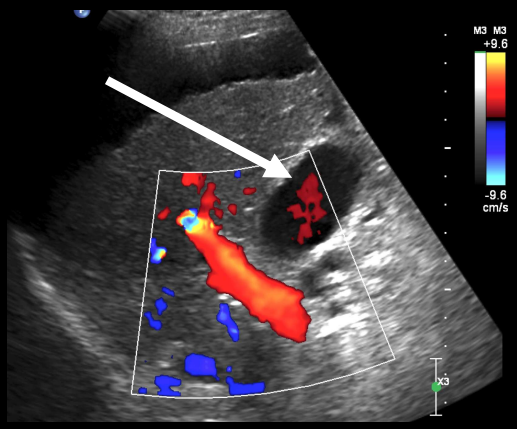
Sound waves interacting with bile/fluid causing motion. Notice it's dark red.



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Case 4

RUQ pain

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What's the finding?

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HCC
What to look at next?

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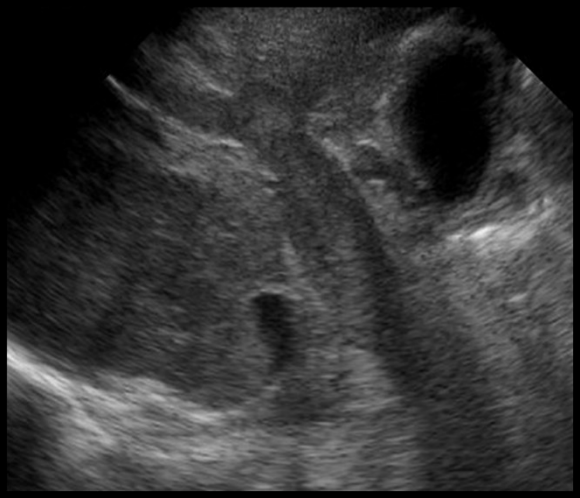
Portal Vein
Next step?



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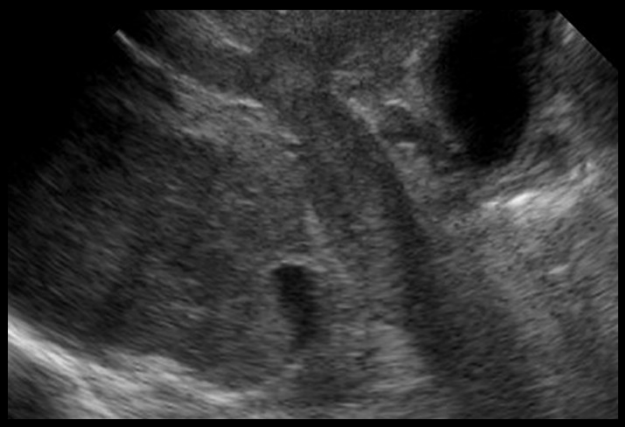
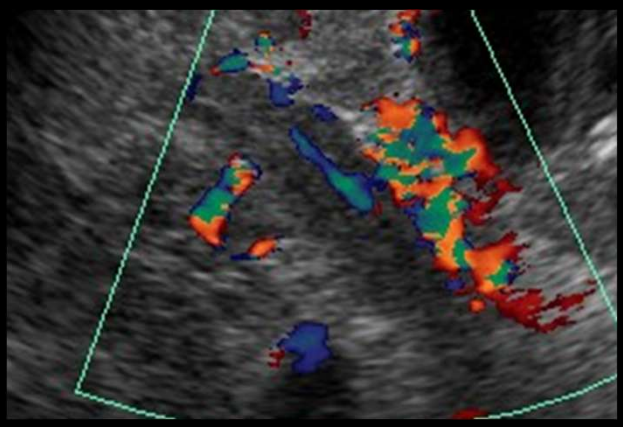
Color Doppler
Are we finished?





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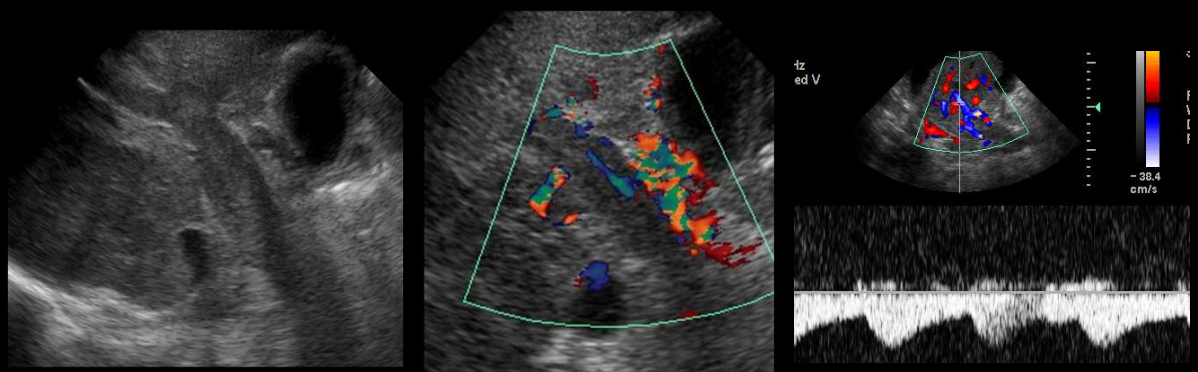
Spectral Doppler Waveform



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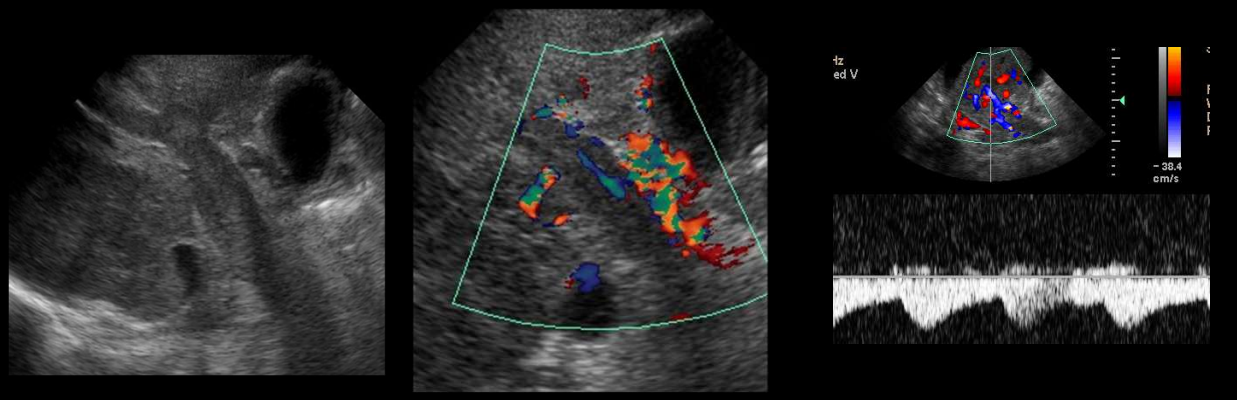
HCC Invading Portal Vein

- Portal vein is involved in 30% to 60%
- Destroys the portal venous walls
- Invades the lumen of the vessel



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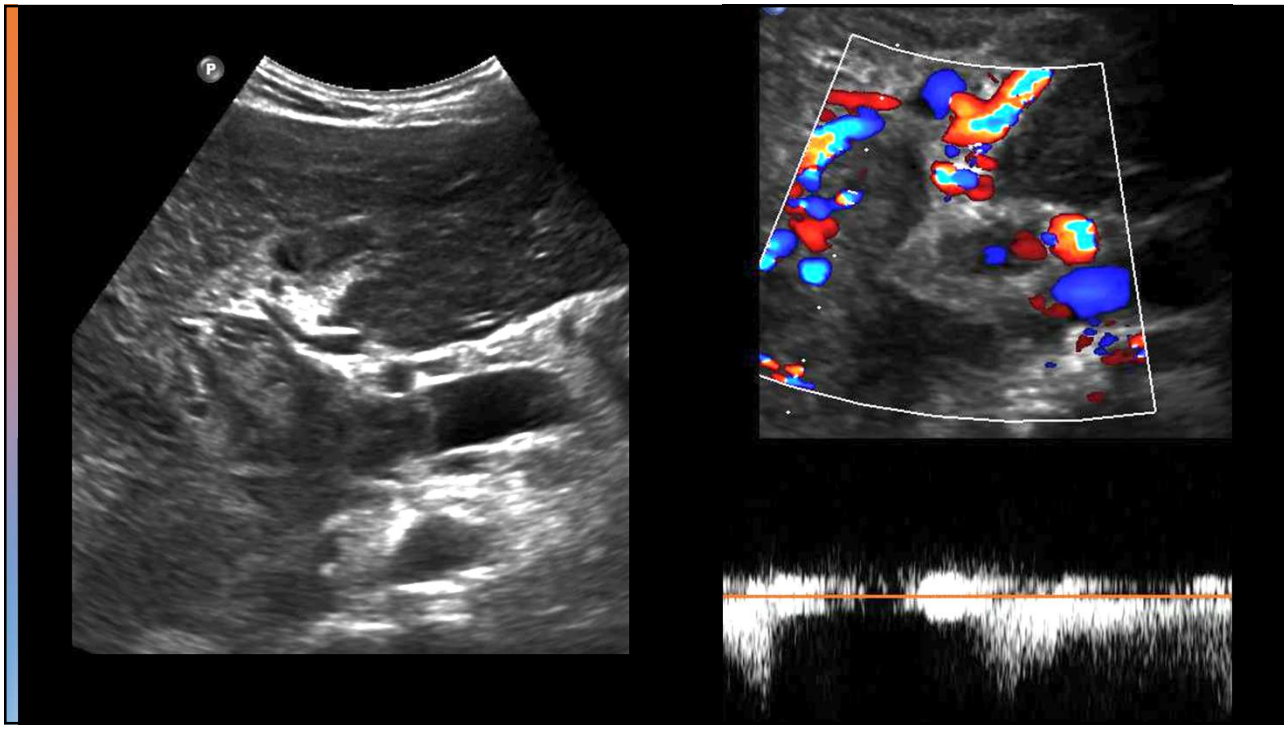

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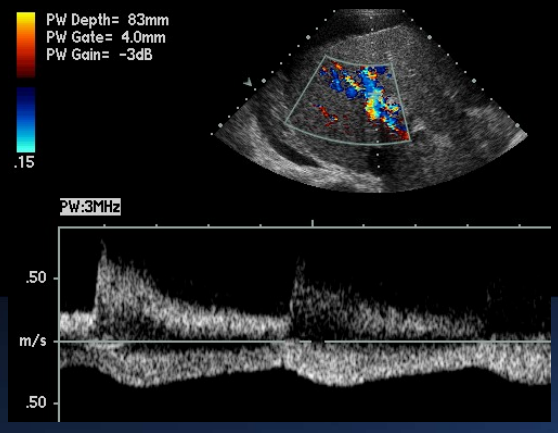
Case 5

What needs to be evaluated with this finding?



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Portal Hypertension

- This pressure gradient is normally ≤ 5 mmHg
- Pressure gradient > 6 mmHg portal hypertension
  - Portal flow reverses and flows away from the liver
- Pressure gradient > 10 mmHg portal hypertension becomes clinically significant
  - Esophageal varices >10 mmHg
- Variceal rupture may occur at a gradient >12 mmHg

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Main causes

Alcoholic cirrhosis	Schistosomiasis
• Western countries • Portal hypertension >90% of patients with cirrhosis	• Other parts of world

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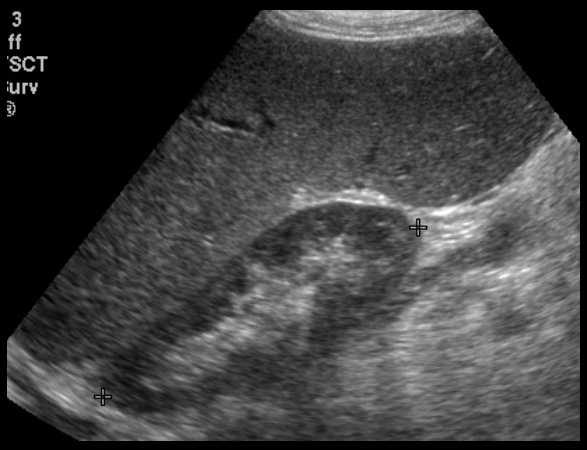
Clinical Signs

- Ascites
- Splenomegaly
- GI bleeding
- Jaundice
- Encephalopathy
- Hematemesis
- Palmar erythema
  - Result of abnormal serum estradiol levels
- Caput medusae
  - Tortuous collateral veins around the umbilicus



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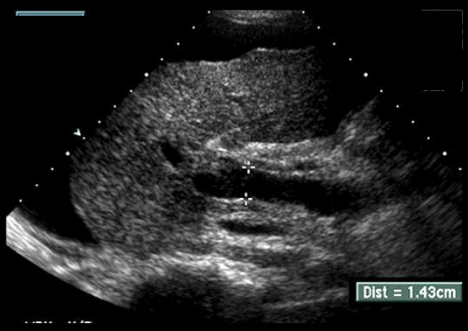
Ultrasound Findings

- > 13 mm
  - Measure where PV crosses IVC or at the hilum
- Hepatofugal flow in portal vein
- Hepatopetal flow in hepatic artery
- Decreased flow splenic vein



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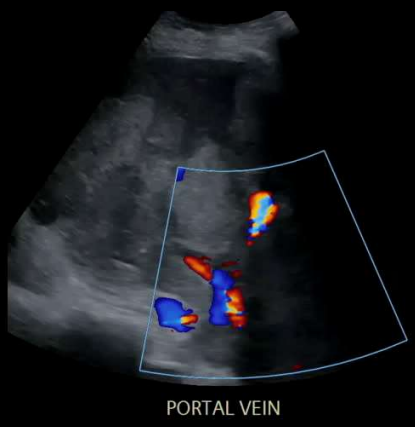
Portal Hypertension and Its Effects on the Body

- Splenomegaly
- Splenic Vein Flow Direction
- Recanalized umbilical vein
- Abdominal collaterals
- Varices
- Spleno-renal shunt



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Portal Hypertension

Portal hypertension has significant morbidity and mortality rates

Variceal hemorrhage is the most serious complication

- Occurs when portal pressures rise >12 mmHg
- Rupture of varices
  - GI bleed
    - Can be fatal

Gastric Varices

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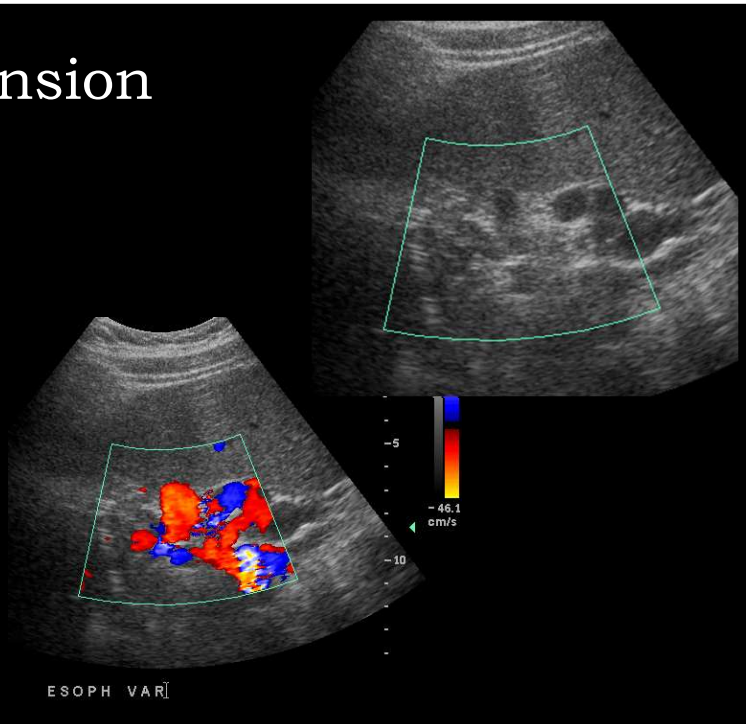
Portal Hypertension

Gastroesophageal variceal hemorrhage most serious and lethal complication

- 30 - 60% mortality rate with each episode
- 70% chance of bleeding again
  - 30% chance of death



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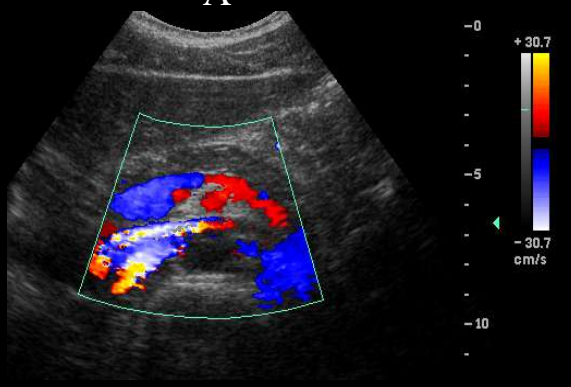
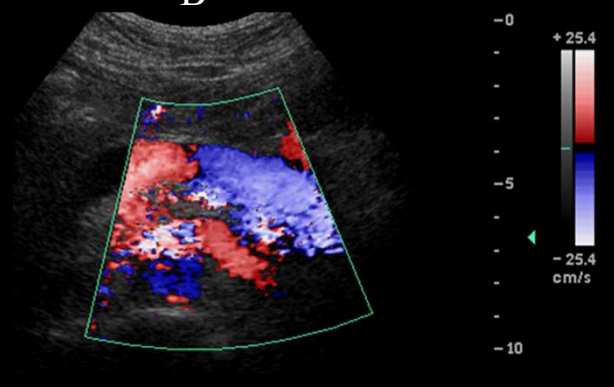
Which Image Demonstrates Normal Flow in Splenic Vein?

A



B



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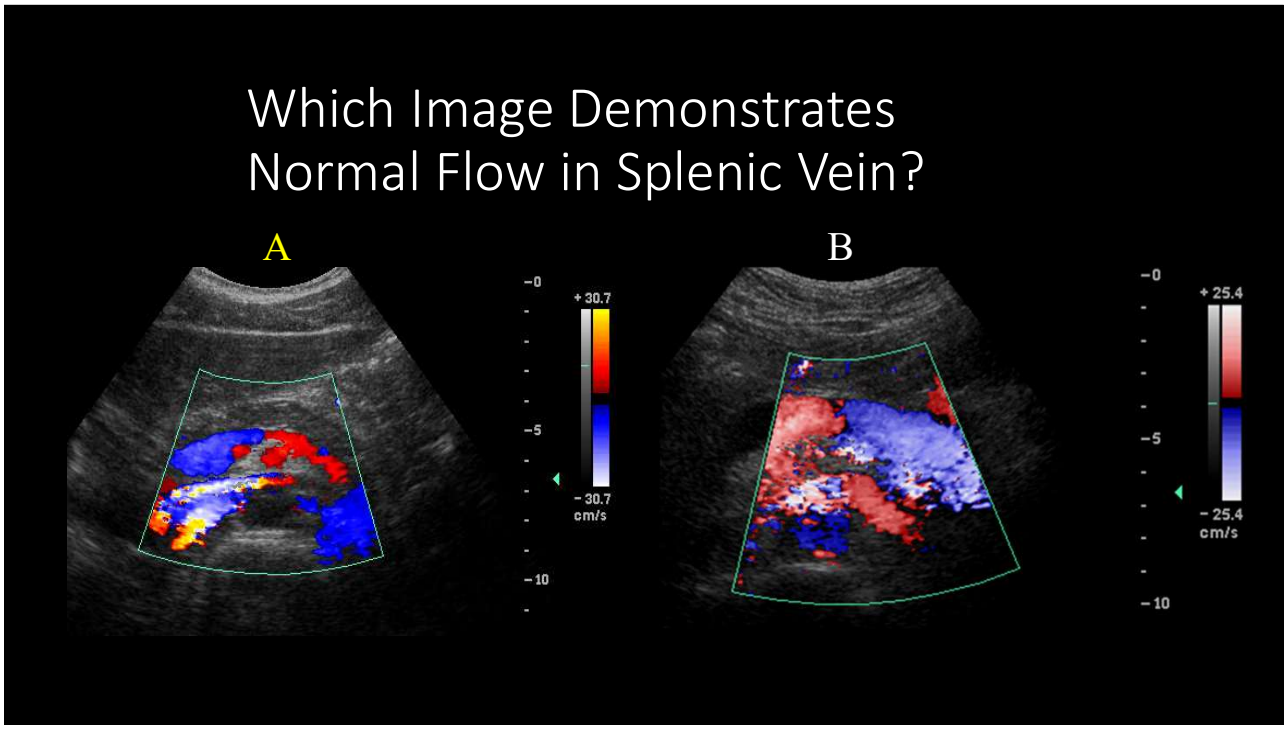

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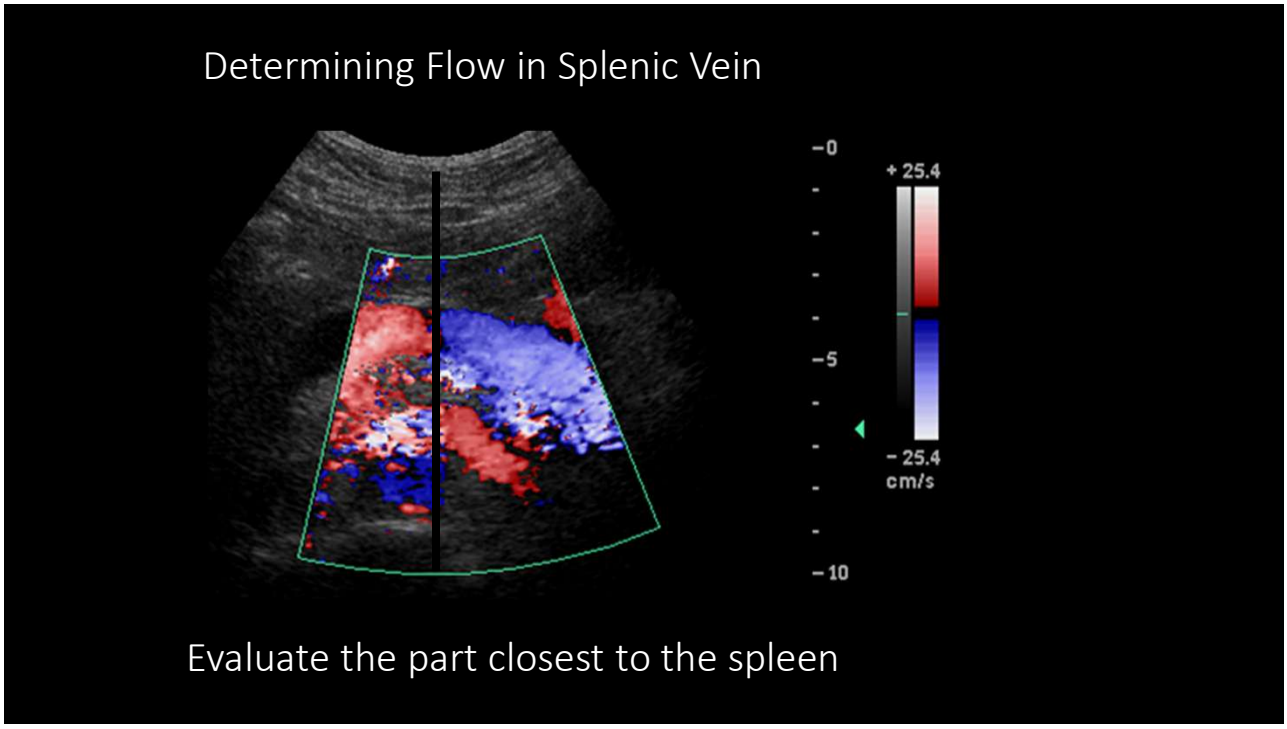

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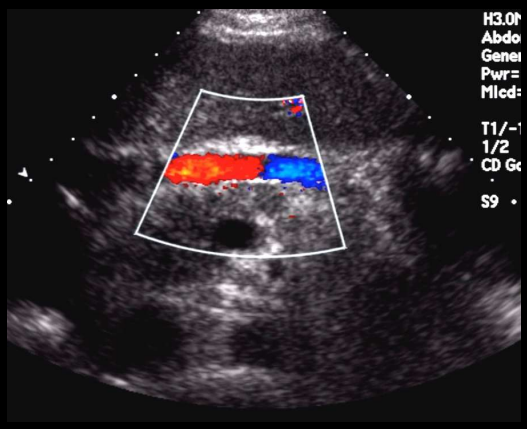
What's your Diagnosis?

- Normal flow in the splenic vein
- Reversed flow in the splenic vein
- Reversed flow in the portal vein
- Collateral flow



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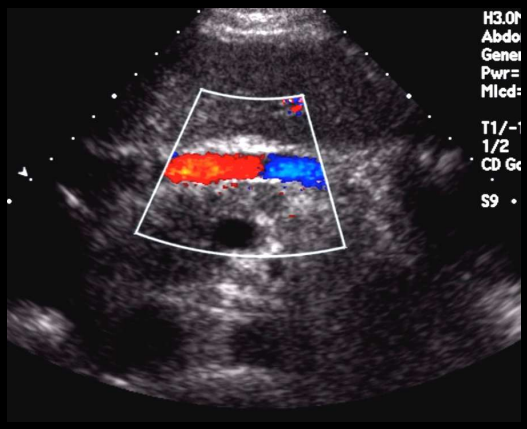

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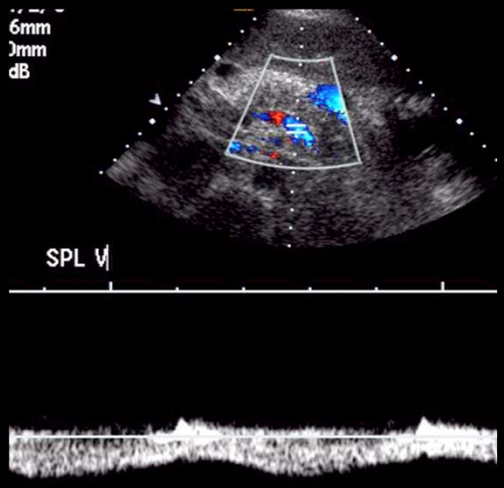
Collateral flow

- This vessel is superior to the pancreas
- The portal confluence is seen posterior to this vessel
- Small splenic vein with reversed flow



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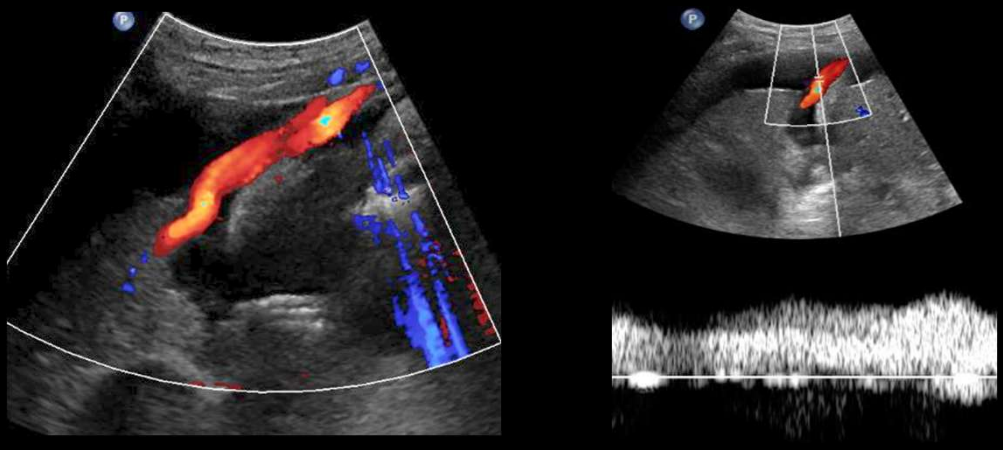

Recanalized Umbilical Vein

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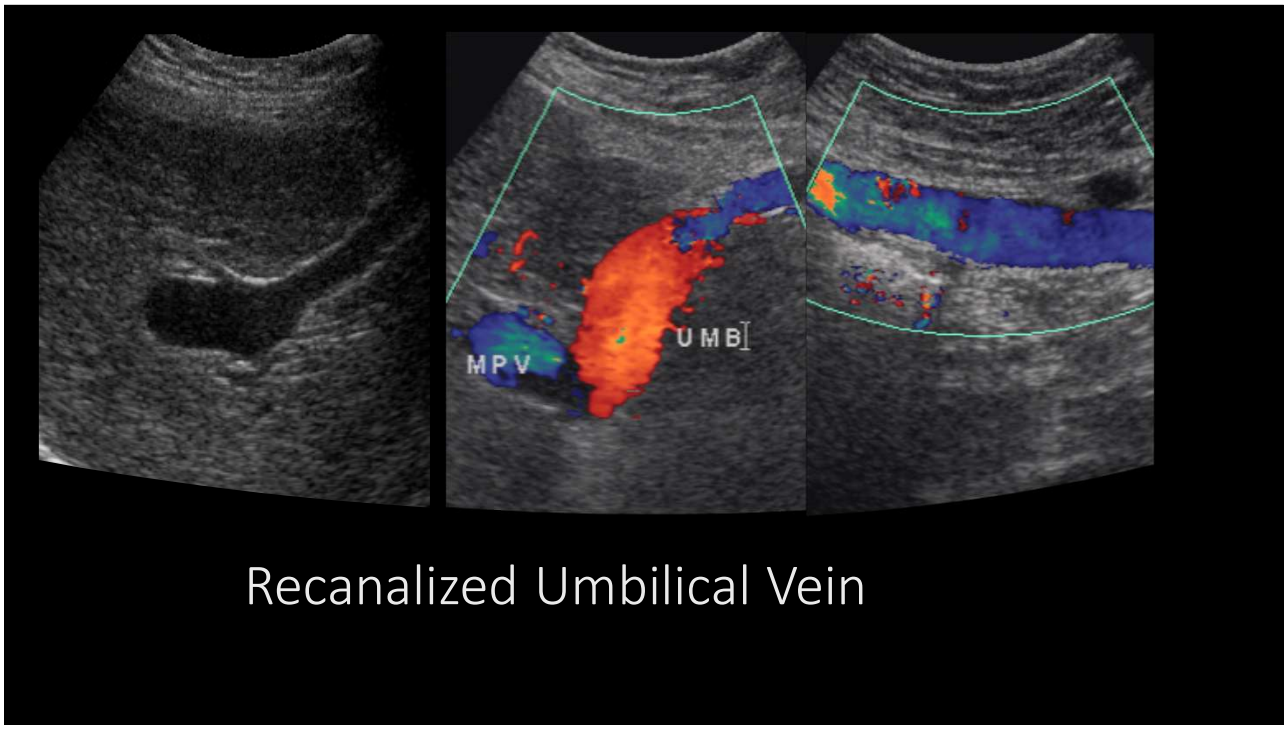

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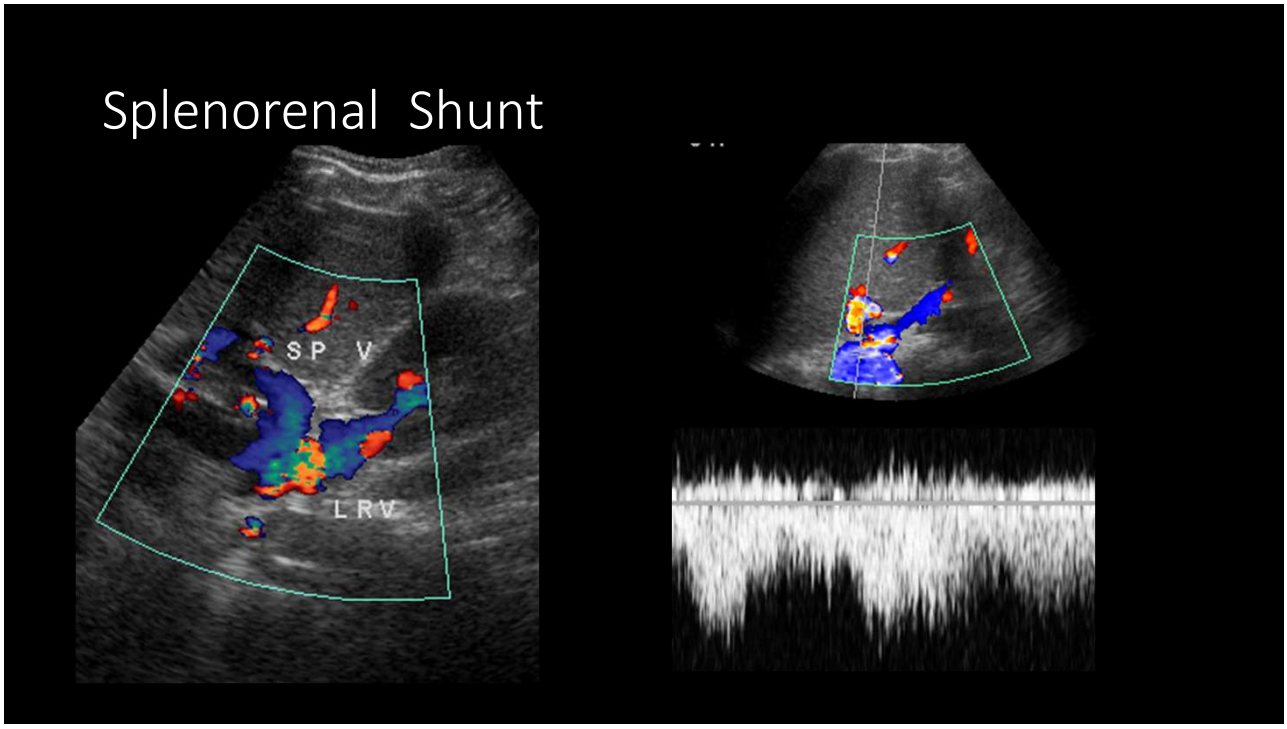

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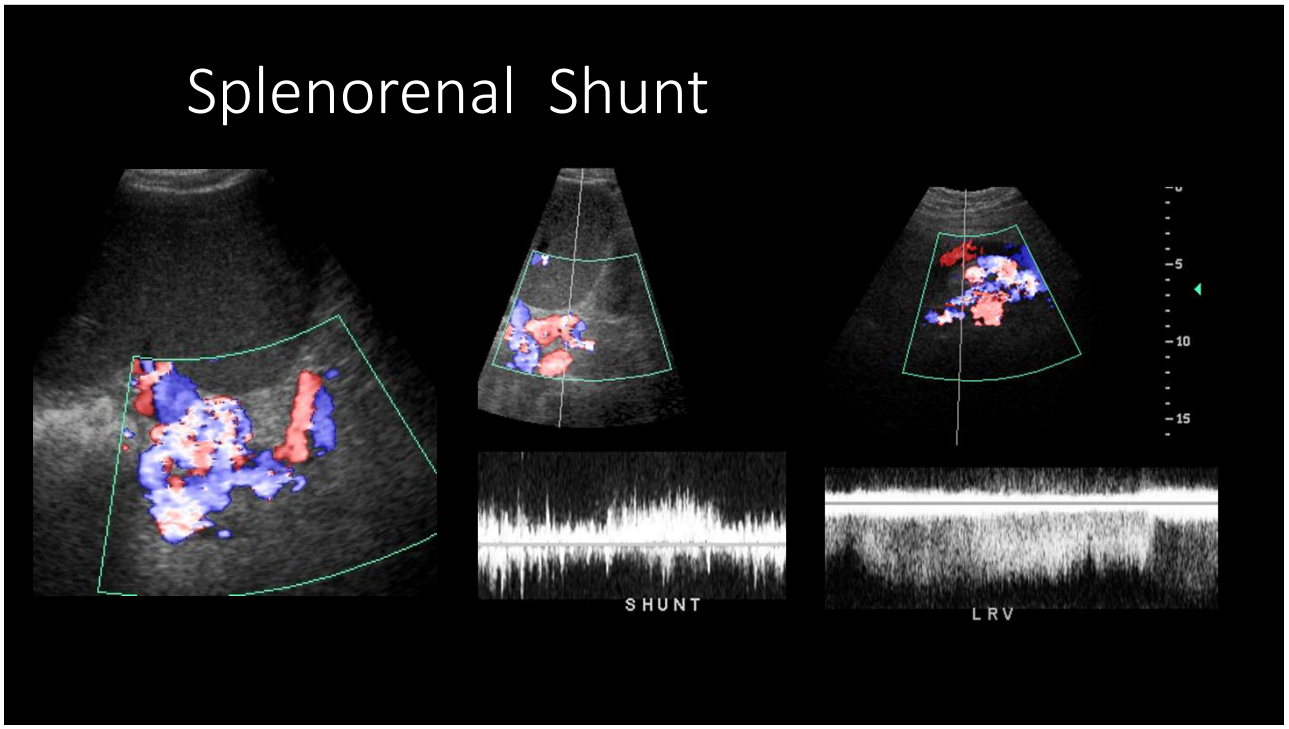

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Case 6

- Elevated Alk Phos and GGT

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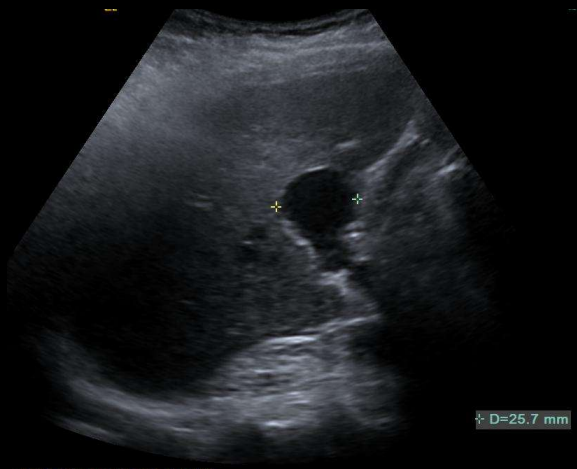
Next Step?



Images courtesy of Ted Whitten

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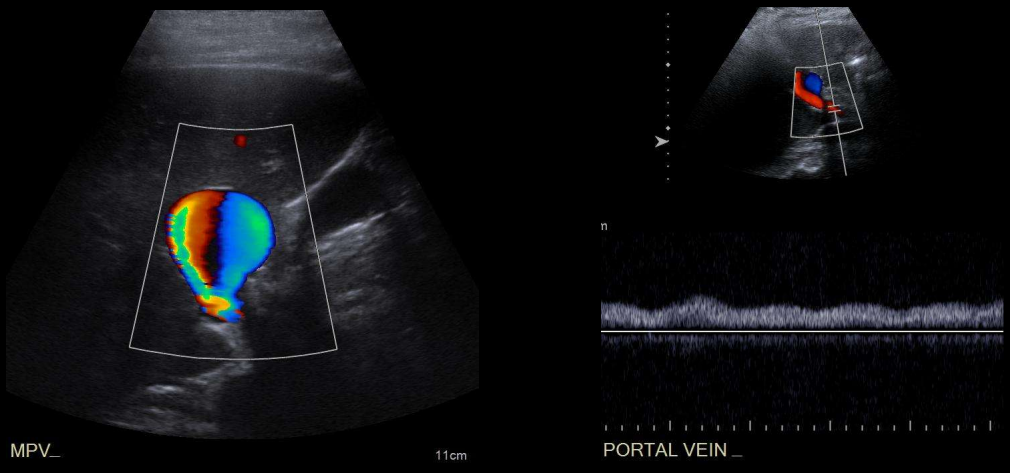
Portal Vein Aneurysm



Images courtesy of Ted Whitten

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Portal Vein Aneurysm Causes

- Portal Hypertension
  - Most common cause from liver cirrhosis
- Pancreatitis:
  - Severe inflammation
- Trauma
  - Injury to the portal vein from an external force or surgery

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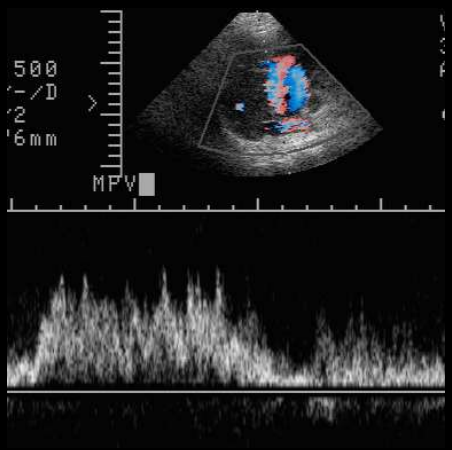
Portal Vein Aneurysm



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Case 7: What finding is seen?

Images courtesy of Ted Whitten

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Case 7 – Portal Vein Gass

- Echogenic mobile foci in lumen of portal vein
- Doppler waveform demonstrates sharp spikes

Images courtesy of Ted Whitten

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Portal Venous Gas Causes

Pediatrics

- Umbilical vein catheterization
- Necrotizing enterocolitis (NEC)
- Neonatal gastroenteritis
- Postoperative corrective bowel surgery

Adult

- Ischemic bowel)
- Necrotic/ulcerated colorectal carcinoma
- Inflammatory bowel disease (IBD)
- Perforated peptic ulcer

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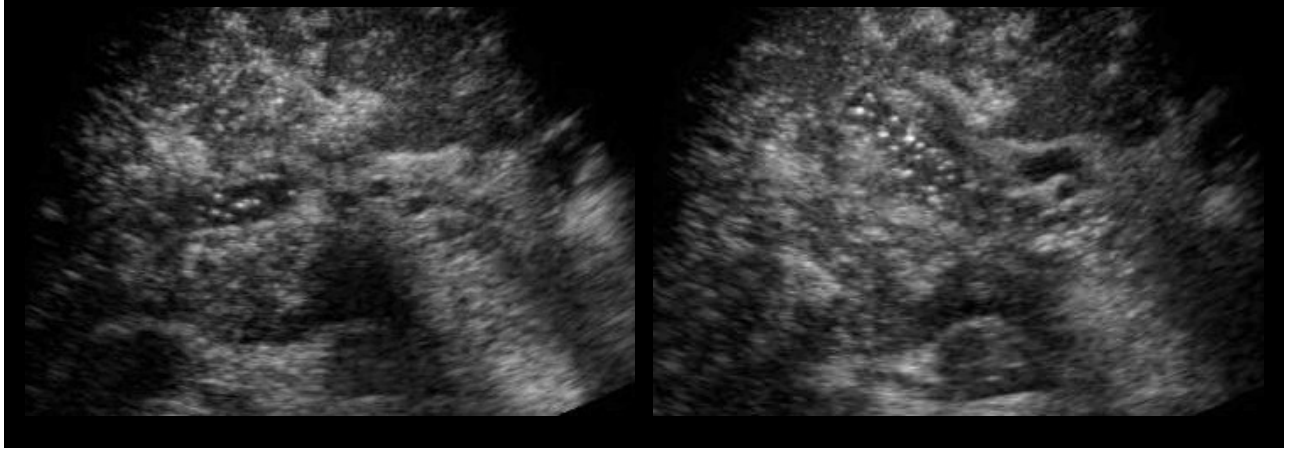
Portal Venous Gas Causes

Serious sign associated with high mortality rates, especially when linked to mesenteric ischemia



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Pneumobilia

- Presence of gas within biliary system
- Causes
  - Biliary surgery or endoscopic procedures (e.g., ERCP)
  - Incompetent sphincter of Oddi
  - Spontaneous biliary-enteric fistula, which can occur from gallstone ileus
  - Infections caused by gas-forming bacteria, such as emphysematous cholangitis

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Pneumobilia

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Measuring Resistive Index Correctly

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Renal Resistive Index - RI

- PSV– EDV/PSV
- Renal vascular resistance
- Sensitive however non- specific
- Normal : 0.6- 0.7
- > 0.7 abnormal

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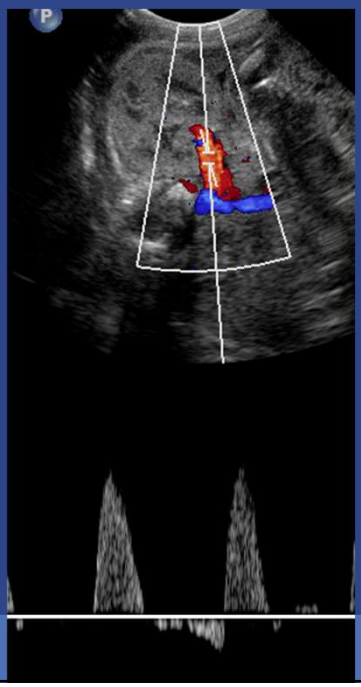
Elevated Resistive Index- Nonspecific

- Kidney disease
- Hydronephrosis
- Renal vein thrombosis
- Perinephric Collections



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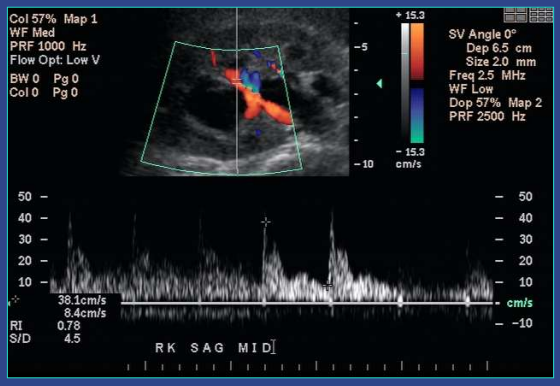
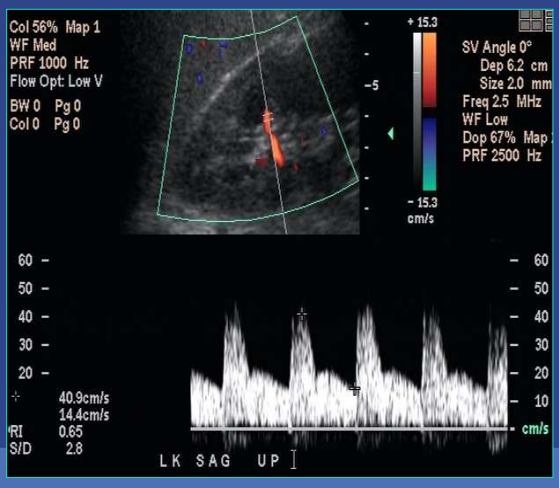
Elevated RI - Hydronephrosis

Obstructed kidney RI- 0.78



Normal kidney RI – 0.65



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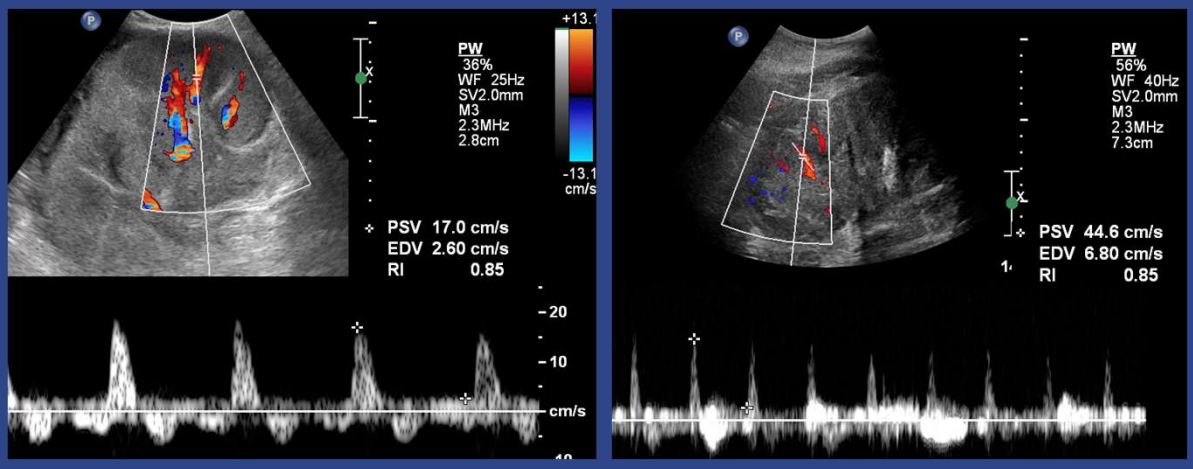
What's wrong with these images?



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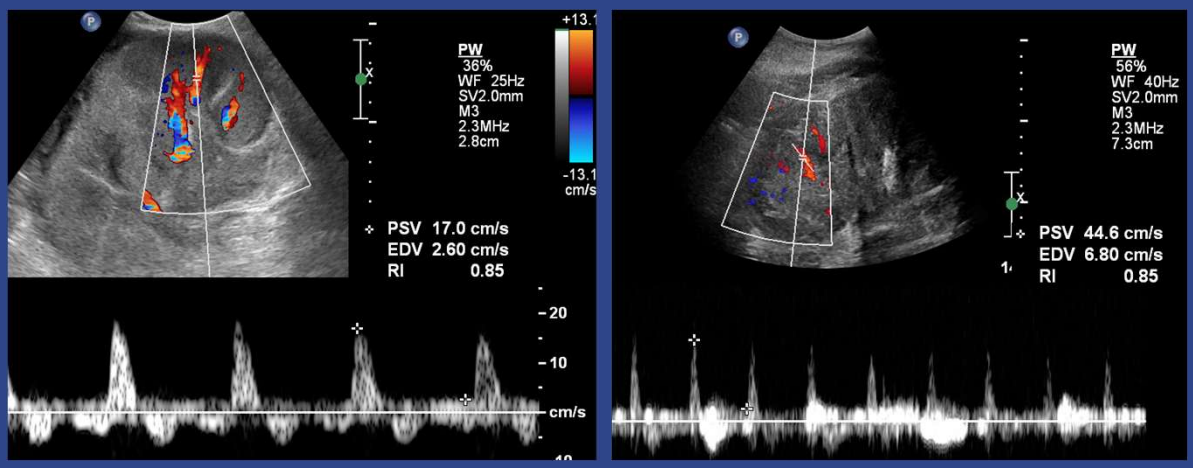
Diastole measured incorrectly



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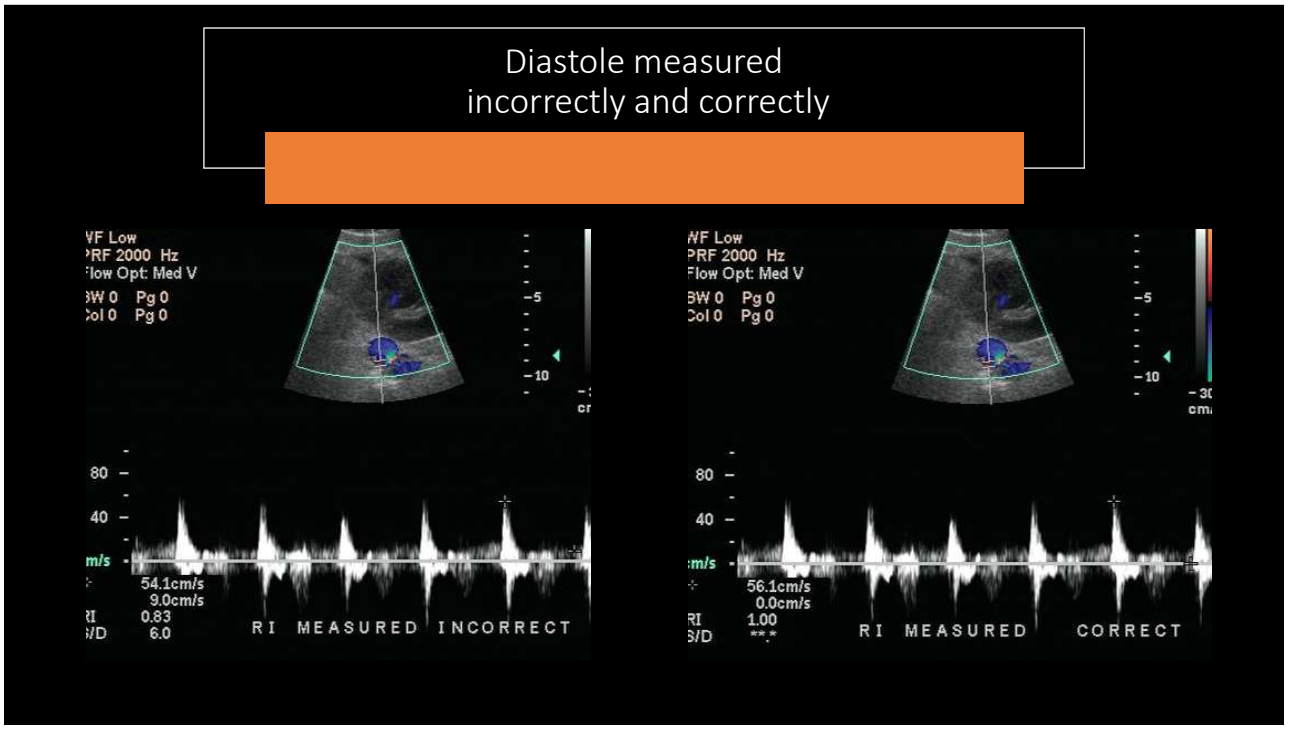

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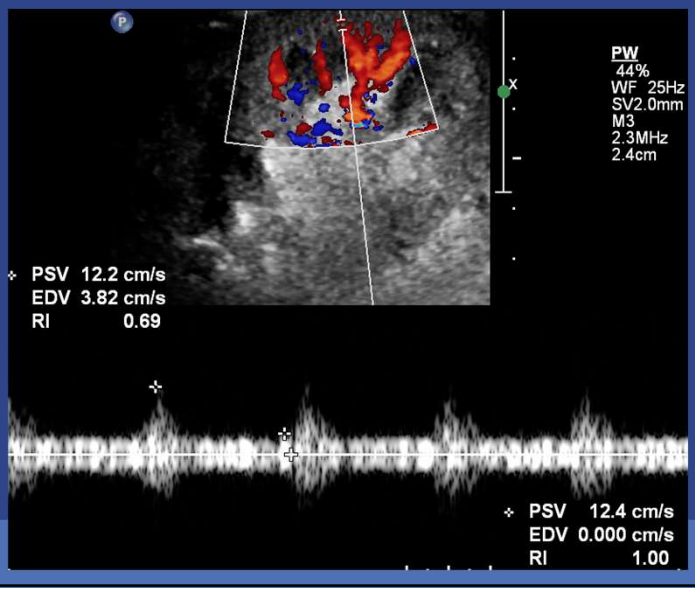
Wrong and Correct

0.69 is normal value



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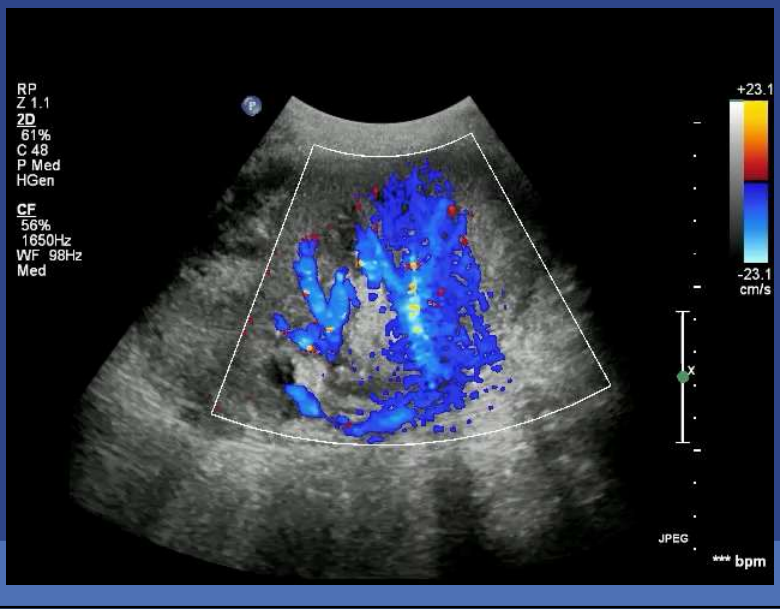
High RI of 1.0



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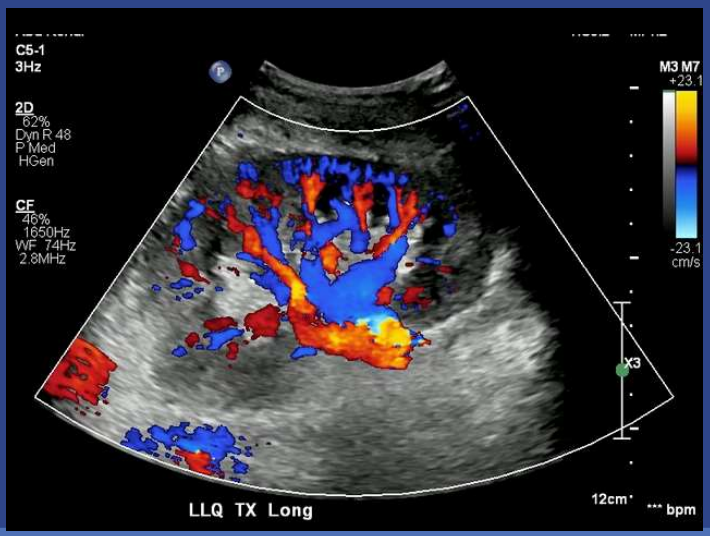
Normal RI



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RI

Provides information about resistance to blood flow within intrarenal arteries

- Reflects both local kidney issues and systemic vascular conditions.

Normal typically between 0.5–0.7

Elevated RRI (e.g., ≥ 0.8) suggests increased resistance

- Arterial stiffness
- Pathological processes that reduce blood flow

Weerakkody Y, Carroll D, Alsmair A, et al. Renal arterial resistive index. Reference article, Radiopaedia.org (Accessed on 17 Aug 2025) https://doi.org/10.53347/rID-8643

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Elevated RI

Non-invasive indicator of increased intrarenal vascular resistance

Cannot differentiate between various causes of intrinsic renal disease.

Associated with increased risk of transplant loss

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Elevated RI in Chronic Kidney Disease (CKD)

- **S**uggests increased intrarenal vascular resistance and reduced vascular compliance
- **A**ssociated with a higher risk of CKD progression
- **P**atients with CKD and hypertension associated with increased mortality, independent of other risk factors
- Tends to be higher in diabetic kidney disease and increases with the severity of the disease

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Reasons for Elevated Values

- Medical renal disease
- Acute Tubular Necrosis (ATN)
- Tubulointerstitial disease
- Ureteric obstruction
- Extreme hypotension
- Perinephric fluid collection
- Transplant rejection

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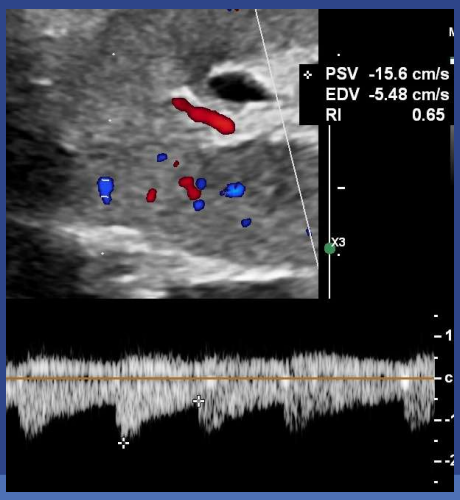
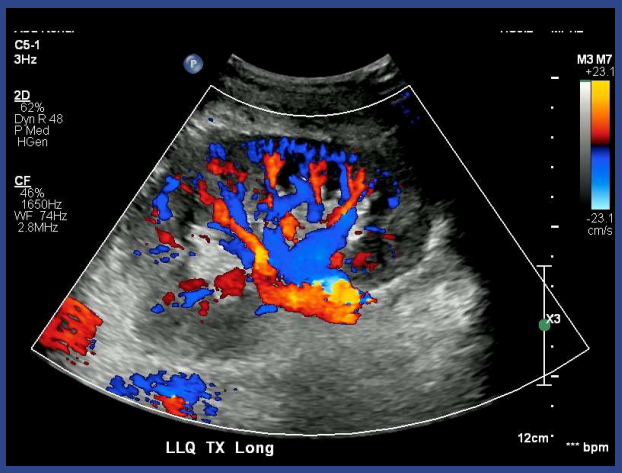
Normal RI





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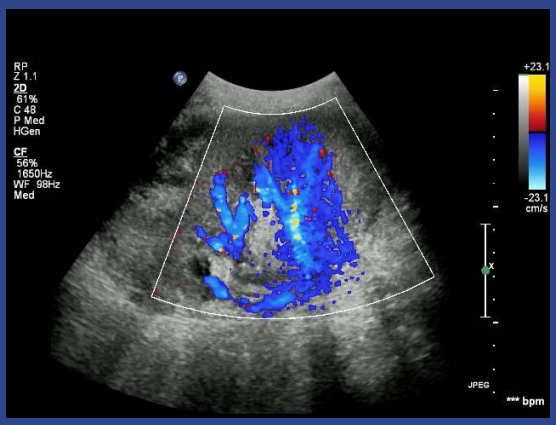
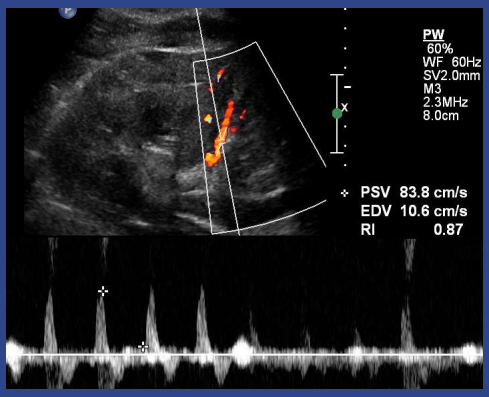
RI of 1





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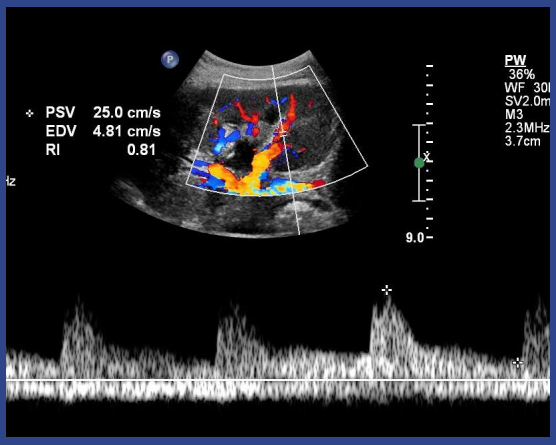
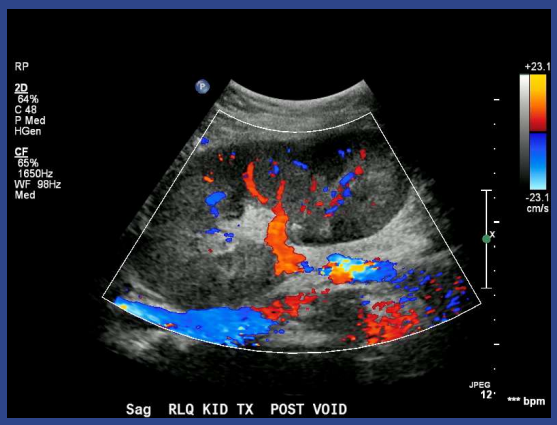
RI > 8





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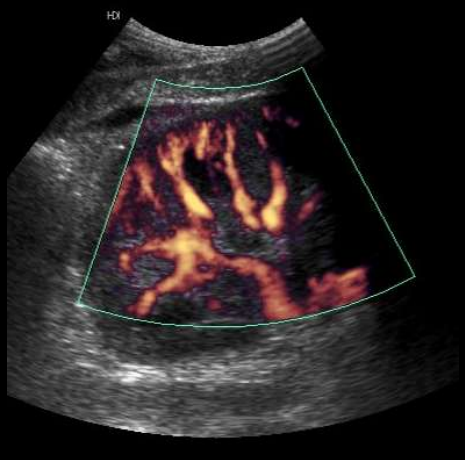
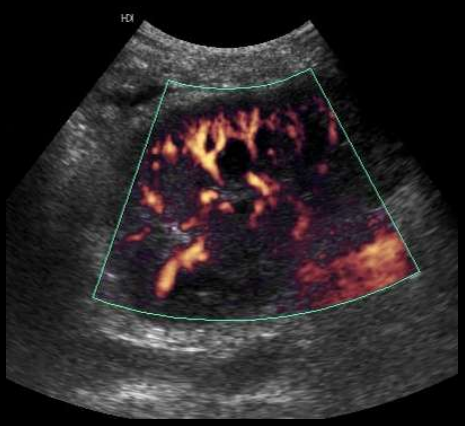
Power Doppler: Look at flow to cortex





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Last Case: What does this finding indicate?

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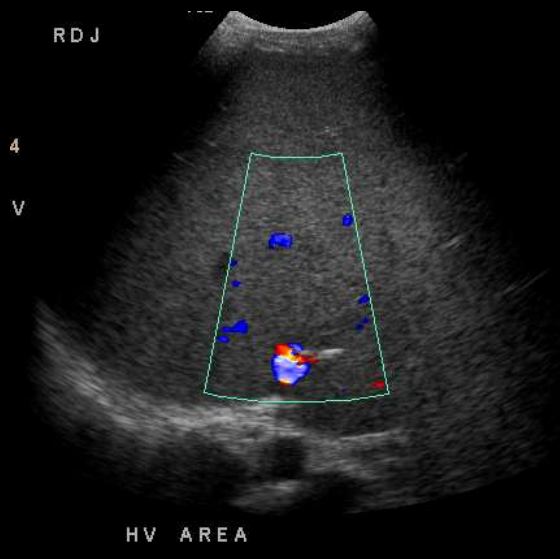
Hepatic Vein Thrombosis

Budd-Chiari Syndrome

- Named after George Budd, a British physician, and Hans Chiari, an Austrian pathologist

Clinical symptoms

- Vomiting
- Jaundice
- Hepatomegaly
- Abdominal pain
- Abrupt development of ascites
- Hepatocellular dysfunction
- Increased LFTs



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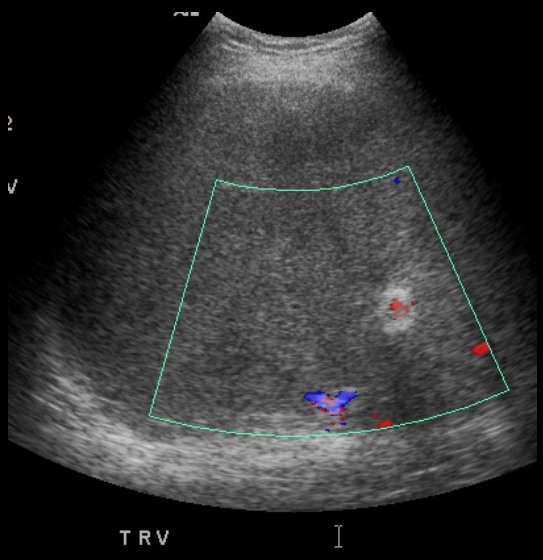
Causes

- Unknown
  - Majority
- Polycythemia vera
  - Common
- Pregnancy
- Postpartum state
- Use of oral contraceptives
- Paroxysmal nocturnal hemoglobinuria
- Hepatocellular carcinoma
- Lupus anticoagulants



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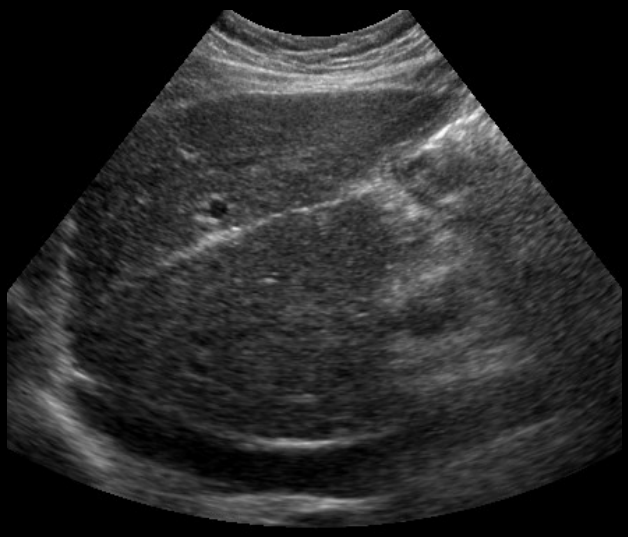
Sonographic Signs

- Non-visualization of one or more hepatic veins
- IVC obstructed or occluded cephalad to hepatic veins
- Enlarged caudate lobe
  - Volume overload
- Portal vein flow sluggish or reversed due to outflow obstruction



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Thank You

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