

## **Instructor's Digital Curriculum Resource-**

### **For Techniques in Noninvasive Vascular Diagnosis-4th edition.**

by Robert J. Daigle, BA, RVT, RVS, FSVU, FSDMS

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## **Chapter 7. Venous Imaging for Insufficiency**

### **Techniques In Noninvasive Vascular Diagnosis-4th edition**

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### **Definitions for this chapter**

- **Valsalva maneuver**
  - moderately forceful attempted exhalation against a closed airway, usually done by closing one's mouth and "bearing down" with stomach muscles
- **Reflux**
  - abnormal, reversed flow direction
- **In situ**
  - Latin for "left in place" or in position

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### **Definitions for this chapter**

- **Fascia**
  - A thin sheath of fibrous tissue enclosing a muscle or other organ.
- **Tumescence in venous ablation**
  - Injecting saline and lidocaine to cause local swelling around the vein to be "cooked". Acts as a heat absorber and prevents burns to the underside of skin.

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## **Venous Insufficiency Venous Incompetence**

- **Primary**
  - Congenital absence or malfunction of valves
- **Secondary**
  - Post phlebotic- damage to valves secondary to thrombosis and/or venous outflow obstruction

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## **Symptoms of Venous Insufficiency**

- **Recurrent calf, ankle, or foot swelling.**
- **Varicosities.**
- **Venous claudication.**
- **Stasis dermatitis.**
- **Ulceration.**
- **Chronic limb swelling.**

*Note that these symptoms are distinctly different from those of acute venous thrombosis.*

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## Venous Insufficiency Symptoms



## CEAP

- Clinical-Etiology-Anatomy-Pathophysiology (CEAP)
- Created by an international ad hoc committee of the American Venous Forum in 1994
- Classification system of lower extremity chronic venous disorders
- Scale is C0 – C6

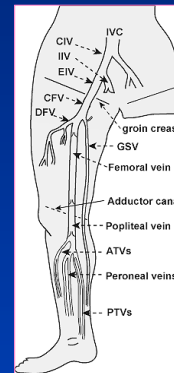
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## CEAP

- C0- no sign of venous disease when looking at the leg
- C1 - spider or reticular veins on the leg
- C2 - presence of varicose veins
- C3 - Varicose veins and leg swelling (ankle)
- C4 - Pigmentation or eczema at lower leg and ankle, lipodermatosclerosis (hardening of the soft tissues)
- C5 - healed venous stasis ulceration
- C6 - Active and open venous stasis ulcer

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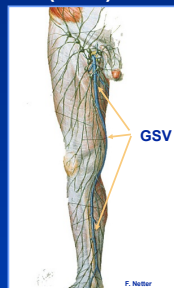
## Anatomy Review



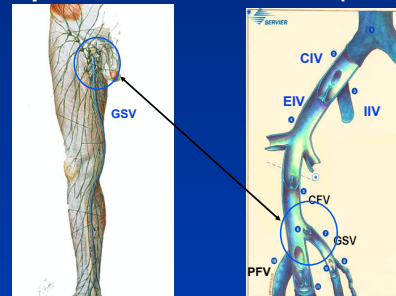
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## Anatomy Review Great Saphenous Vein (GSV)

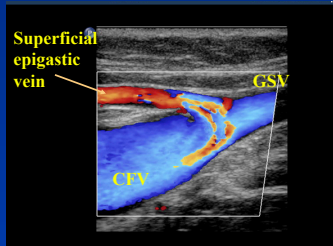
- Joins deep system at CFV
- Carries approx. 15% of venous blood volume in leg.
- Often anomalous, with double systems (8%), or non-continuous (25%)
- No adjacent artery



## Saphenofemoral Junction (SFJ)

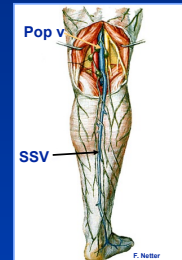


## Superficial Epigastric Vein

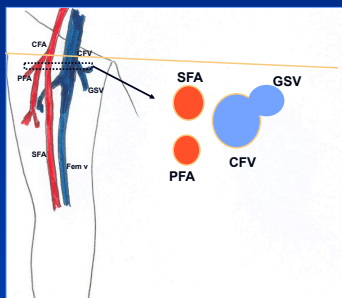


## Small Saphenous Vein (SSV)

- Posterior aspect of calf
- Typical confluence is at popliteal vein
- In 20-30 % of population, SSV will enter above the popliteal vein or join the peroneal vein
- No adjacent artery



## Crayon Venous Anatomy



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## Venous Valve Distribution

- IVC - 0
- CIV - 0
- EIV - 0 in most
- FV - 4
- Pop - 2
- PTV - 10
- Per - 10
- ATV - 10



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## Imaging Technique

- Torso elevated 10-20 degrees in semi Fowler's position
- Leg rotated externally
- Start at groin crease in transverse plane



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## Recommended Venous Protocols

Protocols based on "logic" and symptoms

1. Acute deep venous thrombosis protocol
2. Venous insufficiency protocol
  - Step #1: Rule out chronic DVT
  - Step #2: Reflux test of deep veins
  - Step #3: Identify reflux in GSV, SSV
  - Step #4: Identify incompetent perforators
3. Pre-ablation protocol (includes #2)
4. Vein mapping for arterial bypass

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## Protocol #2 - Insufficiency

### Protocol for Venous Insufficiency

- **Chronic outflow obstruction can cause venous insufficiency.**
- **Ablating or removing GSV if it's functioning as a major collateral is a no no!**

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## Protocol #2- Venous Insufficiency

### Step #1

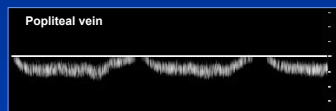
#### Rule out chronic DVT in proximal veins, **Quickly**

- Compress CFV, prox FV, & Pop. veins only
- Record spontaneous flow with respiratory variation at popliteal vein
- Don't scan calf veins for deep vein insufficiency.

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### No chronic outflow obstruction if:

- CFV and Popliteal veins are compressible
- If respiratory phasic flow is present at popliteal v.



The above findings also rule out acute DVT.

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## Protocol #2- Venous Insufficiency

### Step # 2

#### Protocol for Reflux Testing

- **Deep veins- test 2 sites only**
  - CFV
  - Proximal femoral vein
  - Popliteal vein
- **Initial exam with patient in reverse Trendelenburg or semi-Fowler's position.**

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## Venous insufficiency

### Evaluate Valve Competency

- Spectral Doppler – quantitative
- Color Doppler- qualitative
- Valsalva
- Proximal limb compression
- Following distal limb compression

Patient in reverse Trendelenburg position

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### Normal proximal CFV valve with Modified Valsalva (hand placed on abdomen, pt. pushes up against hand)



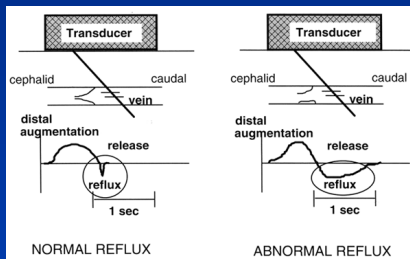
When in PowerPoint Show, click on link below for video demo on youtube.

<http://youtu.be/cUFno1hBpE>

Movie- CFV valsalva.mov

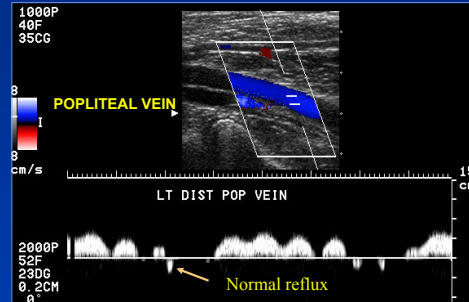
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## Normal versus Abnormal Reflux



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Some venous reflux is common, it takes a moment for valves to close.

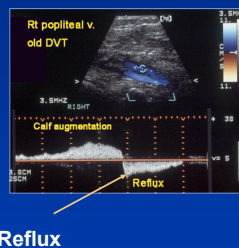


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## Protocol #2- Insufficiency - Step #2

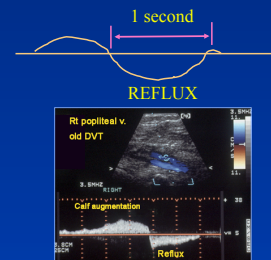
### Deep System: Popliteal v.

- Patient in semi-Fowler's position, or reverse trendel.
- Transducer on Pop V. Squeeze calf to augment, then watch for reflux following augmentation.
- Record & measure duration



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## Reflux Duration Criteria

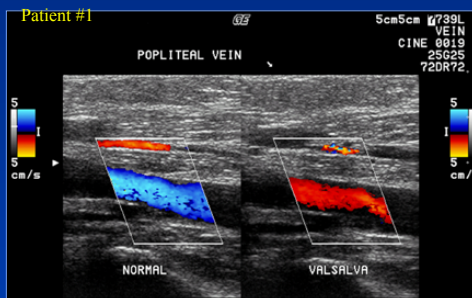


- abnormal  $\geq 1.0$  seconds for deep veins

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## Venous insufficiency

Often, Valsalva will cause reflux in the entire deep system.



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If popliteal vein valves are competent, patient will not have deep vein insufficiency.

Competent popliteal vein valves are the critical components of the veno-motor pump.

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# Protocol #2- Insufficiency -

## Step # 2

### Deep System: CFV

- Evaluate CFV, & proximal Fem V: Use modified Valsalva.
- Place your hand on patient's abdomen, have patient hold breath and press upward with "stomach" against your hand.

The image displays a Doppler ultrasound waveform. The top section shows a B-mode image of a vessel. Below it, two waveforms are shown: 'CFV VALSALVA' and 'REFLUX'. A yellow arrow points from the word 'Reflux' to the 'REFLUX' waveform. The 'REFLUX' waveform shows a significant reverse flow during the Valsalva maneuver. Technical details at the bottom include: 08:20:14, 6cm, RBLN, PULSED, 7.0, 60Hz, TSBID, 8, 91.0, 6, RDZB21.

Reflux

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| LOCATION          | TIME           |
|-------------------|----------------|
| Deep Veins        | ≥ 1.0 seconds  |
| GSV, SSV          | ≥ 0.5 seconds  |
| Perforating Veins | ≥ 0.35 seconds |

Longer durations are observed in supine patients.

Above values apply for a patient in a standing position.

# Abnormal Reflux Times

| LOCATION   | TIME           |
|--|----------------|
| Deep Veins   | ≥ 1.0 seconds  |
| GSV, SSV   | ≥ 0.5 seconds  |
| Perforating Veins  | ≥ 0.35 seconds |
| Longer durations are observed in supine patients.        |                |
| Above values apply for a patient in a standing position. |                |

Labropoulos N, Tsoungas J, Pryor L, et al. Definition of Venous Reflux in Lower Extremity Veins. *J Vasc Surg.* 2003; 38: 793-798.

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# Proximal Femoral Vein for Reflux

The image is a Doppler ultrasound scan of the proximal femoral vein. At the top, it is labeled 'SWEDISH MEDICAL CENTER'. The main part of the image shows a B-mode ultrasound of the vein with a blue color overlay indicating flow. Below this, a spectral Doppler waveform is displayed, showing a large, sustained flow during the Valsalva maneuver, which is labeled 'VALSALVA'. The waveform is characterized by a large, sustained flow during the Valsalva maneuver, indicating reflux. The y-axis is labeled 'cm/s' with a scale from -15 to 15. The word 'Reflux' is written in yellow at the bottom. A color scale on the left indicates flow direction: blue for S (superior) and red for I (inferior).

The figure consists of three vertical panels, each showing a cross-section of a leg with a superficial vein (top) and a deep vein (bottom) connected by a perforating vein. Arrows indicate the direction of blood flow.

- Normal veins:** In the superficial vein, flow is upward (indicated by a long upward arrow). In the deep vein, flow is also upward (indicated by a long upward arrow). The perforating vein shows flow from the superficial to the deep vein (indicated by a downward arrow).
- Superficial v incompetence:** In the superficial vein, flow is downward (indicated by a long downward arrow). In the deep vein, flow is upward (indicated by a long upward arrow). The perforating vein shows flow from the superficial to the deep vein (indicated by a downward arrow).
- Deep v incompetence:** In the superficial vein, flow is upward (indicated by a long upward arrow). In the deep vein, flow is downward (indicated by a long downward arrow). The perforating vein shows flow from the superficial to the deep vein (indicated by a downward arrow).

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**Most patients with severe symptoms of insufficiency (venous ulcers), however, have multiple system incompetence.**

D= deep veins  
S= superficial  
P= perforating

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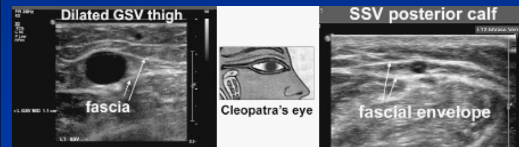
**Protocol #2 -  
Step #3**

**Determine if the superficial system is incompetent**

- Evaluate the entire Great Saphenous Vein (GSV) for reflux
- Evaluate Small Saphenous Vein (SSV) only if it's large and dilated.
- Evaluate perforating veins (if distended).

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**Saphenous veins are contained within fascial envelopes**

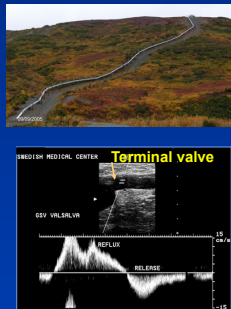


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**Protocol #2- Insufficiency -  
Step # 3**

**Great Saphenous Vein**

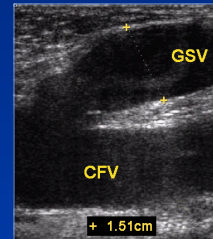
- Evaluate GSV for reflux
- "Assisted" valsalva to evaluate GSV terminal valve
- Also "massage" the vein from distal to proximal, look for reflux, post augmentation



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**GSV diameter consistent with reflux**

- SFJ > 9.0 mm
- mid thigh > 7.0 mm
- mid calf > 5.0 mm

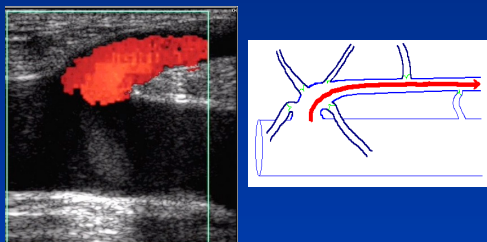


Engelhorn, Salles-Cunha S, et al., Relationship between reflux and greater saphenous vein diameter. J Vasc Technol, 21 (3):167-172, 1997

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**Protocol #2- Insufficiency -  
Step # 3**

**Incompetent Terminal Valve - GSV**



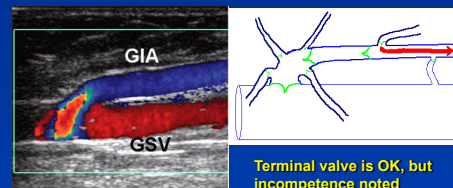
Oliver Pichot

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**Protocol #2- Insufficiency -  
Step # 3**

**If GSV Terminal Valve is Competent..**

- Identify the highest level of reflux, i.e. proximal, mid or distal GSV



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**Protocol #2- Insufficiency -  
Step # 3**

## Patient Position: Standing or Not?

- No need if popliteal is positive in semi-Fowler's position.
- Maybe, if Pt. is truly symptomatic and no reflux found when reclined.
- Theoretically, standing is the best reflux test position, but practically, it's difficult.

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**Protocol #2- Insufficiency -  
Step # 3**

## Patient Standing.

- Test popliteal vein for reflux
- Test CFV (manual valsalva) for reflux

Optional, high-tech  
method- rapid  
cuff inflator/  
deflator



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**Protocol #2- Insufficiency -  
Step # 3**

## Abnormal Reflux Time

- With patient standing
  - Deep vein veins  $\geq 1.0$  seconds
  - GSV, SSV  $\geq 0.5$  seconds
  - Perforator veins  $\geq 0.35$  seconds
  - Longer durations observed in supine patients



Labropoulos N, Tiongson J, Pryor L, et al. Definition of Venous Reflux in Lower Extremity Veins. J Vasc Surg. 2003; 38: 793-798.

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**Protocol #2- Insufficiency -  
Step # 3**

- Assess small saphenous vein, identify in transverse plane.



Transverse view of normal small saphenous vein.

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**Protocol #2- Insufficiency -  
Step # 3**

- Assess small saphenous vein:
  - if it's large
  - If there are associated varicosities
  - Look for reflux following calf augmentation.

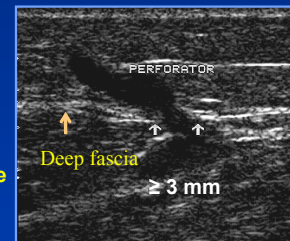


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**Protocol #2- Insufficiency -  
Step # 4**

## Identify Incompetent Perforating Veins

- Perforating veins course from superficial to deep veins
- If incompetent, local venous reflux can cause varicose veins and ulceration



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## Protocol #2- Insufficiency - Step # 4

### Perforating Vein Anatomy



It's difficult to see normal perforators, but easy to identify incompetent ones.

**90% of incompetent PVs are  $\geq 3.5$  mm**

Most visualized perforating veins are here.

## Protocol #2- Insufficiency - Step # 4

### Perforator Evaluation

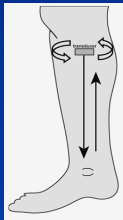
- Patient sitting, leg dependent
- or patient standing



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## Protocol #2- Insufficiency - Step # 4

### Perforator Evaluation



Transverse scan, medial approach, scan straight down to ankle.

Scan for defects in deep fascia.

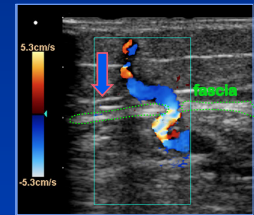
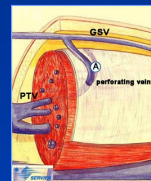
Move transducer one-probe width and repeat scan.

Proceed until entire calf circumference is scanned.

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## Protocol #2- Insufficiency - Step 4

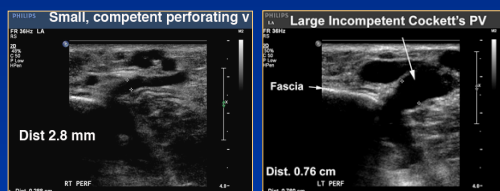
- Color Doppler can be used to good effect initially, on a suspect incompetent PV.
- If color is abnormal, then use Spectral Doppler and measure time.



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## Protocol #2- Insufficiency - Step # 4

### Cockett's Perforating Veins



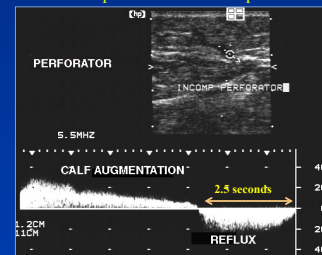
Also, measure the PV diameter on those suspected of being incompetent.

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## Protocol #2- Insufficiency - Step # 4

### Incompetent Perforator

Determining flow direction is sometimes tricky, but it's not important in this example: WHY?



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Don't identify, label, record, play with, marvel at, swoon over, normal perforating veins



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### Protocol #3-

## Protocol #3 Pre-op assessment for vein ablation procedures.

- This protocol includes determination of incompetent venous segments, (Protocol #2,) but with added information and procedures.
- You should determine what the ordering physician requires prior to exam.

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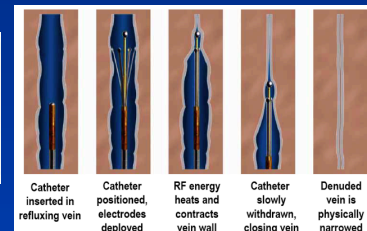
## Vein Ablation (Closure) Procedures

- Obliterates the great saphenous vein, or small saphenous vein.
- Current, 3 methods:
  - Laser (EVLT)
  - Radiofrequency- (VNUS)
  - Sclerosing foam injection

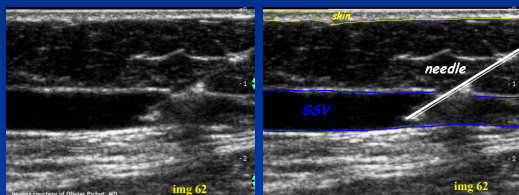
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### Protocol #3- Pre-op for vein ablation

## Radiofrequency Method

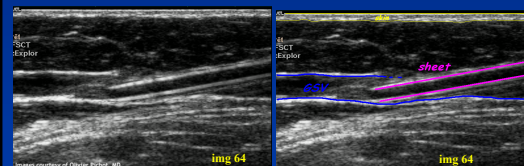


Needle is inserted into GSV usually in the distal thigh or proximal calf.



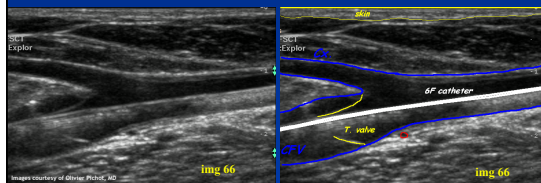
Images courtesy of Olivier Pichot, MD

## Ultrasound-Guided Catheterization Sheath



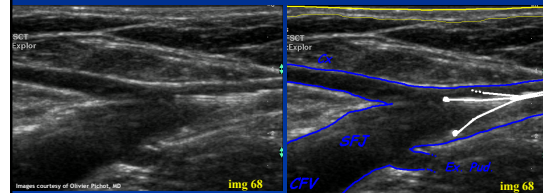
Ultrasound images are courtesy of Olivier Pichot, MD  
CHU de Grenoble, France.

## Ultrasound-Guided Catheter Positioning Catheter pre-positioning into the CFV



Ultrasound images are courtesy of Olivier Pichot, MD  
CHU de Grenoble, France.

## Catheter positioned below the SFJ tributaries



Ultrasound images are courtesy of Olivier Pichot, MD  
CHU de Grenoble, France.

## Small Saphenous Vein with catheter- transverse view

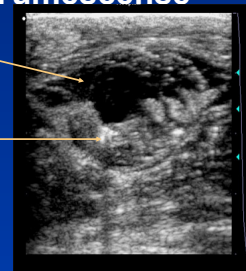


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## SSV Tumescence

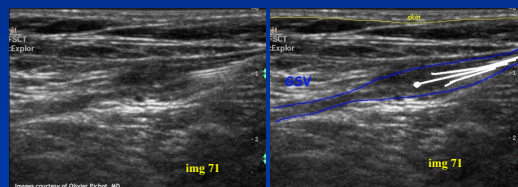
Lidocaine/saline fluid

Catheter in  
compressed vein



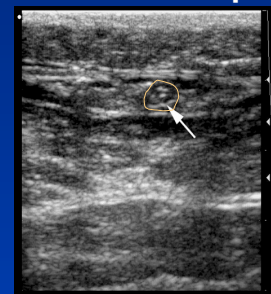
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## The electrodes are activated and slowly withdrawn along the vein.



Ultrasound images are courtesy of Olivier Pichot, MD  
CHU de Grenoble, France.

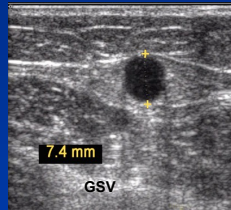
## Thrombosed SSV post-RF



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### Protocol #3- Pre-op for vein ablation

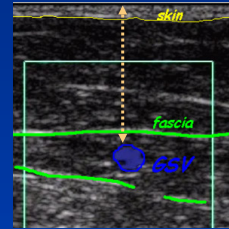
- Measure diameter of GSV at origin, mid lower and thigh
- Radio frequency venous closure limited to veins 2- 14 mm in diameter.



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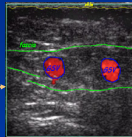
### Protocol #3 - Pre-op for vein ablation

- Note if GSV is excessively deep, or superficial.
- A superficial (< 1 cm) vein may require additional tumescence.



### Protocol #3- Pre-op for vein ablation

- Mark course of GSV on skin in thigh
  - a road map for tumescence
- Mark accessory GSVs
- If warranted, mark course of SSV (LSV)



### Protocol #3- Pre-op for vein ablation

- Identify the source vessel of large varicosities



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## Vein Mapping Prep.

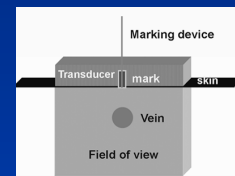
- Mark the mid-point of the transducer. Apply a strip of clear tape on the side of the transducer.
- Mark the middle of the transducer



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## Vein Mapping

- Identify the proximal GSV
- Position the vein in the center of the ultrasound field of view
- Create an indentation on the skin over the vein at the mark on the transducer.



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## Vein Mapping

- Move the probe a few cm, then repeat over the vein.
- Continue until the course of the vein is marked with indentations.
- Wipe off gel, connect dots with an indelible marker.



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## So far...

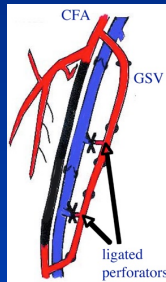
- Protocol #1- for Acute DVT
- Protocol #2- Insufficiency
  - Step #1: Chronic outflow obstruction?
  - Step #2: Incompetent deep veins?
  - Step #3: Incomp. superficial veins?
  - Step #4: Incompetent perforators?
- Protocol #3 -Preop evaluation for vein ablation

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## Protocol #4- Pre-op for arterial bypass

### Protocol #4

- Pre-operative assessment to determine suitability of GSV for arterial bypass conduit.
- Rule out chronic DVT.
- Is the vein
  - Continuous?
  - Of adequate size?
  - Sclerosed or post-thrombotic



## Protocol #4- Pre-op for arterial bypass

### Protocol #4

- An "in situ" vein bypass, the GSV remains in place (in-situ).
- Valves are excised with a valvulotome.
- Perforating veins and tributaries are ligated and cut.
- The proximal GSV is cut and sewn into the CFA, the vein is sewn in distally to bypass the occluded arterial segment.

