Venous Ultrasound 2 - Venous Thrombosis/Obstruction, Pelvic Congestion Syndrome

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Disclosures: None

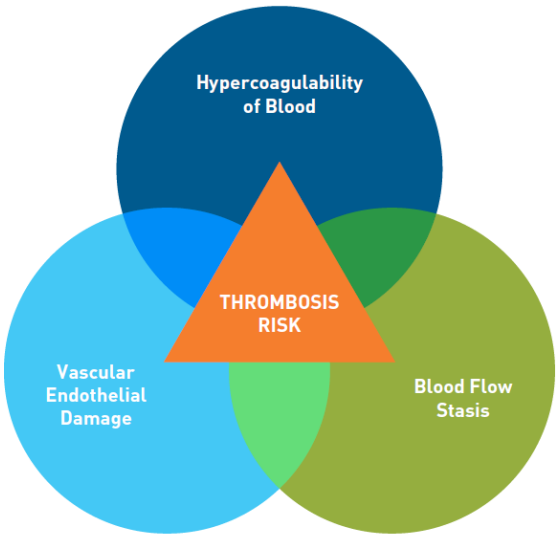
Goals For Todays Presentation

- Establish a general overview for diagnosing and characterizing DVT
- Discuss current standards and protocols for Lower / Upper Extremity Venous Duplex and Abdominal / Pelvic Venous Duplex Exams
- Assess the etiology, pathogenesis and treatment options for Pelvic Congestion Syndrome, May-Thurner Syndrome and Venous Thoracic Outlet Syndrome
- Tips and tricks commonly used to improve image optimization
- Review case studies, outcomes and pitfalls that a clinician may encounter

How is a DVT Diagnosed via Duplex Ultrasound?

- Linear transducers with a wide bandwidth (L3-8, L2-9)
- Loss of venous compressibility, (Total / Partial) with external transducer pressure.
- Absence or diminished flow via Spectral Doppler waveform.
- Partial or total color filling defect via Color Doppler flow. (Power Doppler)
- Monophasic flow, via Spectral Doppler, in the Common Femoral Vein may be indicative of a more proximal intrinsic obstruction vs extrinsic compression.

FIGURE 2. Virchow's Triad[10]



Adapted from Anderson FA Jr, Spencer FA. Risk factors for venous thromboembolism. *Circulation*. 2003;107(23 suppl 1):I9-I16. doi: 10.1161/01.CIR.0000078469.07362.E6.

TABLE 1. Risk Factors for VTE[10]

Strong	Moderate	Weak
• Fracture of pelvis, hip, or long bones of leg • Hip or knee arthroplasty • Major general surgery • Major trauma • Spinal cord injury	• Arthroscopic knee surgery • Central venous lines • Congestive heart failure • Estrogen therapy • Malignancy • Paralytic stroke • Pregnancy/postpartum • Genetic thrombophilia	• Bed rest >3 days • Prolonged immobility • Age • Laparoscopic surgery • Obesity • Varicose veins

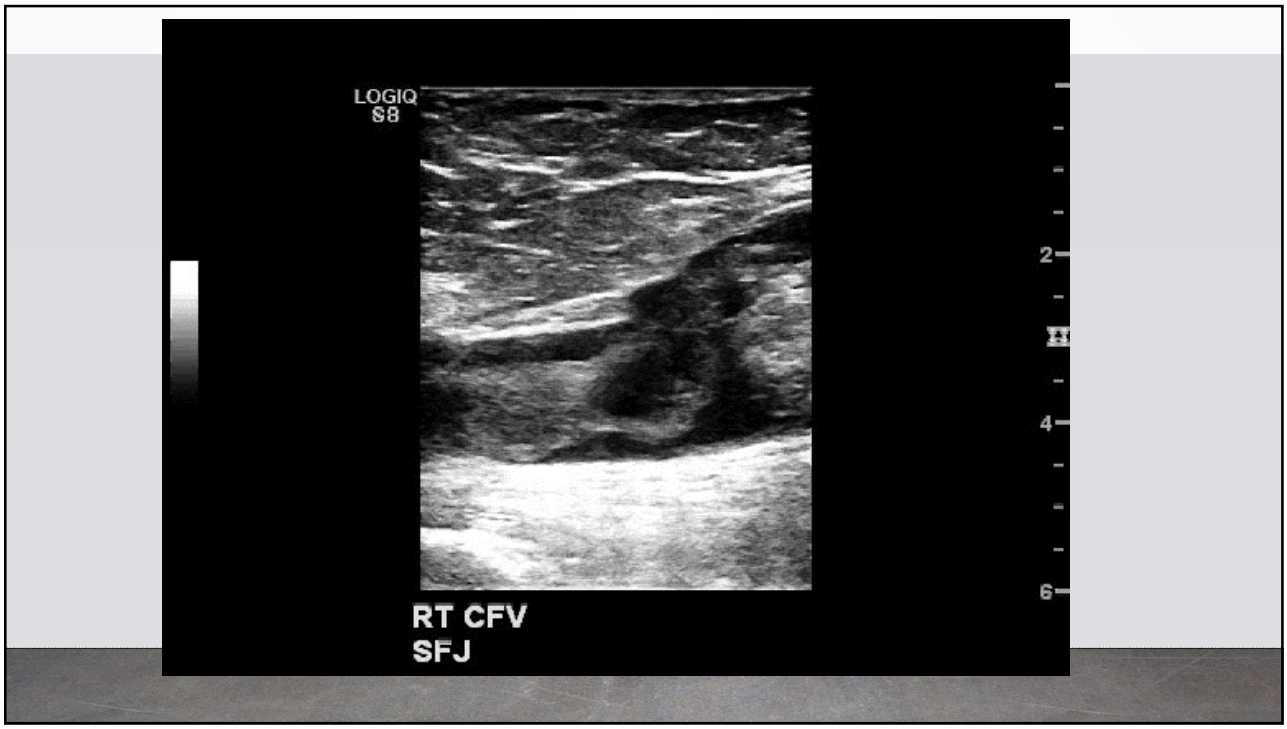
Adapted from Anderson FA Jr, Spencer FA. Risk factors for venous thromboembolism. *Circulation*. 2003;107(23 suppl 1):I9-I16. doi: 10.1161/01.CIR.0000078469.07362.E6.

Venous Thromboembolism and Cancer

- It is estimated that approximately 4–20% of cancer patients will experience VTE at some stage, the rate being the highest in the initial period following diagnosis. (1)
- Tumors can compress veins, resulting in venous stasis, thus encouraging thrombosis.
- In the setting of idiopathic DVT, it is to be assumed that a patient has cancer until proven otherwise.

Clinical Presentation of Acute Deep Vein Thrombosis

- Presents as anechoic / hypoechoic / or mixed echogenicity
- Thrombus can be poorly attached or mobile in character
- Typically results in partial to total loss of venous compressibility
- Vein lumen is dilated or distended
- Diminished or absent Spectral Doppler signals and Color filling defect
- Multiple collateral vessels or dilated superficial vessels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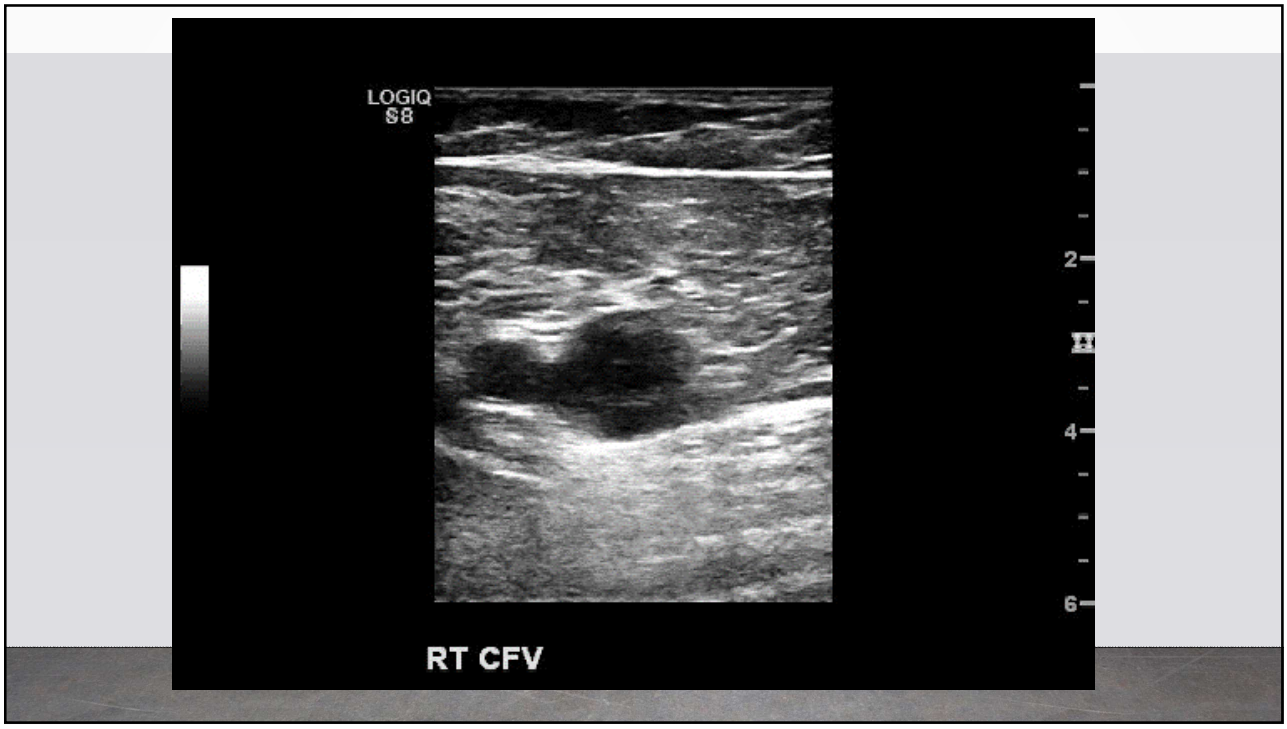
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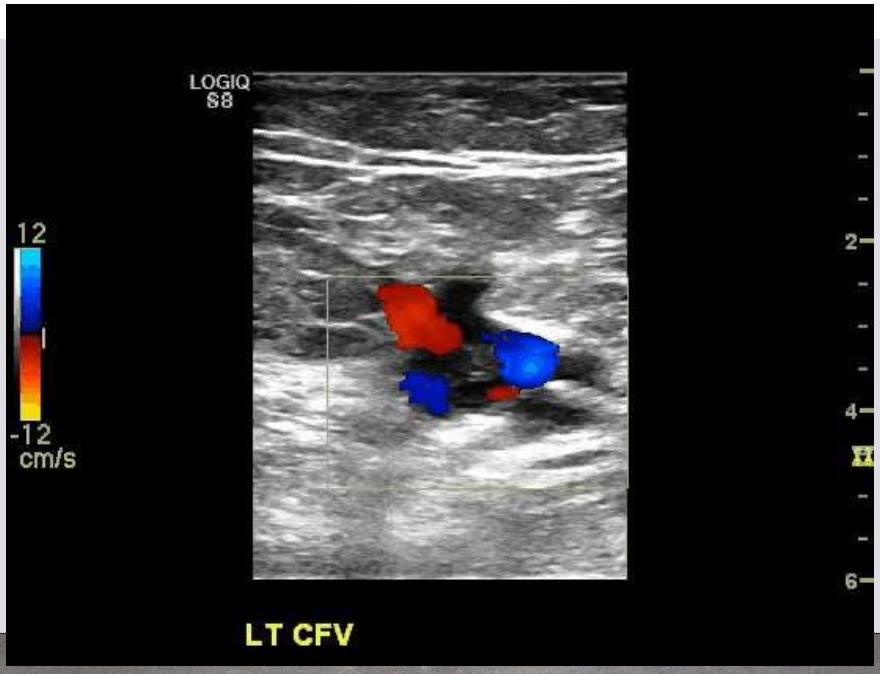
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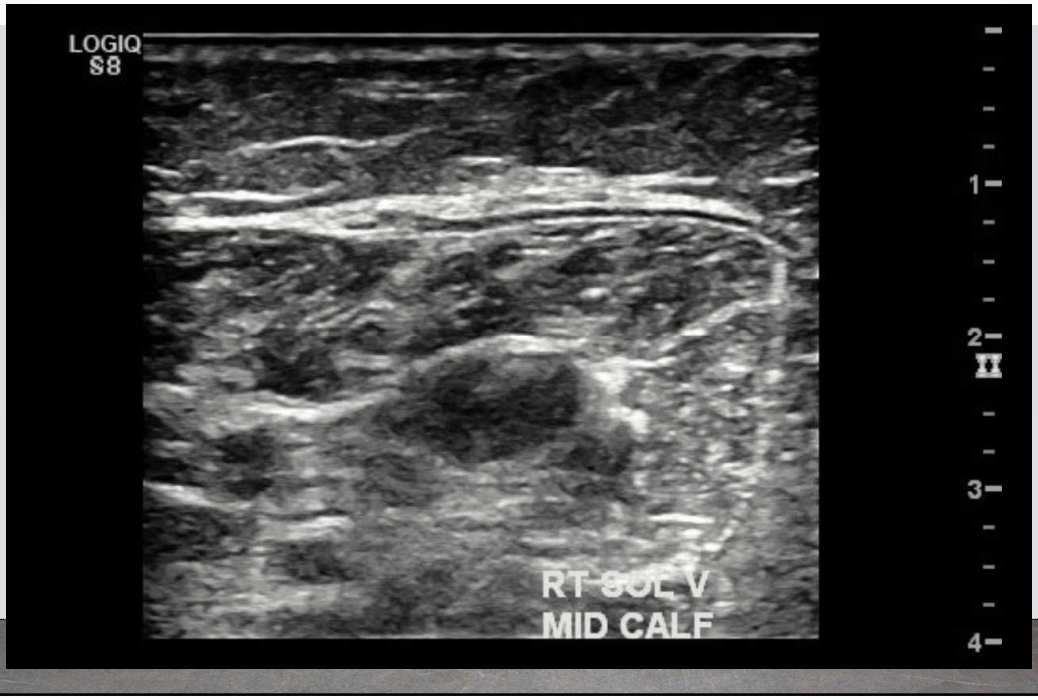
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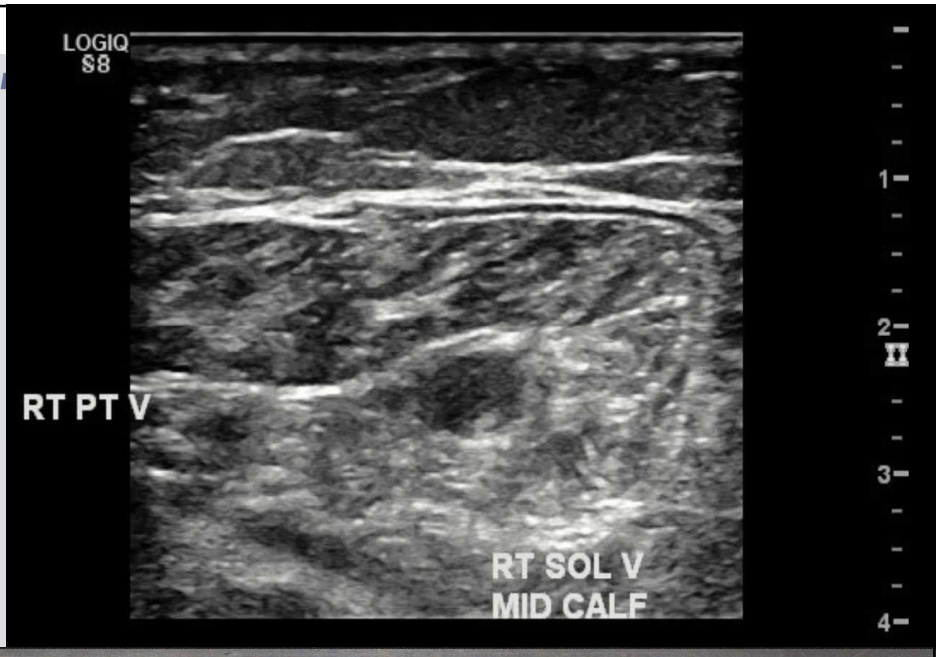
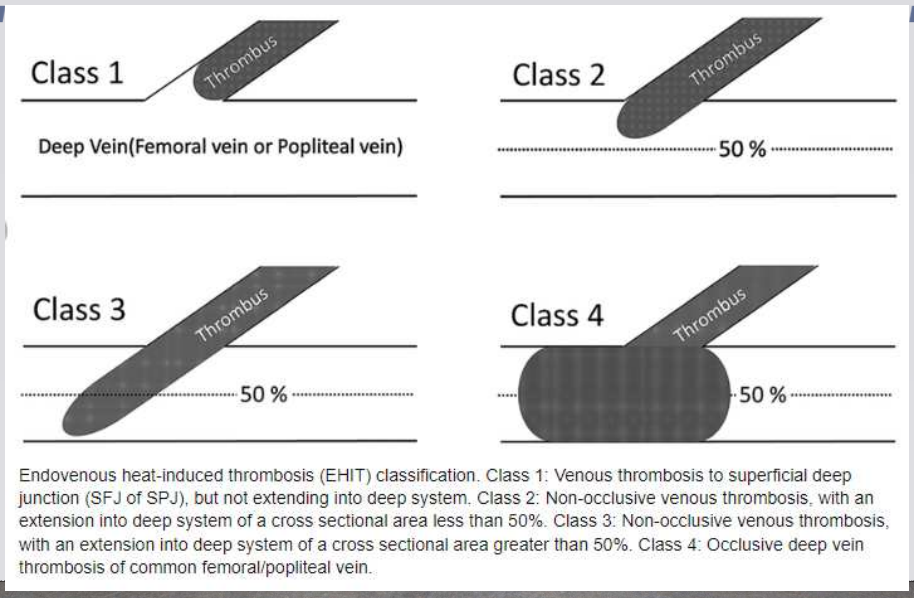
Acute DVT: Soleal Vein Communicating with Posterior Tibial Vein



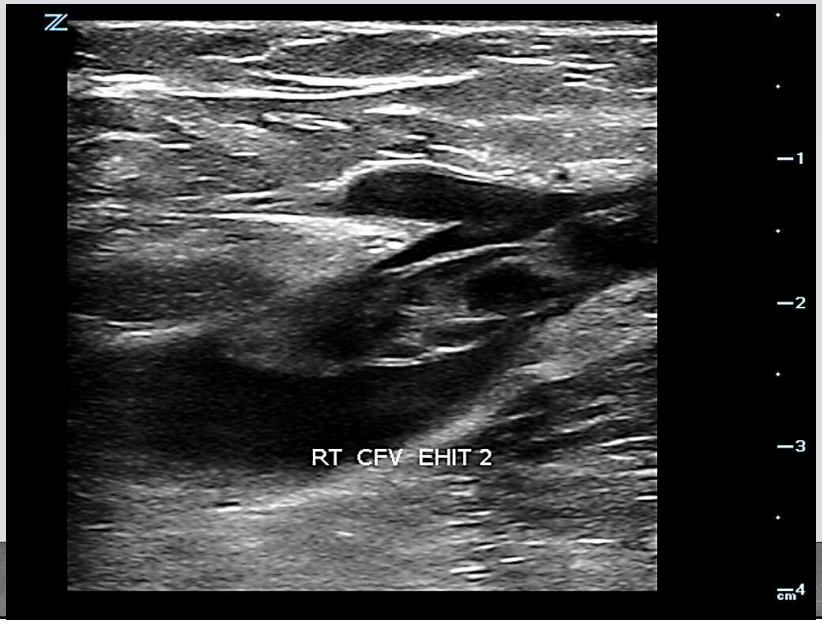
Endovenous Heat Induced Thrombus

- Classification of endovenous heat-induced thrombosis (EHIT)
  - I = junction.
  - II = <50% lumen.
  - III = >50% lumen.
  - IV = occlusive deep venous thrombosis
- Typical sites of occurrence:
  - (SFJ) Sapheno-femoral junction, GSV connects to CFV
  - (SPJ) Sapheno-popliteal junction, SSV connects to Pop
  - At the site of a perforator vein

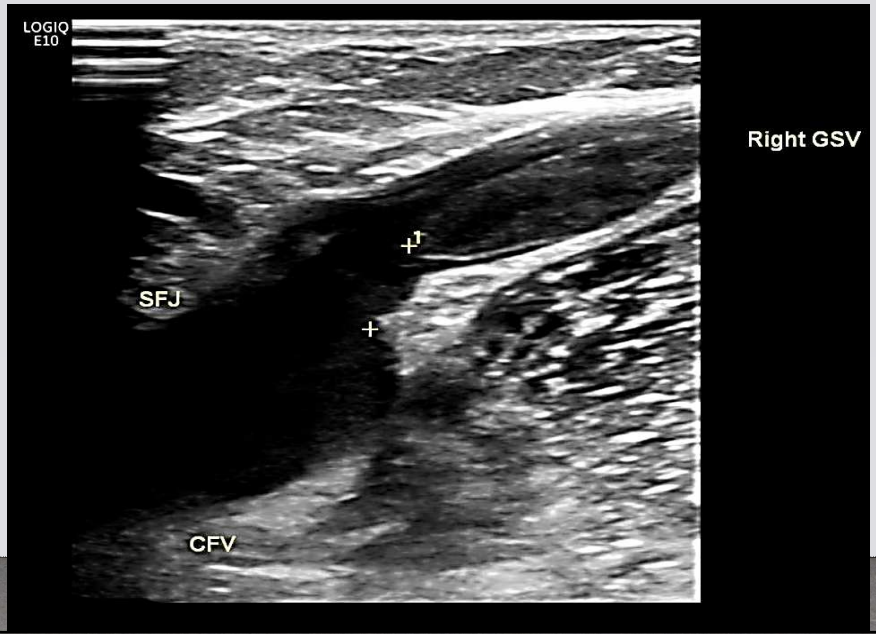


Endovenous heat-induced thrombosis (EHIT) classification. Class 1: Venous thrombosis to superficial deep junction (SFJ of SPJ), but not extending into deep system. Class 2: Non-occlusive venous thrombosis, with an extension into deep system of a cross sectional area less than 50%. Class 3: Non-occlusive venous thrombosis, with an extension into deep system of a cross sectional area greater than 50%. Class 4: Occlusive deep vein thrombosis of common femoral/popliteal vein.

1 Day Post Radio Frequency Ablation of the Right GSV (EHIT 2)



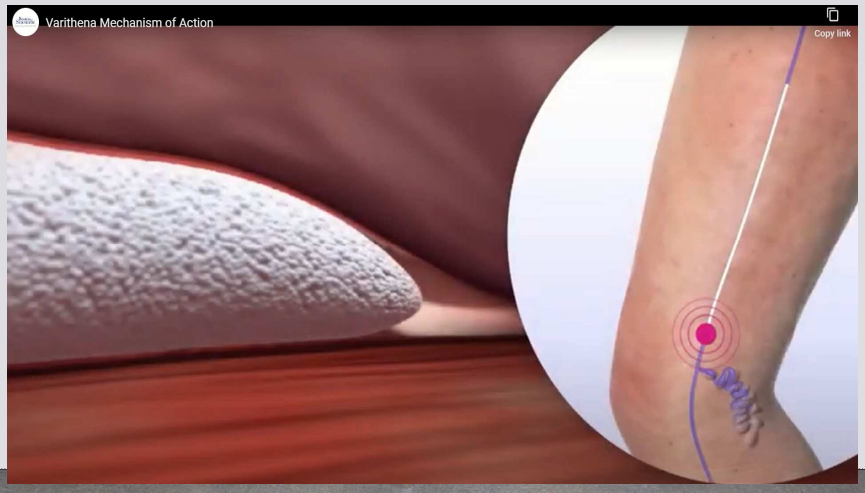
7 Days Post RFA of Right GSV



Chemical / Foam Induced Thrombus

- Chemical induced thrombus via compound foam or Varithena (polidocanol injectable foam)1%
- Typical sites of occurrence:
  - Intramuscular calf veins
  - At the site of a perforator vein in the calf
  - (SFJ) Sapheno-femoral junction, GSV connects to CFV
  - (SPJ) Sapheno-popliteal junction, SSV connects to Pop

Varithena (polidocanol injectable foam) 1%

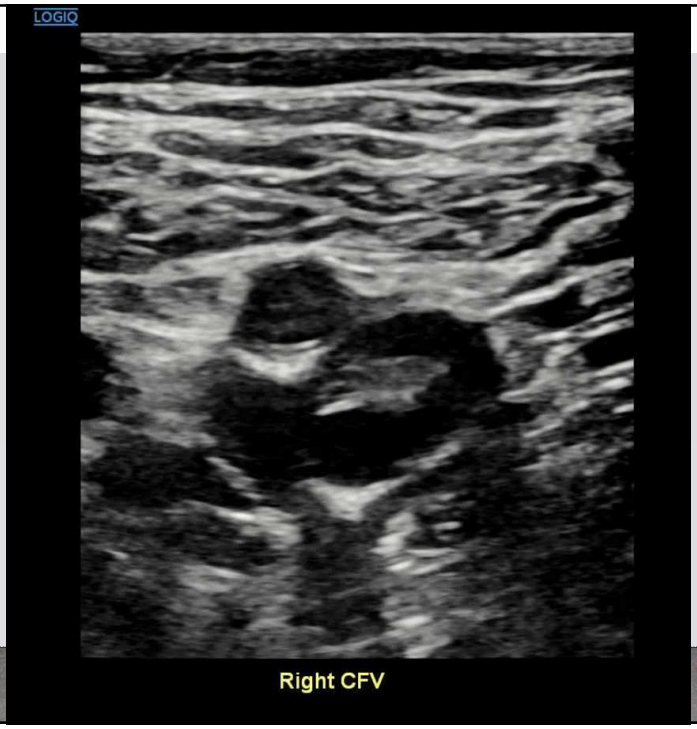


Chemical / Foam Induced DVT

Foam induced thrombus in the Posterior Tibial vein via an incompetent Great Saphenous perforator vein.

What is Chronic Deep Vein Thrombosis?

- Recanalization of a vein, post acute deep vein thrombosis, involves a complex multi-phasic process of remodeling
- Hyperechoic or mixed echogenicity (cobweb appearance)
- Typically results in partial loss of venous compressibility, sometimes it will occlude the entire vessel and collateral vessels will be present
- Vessel recanalization may result in diminished Spectral Doppler waveforms or color Doppler filling
- A fibrous membrane may remain behind within the lumen of the vein (Synechia)
- Vein will typically display evidence of venous reflux with distal augmentation (Post-Phlebitic Syndrome), due to damage of the semilunar venous valves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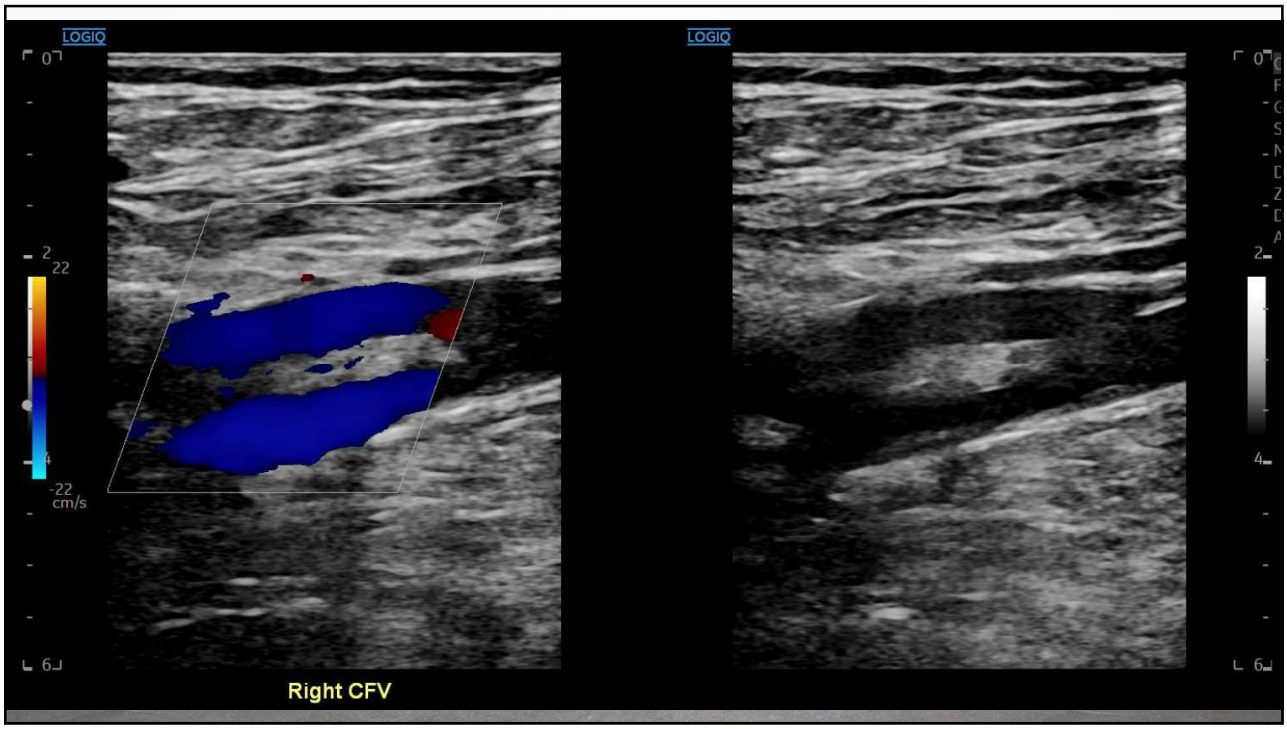
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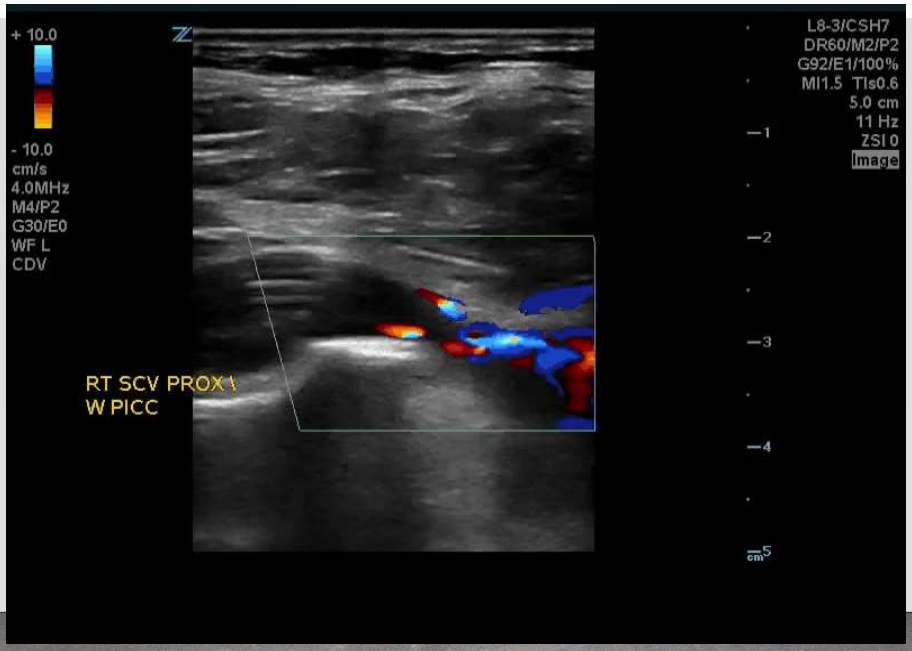
Upper Extremity Deep Vein Thrombosis

- Unilateral upper extremity pain, swelling, and arm fatigue
- Typically caused by peripheral IV lines, trauma, Paget-Schroetter / Thoracic Outlet Syndrome or cancer
- If the more proximal superior vena cava (SVC) is involved, facial plethora and chest wall edema may be noted
- Prominent superficial collateral veins may appear on the shoulder and anterior chest wall, known as Urschel's sign
- Work with your staff to establish the best practices for evaluating upper extremity vessels

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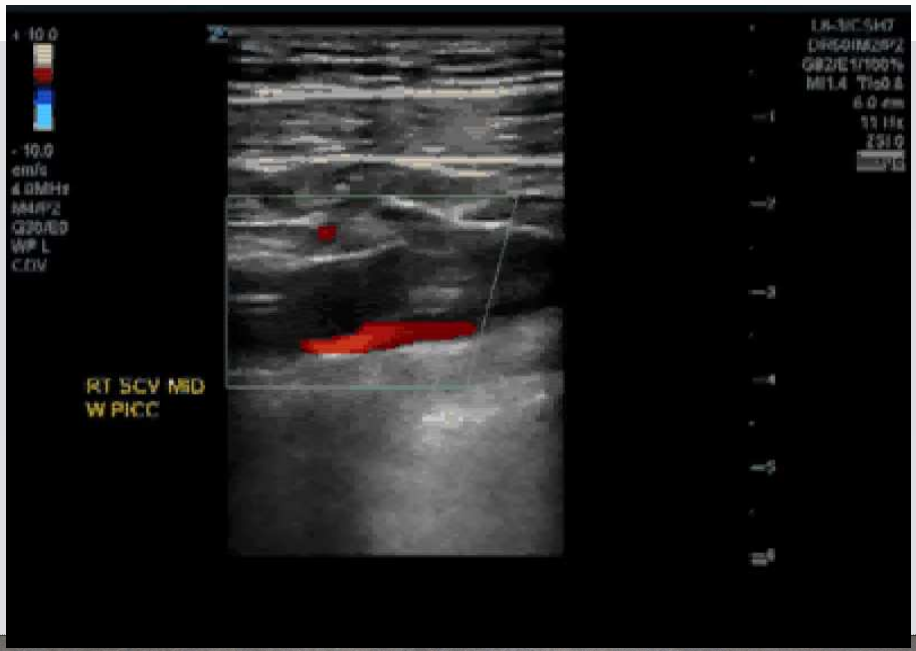
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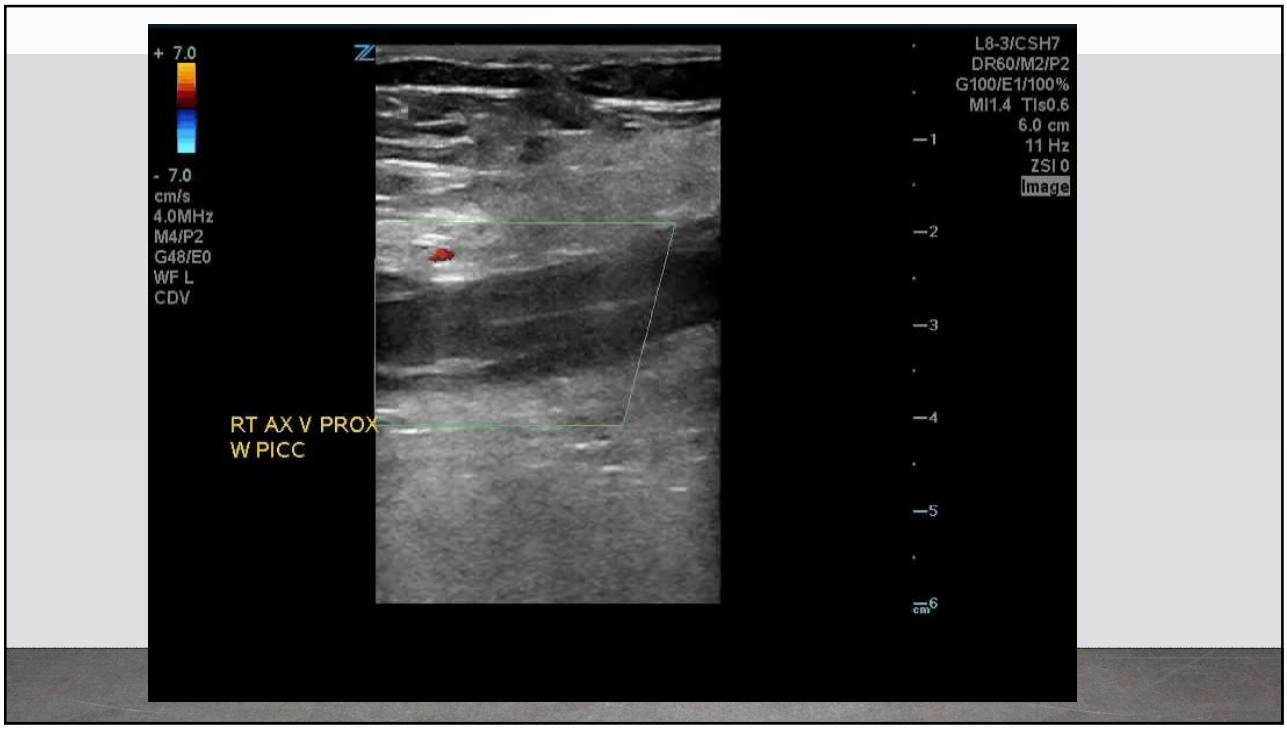
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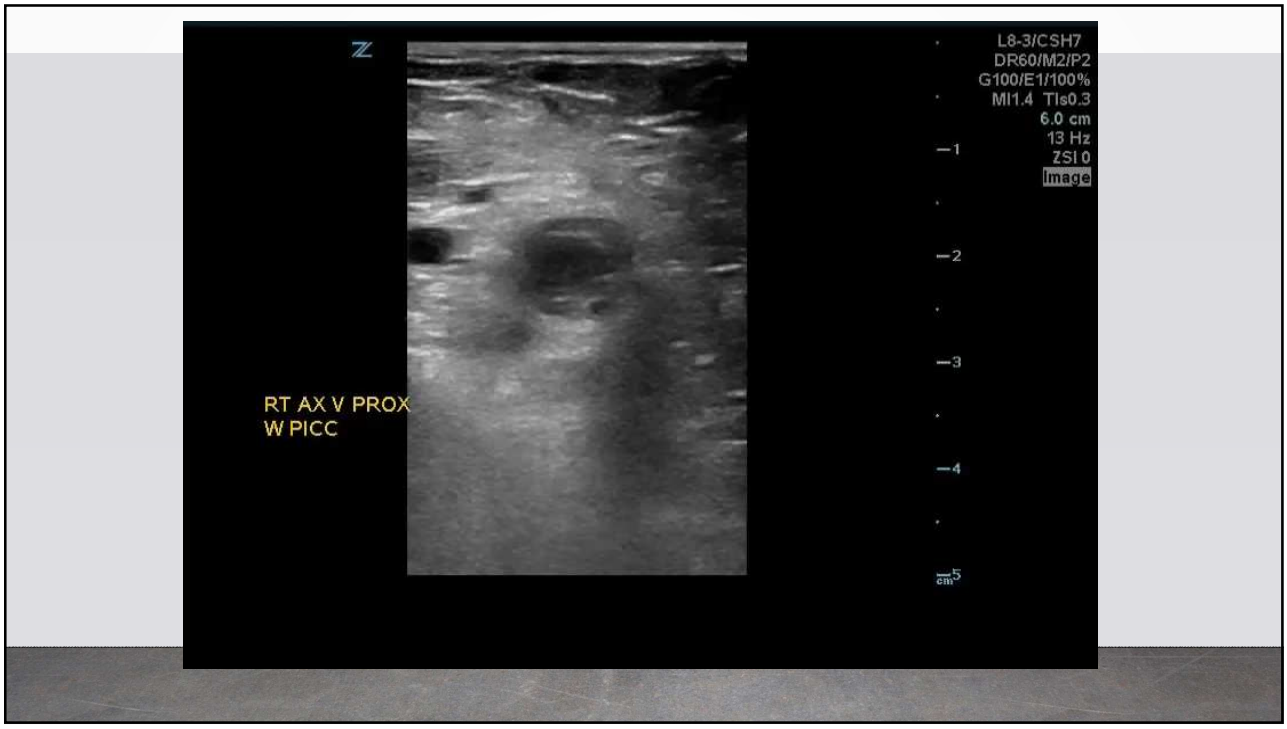
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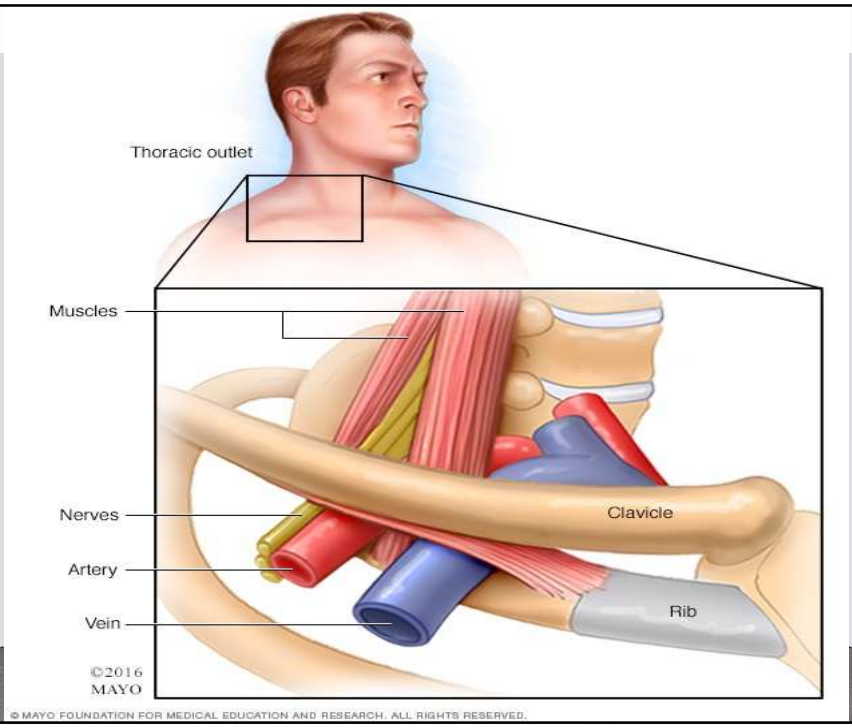
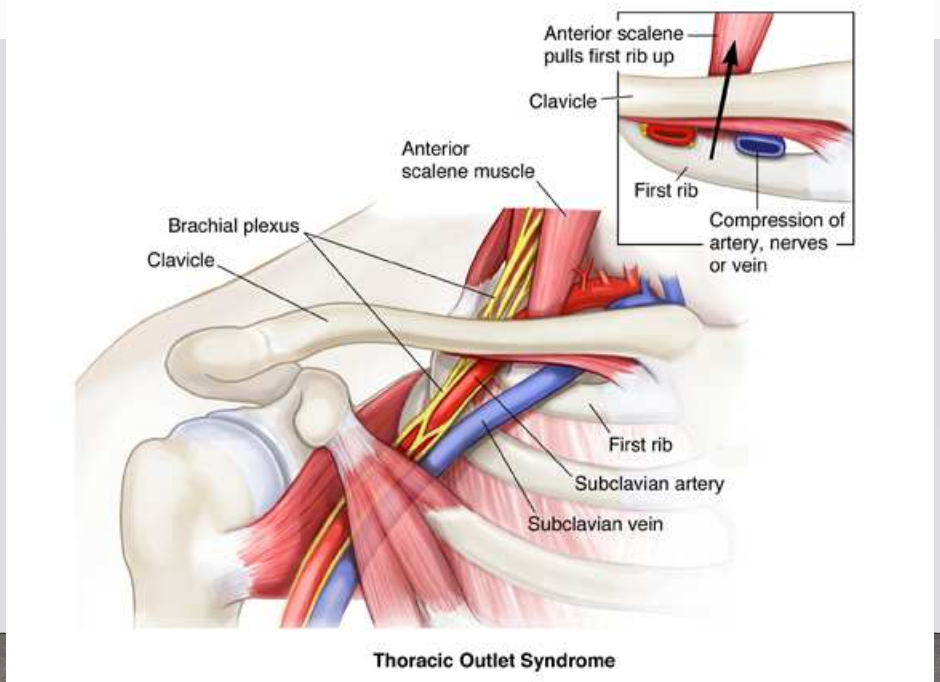
What Is Thoracic Outlet Syndrome (TOS)?

- A group of disorders that occur when certain blood vessels or nerves are compressed at rest or with shoulder abduction (TOS maneuvers)
- Thoracic outlet syndrome affects the space between the clavicle and first rib (thoracic outlet). Common causes include trauma, repetitive injuries, pregnancy, anatomical defects such as having an extra rib.
- Symptoms include pain in the shoulders / neck, numbness, weakness, coldness in the fingers and in rare cases thrombosis of the subclavian vein.
- Many patients suddenly develop a swollen and discolored arm with pallor, a weak or absent pulse in the affected arm, which also may be cool to the touch and appear paler than the unaffected arm.
- Immediate treatment is critical. Patients usually require catheter-directed thrombolysis, anticoagulation, and then surgery to decompress the thoracic outlet
- Post-operative treatment involves physical therapy, pain relief and bilateral upper extremity surveillance (via U/S).
- Surgery may be required to relieve the compression and to prevent future thrombotic events.

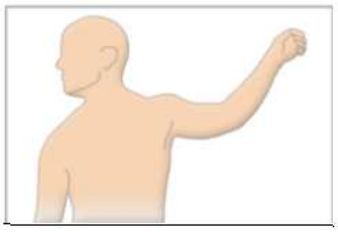




Thoracic Outlet Syndrome

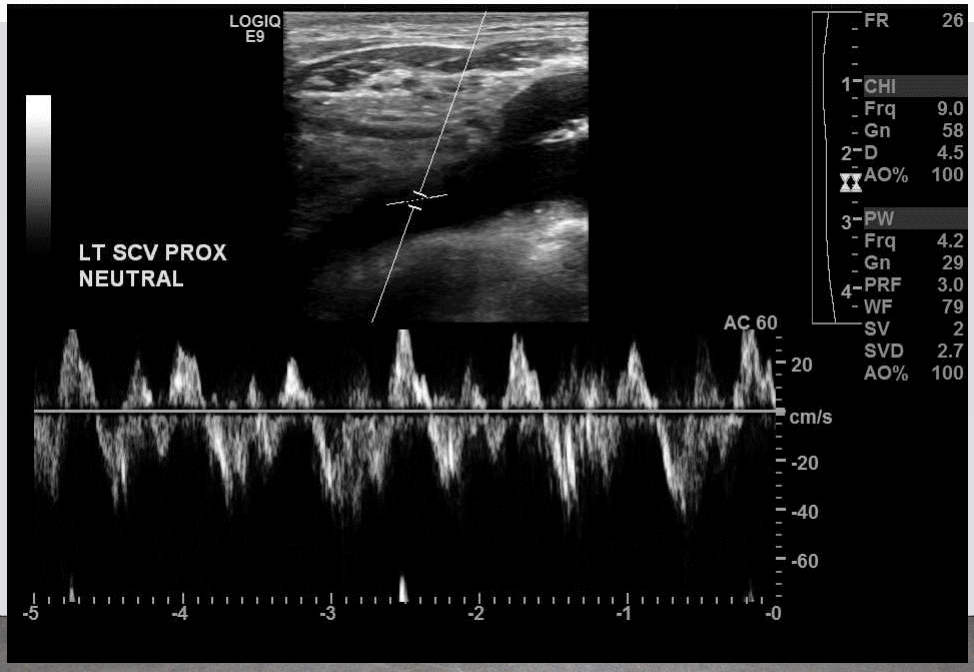
What are the provocative maneuvers?

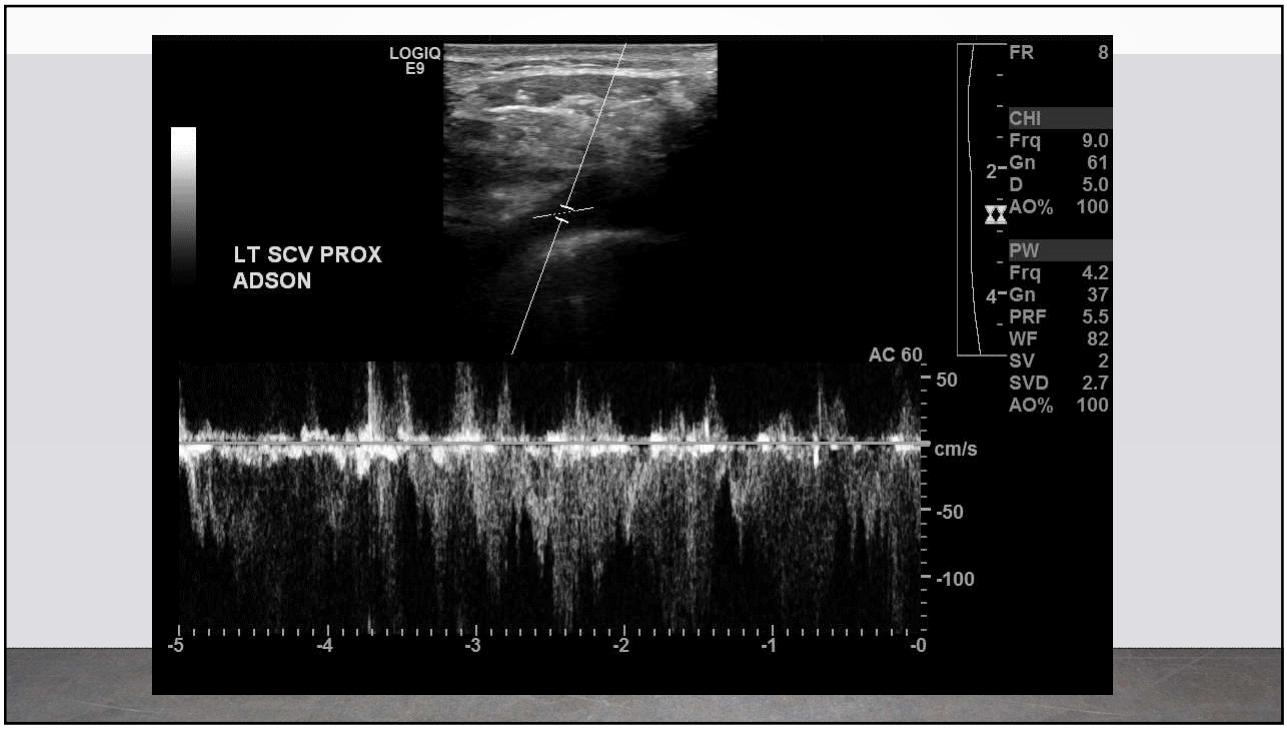
- Subclavian and axillary veins are initially assessed in the resting position
- Arm is placed in the surrender position with shoulders at a 90° abduction-external rotation and elbows flexed to 90° and tilting the neck away from the limb being tested



Venous Thoracic Outlet Syndrome Case Study 1

- 22 y/o Male, Left-handed was lifting weights when his left arm began to swell
- Initial duplex performed at Emergency Department was negative for DVT
  (False Negative)
- CT exam was performed which resulted in extensive DVT of the left upper extremity. Patient was subsequently anticoagulated
- Arrives for a vascular consultation, which begins with a bilateral venous duplex with dynamic TOS maneuvers

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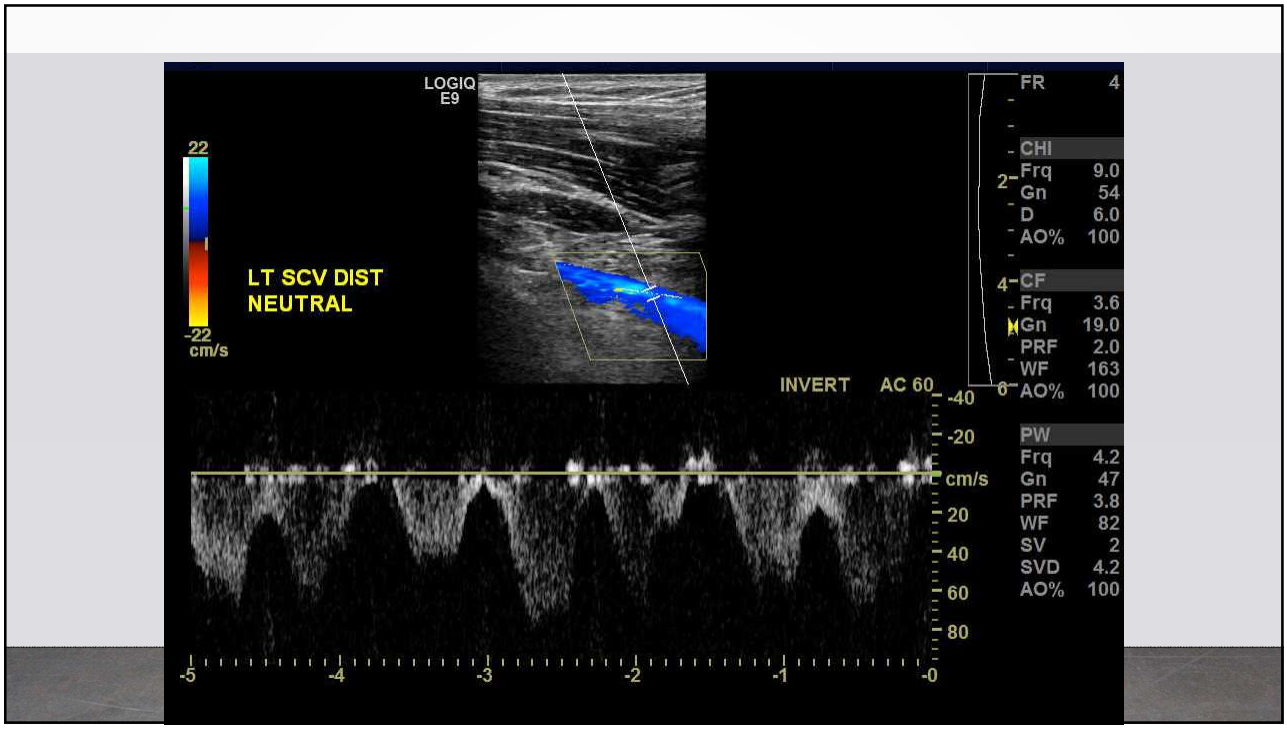
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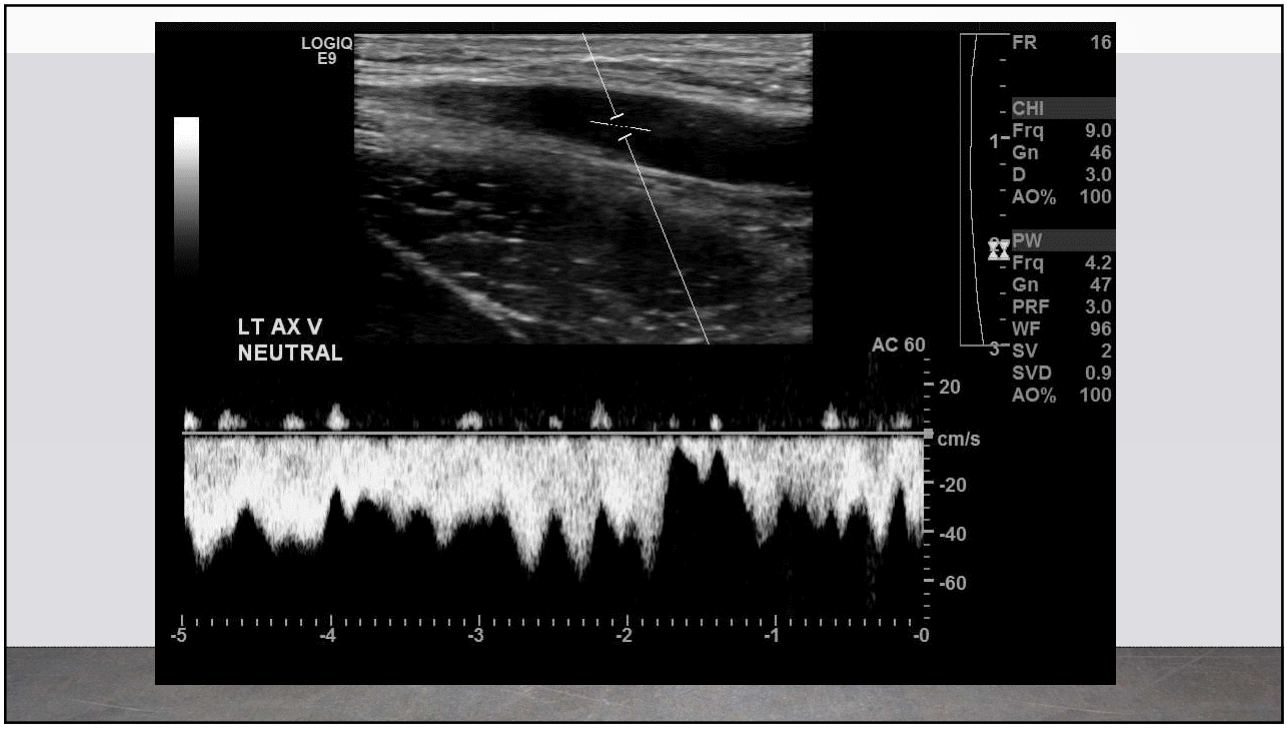
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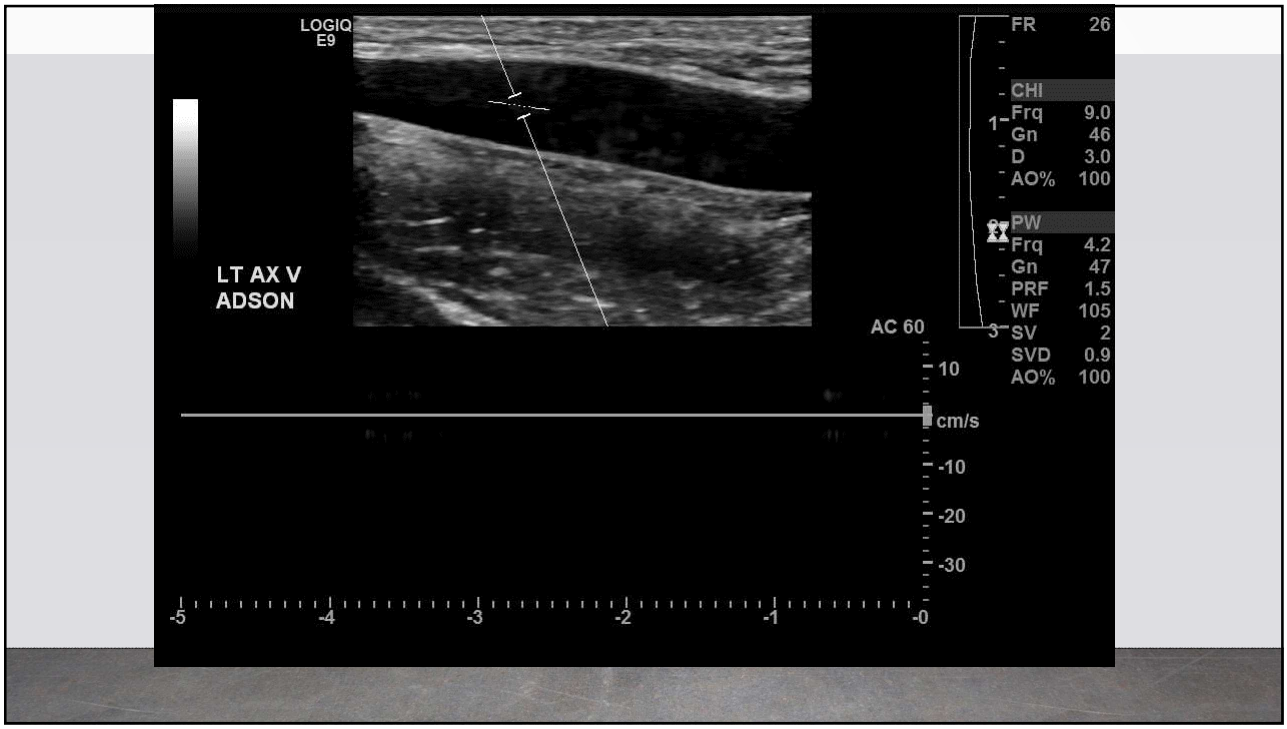
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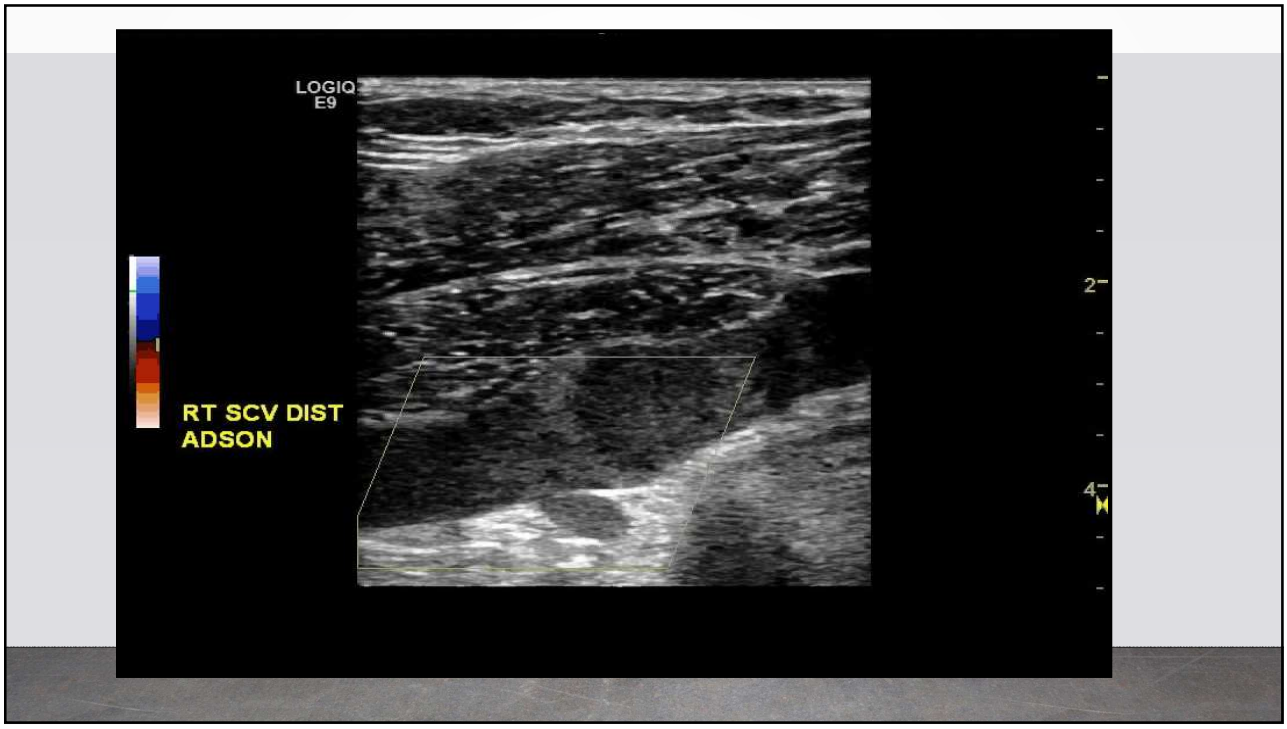
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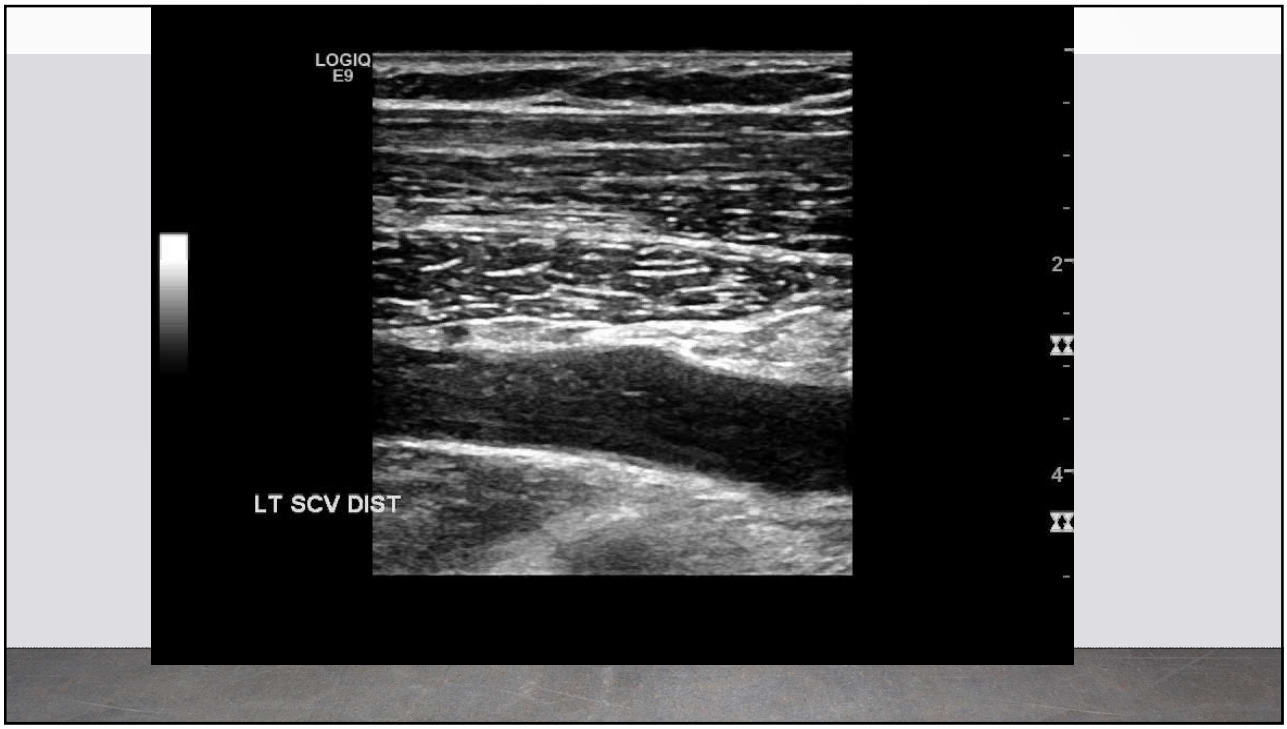
Case study #2

- 42-year-old, right-handed male, with history Left upper extremity DVT
- Being treated with Pradaxa with left venous thoracic outlet syndrome
- s/p catheter directed thrombolysis at an outside hospital now s/p left first rib resection and venoplasty
- <48 hrs post 1st rib resection the left subclavian & axillary vein thrombosed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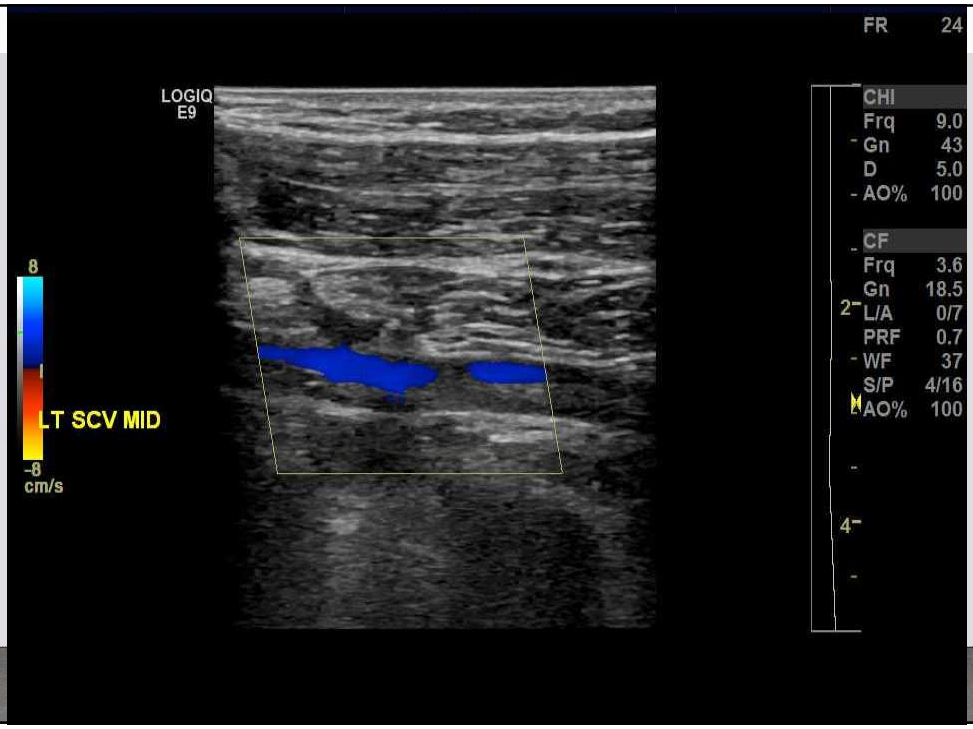
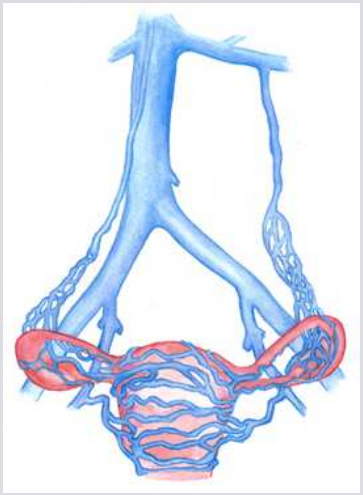
1 year follow up



Pelvic Congestion Syndrome

- A group of disorders of the pelvic venous circulation, which causes chronic pelvic pain in women of premenopausal age.
- The initial clinical evaluation will ultimately guide the treatment options
- Trans-abdominal / Trans-vaginal Venous Duplex is the imaging modality of choice for detection, (CT or Fluoroscopy for intervention)



Clinical Presentation of Pelvic Congestion Syndrome

Chronic Pelvic Pain	Pelvic Varices	Leg Symptoms	Renal Symptoms
• Dysuria • Dyspareunia • Post-Coital Pain • Hemorrhoids	• Vulvar • Labial • Gluteal • Perineal • Scrotal	• Varicose veins • Swelling / Edema	• Flank Pain • Henaturia

Primary Causes of Pelvic Congestion Syndrome

- Incompetent Ovarian / Gonadal veins
- Incompetent Internal iliac veins

Secondary Causes of Pelvic Congestion Syndrome

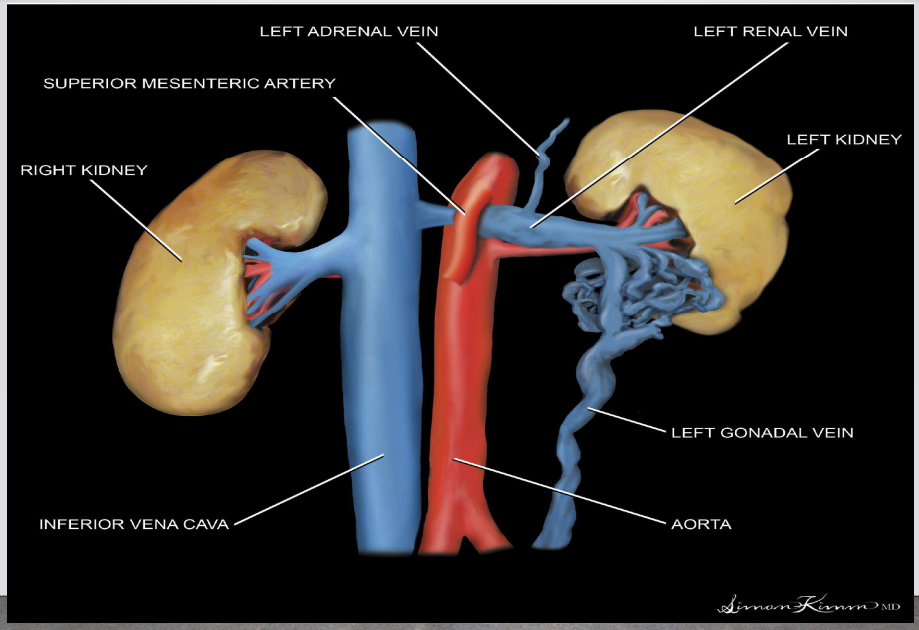
- Venous outflow obstruction due to extrinsic compression
- May-Thurner anatomy- the compression of the left common iliac vein between the right common iliac artery and the spine
- Nutcracker anatomy- the compression of the Left renal vein between the SMA and the aorta, Aorta-mesenteric angle <23-35*
- Retro aortic course of the left renal vein causing compression between the aorta and the spine

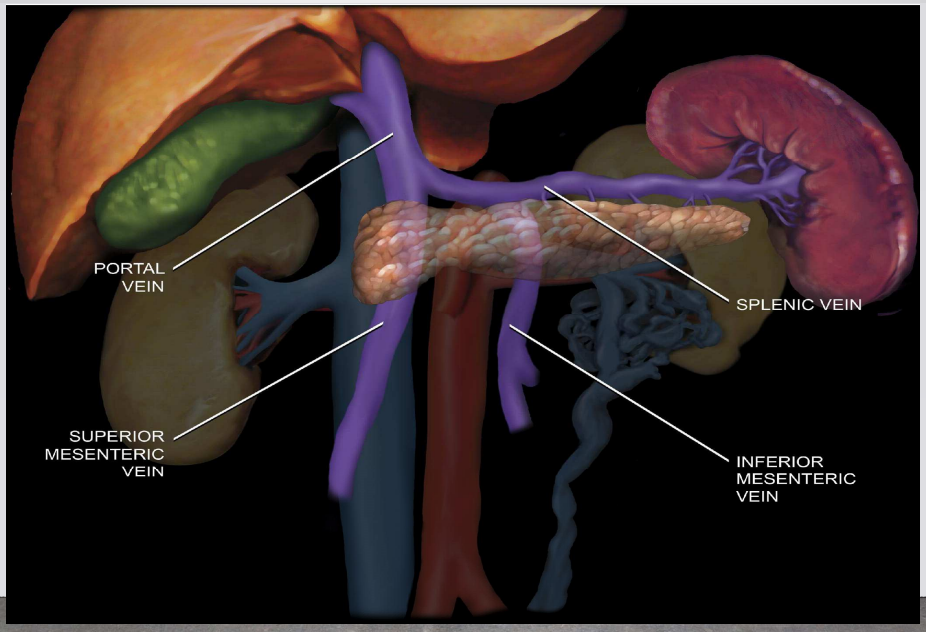
Performing the Duplex Ultrasound

- Patients are typically scheduled in the morning and should fast for 12 hours prior to exam to limit bowel gas
- Renal / gonadal veins should be assessed in the supine position and again with the patient in reverse Trendelenburg, note the direction of flow in the ovarian veins (retrograde vs antegrade).
- Assess ovarian / gonadal veins throughout their entire course, noting any dilations or tortuosity.
- Assess the uterus transabdominally to document para-uterine collaterals or adnexal varices
- Left Common iliac vein velocity and diameter should be measured at the compression site, (CIV between R CIA and spine), and at the distal CIV, (Use Internal Iliac vein as a landmark).
- Perform the transvaginal exam to assess para-uterine / adnexal varices, internal iliac reflux and establish pelvic escape points.

Anatomical Landmarks

- Use the SMA as a reference point to distinguish the Left Renal vein from the Splenic vein.
- The best anatomical landmark for imaging the Left gonadal vein is the psoas muscle.
- The upper part of the Left gonadal vein is located on the anterior side of the psoas muscle and the inferior segment runs along the anteromedial aspect.
- Evaluate the Uterus and Adnexal regions noting any dilated para-uterine collaterals or escape points


LEFT ADRENAL VEIN
LEFT RENAL VEIN
SUPERIOR MESENTERIC ARTERY
LEFT KIDNEY
RIGHT KIDNEY
LEFT GONADAL VEIN
INFERIOR VENA CAVA
AORTA
Simon Kenn MD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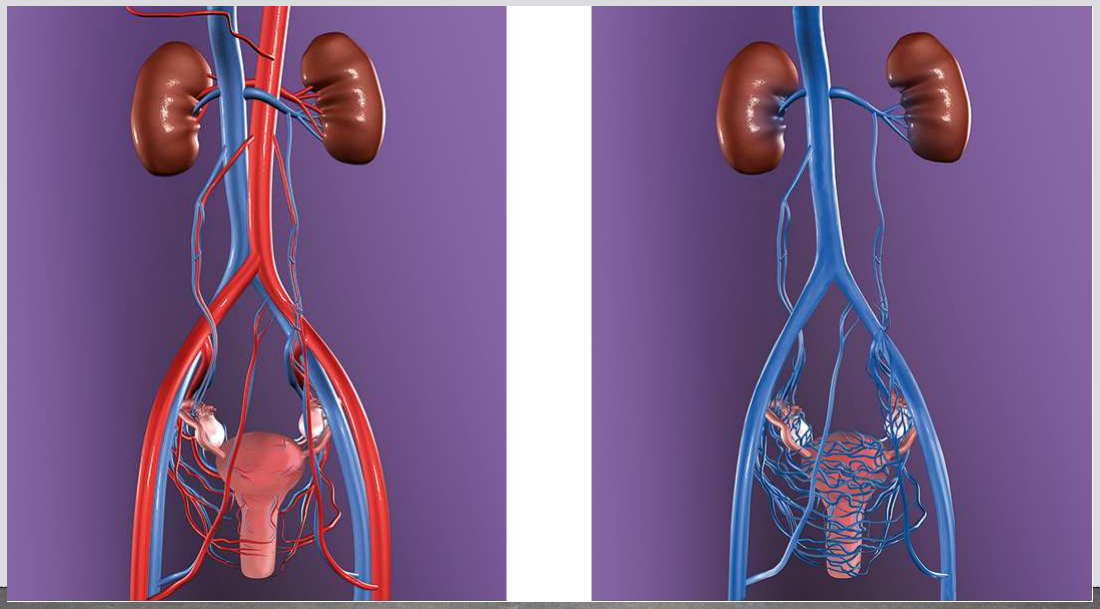
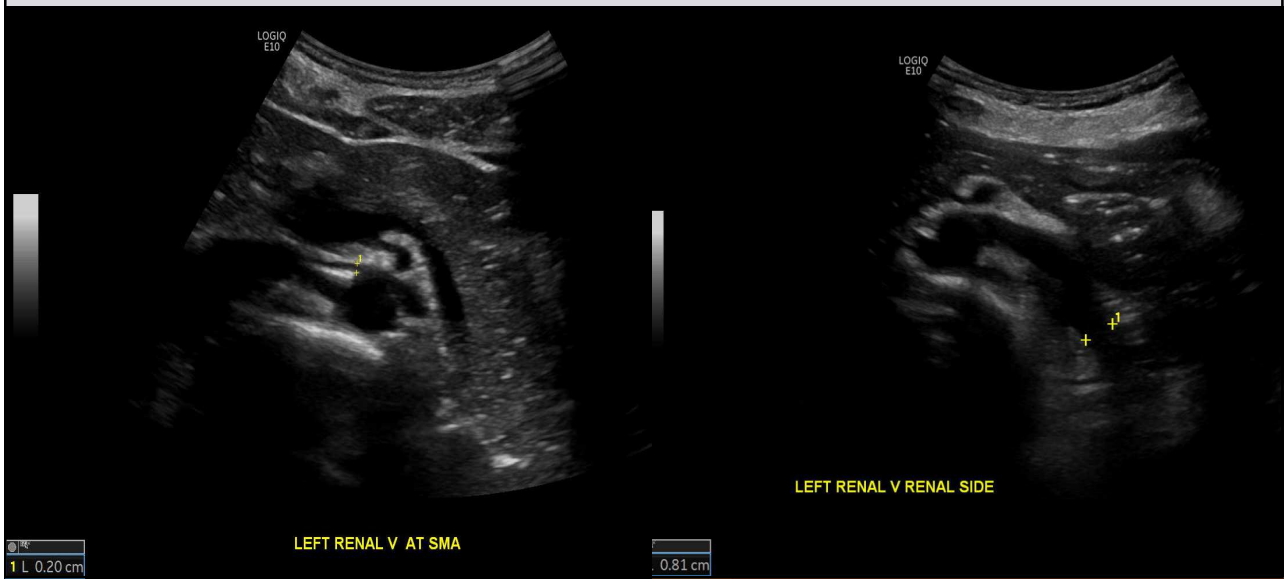
INFERIOR MESENTERIC VEIN



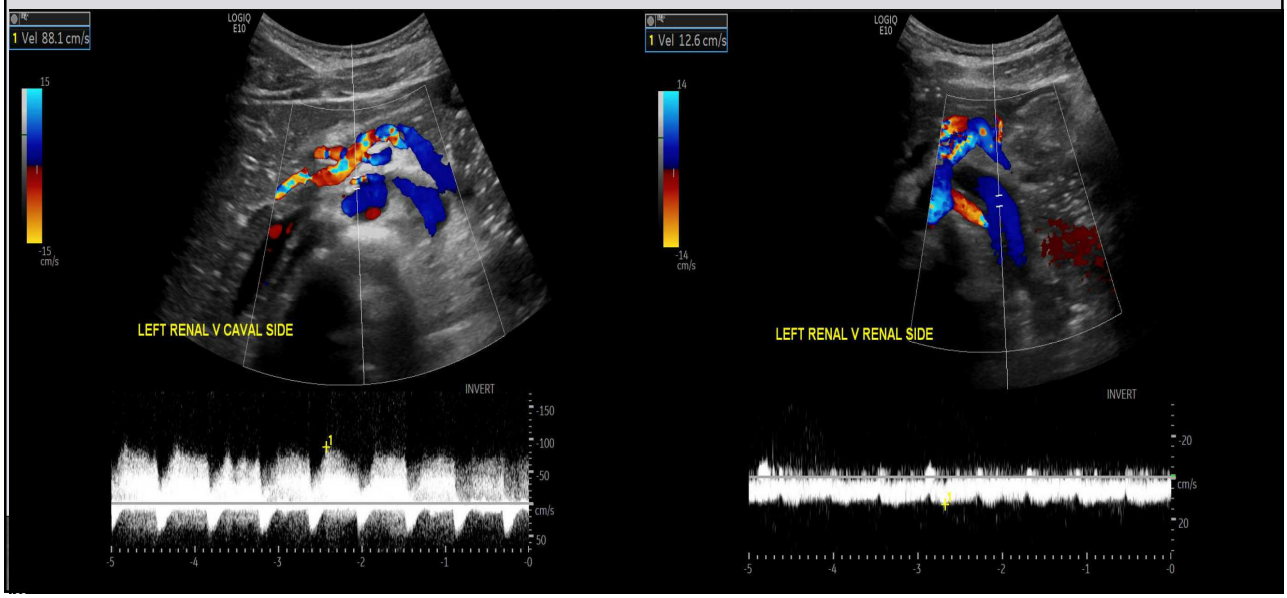
Criteria for documenting Nutcracker anatomy

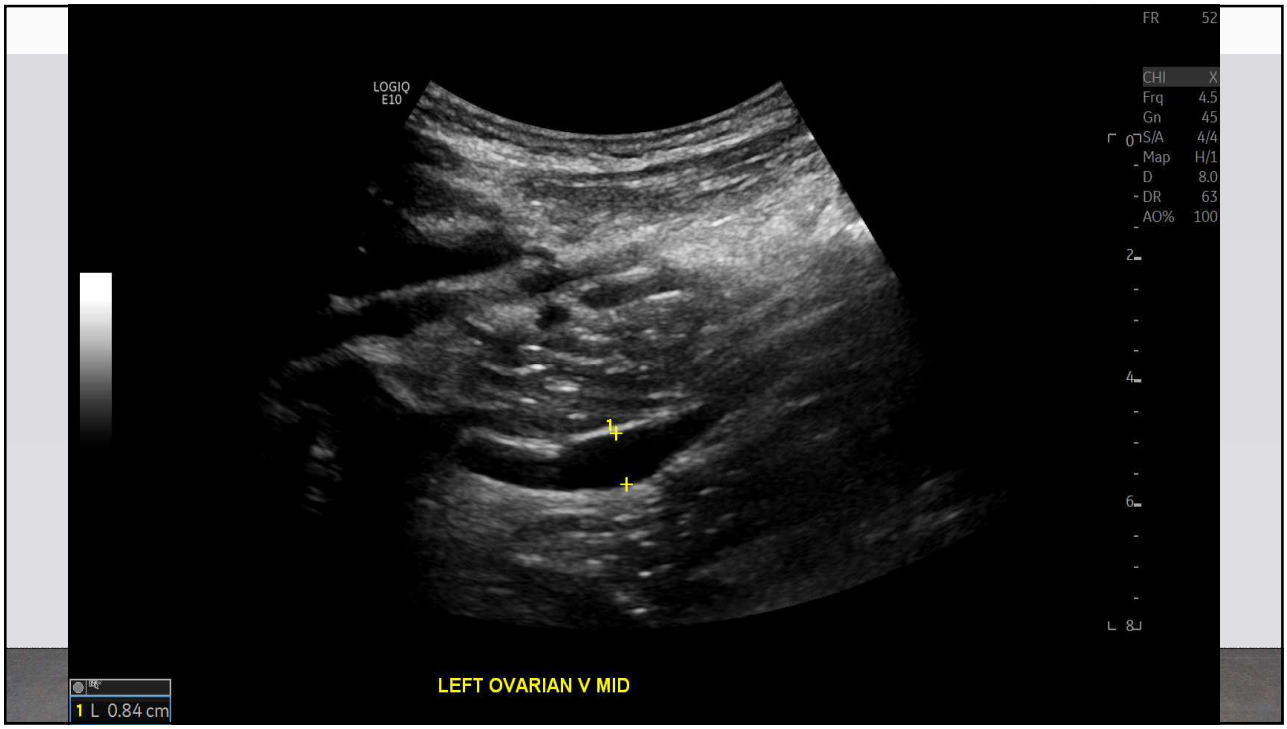
- Competent ovarian veins range from 3.2 - 3.6mm
- Patients with Nutcracker anatomy range from 8-11mm
- An ovarian vein diameter of >6mm is considered abnormal
- LRV diameter ratio (Renal / Caval) = (Diameter ratio >5.0 is consistent with Nutcracker anatomy)
- LRV PSV ratio (Caval / Renal) = (PSV ratio >5.0 is consistent with Nutcracker anatomy)

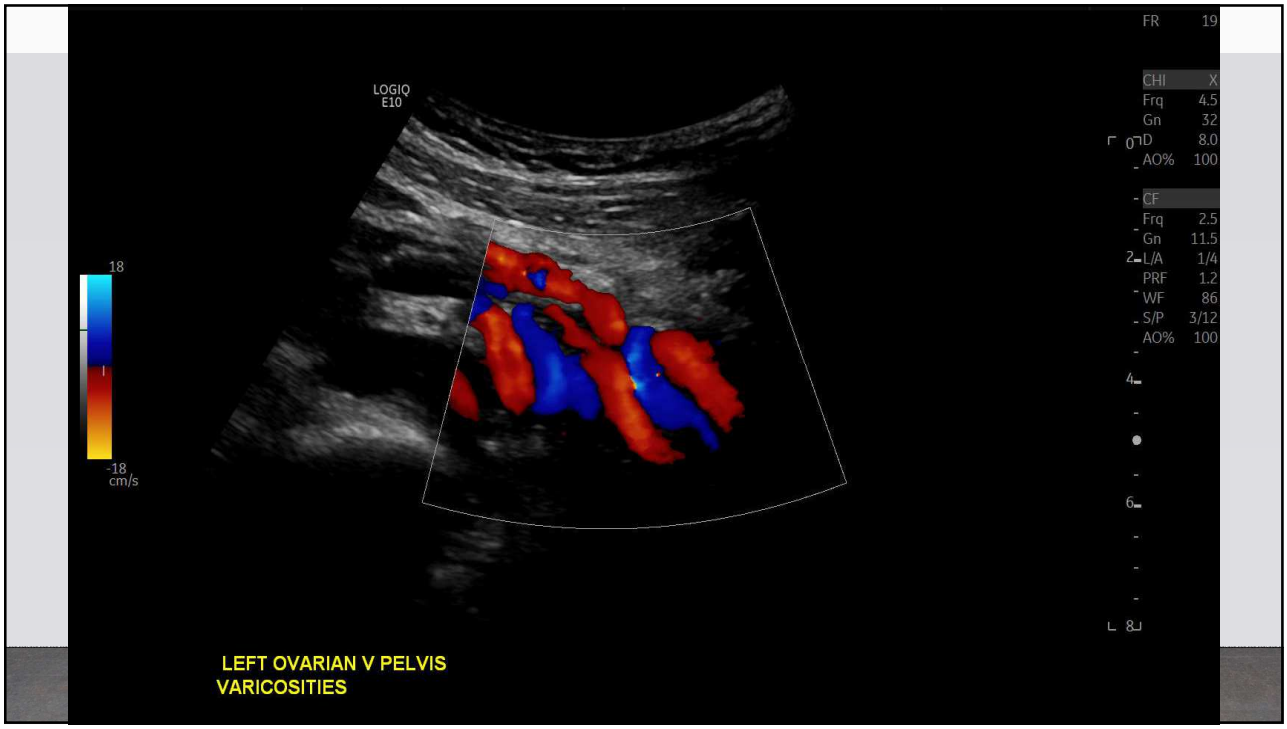
Renal Vein Diameter Ratio (4.0)
Distal Renal Vein / Compression Site (mm)

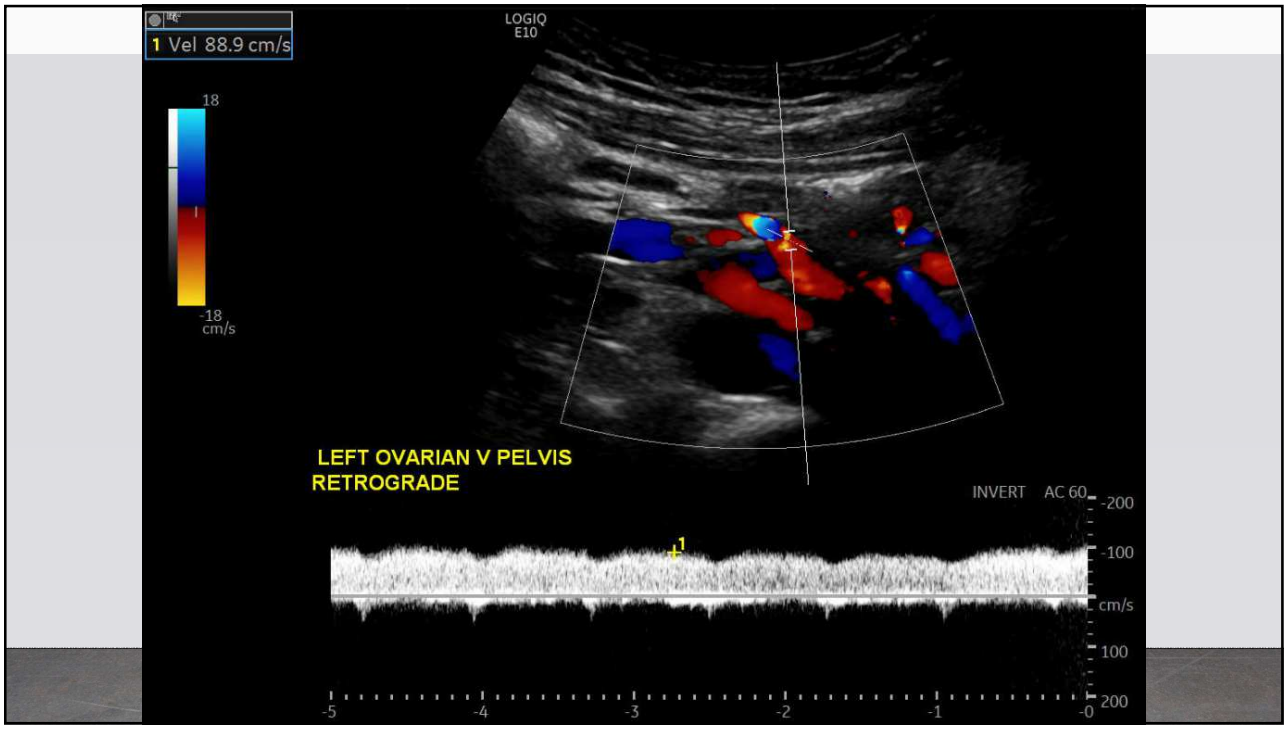


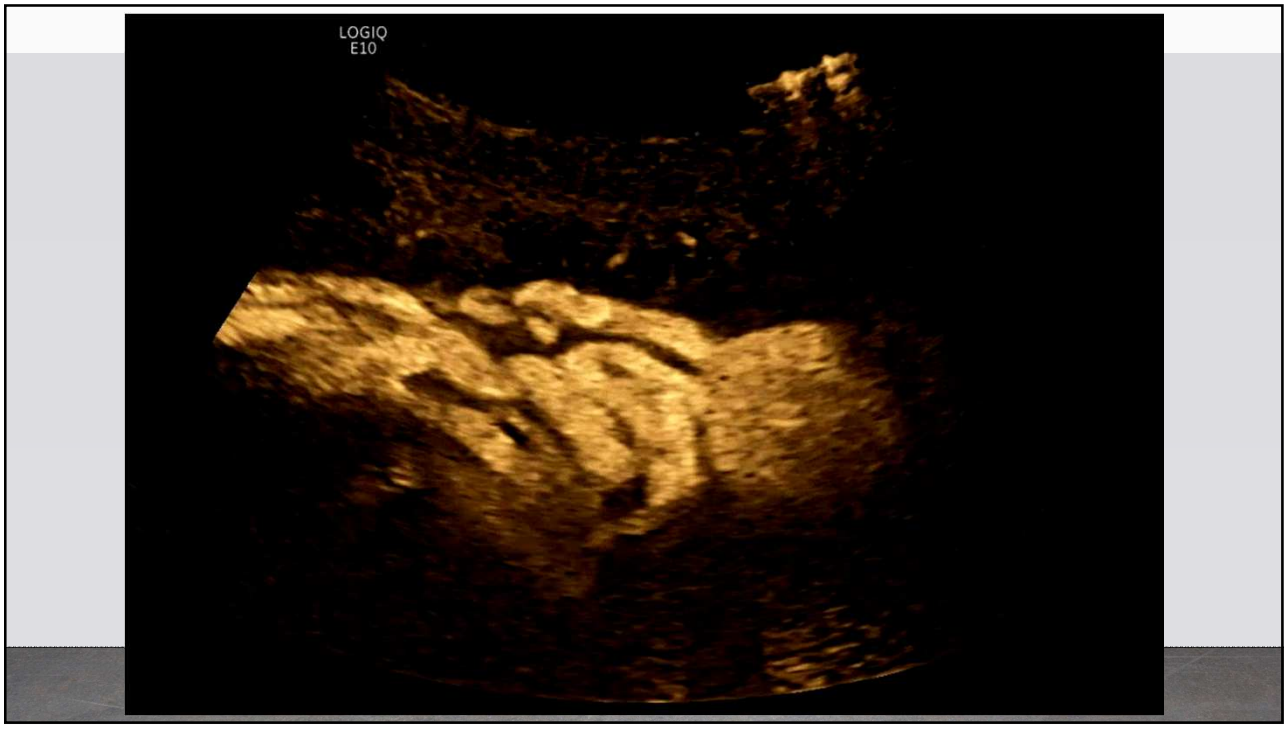
Peak Venous Velocity Ratio (6.9)
Caval Side / Renal Side

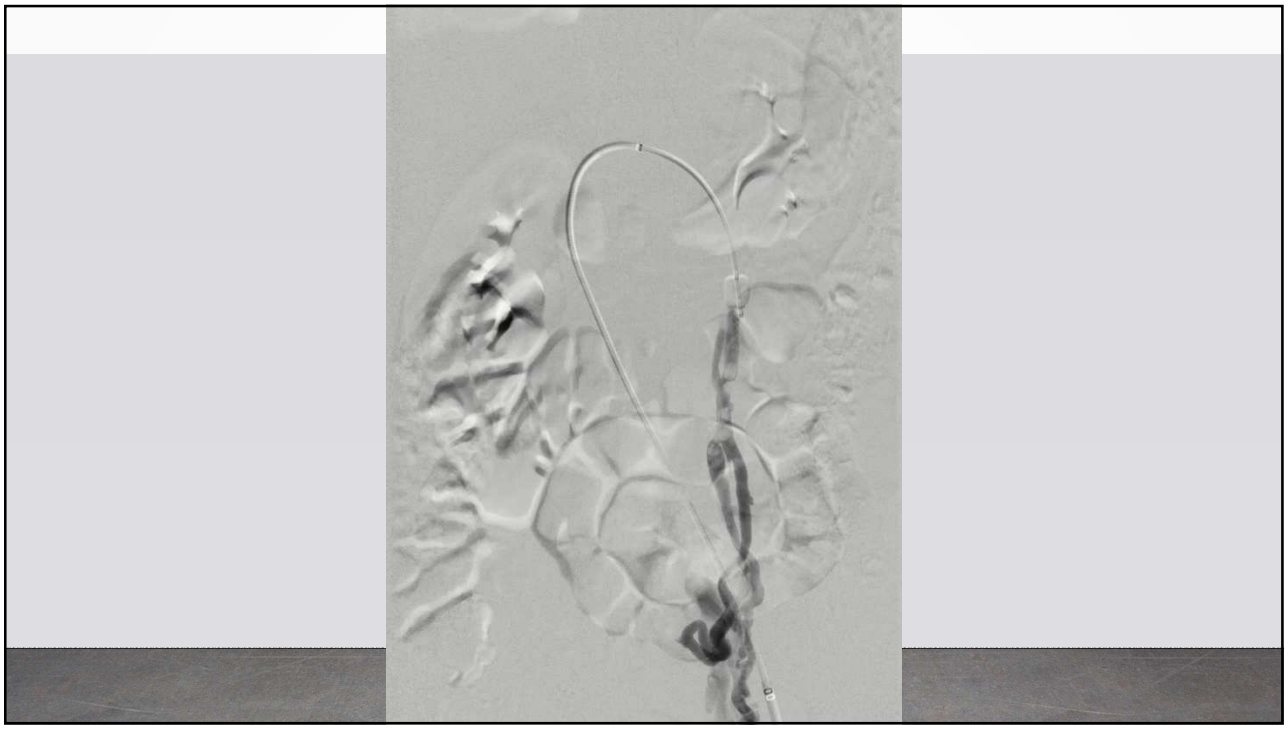


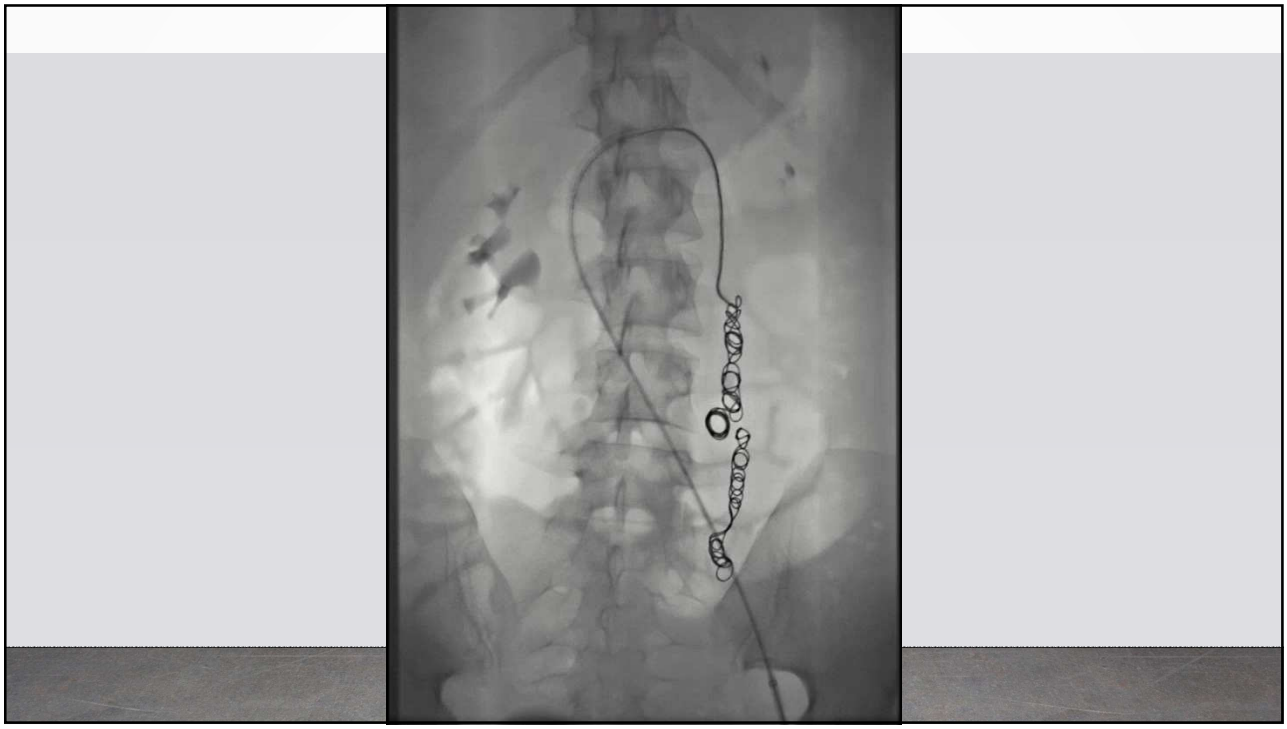

LOGIQ
E10
FR 52
CHI X
Frq 4.5
Gn 45
S/A 4/4
Map H/1
D 8.0
DR 63
AO% 100
1 L 0.84 cm
LEFT OVARIAN V MID


LOGIQ
E10
FR 19
CHI X
Frq 4.5
Gn 32
D 8.0
AO% 100
CF
Frq 2.5
Gn 11.5
L/A 1/4
PRF 1.2
WF 86
S/P 3/12
AO% 100
18
-18
cm/s
LEFT OVARIAN V PELVIS
VARICOSITIES


1 Vel 88.9 cm/s
LOGIQ
E10
18
-18
cm/s
LEFT OVARIAN V PELVIS
RETROGRADE
INVERT
AC 60
-200
-100
cm/s
100
200
-5
-4
-3
-2
-1
-0


LOGIQ
E10



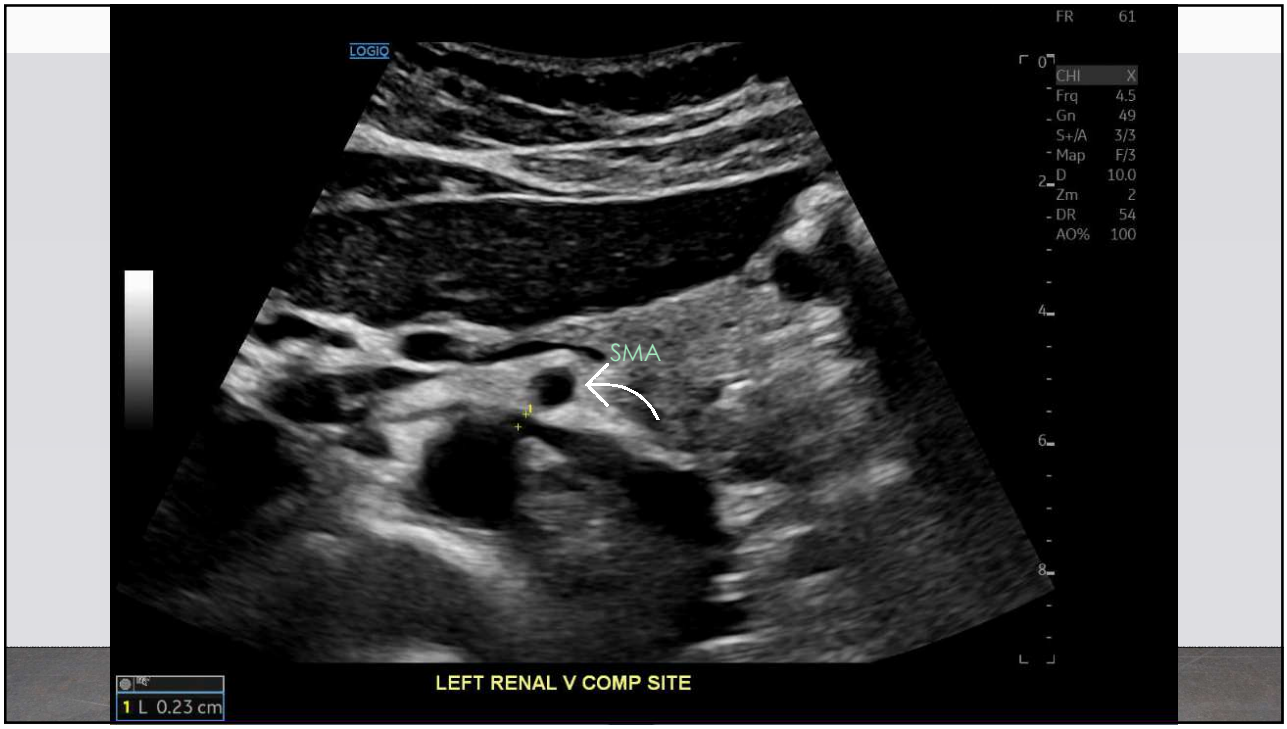


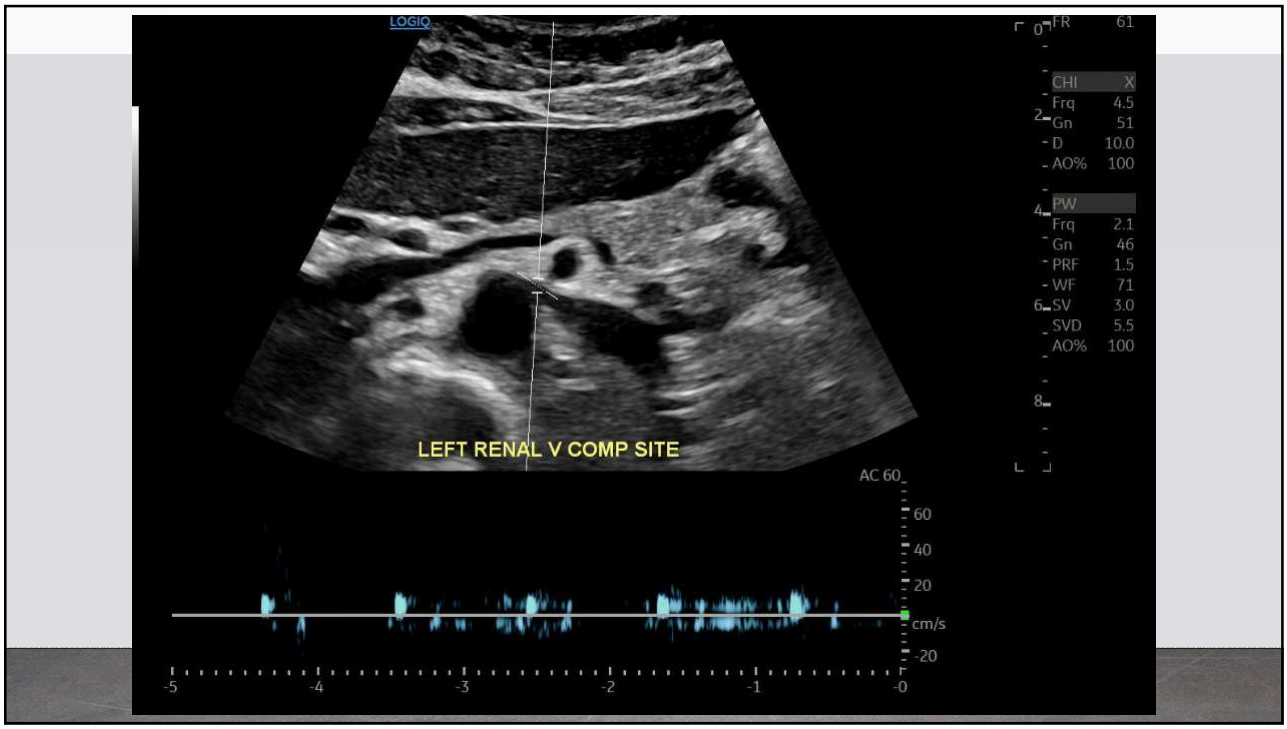
To Treat or Not to Treat?

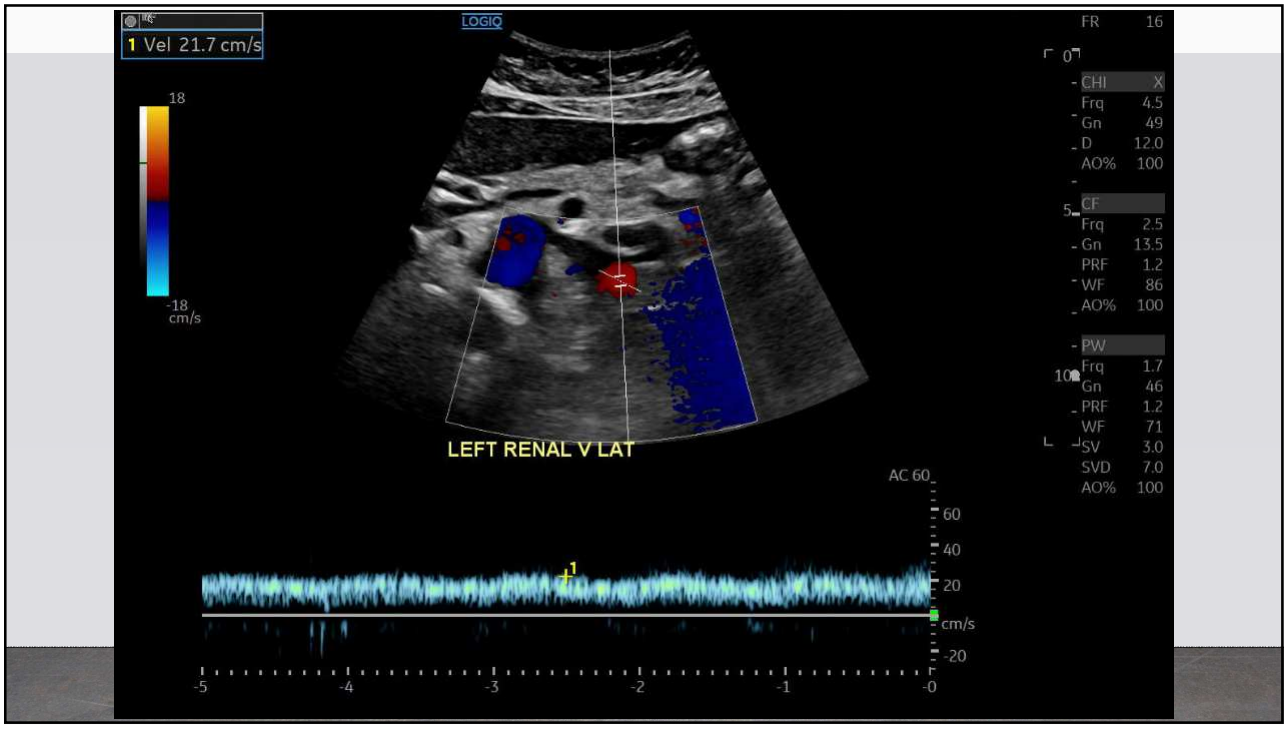
When the compression is so severe the body may re-route venous flow to the internal iliac system and pelvic collaterals.

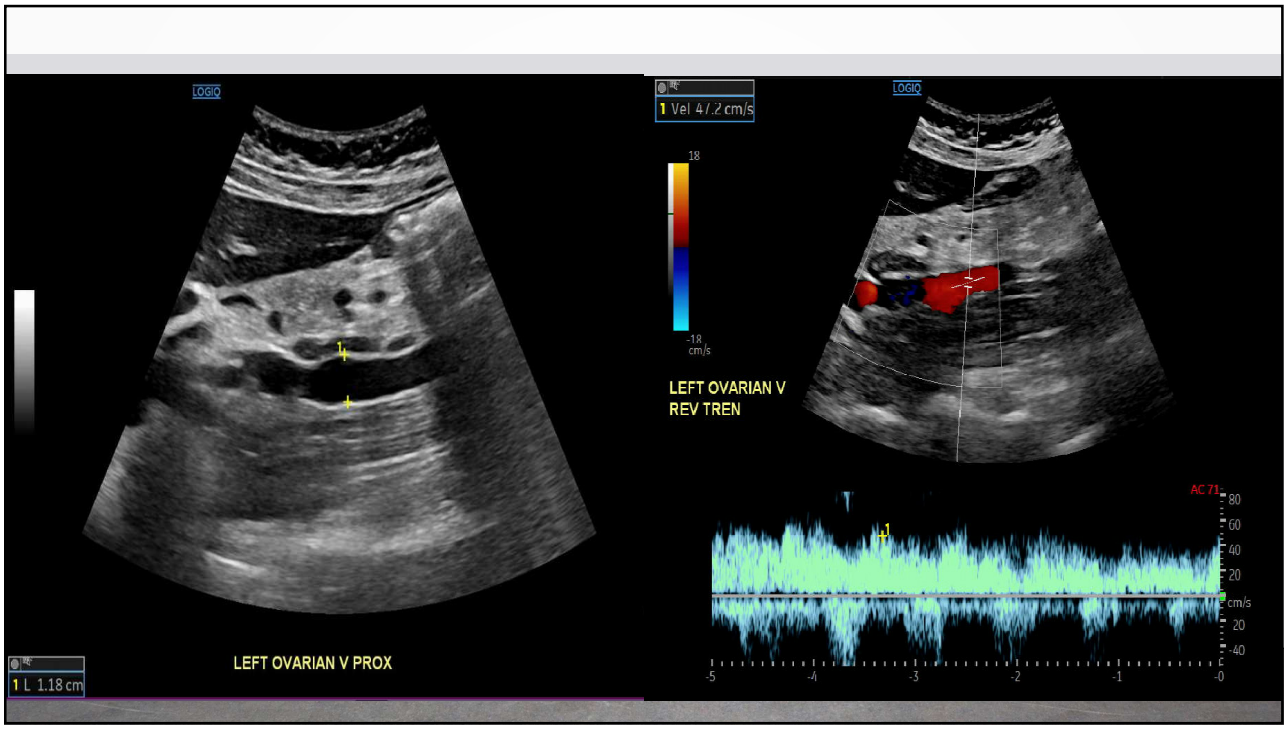
Retro-aortic collateral vessels may be present.

Treatment from the bottom up may be the best approach to avoid long-term complications

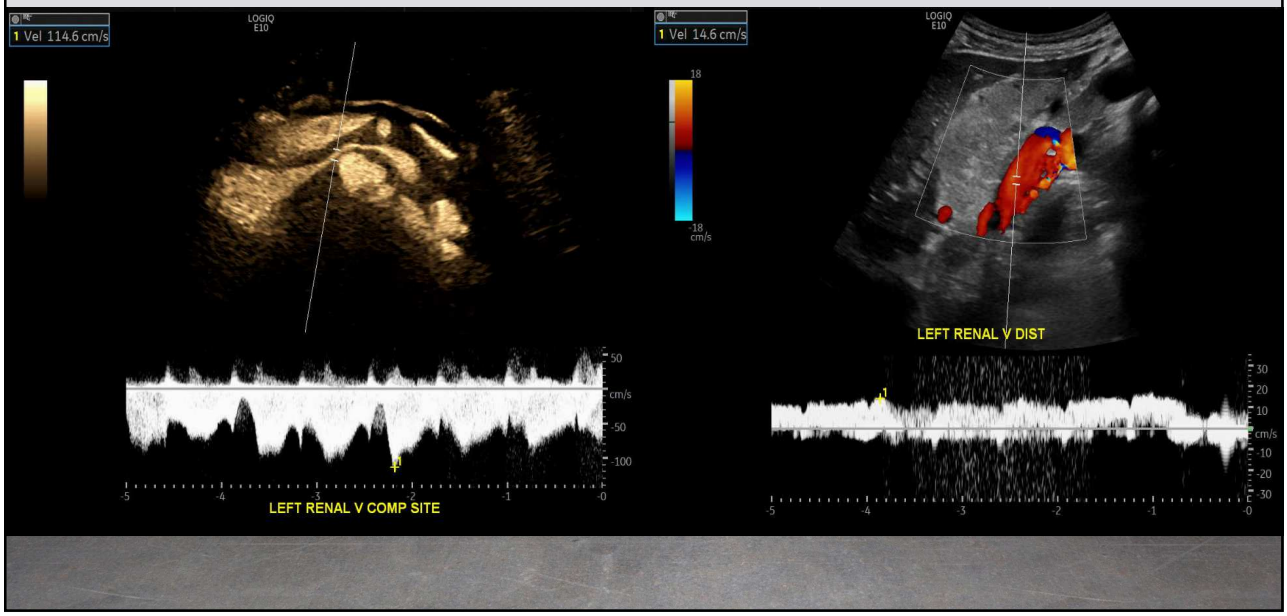



LOGIQ
FR 61
CHI X
Frq 4.5
Gn 51
D 10.0
AO% 100
PW
Frq 2.1
Gn 46
PRF 1.5
WF 71
SV 3.0
SVD 5.5
AO% 100
LEFT RENAL V COMP SITE
AC 60
60
40
20
cm/s
-20
-5
-4
-3
-2
-1
-0

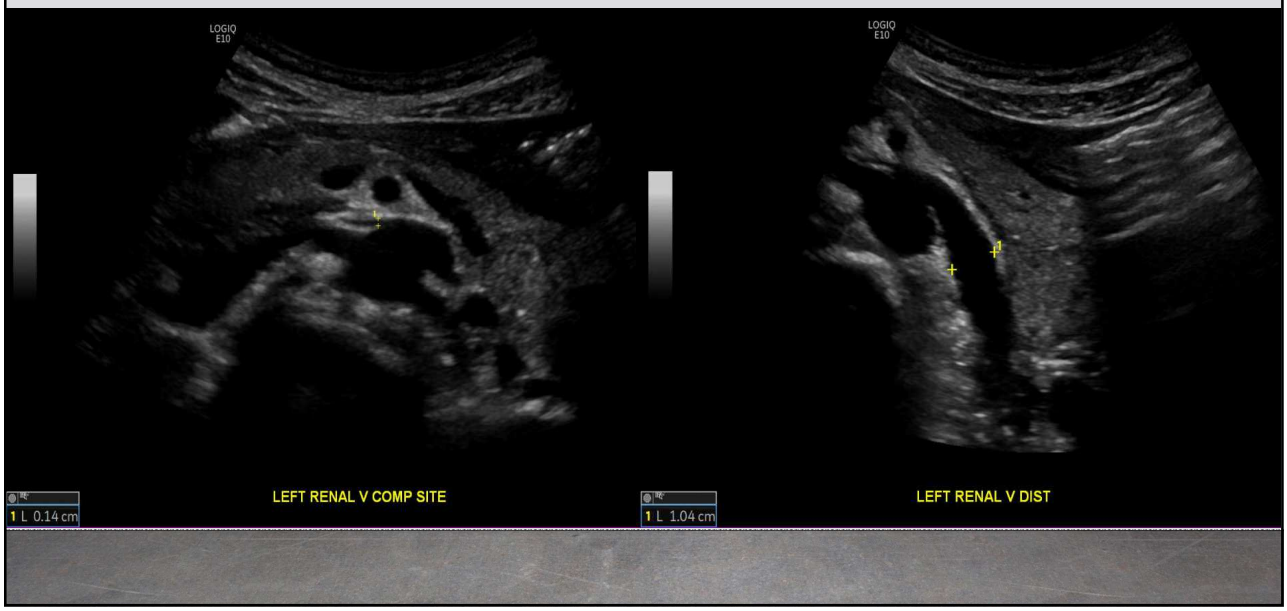

1 Vel 21.7 cm/s
18
-18
cm/s
LOGIQ
FR 16
CHI X
Frq 4.5
Gn 49
D 12.0
AO% 100
CF
Frq 2.5
Gn 13.5
PRF 1.2
WF 86
AO% 100
PW
Frq 1.7
Gn 46
PRF 1.2
WF 71
SV 3.0
SVD 7.0
AO% 100
LEFT RENAL V LAT
AC 60
60
40
20
cm/s
-20
-5
-4
-3
-2
-1
-0

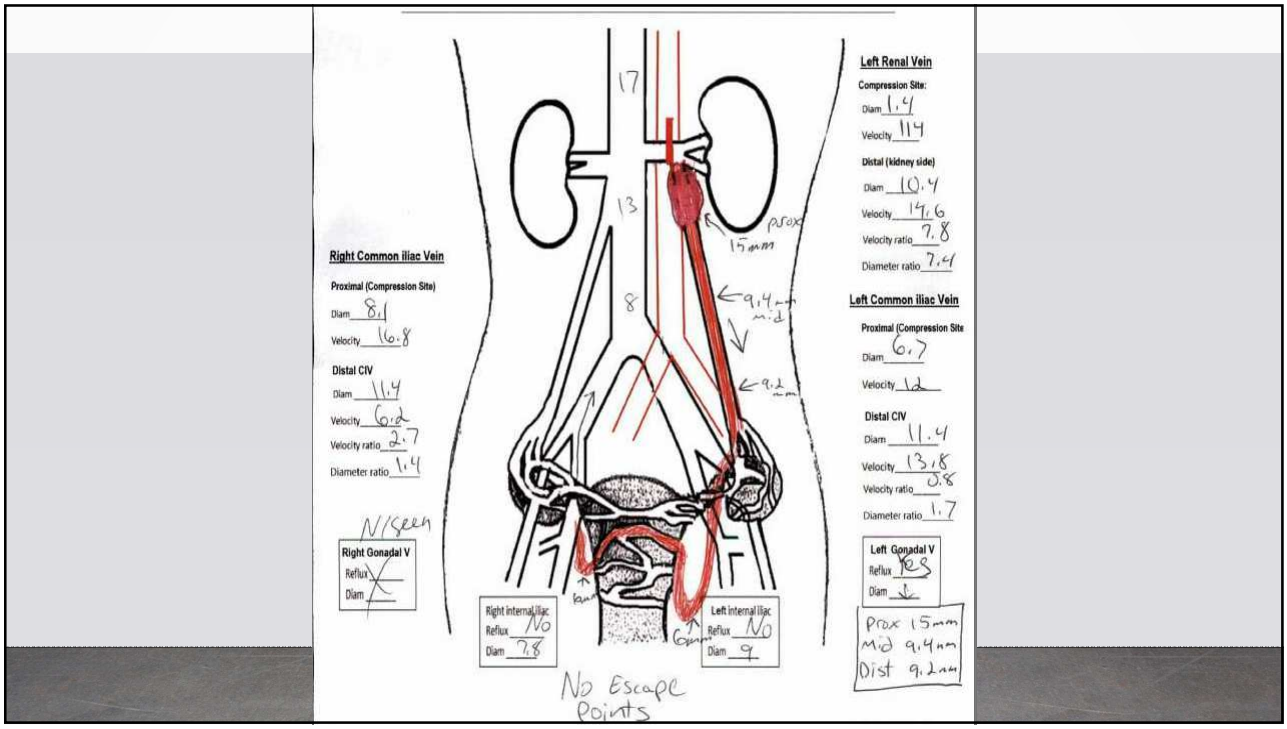


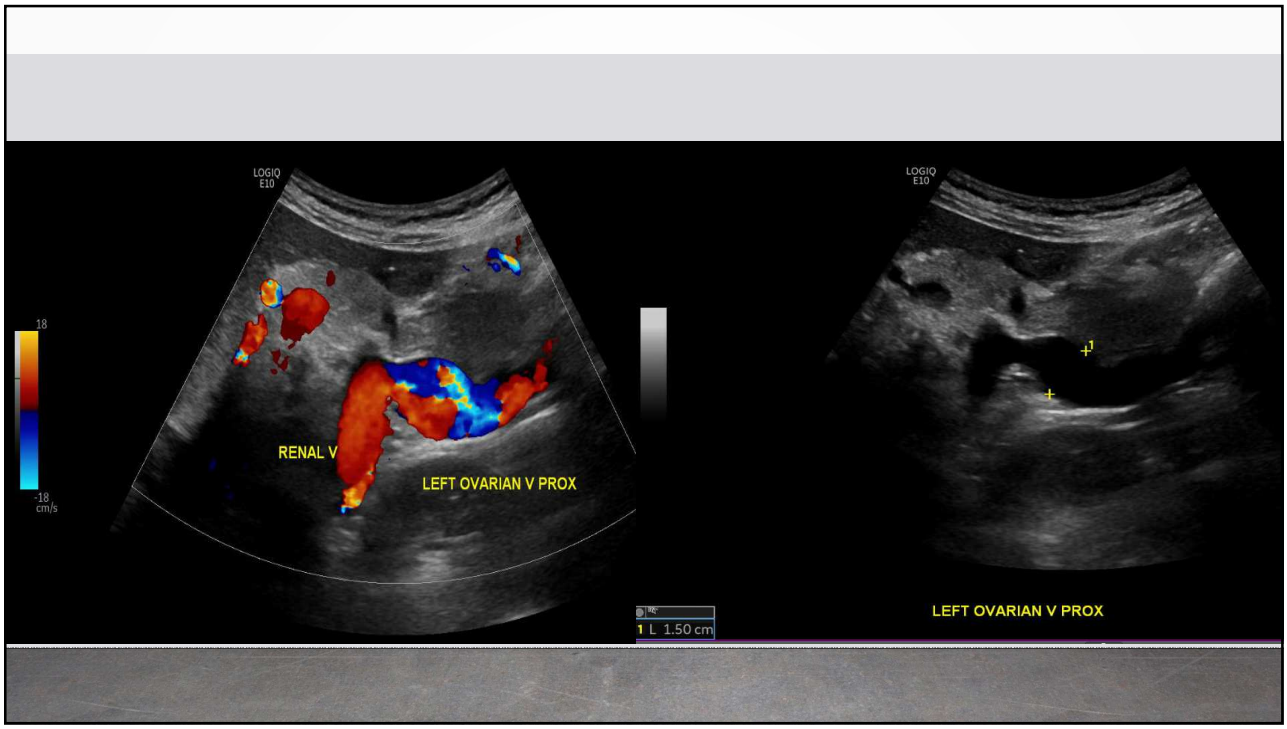
Velocity Ratio (cm/sec) 114.6 / 14.6 =7.8

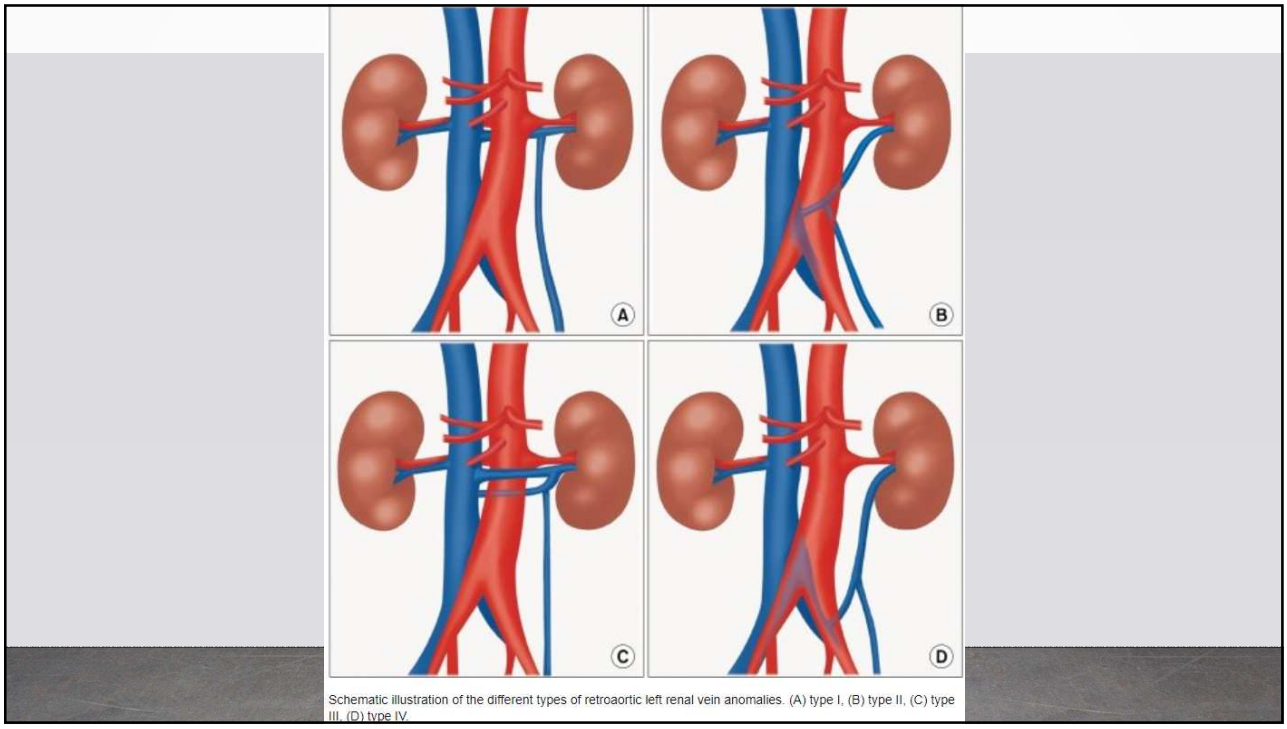


Diameter Ratio (mm)10.4 / 1.4 = 7.4

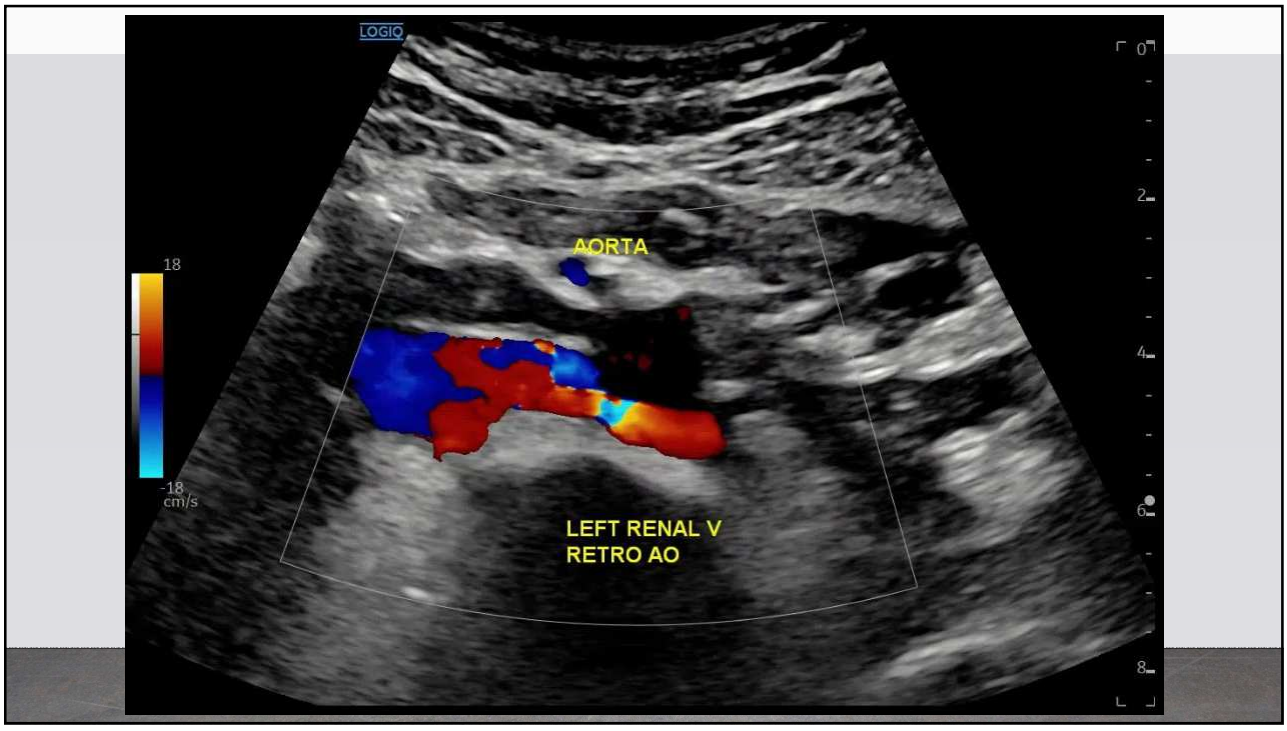


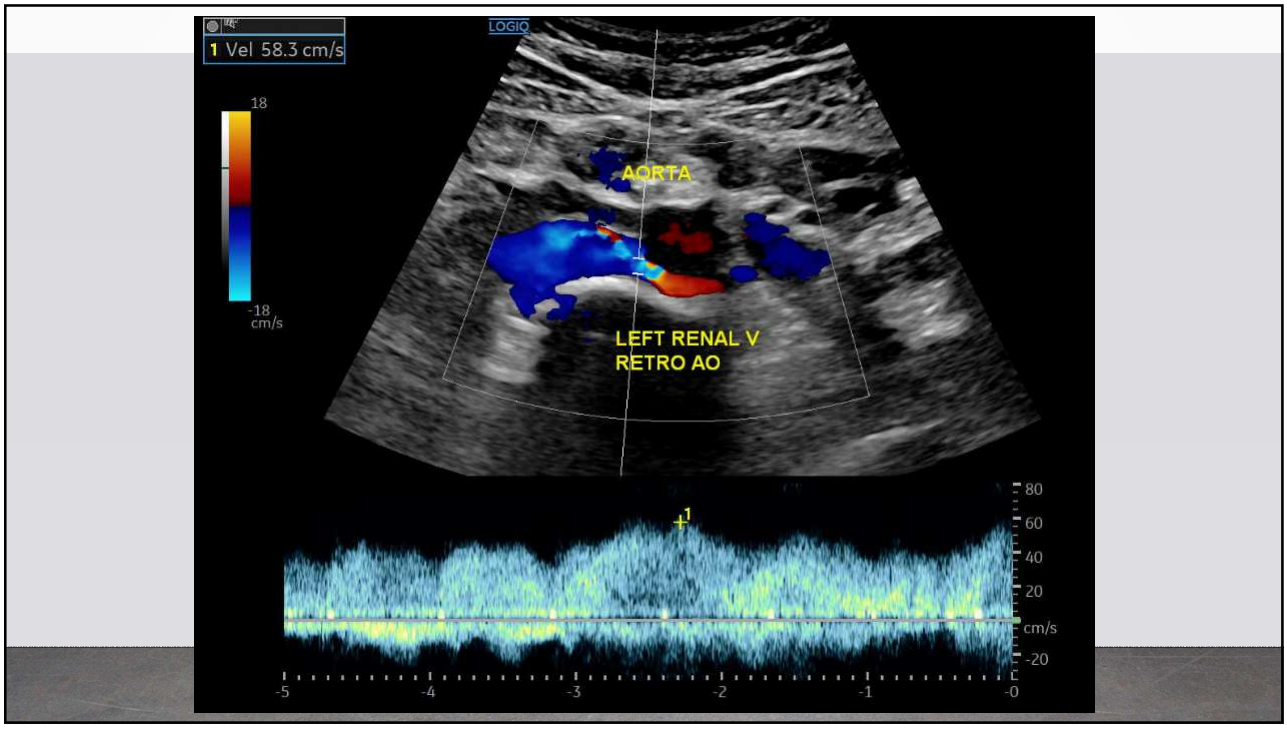


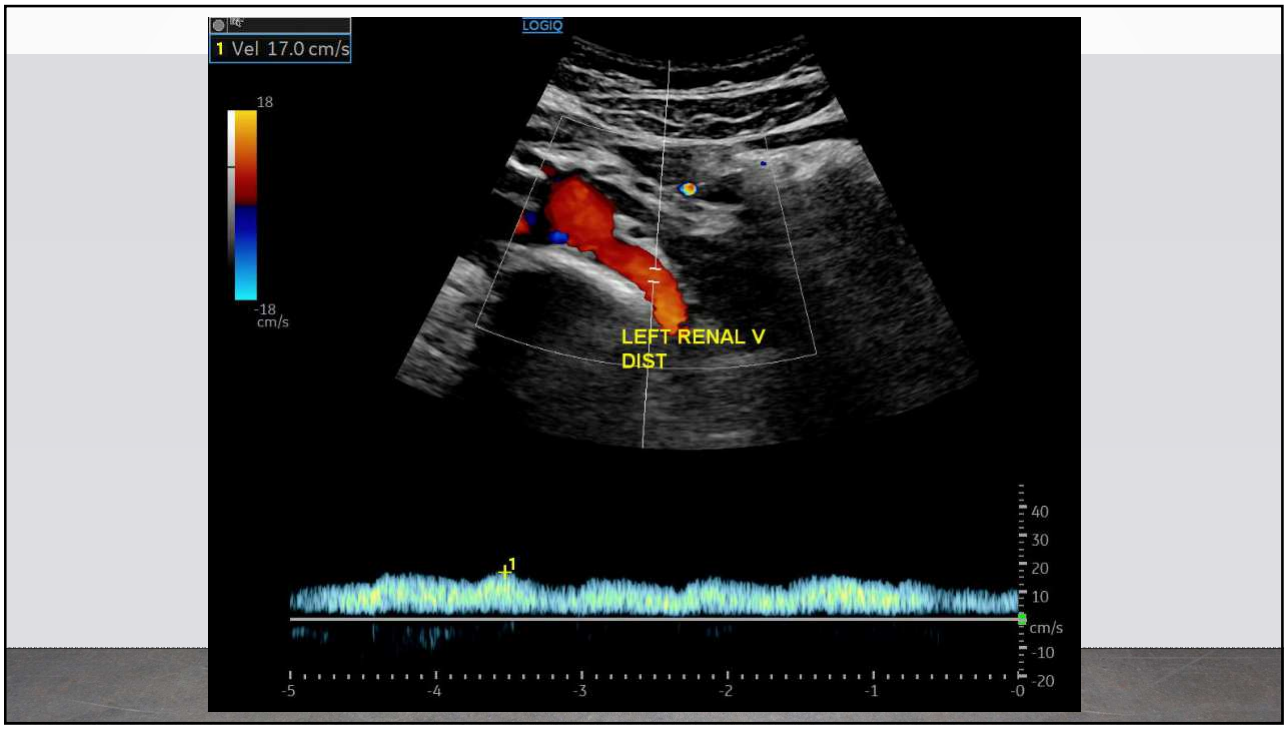




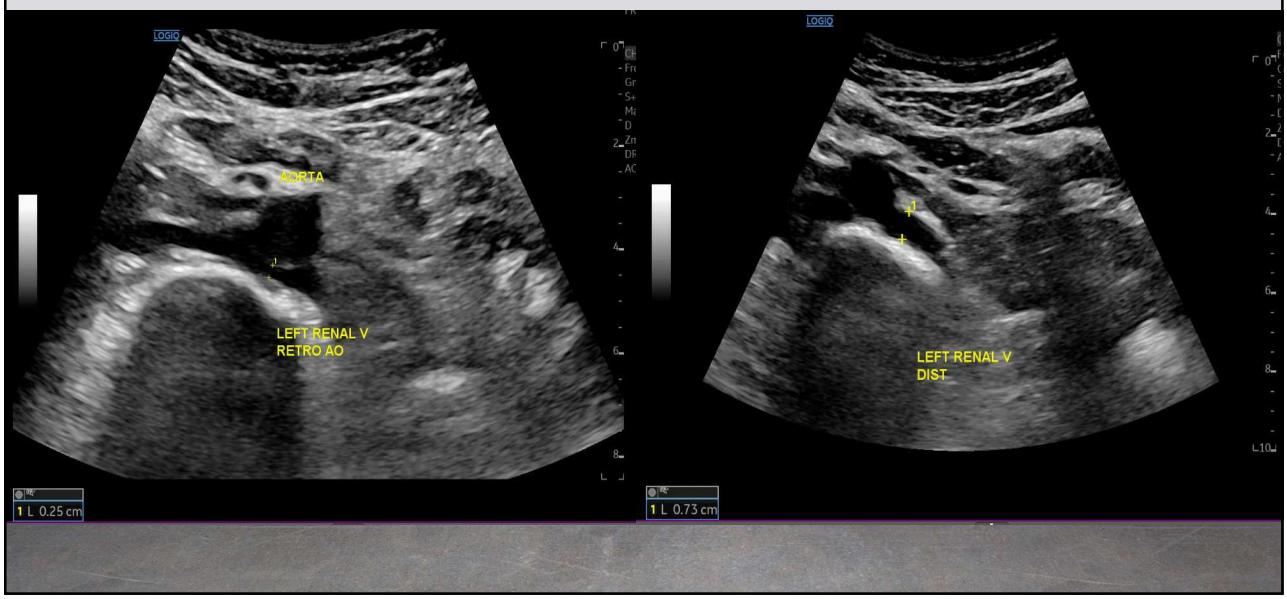
Schematic illustration of the different types of retroaortic left renal vein anomalies. (A) type I, (B) type II, (C) type III, (D) type IV.

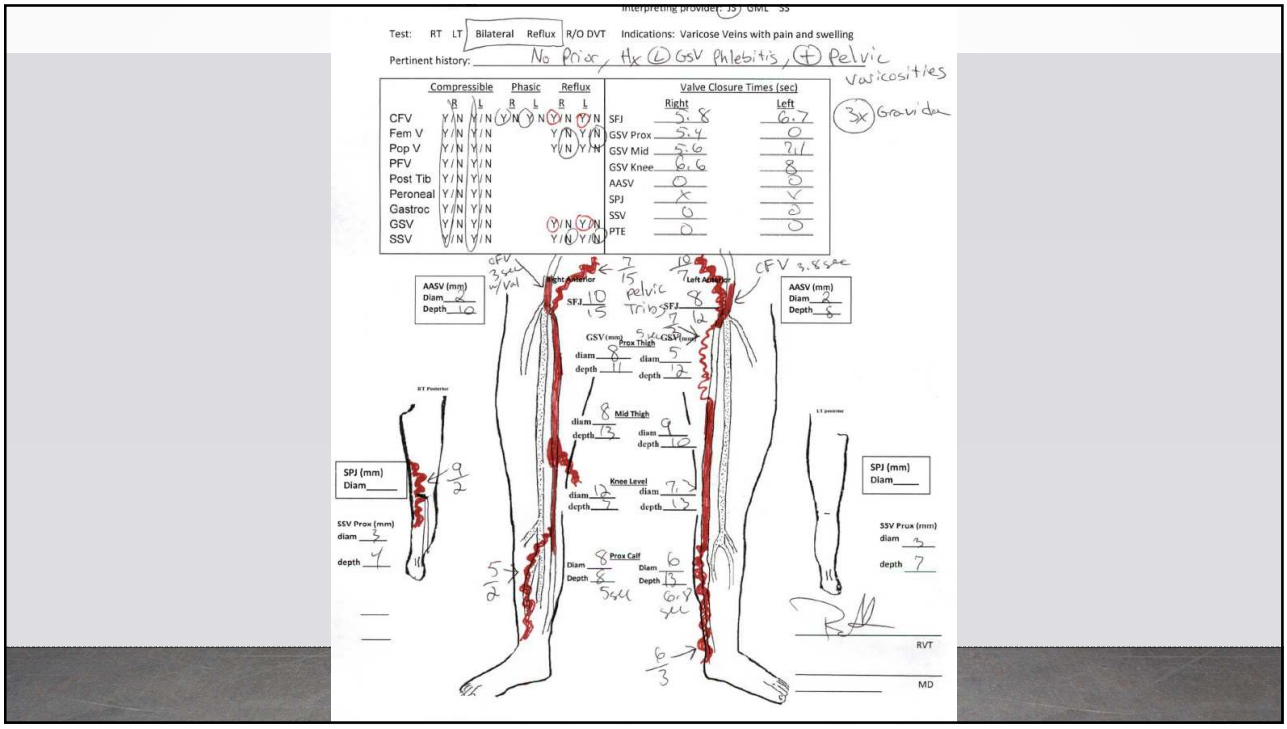

LOGIQ
AORTA
LEFT RENAL V
RETRO AO
18
-18
cm/s


1 Vel 58.3 cm/s
LOGIQ
AORTA
LEFT RENAL V
RETRO AO
18
-18
cm/s
80
60
40
20
cm/s
-20
-5
-4
-3
-2
-1
-0



Diameter Ratio 2.9 / Velocity Ratio 3.4





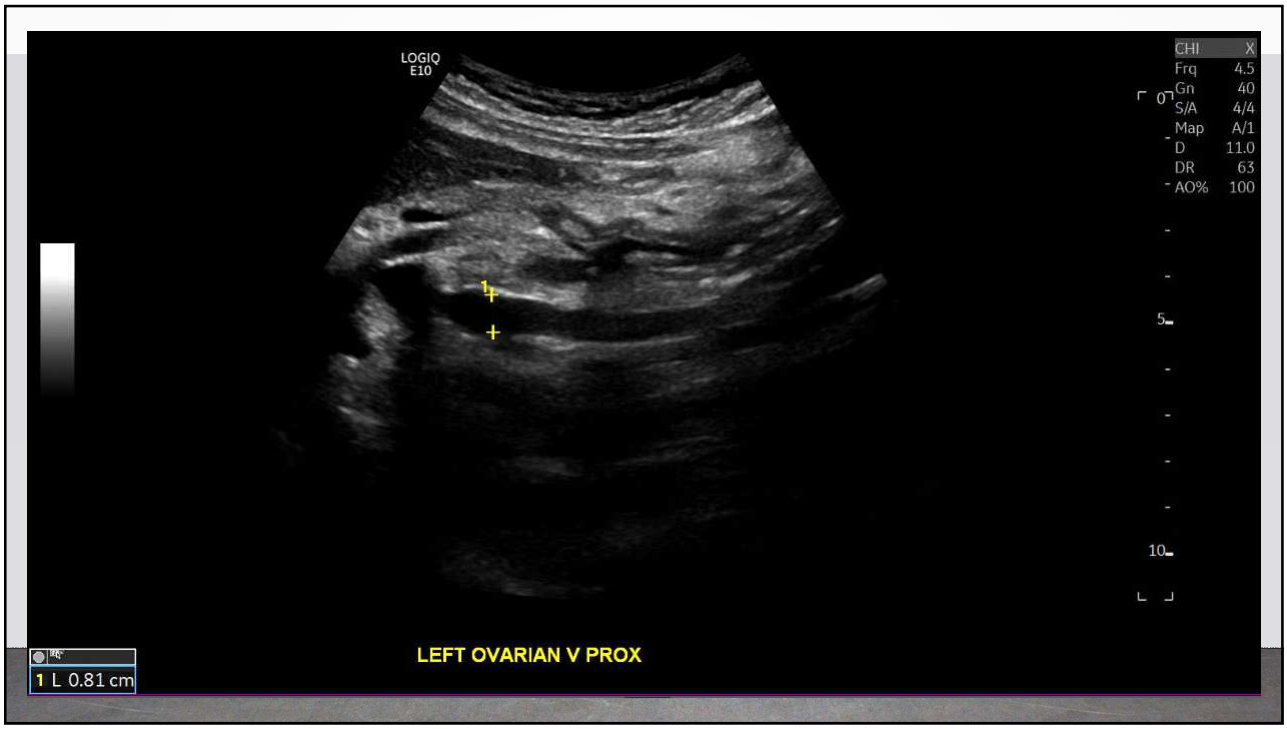
Interpreting provider: JS GMT SS

Test: RT LT Bilateral Reflux R/O DVT Indications: Varicose Veins with pain and swelling

Pertinent history: No Prior, Hx (L) GSV Phlebitis, (+) Pelvic varicosities (3x) Gravidas

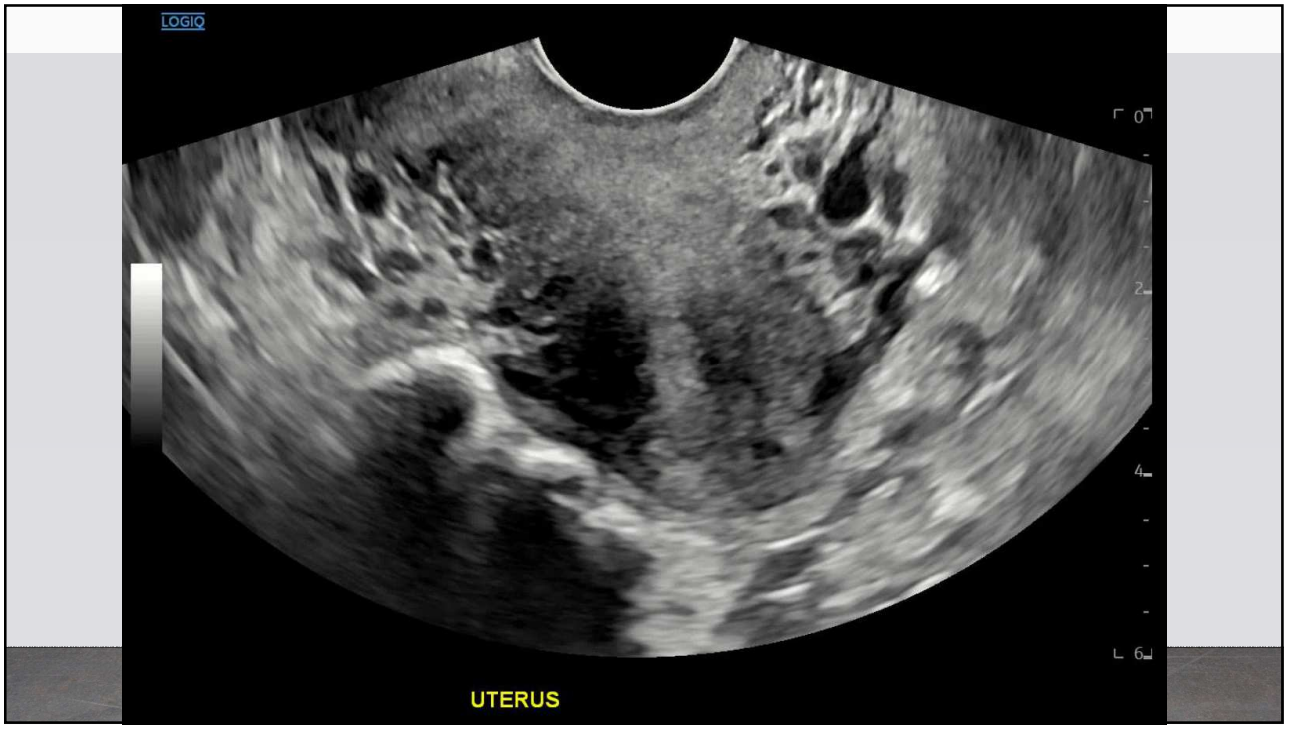
	Compressible R	Compressible L	Phasic R	Phasic L	Reflux R	Reflux L
CFV	Y/N	Y/N	(Y)/N	Y/N	(Y)/N	(Y)/N
Fem V	Y/N	Y/N			Y/N	Y/N
Pop V	Y/N	Y/N			Y/N	Y/N
PFV	Y/N	Y/N				
Post Tib	Y/N	Y/N				
Peroneal	Y/N	Y/N				
Gastroc	Y/N	Y/N				
GSV	Y/N	Y/N			(Y)/N	(Y)/N
SSV	Y/N	Y/N			Y/N	Y/N

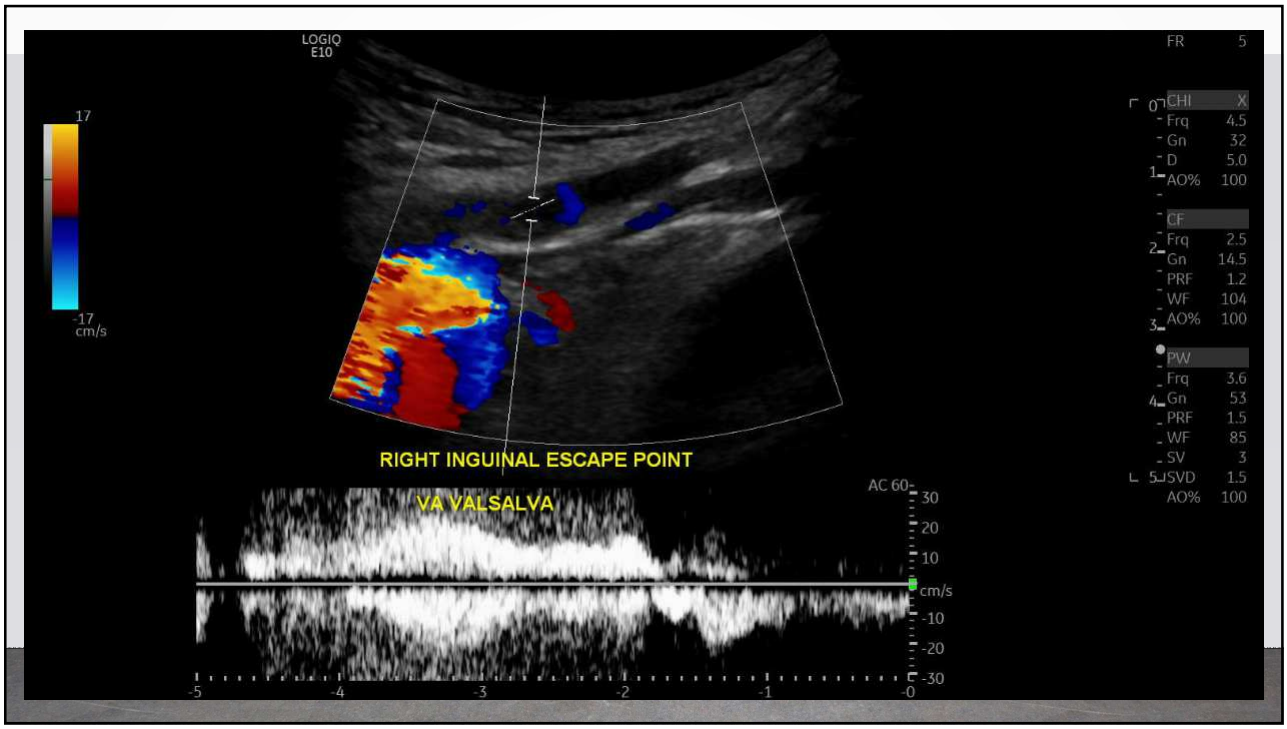
Valve Closure Times (sec)	Right	Left
SFJ	5.8	6.7
GSV Prox	5.4	0
GSV Mid	5.6	7.1
GSV Knee	6.6	8
AASV	0	0
SPJ	X	X
SSV	0	0
PTE	0	0

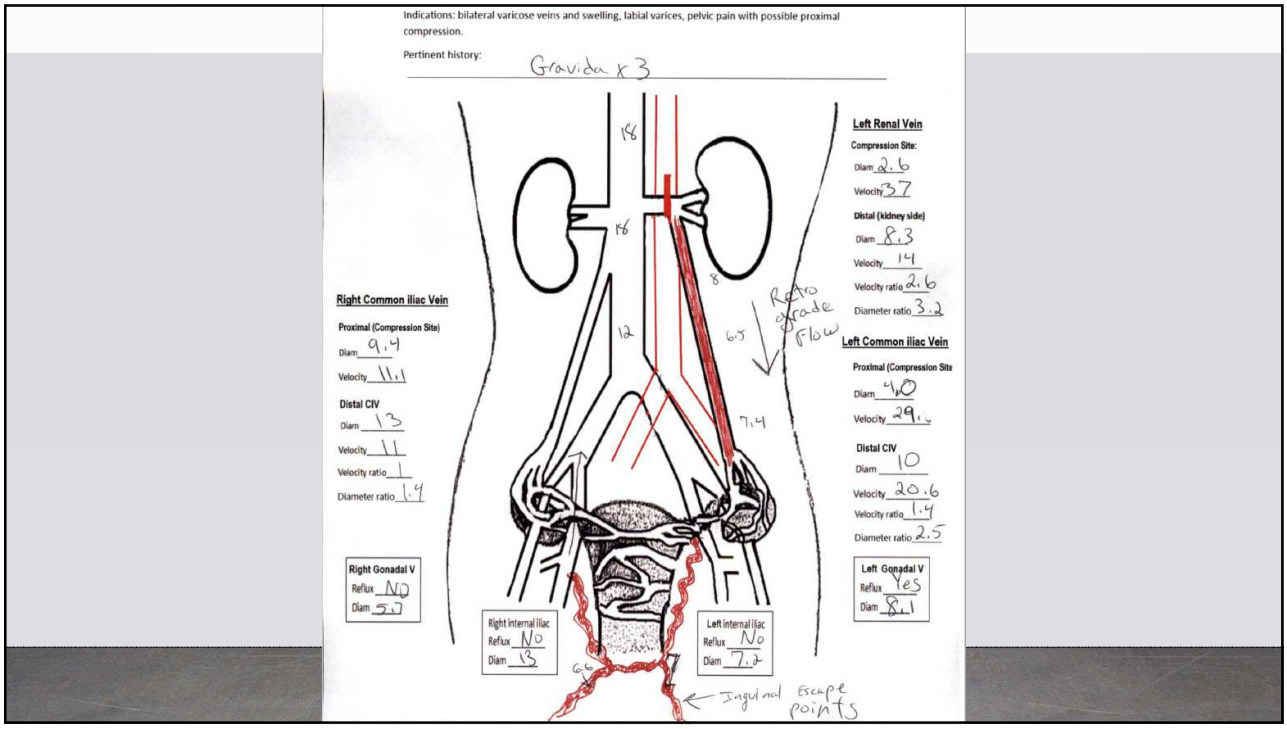

LOGIQ
E10
CHI X
Frq 4.5
Gn 40
S/A 4/4
Map A/1
D 11.0
DR 63
AO% 100
1 L 0.81 cm
LEFT OVARIAN V PROX


1 Vel 10.0 cm/s
LOGIQ
E10
FR 5
CHI X
Frq 4.5
Gn 43
D 11.0
AO% 100
CF
Frq 2.5
Gn 14.5
PRF 0.8
WF 70
AO% 100
PW
Frq 2.1
Gn 53
PRF 1.5
WF 87
SV 3
SVD 5.9
AO% 100
12
-12
cm/s
LEFT OVARIAN V
REV TREN
30
20
10
cm/s
-10
-5
-4
-3
-2
-1
-0

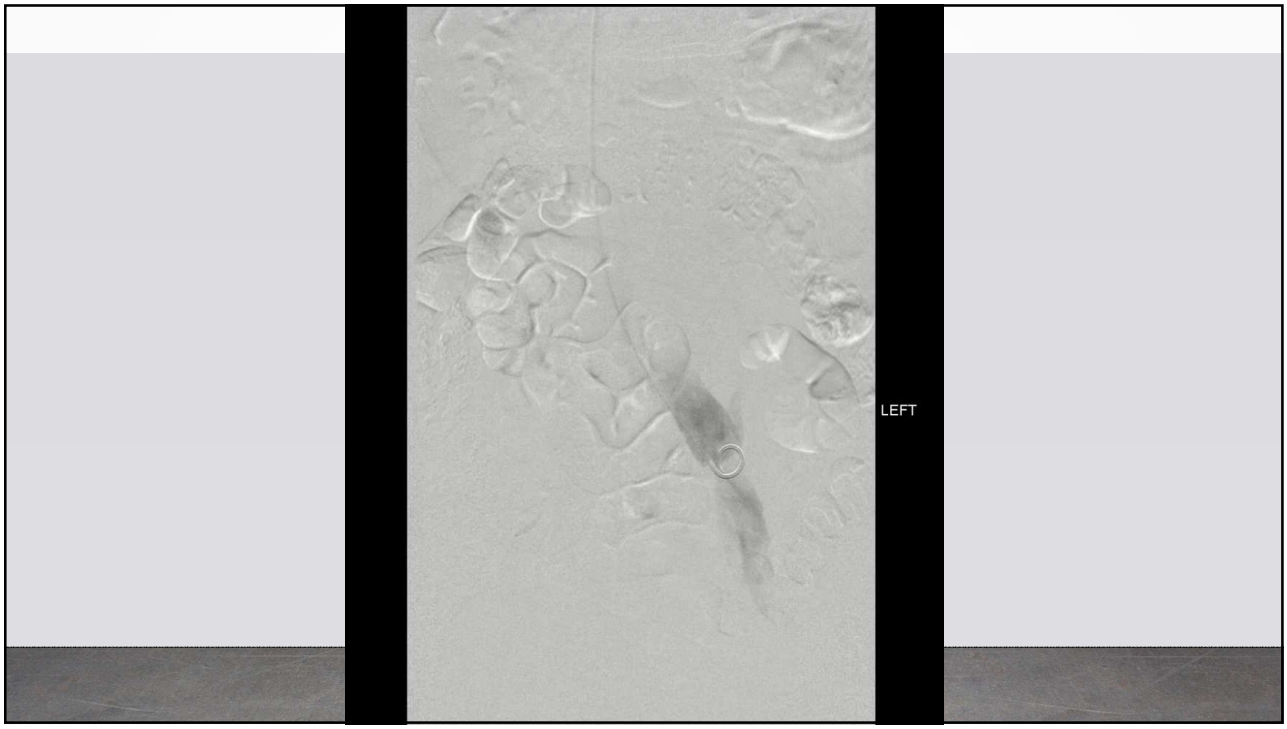

LOGIQ
E10
CHI
Frq 4.5
Gn 48
S/A 4/4
Map A/1
D 9.0
DR 63
AO% 100
RIGHT PARA UTERINE COLLATERAL
1 L 0.66 cm

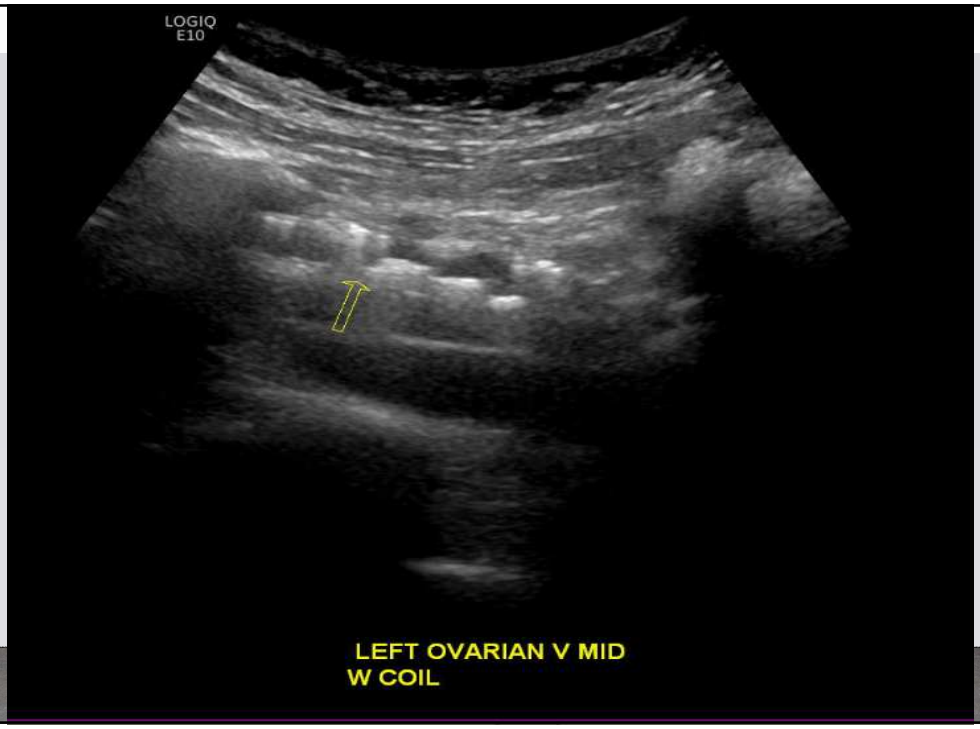

LOGIQ
UTERUS

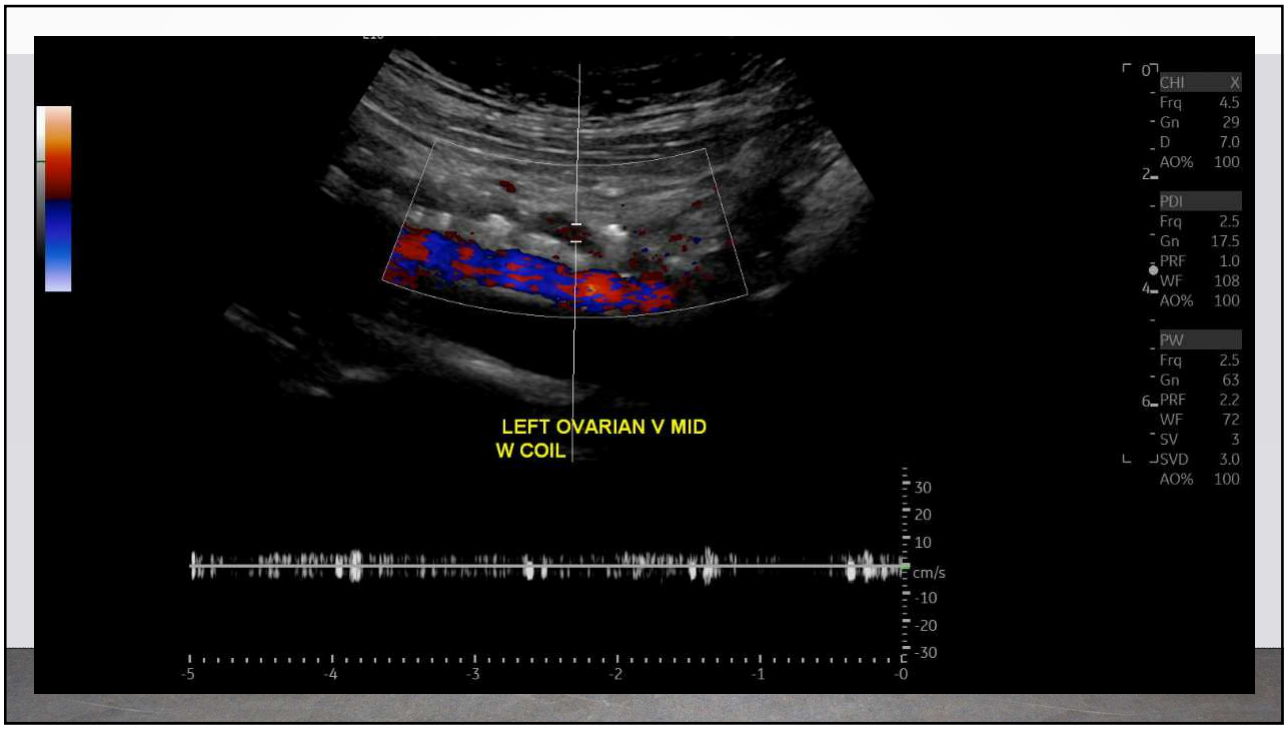

LOGIQ
E10
17
-17
cm/s
RIGHT INGUINAL ESCAPE POINT
VA VALSALVA
AC 60
30
20
10
cm/s
-10
-20
-30
-5
-4
-3
-2
-1
-0
FR 5
CHI X
Frq 4.5
Gn 32
D 5.0
AO% 100
CF
Frq 2.5
Gn 14.5
PRF 1.2
WF 104
AO% 100
PW
Frq 3.6
Gn 53
PRF 1.5
WF 85
SV 3
SVD 1.5
AO% 100

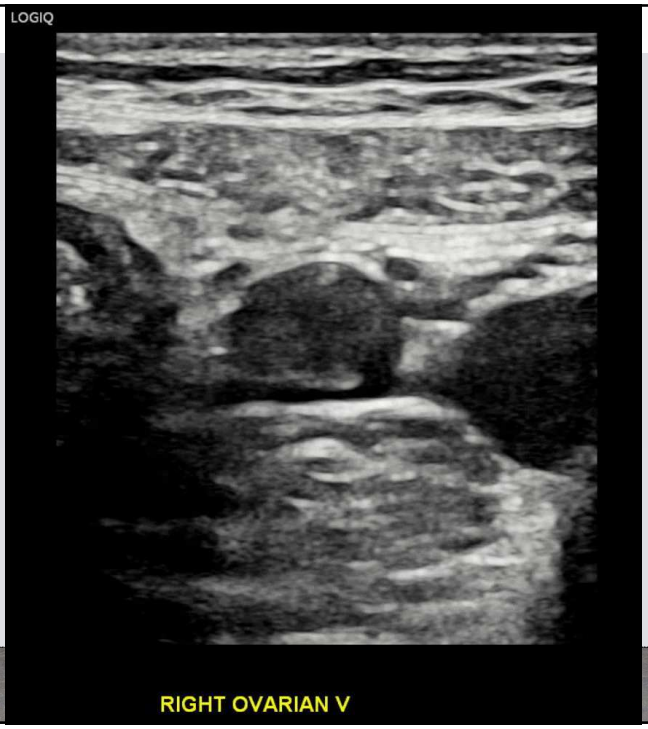

Indications: bilateral varicose veins and swelling, labial varices, pelvic pain with possible proximal compression.
Pertinent history: Gravida x 3
Right Common iliac Vein
Proximal (Compression Site)
Diam 9.4
Velocity 11.1
Distal CIV
Diam 13
Velocity 11
Velocity ratio 1
Diameter ratio 1.4
Right Gonadal V
Reflux NO
Diam 5.7
Left Renal Vein
Compression Site:
Diam 2.6
Velocity 37
Distal (kidney side)
Diam 8.3
Velocity 14
Velocity ratio 2.6
Diameter ratio 3.2
Retro grade flow
Left Common iliac Vein
Proximal (Compression Site
Diam 4.0
Velocity 29.6
Distal CIV
Diam 10
Velocity 20.6
Velocity ratio 1.4
Diameter ratio 2.5
Left Gonadal V
Reflux Yes
Diam 8.1
Right internal iliac
Reflux No
Diam 13
Left internal iliac
Reflux No
Diam 7.2
Inguinal Escape points
18
18
12
8
6.5
7.4
6.6

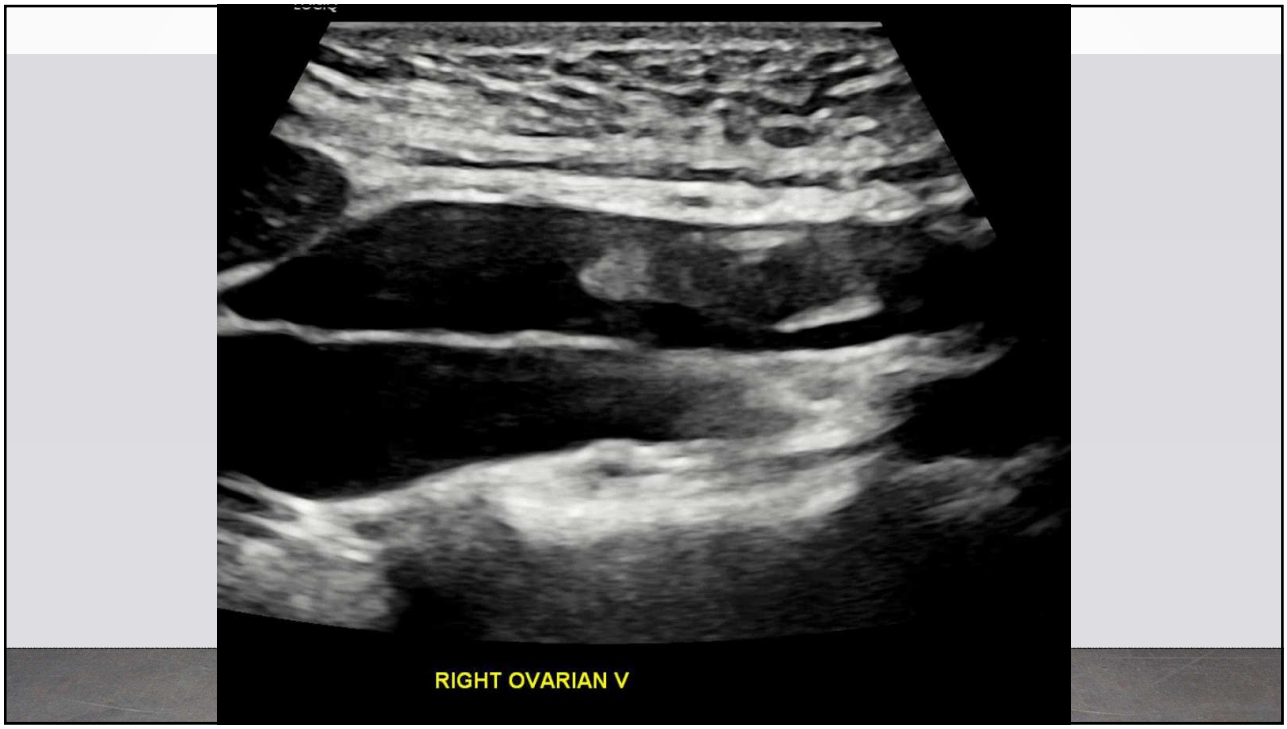

LEFT

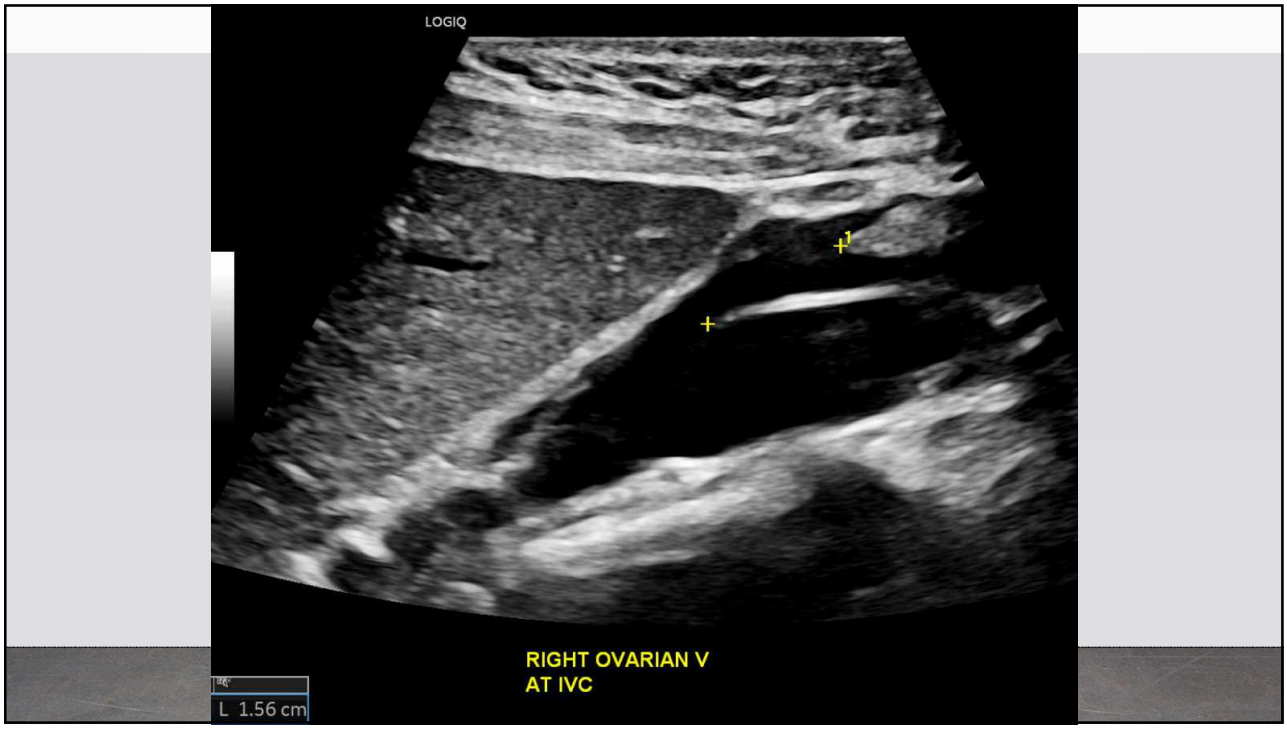

LEFT


LOGIQ
E10
LEFT OVARIAN V MID
W COIL


CHI X
Frq 4.5
Gn 29
D 7.0
AO% 100
PDI
Frq 2.5
Gn 17.5
PRF 1.0
WF 108
AO% 100
PW
Frq 2.5
Gn 63
PRF 2.2
WF 72
SV 3
SVD 3.0
AO% 100
LEFT OVARIAN V MID
W COIL
30
20
10
cm/s
-10
-20
-30
-5
-4
-3
-2
-1
-0


LOGIQ
RIGHT OVARIAN V


RIGHT OVARIAN V


LOGIQ
RIGHT OVARIAN V
AT IVC
L 1.56 cm

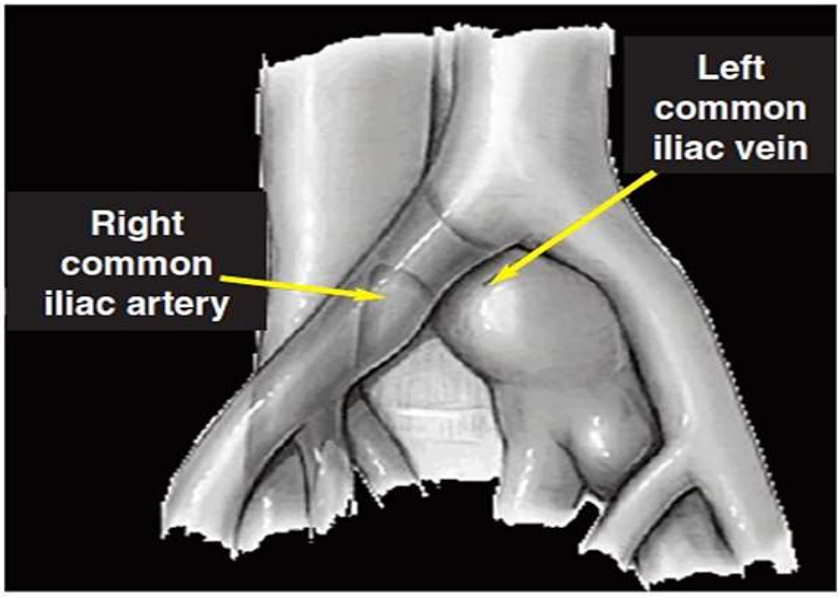
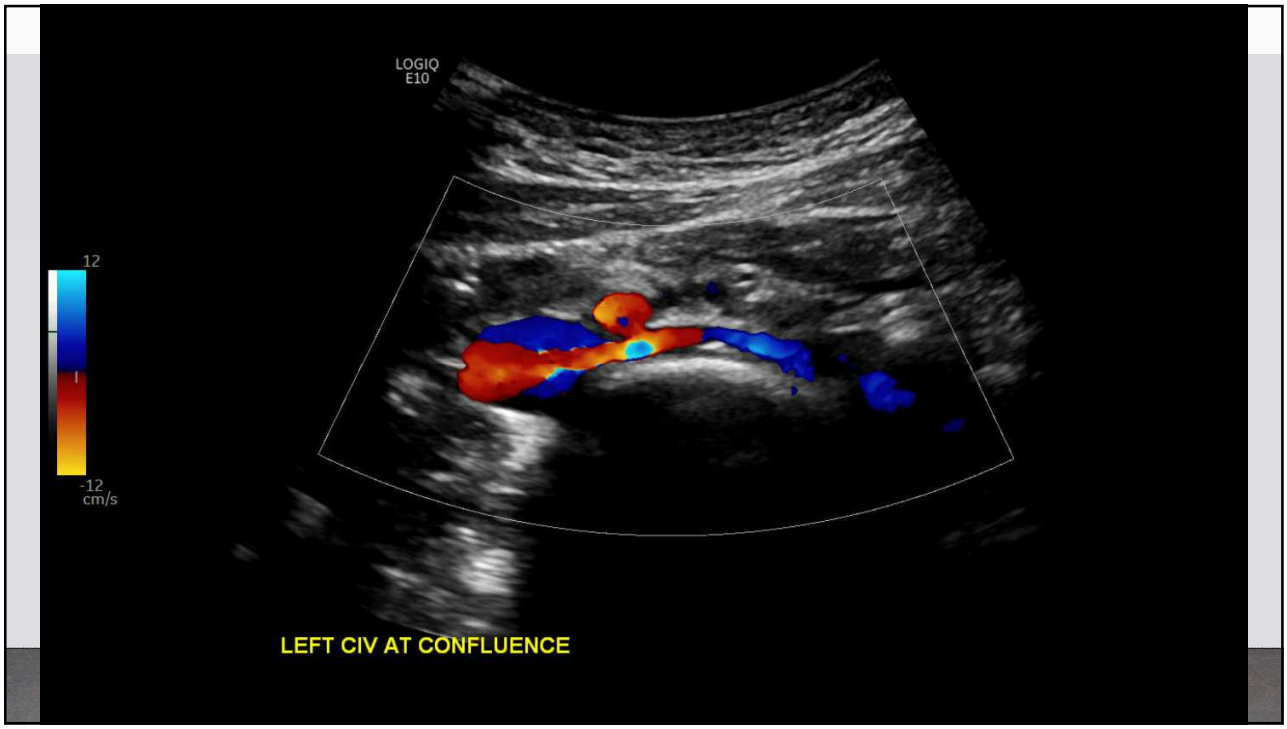


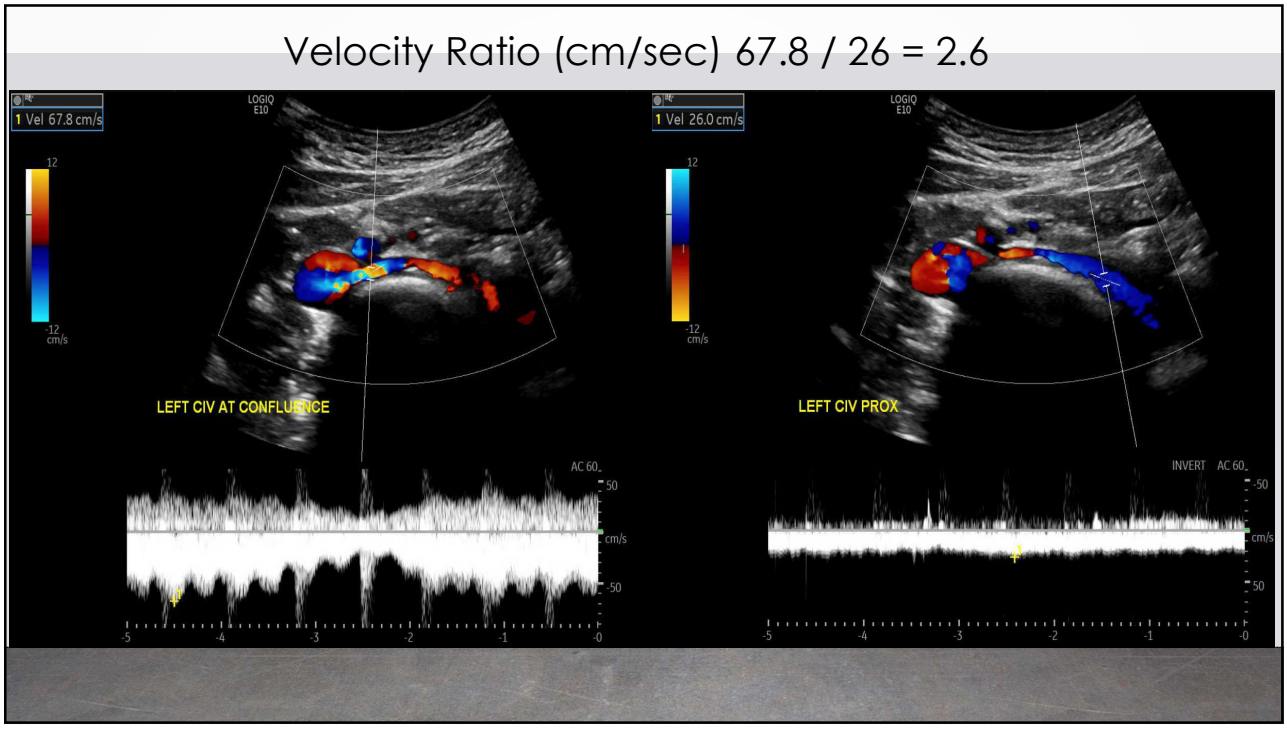
Figure 1. Illustration demonstrating the anatomic compression seen in May-Thurner syndrome.

Criteria for documenting May-Thurner Syndrome

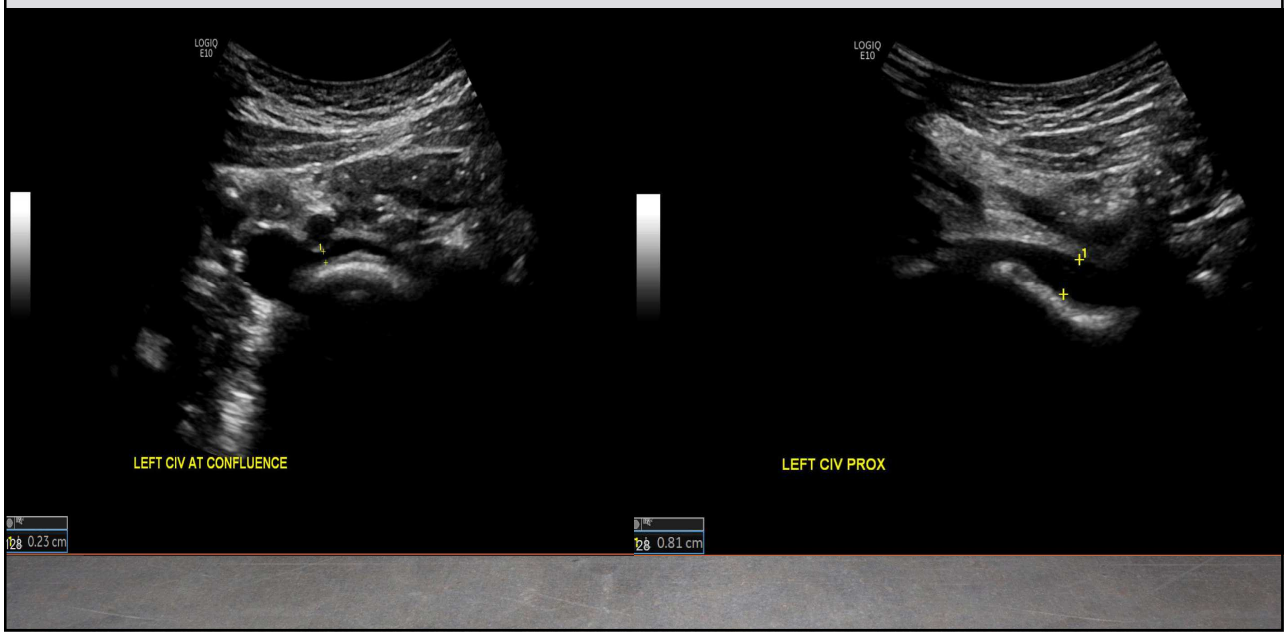
- Diameter reduction of ≥50% and a peak venous velocity ratio of ≥2.5, absence of flow within the common iliac vein, spurring and/or wall thickening within the common iliac vein.
- Monophasic venous waveforms documented distal to the compression site, (common femoral or external iliac vein).
- Conventional Venography or IVUS (Intra Vascular Ultrasound) are considered the Gold Standard for diagnosis and treatment

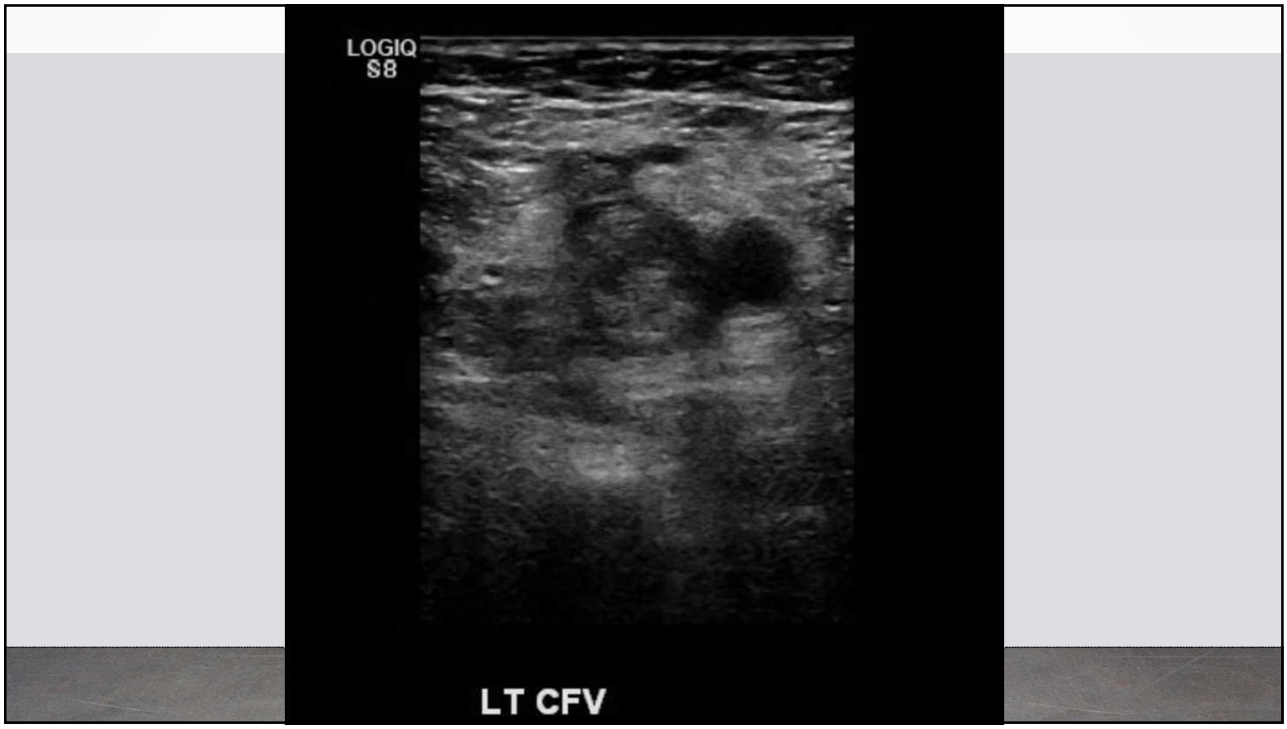


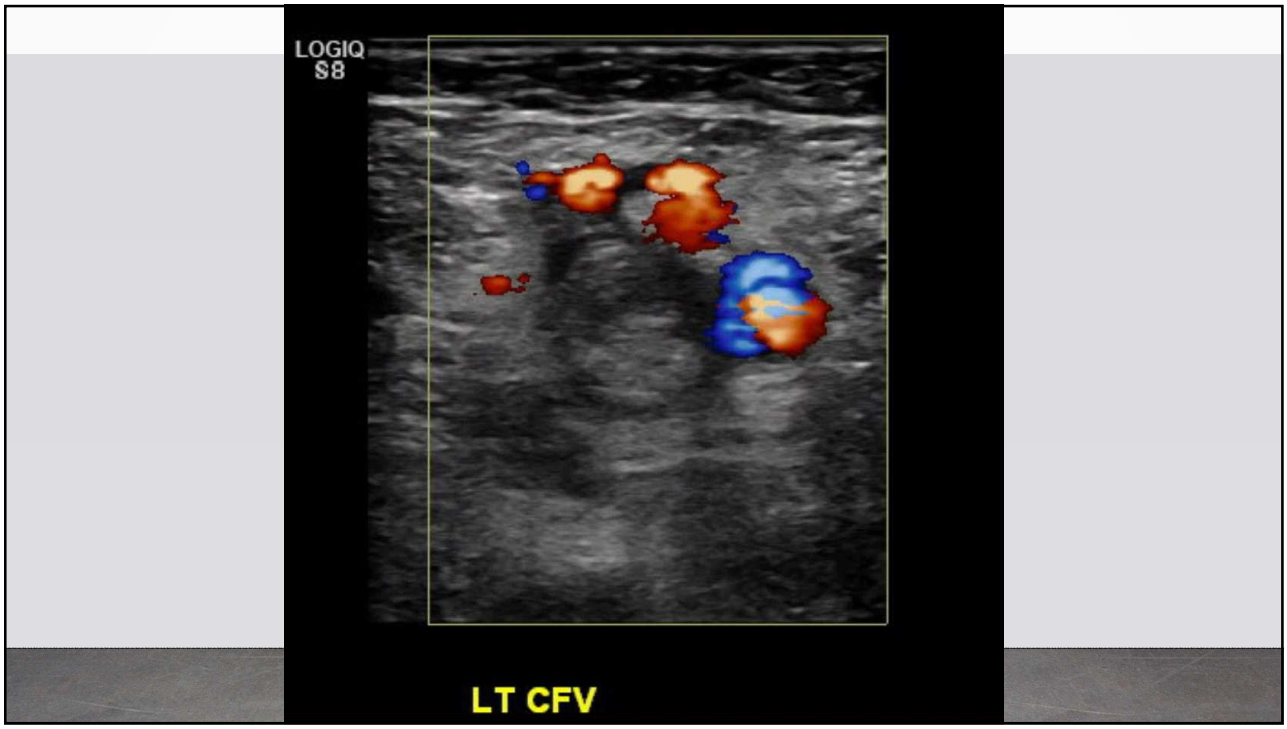
Velocity Ratio (cm/sec) 67.8 / 26 = 2.6

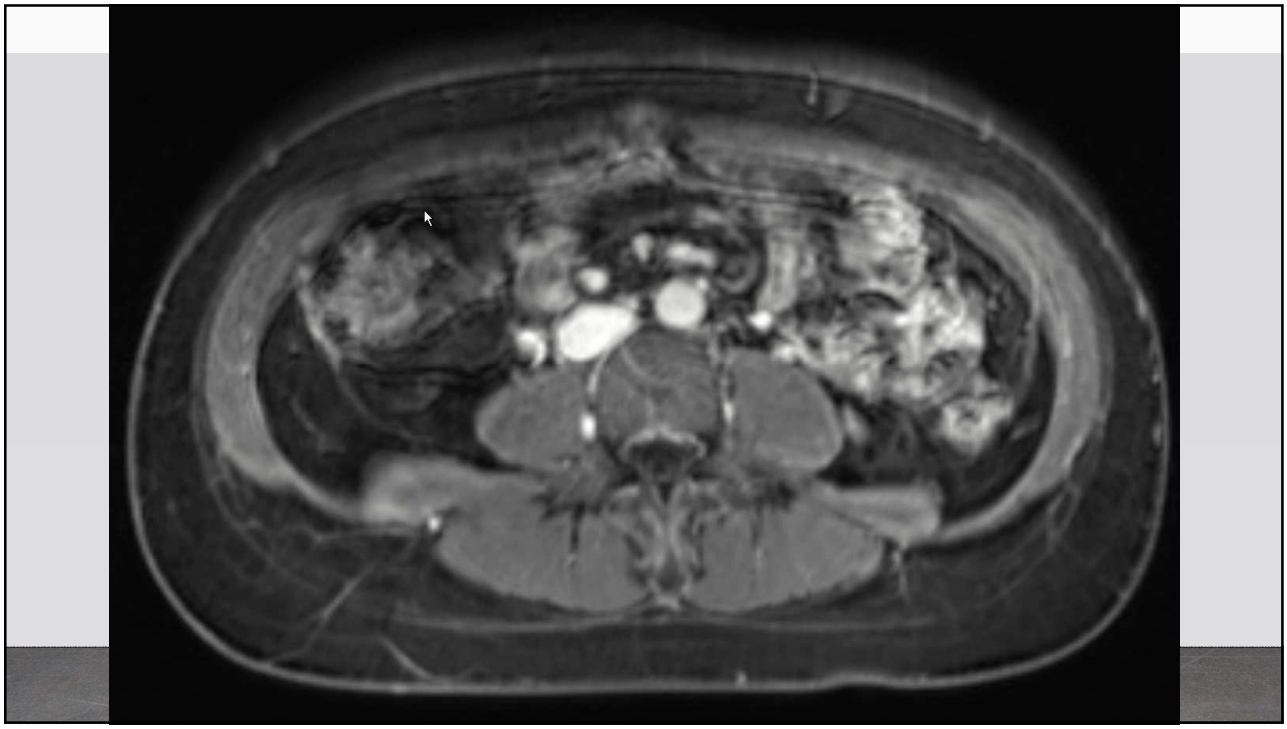


Diameter Ratio (mm) 8.1 / 2.3 = 3.5



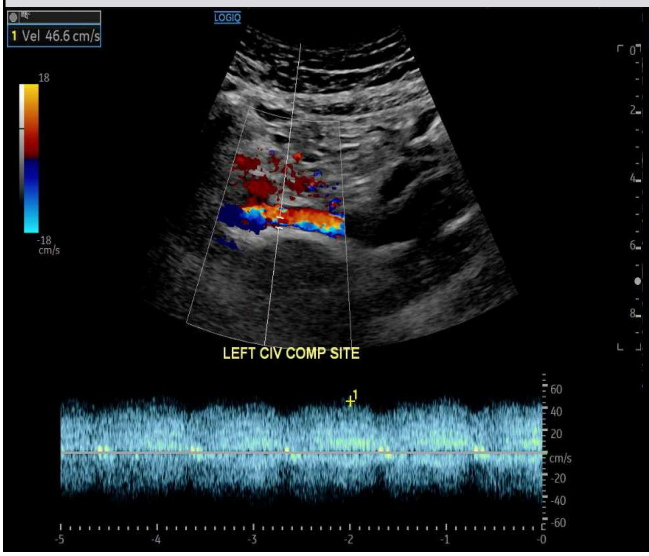



LOGIQ
S8
LT CFV

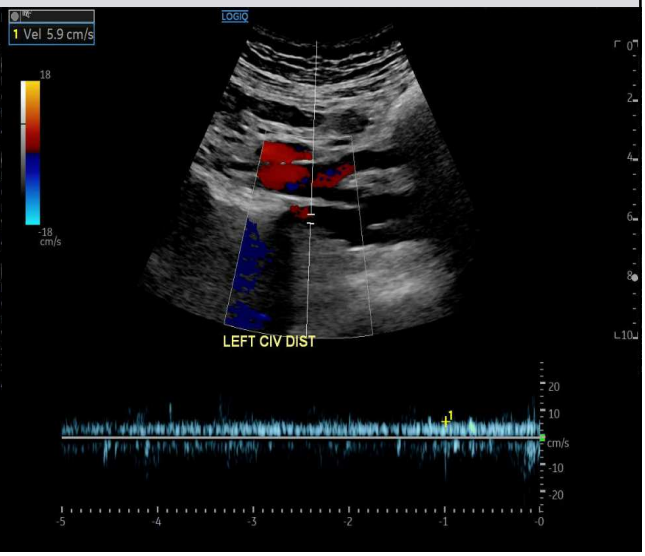


Velocity Ratio 46.6 / 5.9 =7.8

Peak Venous Velocity

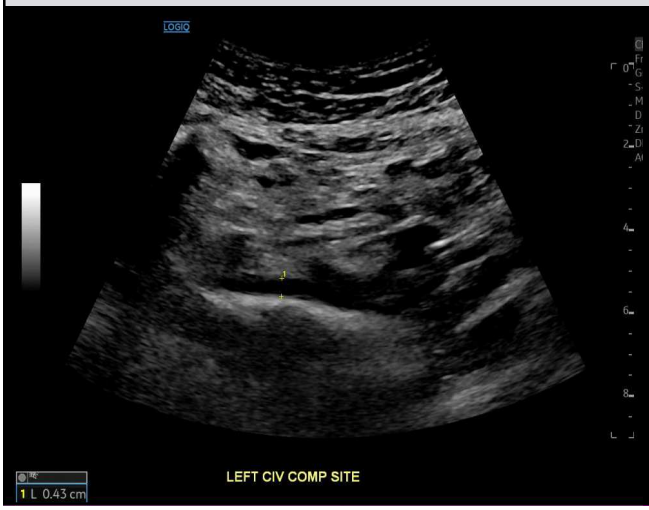


Monophasic Flow Profile

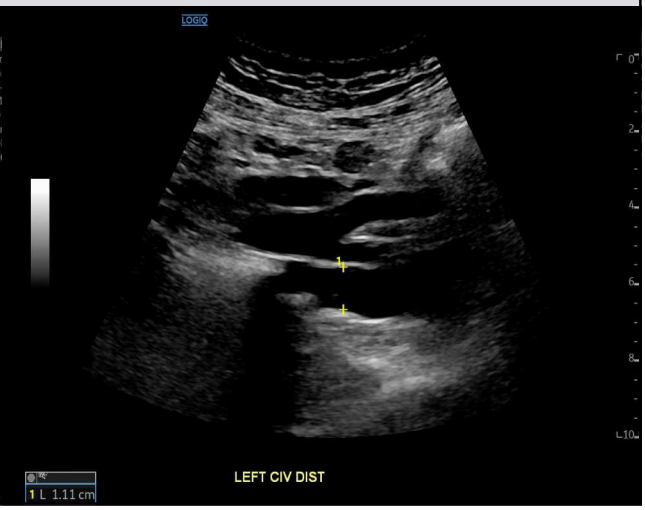


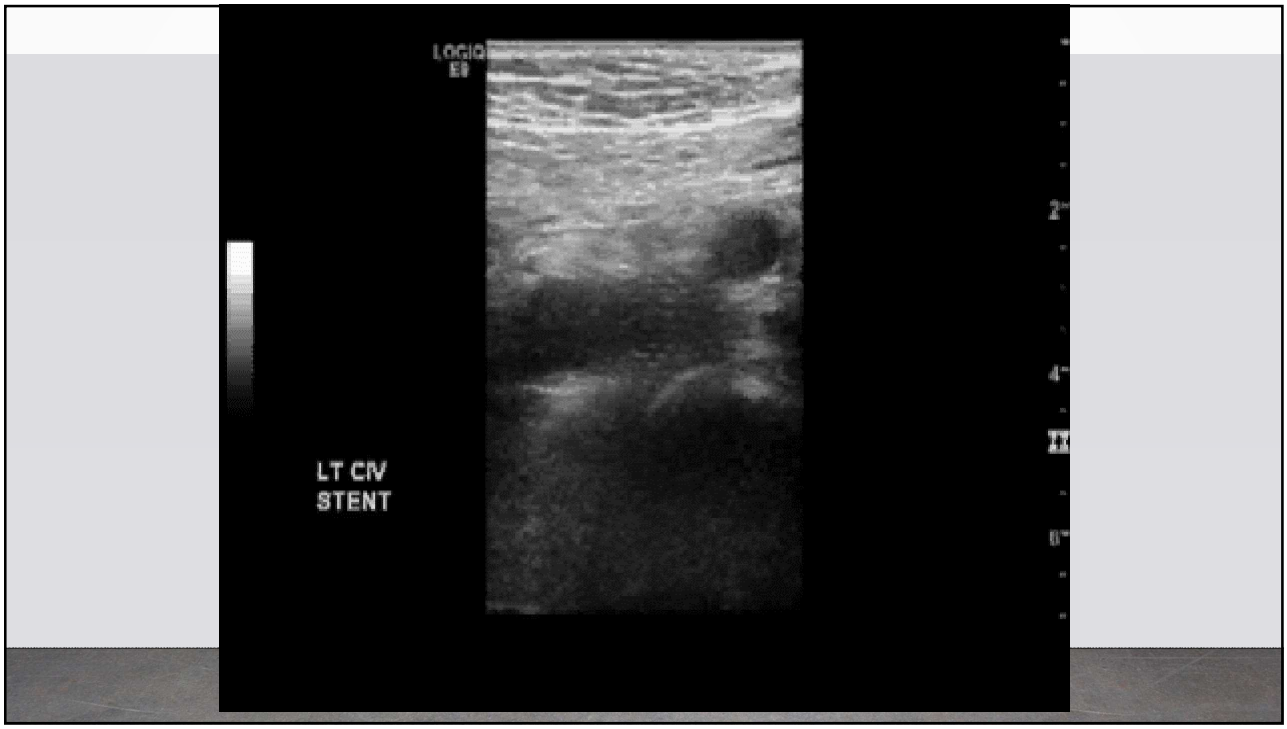
Diameter Ratio 1.11 / 0.43 = 2.58

Left Common Iliac Vein @ Confluence of Right Common Iliac Artery



Left Distal Common Iliac Vein Left





Characterization of thrombus is vital to appropriate treatment

- How does the vein compress?
- Does the thrombus appear acute, chronic or of indeterminate age?
- How close is the thrombus to the SFJ or SPJ?
- Is flow absent or present via spectral Doppler?
- Obtain still images or Cine clips in the Transverse and Longitudinal plane.
- The more images the better

If Nut-Cracker or May-Thurner anatomy is suspected….

- An Abdominal / Pelvic venous duplex, in conjunction with a lower extremity venous reflux exam, should precede initial clinical assessment.
- Assess the Left renal vein and bilateral ovarian veins in supine and then in reverse Trendelenburg.
- Use the branches of the descending Aorta as your landmark for Renal vein compression points, (SMA is just distal to the Celiac Trunk).
- Use the bifurcation of the common iliac arteries as a reference point for imaging Left common iliac vein at its greatest point of compression.
- Assess the uterus, adnexa and internal iliac veins
- Note the anatomical escape points i.e., Pudendal, Obturator, Inguinal, Gluteal

In the setting of Venous Thoracic Outlet Syndrome

- Upper extremity venous duplex to assess subclavian and axillary veins at rest and with provocative maneuvers
- Assess the patient bilaterally, as symptoms may only be present in the dominant arm
- Easily repeatable, high sensitivity, no exposure to contrast or radiation.
- Ultrasound is the only imaging modality which allows us to accurately assess blood velocity

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