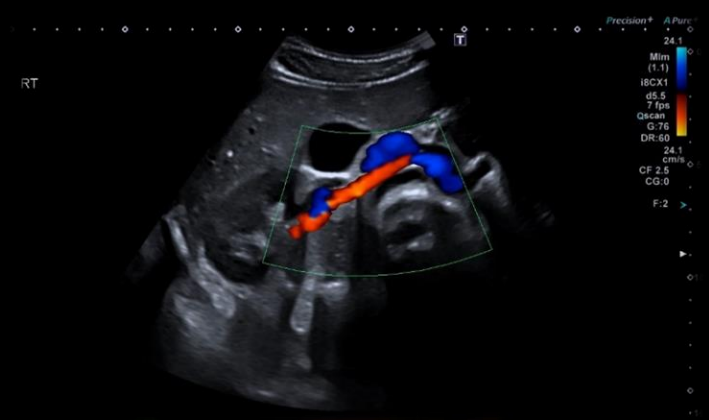
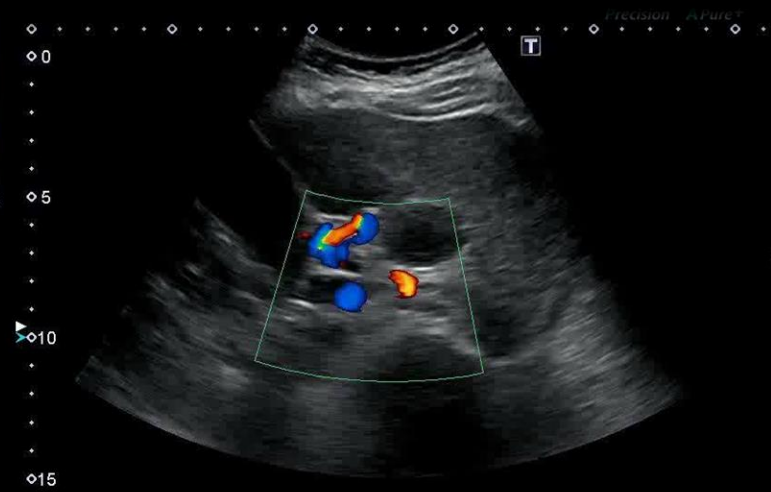
UNC REX HEALTHCARE

VERSION 2

PRESENTED BY JANETTE WYBO, BAS, RDMS, RDCS, RVT

CELIAC - SMA - RENALS OH MY !





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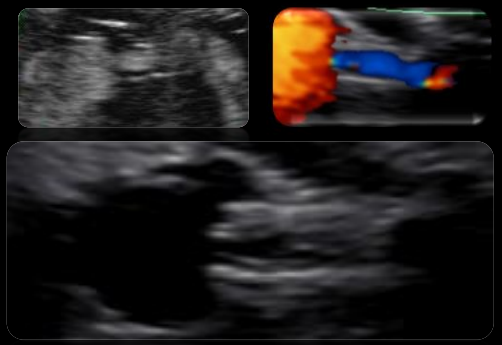
ASCENSION PROVIDENCE HOSPITAL SCHOOL OF DMS



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A Special Thanks To The :
UNC Rex Healthcare
North Carolina Heart and Vascular Hospital
Peripheral Vascular Lab Team

- S. Wayne Smith M.D.,RVT,RDMS,FSVM,RVPI
- Patrick A Washko BSRT,RDMS,RVT,FSVU
- Robert Mendes M.D
- Elvira Castellanos RDMS,RVT
- Otis Darden RDMS,RVT
- Dorian de Frietas M.D. RVPI
- Kelly Edwards BS RDMS
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- Anna Moore BS , RDMS, RVS
- Liliana Nanez M.D. RPVI
- Jim Morgan MS, RVT
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- Brandy O'hara RDMS, RVS
- Olusegun Osinbowale, M.D. RVPI
- Hillary Sawyer RVT
- Bob Scissons RVT,FSVU (Honorary Staff Member)
- Daniel Sherrill RVT
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- Brian Stull, RDMS,RVT
- Aaron Thomas, P.A.C, RVT
- Sharon Wertz RDMS, RDCS, RVS

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How Long Have You Been Performing Vascular Ultrasound Exams?

A. 0-2 years

B. 3-5 years

C. 6-10 years

D. Before they had color Doppler!

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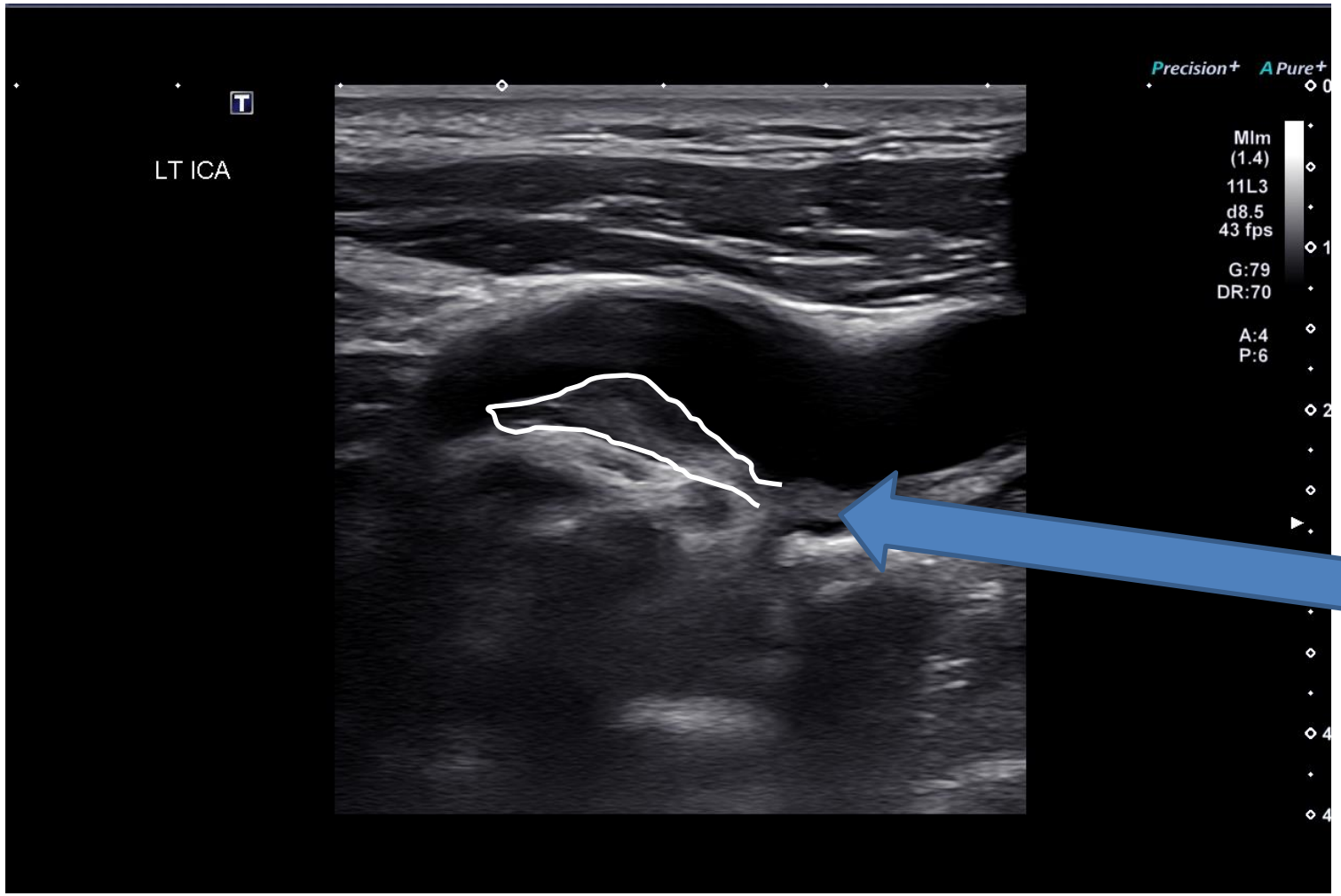
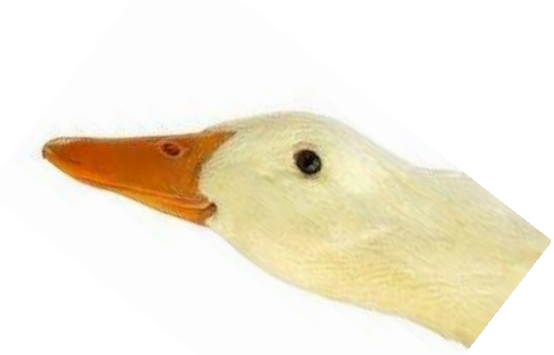
When you've been scanning for a while... You Start Seeing Things...



Does anyone see a Duck?



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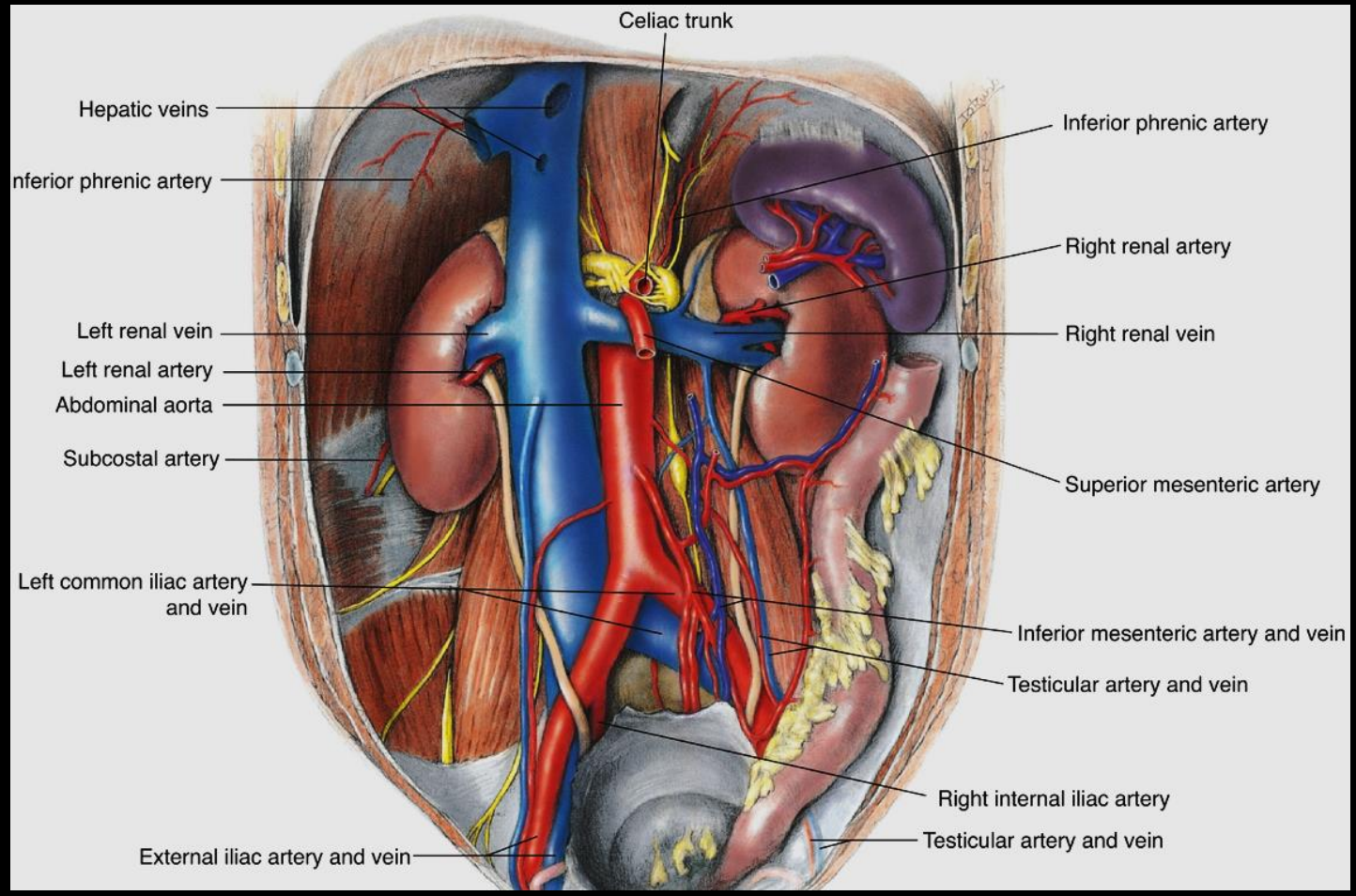
Does Everybody See A Sloth ?

Patrick's Ultimate Goal Everyday is to...

Make Duplex Doppler The Gold Standard!

First Step – Know Anatomy

- Aorta
- IVC
- Celiac
- SMA
- IMA
- Renal Arteries
- Renal Veins



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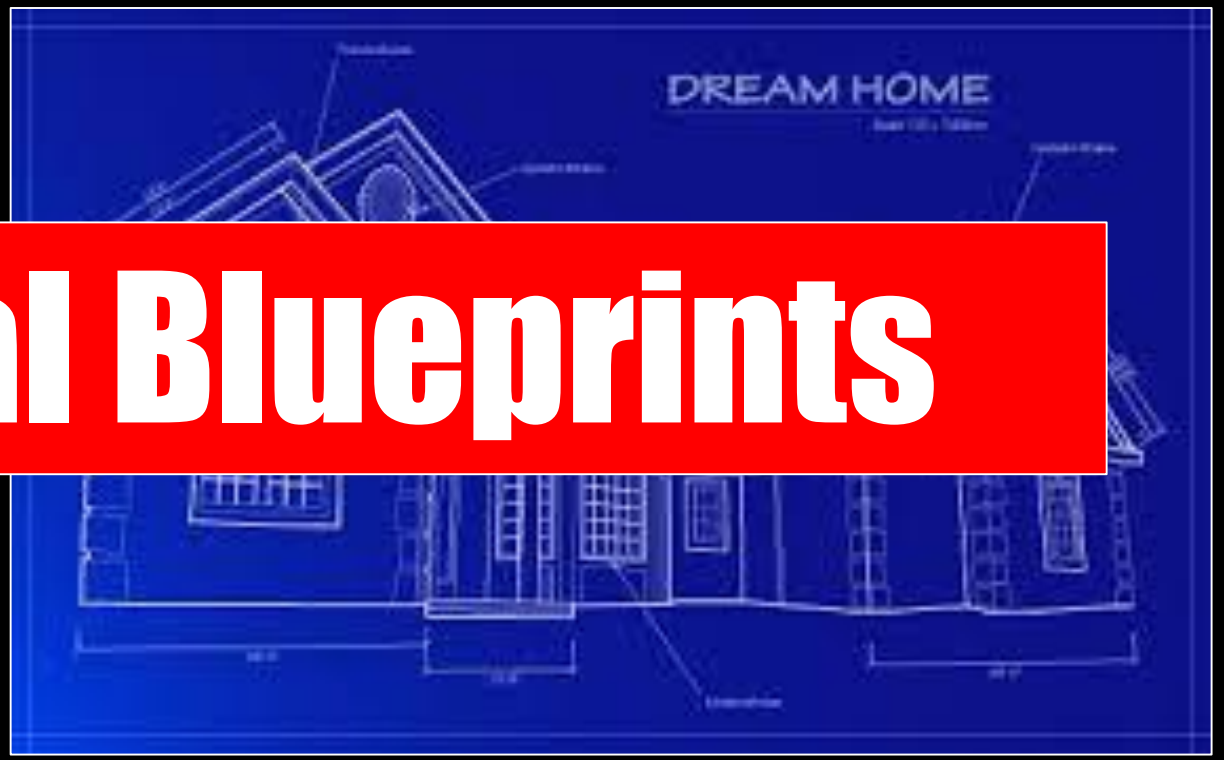
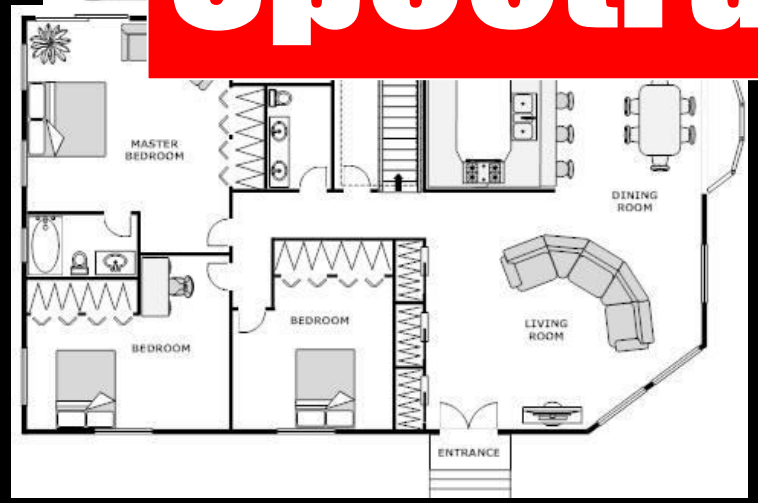
2ND STEP – KNOW NORMAL FLOW PATTERNS

** BLUEPRINTS ARE ESSENTIAL IN COMPLEX MATTERS !*





Spectral Blueprints

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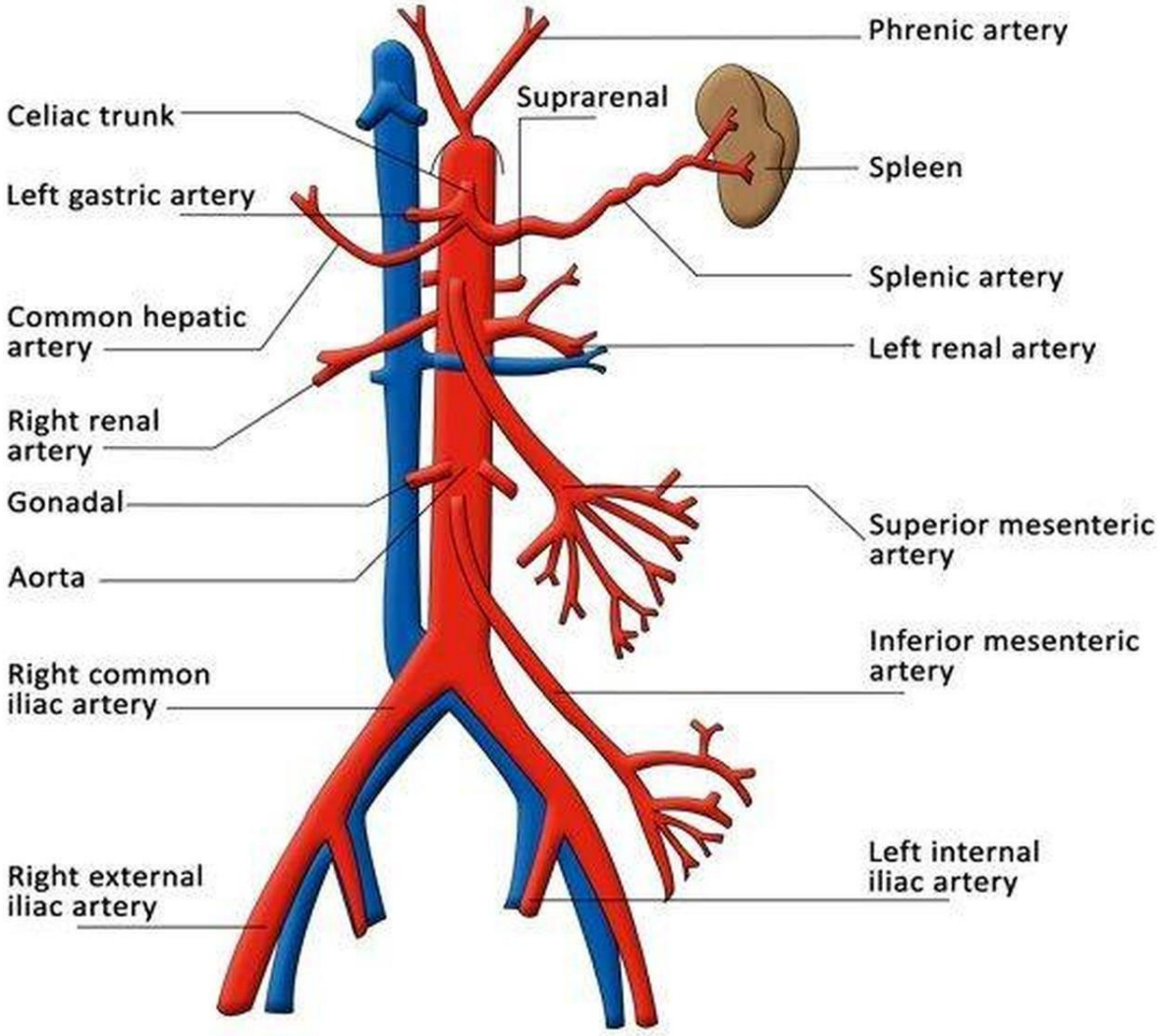
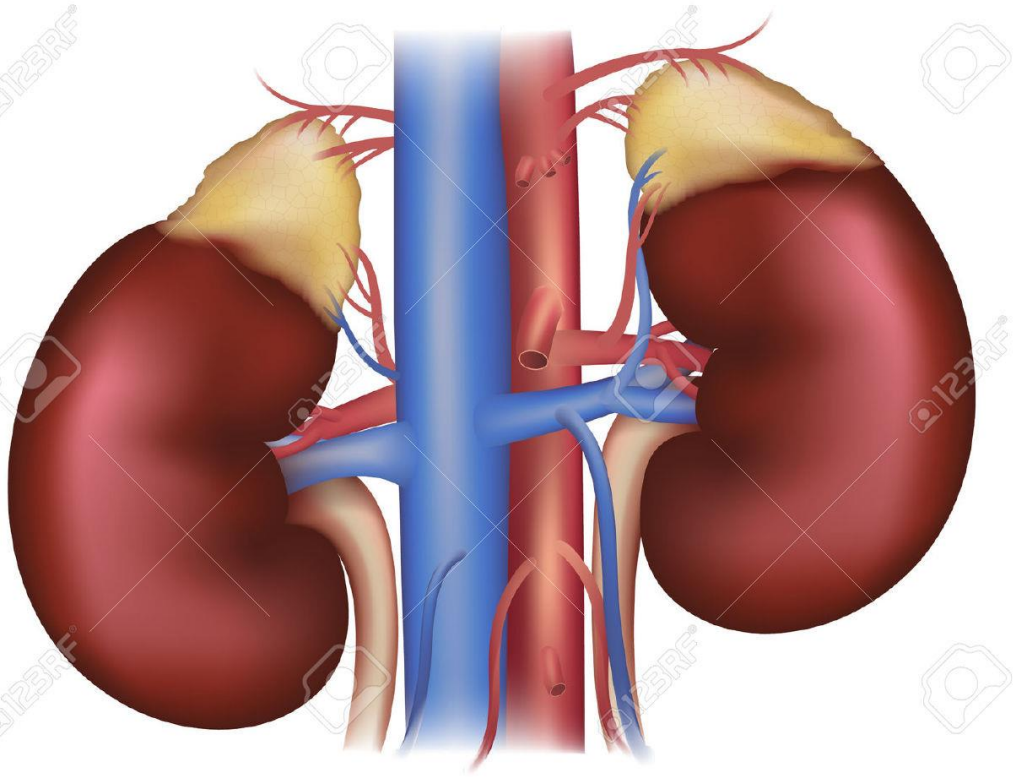
Arterial Flow Patterns





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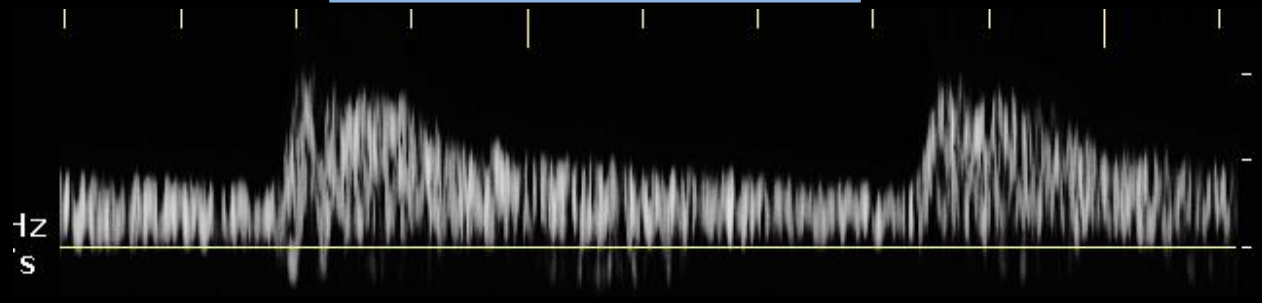
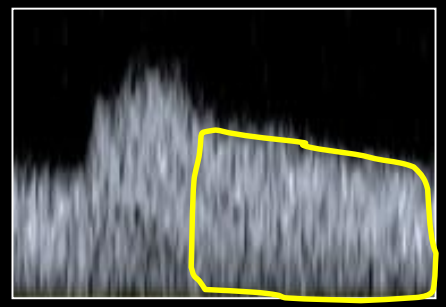
Low Resistance Flow

- Renal arteries
- Celiac and Branches
  - –Hepatic, splenic
- ICA
- Vertebral arteries

High/continual Diastolic Flow

If high resistance is seen in a low resistance bed,





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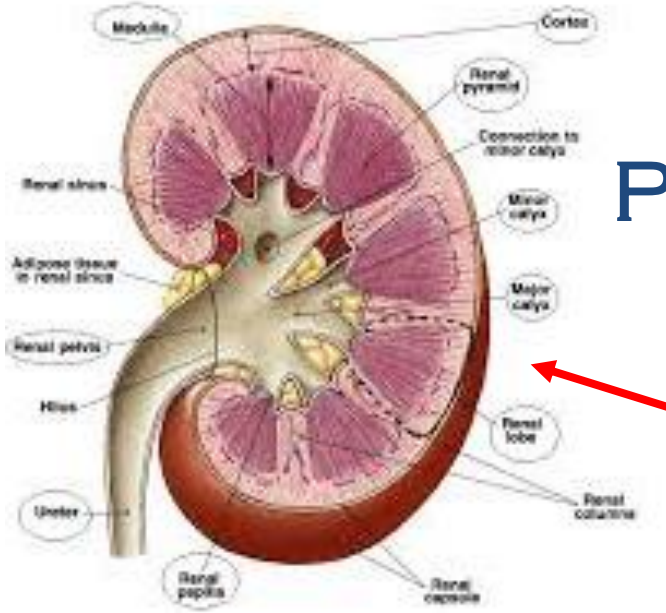
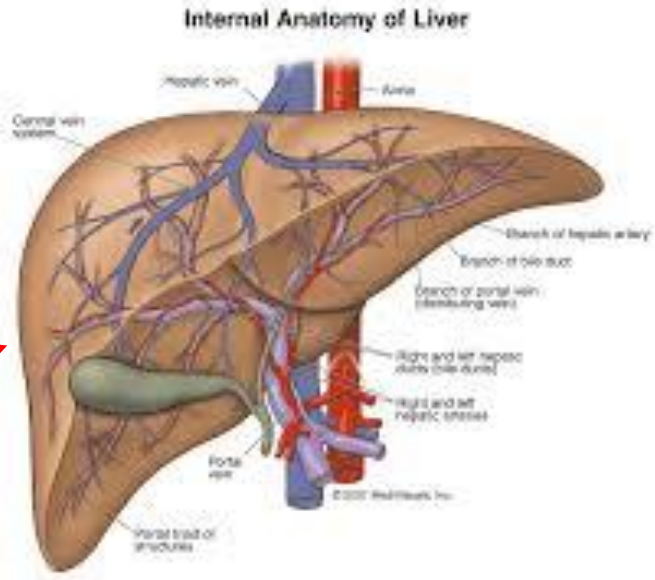
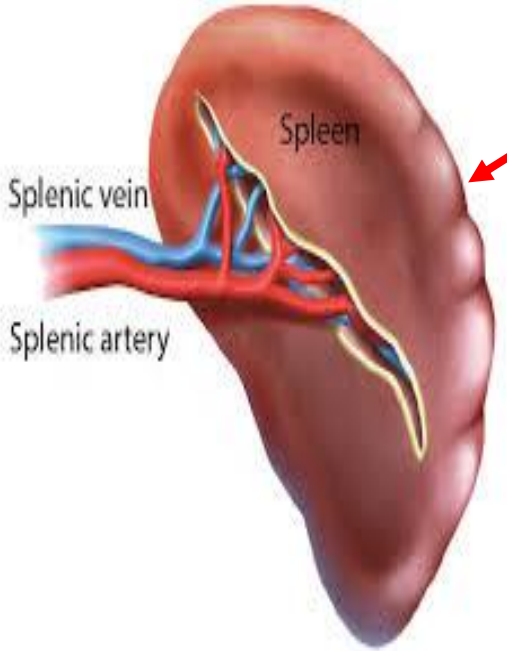
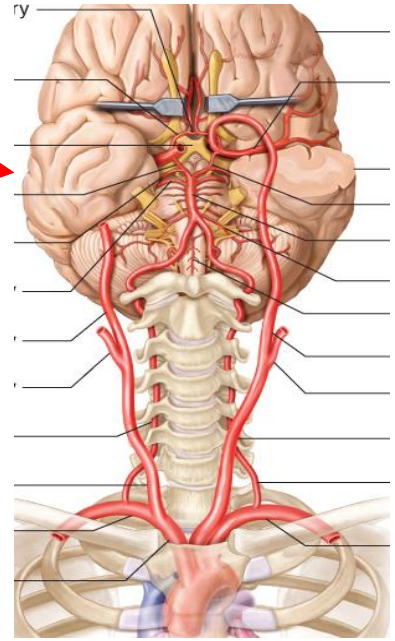
Low Resistive Parenchymal Organs









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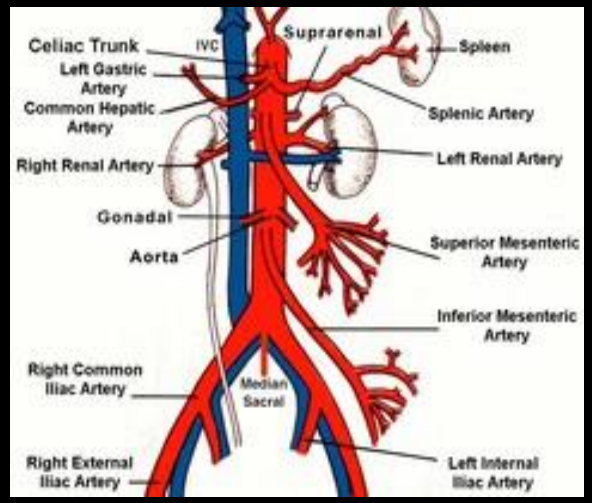
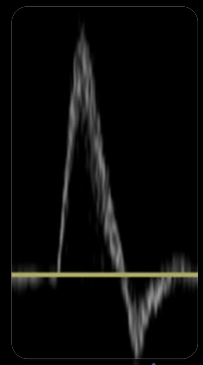
High Resistant Flow

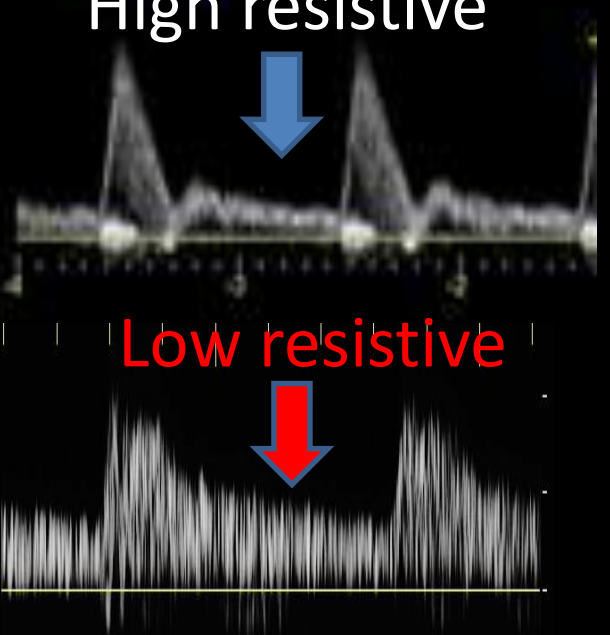
- Aorto-iliac arteries
- Upper and lower peripheral arteries
- Fasting SMA
- Subclavian artery
- External carotid artery



Low or no Diastolic Flow



High resistive



Low resistive

If low resistance is seen in a high resistance bed, something is usually not right !

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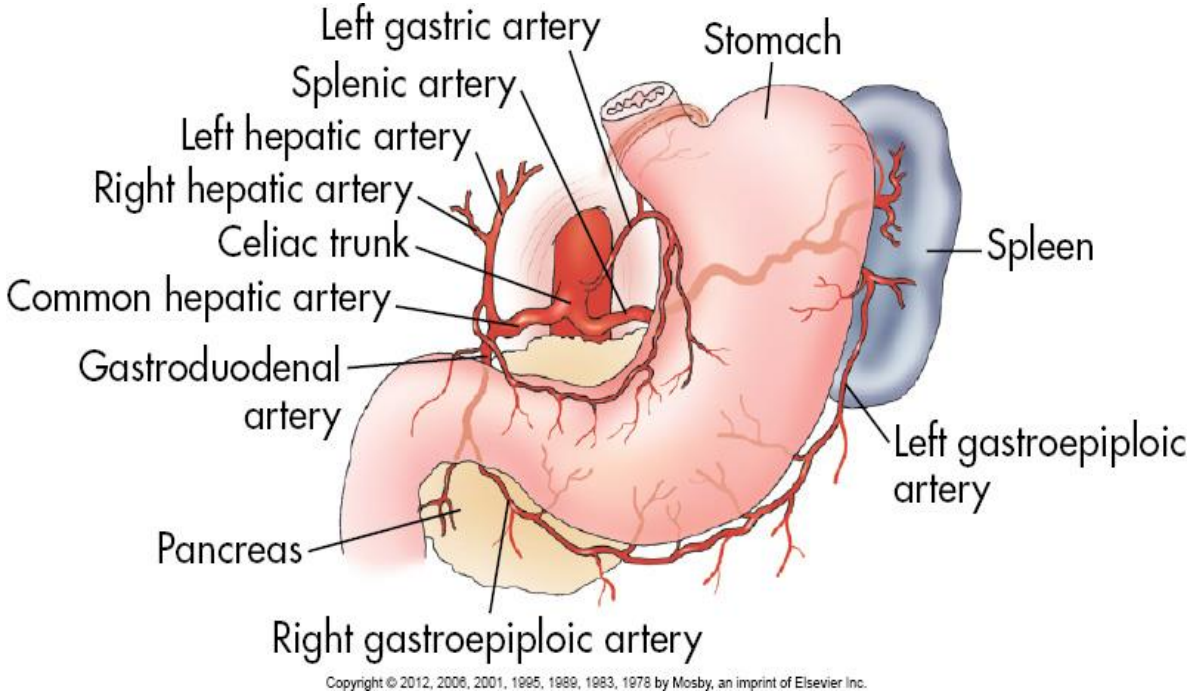
Celiac – SMA Arteries



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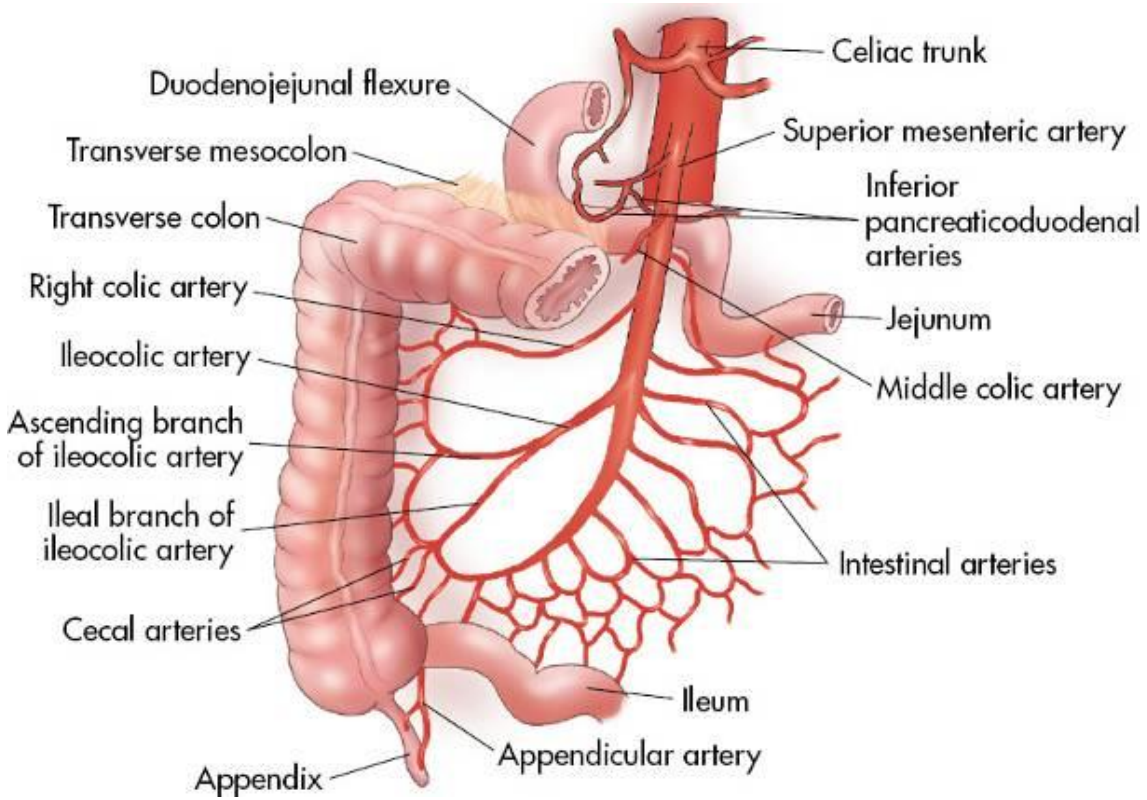

Celiac trunk Flow Distribution
Low Resistive Flow

SMA Flow Distribution
High Resistive Flow

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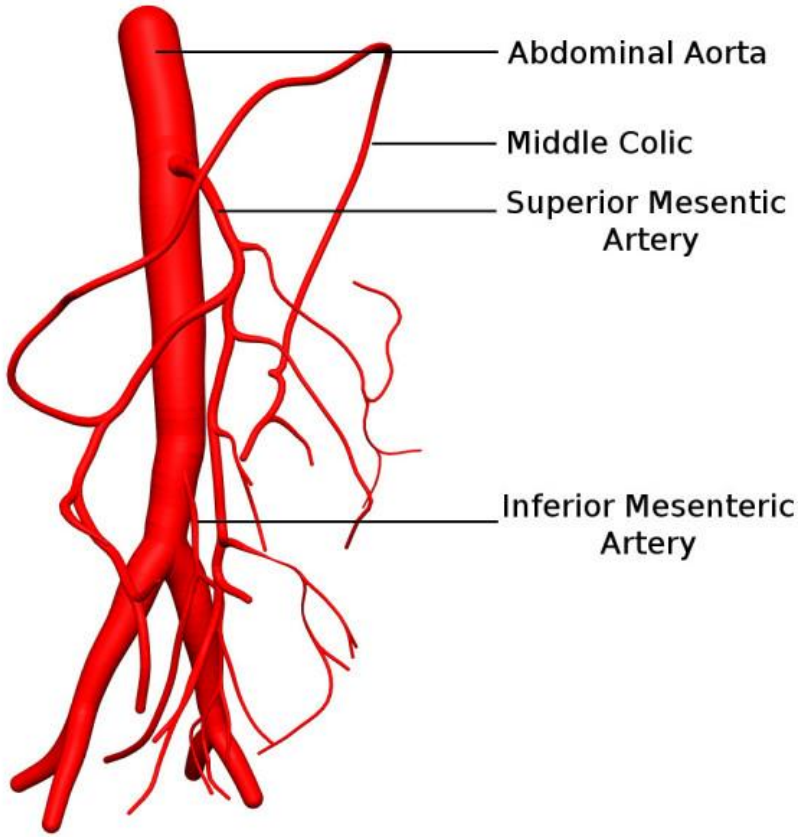
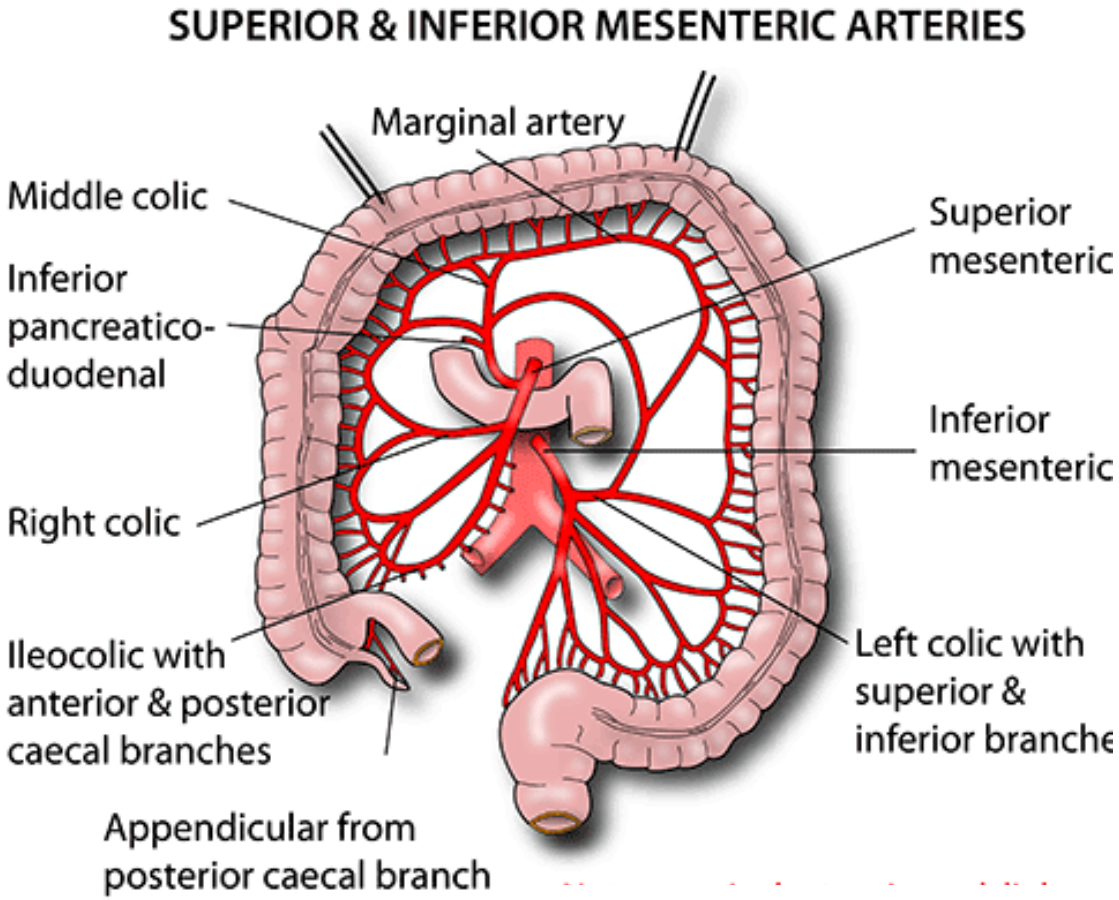
SMA – IMA Arteries





IMA Flow Distribution
High resistive flow

SMA and IMA Flow Distribution

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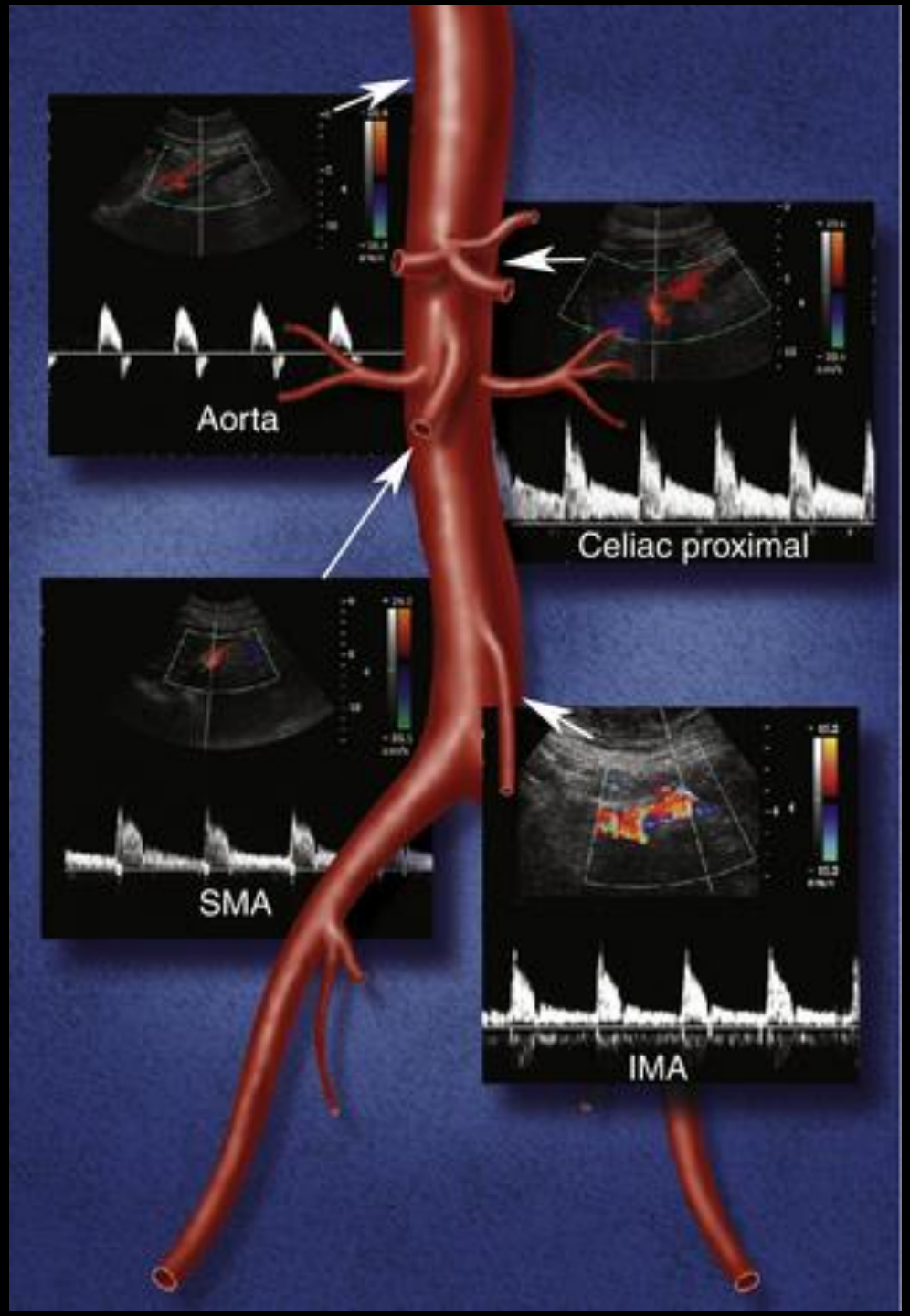

MESENTERIC DOPPLER EXAM

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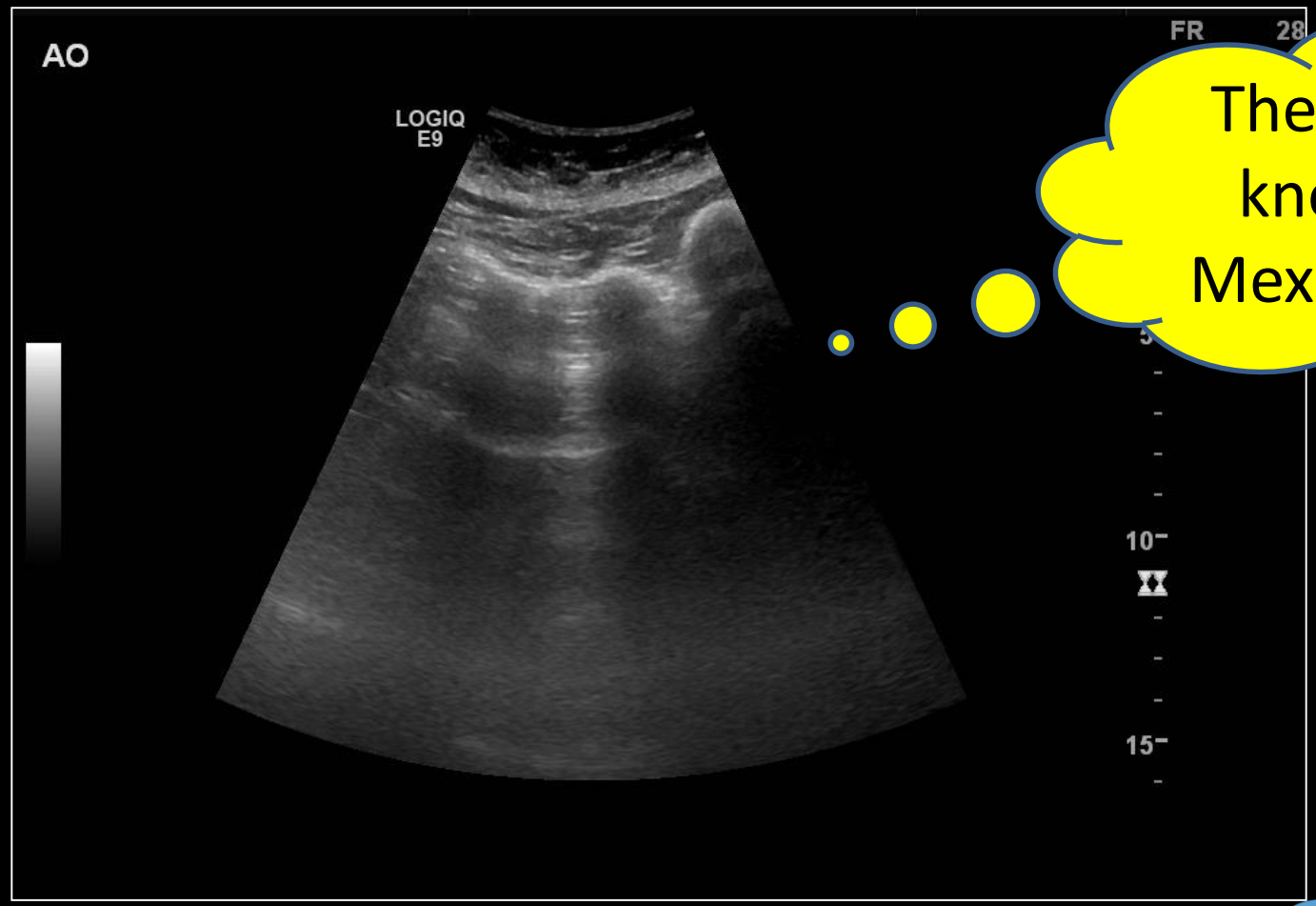
Putting the transducer down for your Duplex Doppler Patient!



They'll never know I had Mexican food!

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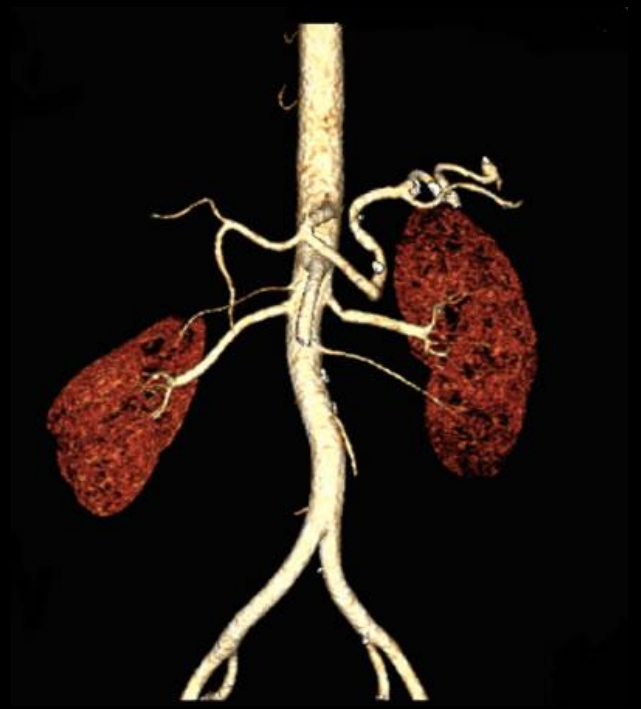
Visceral Duplex Doppler Prep



- Nothing but fluids, Jell-O after 9 pm
- Jell-O is ok for breakfast
- Please take meds !
- No smoking
- Mild laxative (Milk of Magnesia)
- Patients are encouraged to bring a snack for after exam

Research if any prior Duplex Doppler or comparative imaging exams available!

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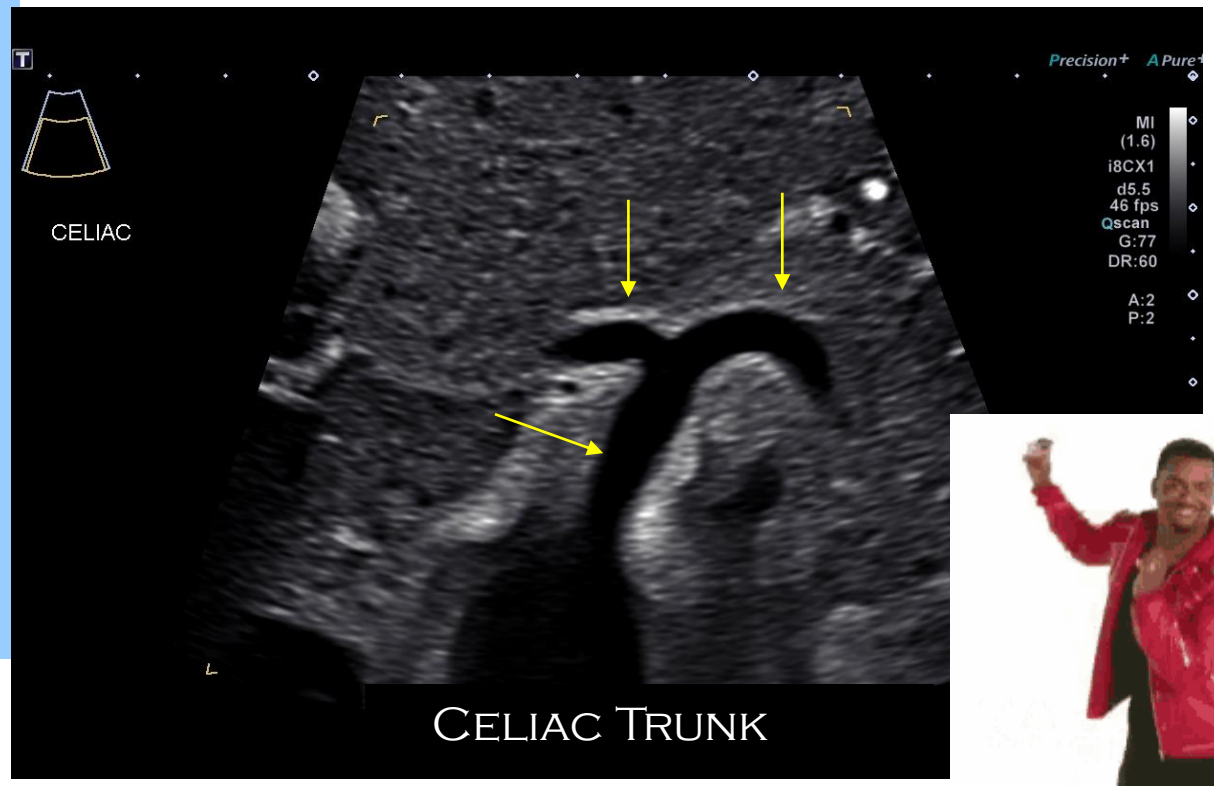
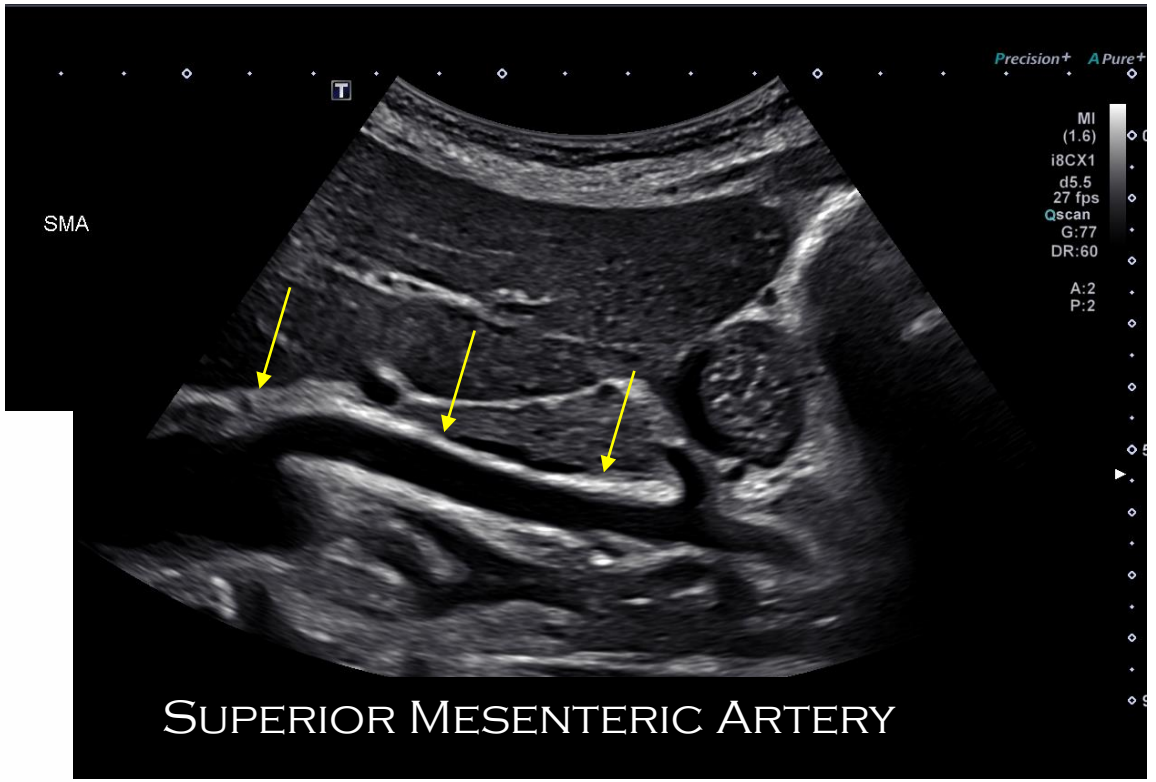
Typical Celiac SMA Examination UNC Rex Healthcare



Celiac Trunk



Superior Mesenteric Artery

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Risk Factors

Atherosclerosis of mesenteric vessels affects
approx. 18% of adults > 65

- Progressive disease leads to blood flow reduction 2nd to sstenosis or occlusion of two or more of major arteries (celiac, SMA, IMA)
- HTN
- Diabetes
- Smoking
- Hypercholesterolemia, obesity, age and genetic factors
- Generalized Atherosclerotic disease (carotid, coronary, renal, extremity arterial, Increased incidence of AAA)
- mesenteric arteries: Females more common

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Clinical Presentation

- Post-prandial pain "Food Fear" (sitophobia)
- Recent unexplained weight loss
- Symptoms often delayed if extensive collateral flow
- Negative GI workup
- Patients are commonly misdiagnosed / other suspected diagnoses
  - Eating disorders, Gallbladder
- Diagnosis often delayed (average time to diagnose 12-18 months!
- CLINICALLY - Abdominal bruit heard
- ACUTE Mesenteric Ischemia – Emboli travels from heart or Ao causing sudden ischemic bowel (SMA most often). Catastrophic event with bowel with becoming infarcted that could lead to death. Needs immediate surgical invention so CT angiography is usually diagnostic modality.

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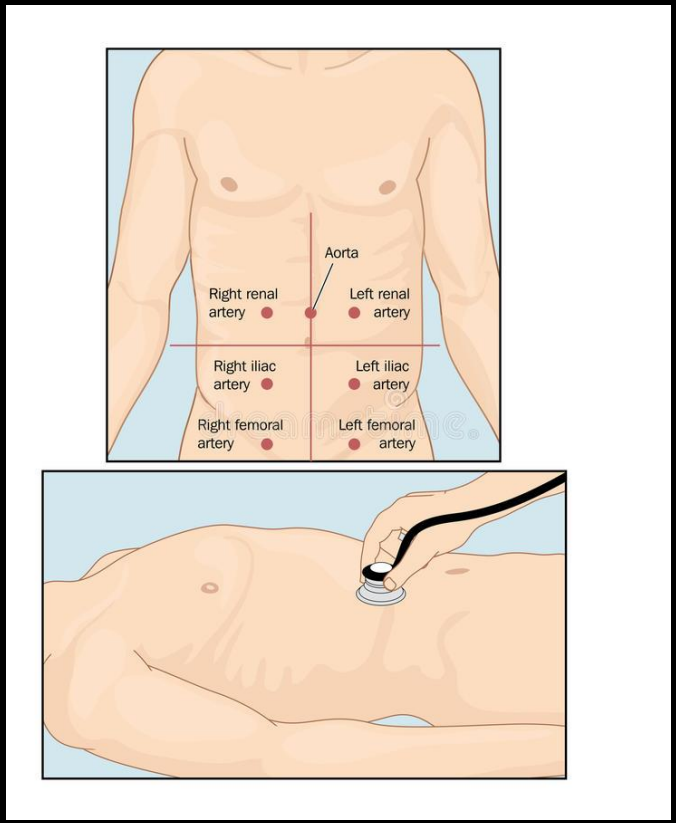
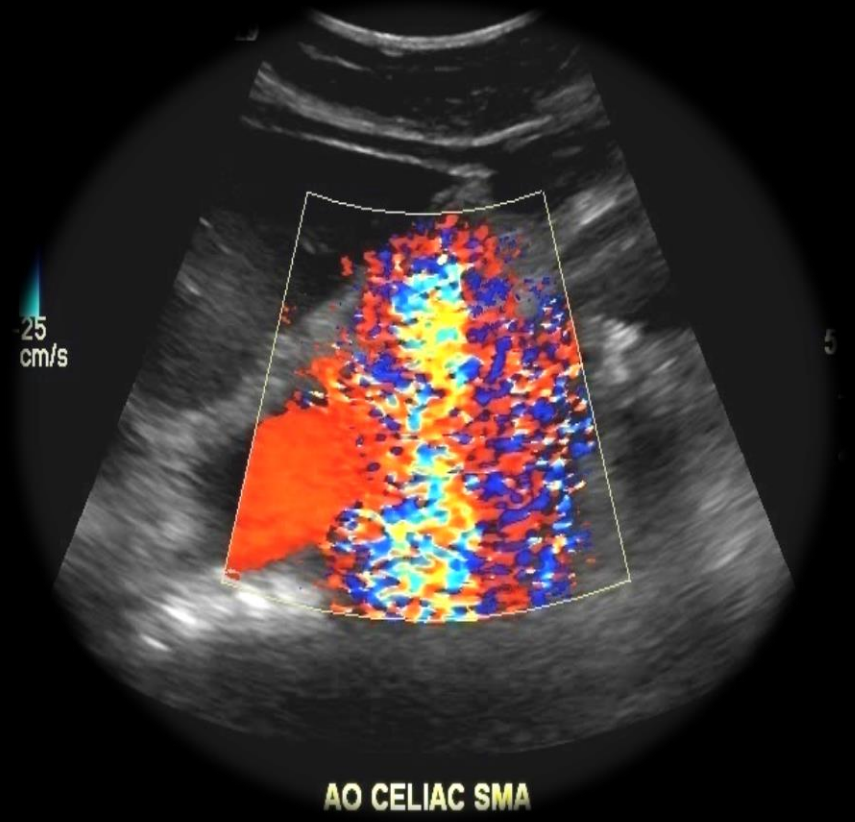
Abdominal Bruit may be heard during Physical Exam





Duplex Doppler is preferred diagnostic test

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Patient Positioning

- Supine
- Semi-upright position
- Erect
- Use liver as a window
- Oblique approaches

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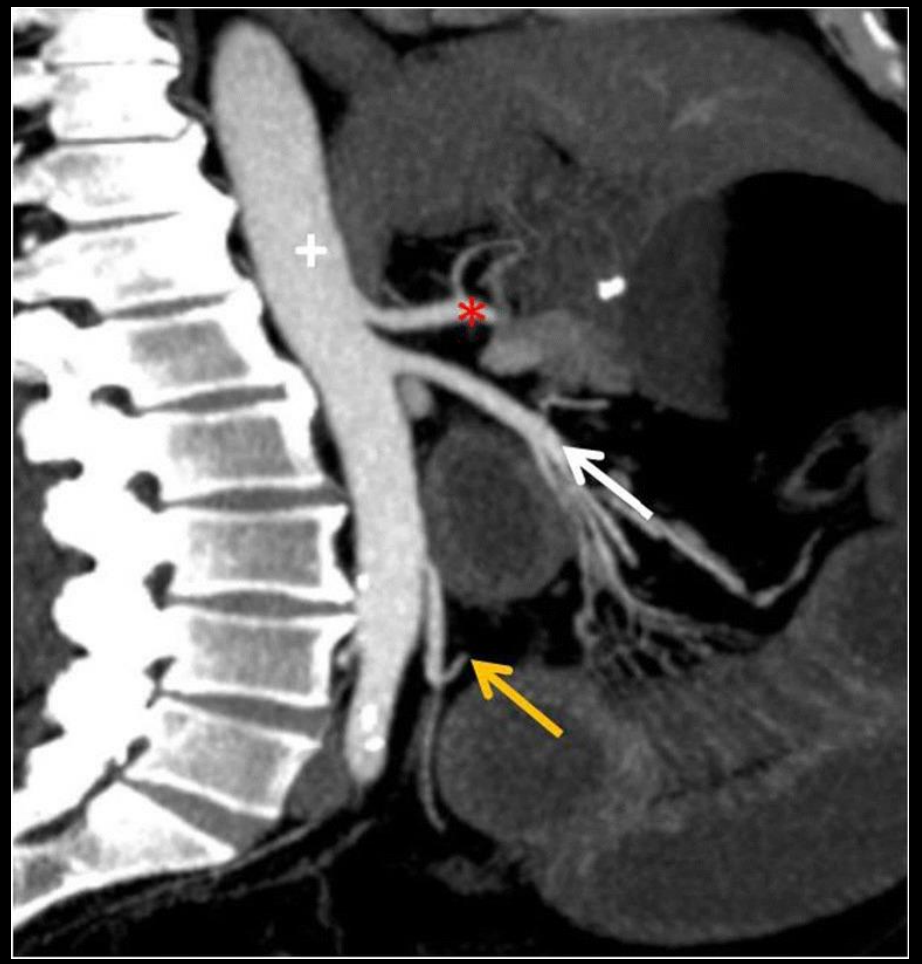
Mesenteric Doppler Protocol

- Aorta
- Celiac
- Celiac branches
  - –Splenic
  - –Hepatic*ck direction
- SMA – Prox, mid *distal
- IMA*If visualized
- Evaluate with 2D, color and obtain PSV, EDV Doppler



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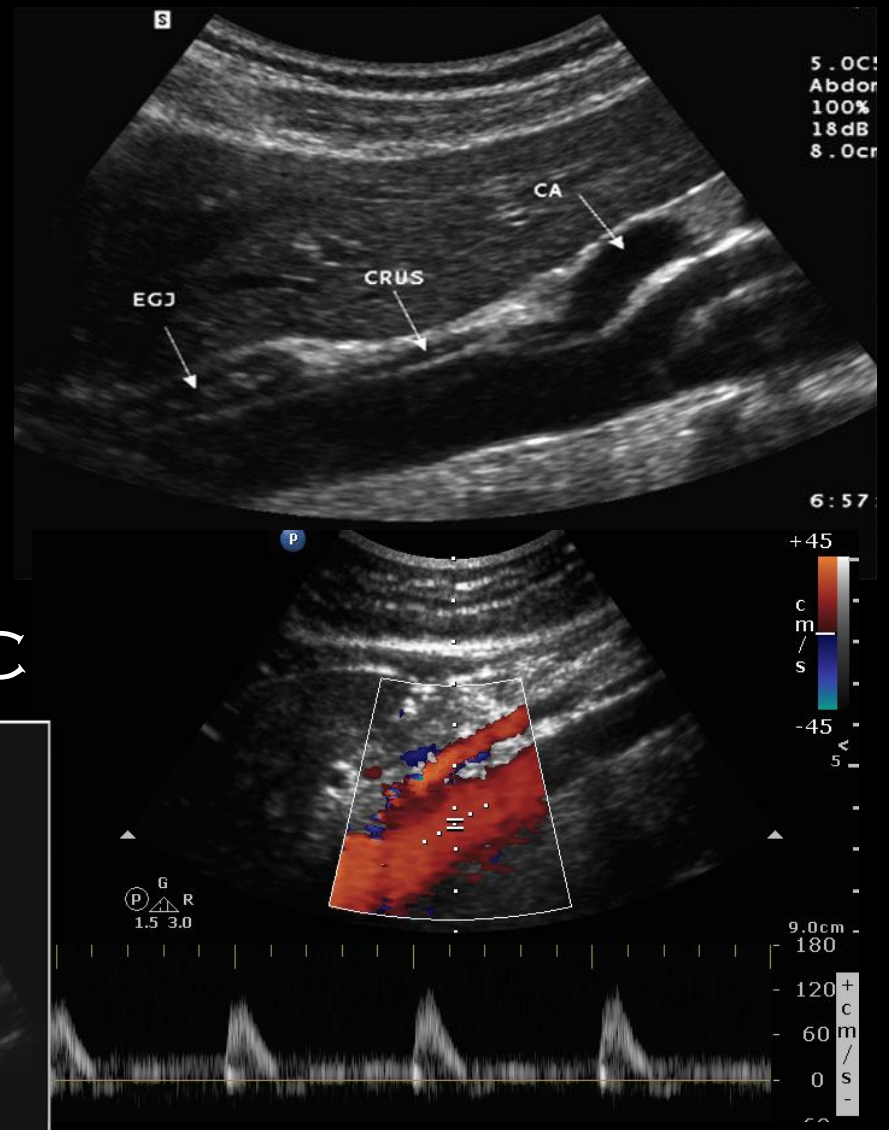
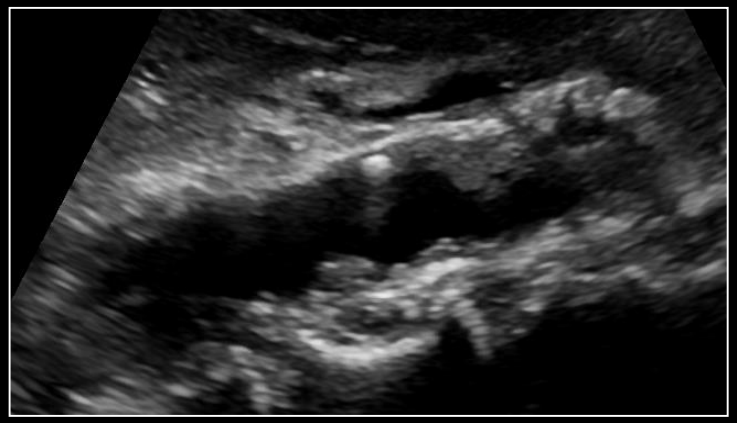
Aorta

- Identify Vasculature
- Doppler at Level of celiacc artery
- Use PSV for ratios
- Normal Ao PSV < 100 cm/sec





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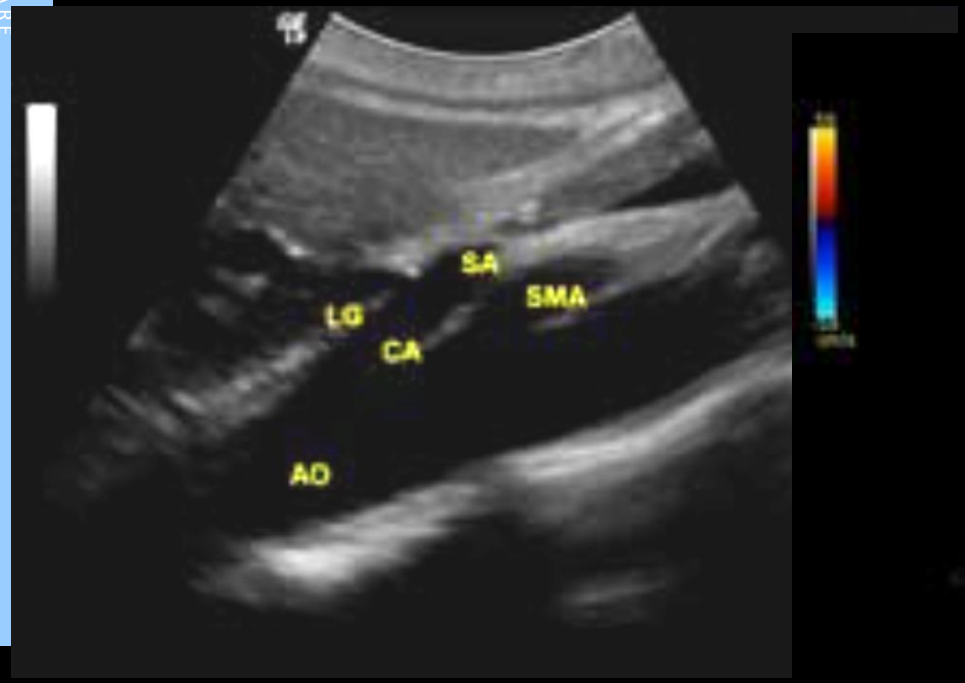
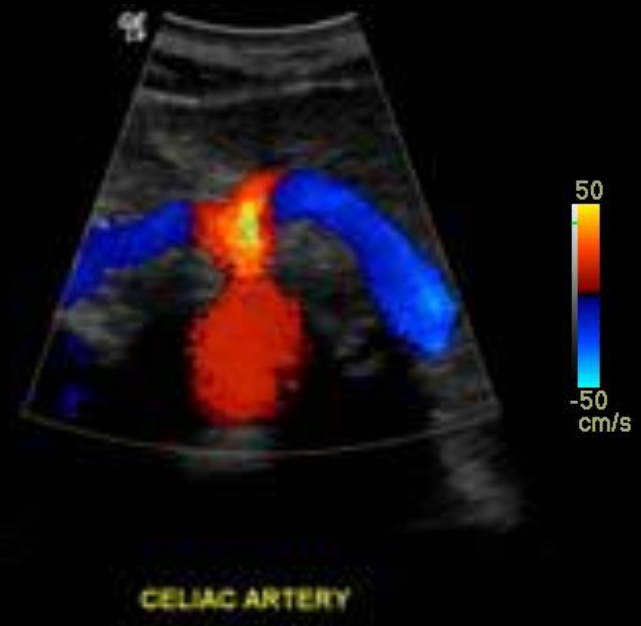
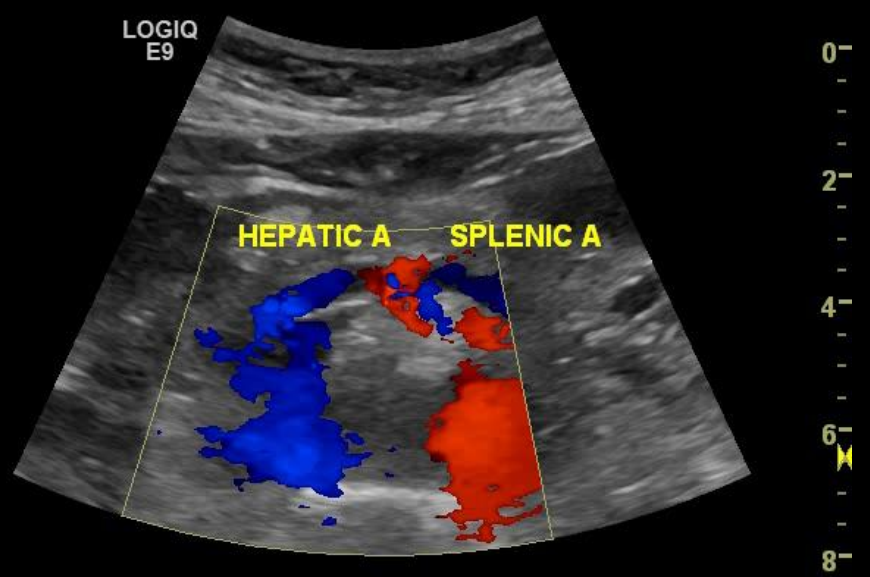
Celiac Artery







Classic Celiac Anatomy is seen in 65-75% of the population

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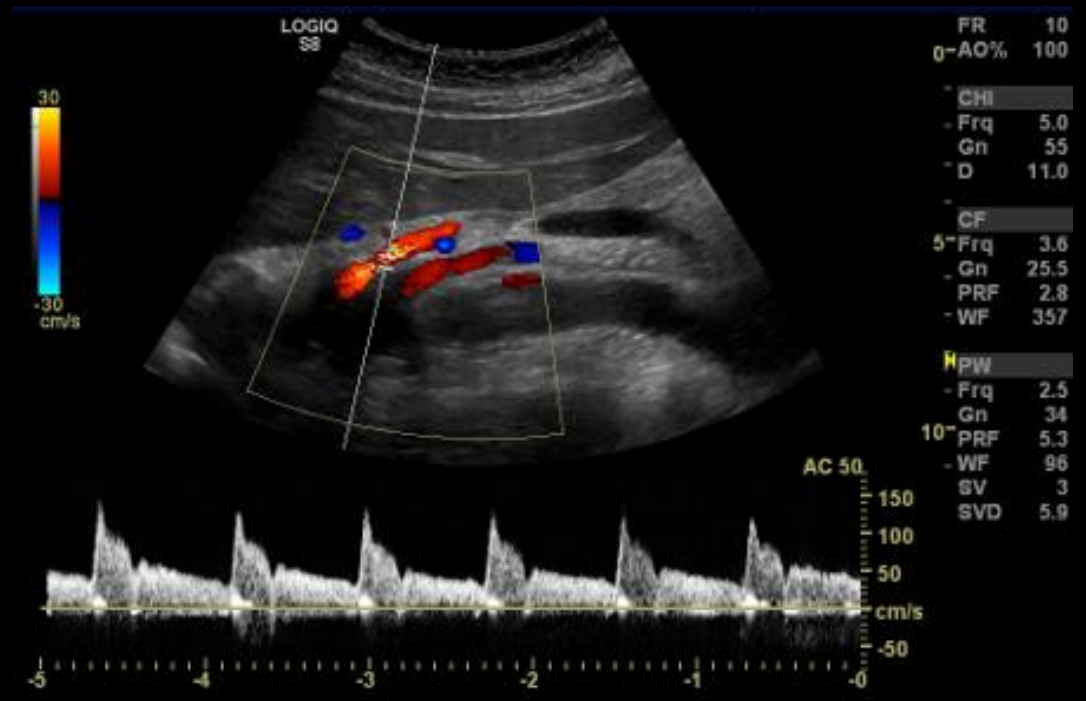
Normal Celiac Artery



- Celiac PSV < 200 cm/sec
- EDV 35 cm/sec

- Rapid systolic upstroke
- high diastolic flow feeding low resistance vascular bed
- Uniform velocities without turbulence

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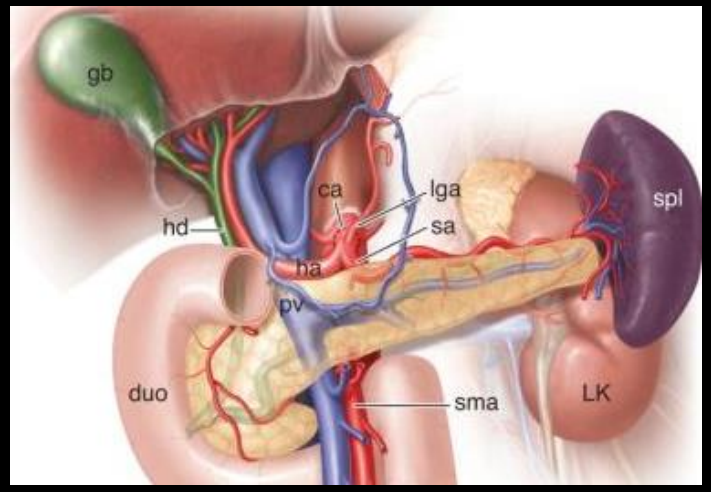
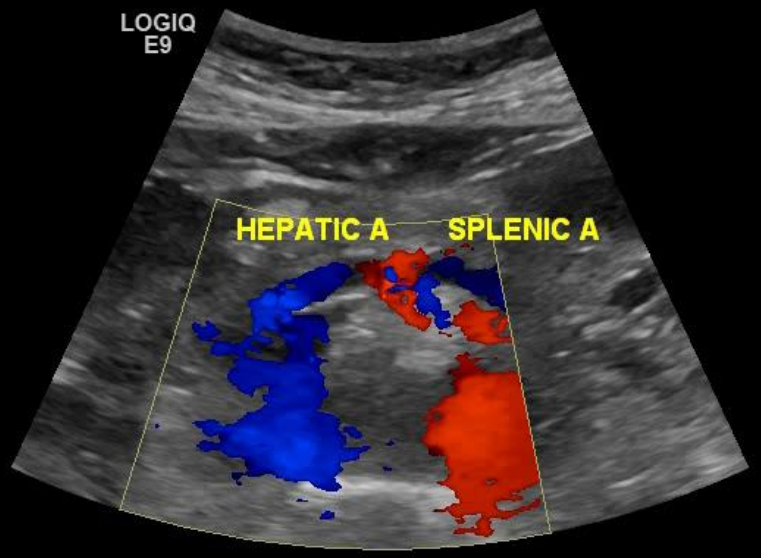
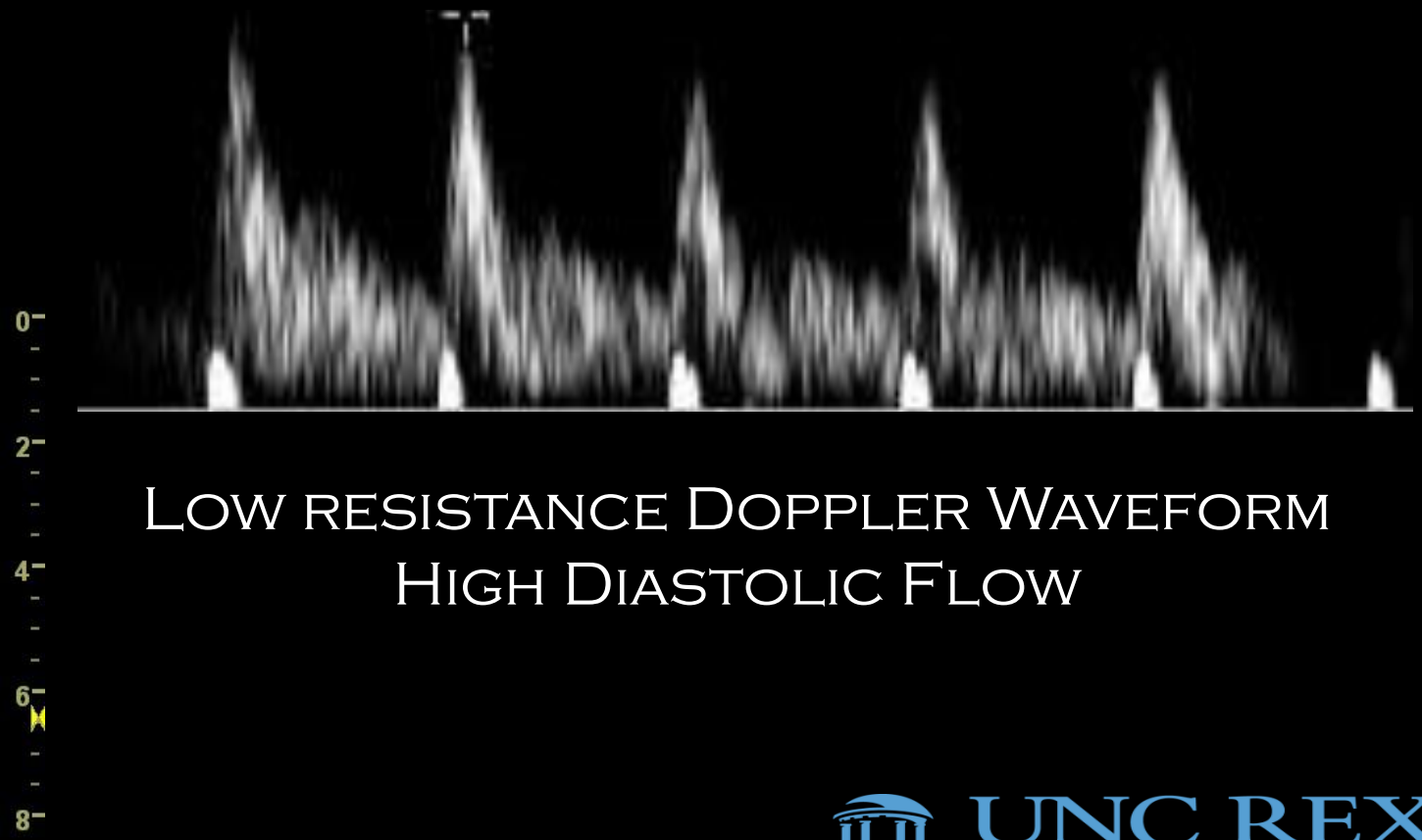
Normal Splenic Artery







Low resistance Doppler Waveform
High Diastolic Flow

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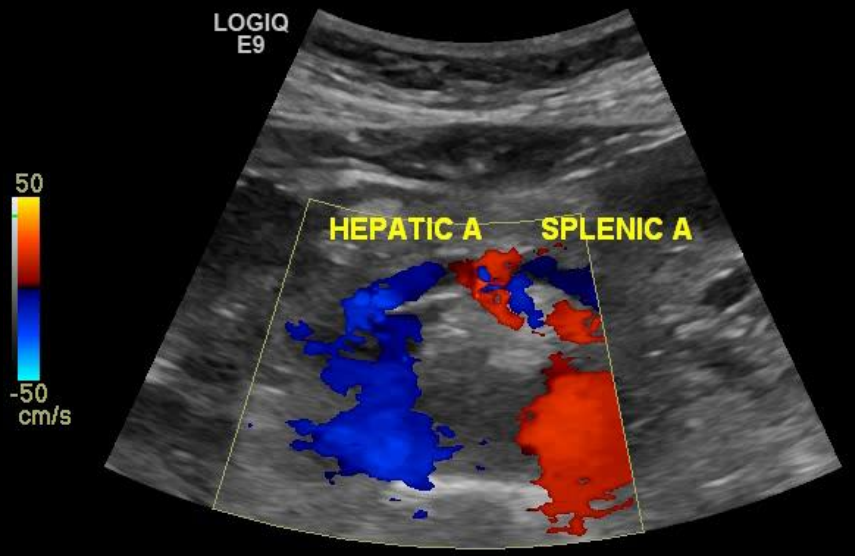
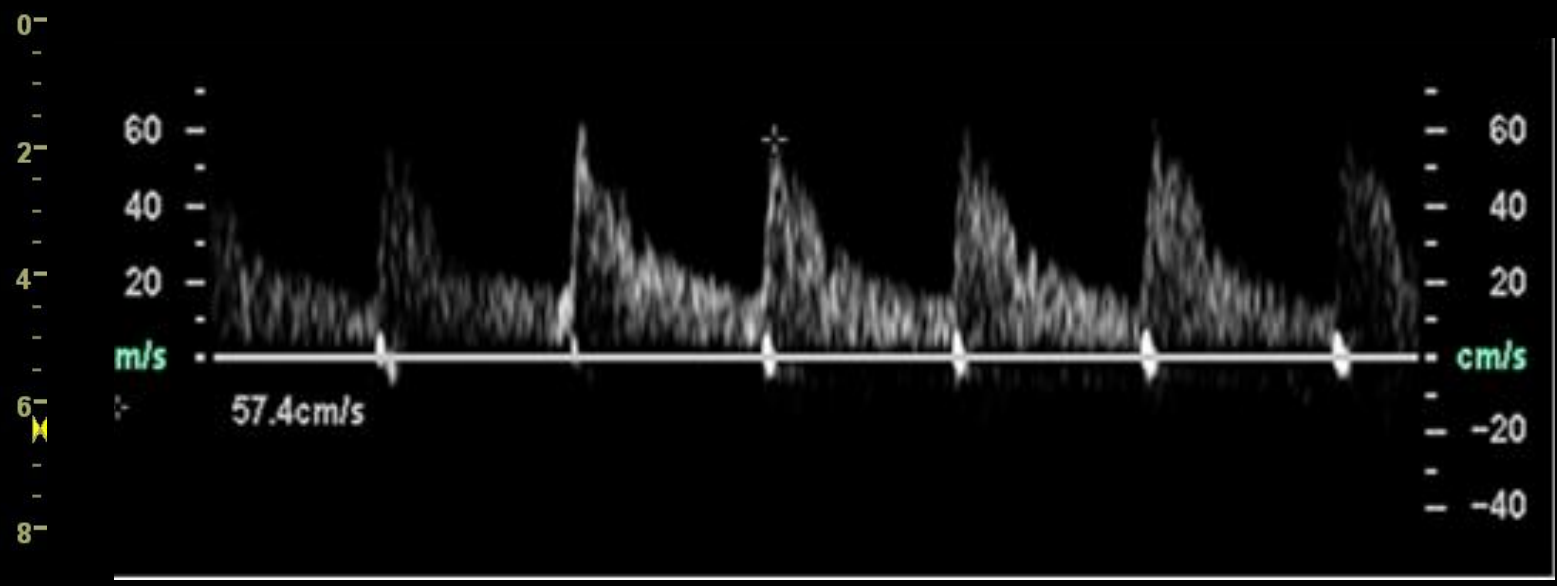
Normal Common Hepatic Artery





Low resistance Doppler Waveform
High Diastolic Flow

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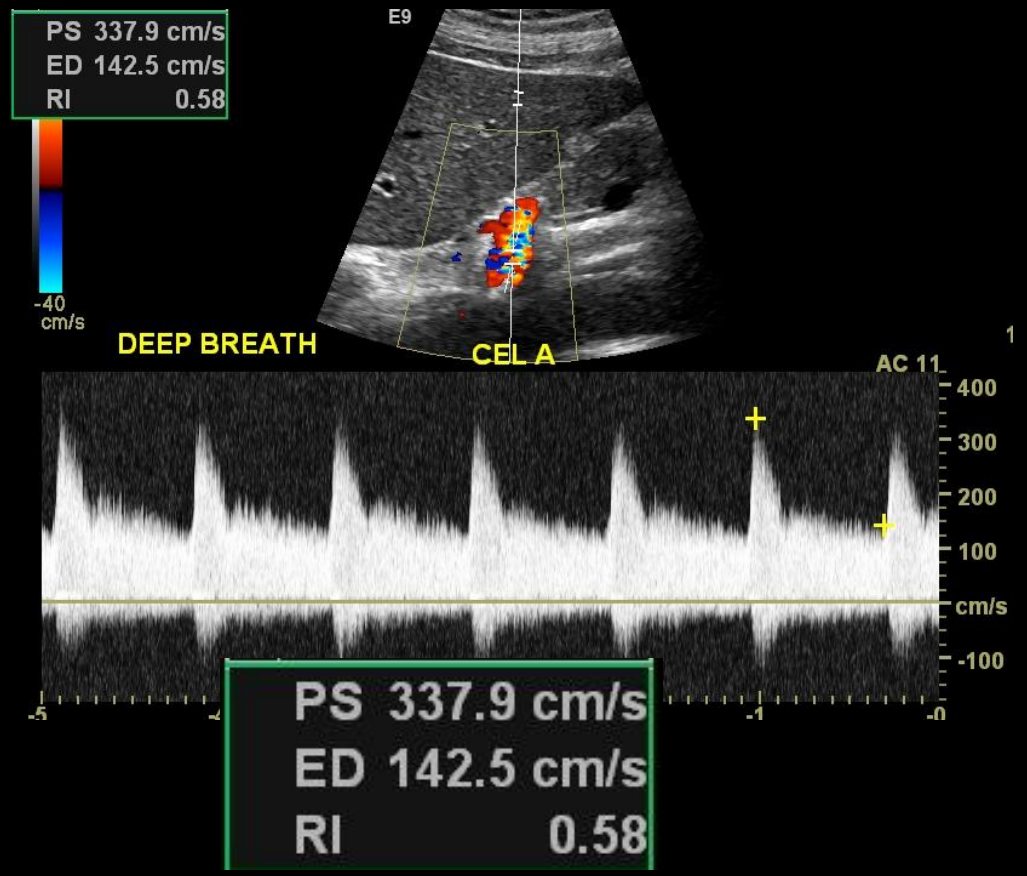
Celiac Artery Stenosis Diagnostic Criteria

Stenosis 70% or greater
- PSV > 200 cm/sec
- EDV> 55 cm/sec

Post stenotic turbulence

*Important to Obtain a few Dopplers to confirm highest PSV and reproducible



Moneta GL, Yeager RA, Dalman R, et al. Duplex ultrasound criteria for diagnosis of splanchnic artery stenosis or occlusion J Vasc Surg 1991:14:511-8
Robert M. Zwolak, MD, PhD et.al JVS 1998

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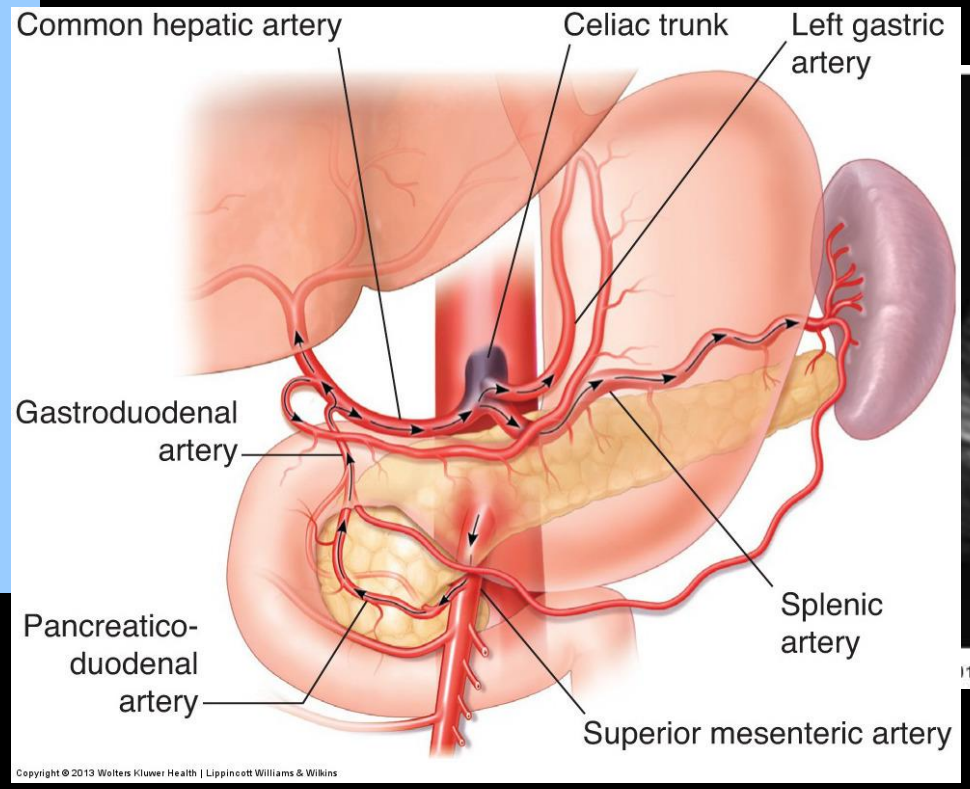
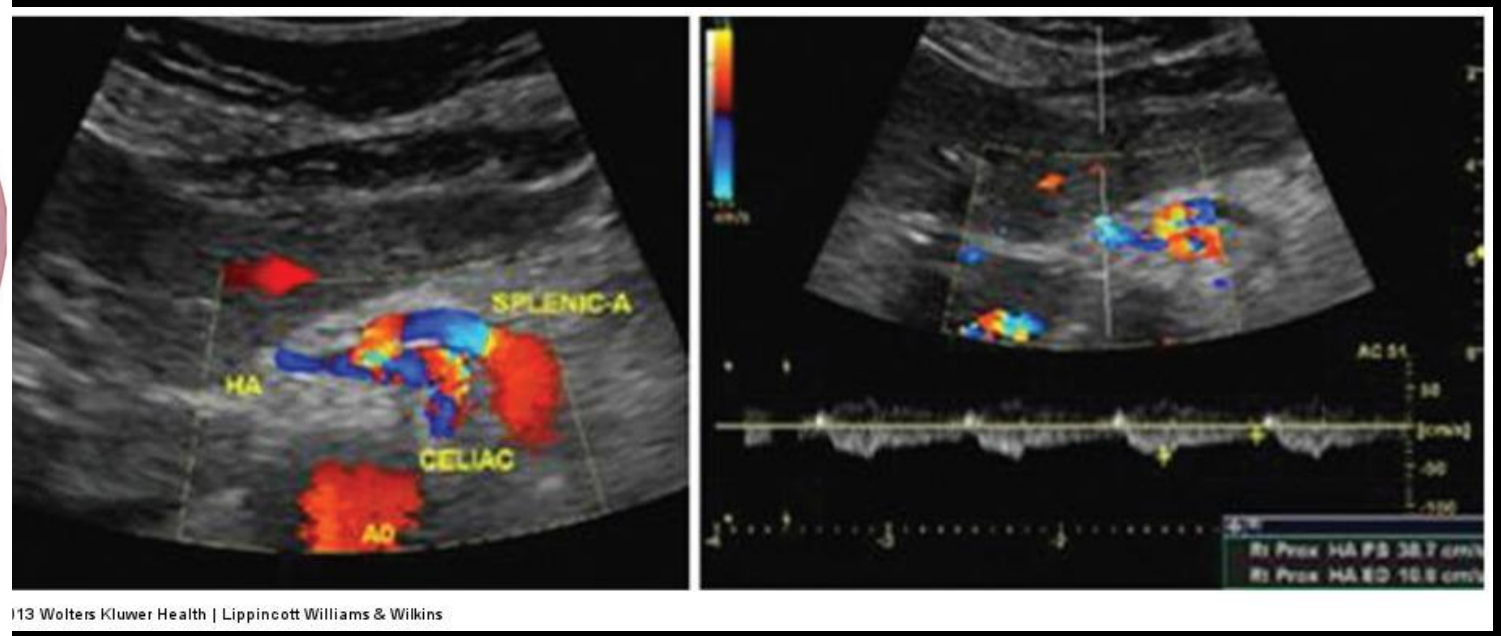
If the celiac is occluded/severely stenotic Look for retrograde collateral flow in common hepatic artery and antegrade flow in splenic artery





Ref – Textbook of Diagnostic Sonography, Hagen-Ansert, 2018

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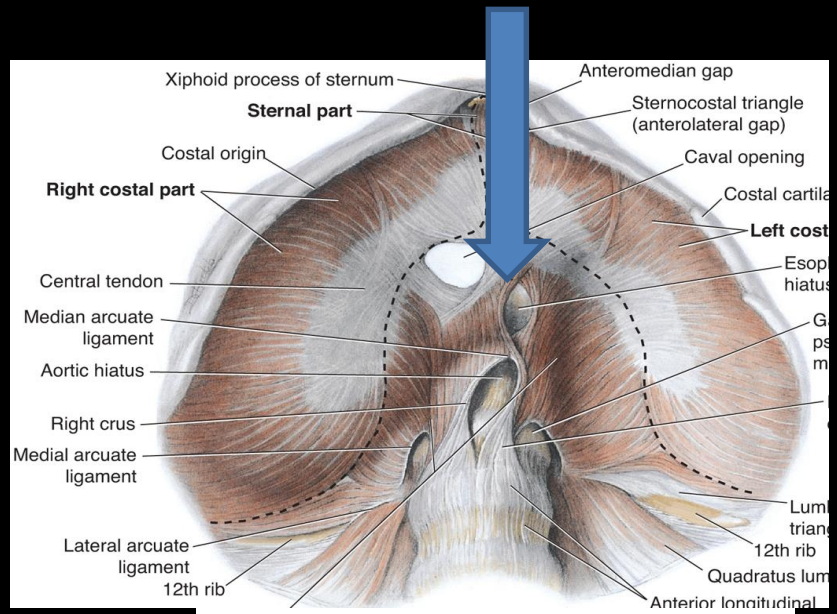
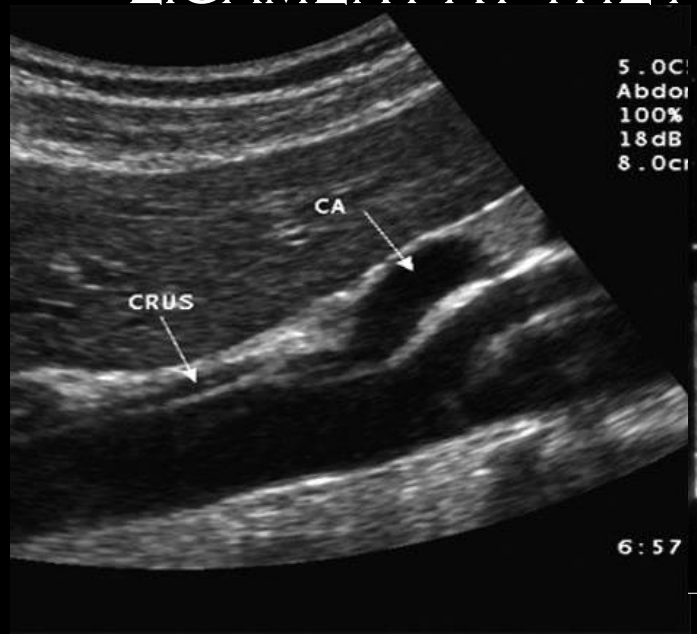
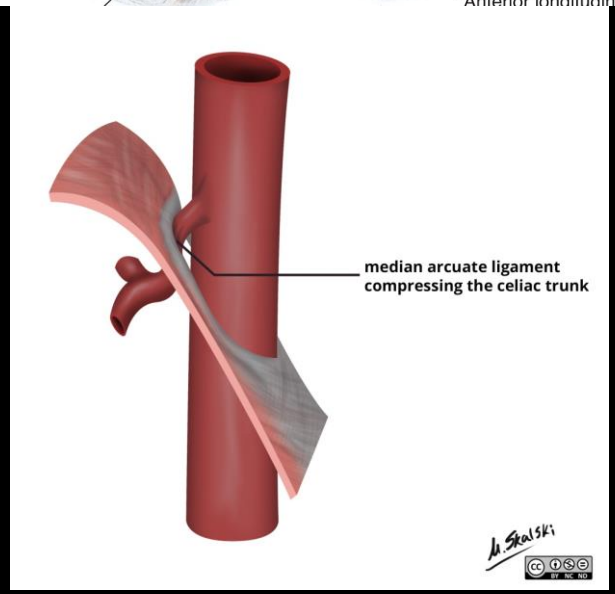
If increased Celiac PSV Consider Celiac Compression

Median Arcuate Ligament Syndrome

- Two diaphragmatic crura arise from vertebral bodies on each side
- pass superior/anterior to surround aortic opening joined by the median arcuate ligament at the aortic hiatus
-
-
-







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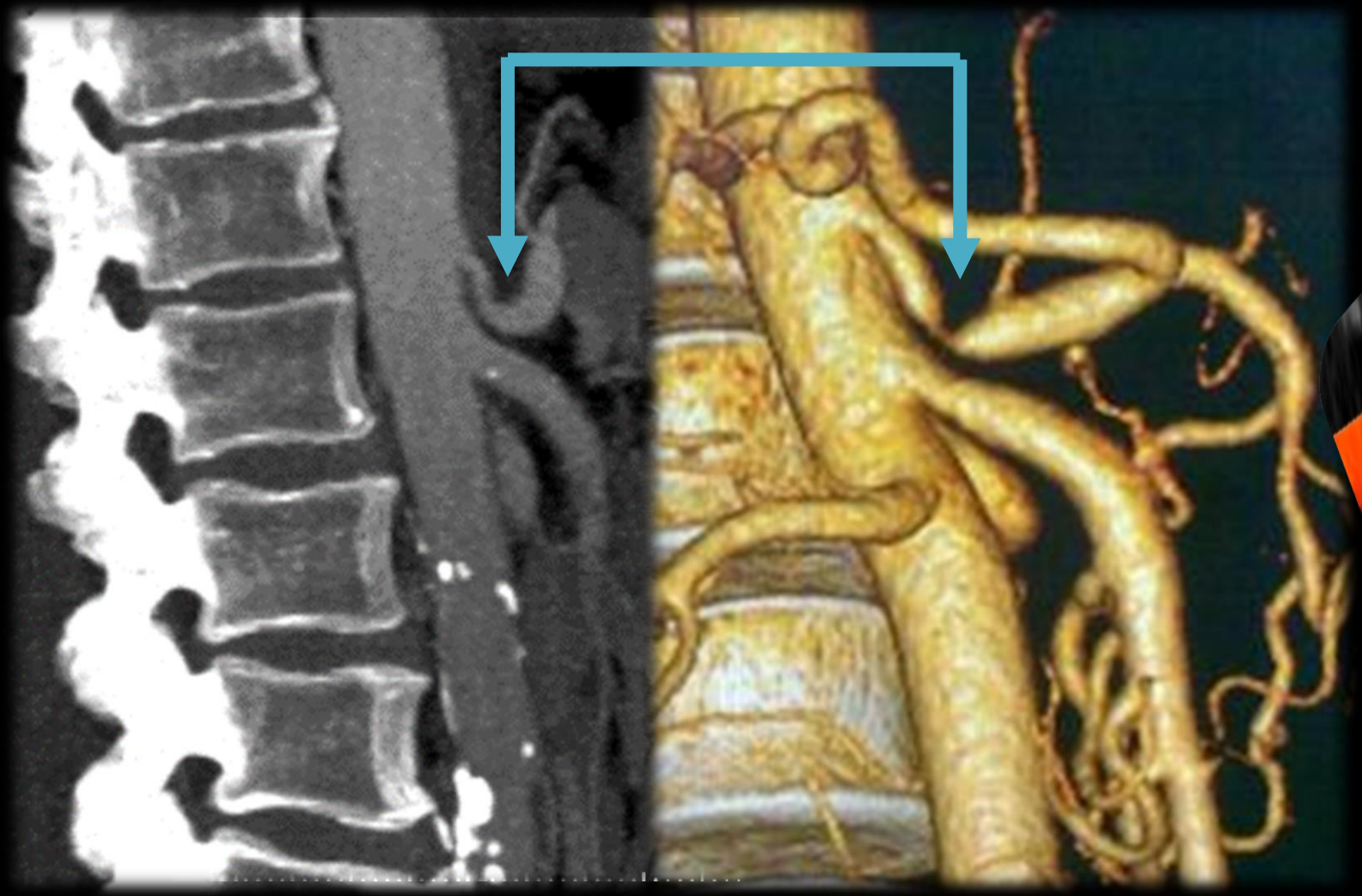
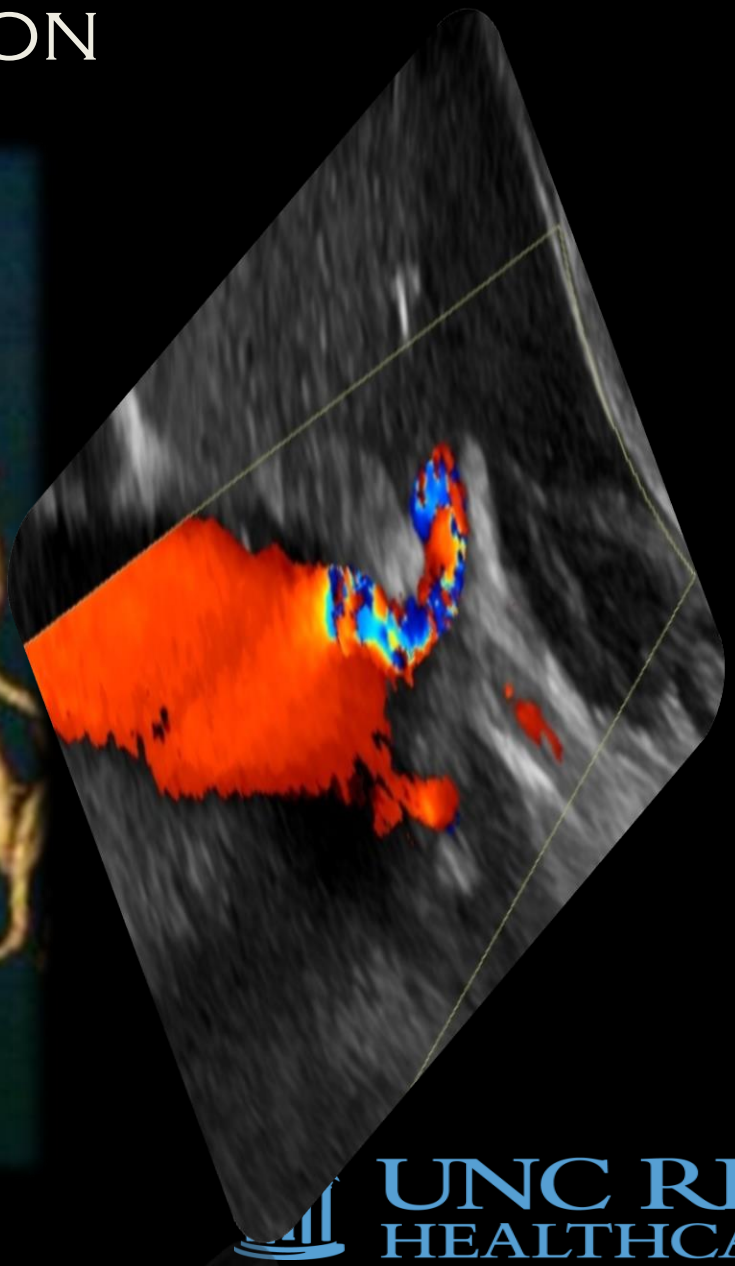
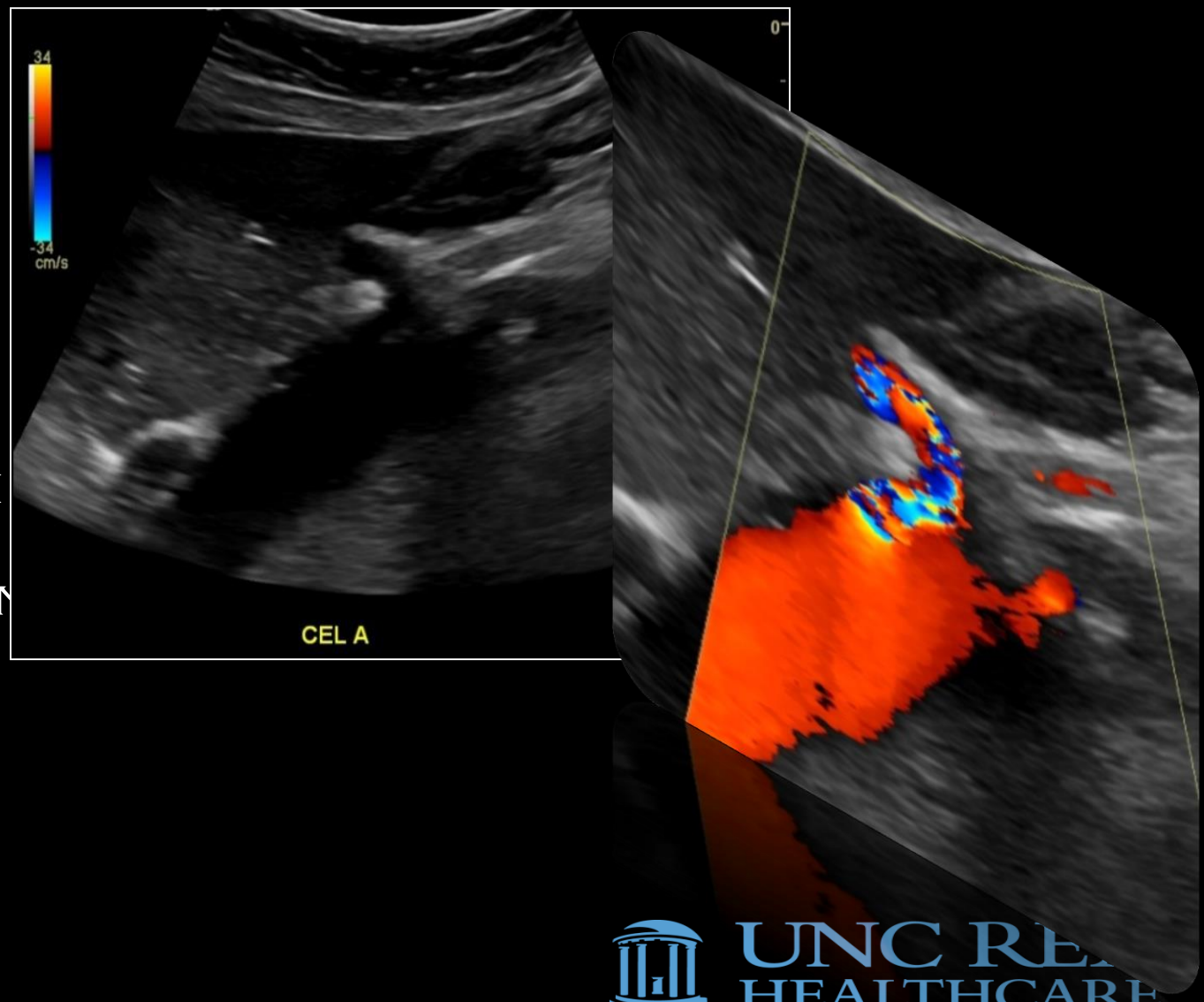
Celiac Compression





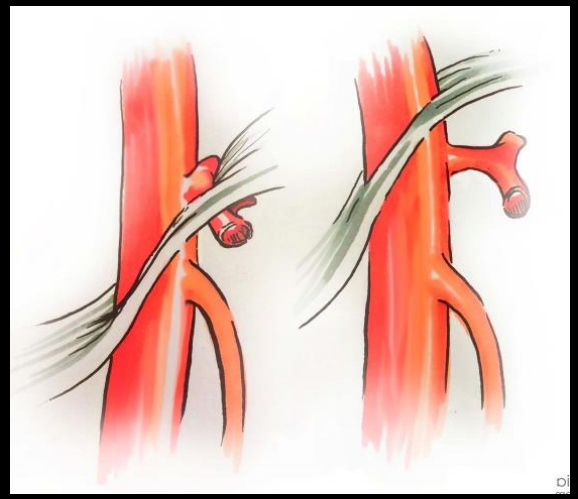
Celiac Compression

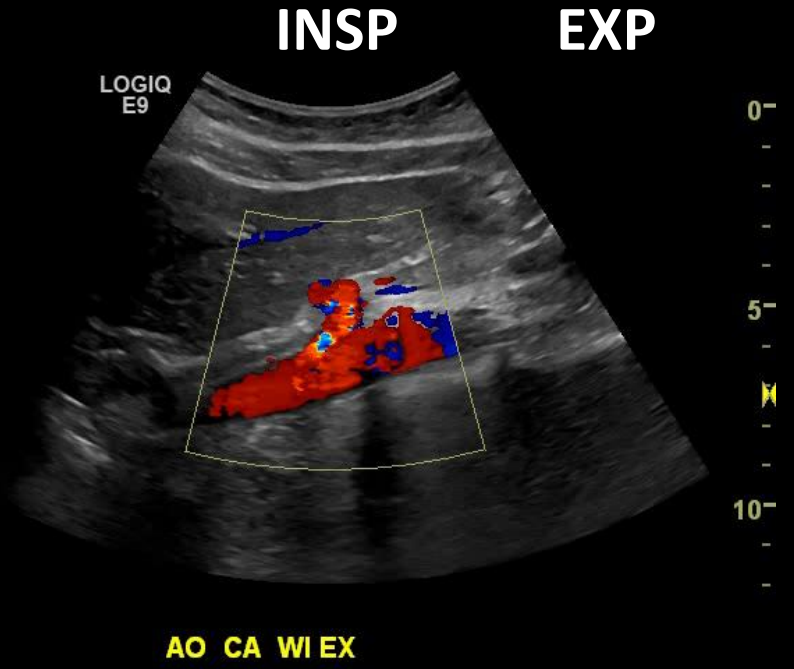
- Most commonly affects-
  - Young age (20-40 yrs.)
  - Female
  - Thin
- Characteristic indentation or "hooked" appearance
- Will help to differentiate from atherosclerotic narrowing
- Often intermittent compression
- Evaluate with patient with inspiration/expiration
- possibly supine and erect



Celiac Compression

- PSV decreases with inspiration
- PSV also decreases with **upright** position
- Some have severe compression that persists during BOTH insp/Exp
- Look for post stenotic dilatation
- SMA rarely involved
- Collateralization can occur from SMA through pancreaticoduodenal arcade (look for retrograde GDA)





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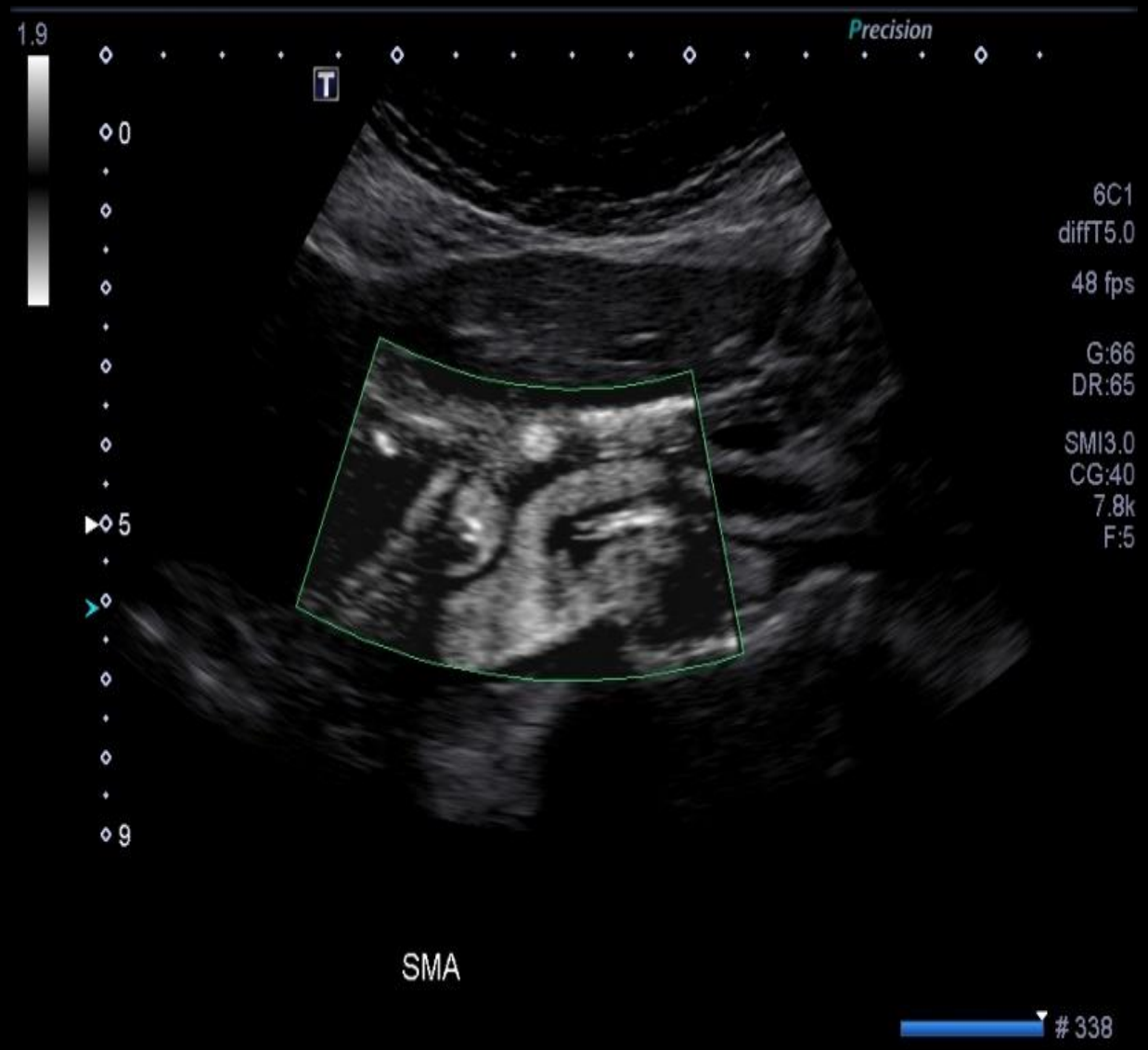
Symptomatic Median Arcuate Ligament Patient



Angiogram with
Post Stenotic Dilation

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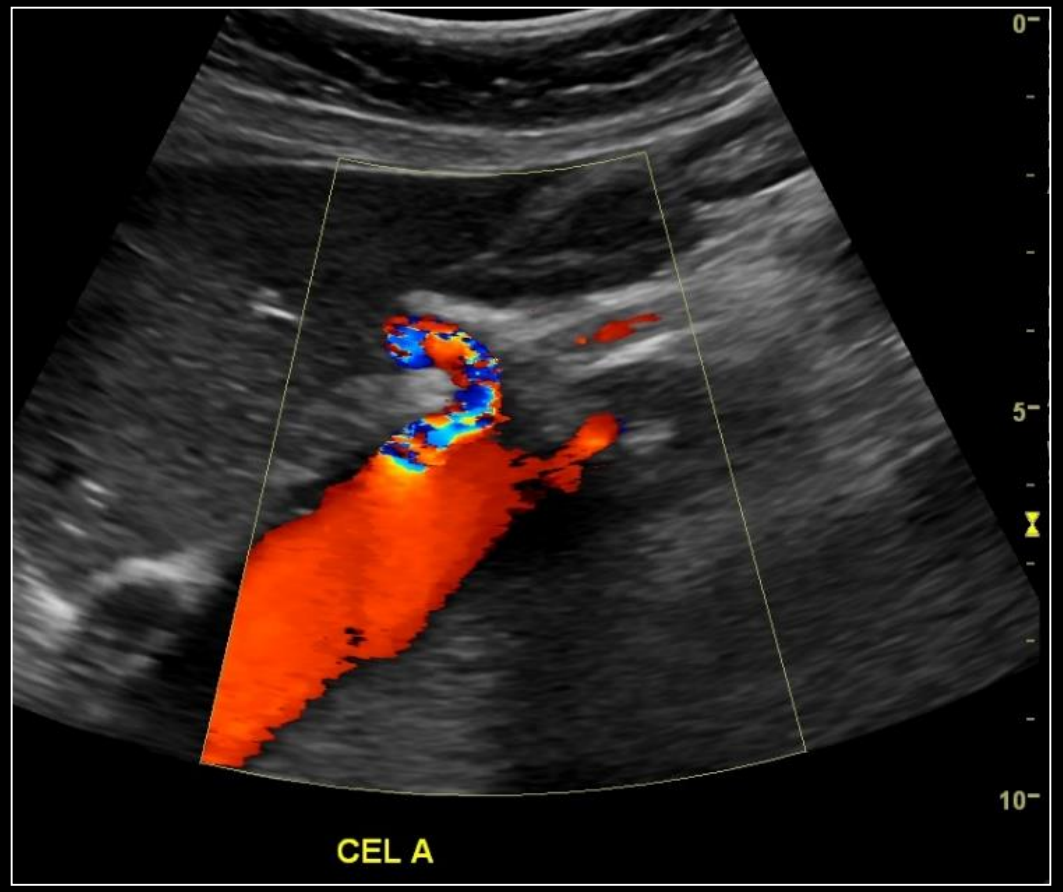
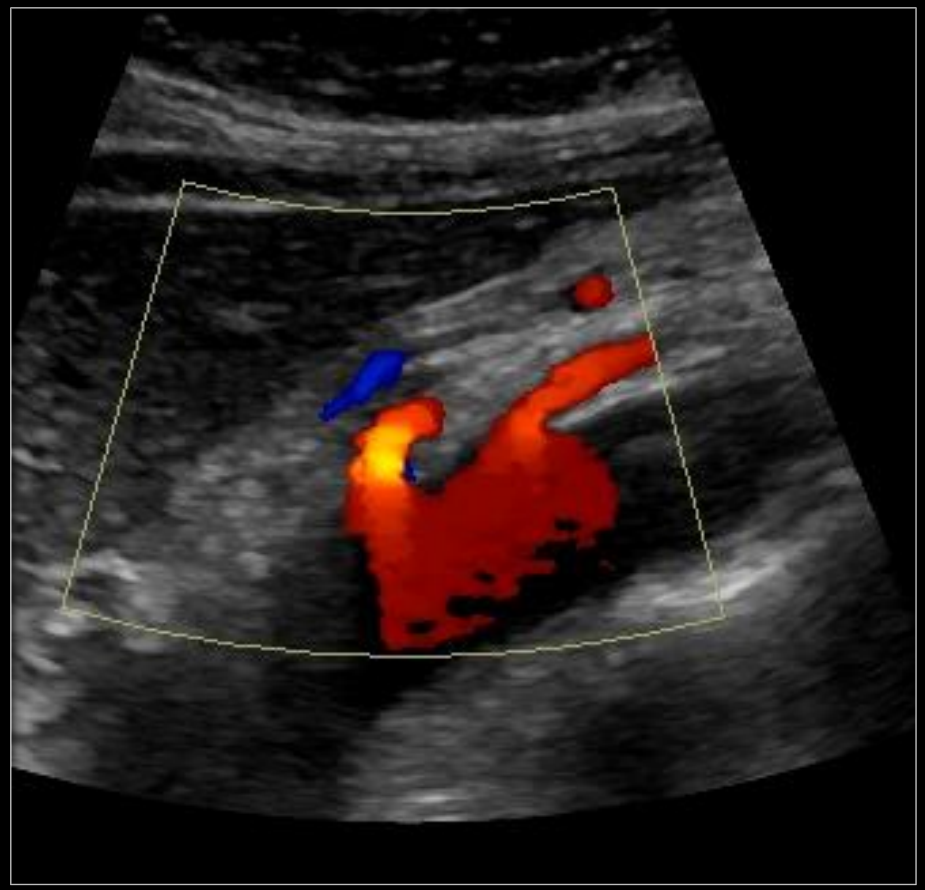
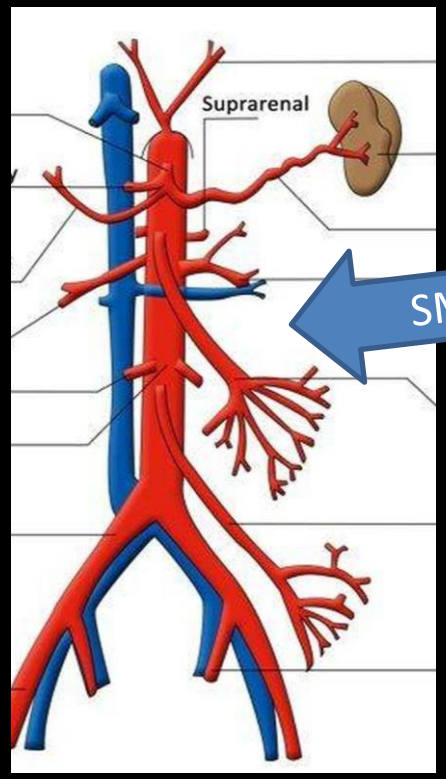
Pre and Post Surgical Procedure





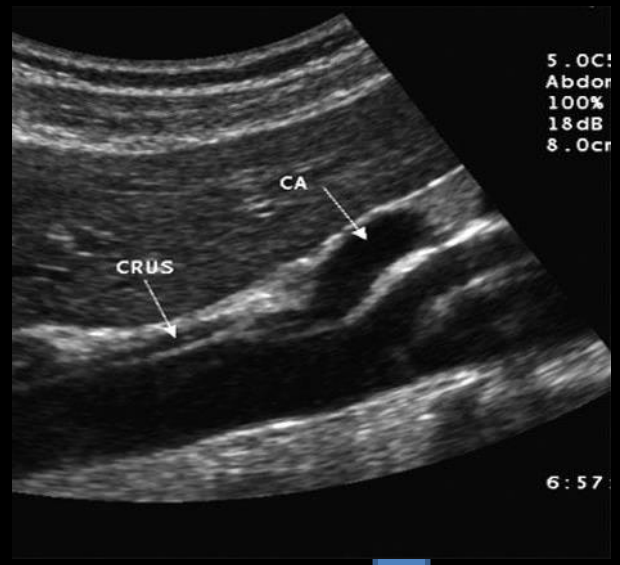
Superior Mesenteric Artery

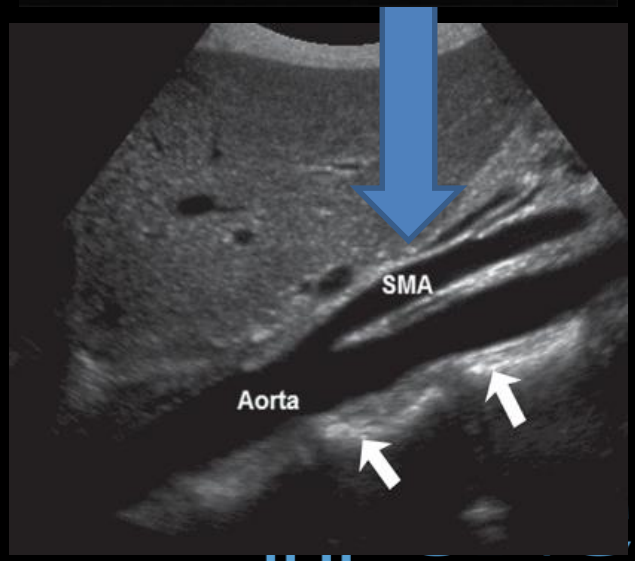


- Arises 1-1.5cm below celiac
  - Runs parallel to AO

Just superior to renal arteries

- LRV passes underneath SMA



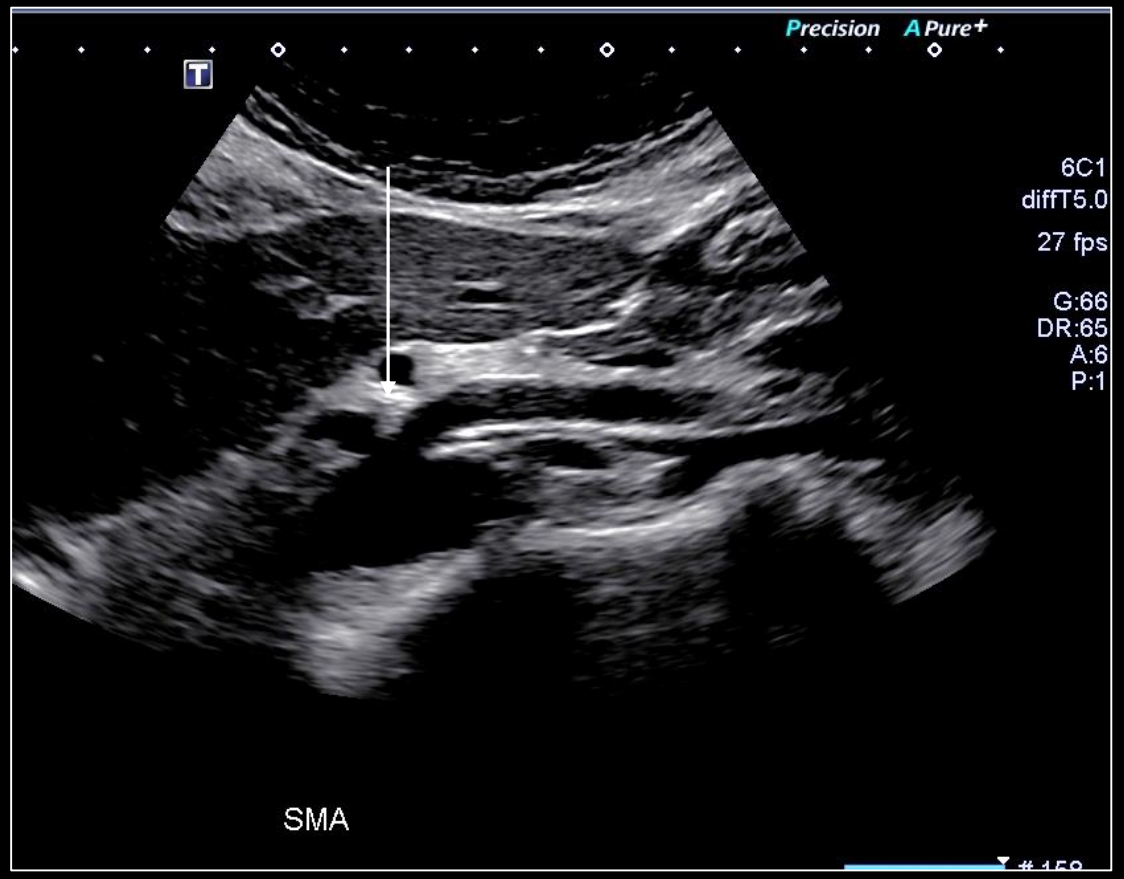


REX HEALTHCARE

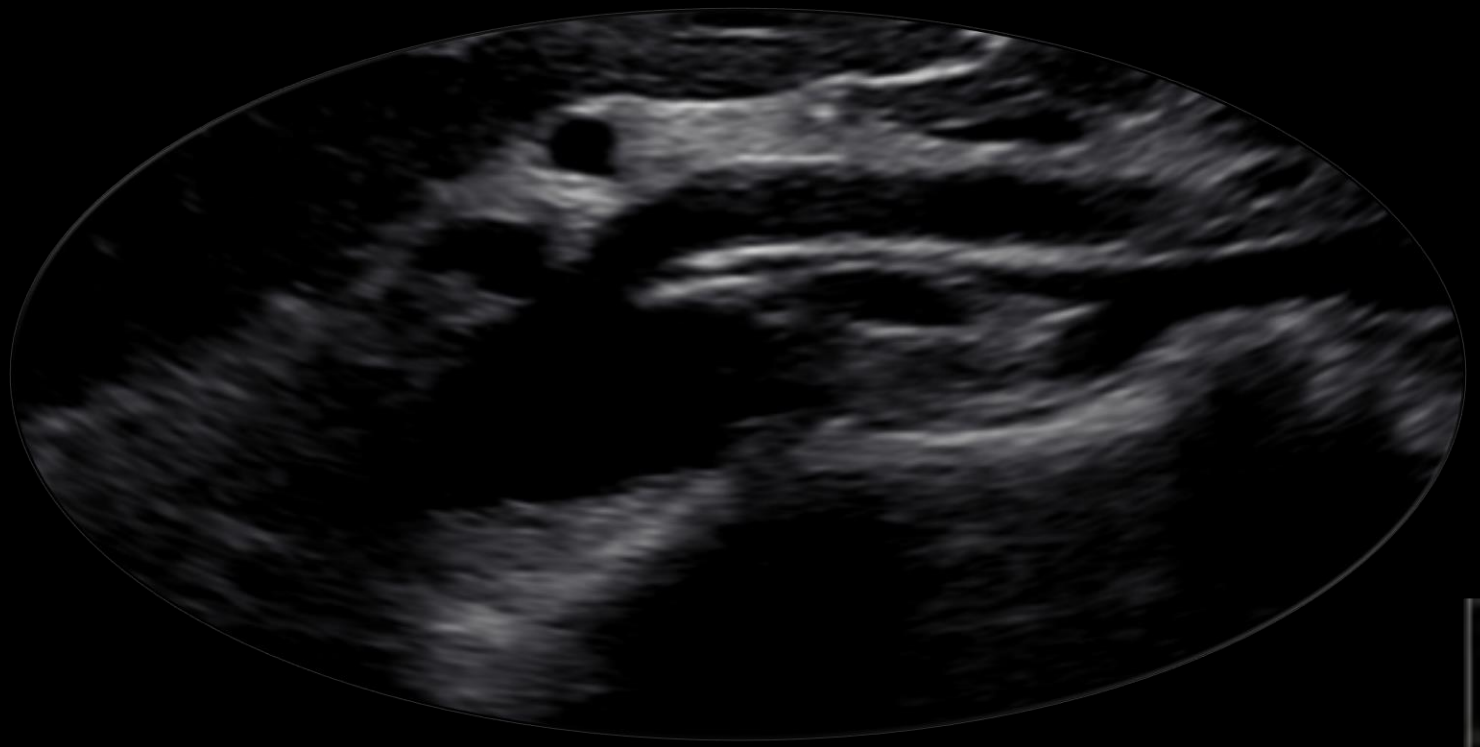
Anatomical Variants

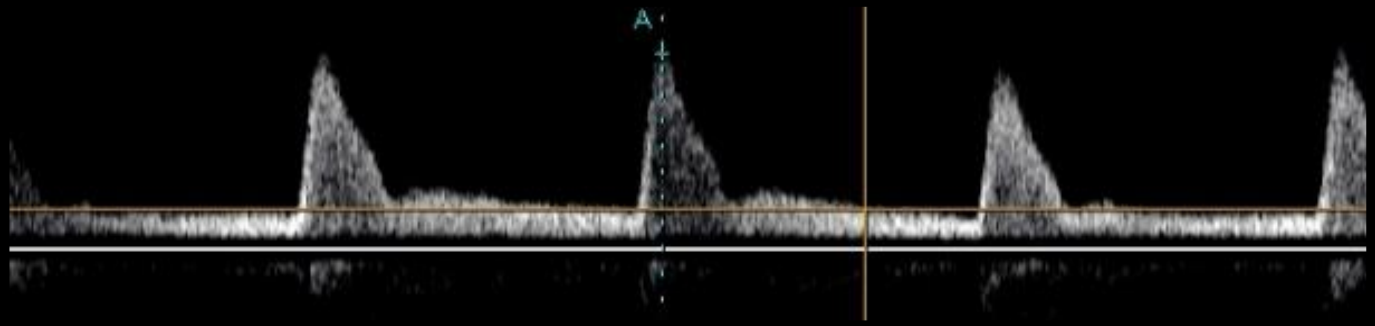
Separate Origins Celiac and SMA

Common Origin Celiac and SMA



Celiac and SMA Common Trunk





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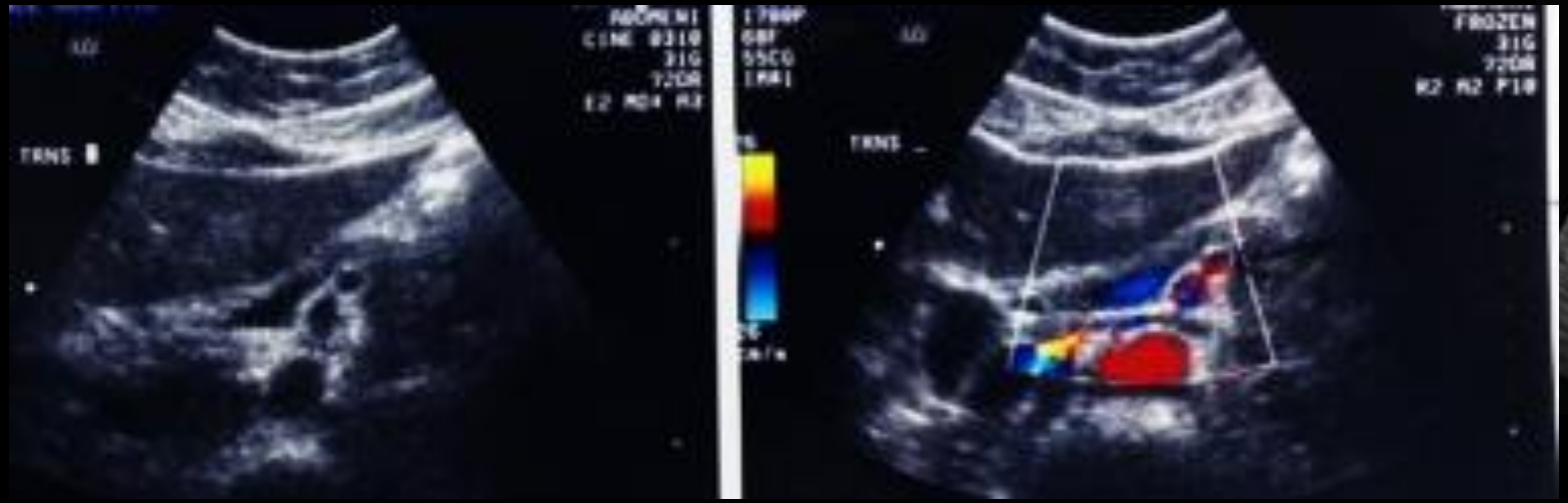
Another SMA Vascular Anomaly Replaced Right Hepatic Artery

right hepatic artery off the SMA
common variant noted
approximately 35%

- Alters flow dynamics (SMA more Low Resistive)



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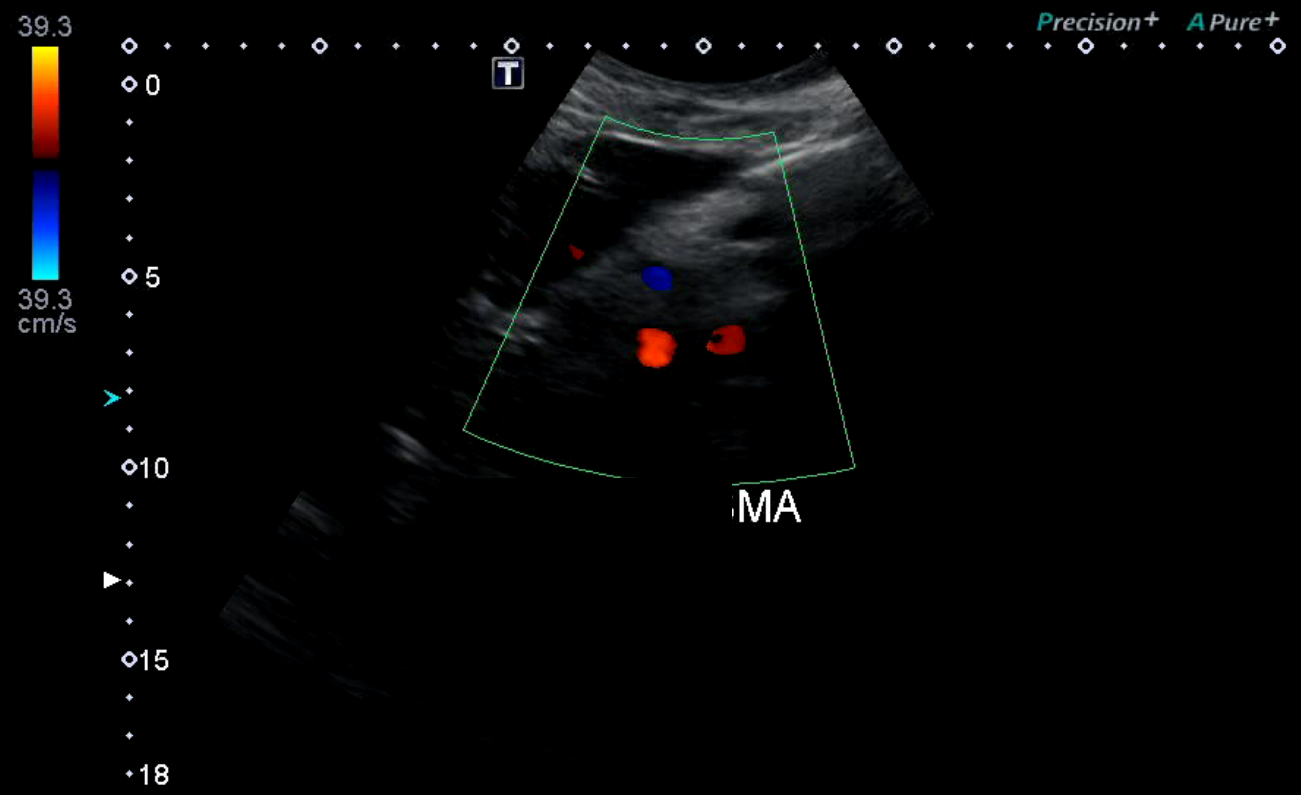
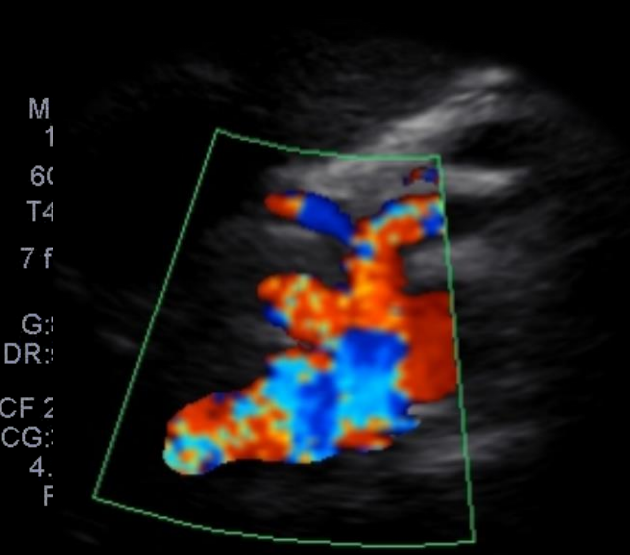
Right hepatic artery off Superior Mesenteric artery





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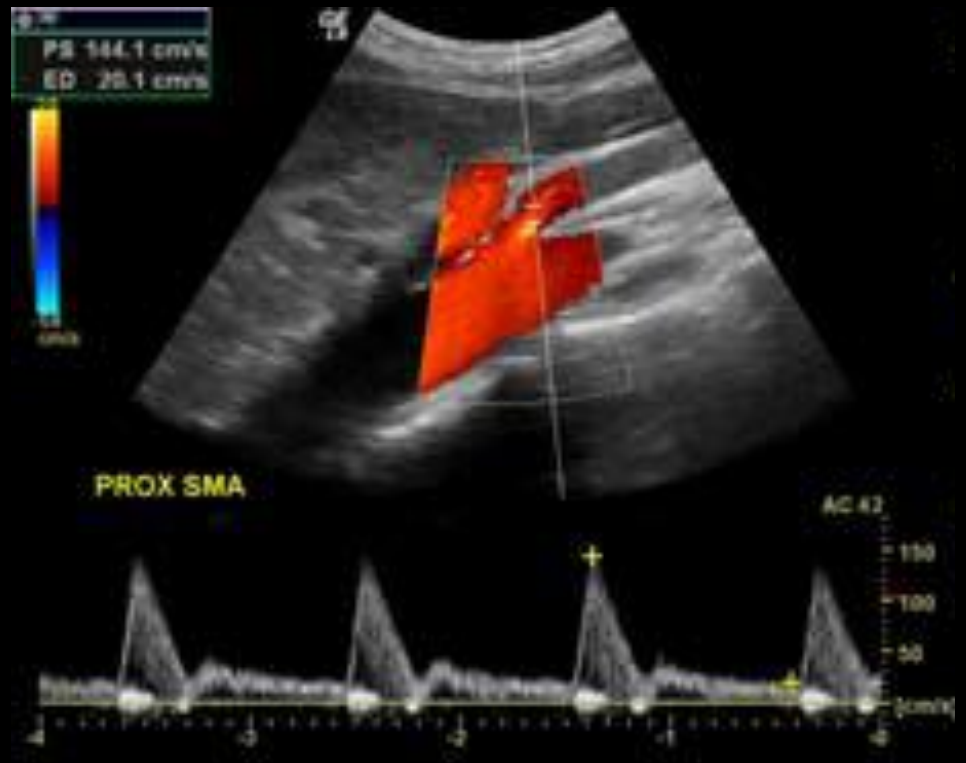
Normal SMA Doppler Waveform

- Rapid systolic upstroke
- Low diastolic flow since feeding a high resistant vascular bed (fasting patient)
- Uniform velocities without turbulence



SMA fasting PSV <275 cm/sec
EDV 14 cm/sec

SMA (postprandial)
Look

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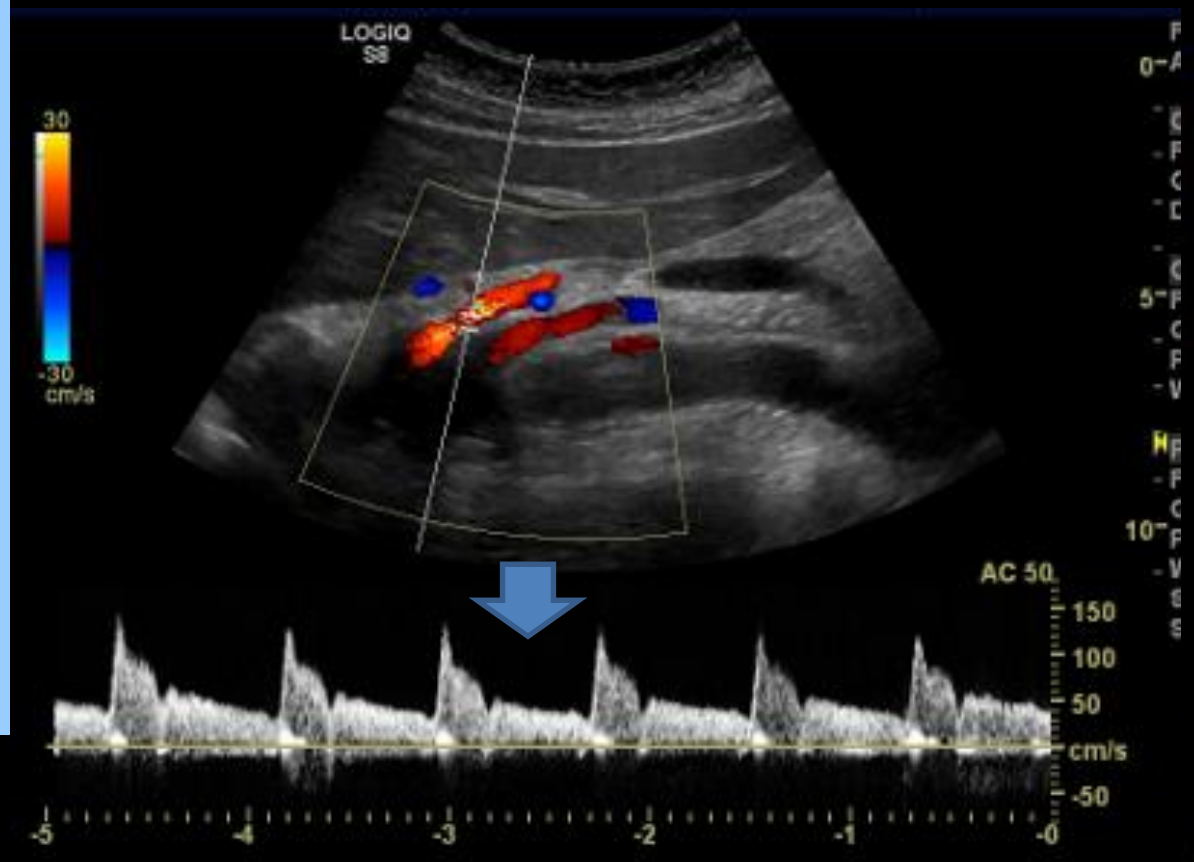
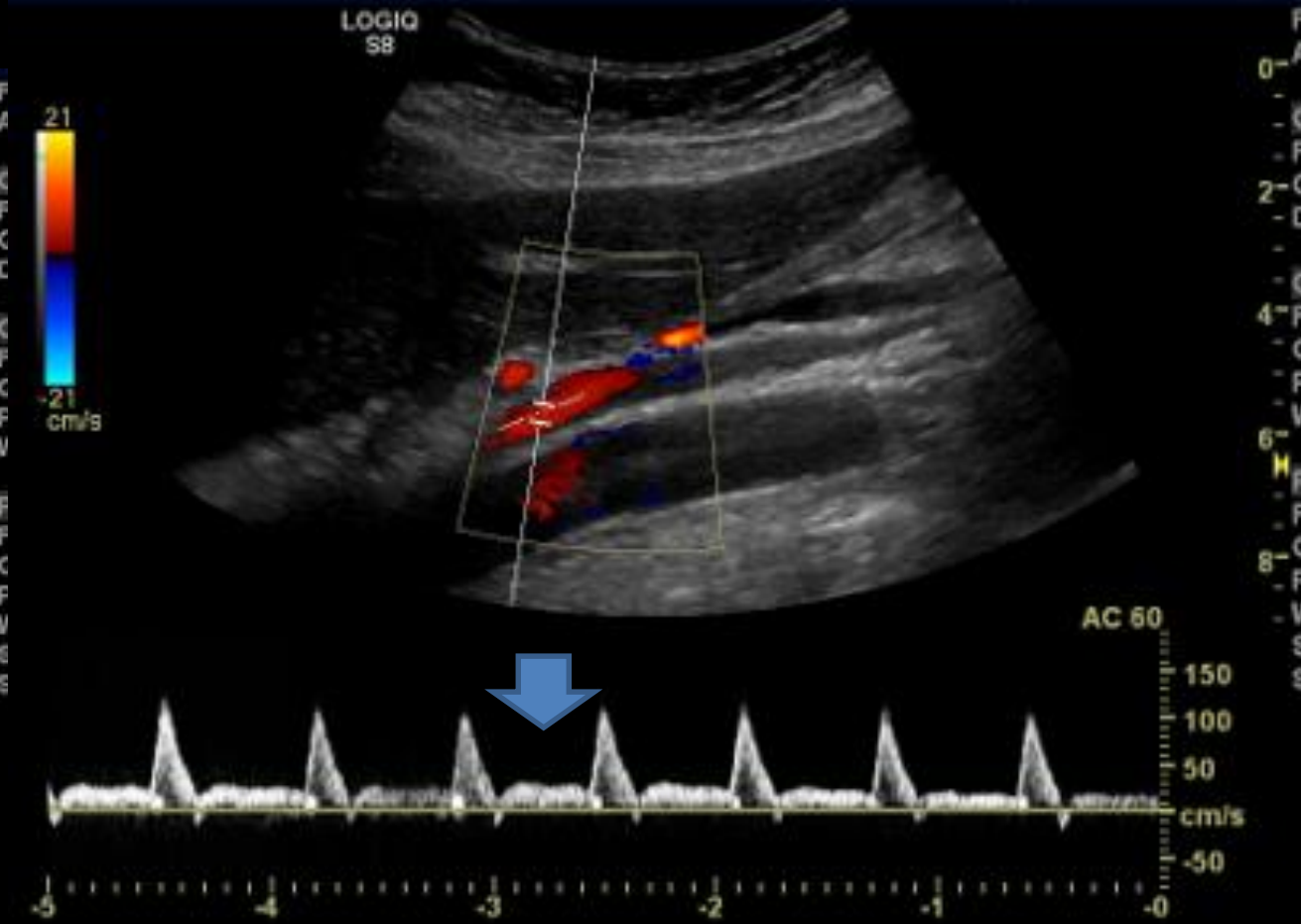
CELIAC – SMA Doppler Comparison



CELIAC - Low Resistant



SMA – Higher resistant

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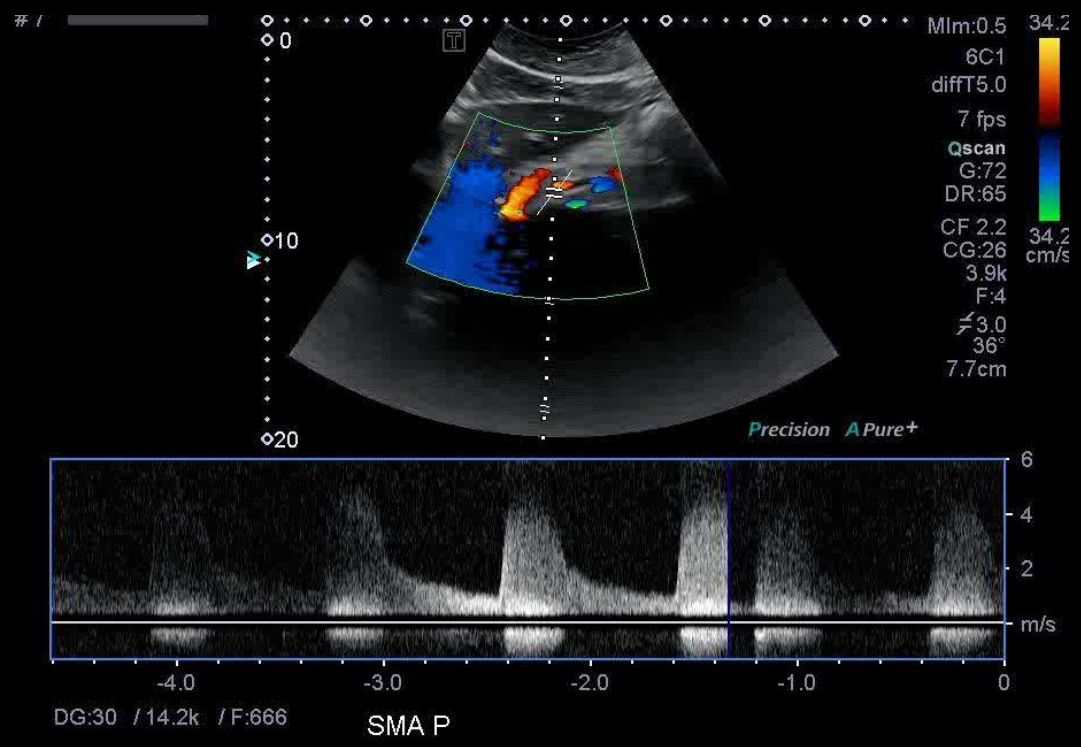
SMA Stenosis Diagnostic Criteria

Stenosis 70% or greater

- PSV > 275 cm/sec
- EDV velocity >45 cm/sec
- Focal increase in velocity
- Post-stenotic turbulence

*Important to Obtain a few Dopplers to confirm highest PSV and reproducible



Moneta GL, Yeager RA, Dalman R, et al. Duplex ultrasound criteria for diagnosis of splanchnic artery stenosis or occlusion J Vasc Surg 1991:14:511-8
Robert M. Zwolak, MD, PhD et.al JVS 1998

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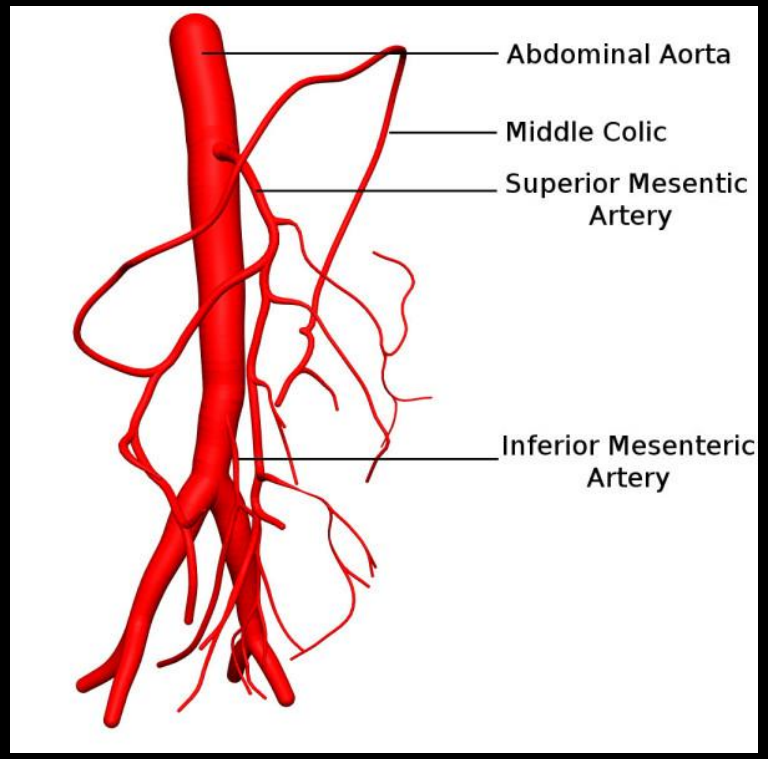
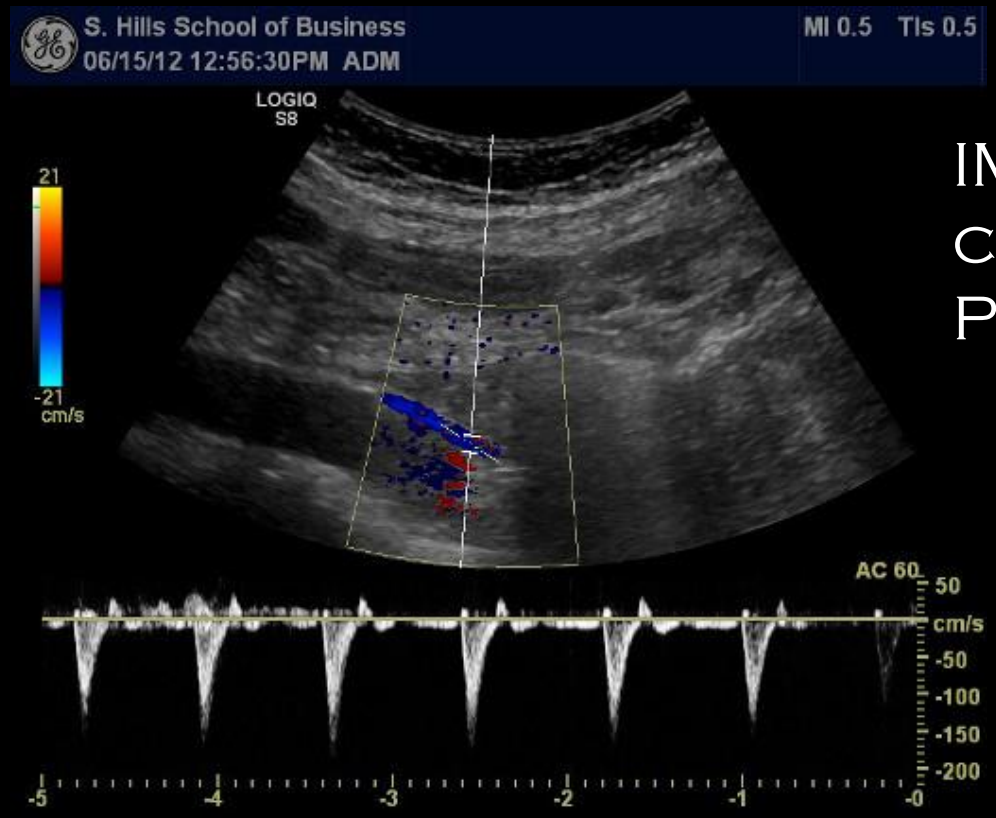
Normal IMA Doppler Waveform

- Rapid systolic upstroke with uniform velocities
- Low diastolic flow feeding a high resistant vascular bed in a fasting patient (looks like SMA)
- No turbulence





IMA - No validated criteria for normal PSV 70-200cm/sec

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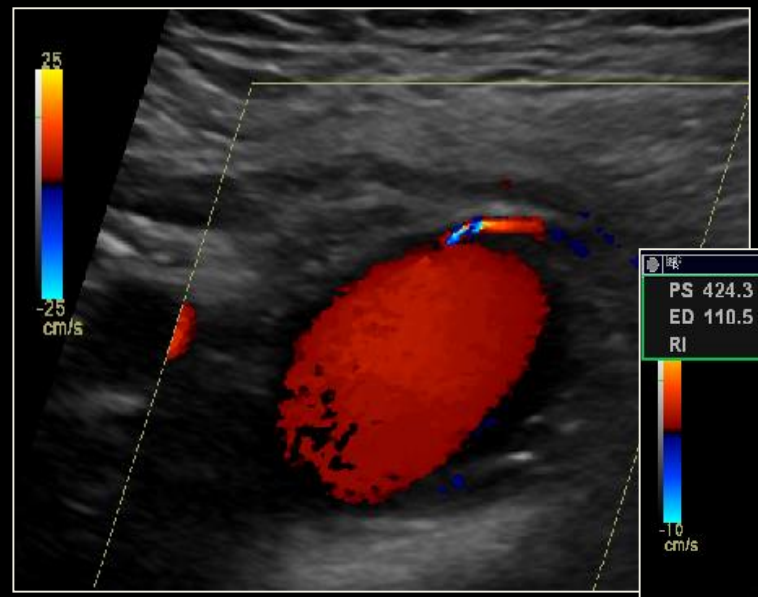
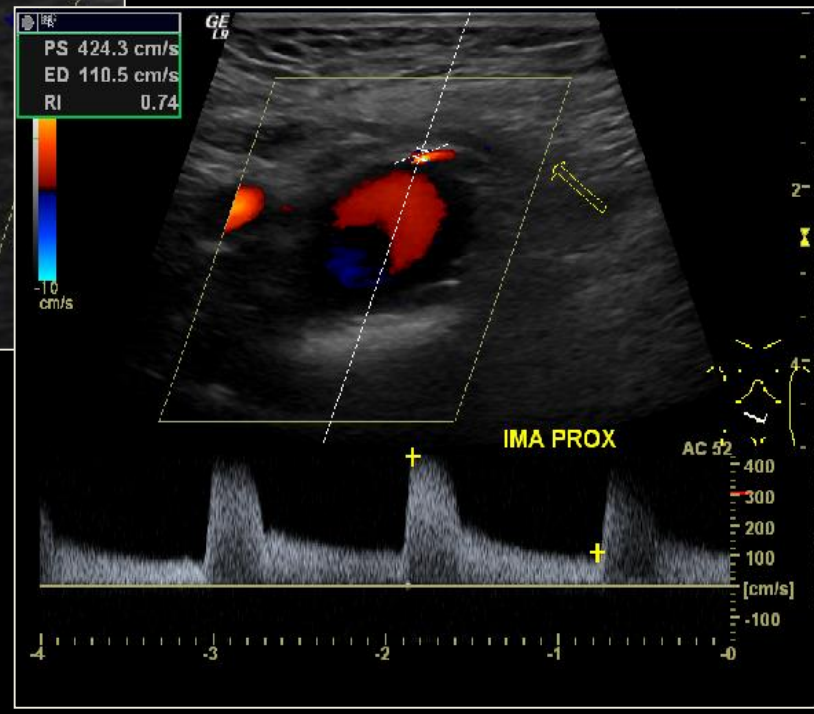
IMA Stenosis Diagnostic Criteria

Stenosis 70% or greater
- Limited published

velocity criteria
- PSV > 200 cm/sec
- EDV velocity >45cm/sec
- Focal increase in PSV
- Post-stenotic turbulence





IMA PSV 424.3 cm/sec

*Pellerito JS, Revin MV, Awelrod DJ, Ryoo S, Naidich JB,. Comparative Analysis of Doppler Criteria for the Diagnosis of Mesenteric Stenosis. RSNA Presentation, 2006

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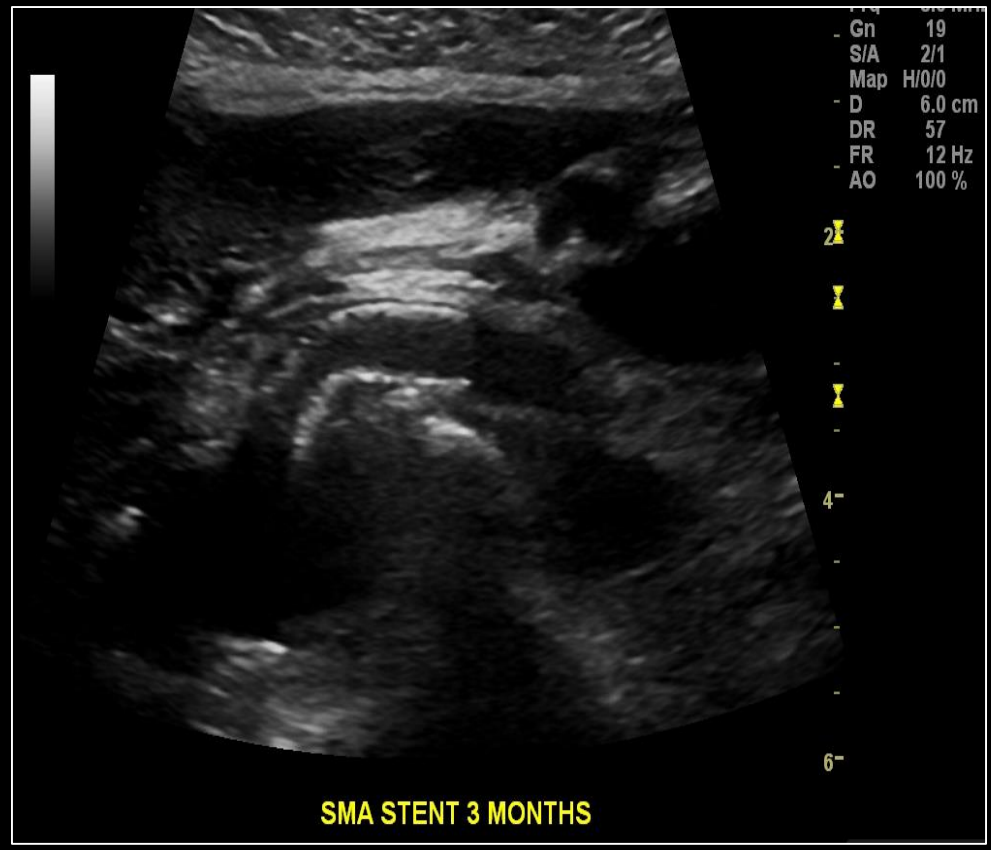
TREATMENT

- Percutaneous angioplasty
- Stenting
- Embolectomy
- Surgical by-pass



CASE STUDY

68 year old male with Hx of HTN, epigastric pain after eating (cramping sensation) with nausea

Unexplained 50 lb. weight loss in last year

Previous CABG, EVAR and new diagnosis of Parkinson Dz

Presents for Mesenteric Doppler Exam

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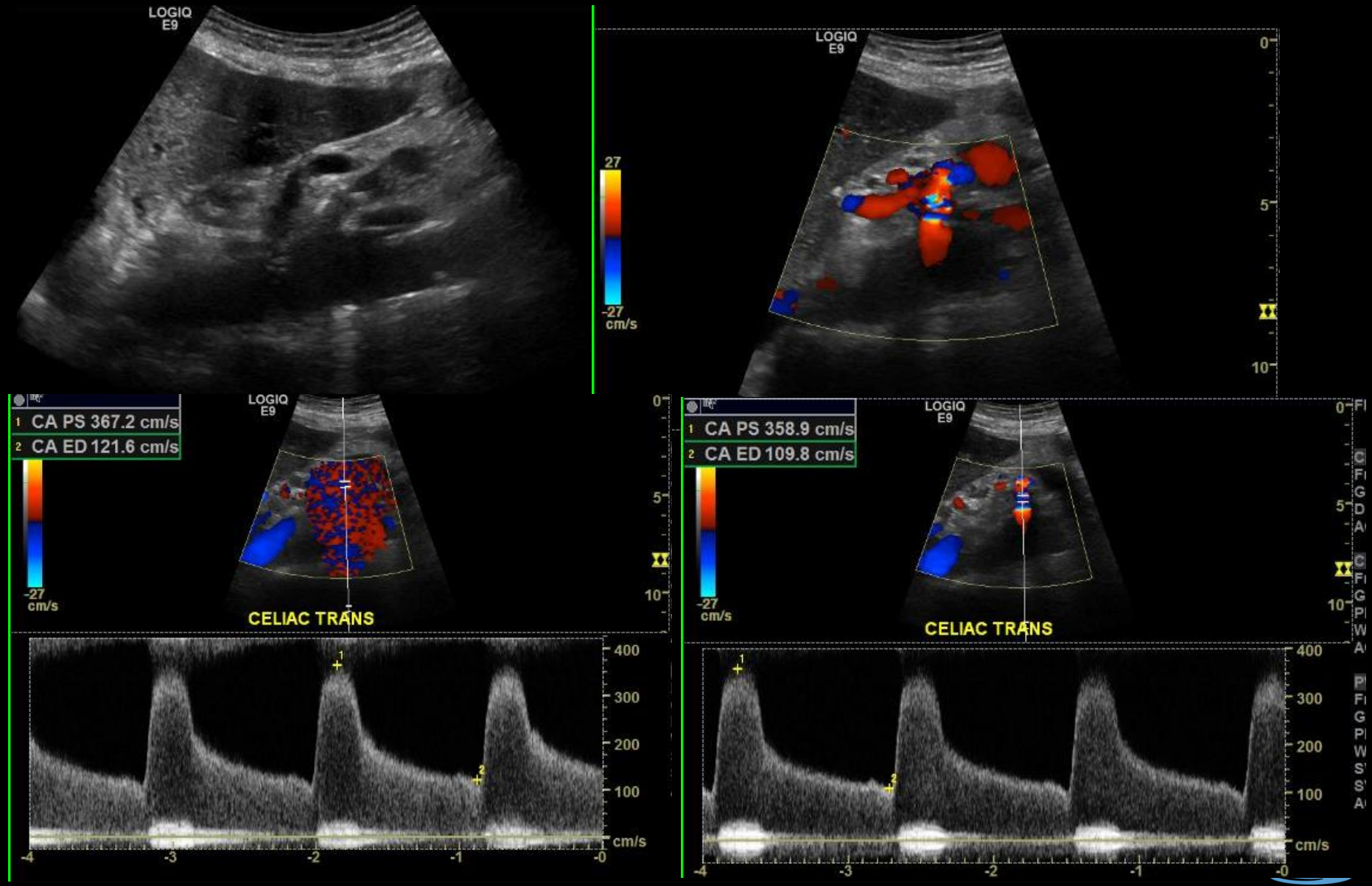
Mesenteric Doppler Exam



Celiac PSV 367 cm/sec

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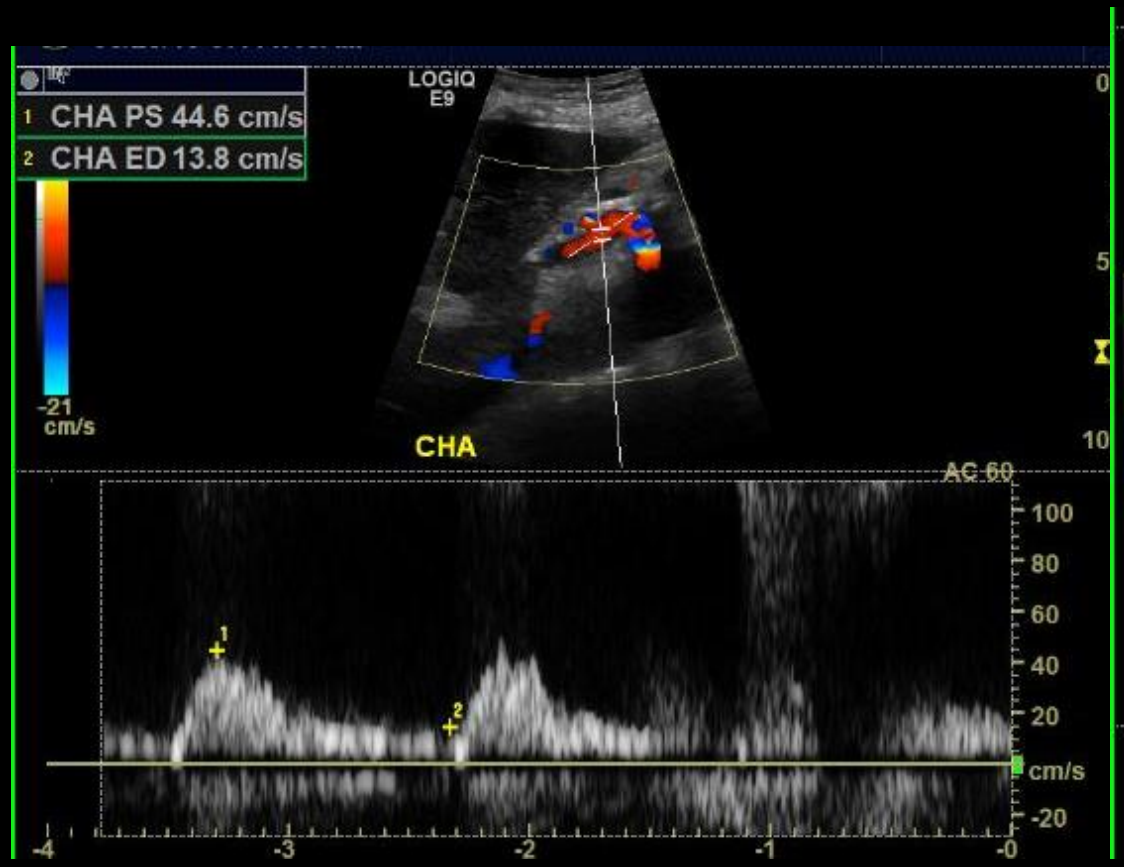
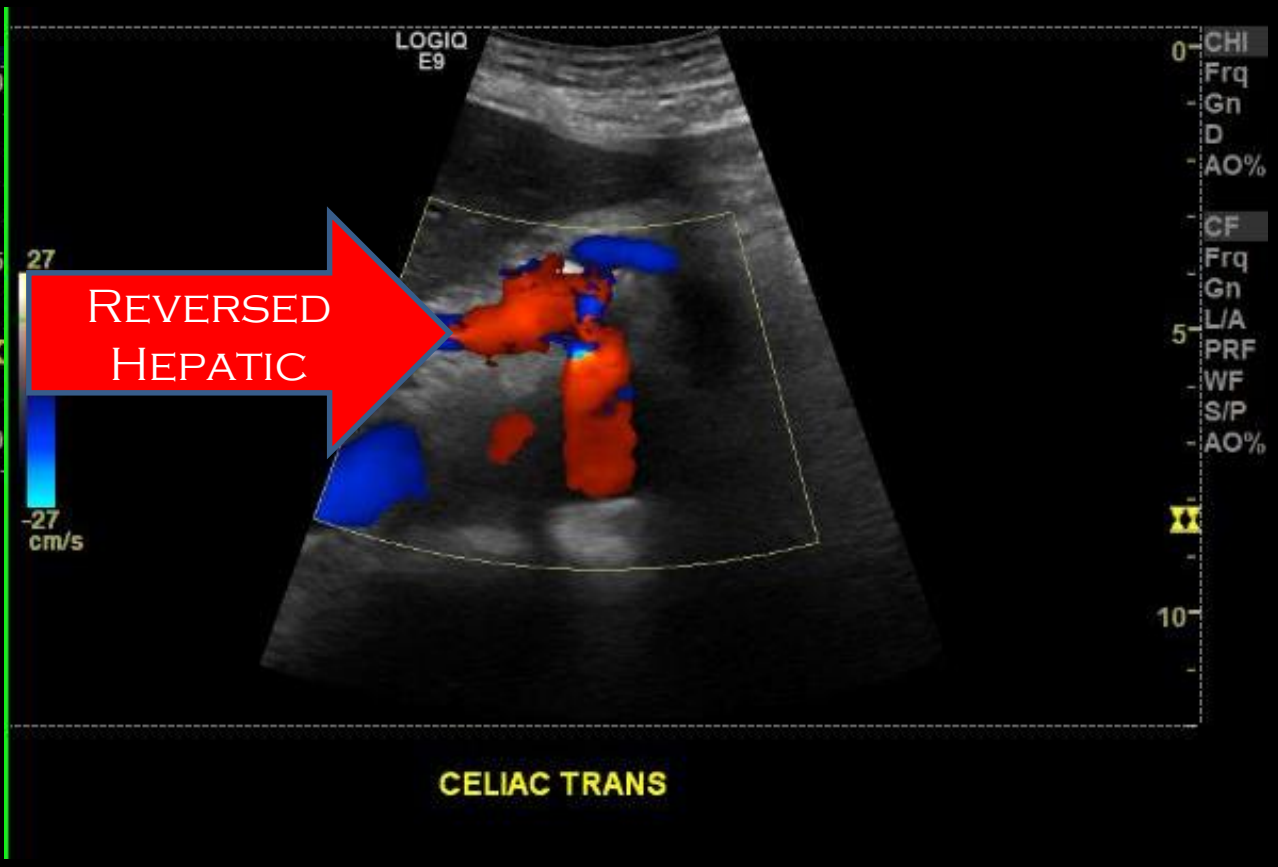
Hepatic Artery Doppler





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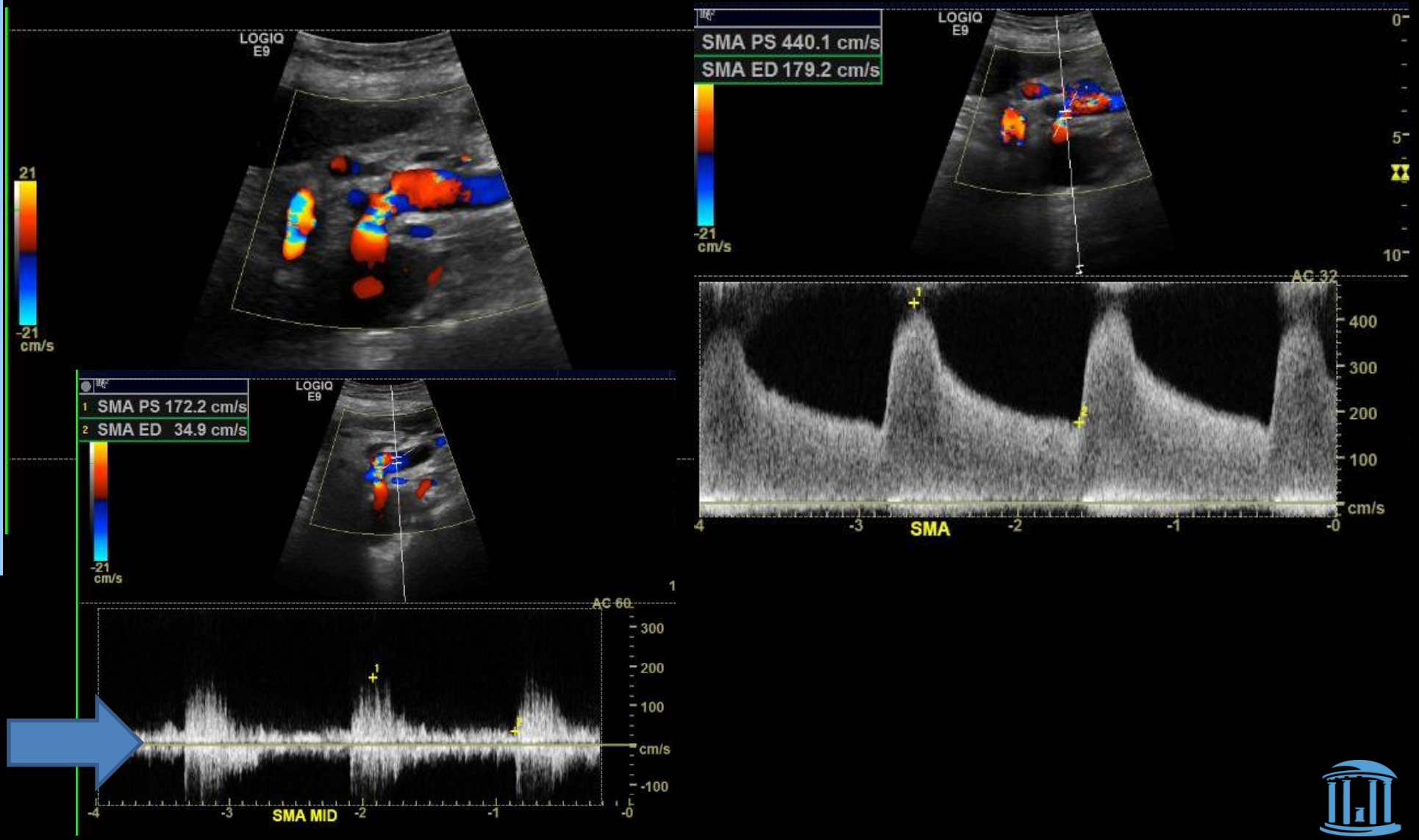
SMA Doppler



SMA PSV
440 cm/sec

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Mesenteric Doppler Case Study

- Celiac artery highest PSV 367 cm/sec, EDV 122 cm/sec
- SMA highest PSV 440 cm/sec, EDV 180 cm/sec
- Reversed hepatic artery flow with tardus parvus noted
- PSV Celiac/Aortic ratio = 6.8 PSV SMA/Aortic ratio = 8.1
- > 50% stenosis if ratio is 3 or greater

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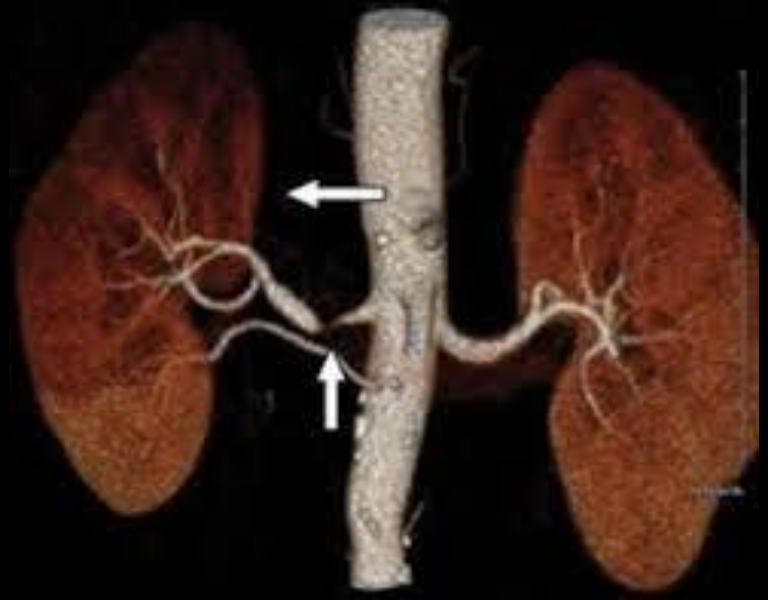
Renal Duplex Doppler



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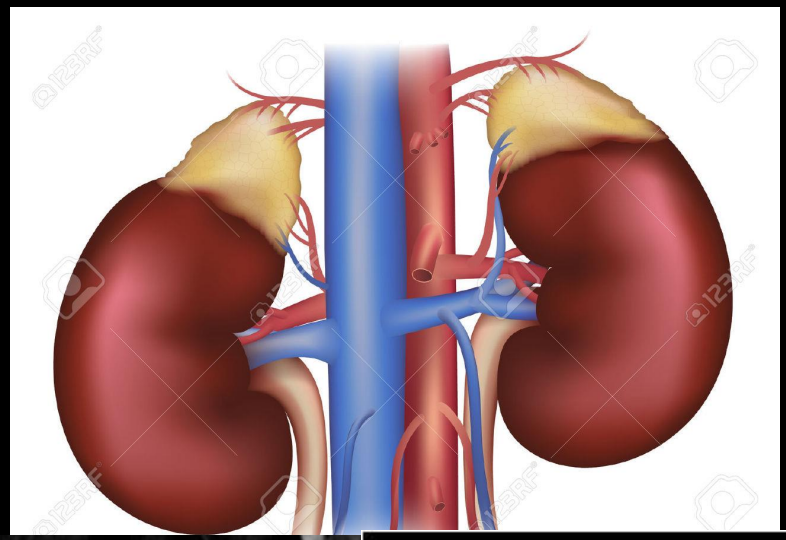
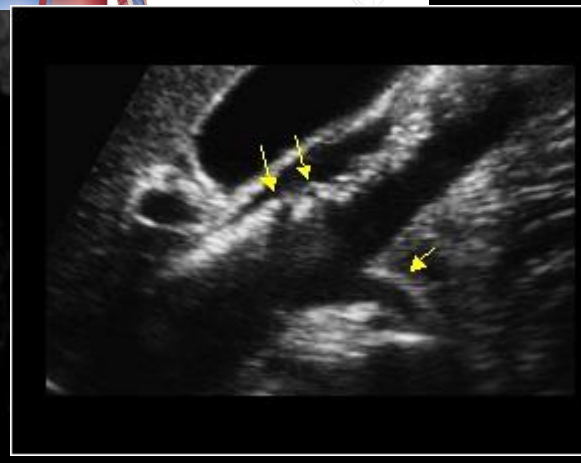
Renal Artery Anatomy

- Located 1-2 cm below the SMA
- RRA has a longer course and course post to IVC
- LRV travels between Ao and SMA
- Arise from the lateral or posterolateral wall of the abdominal aorta
- ~25% of pts have duplicated renal arteries – limits findings

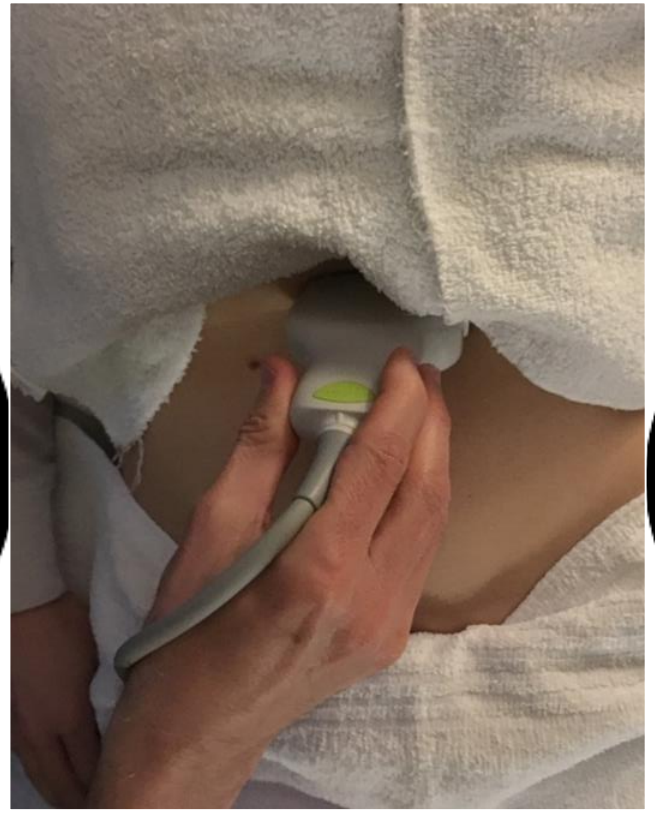


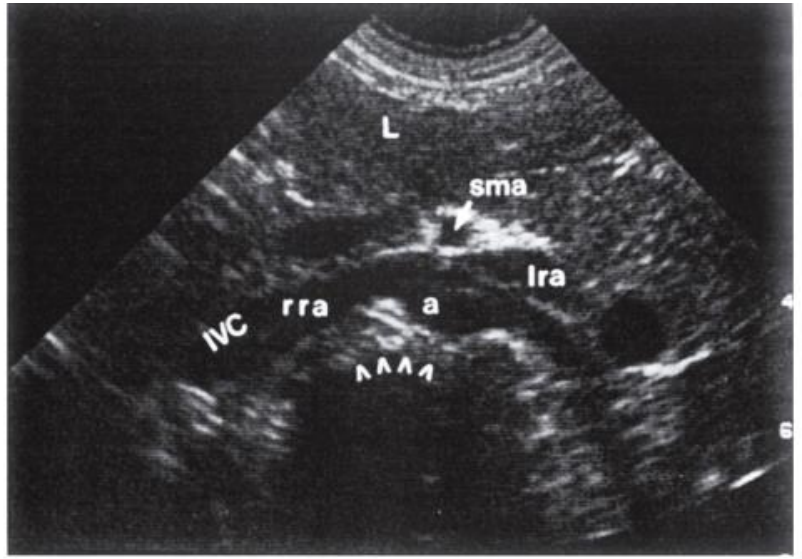


Renal Artery Anatomy

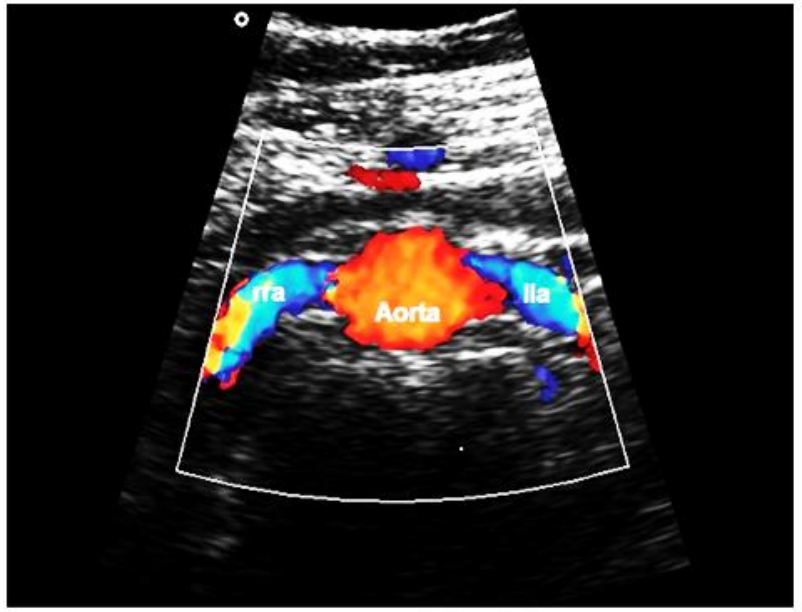
RRA 9-10 o'clock

LRA 2-4 o'clock





B



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Why Are We Performing Renal Duplex?

Indications

- Evaluate patients with hypertension (renovascular HTN)
  - –Uncontrolled despite optimal medical treatment
    6% of patients with uncontrollable or malignant HTN have RAS
  - –HTN with progressive decline in renal function
  - –Abrupt onset of HTN

- Follow up renal artery stent or angioplasty
- Abdominal or flank bruit
- Compare with other imaging modality that suspects vascular abnormality (aneurysm, pseudoaneurysm, AVF)
- Evaluate if known aortic dissection to eval if compromise flow
- Renal vascular abnormality (renal vein thrombosis, Nutcracker syndrome, congenital renovascular dz)

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Two Major Causes of RAS

Atherosclerosis – more than 2/3 of patients

- Primarily affects men over the age of 45
- Usually involves the aortic orifice at proximal main renal artery
- particularly common in patients with diffuse atherosclerosis, but can occur as a relatively isolated renal lesion.

Fibromuscular dysplasia – In comparison to atherosclerosis, fibromuscular dysplasia

- most often affects younger women and typically involves the mid-distal main renal artery or intrarenal branches

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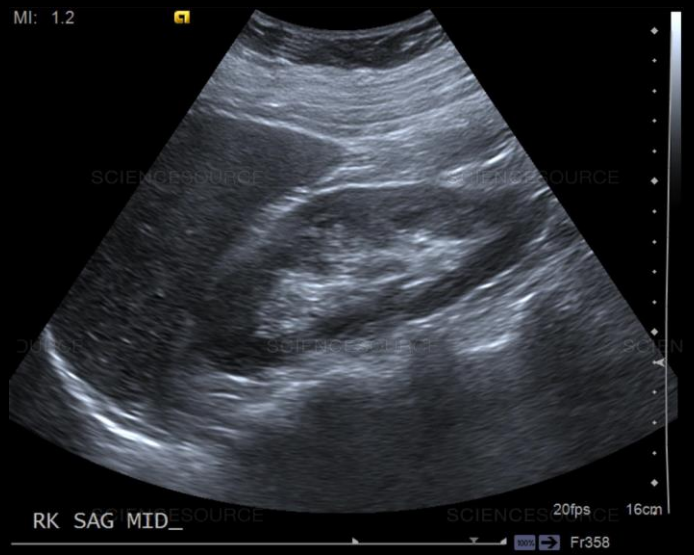
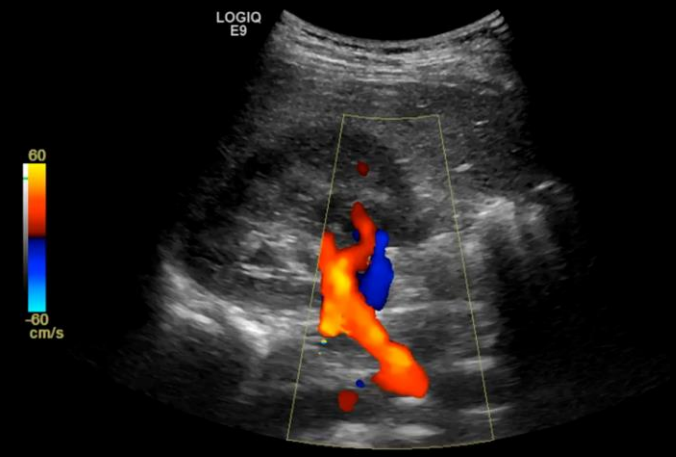
Other Less Common Causes of RAS:

- Vasculitis (Takayasu's arteritis)
- Dissection of the renal artery
- Thromboembolic disease
- Renal artery aneurysm
- Renal artery coarctation
- Extrinsic compression
- Radiation injury

Renal Doppler Protocol

- Complete kidney ultrasound
  - –Renal length, Gray scale
- Aorta PSV
- Main renal artery – Prox, Mid, Distal (hilum)
- Intrarenal arteries
- color and spectral Doppler ≤ 60°
  - –PSV, EDV
- Indicate where exam is limited





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Renal Duplex Doppler Exam

- Can Be Extremely difficult studies
- Skinny is not always easy !
- Experience plays key role
- Know how to optimize equipment settings
- Breathing, CHF, Gas can hinder exam
- Multiple angles of Interrogation Approach (Sag, Trans, Coronal, Supine, RLD, LLD)

Utilization of Probes

- Standard Convex ,Curved
- Vector
- DO NOT BE AFRAID TO USE NON-STANDARD PROBES FOR INSONATION !
- Multiple angles of Interrogation
- Patients disserve excellence in image quality and So does your reading Physician

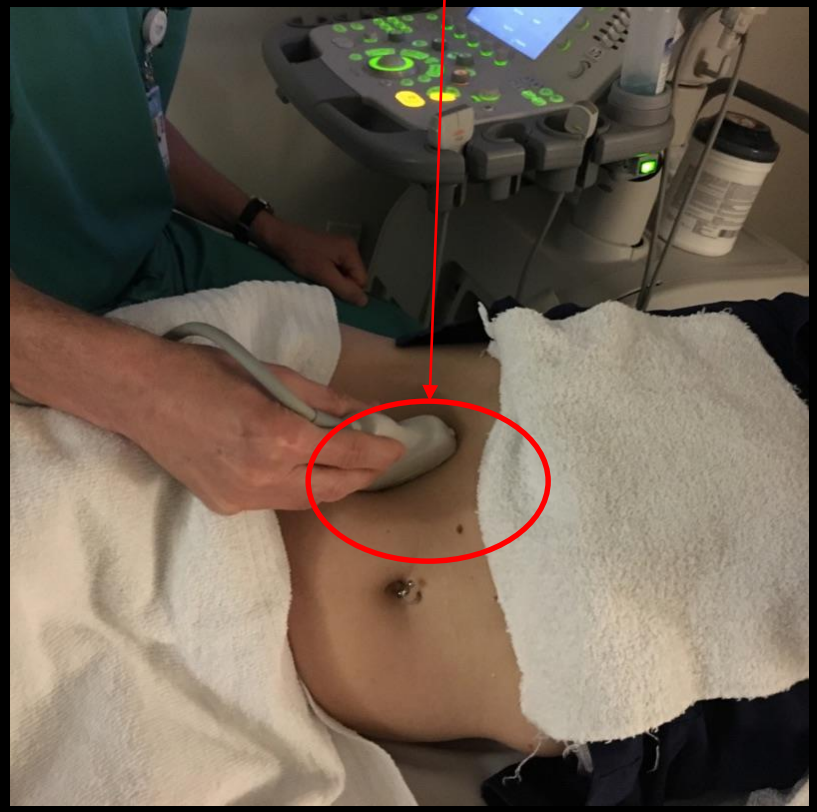
Know your Tools

- Linear array scanhead
- Curved array scanhead
- Phased array scanhead

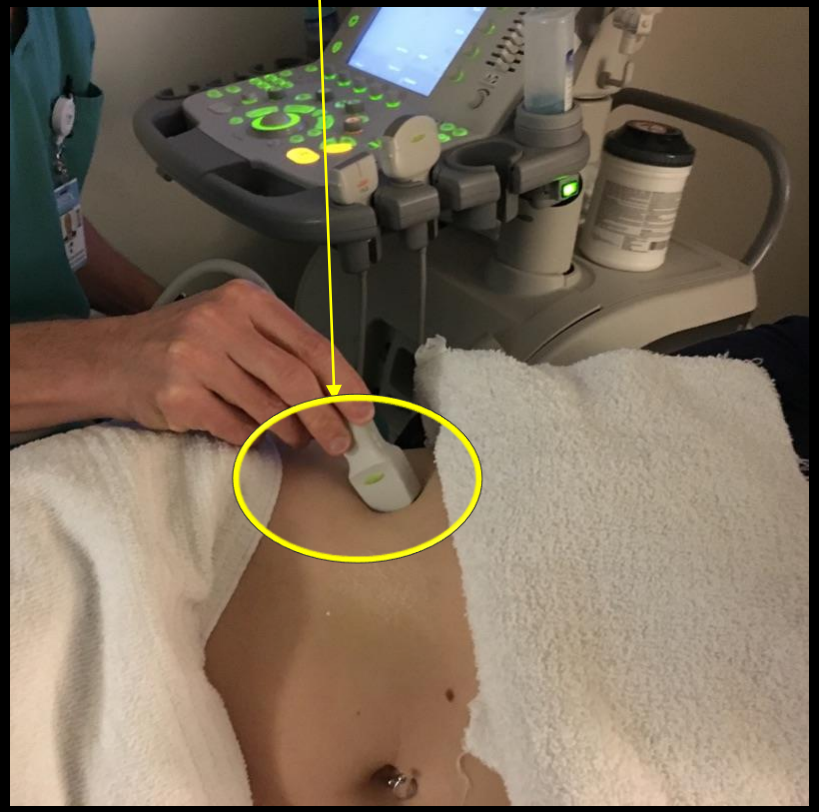
USE LOTS OF GEL!

Oblique and Lateral Probe Change for Intercostal Interrogation

Curved



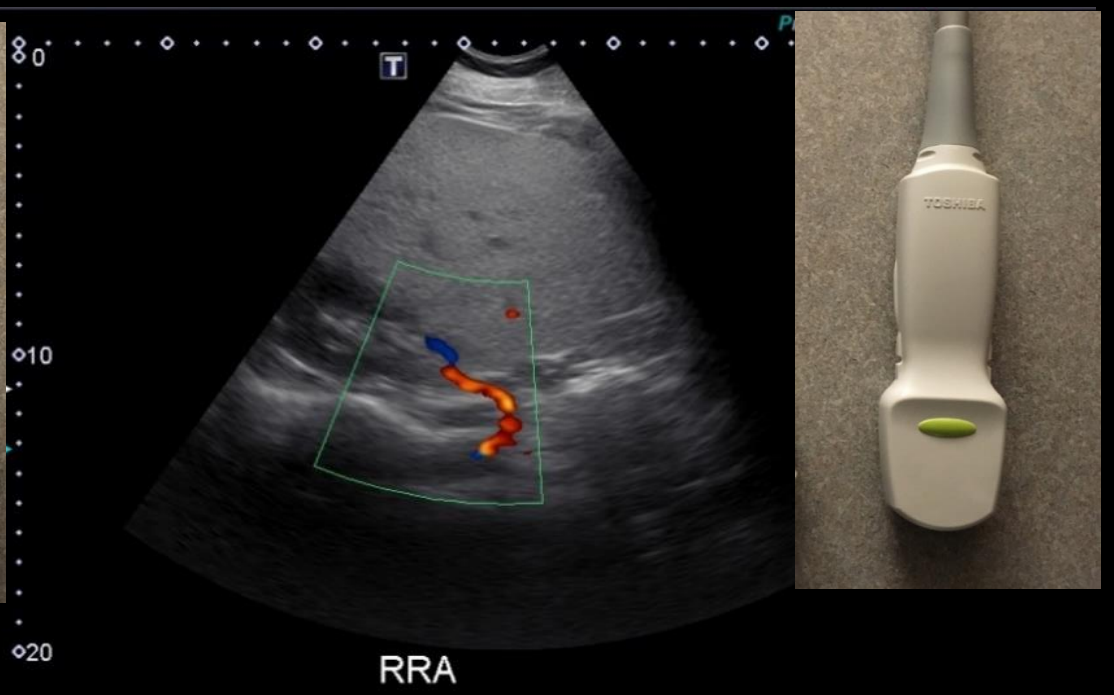
Micro Convex



Probe Changes Can Makes large Differences

Curved 6C-1

Micro Convex 6MC-1



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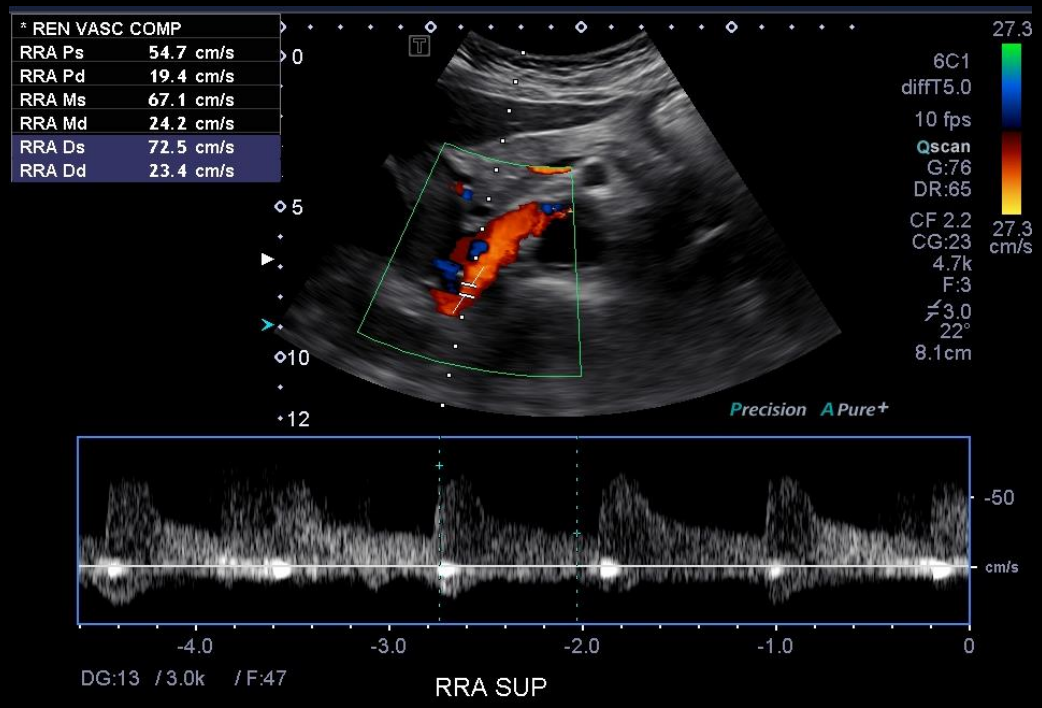
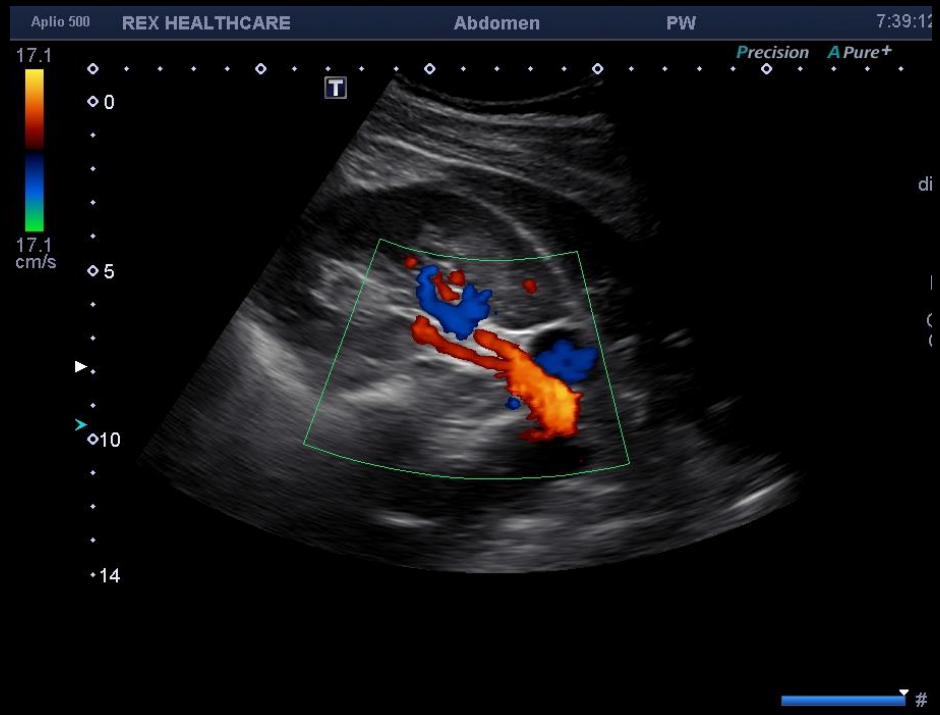
Flow Direction Does not Change

Supine RRA PROX



LLD RRA DISTAL



This is one of the reasons Why Renal Arteries need To be Interrogated From Multiple Angles!

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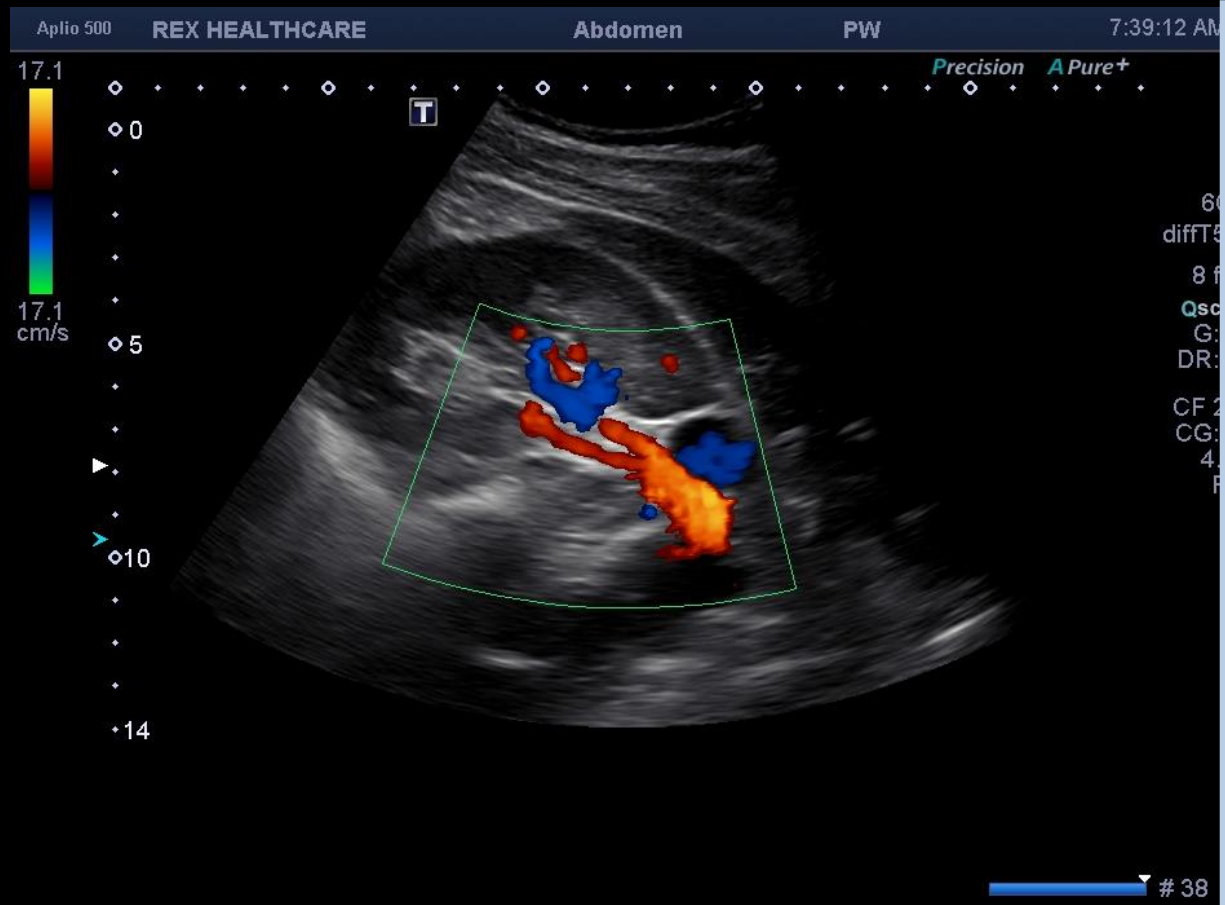
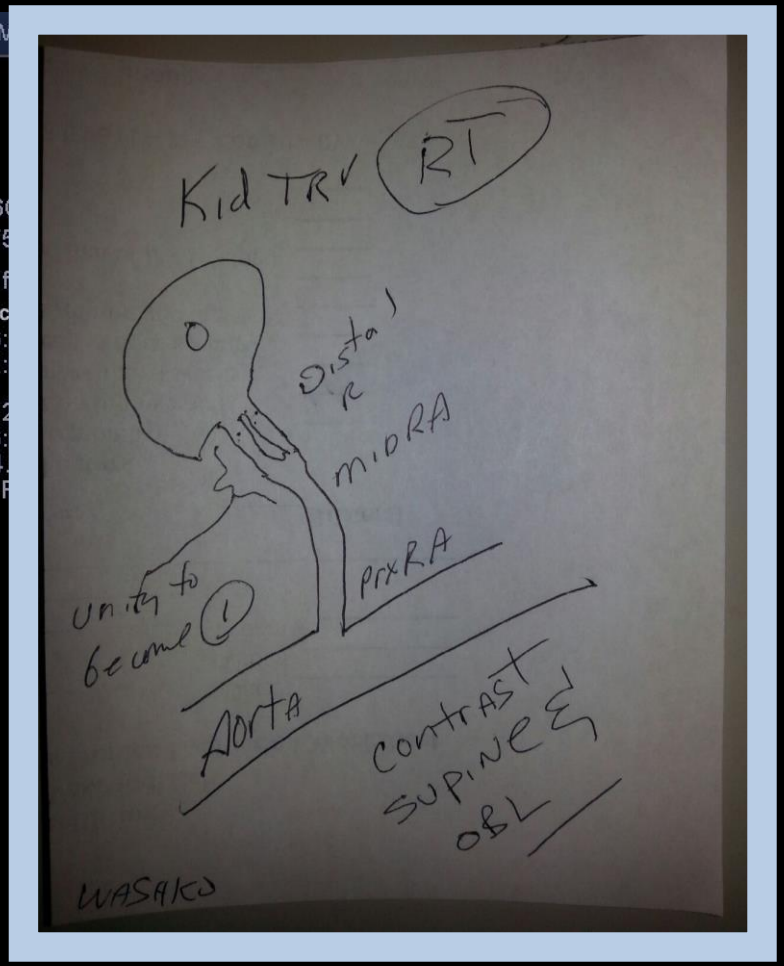
Don't Be afraid To *DRAW* ...





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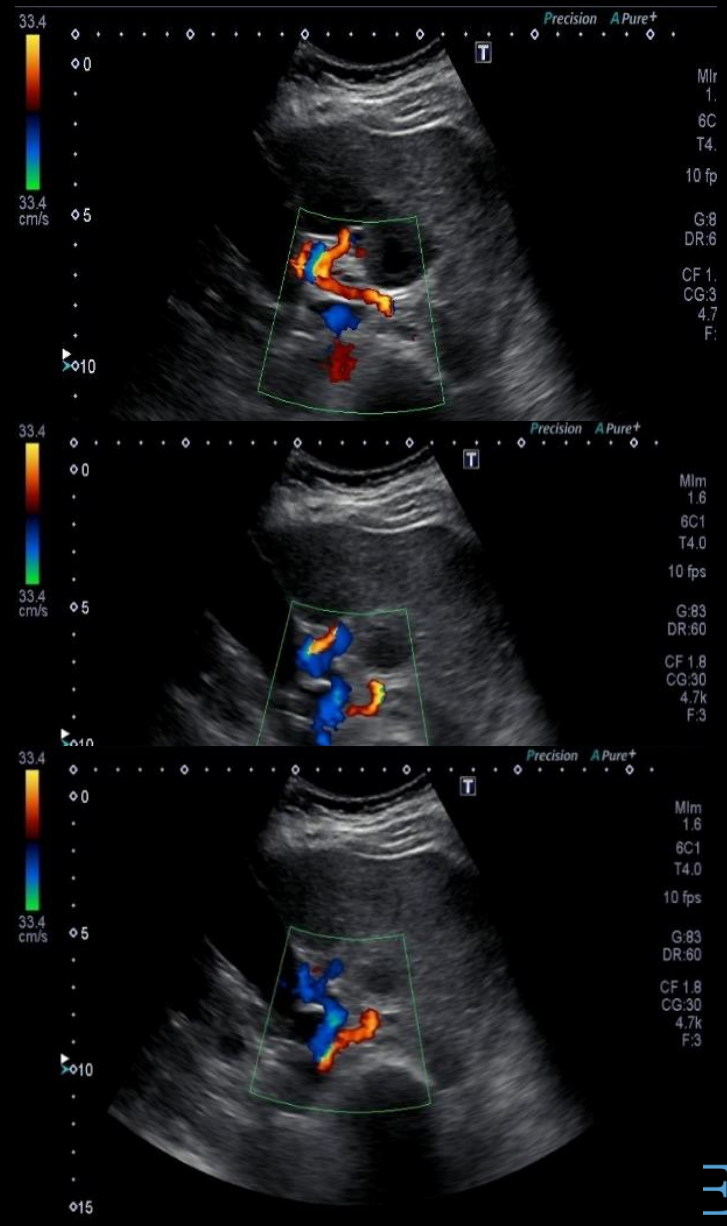
Tortuous Vessels

Supine



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Settings- Settings- Settings .....

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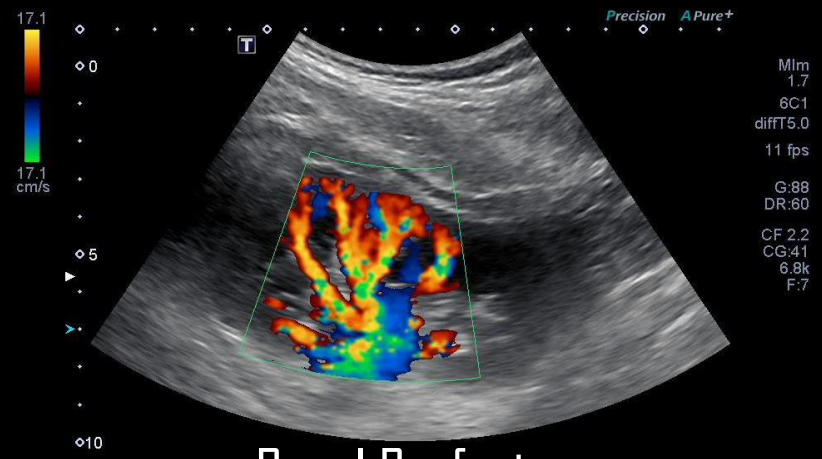
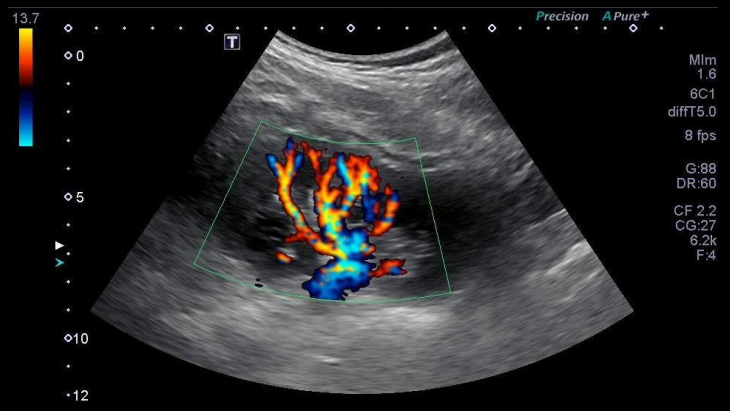
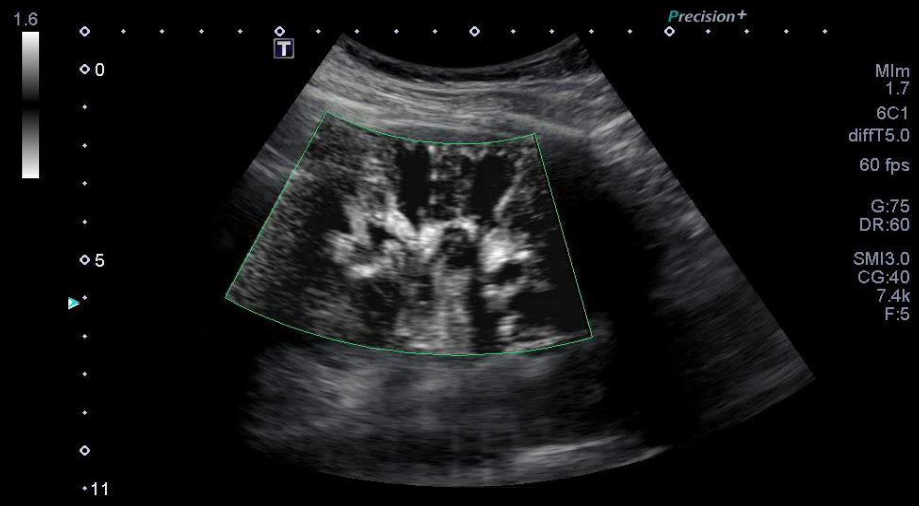
Renal Perfusion Settings



Renal Perfusion



Directional Power Doppler



Monochrome -SMI

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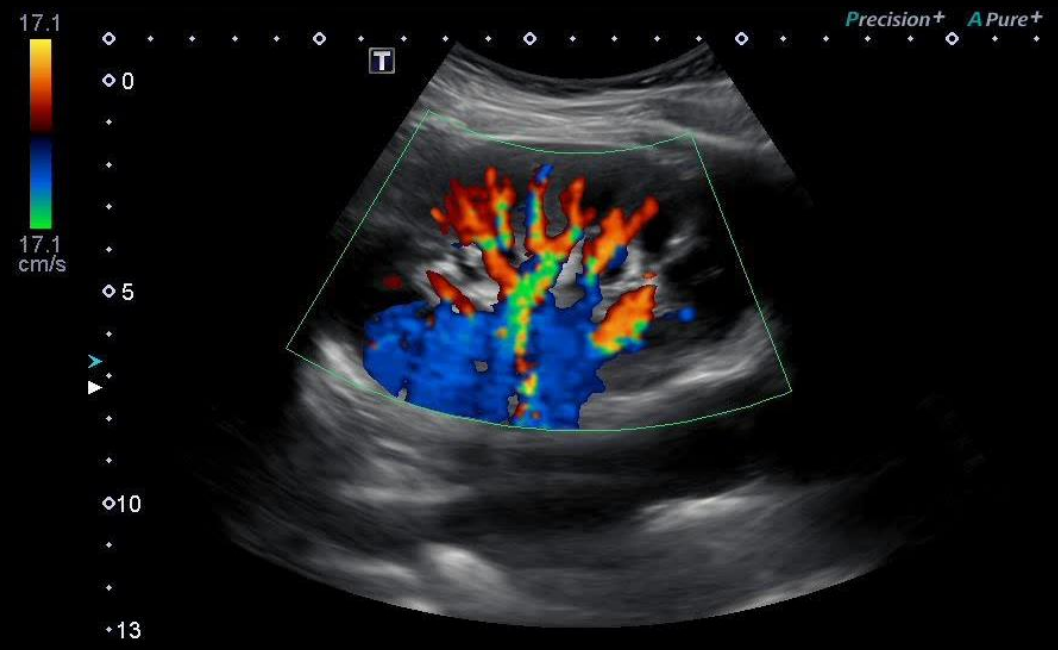
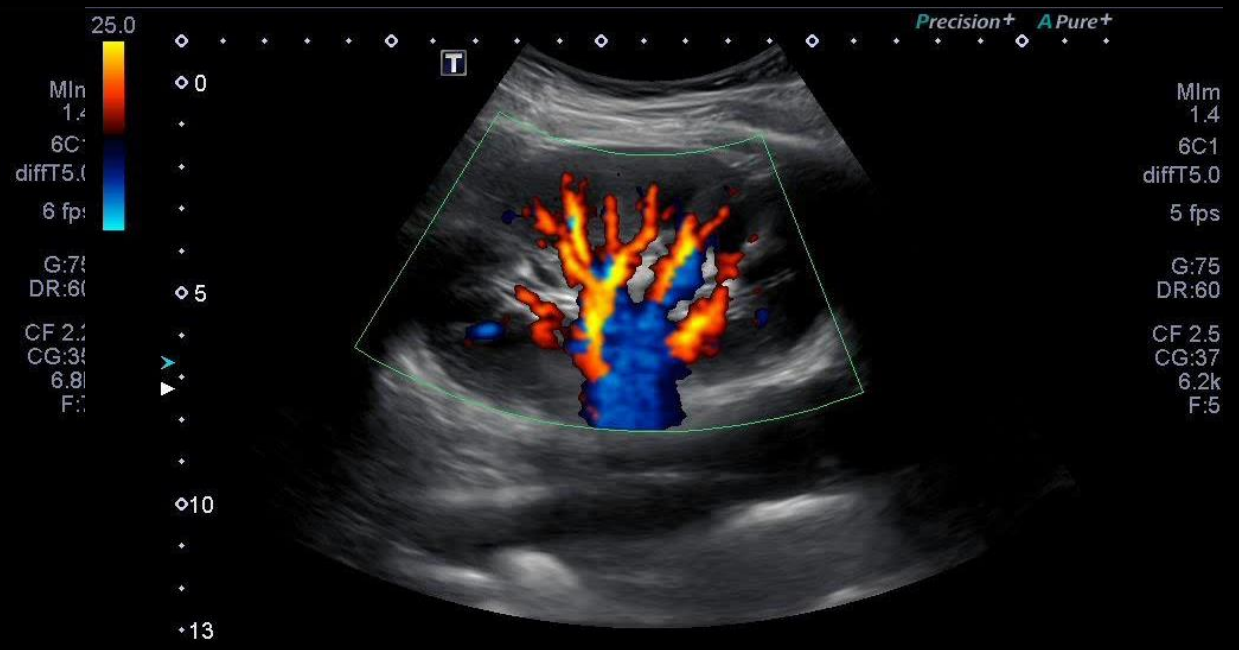
Don't Forget About Directional Power Doppler !





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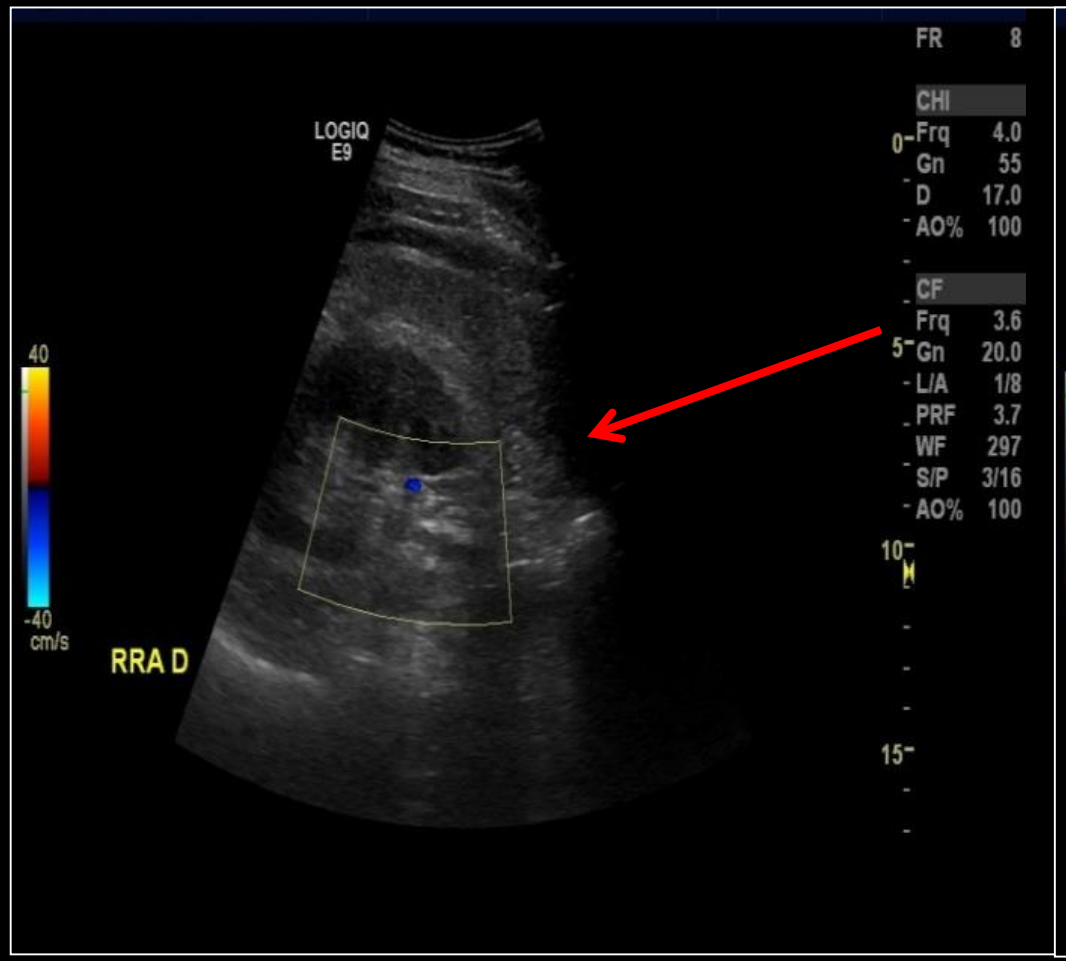
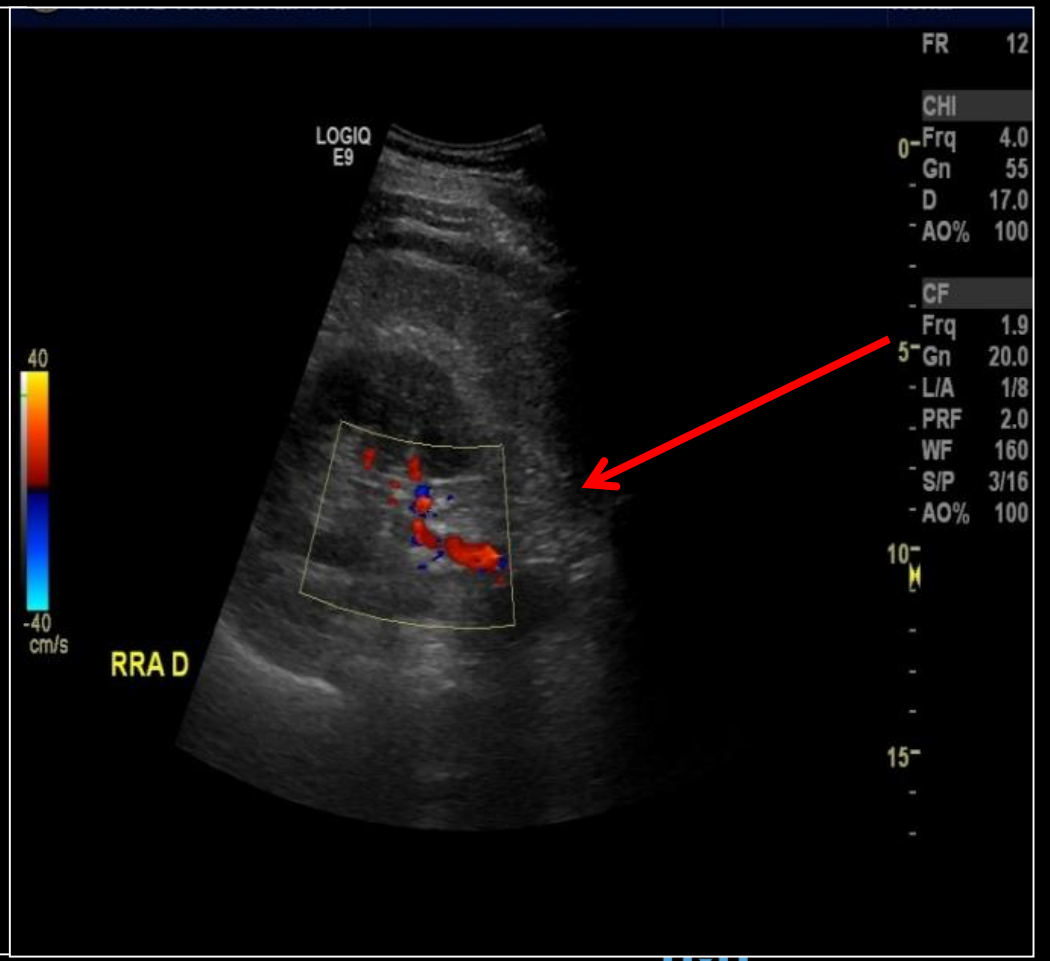
Color Frequency Change

Poor color flow



Lower color frequency



REX HEALTHCARE

DIAGNOSTIC CRITERIA
DIRECT METHOD – COLOR + DOPPLER

RENAL / AORTIC RATIO (RAR) > 3.5

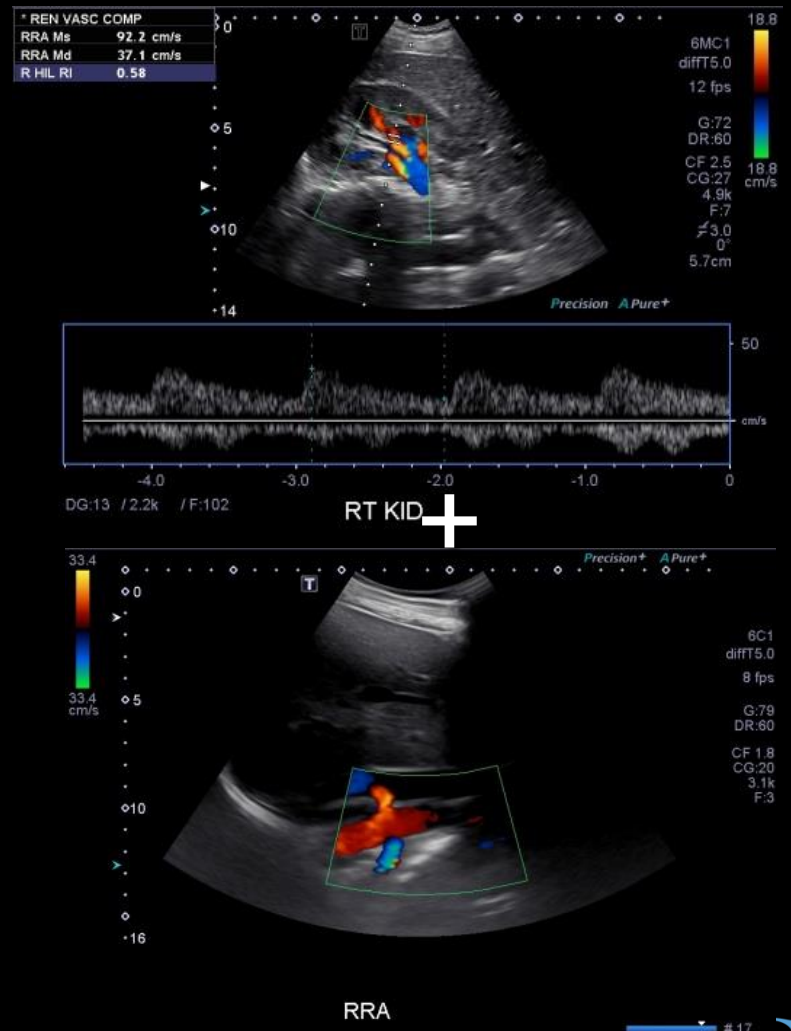
PEAK SYSTOLIC VELOCITY OF RA
PEAK SYSTOLIC VELOCITY OF AO

PSV > 180-200 CM/SEC

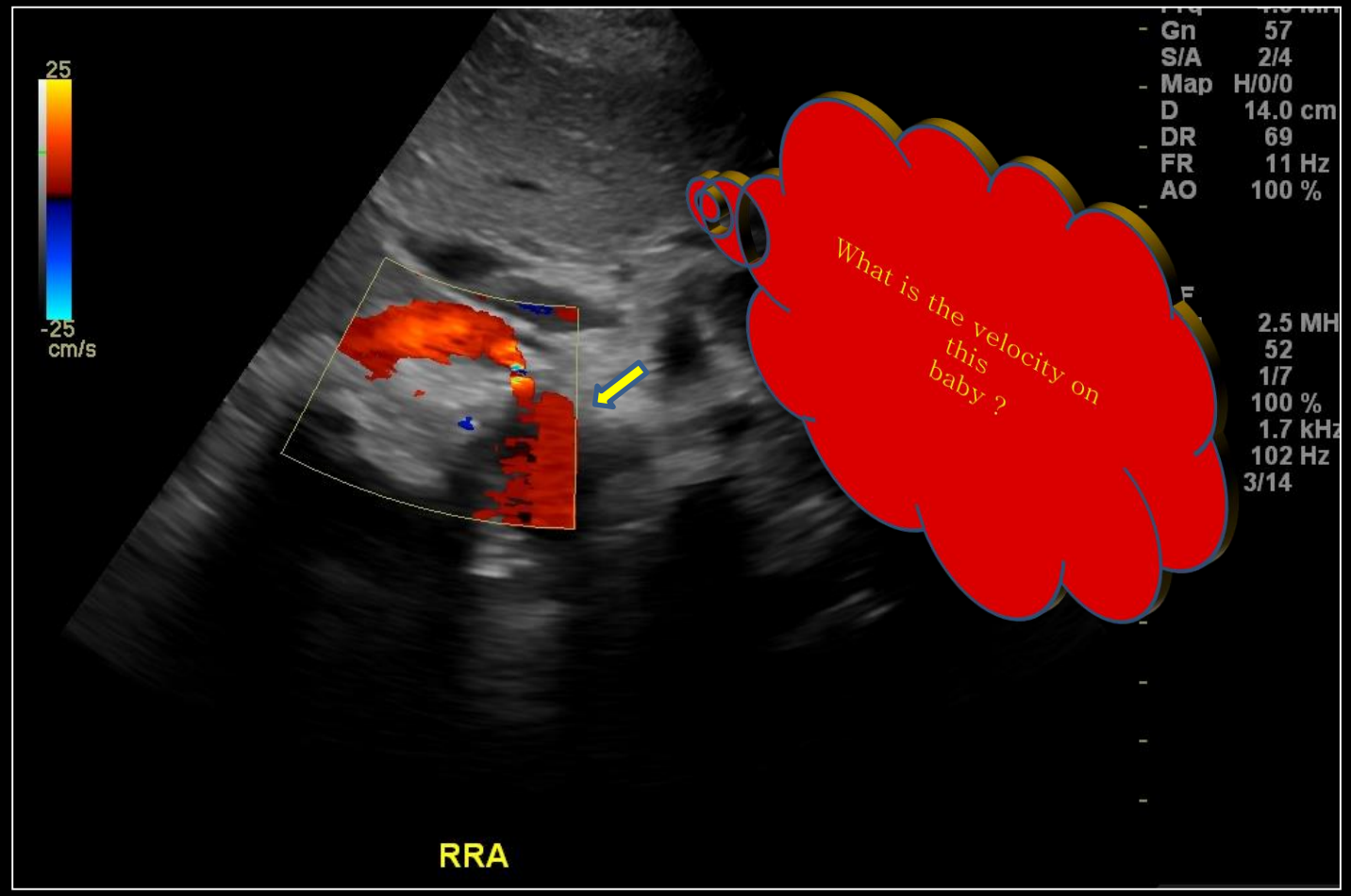
PSV >225-240 CM/SEC (PATRICK'S LAB)

VELOCITIES SHOULD BE REPRODUCIBLE
LOOK FOR POST STENOTIC TURBULENCE

AORTIC VELOCITIES LESS THAN -40 -50CM/SEC AND GREATER THAN 120 CM/SEC CAN SKEW RAR RESULTS



Right Renal Artery



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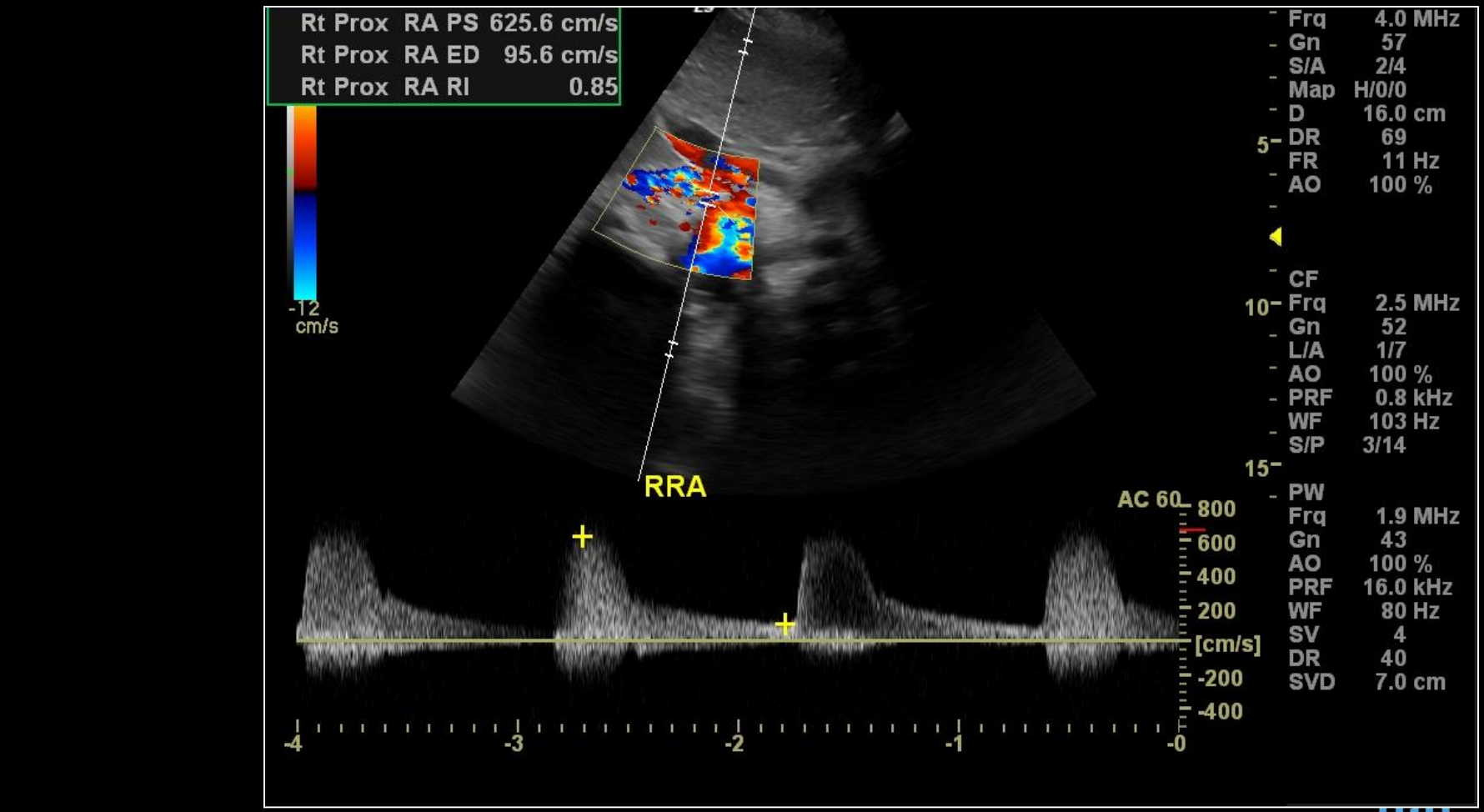
Prox RRA PSV 625 cm/sec
EDV 95 cm/sec



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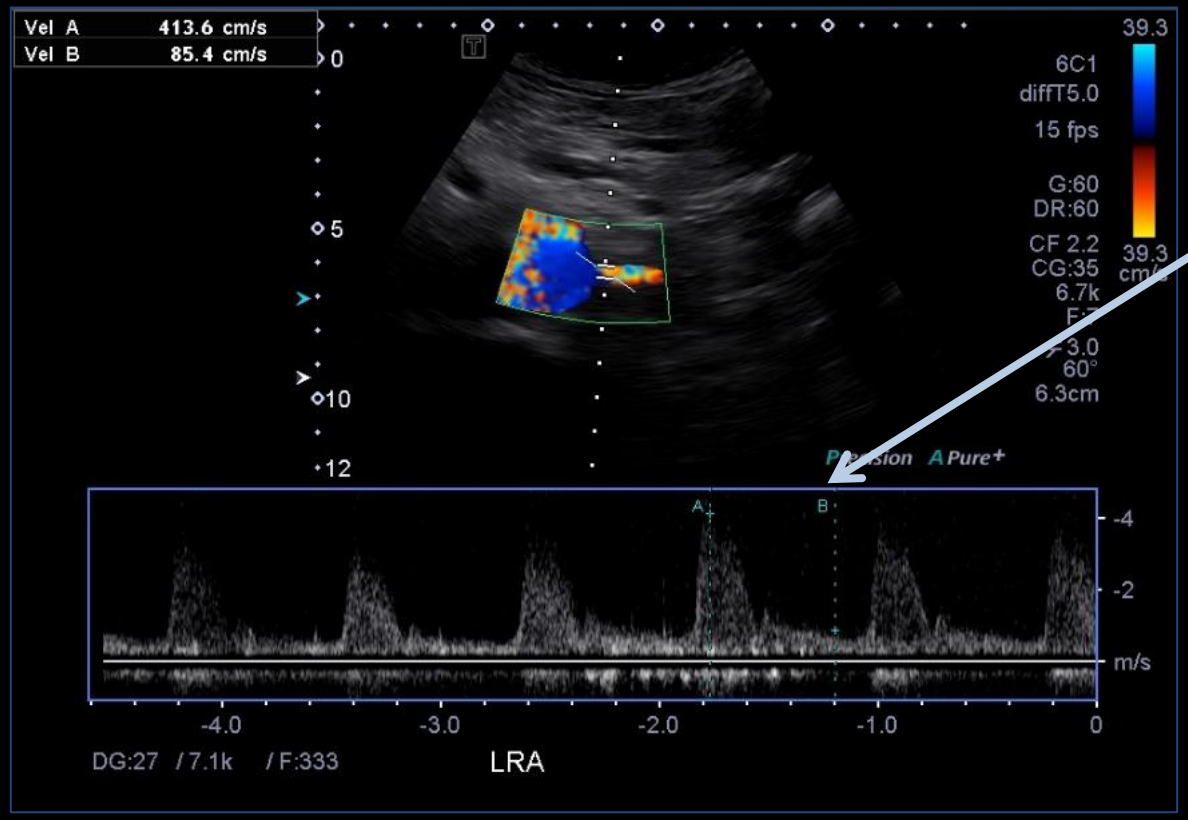
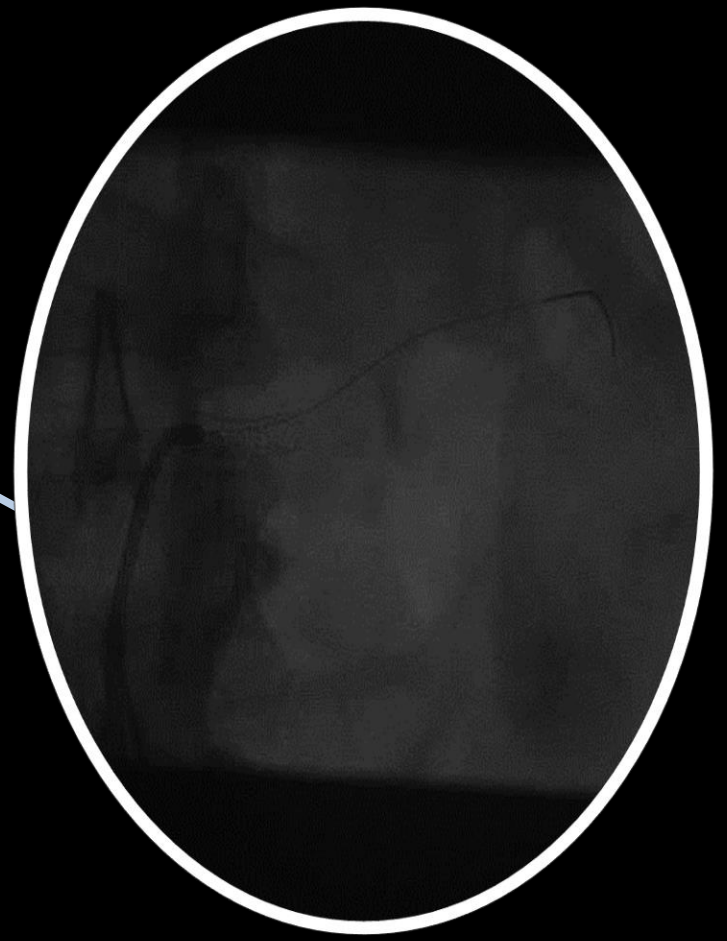
Prox LRA Stenosis





Vel A	413.6 cm/s
Vel B	85.4 cm/s

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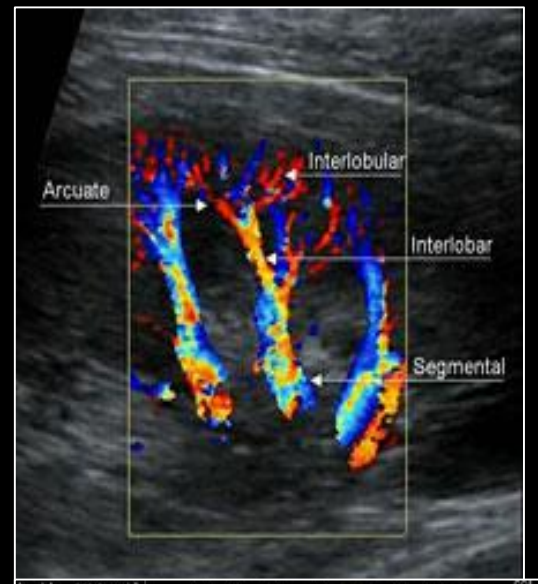
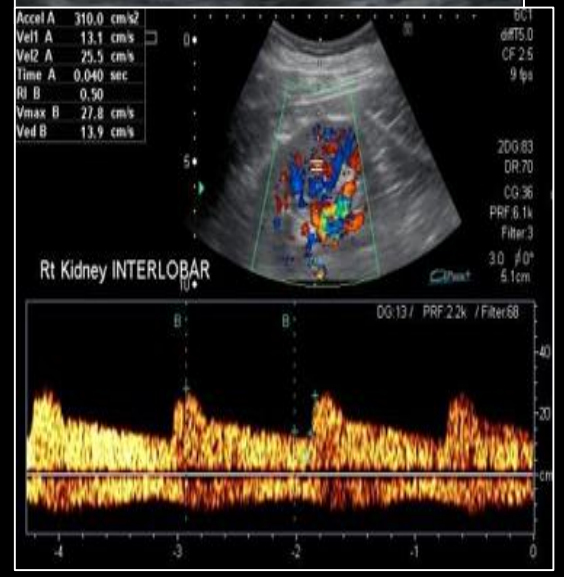
Diagnostic Criteria
Indirect Method

- Kidney lengths-cortex assessment for reduced size
- Perfusion Kidney- color Doppler used to assess the perfusion to the edge of the renal cortex
- Obtain Resistive Index with spectral Doppler of kidney parenchyma at segmental, interlobar arteries and arcuate arteries
- Look for signs of tardus parvus (distal to stenosis) "slow to rise, slow to fall"

  slow systolic upstroke
- Quantify with Acceleration Time
  - Acceleration time (AT) > 0.07 sec is ABN
  - Resistivity Index (RI) >0.7 is ABN
  - angle correct 0-30°





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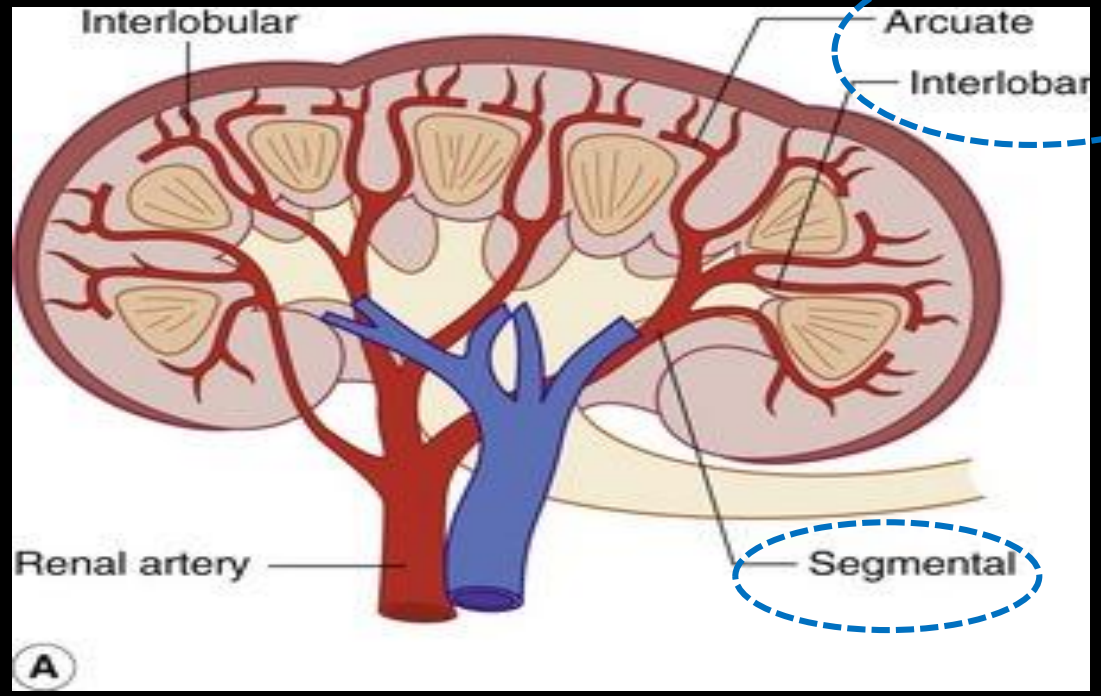
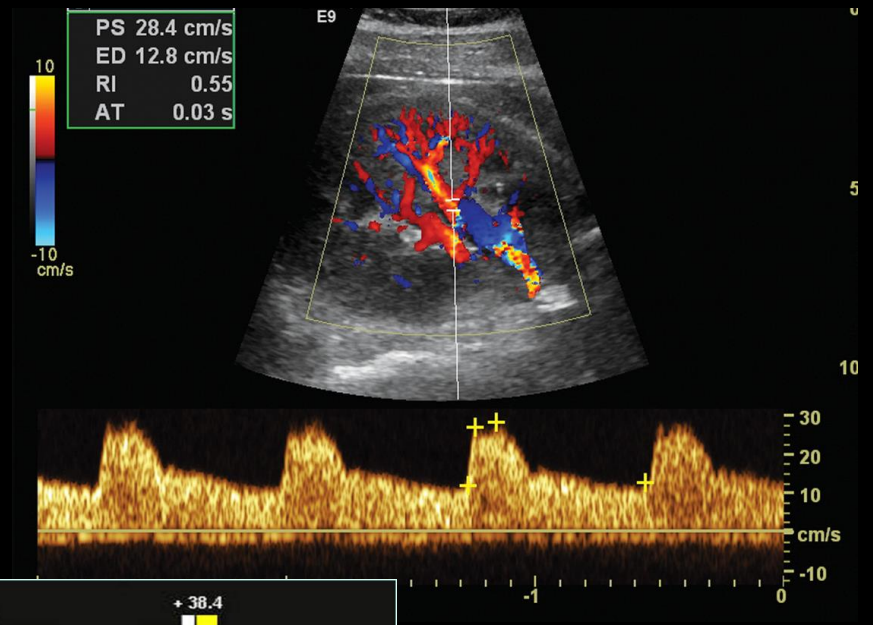
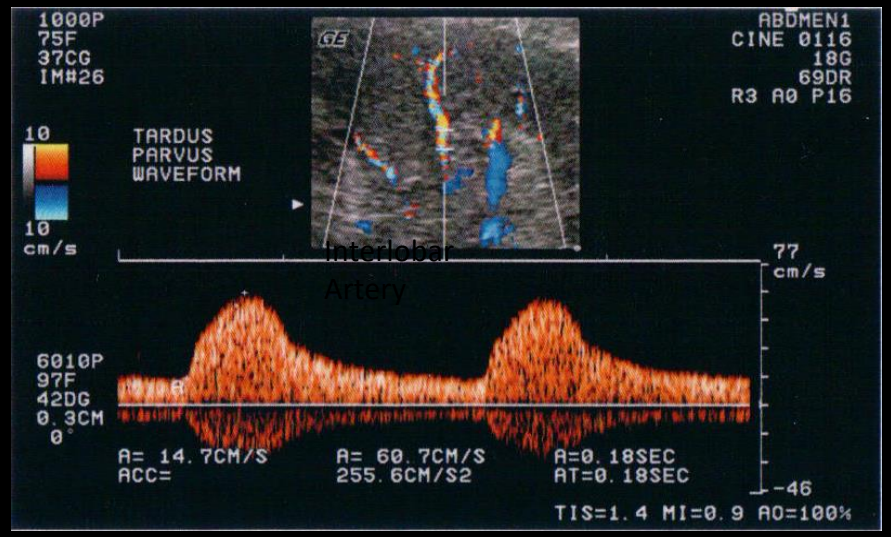
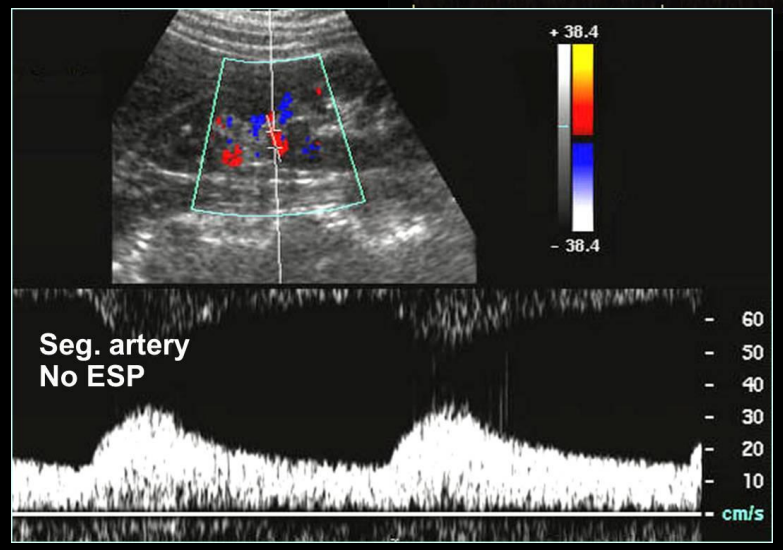
Indirect Method (Qualitative)





Doppler upper, mid & lower poles within kidney





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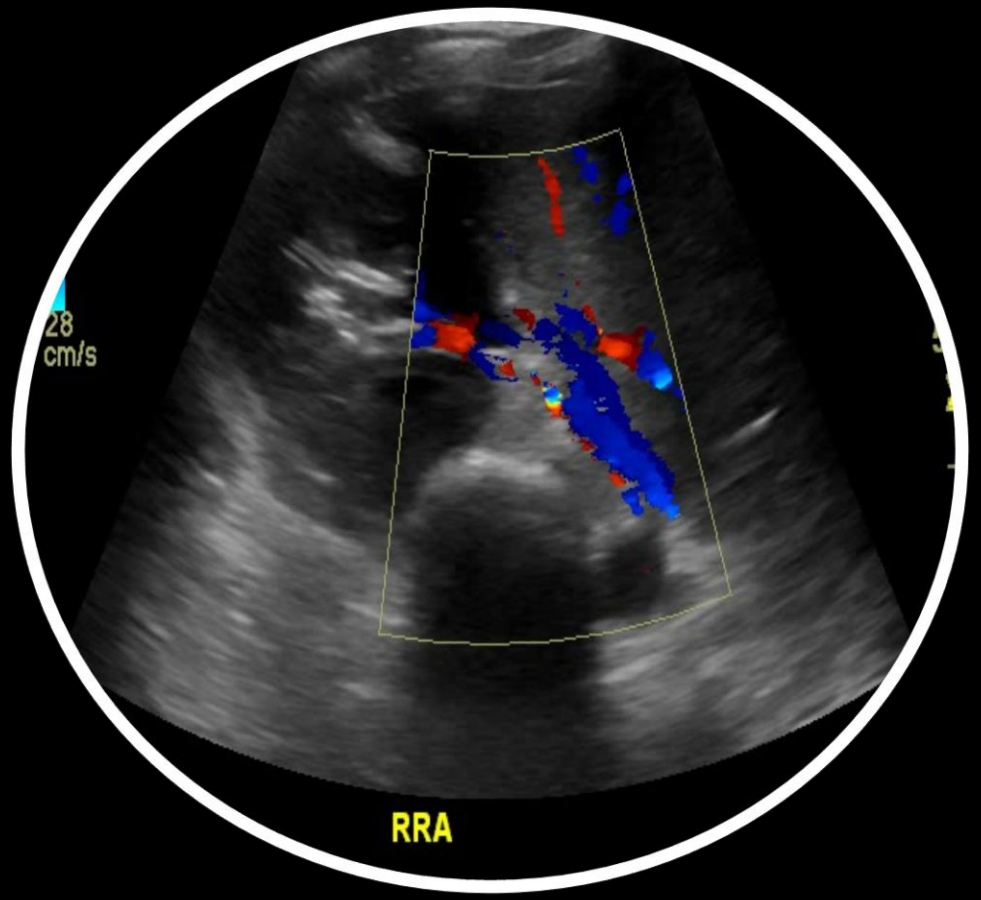
Fibromuscular Dysplasia

Fibromuscular dysplasia are uncommon associated with heterogeneous histologic changes that may affect the carotid circulation as well as the visceral and peripheral arteries.

String of beads is the classic radiographic finding seen in FMD.

FMD usually affects young to middle-aged adults, mostly women, but it can also affect children.



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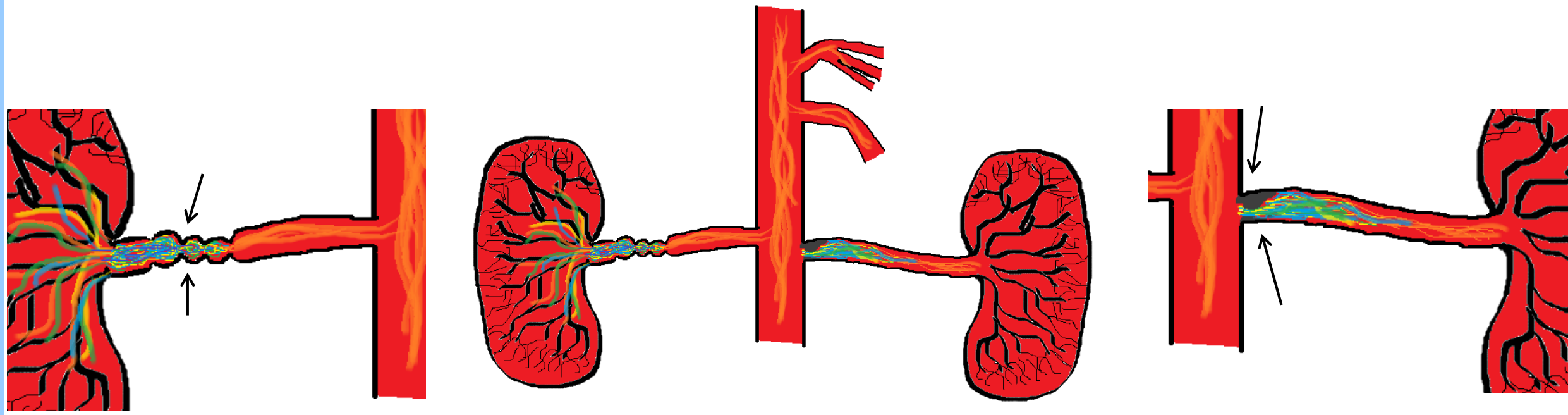
Fibromuscular Dysplasia vs Atherosclerosis



FMD
(Fibromuscular dysplasia)

Atherosclerotic
(ostial lesion)

Drawn By
Laura Tastad RVT

Think Location-Location-Location

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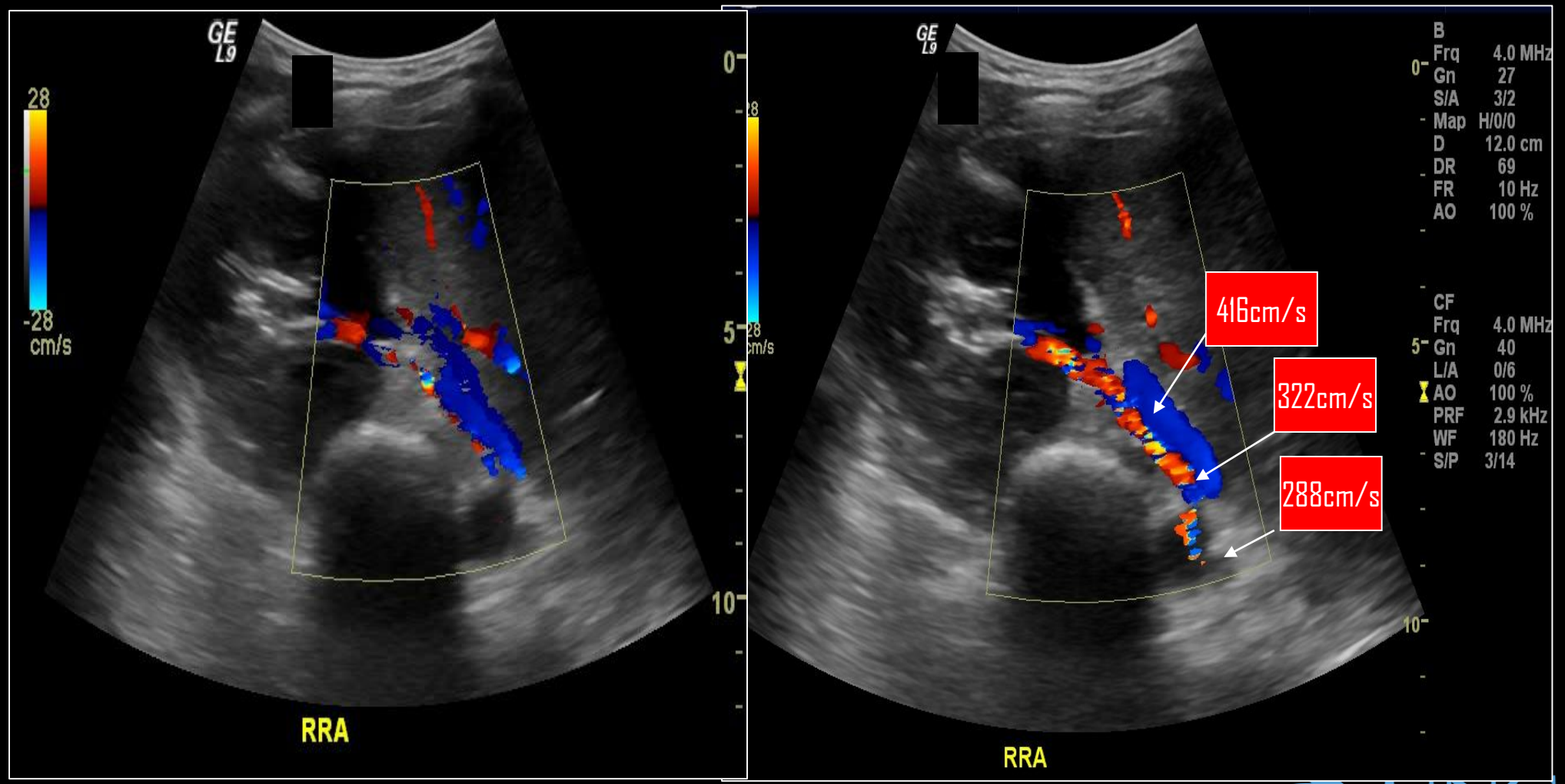
Obtain Velocities where aliasing occurs

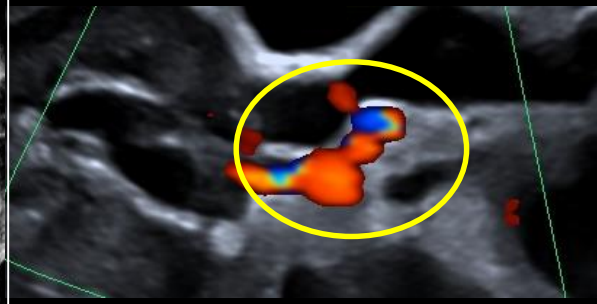


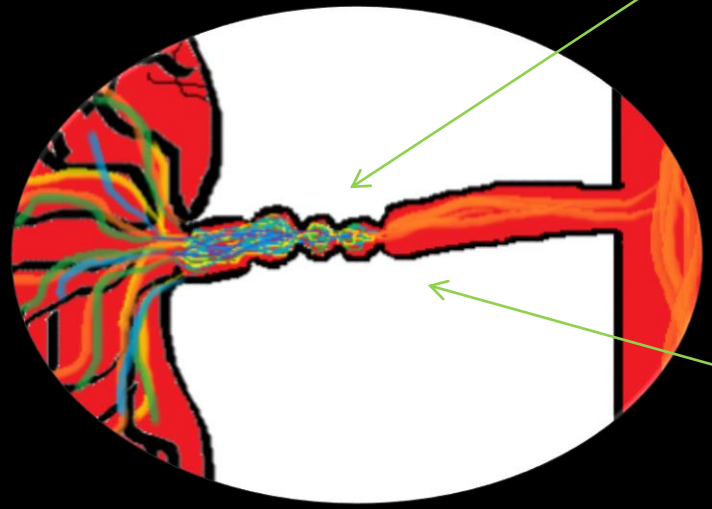
How to Differentiate FMD

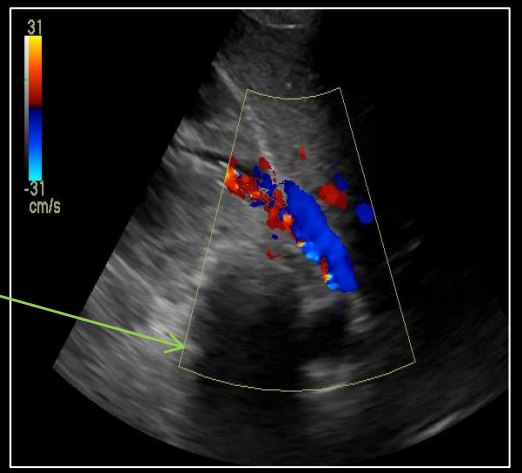
Both cause Renovascular Disease

Atherosclerotic DZ (Proximal)

Fibromuscular dysplasia (Mid-Distal)







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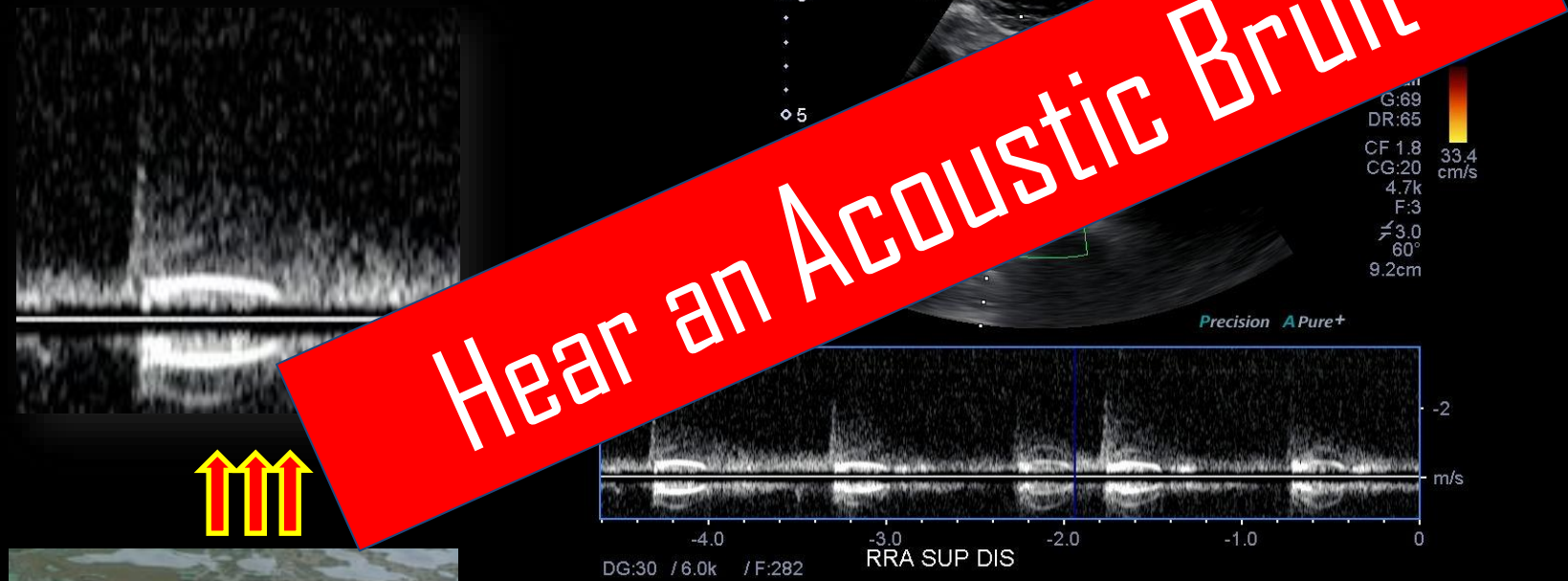
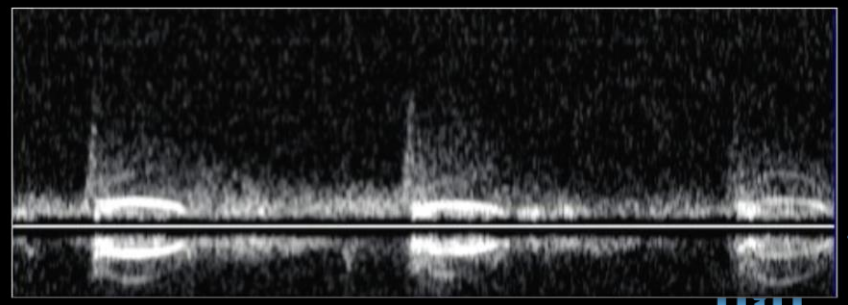
Fibromuscular Dysplasia
Clinical finding





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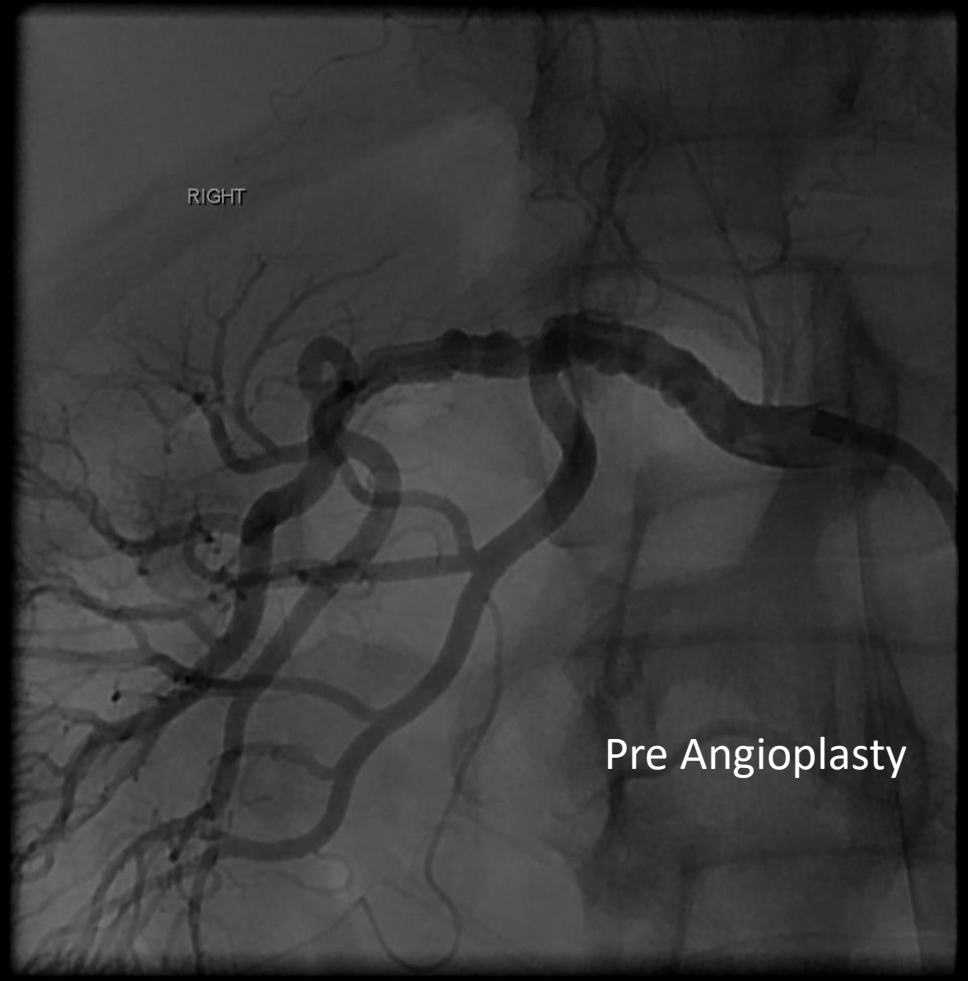
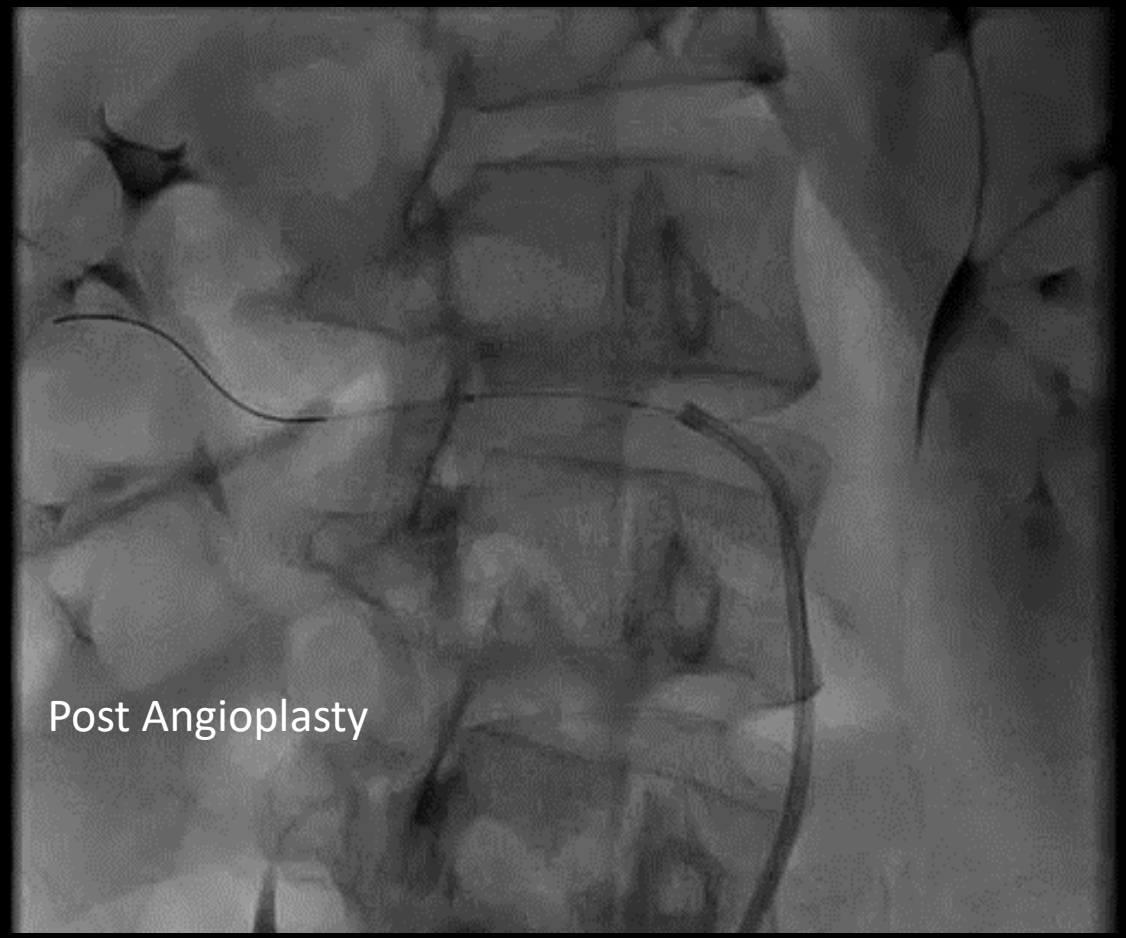
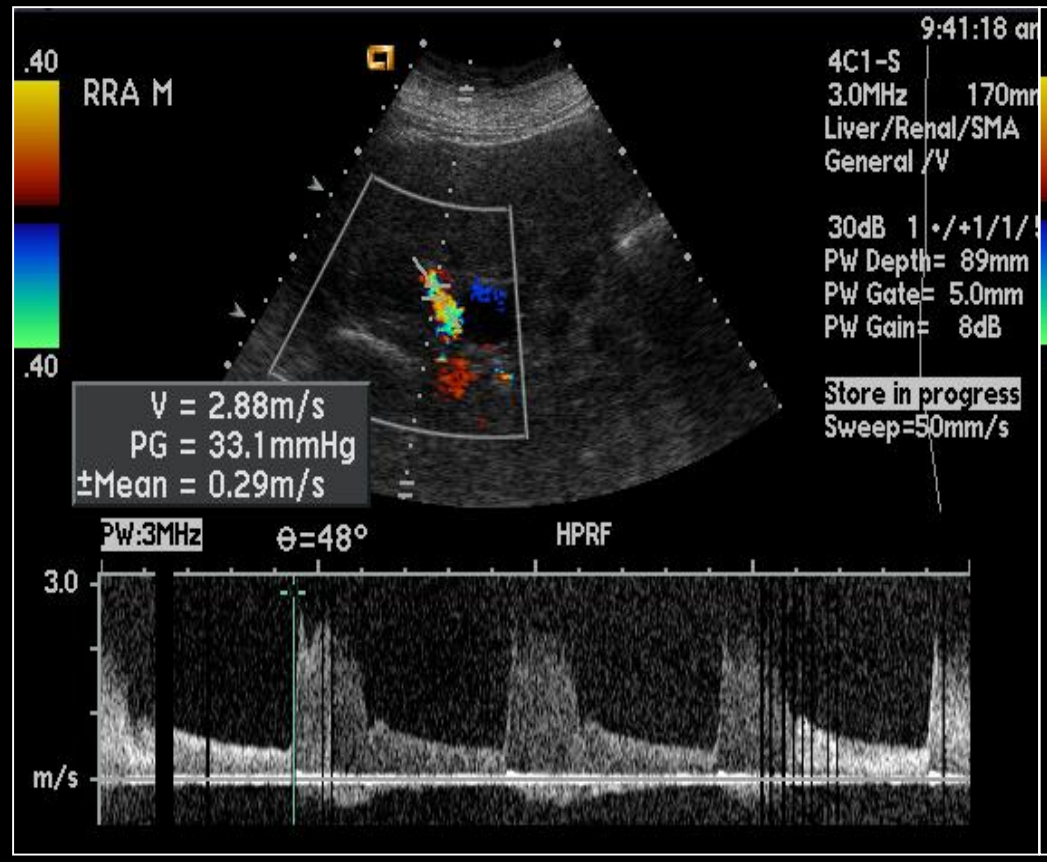
Fibromuscular Dysplasia

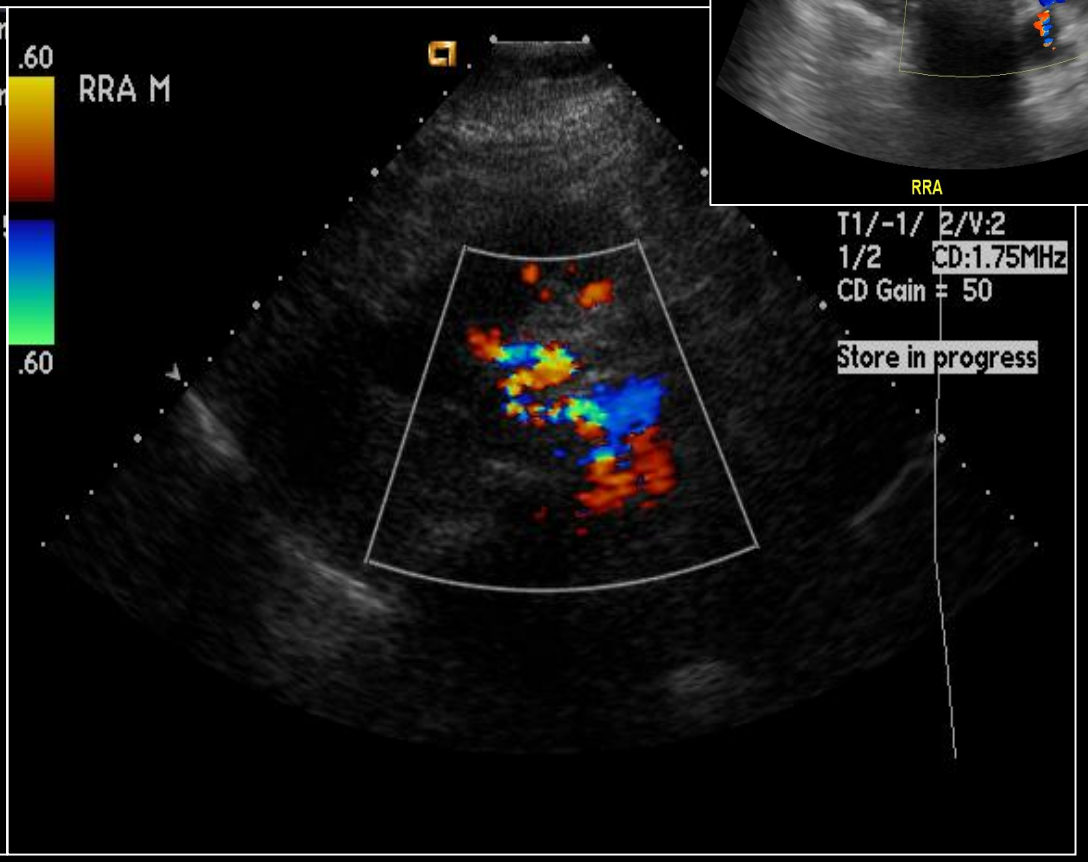
Pre and Post Angioplasty

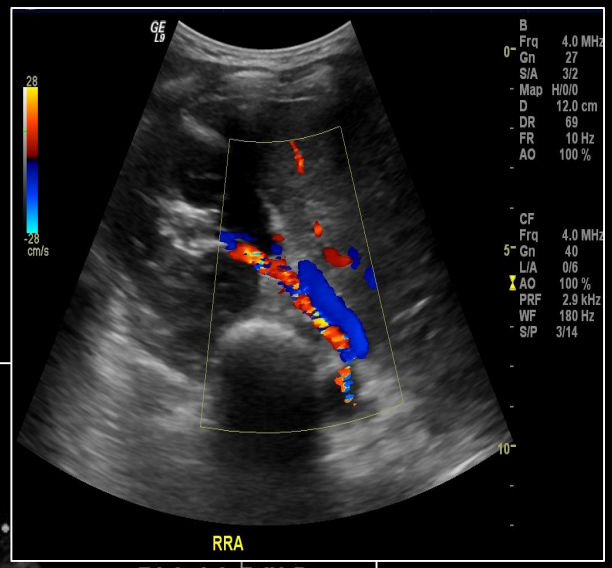




Is this FMD?







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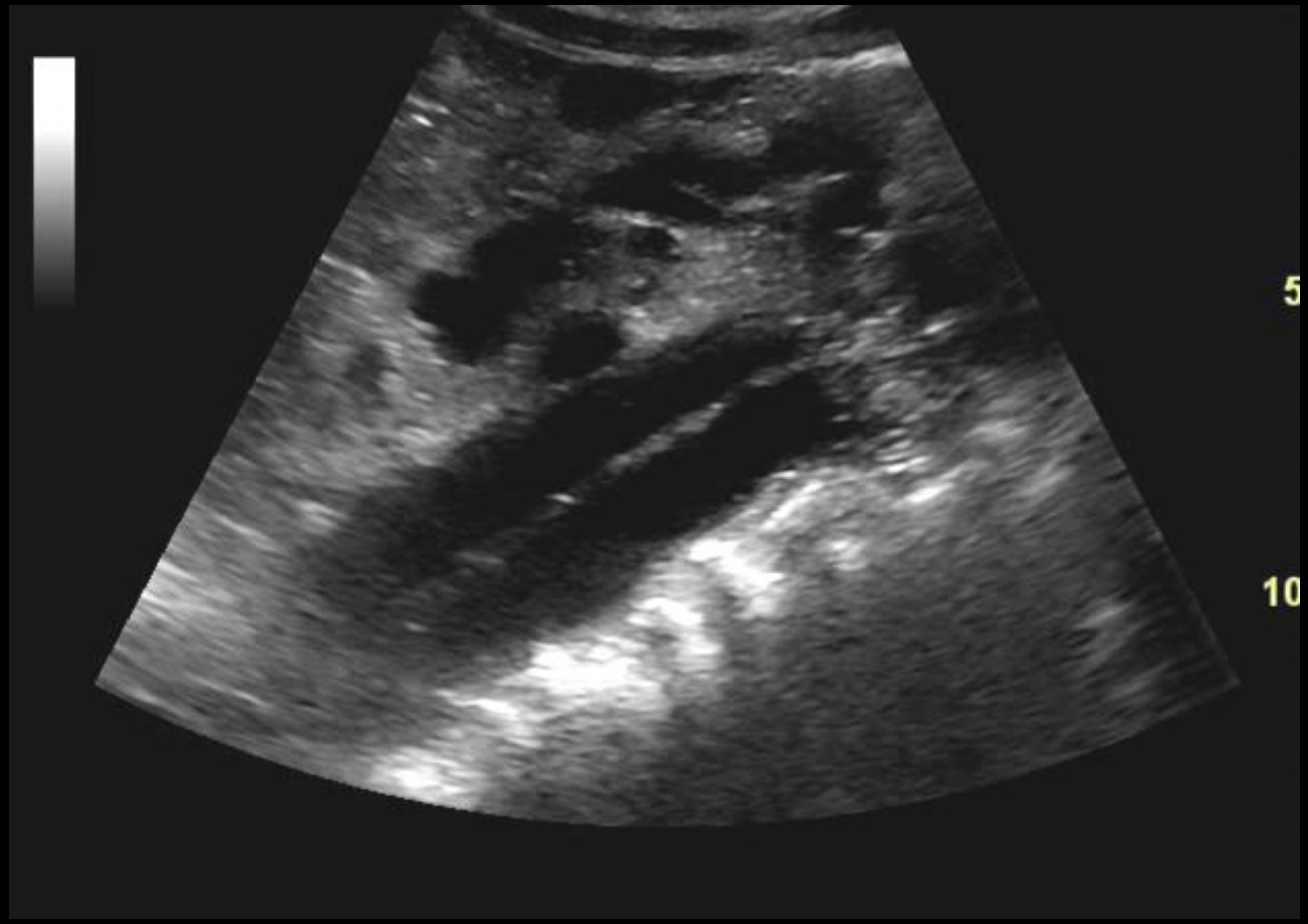
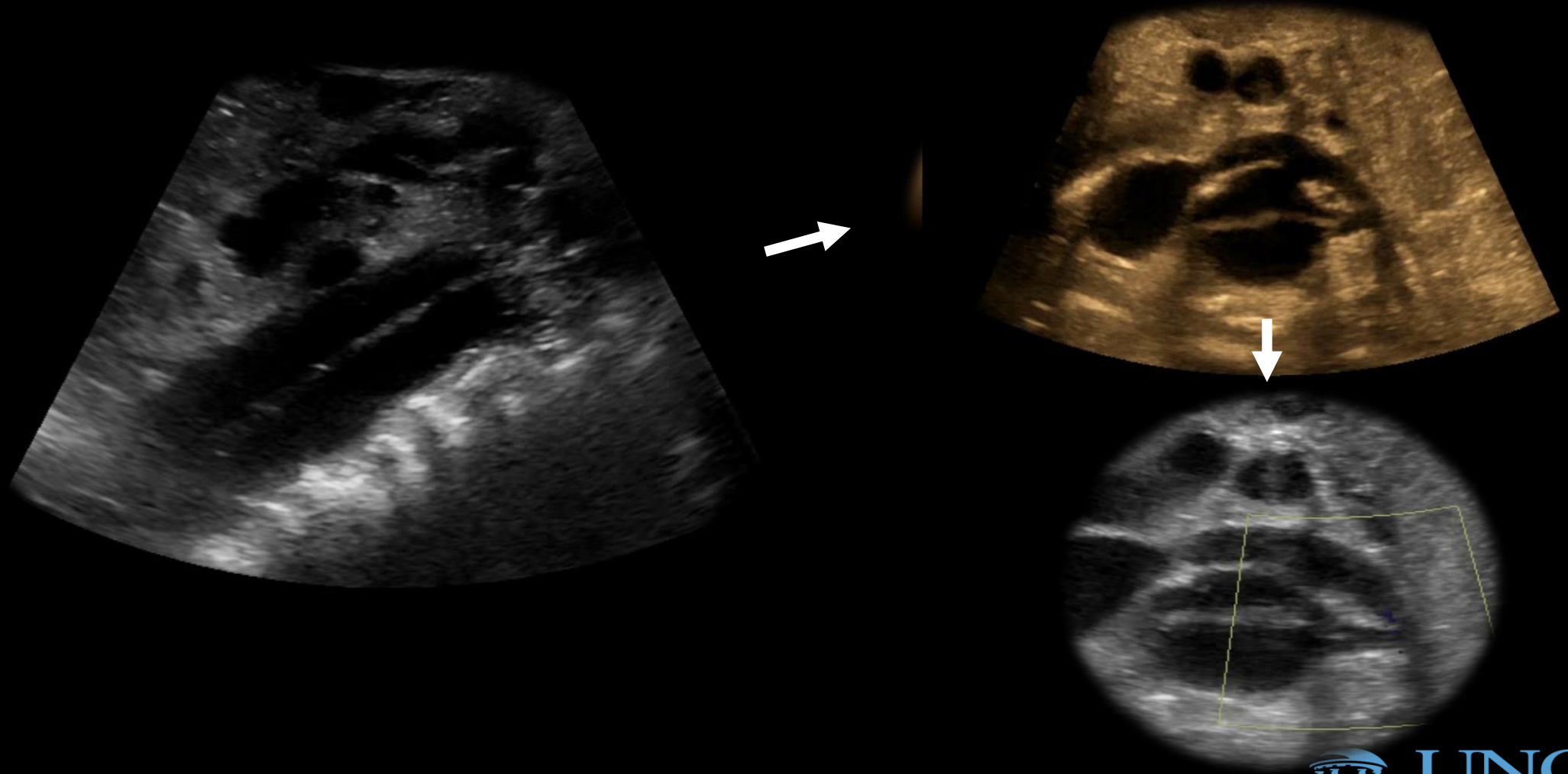
LET'S FINISH WITH AN INTERESTING VASCUALR CASE!

Sagitta Aorta – what is next step?

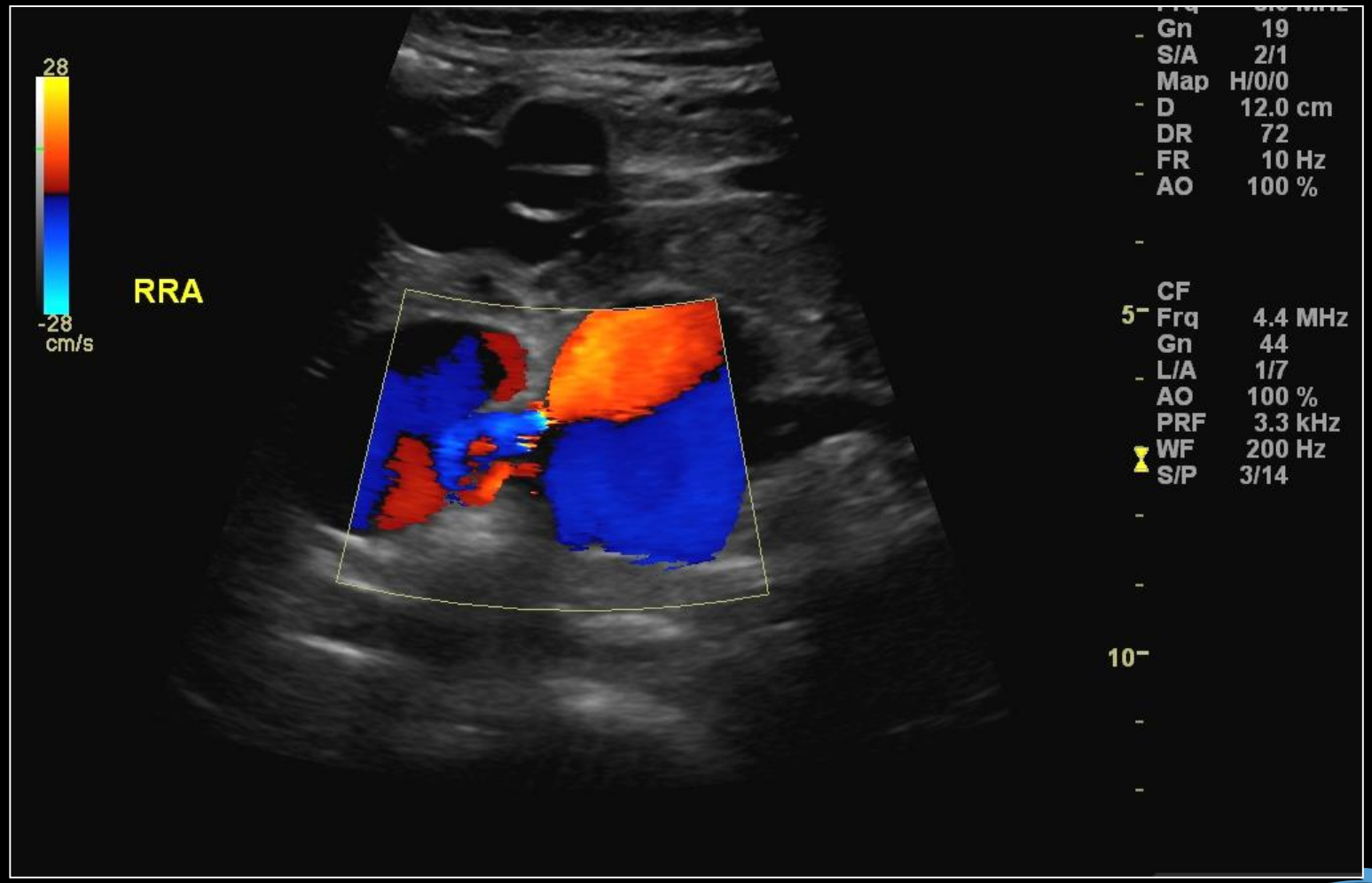


Always Obtain Two views !

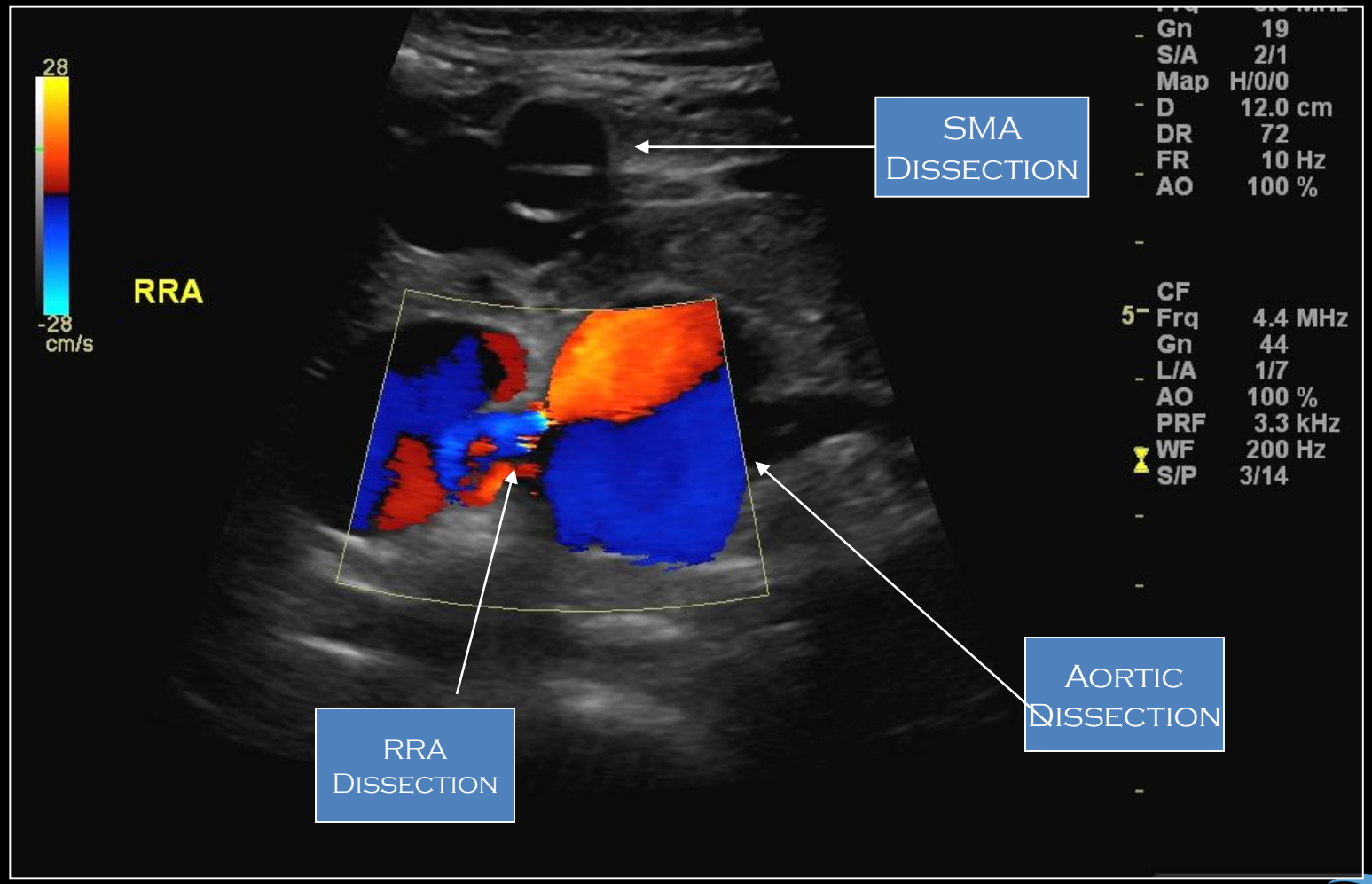
ABD AORTA Sag and Trans



Color Images



Color Images



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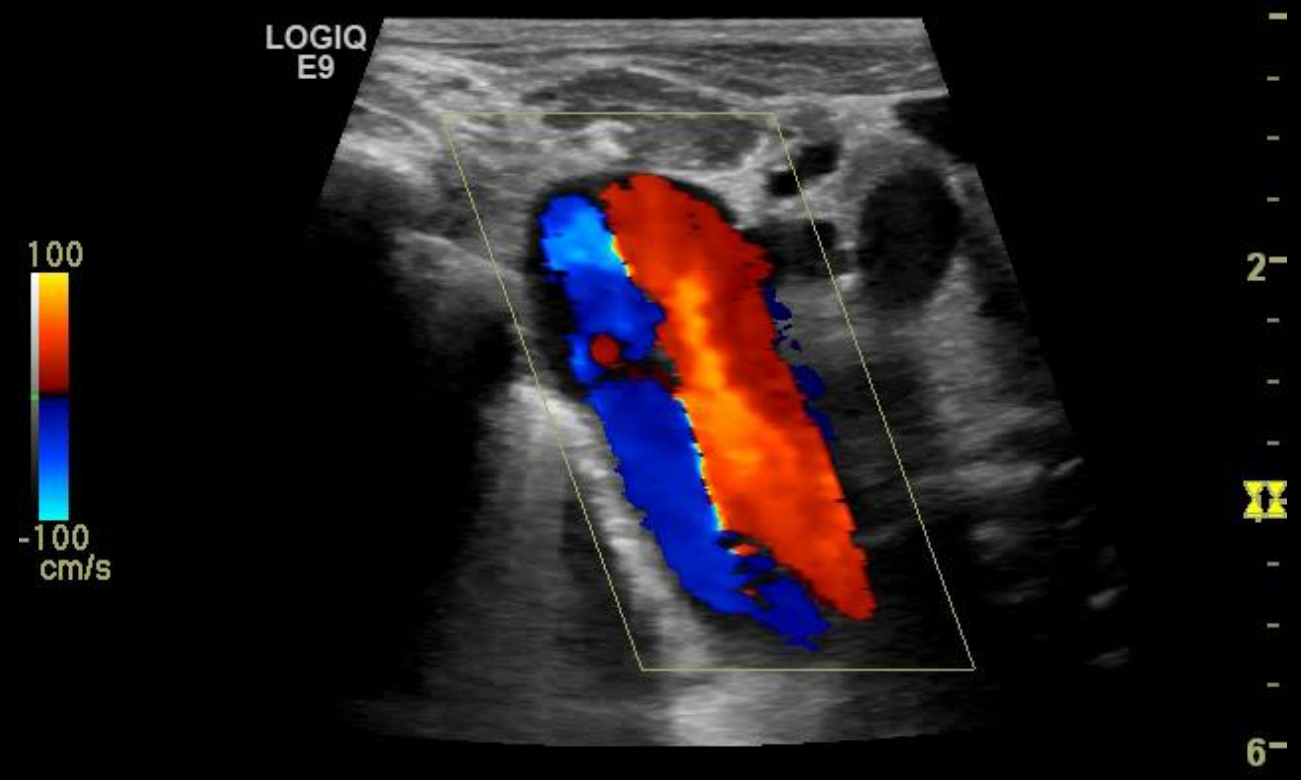
Left Subclavian Artery



Any Questions?

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Thank You!

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