



Ultrasound Vascular: DVT & CVL insertion

Sameh Salem

USG for DVT

Ultrasound for DVT

- **Major criterion** - *Failure to compress vascular lumen*
 - Non visualization of lumen
 - Acute thrombus can be anechoic
 - Slow flowing blood can have internal echoes
- **Minor criterion** - **Absence of normal doppler signals**
 - Absence of flow
 - Absence of respiratory variation in flow
 - Decreased augmentation with distal compression
 - Distension of vessel

Compression USG

***The primary diagnostic modality
+ clinical probability + D-dimer***

*Noninvasive
readily available
no contraindication*

*Cheap
repeatable
no radiation*

Portable

***Blavias M, Lambert MJ, Harwood RA et al. Lower-extremity Doppler for DVT can
emergency physicians be accurate and fast:
Acad Emerg Med 2000;7:120-126.***

Compressibility

- **Collapse of lumen of vein**
 - Complete apposition of anterior and posterior wall

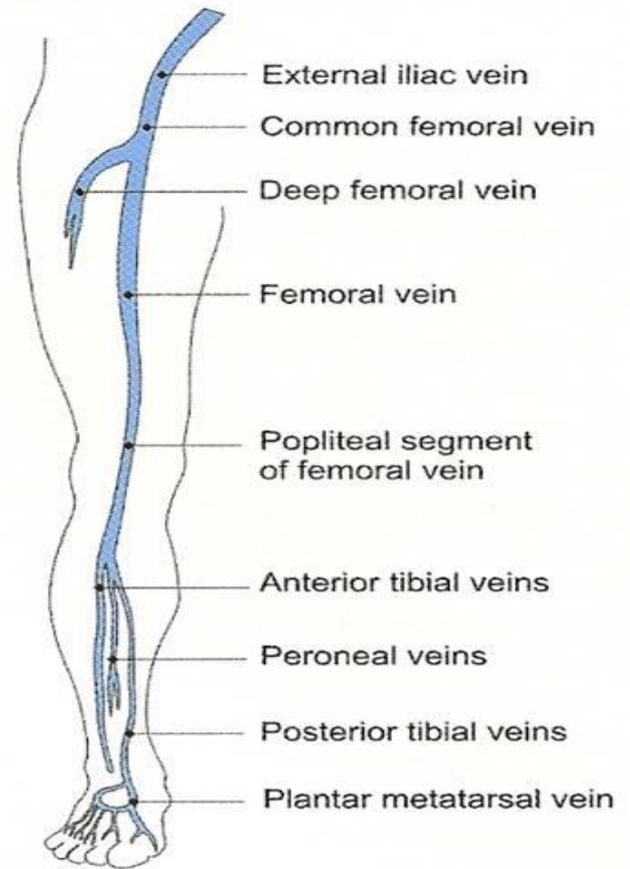
*May visualize thrombus
but
not necessary for diagnosis*

- **Compress with transducer in short axis**
 - Use to follow course of vein

Longitudinal axis compression:
*slides off vessel wall
leading to false negative result*

Anatomy of LL venous system

- *Most believe only proximal DVT needs treatment.*
- *But 20% of calf DVT may propagate to the more proximal veins.*

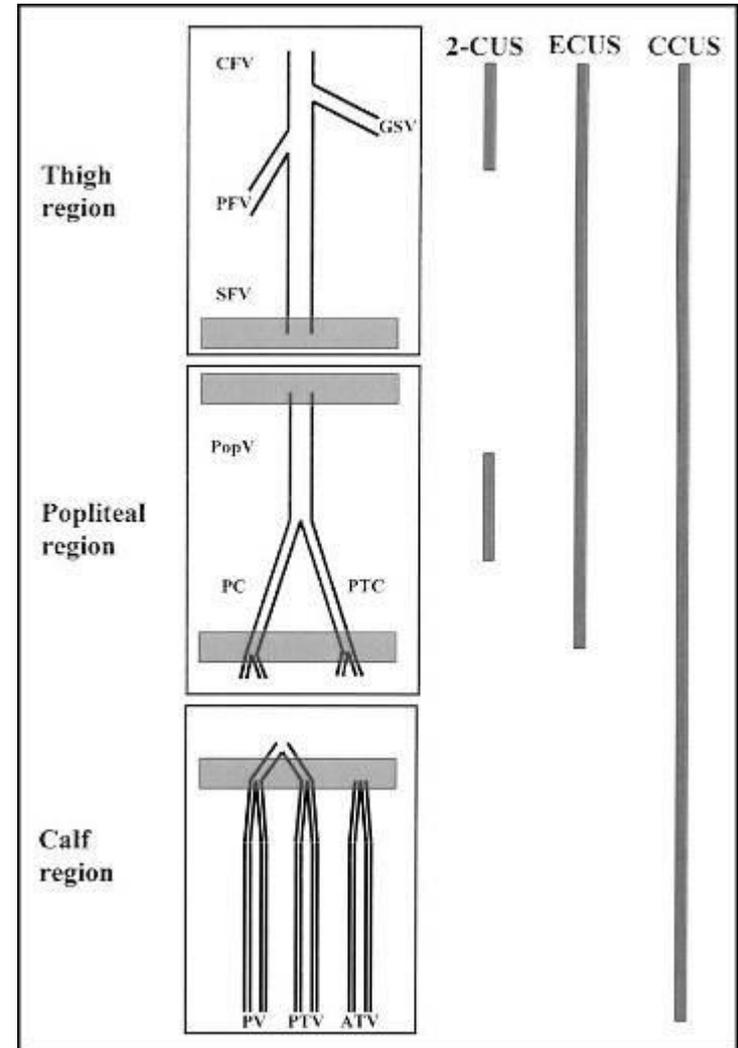


Pezzullo JA, Perkins AB, Cronan JJ: symptomatic DVT: Dx with limited compression USG. Radiology 1996; 196:67-70

Scarvelis D, PS Wells. Dx and Tx of DVT. Canad Med Ass L. 2006; 175(9): 1087-92

USG Protocols

- **2-point compression USG**
[2CUS]
Scan only the groin and popliteal fossa
i.e. CFV and proximal SFV, and Pop V
- **Extended compression USG**
[ECUS]
 - From groin to thigh then to popliteal fossa
i.e. CFV, SFV, Pop V till trifurcation
- **Complete compression USG**
[CCUS]
 - From groin to calf, every cm
 - i.e. CFV to paired calf veins



USG Protocols

CCUS is Time consuming

Difficult to identify the calf veins

Normal variants occur

Elias et al. Thromb Haemost 2003; 89: 221-227

Schellong et al. Thromb Haemost 2003; 89: 228-234

USG Protocols

2 CUS

- Easy & fast to perform:
 - femoral & popliteal
regions are superficial
 - **5.5 mins for 2CUS Vs 37 mins for CCUS**
- ER physicians are competent in performing 2-CUS
 - 98% agreement with vascular sonographers
 - Median time=3 min 28 sec

Poppiti R et al. J Vasc Surg. 1995; 22: 553-57

Blaivas M et al. Acad Emerg Med 2000; 7(2): 120-126

Hardware preparation

- High frequency linear transducer
5-10MHz
- Mainly B mode imaging
- Color flow / Pulse wave Doppler application optional
- Adequate transonic Gel
- Adjust Depth when scanning mid-thigh level [veins go deeper]
- *Curved transducer in deep veins e.g. edema, and obesity*



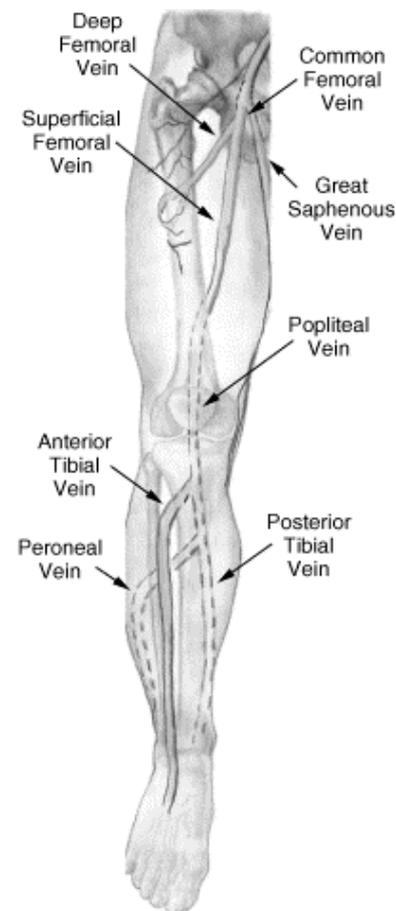
Image Acquisition

- **Head of bed to 45°**
- Patient in supine position with *slightly externally rotation and flexion of hip*
- **Transverse scan**
- *Start just below the inguinal ligament*



Lower Extremity Venous Anatomy

- External Iliac
- Common Femoral Vein
 - Deep femoral vein
 - Superficial Femoral Vein
 - Popliteal Vein
 - Anterior Tibial Vein
 - Posterior Tibial Vein
 - Peroneal Vein



Anatomy on moving distally

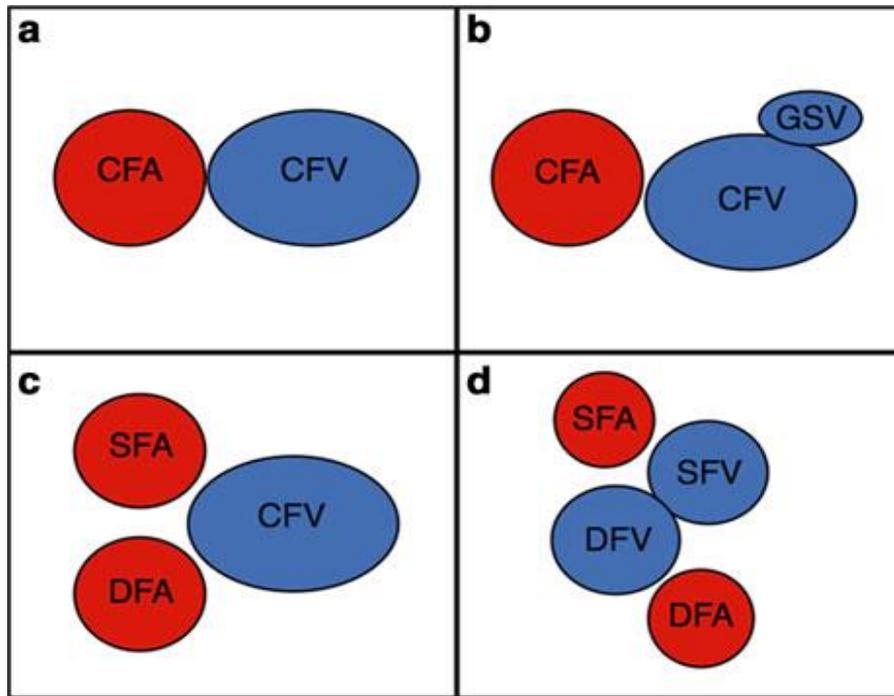


Image Acquisition

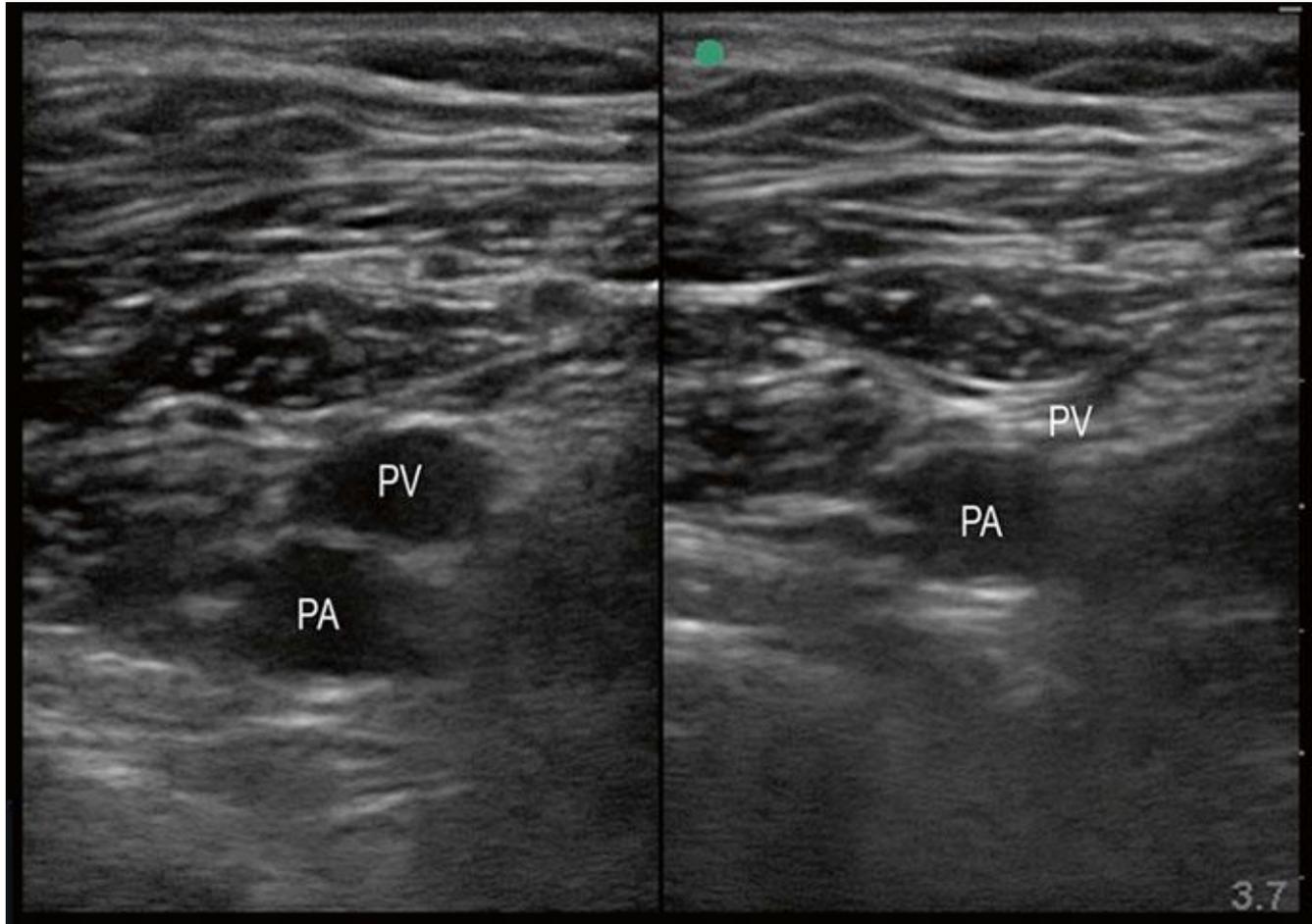
Site: Popliteal fossa right behind the knee to assess Pop. V

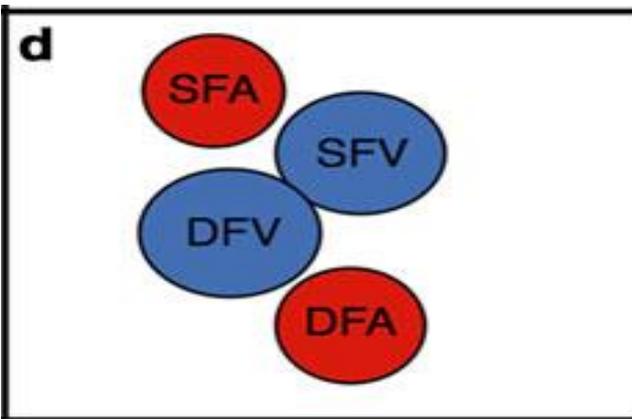
Pop. V is superficial the Pop. A



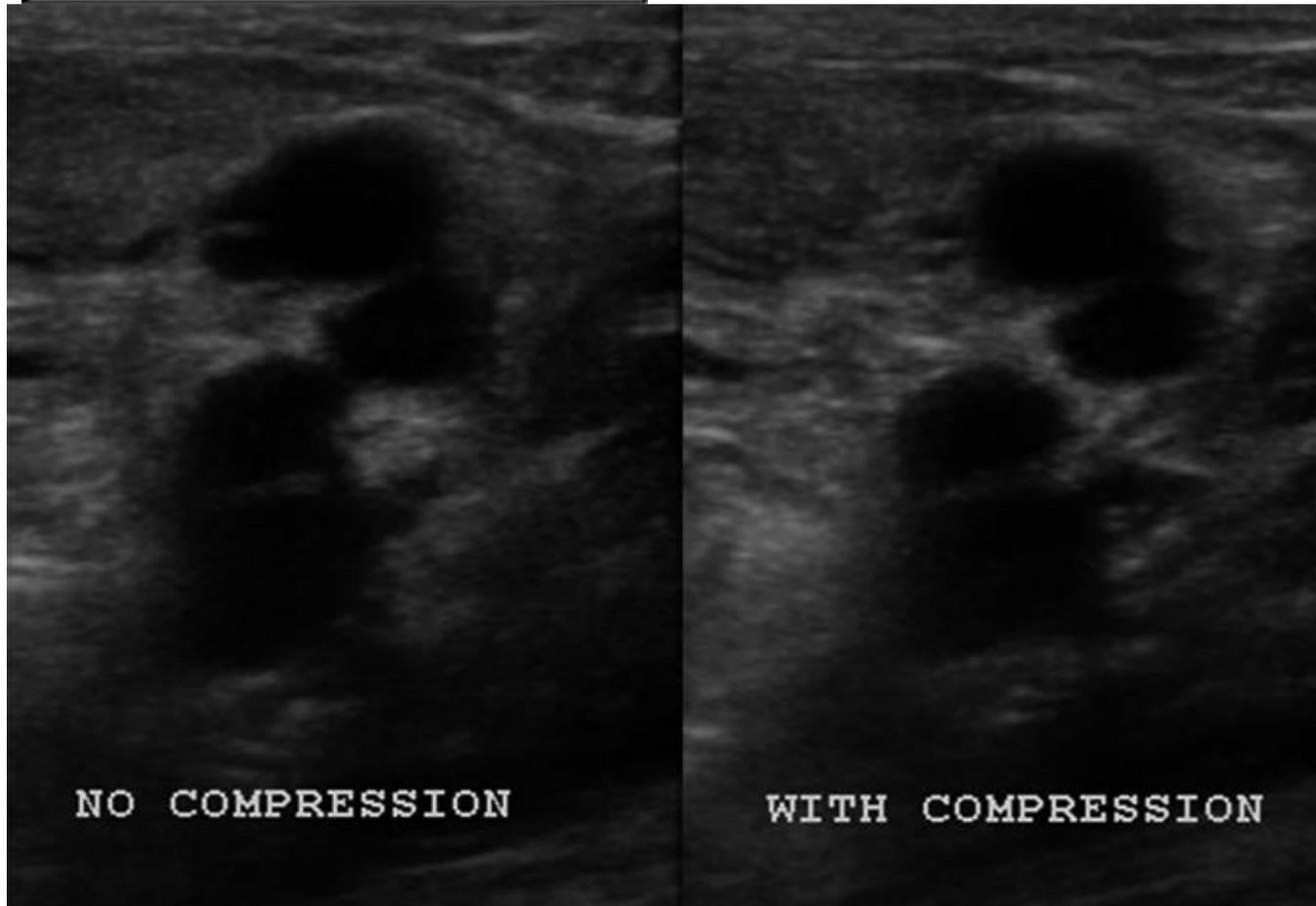
Assess the compressibility on the proximal 2cm just distal to the trifurcation where the veins split into anterior and posterior tibial veins and peroneal vein

Pop. V

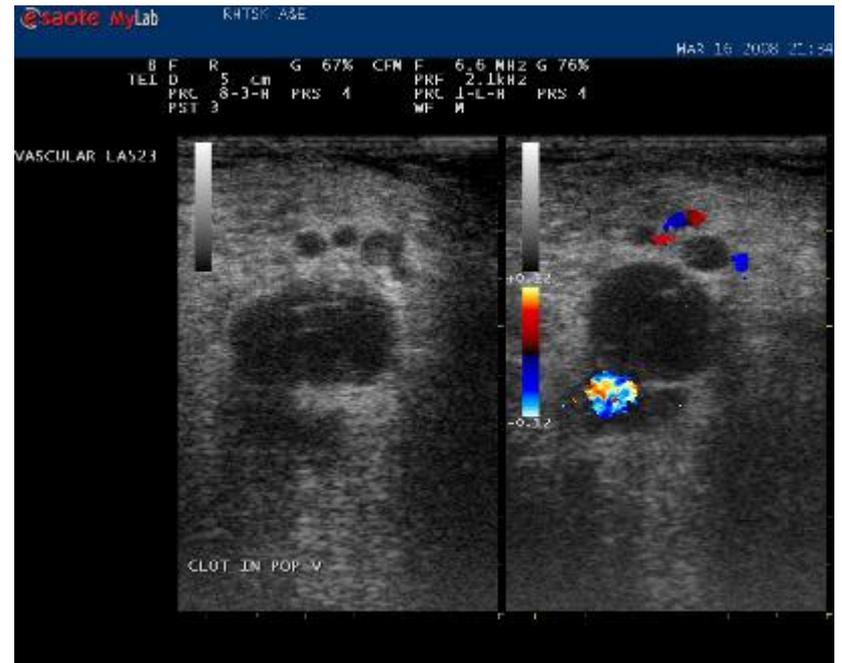
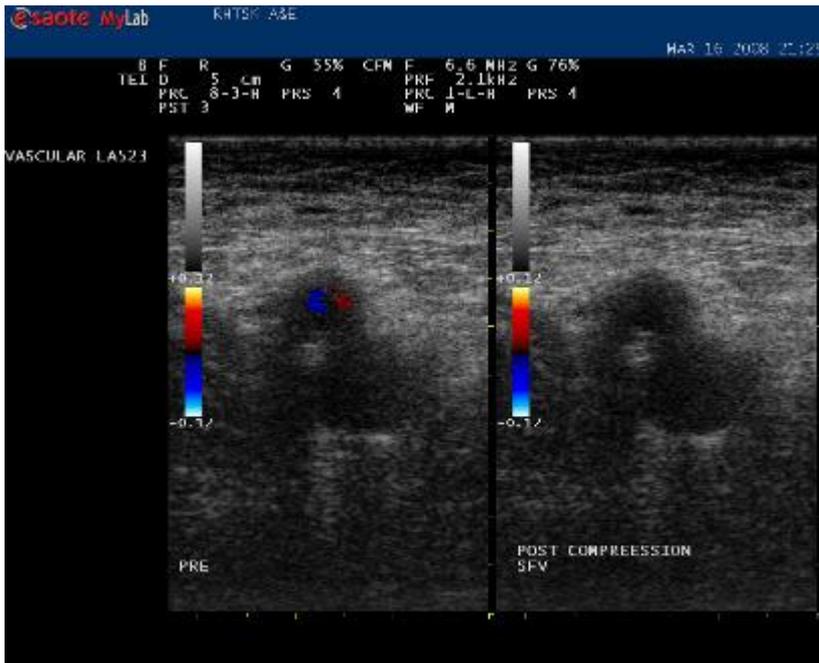




Compression



DVT features



***Left SFV and Pop V failed to compress ie. DVT +ve.
Also absence of color flow doppler signs in these 2 viens***

B-mode Image Features

Acute vs. Chronic DVT

Acute

Homogeneous,
smooth
Hypoechoic
Soft,
spongy (deforms With
compression)
Vein is dilated
Free floating tail

Chronic

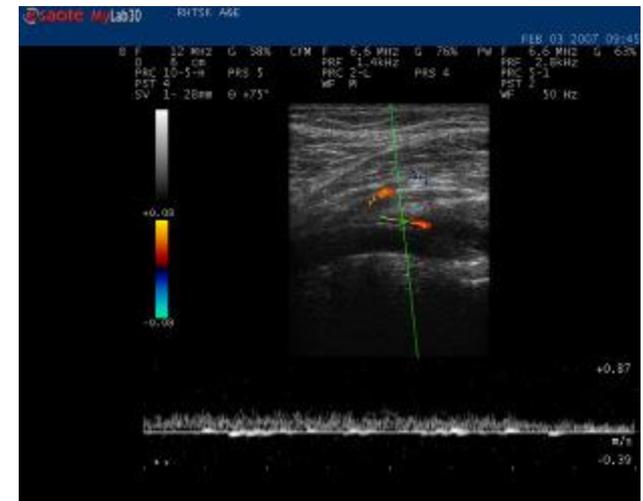
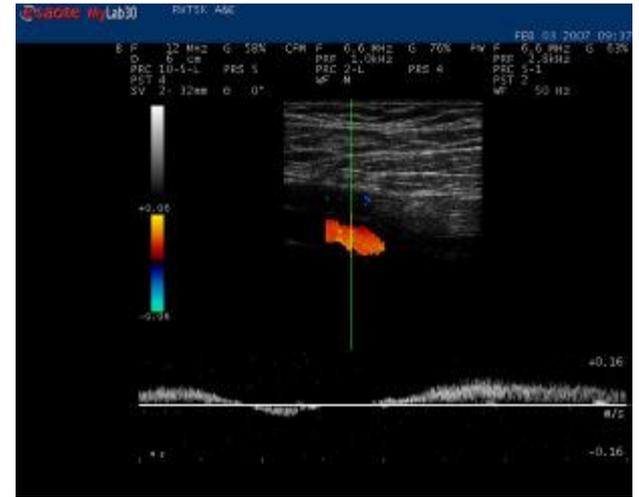
Heterogeneous,
irregular, synechiae
Echogenic
Stiff (not
deformable)
Vein normal or small
size
Thickened vein wall
(recanalization)
Collaterals present

Doppler Assessment

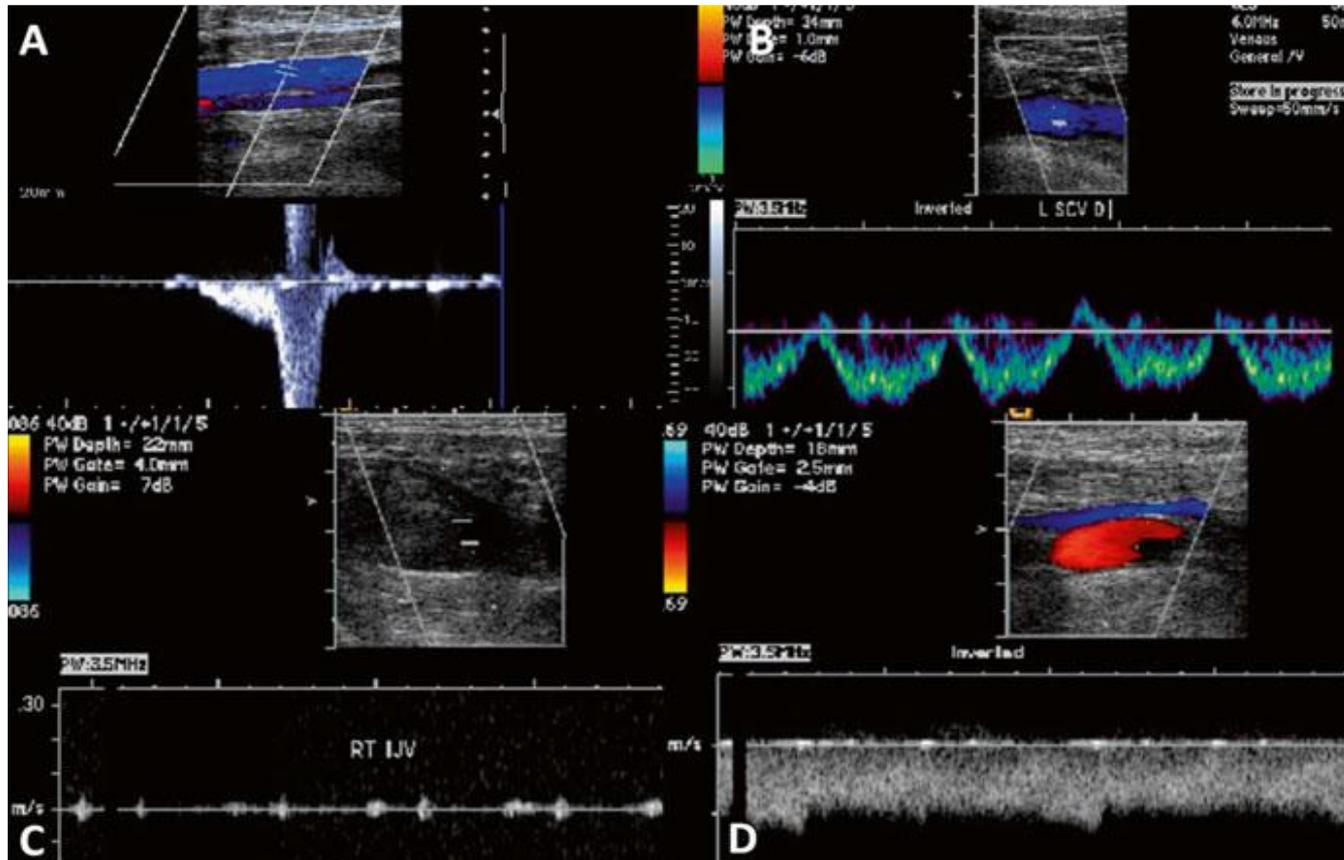
- *Not an essential examination for identifying DVT*
 - *Provide more info about the blood flow with in the vessels e.g. Venous obstruction*
- ***Useful in anatomical areas where compression is not possible e.g. Iliac veins***
- **Color flow and Pulse-wave doppler studies**

Pulse-wave Doppler

- Appropriate sampling size
- **Avoid angle >60** to prevent inaccurate measurement of doppler flow
- Normal **phasic** change occurs during respiration in the proximal veins e.g. CFV, SFV
- **Augmentation** >100% of flow by squeezing the calf or flexing the ankle

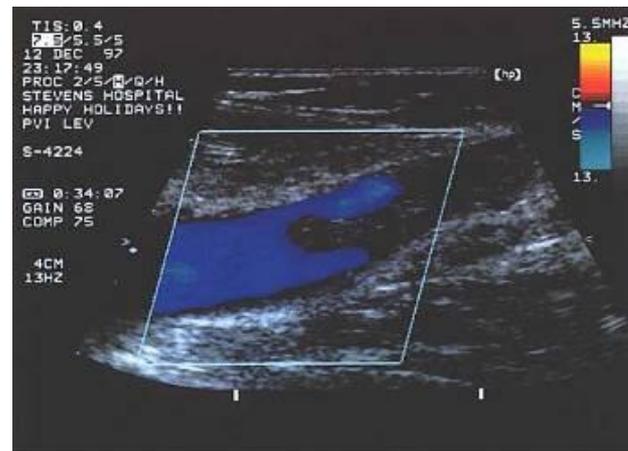
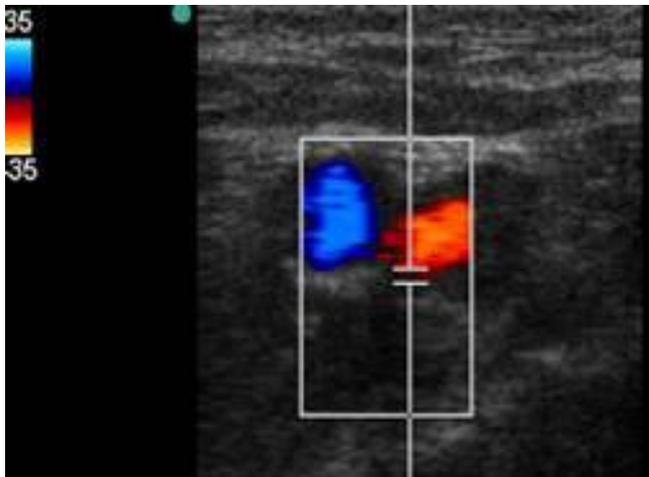


Spectral Display



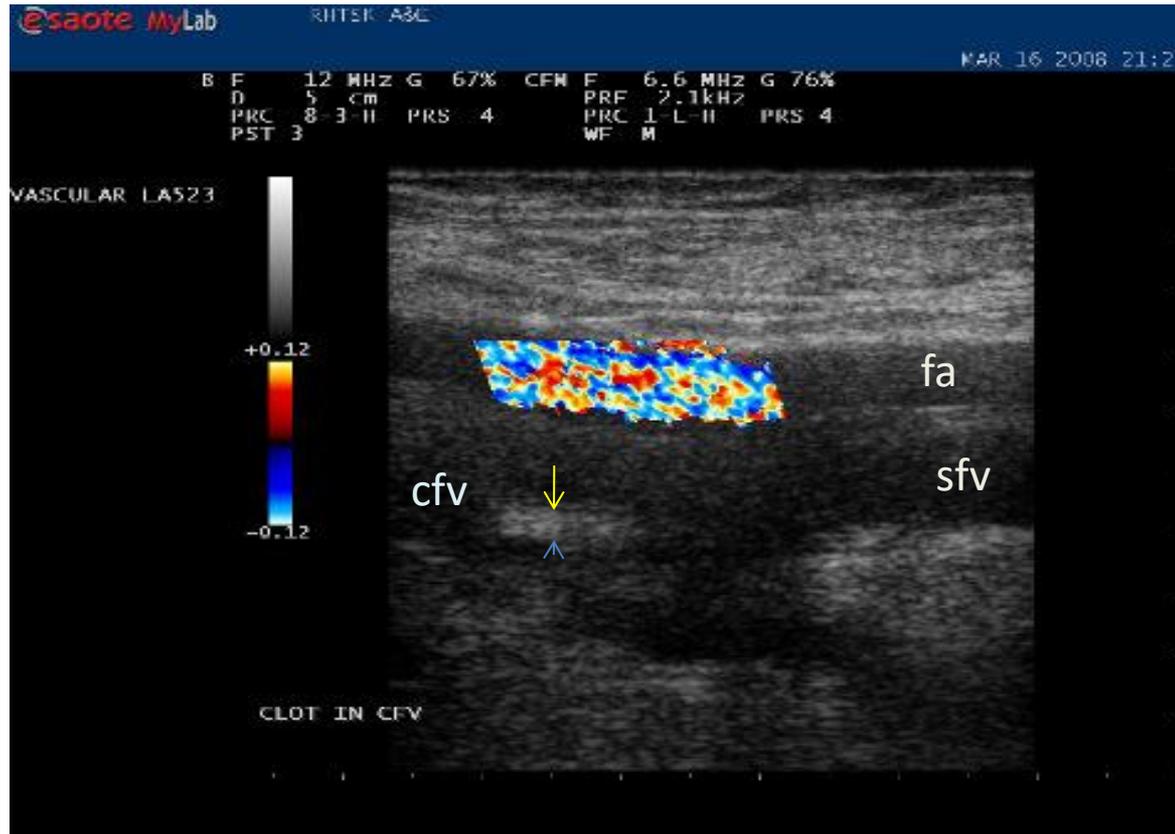
Color Flow Doppler

- Aid to differentiate the veins from arteries
 - Color should be able fill up the vein completely.
 - *If not: clots may be present*



2-D grayscale and color image of acute superficial femoral vein DVT with a "free floating" tail.

Color Flow Doppler



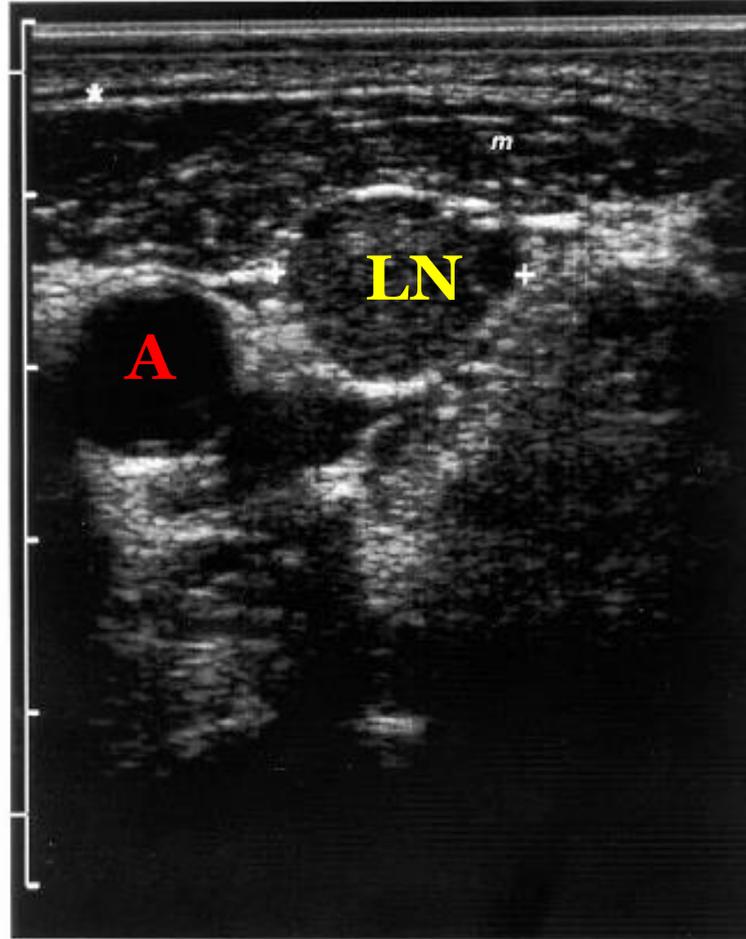
Absence of flow in the CFV and SFV with echogenic clots

Pitfalls

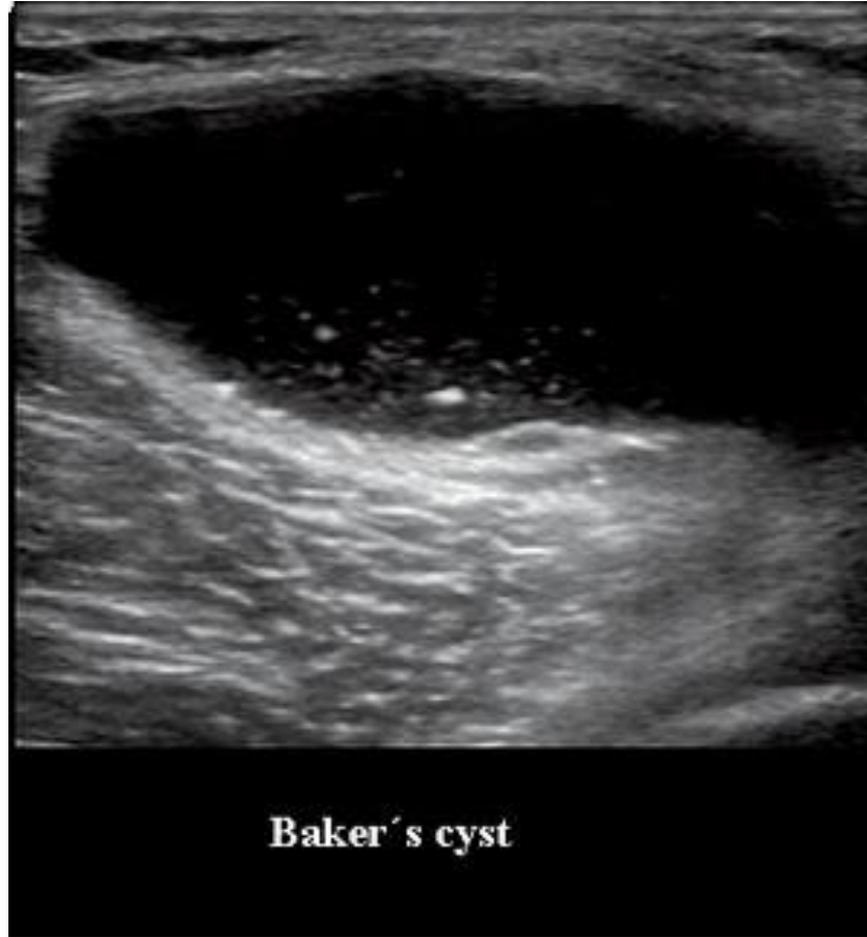
- **Anatomical variation**
 - 32.5% have multiple SFV
 - 42% have more than 1 POP veins in popliteal fossa; 5% true duplications
- **Technical aspect [Doppler may help]**
 - Groin Lymph Nodes: mistaken as a thrombosed vein
 - Mistaken an artery as a vein with failed compression

Quinlan DJ, AAlkhan R, Gishen P Sidhu PS. Variations in Lower limb venous anatomy: implications for USG diagnosis of DVT. Rdaiology 2003; 228:443-448.

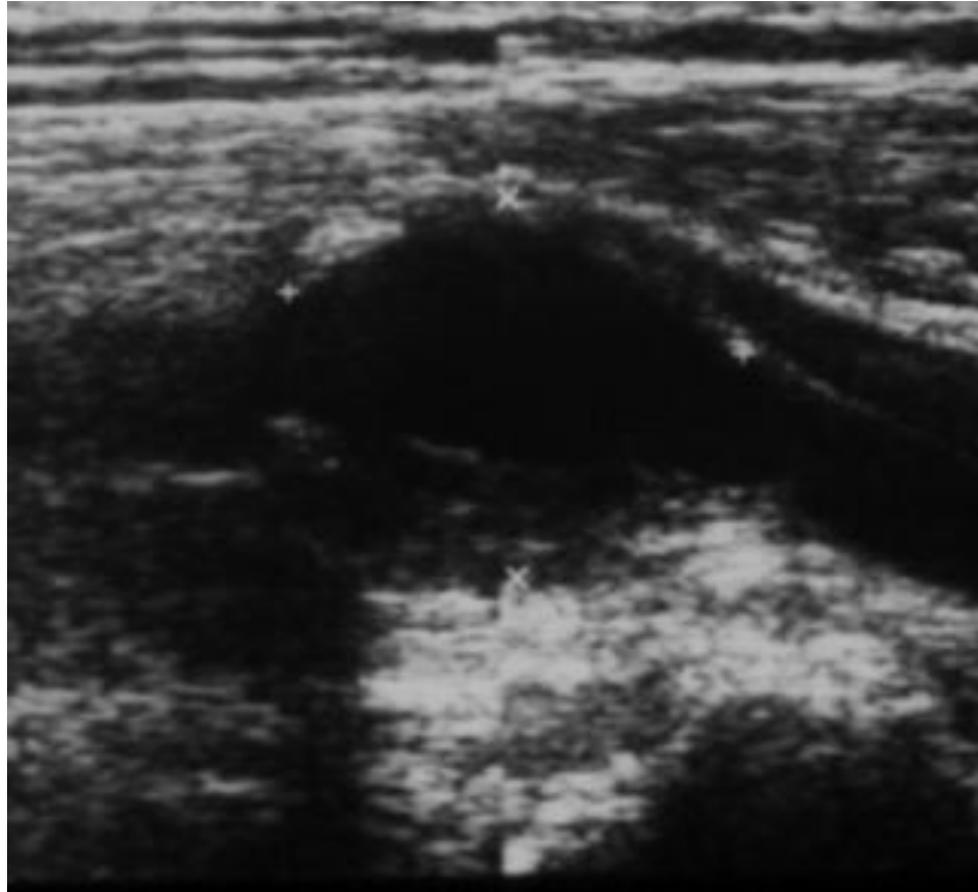
Lymph Node



Baker Cyst



Popliteal Artery Aneurysm



Limitation of USG

- **Acute on chronic DVT**
 - Not accurate to differentiate old/new clots
 - Need venography
- **Physical obstacles**
 - POP/Cast in situ
 - Surgical emphysema/open laceration wound
 - Iliac veins/IVC: *relies on doppler flow assessment because compression is impossible*

Well Score

Active cancer (on treatment for last 6 months or palliative)	1
Paralysis, paresis or plaster immobilization of lower limb	1
Immobilization previous 4 days	1
Entire leg swollen	1
Calf swollen by more than 3 cm	1
Pitting edema	1
Collateral superficial veins (non-varicose)	1
Probable alternative diagnosis	- 2

High DVT Risk = 3+

Moderate DVT Risk = 1-2

Low DVT Risk = < 1

If both legs are symptomatic, score the more severe leg.

D- dimer

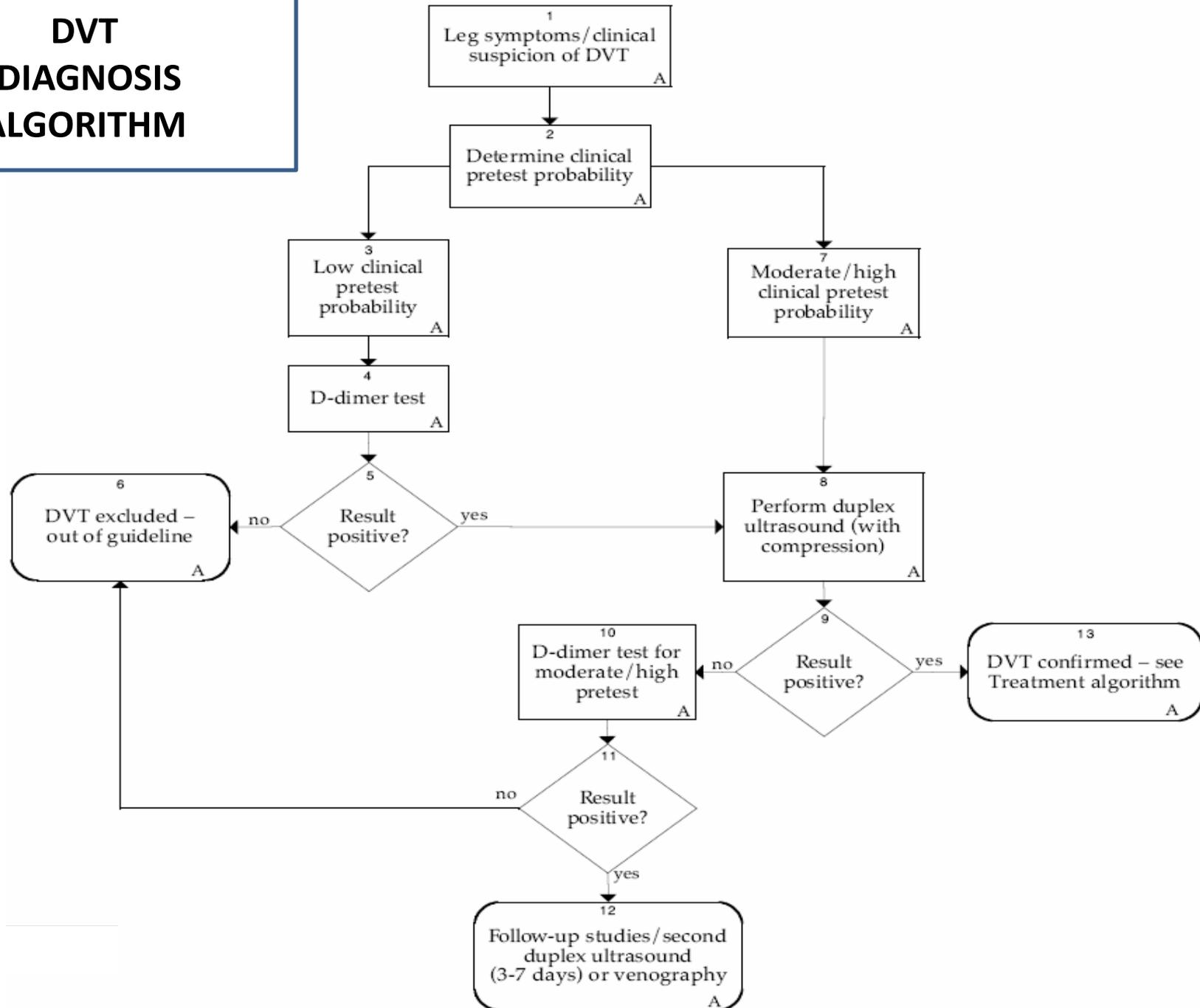
- Fragments
 - *Degradation of fibrin by plasmin*
- Elevated in any condition where clots form
 - *Trauma, recent surgery, cancer, sepsis*

Low specificity (not confirmatory)

r/o DVT when -ve (85-95% high sensitivity)

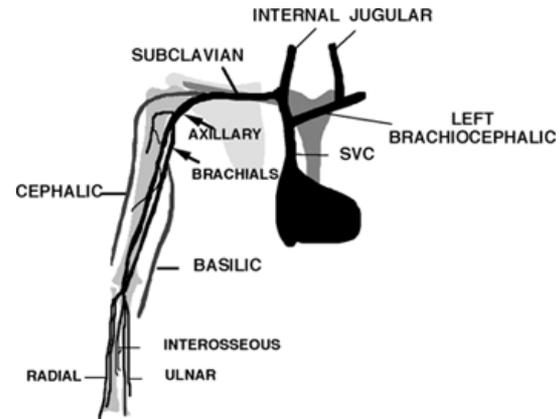
- Elevated for 7 days

DVT DIAGNOSIS ALGORITHM



Upper Extremity DVT

- Massive PE extremely rare
- **Lower incidence**
 - Fewer venous valves
 - Higher flow rate
 - Less frequent immobility
 - Decreased hydrostatic pressure
 - Malignancy, catheter induced
- Clavicle prohibits adequate compression
 - ***Evaluate using color or spectral Doppler***



CONCLUSION

Diagnosing DVT by CUS:

- *Visualizing echogenic material*
 - *Non-compressible vein segment*

 - *In symptomatic patients: 2 CUS (CFV & PV)*
 - *In asymptomatic patients : 2CUS missed 20 % of DVT*
- CCUS should be done in asymptomatic patients with -ve 2CUS***

Repeat in one week if –ve in moderate and high risk patient

40 % of PE patients do not have DVT

Girad et al., Chest.2005;128(3):1593-600

Ultrasound Guided CVL INSERTION

History

Landmark-based methods

Failure rates 30%

complication rates 18.8%

Arch. Intern Med. Feb 1986;146(2):259-61

Femoral venous access during CPR

31% of catheters were not in the femoral vein.

JEmerg Med. 1984;1(5):387-91

ultrasonography for CV access was first described in 1978

Anesth Analg. Jan-Feb 1978;57(1):118.

Advantages of U/S guided CVL insertion

- Increased cannulation success rate
- Increased 1st attempt success
- Decreased complication rate
- Detection of anatomical variation
- Detection of thrombosis
- Optimal vessel selection
- Confirmation of catheter site
- Rule out complications

Contraindications

Absolute:

- Infection
- Thrombosis

Relative:

- Severe coagulopathy & bleeding disorder (femoral access is preferred)
- Inability of patient to tolerate supine positioning
- Lack of patient cooperation
- Morbid obesity of patient
- Contralateral pneumothorax or hemothorax
- Inability of patient to tolerate ipsilateral pneumothorax
- Current or prior vessel injury
- High-pressure ventilator settings
- IJV access is prohibited by the placement of a cervical spine collar
- Presence of Greenfield or IVC filter in FV cannulation (Potential exists to snag the filter with the central line guidewire.)

A meta-analysis demonstrated that the relative risk of complications decreased by 57% when ultrasonography was used.

Sites

- IJ
- Subclavian
- Femoral
- PICC

3 steps approach

Step1 pre-procedural scan



Evaluate vascular patency & select optimal vessel



Step 2 procedure



Real time U/S guided puncture & placement of guide wire and its identification in the lumen



Step3 post-procedural scan



Rule out complications and follow up

Pre-procedural scan

Vessel patency

(inspiratory collapse or compressibility)

Easy accessibility

(distance measurement between skin and the vessel)

Diameter

(should be more than 3 times the caliber of catheter)

Anatomical variation

- *Intended purpose (avoid neck line in neck surgery)*
 - *Intended duration*

Pre-procedural preparation



- **Probe selection:**

Linear, high frequency

Curved, low frequency in deep veins

(obese, subcutaneous edema, anatomical anomalies)

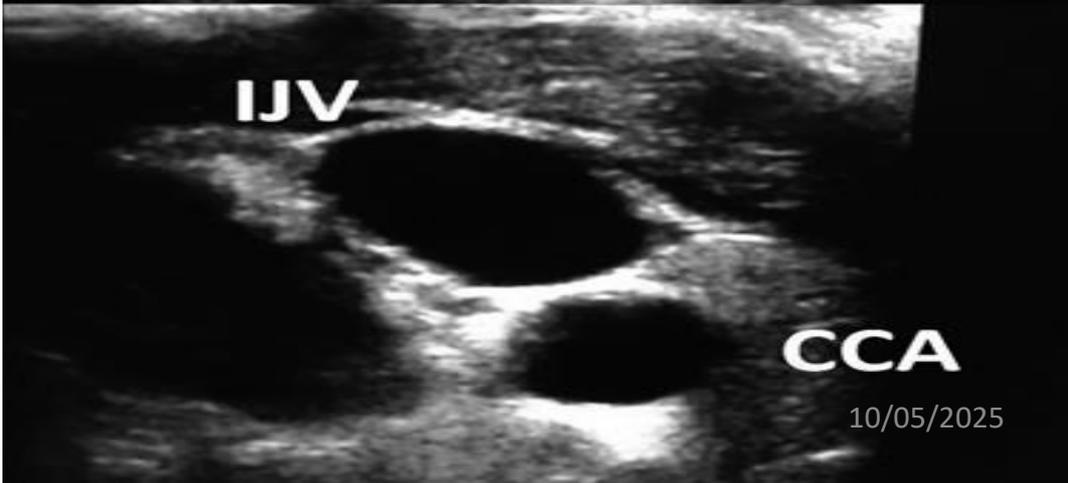
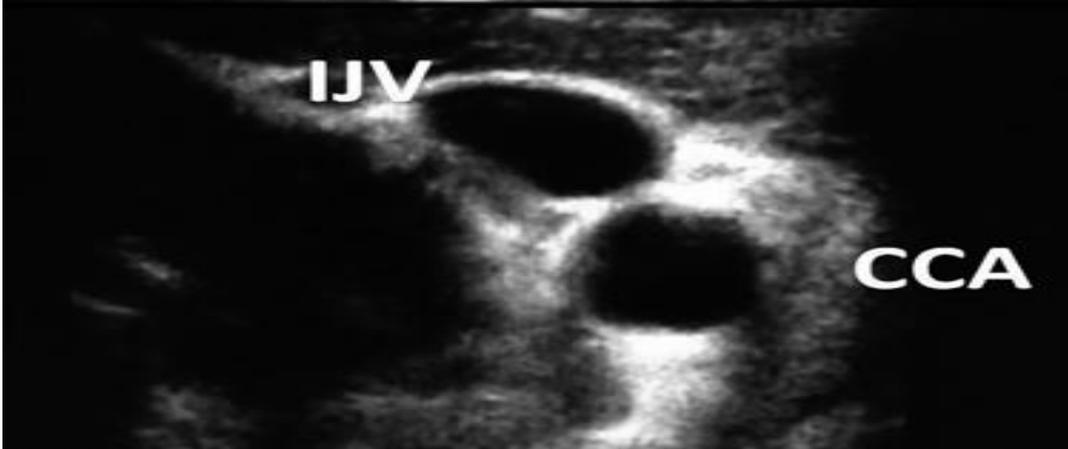
- **Sterile technique (CRBSI bundle)**
- **U/S machine opposite to the operator**
- **Time out checklist (safety)**
- **ECG monitoring**

Pre-procedural scan

vein	artery
elliptical	circular
Usually Larger, change with position	Usually smaller than the adjacent vein
Easily compressible	Non compressible
Color flow fill completely (color mode)	Pulsatile
Demonstrate phasicity & augmentation in Doppler mode	negative

Tips for 1st time U/S guided CVL insertion

- **Strict sterilization**
- **Avoid pressing too hard**



Tips for 1st time

U/S guided CVL insertion

- Optimize two dimensional image (center the image, adjust depth, gain,& focus while obtaining proper orientation of the anatomy with *standardization of the dot on the left*)
- Exclude thrombosis by applying probe pressure

Axis

The short-axis:

- concomitant visualization and avoidance of the adjacent arteries,
- when space is limited (eg, IJV).

The long-axis:

- better visualization of the advancing needle,
- threading of the guidewire,
 - avoidance of inadvertent puncture of the posterior vessel wall.



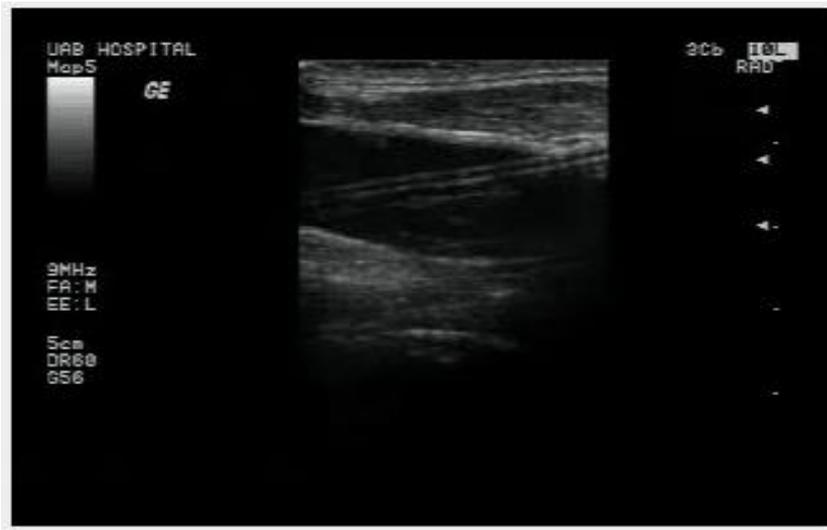
IJ

Dynamic - Real time



Static





IJ

Wire-in-needle (WIN)

Stone MB, Mallin M, Cook J. Another WIN for point-of-care ultrasound: the wire-in-needle modified Seldinger technique for ultrasound-guided central venous access. *Acad Emerg Med.* Jun 2013;20(6):E14-5.

Subclavian

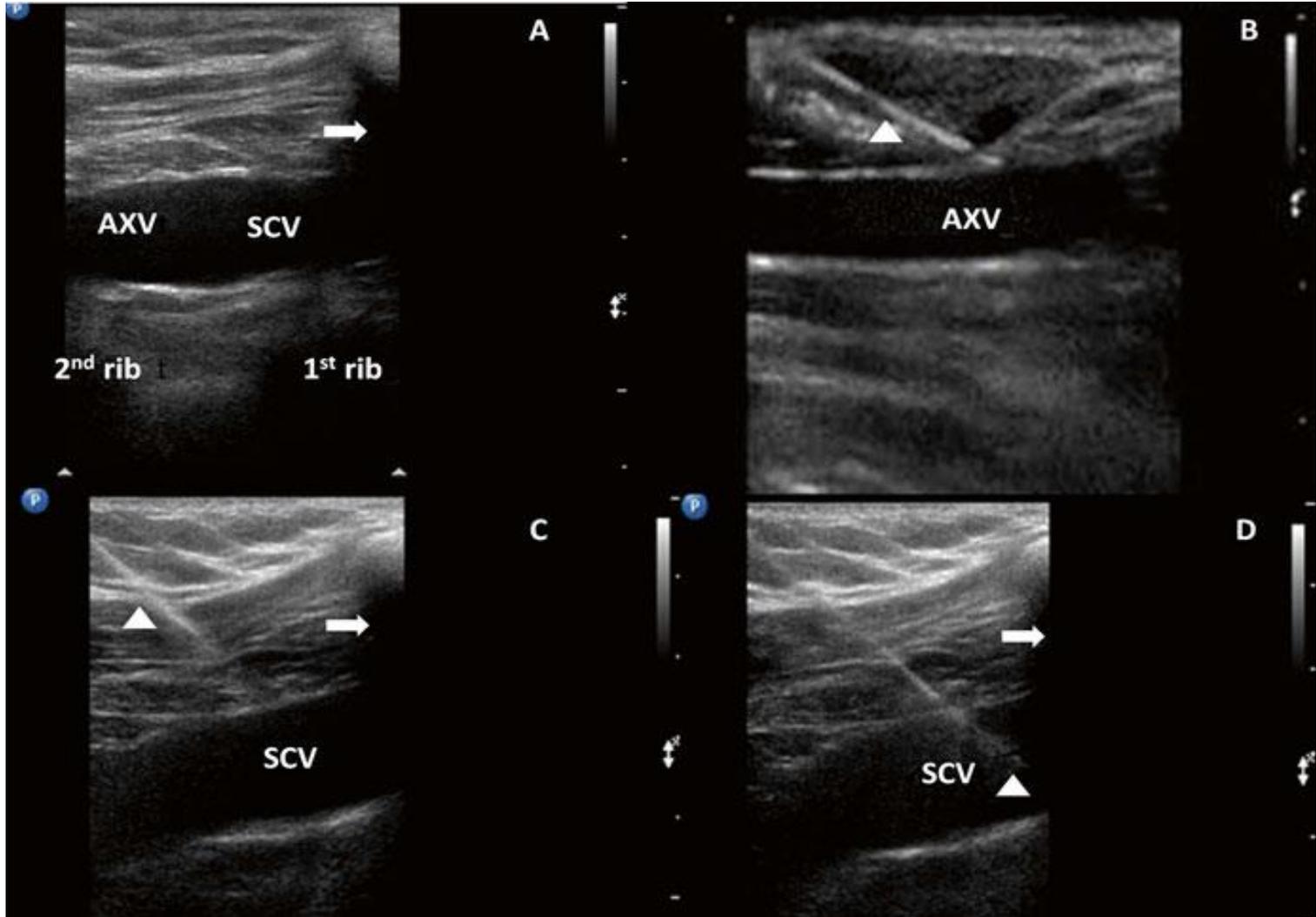
Supraclavicular

Infraclavicular

Vein is ant. To the artery

**Pulsed-wave doppler demonstrates
the characteristic pulsation of the artery
and the respiratory hum of the vein**

SCV



Femoral

- Abduct the hip with external rotation
- Reverse Trendelenburg

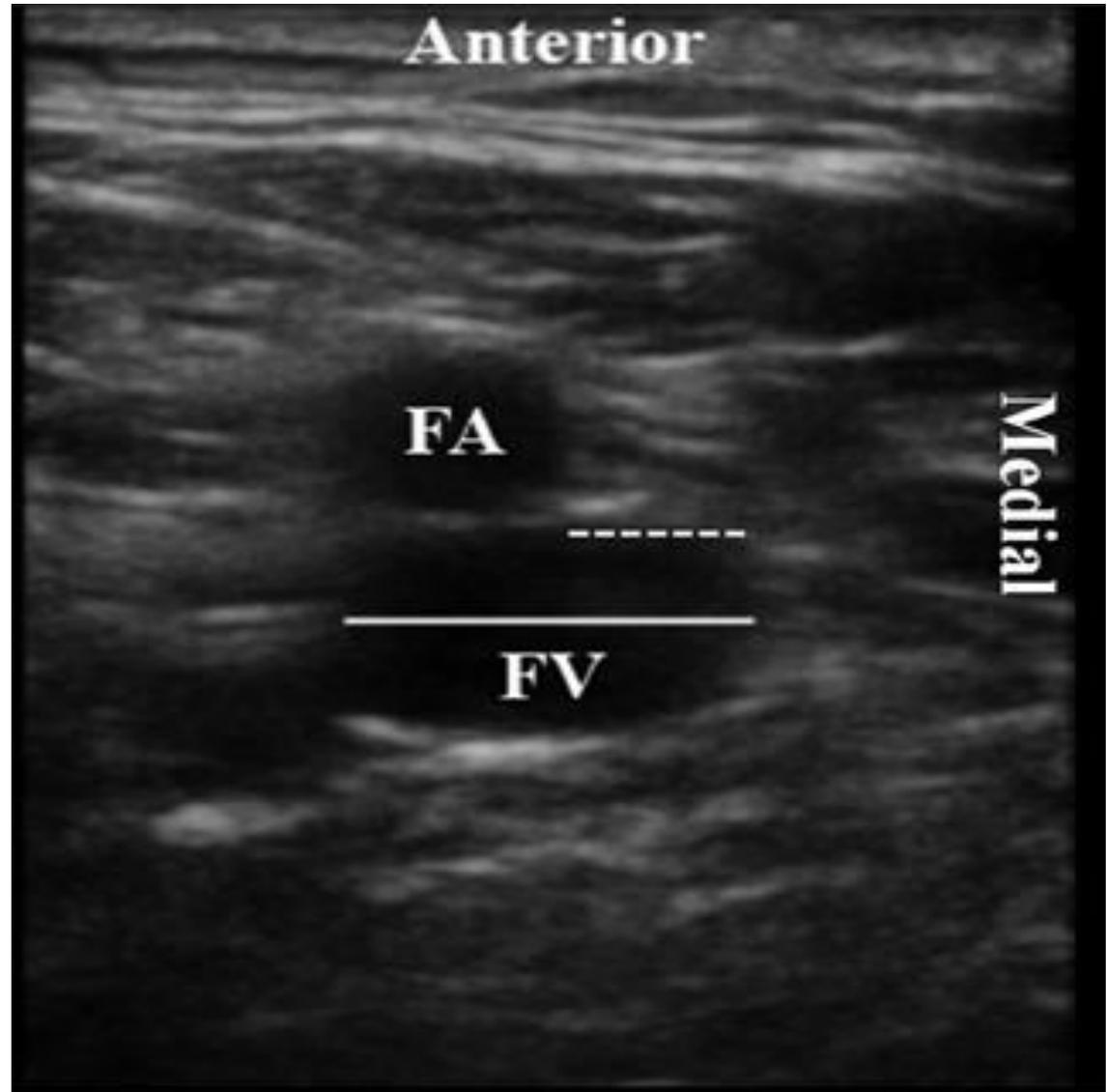


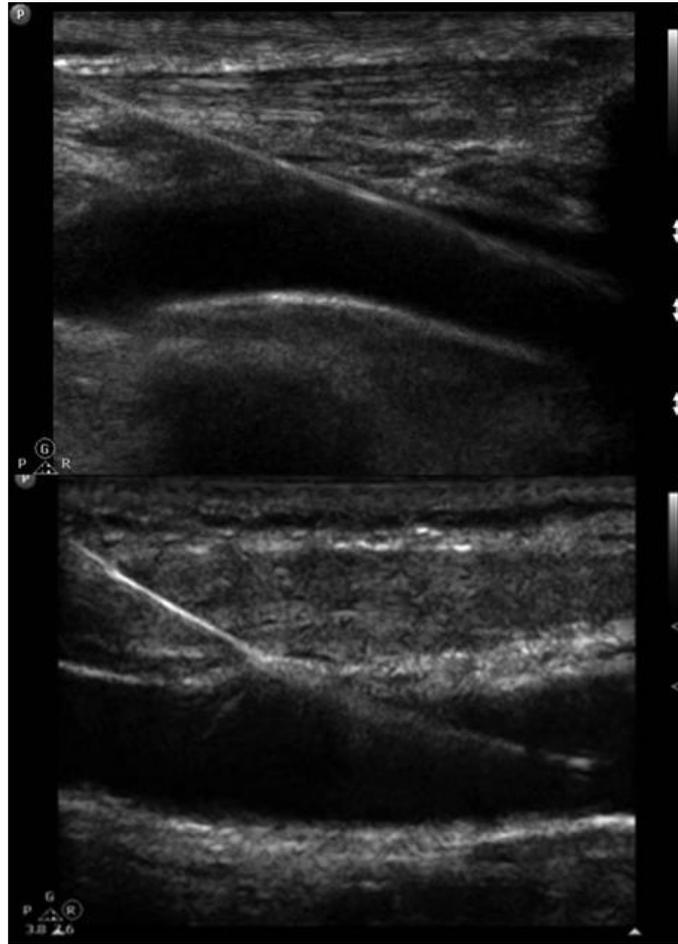
Table 1. Depth, diameter, and vein exposed at each distance for 180 vessel pairs

	Distance from inguinal ligament			<i>p</i> value
	0 cm	2 cm	4 cm	
Depth (cm)				
Femoral artery	1.7 (0.6)	1.7 (0.7)	1.9 (0.8)	0.478
Femoral vein	2.0 (0.7)	2.1 (0.8)	2.5 (0.8)	0.049*
Diameter (cm)				
Femoral artery	0.9 (0.2)	0.8 (0.2)	0.8 (0.2)	0.449
Femoral vein	1.1 (0.3)	1.1 (0.3)	1.0 (0.3)	0.467
Femoral vein exposed (cm)	0.9 (0.4)	0.7 (0.3)	0.5 (0.4)	0.001*
Femoral vein exposed (%)	83 (21)	65 (25)	56 (30)	0.001*

Values are reported as mean (SD).

*Statistical significance, $p < 0.05$.

Guide wire identification before dilatation



Special challenges in ICU

- **Previous attempts**
- **Prohibitive tubing or dressing at site of insertion**
- **Subcutaneous air and or edema**

Training: Simulation-based ultrasound helps inexperienced operators achieve greater successful central line placement rates with an improved safety profile.

Sekiguchi H, et al., : results of a successful internal medicine house staff training program.

Chest. Sep 2011;140(3):652-8.

Evidence based use and safety

American society of cardiovascular anesthesiologists recommendations 2012

- **IJ**
Trained clinicians should use **real-time U/S whenever possible to improve cannulation success and to reduce the incidence of complications**
(category A, level1)
- **Subclavian**
High risk patients may benefit from U/S screening before cannulation (category A, level3)
- **Femoral**
U/S should be used to identify vessel overlap and patency (category C,level2)

Precautions

post procedural scanning

**Rule out immediate complications
(Pneumothorax, hematoma, malposition)**

Lack of experience

Posterior wall puncture

Documentation

A. Written Elements

1. Procedural consent
2. Indications for the procedure;
3. Safeguards taken for major procedures (time out, correct side);
4. Methods and measures taken to ensure sterility;
5. Procedural sedation, if used, including the agent, amount,
6. Local anesthetic agent, concentration, and amount infiltrated;
7. Anatomic site, target vessel patency, and approach to the target vessel;
8. Use of ultrasound, in plane or out of plane, and visualization of needle entry;
9. Type, gauge, and length of the catheter used;
10. Number of passes/attempts and any complications;
11. Confirmation of successful placement;
12. Postprocedural annotation of patient tolerance of the procedure and appearance of the site.

B. Image Retention

1. Preprocedure venous compressibility and patency and surrounding structures;
2. Entrance of the needle tip into the vessel lumen;
3. Postprocedure flush to ensure intraluminal placement

Conclusion

**U/S guided CVL insertion is one
of top 11 evidence based practices**

***Its implementation in routine practice increases
the safety of the procedure and the satisfaction
of the patient***



Improving the standard of care.

DISCUSSION ?!