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Doc, My Belly Hurts!: Options for Abdominal Imaging

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SDMS ANNUAL CONFERENCE DENVER, CO

09/18/2025

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Objectives of this Presentation

- Provide an overview of the common arterial abdominal exams performed in the vascular lab.
- Discuss the indications, purpose, symptoms, protocols, and disease processes of these studies.
- Discuss limitations to these exams (body habitus, bowel gas, etc) and provide tips and tricks to how to overcome these limitations.

3

When to order a renal artery duplex?

4

Purpose of renal artery exam

- To assess the patency of the renal arteries and to identify the presence of hemodynamically significant stenosis. Arteries are evaluated for atherosclerotic disease and also for fibromuscular dysplasia. Renal size and bloodflow into the renal segments are also evaluated.

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Indications for renal artery disease

- New onset of hypertension
- Hypertension not responding to medical management
- Follow up after revascularization (renal bypass, angioplasty, or stenting)
- Increase in BUN, creatinine
- Renal failure
- Pulmonary edema, CHF in some patients
- Small kidneys
- Suspected renal fibromuscular dysplasia
- Evaluation of abdominal bruit

6

Limitations for renal artery duplex

- Excessive bowel gas
- Recent abdominal surgery (limits acoustic windows)
- Shortness of breath, rapid breathing, inability to suspend respiration (difficult to obtain accurate Doppler recordings)
- Patient not NPO
- Body habitus (obesity)

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Protocol - Doppler

- Aorta: At the level of the renal arteries
- Right and left renal arteries: Origin, proximal, mid, and distal vessel
- Parenchyma: One each from upper, mid, and lower pole with both RI & AT documented
- Right and left renal veins: one image
- Grafts: Proximal, mid, distal and anastomotic sites as well as inflow and outflow vessels
- Stent: Proximal, mid, distal include inflow and outflow of stent

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Protocol - Grayscale

- Aorta at level of the renal arteries
  - Used to calculate RAR
- Renal artery origin and hilum bilaterally
- Kidney: 3 longitudinal measurements (record largest on report)
- Any abnormalities of kidney (such as hydronephrosis, masses, or cysts) should be adequately imaged and described on the written report
- Bypass grafts or stents

9

Protocol – Color and color power angio

- Bilateral renal artery – origin and hilum
- Stent or bypass graft
- Stenosis at mid or distal to aid in diagnosing FMD

10

Calculating the Renal/Aortic Ratio (RAR)

Renal/Aortic Ratio (RAR) = PSV renal artery/PSV aorta

Criteria for normal vs abnormal is RAR of 3.5

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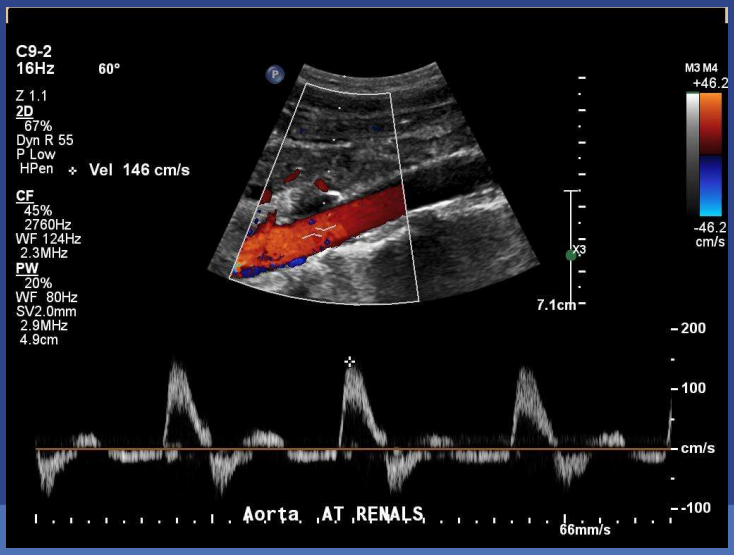
Juxtarenal Aorta



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RAR - Pitfalls

- *Low aortic velocity (<40 cm/sec)*
  - If the RAR is >3.5 with a low aortic velocity, care should be taken about making an interpretation of a 60-99% stenosis.
  - Base findings on elevated renal artery velocities (>200cm/sec)
    - Turbulence
  - Look for cause for the low velocity such as aortic occlusion, etc.
- High a*ortic velocity is high (>100 cm/sec)*
  - Ex: renal PSV of 250 cm/sec and aortic velocity of 120 cm/sec gives an RAR of 2.1.
    - Underestimated RAR

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RAR – Pitfalls

- *AAA*
  - *Take velocities throughout aneurysmal abdominal aorta to determine validity of RAR*
  - RAR should be recorded with patients having aneurysms but it should be made clear that it may not be accurate due to the abdominal aortic aneurysm.
  - Use peak systolic velocity and the presence or absence of turbulence will be used to determine if significant renal arterial stenosis is present.

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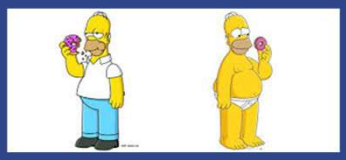
Scanning Technique

15

Who is our Patient

- Patient evaluation
  - Visually (not judging)
  - Knowing your Probe
    - Go to the lowest frequency ; have it available on your machine or grab it after you get the patient situated
      - Phased S5-1, S4-1
      - Curved C2-9, or C 1-5



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Scanning Technique

- Communicate with patient
  - Time
    - Length of exam
      - Restroom stop
  - May be uncomfortable
    - Make patient comfortable
      - Fold pillow, blanket, empty pockets…

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Scanning Technique

- Breathing instruction
  - Deep in and hold
  - Deep in and blow out and hold
  - Small breath in and hold
  - Just hold (STOP)
  - Whatever works!

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Ergonomics

- Cart position (height)
  - Do you sit or stand while scanning?
  - Side rail up (safety and easy for patient to change positions)
- Machine height
  - Move patient close to you, or whatever is more comfortable to you.
  - Save your elbow, neck &shoulder!!!!

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Ergonomics

- Patient positioning
  - Different window
  - Different scan planes
    - Decubitus, supine, oblique, prone
    - Label image specific to scan plane
    - This will help on follow up exams

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Scanning Technique

- Known your equipment
  - Optimization
    - Dynamic range
      - Penetration
      - Chromo maps
      - Harmonics
      - I Scan
    - Specialized presets
    - Protocols/ Scan Assist
      - Get to be besties with your apps people.
      - They can make your job easier!!!

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Tips and Tricks

- Keep trying different windows
- Patient positioning
  - Trendelenburg position
  - Reverse Trendelenburg position
  - Decubitus or semi-decubitus
    - It will help to work around bowel gas
- Time – It really does work!
  - If patient is not properly prepped and you are unable to obtain a decent window, have the patient come back in a few hours.
    - Gas-X

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Limitations and Patient Prep

Limitations

- Excessive bowel gas
- Recent abdominal surgery limits viewing window
- Patient not NPO
- Shortness of breath/rapid breathing (difficult to obtain accurate Doppler recordings)
- Body habitus
- Patient inability to withstand pressure from US probe

Patient Prep

- NPO at least 8 hours
- Preferably from midnight the night before
- Yes, this includes coffee
- Water for medications is OK
- Simethicone preparation may be considered for optimal exam e.g. Gas-X
- NO SMOKING!

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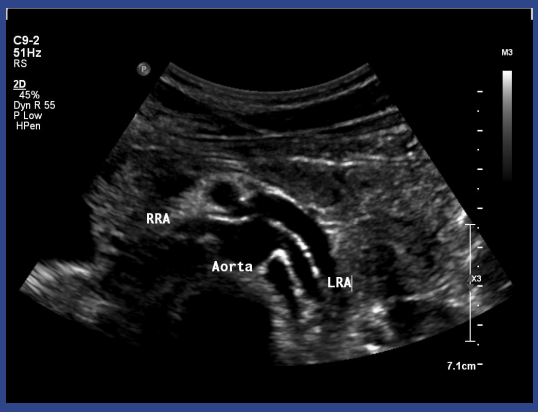
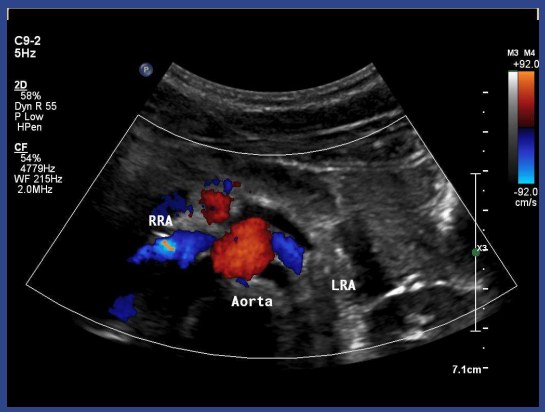
Renal arteries





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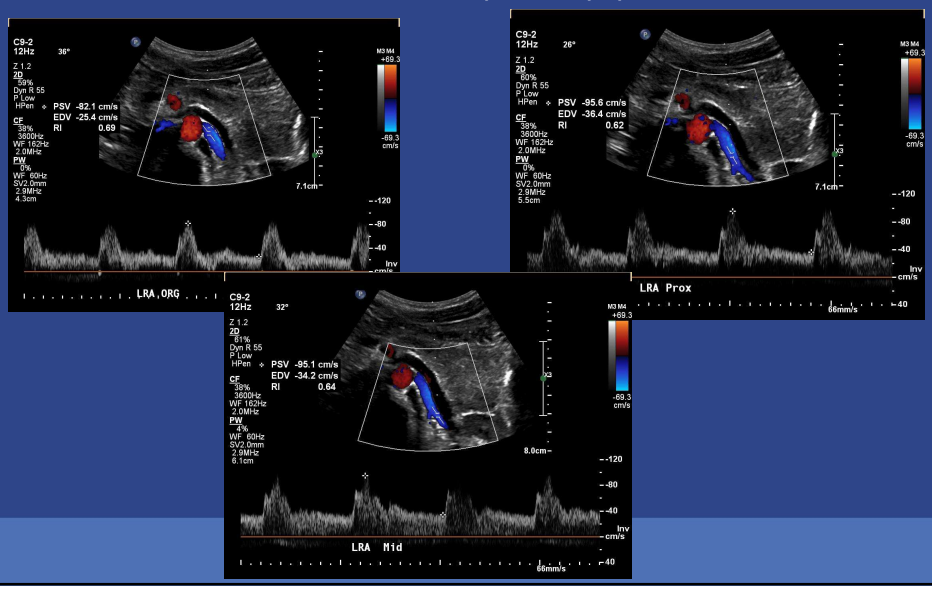
Renal artery Dopplers



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Kidney measurement

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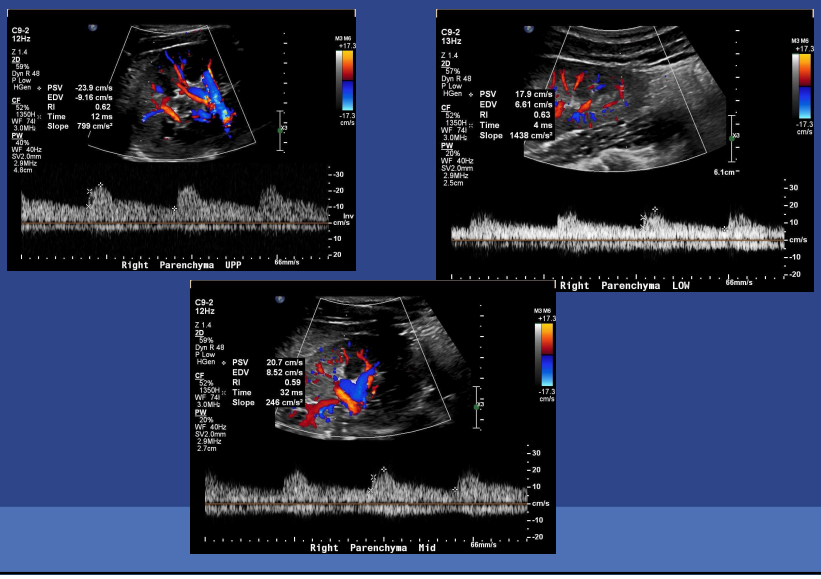
Kidney parenchyma



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Parenchymal Flow

- Resistive index: calculated by ultrasound machine
- PSV – EDV/PSV
- Normal values .53 - .7 (an increase in RI may indicate intrinsic kidney disease).

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Parenchymal Flow

- Acceleration time: the time from the start of flow to peak flow in milliseconds.
- Normal values <100 m/sec
  - An increase in AT may suggest significant renal artery stenosis resulting in delayed perfusion of the kidney or perfusion of the organ via collaterals
- There can still be renal artery stenosis in the setting of a normal acceleration time
- If acceleration time is different in one of the poles, this may indicate accessory renal artery stenosis
  - May require further evaluation

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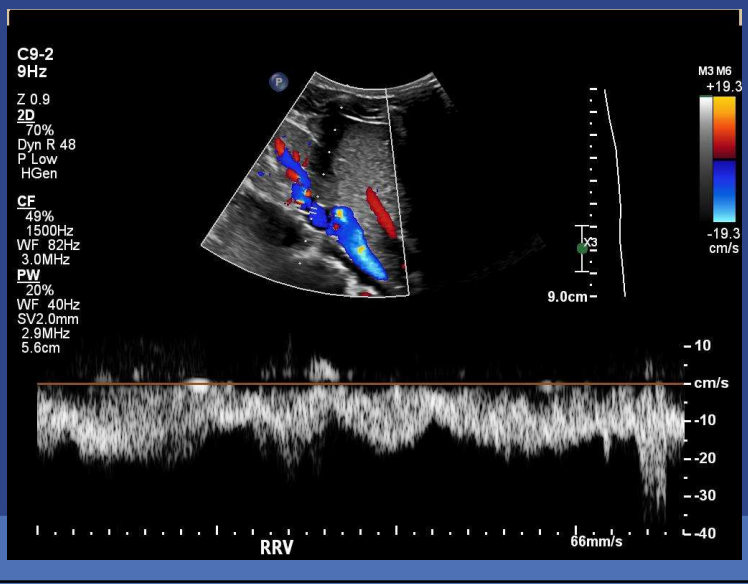
Renal vein



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Oblique image of kidney to aorta

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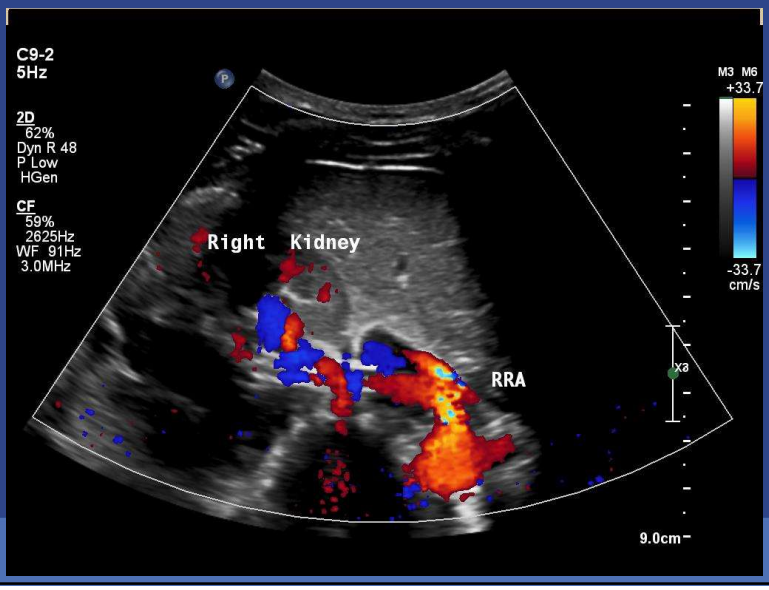
Oblique image of kidney to aorta



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Interpretation of Renal Artery Stenosis

- 0-59% stenosis: Renal PSV ≤ 200 cm/sec Renal-aortic ratio (RAR) ≤ 3.5
- 60-99% stenosis: Renal PSV > 200 cm/sec and RAR > 3.5 > 80% stenosis if EDV >150 cm/sec
- Occluded Absent flow
- This classification is only accurate for predicting the amount of diameter reduction in the setting of atherosclerotic renal artery stenosis. It is not reliable for accurately predicting disease in the setting of fibromuscular dysplasia. The statement "ultrasound features consistent with fibromuscular dysplasia" will be used when turbulent flow and a velocity shift are noted mid or distal renal artery and/or beading is present.

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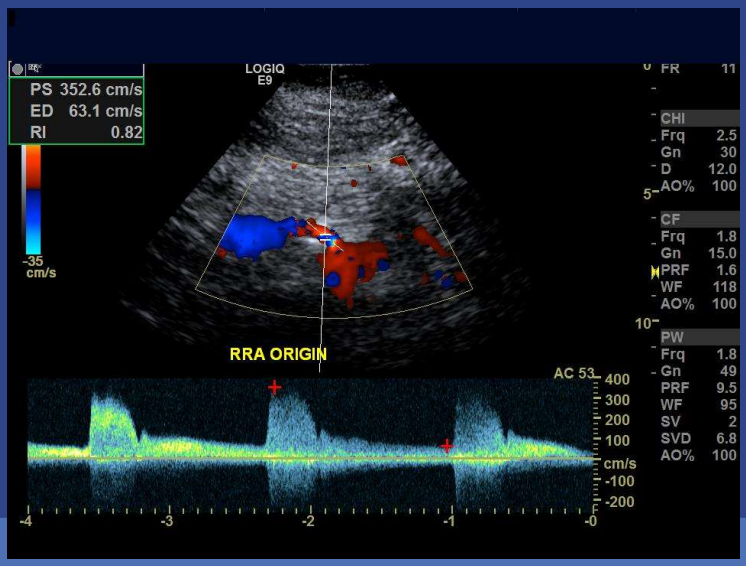
Renal artery w/ ASO



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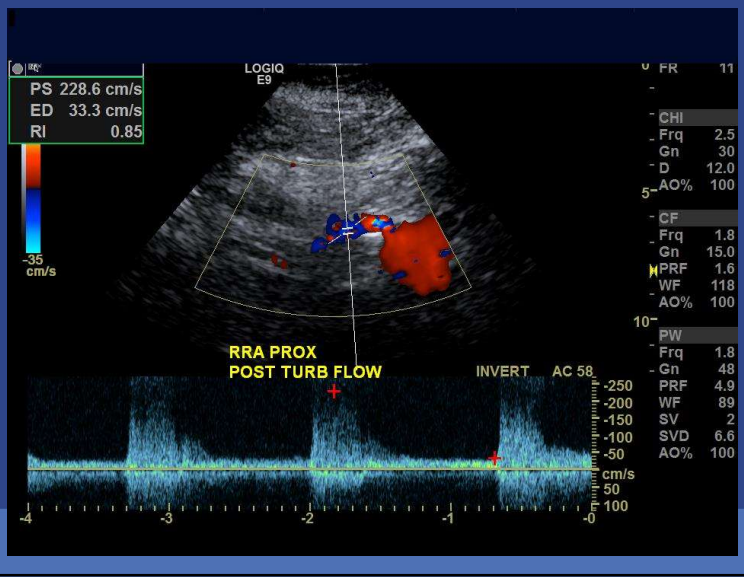
Renal artery – post stenotic turbulence



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Fibromuscular Dysplasia

- Rare(ish) medical condition
- Characterized by abnormal cellular growth in the walls of medium and large arteries
  - Most common is ICA RRA
    - Mid to distal vessel
  - Can also be in iliacs, mesenterics, coronary arteries, etc
- Can cause ‘string of beads’ appearance

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Ultrasound Pearls: Renal FMD

- The patient is a middle aged woman
- No atherosclerotic plaque visualized or minimal plaque out of proportion to velocity shifts
    - Beware: some patients may have both FMD and ASO
- Turbulent flow plus velocity shift in mid to distal RRA
- "String-of-beads" vessel morphology seen with color Doppler and color power angiography
    - Most common type of FMD (medial fibroplasia)
- CPA particularly useful

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FMD Case Study

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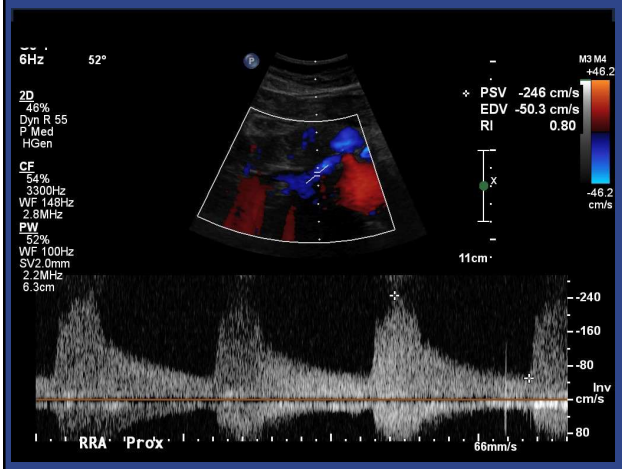
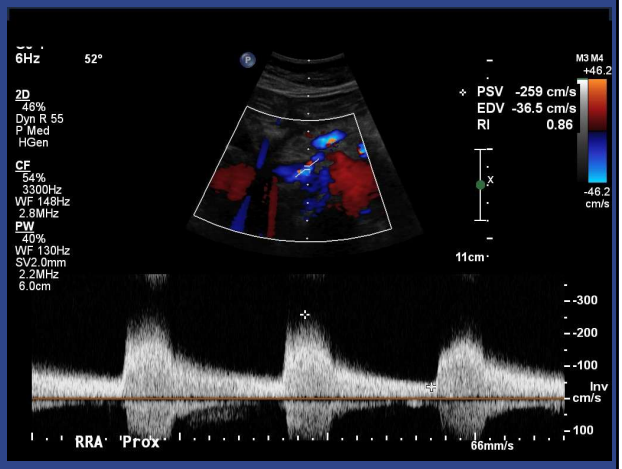
FMD Case Study





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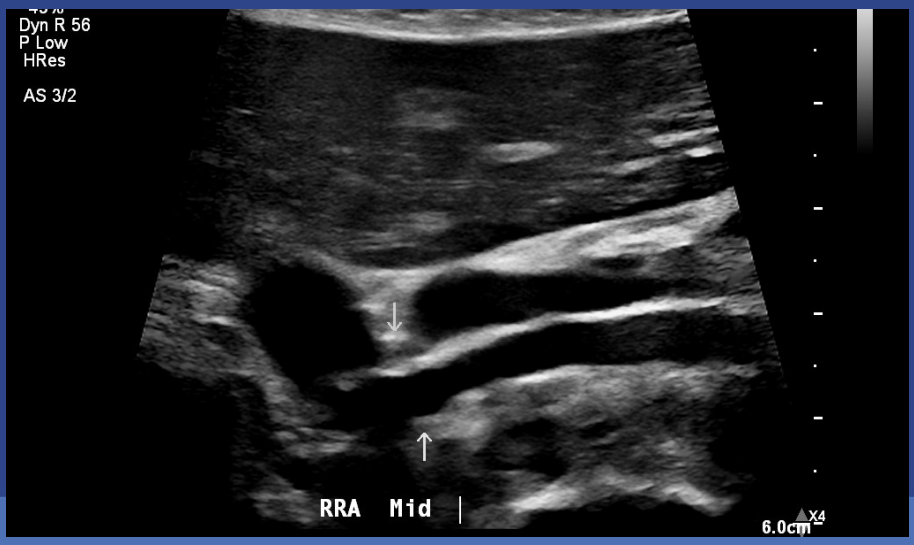
FMD Case Study



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FMD Case Study - CPA

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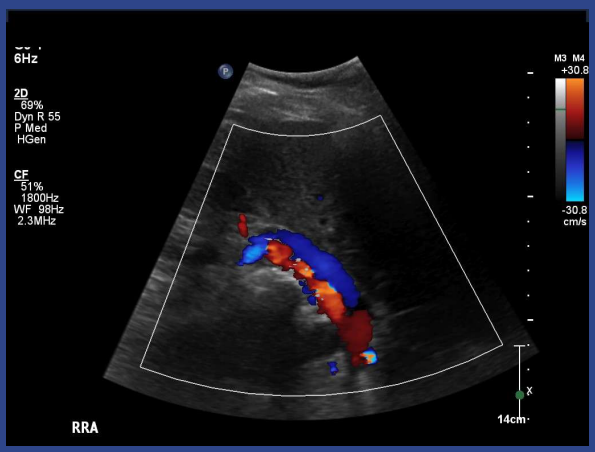
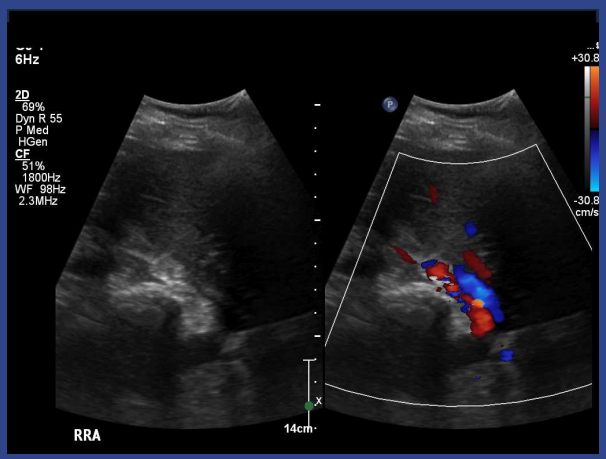
FMD Case Study





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FMD - Interpretation

- Turbulent flow and elevated velocities at mid or distal vessel consistent with fibromuscular dysplasia (percentage stenosis categories for atherosclerotic disease only)

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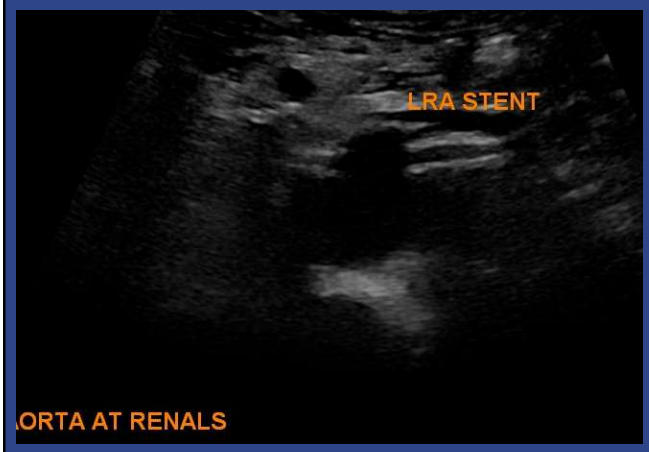
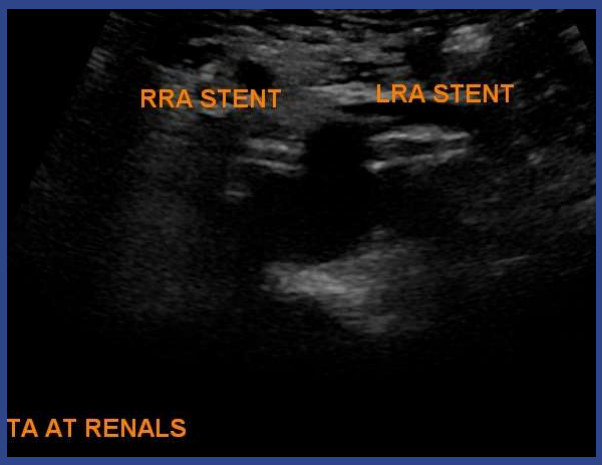
Renal artery stenting





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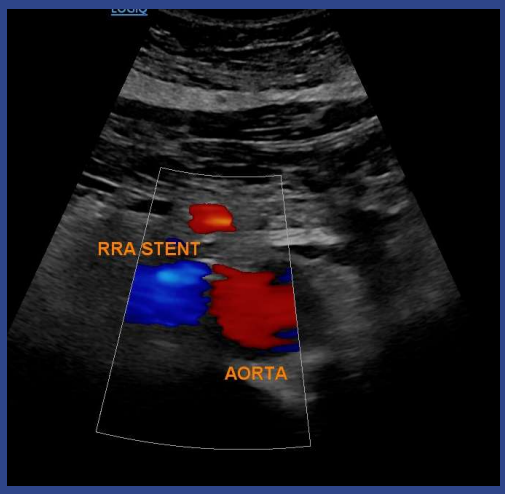
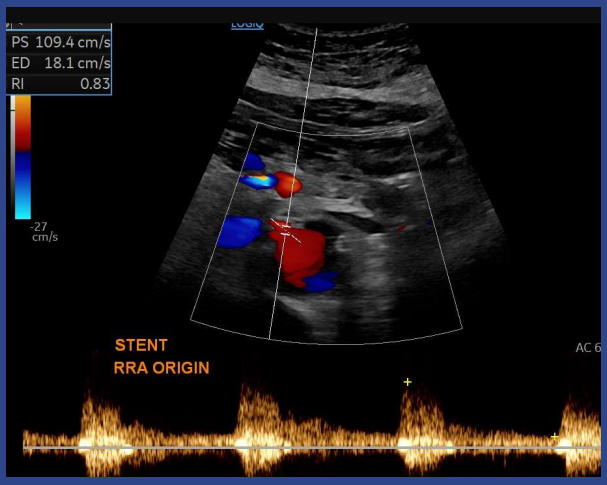
Renal artery stenting





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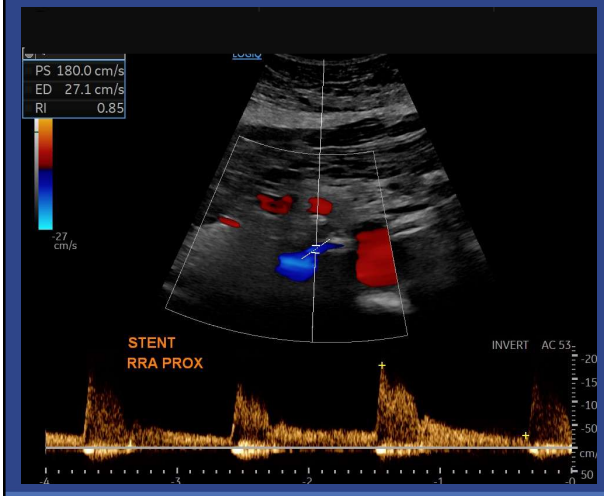
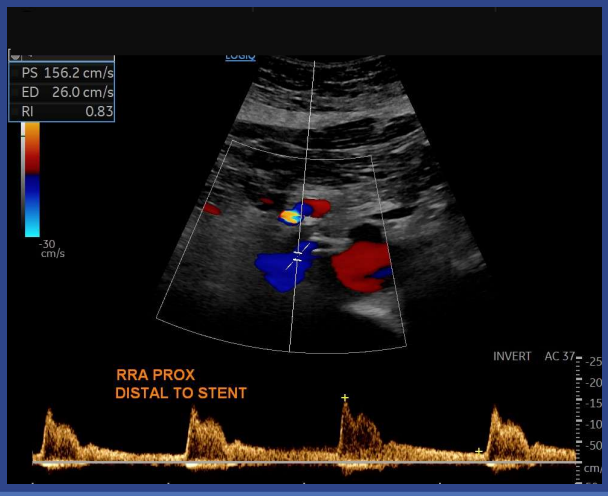
Renal artery stenting





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When to order an aortoiliac duplex?

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Purpose of aortoiliac duplex

- To determine the presence of aortic aneurysm and/or ectatic vessels, dissection, pseudoaneurysm, stenosis, intraluminal thrombus, or plaque.

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Indications for aortoiliac duplex

- Pulsatile abdominal mass
- Abdominal or back pain
- Embolic ‘shower’ or blue toes

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Causes of AAA

- Emphysema
- Genetic factors
- High blood pressure
- High cholesterol
- Male gender
- Obesity
- Smoking
- Unknown

50

Protocol - Doppler

- Aorta: Proximal, at renals, mid, and distal
- Common Iliac Artery: Right and left at origin and proximal

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Protocol - Grayscale

- Plaque present: Transverse and longitudinal images should be taken to demonstrate plaque or laminated thrombus.
- MEASUREMENTS (longitudinal and transverse in dual screen):
- Aorta: Proximal, at renals, mid, and distal
- Common Iliac Artery: Right and left at origin and proximal
- Additional images and measurements if aneurysm identified

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Limitations for aortoiliac duplex

- Excessive bowel gas
- Recent abdominal surgery
  - limits viewing window
- Patient not NPO
- Body habitus

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Patient Preparation - For any abdominal duplex

- NPO at least 8 hours
  - Preferably from midnight the night before
  - Yes, this includes coffee
  - No, this does not include water for medications
- Simethicone preparation may be considered for optimal exam
  - Gas-X
- NO SMOKING!

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Diagnostic Criteria

- AAA: > 3 cm or a doubling of aortic dimension across 2 contiguous segments.
- Abdominal aortic ectasia: Diameter increases at the area of ectasia but does not meet criteria for AAA (e.g., 2.5 cm at distal)
- Common iliac artery aneurysm: > 2 cm or a doubling of arterial dimension across 2 contiguous segments.
- 50-99% Stenosis: Doubling in PSV across segment of aorta with visualized plaque (or other defect such as thrombus, wall thickening) and post-stenotic turbulence

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The dreaded bowel gas

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The dreaded bowel gas

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Always try from decubitus position

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AAA - example

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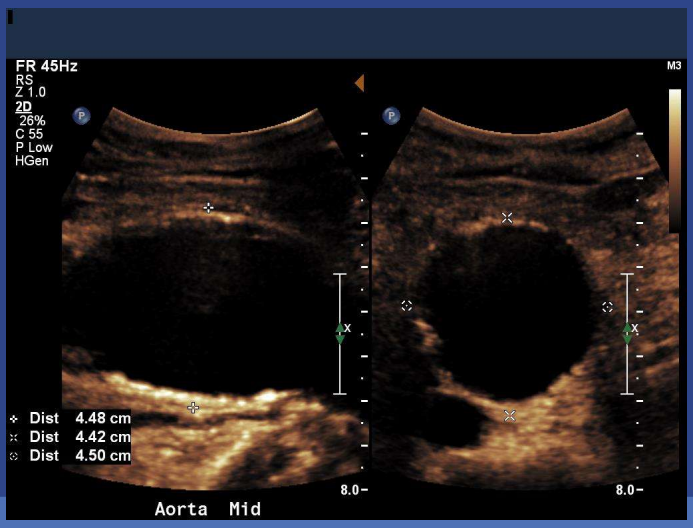
AAA - example



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Aortic dissection - definition

- Aortic dissection results from a tear in the intimal layer of the arterial wall, with dissection in the media.
- Two channels of flow are normally noted: a true lumen and a false lumen.

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Symptoms for AAA or aortic dissection

- Pain in the abdomen or back
  - Severe, sudden, persistent, or constant.
  - Pain may spread to the groin, buttocks, or legs
- Clammy skin
- Dizziness
- Nausea and vomiting
- Rapid heart rate
- Shock

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Aortic dissection - example

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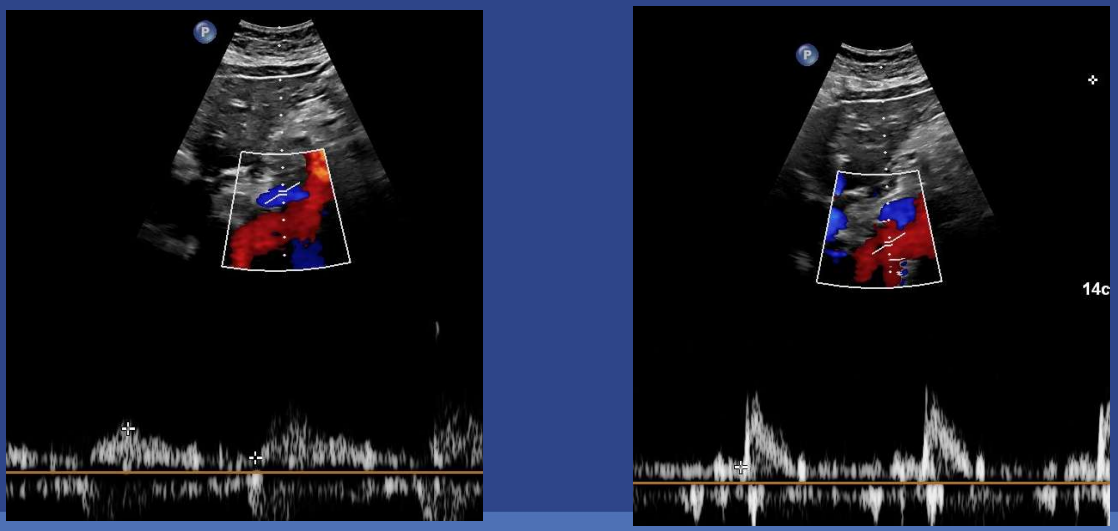
Aortic dissection - example



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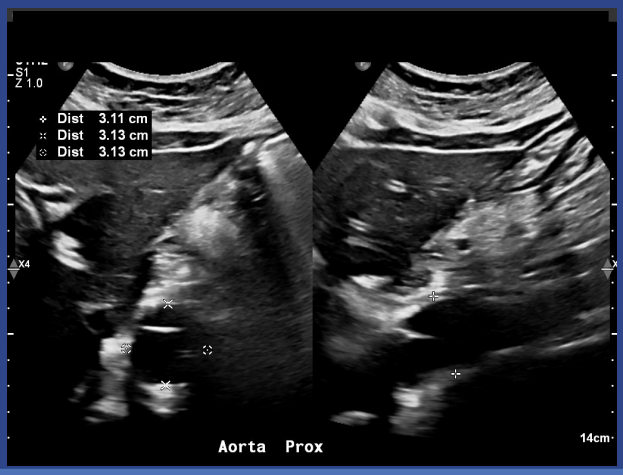
Aortic dissection - example



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When to order a Mesenteric duplex?

66

Purpose of mesenteric duplex

- To assess patency of mesenteric arteries and to identify the presence of hemodynamically significant stenosis.

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Symptoms for Mesenteric ischemia

- Symptoms of long-term (chronic) mesenteric artery ischemia caused by atherosclerosis (ASO)
  - Abdominal pain after eating (post-prandial pain)
  - Diarrhea
  - Nausea
- Symptoms of sudden (acute) mesenteric artery ischemia due to a traveling blood clot:
  - Sudden severe abdominal pain
  - Vomiting
  - Diarrhea
    - Bloody stool

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Indications for mesenteric duplex

- Mesenteric angina
  - Post-prandial pain
    - From 10 min to 3 hours after eating
    - Generally epigastric or periumbilical
    - 'Fear of eating' syndrome (sitophobia)
- Unexplained weight loss
- Bowel ischemia
- Abdominal bruit

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Causes of mesenteric ischemia

- Atherosclerotic disease
  - Mesenteric ischemia is more prevalent in patients that have ASO in other parts of the body (i.e. CAD or PAD)
- Smoking
- High cholesterol
- High blood pressure
- Embolus (usu. from heart or aorta)
  - More prevalent in pts. with arrhythmias
    - A. Fib

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Patient Preparation - For any abdominal duplex

- NPO at least 8 hours
  - Preferably from midnight the night before
  - Yes, this includes coffee
  - No, this does not include water for medications
- Simethicone preparation may be considered for optimal exam
  - Gas-X
- NO SMOKING!

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Limitations of mesenteric duplex

- Excessive bowel gas
- Recent abdominal surgery
  - limits viewing window
- Patient not NPO
  - Actually nullifies results because of changing SMA from low to high resistive.
- Shortness of breath/rapid breathing (difficult to obtain accurate Doppler recordings)
- Body habitus
- Patient inability to withstand pressure from US probe

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Protocol - Doppler

- Aorta: Proximal, mid, and distal
- Celiac: Origin, proximal, and mid
- Splenic: Proximal
- Hepatic: Proximal
- SMA: Origin, proximal, mid, and distal
- IMA: Origin, proximal, and mid
- Bypass Grafts: Proximal, mid, distal, and anastomotic sites, graft inflow and outflow
- Stents: Proximal, mid, and distal include inflow and outflow of stent

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Protocol - Grayscale

- Celiac artery origin and at sites of plaque and/or velocity shifts
- SMA origin and at sites of plaque and/or velocity shifts
- IMA origin and at sites of plaque and/or velocity shifts
- Stents
- Bypass grafts
- Any incidental abdominal findings (such as masses) should be adequately imaged and described on the written report

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Problem solving

- Decubitus or semi-decubitus position to work around bowel gas
  - Keep trying different windows
- Patient positioning
  - Try a Trendelenburg position
  - Reverse Trendelenburg position
  - Push stomach out
  - Big breath in and/or hold breath out
- Time – It really does work!
  - If patient is not properly prepped and you are unable to obtain a decent window, have the patient come back in a few hours.

75

Diagnostic Criteria

- *Celiac*
  - ≤250 cm/sec Peak systolic velocity without post stenotic turbulence is consistent with a 0-69% stenosis.
  - >250 cm/sec Peak systolic velocity with post stenotic turbulence is consistent with a 70-99% stenosis.
- *SMA/IMA*
  - ≤275 cm/sec Peak systolic velocity without post stenotic turbulence is consistent with a 0-69% stenosis.
  - >275 cm/sec Peak systolic velocity with post stenotic turbulence is consistent with a 70-99% stenosis.

  An occlusion may be called when no color flow or spectral Doppler waveform analysis is obtainable, and the vessel is clearly visualized (retrograde flow within the hepatic artery usually will occur and should be documented).

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URGENT VALUE NOTIFICATION

- AAA that is > 5 cm not previously documented at the Cleveland Clinic
- Ruptured AAA
- Previously unknown aortic, renal, or mesenteric artery dissection not previously documented
- New finding of occlusion of bypass graft or stent

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Mesenteric ischemia

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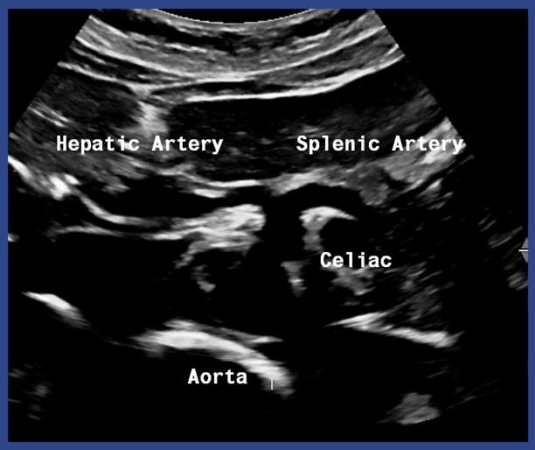
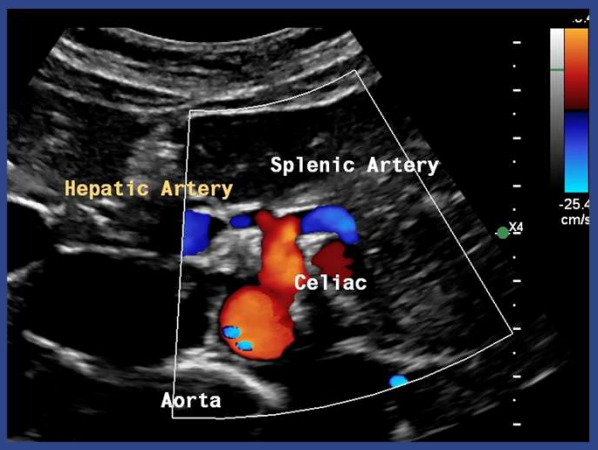
The Seagull Sign





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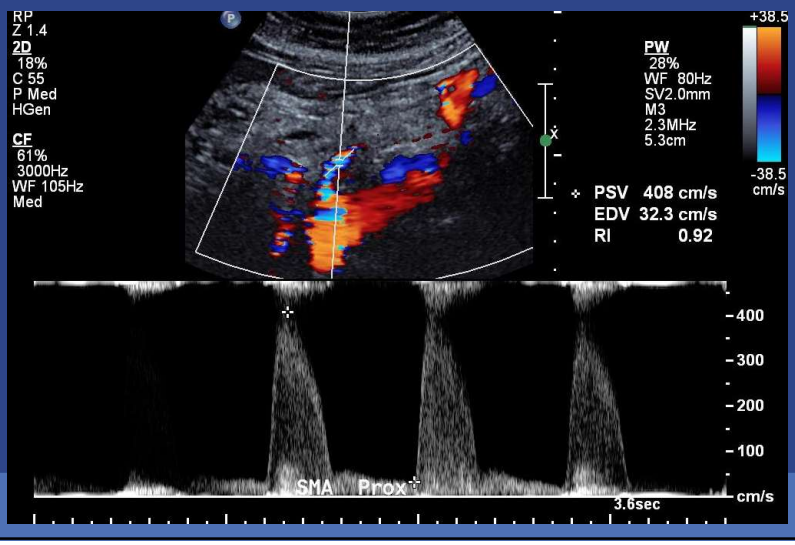
Superior mesenteric artery with hemodynamically significant narrowing

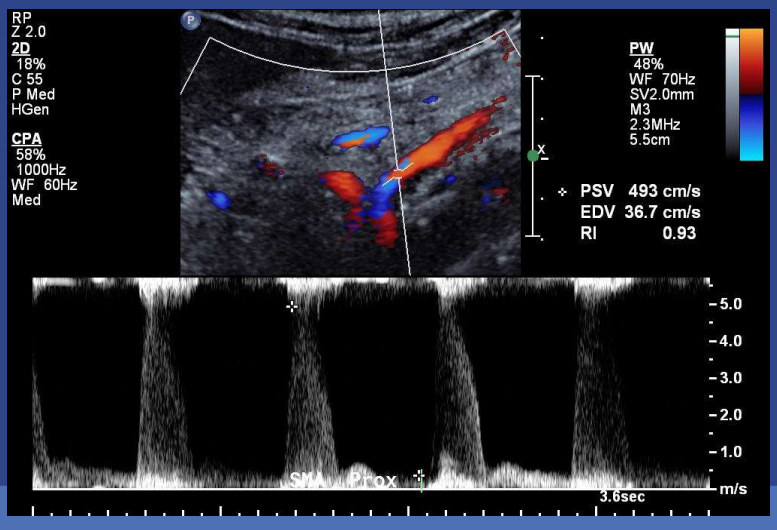


80

Superior mesenteric artery with hemodynamically significant narrowing

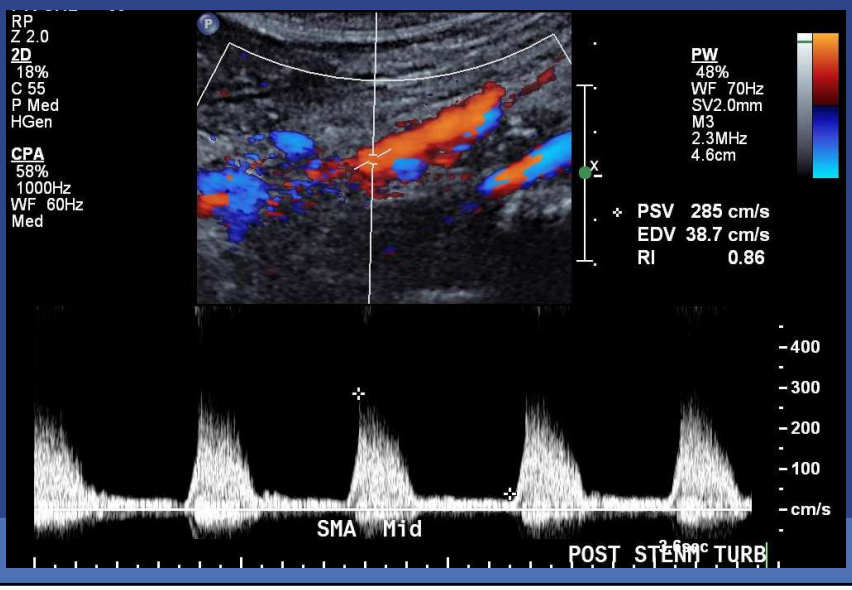
81

Superior mesenteric artery with hemodynamically significant narrowing



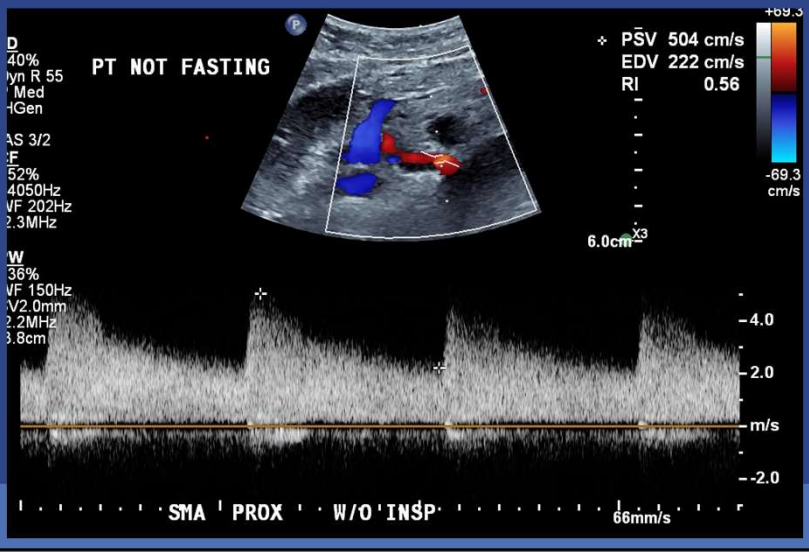
82

Post stenotic turbulence in SMA



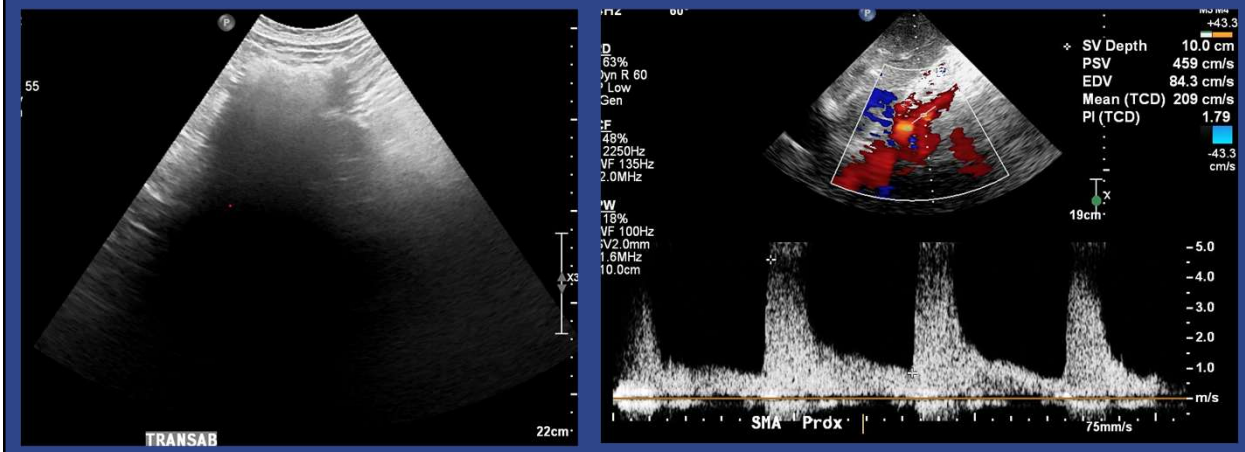
83

Non-fasting SMA



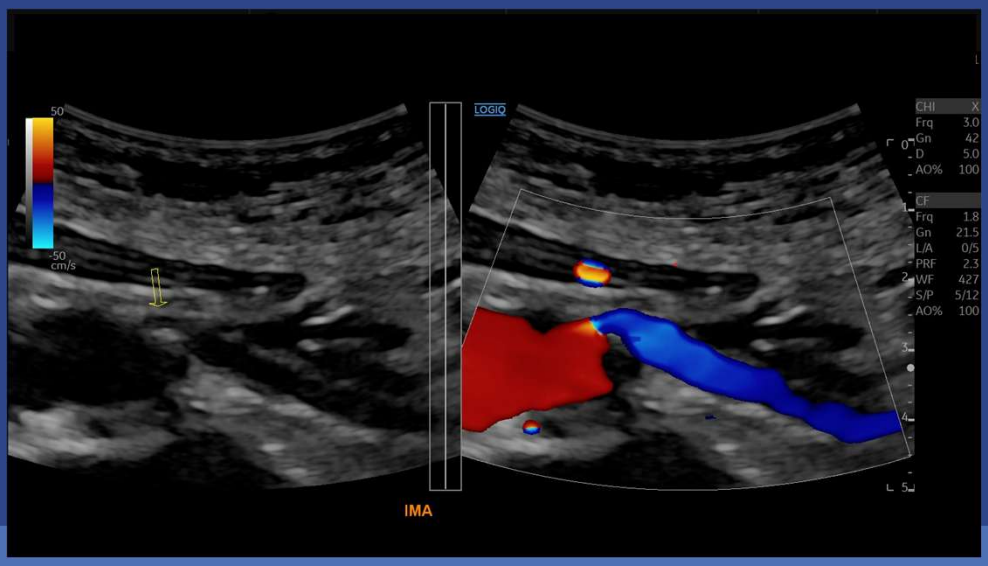
84

The Mighty Sector Probe



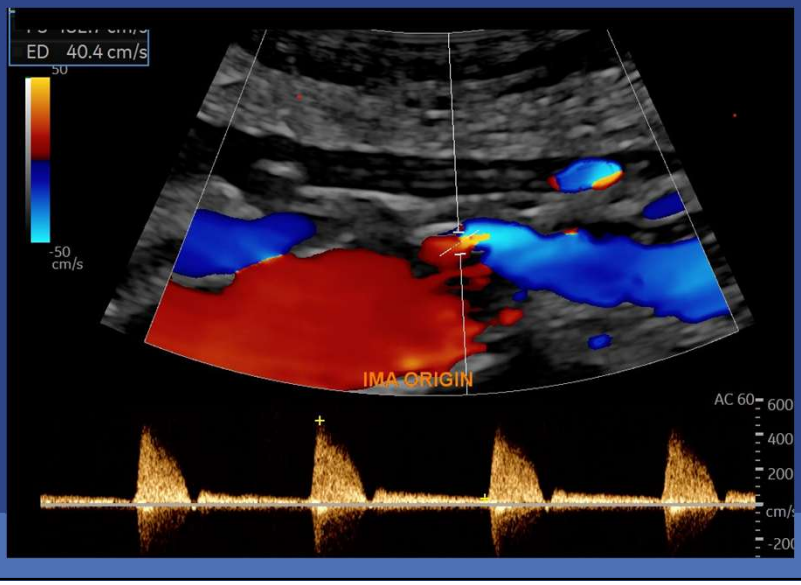
85

Inferior mesenteric artery with hemodynamically significant narrowing



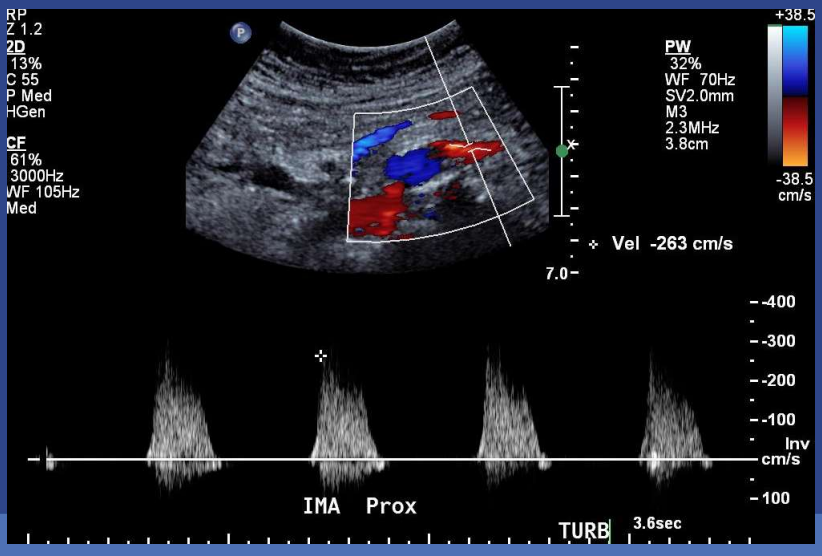
86

Inferior mesenteric artery with hemodynamically significant narrowing



87

Post stenotic turbulence in IMA



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Dynamic compression from Median Arcuate Ligament Syndrome (MALS)

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Dynamic compression from Median Arcuate Ligament Syndrome (MALS)

- Celiac artery has a dynamic increase in PSV to > 250 cm/sec that resolves with deep inspiration and/or upright maneuver.

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MALS - Symptoms

- Abdominal pain
  - Post-prandial
- Nausea
- Vomiting
- Weight loss
- Abdominal bruit

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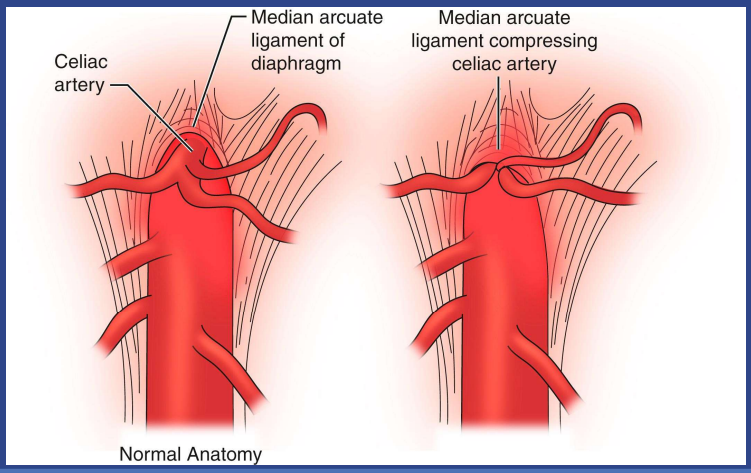
MALS



https://clinicalpub.com/median-arcuate-ligament-syndrome-pathophysiology-diagnosis-and-management/

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MALS - Cause

- MALS is attributed to compression of the celiac axis by the median arcuate ligament which connects the diaphragmatic crura.
  - This happens when the median arcuate ligament passes anterior to the celiac artery and causes compression of the vessel

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Assessment for MALS

- Identify elevated velocities and narrowing in celiac axis with patient supine and breathing normally and/or with full expiration
- Have patient take in a large breath and hold it, while the sonographer evaluates the celiac artery velocities and visible narrowing.
- Have patient stand and re-evaluate the celiac artery both with and without deep inspiration.
- If the velocities in the celiac artery diminish during either of these maneuvers, the patient is positive for MALS
- The protocol for MALS is performed whenever elevated velocities are identified in celiac axis in supine position.

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Example of MALS

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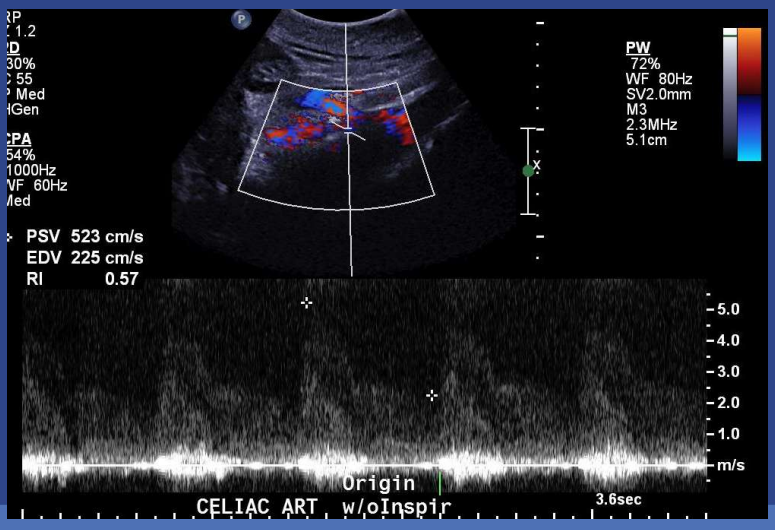
Celiac artery – Elevated velocities w/out inspiration



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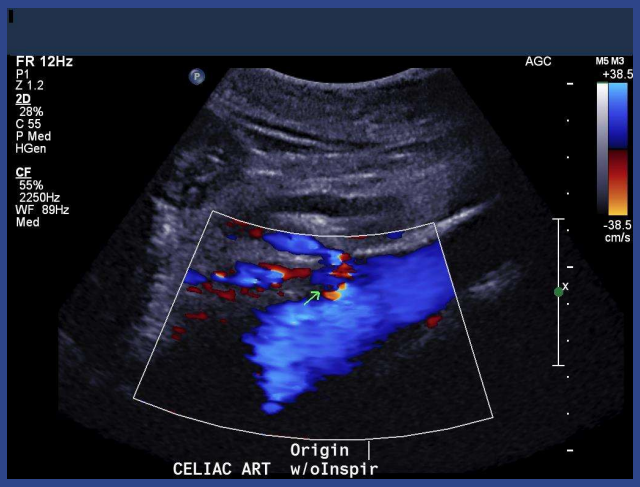
Celiac artery – appears narrowed w/out inspiration



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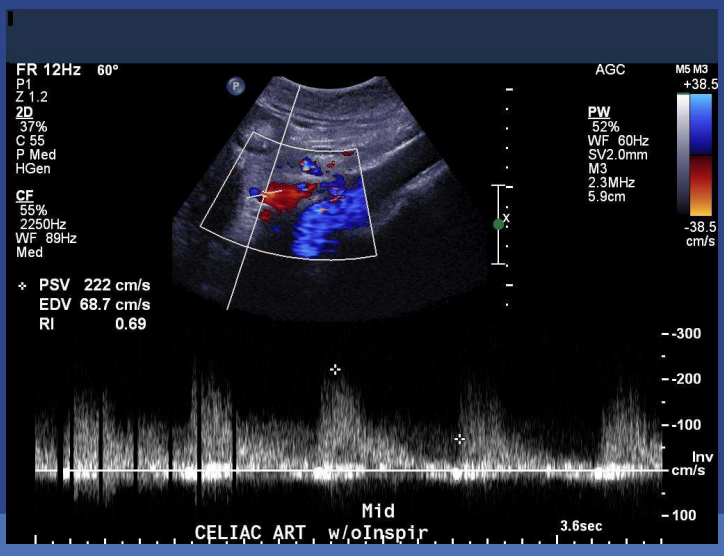
Celiac artery at mid w/o inspiration – notice the ragged appearance to waveform



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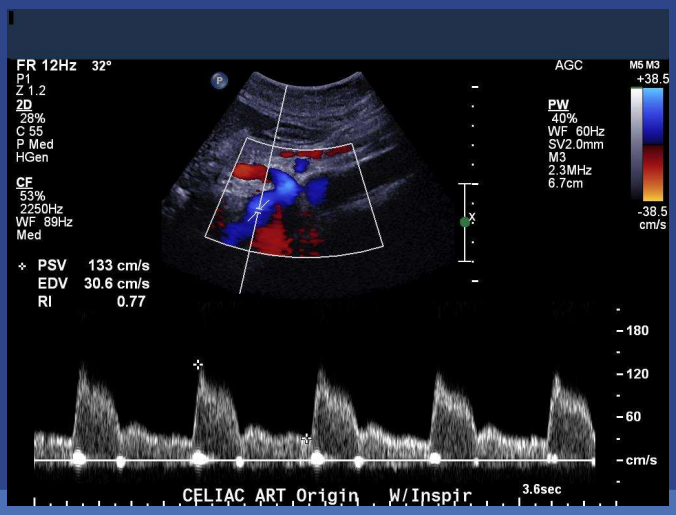
Celiac artery - demonstrates normalized velocities and normal flow pattern with inspiration



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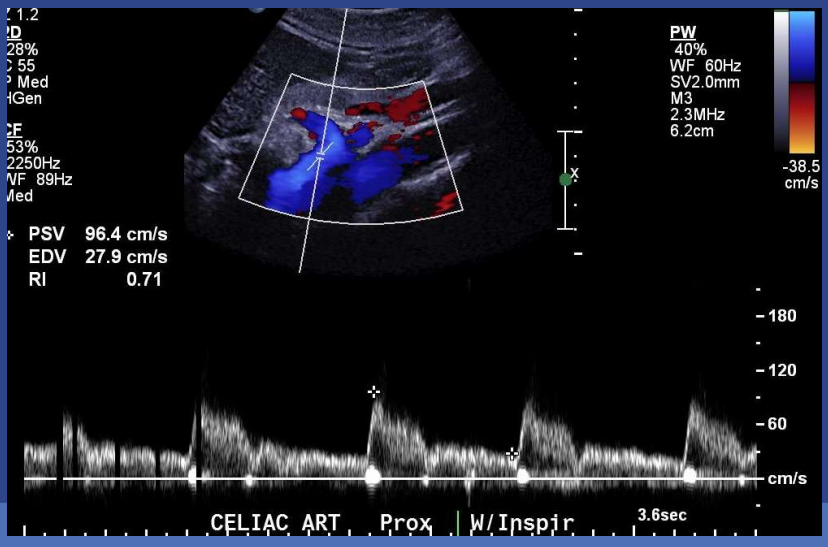
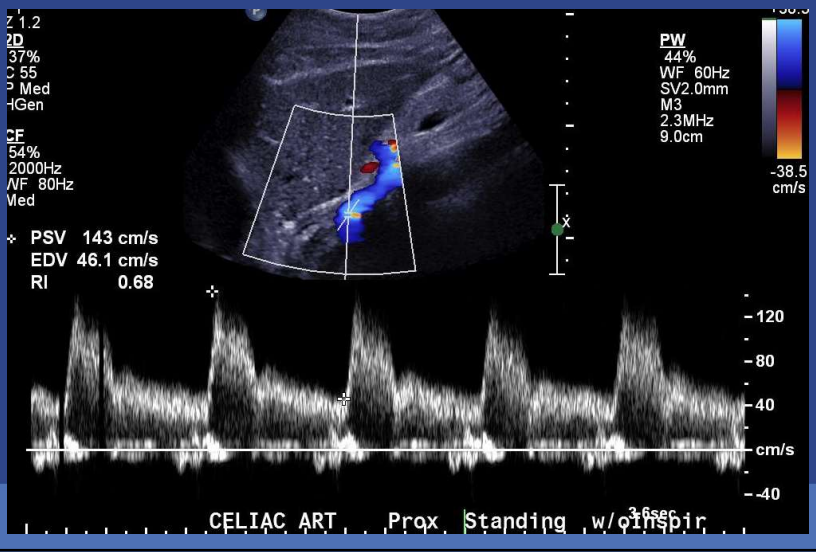
Celiac artery - demonstrates normalized velocities and normal flow pattern with inspiration

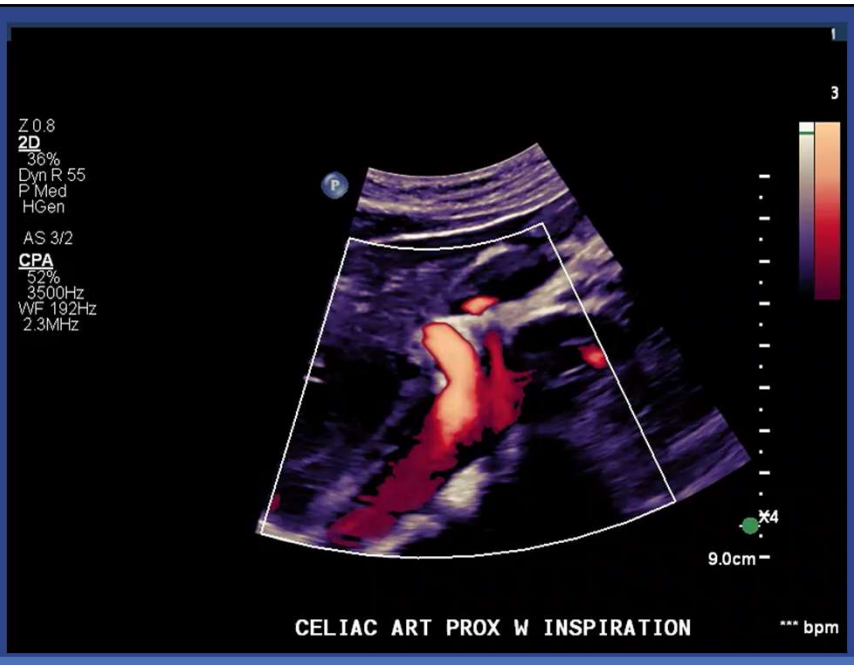


100

Celiac artery – With patient standing – velocities and waveforms are normal



101



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Bonus Round – SMA compression

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Conclusion

- Vascular ultrasound is a very effective tool for diagnosis and monitoring of various pathologies in the abdomen and kidneys
  - No use of contrast
  - Gives important velocity information
  - Reasonably inexpensive compared to other imaging modalities
  - However, it is very technologist dependent
    - Important to have adequate training for techs

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Thank You

- SDMS
- Cleveland Clinic Vascular Lab for all the ultrasound images

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Reference

- Anton G, Burket K, Digiannantonio A, et al. *Cleveland Clinic Foundation Non-invasive Vascular Laboratory Protocols and Procedures Manual.* Cleveland, OH; Cleveland Clinic Foundation; 2013.

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