Venous Disorders, Lymphatic Disorders and Compartment Syndrome
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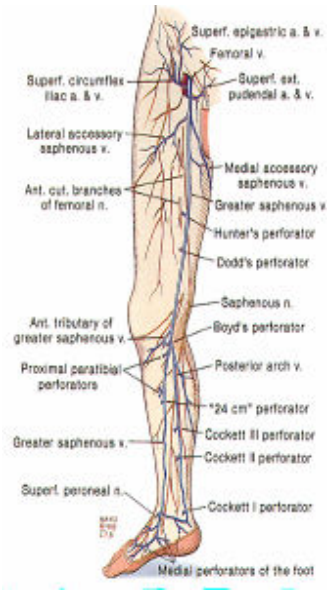
Anatomy:

- The lower limb has two venous systems:
  1. Superficial system:
     - *Great saphenous vein:* starts anterior to the medial malleolus ascending upward on the medial aspect of the leg and thigh to empty in the saphenofemoral junction. The posterior arch vein is a major tributary, which has most of the important perforators (mentioned below) in the leg.
     - *Short saphenous vein*: starts behind the lateral malleolus, ascending upward over the back of the calf, perforates the deep fascia over the popliteal fossa and terminates in the popliteal vein (forming the saphenopopliteal junction) which passes on to become the femoral vein.
  2. Deep system:
     - These are pairs of posterior tibial, anterior tibial veins and peroneal veins.
     - All three join together to form the popliteal vein behind the knee and ascend to form the superficial femoral vein. The superficial femoral vein with the profunda vein (deep femoral) forms the common femoral vein.
- The *perforating veins* join the superficial veins to the deep veins, most important ones are:
  - Hunter's perforator in the mid thigh.
  - Dodd's perforators in the lower thigh.
  - Boyd's perforators in the upper calf.
  - Cockett's perforators in the middle and lower calf (join the posterior tibial vein).

NOTE:

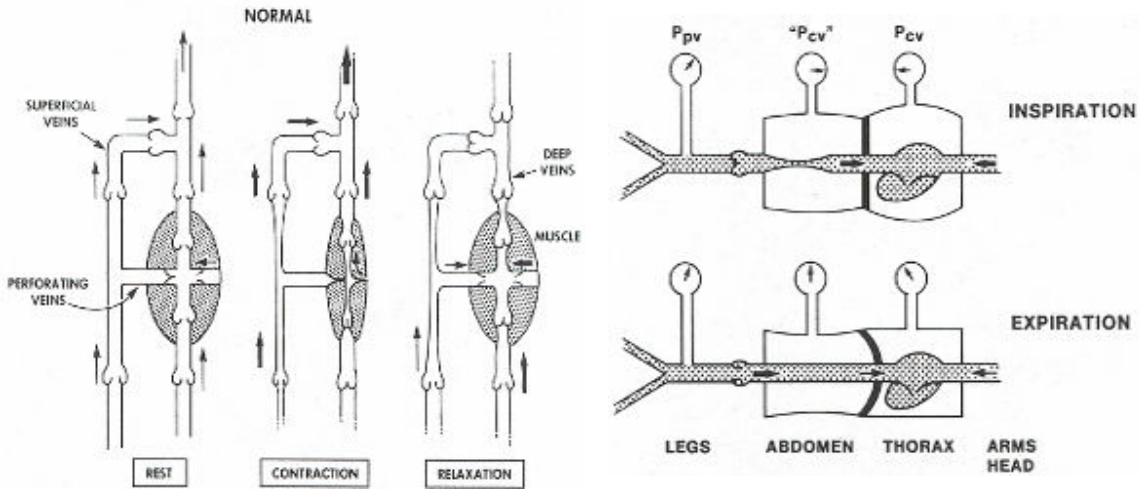
- *The saphenopoliteal junction is variable in position (usually in the popliteal fossa), unlike the saphenofemoral junction which is constant in location.*



Physiology:

- Two mechanisms maintain pressure in the venous system:
  1. *Bi-leaflet valves*:
     - Govern blood flow in a *unidirectional* way from distal to proximal which close when you stand up without walking.
     - These valves increase in number as we go distally.
  2. *Calf muscle pump*:
     - Formed of the gastrocnemius, soleus and deep compartment muscles.
     - It is responsible for pumping venous blood back into the heart from the periphery, and is often called the "peripheral heart" or the "sural (tricipital) pump".
     - At rest, the muscles are relaxed and the valves are open.
     - During contraction the valves above the muscle will open, while those below will close to prevent escape of blood distally.
- Movement of venous blood:
  a. During inspiration:
     - Increase in intrathoracic pressure closes the IVC valve preventing venous return from the lower limbs.

  b. During expiration:
     - Reduction in intrathoracic pressure provides a sucking mechanism of blood.



NOTE:

- *While standing up with arms raised up, the hydrostatic pressure is -50, at the level of the heart it is 0, and at the level of the leg it approaches 100 due to the presence of gravity.*
- *Remember that the normal flow of venous blood is from distal to proximal and from superficial to deep.*

Ambulatory venous pressure (AVP):

- Definition of ambulation: walking.
- Definition of AVP: pressure during walking.
- It's an invasive procedure to monitor the venous system.
- Venous pressure when:
  a. Supine: less 10 mm Hg.
  b. Standing: approaches 90 mm Hg, due to the effect of gravity.
  c. Walking: 25 mm Hg, due to the action of the calf muscle pump, the maximum affect of walking is reached after seven steps.
- In sustained venous hypertension the pressure drop during walking doesn't happen.

Venous Diseases:

Deep vein thrombosis (DVT):

- The formation of a blood clot (thrombus) in the deep system; commonly in the legs (a thrombus in the superficial system is called "superficial thrombophlebitis").
- We usually use anticoagulants (putting the patient on heparin or anticoagulants if the thrombus started in the popliteal vein and more proximal).

Chronic venous insufficiency:

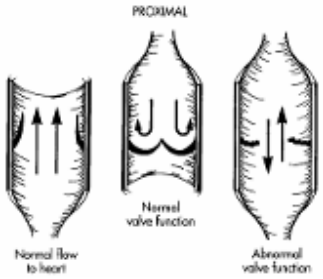
- Presentation most often occurs in:
  a. Skin.
  b. Subcutaneous tissue, presenting as:
     - Telangiectasias.
     - Varicose veins.
     - Reticular veins.

Thrombophlebitis:

- Inflammation of the vein most often associated with thrombus formation.

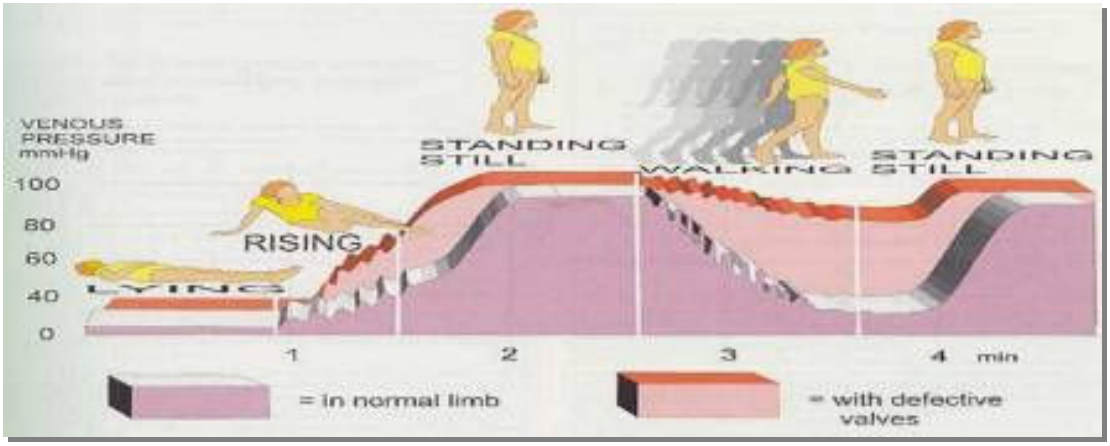
Chronic Venous Insufficiency

- The presence of *irreversible* skin damage in the lower leg as a result of sustained venous hypertension.



Pathophysiology:

- Two mechanisms, both leading to a bidirectional flow.
  1. Reflux (90%); incompetent valves.
  2. Obstruction (10%): causing destruction of valves.
- Changes in venous pressure:
  - As normal individuals, a patient with valvular incompetence will have a venous pressure of zero while lying down, when rising up the pressure starts to rise (0-10), reaching its maximum (90-100) when standing up still without walking due to the effect of gravity.
  - As opposed to normal individuals, a patient with valvular incompetence will have a pressure that drops to only around 75 mm Hg when walking, whereas the normal drop in pressure reaches 25 mm Hg.
  - When the patient stops walking the venous pressure will rise up again to reach the normal standing plateau.
  - Individuals with chronic venous insufficiency have a *short* refractory or refilling time (the time taken to reach standing pressure after walking) compared to normal individuals.



Evaluation:

- History:
  - Dragging dull aching pain, muscle spasm, lower limb swelling (edema), paresthesia, hotness in the leg.
- Physical examination:
  - Detection of hyperpigmentation, venous ulcer and other signs (mentioned below).
- Investigations.
  - Non invasive (Doppler/ Duplex).
  - Invasive (AVP/ venography).

Clinical presentation:

- Could present as:
  1. C_1: telangiectasia (spider veins).
  2. C_2: elongated tortuous bulging veins (opposite telangiectasias which don't bulge), mostly on the medial aspect of the leg (great saphenous vein distribution) because it's usually a consequence of great saphenous insufficiency.
  3. C_3: edema without skin changes.
  4. C4: lipodermatosclerosis (thickening of the skin usually in an area on the medial aspect of the leg above the medial malleolus known as the gator area) which might also be associated with hyperpigmentation and dermatitis.
  5. C_5: healed ulcer, usually on the medial aspect of the leg (same area as C_4).
  6. C_6: active venous ulcers: usually shallow with lots of secretion and exudates surrounded by hyperpigmentation. It occurs usually on the medial aspect of the leg, and the d*orsalis pedis pulse* is usually present (opposite the usually more distal arterial ulcers).

Detection of a facial defect:

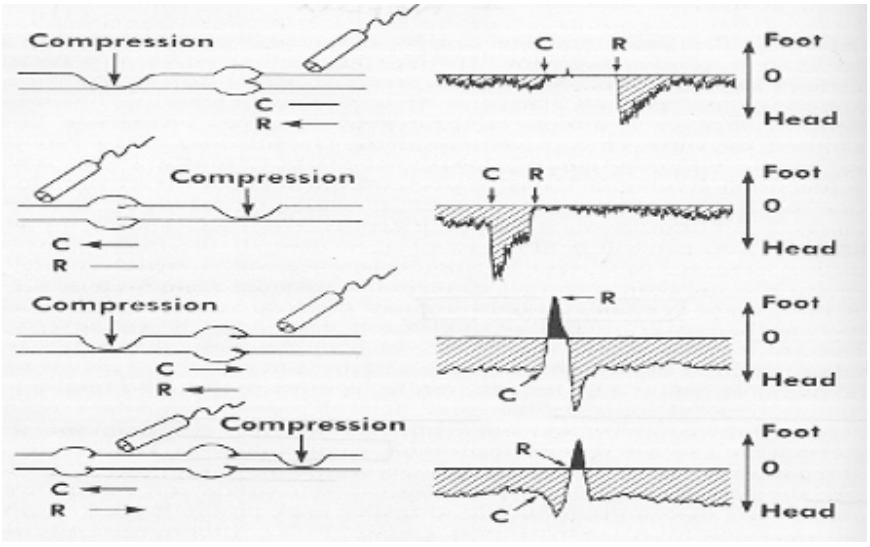
- Examine the patient lying down and standing up with good illumination.
- Examine the abdomen and pelvis to make sure there are no big masses compressing pelvic veins creating lower limb venous hypertension.
- On lying down, we check the medial aspect of the thigh looking for facial defects (this is the area where we find incompetent perforators).
- On standing up, we examine the medial aspect of both legs and comparing them, we examine the back of the leg and the knee.
- Percussion test:
  - Done if there is incompetence of the great saphenous vein or varicose veins.
  - Percuss the vein proximally and feel for a thrill distally, normally you won't feel it.
  - In case of incompetence, the wave will propagate down and can be felt.
  - Most physical examinations to detect the location of incompetent valves are neither *sensitive* nor *specific.*

Investigations:

A. Doppler:

- Hand held ultrasound reflected by moving RBC's to detect the flow of the venous system.
- Hear the movement of blood in the great saphenous vein by asking the patient to inspirate and expirate while the probe is on the saphenofemoral junction.
- Augmentation test:
  - Place the probe at the saphenofemoral junction (lays 2.5 cm lateral to the tubrosity) and squeeze; you are going to hear the sound of the blood flowing proximally, when you release the leg, normally there is no sound.
  - If a sound is heard, that indicates a *bidirectional* flow, a sign of incompetent valves.
  - Sensitivity reaches about 80% because it might reflect the tributaries.

B. CW-Doppler:



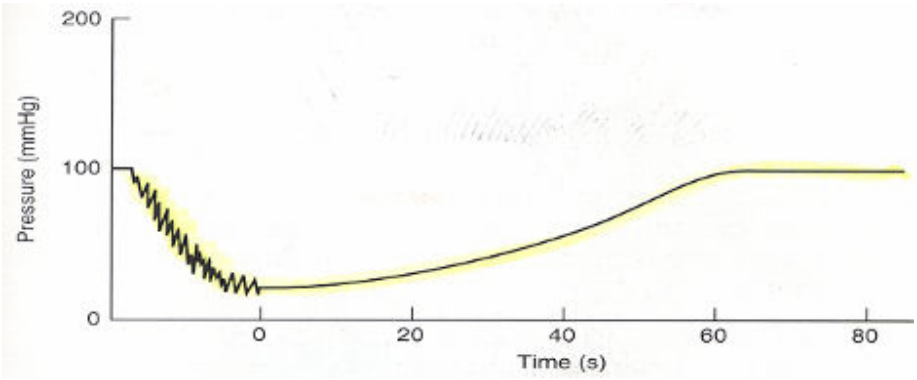
C. Duplex-scanning:

- Ultrasound B-mode with Doppler.
- Detect direction of flow.
- Ask the patient to do the Valsalva maneuver which will increase the intrathoracic and intraabdominal pressures pushing blood down to the leg.
- In this test, a graph of waves will be plotted, and any wave below the baseline means escape or reflux (waves should all be above or all below the baseline, not both above and below).

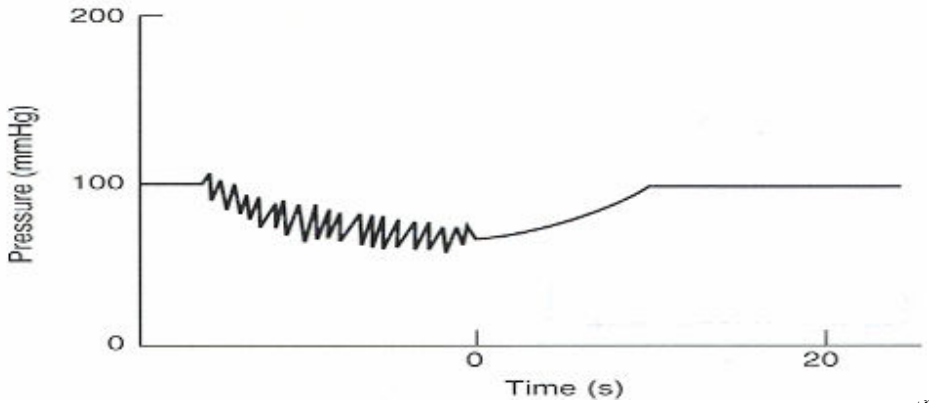
D. Incompetent perforator vein.

E. AVP:

- Not done nowadays (invasive).
- Checks for reflux.
- A 20-21 gauge butterfly needle is inserted in the superficial dorsal (foot) or ankle vein while the patient is standing up with heel raised.
- In normal AVP:
  - Pressure drop while walking from standing still is *more* than 50%, i.e. drop from 90 to 25 mm Hg.
  - Venous refractory or refilling time is *more* than 20 seconds.



- Abnormal AVP:
  - Pressure drop while walking from standing still is less than 50%.
  - Venous refractory time is *less* than 20 seconds.



F. Phlebography:

- Descending venogram (not used nowadays except when planning for surgery in the venous system).
- Inject a dye in the proximal veins and let the patient stand, if reflux is present, the dye will move with gravity.

Treatment:

- Telangiectasias and reticular veins (C_1):
  - Stockings.
  - Sclerotherapy.
- Varicose veins (C_2):
  - Stockings (doesn't treat it, but improves its symptoms and prevents worsening).
  - USG sclerotherapy. (USG; ultrasound guided).
  - Endovenous laser therapy (EVLT).
  - Surgery.
- Edema and cutaneous ulcers (C_3-C_6):
  - Local wound care (if present).
  - Stockings.
  - USG sclerotherapy.
  - EVLT.
  - Surgery.

Compression stocking:

- Many different kinds and materials.
- Aims of compression therapy:
  - Increase extravascular tissue pressure, forcing most of the blood to return via the deep system.
  - Decrease transmural hypertension.
  - Reequilibrate transcapillary fluid exchanges (Starling's law).
- Factors reducing compliance:
  - Hot weather.
  - Difficult application (hard to wear), especially in elderly.
  - Limited colors (females affected more).

Sclerotherapy:

- A 29-30 gauge needle injects a sclerosing agent into a vein, causing fibrosis, thus preventing blood flow and leading to disappearance of telangiectasias or minor varicosities of the lower limb.
- Make sure the sclerosing agent is injected *inside* the vein to avoid complications, such as pigmentation, allergic reaction, necrosis and pain. ☝
- Polidocanol has the least complications compared to other sclerosing agents. ☝

Endovenous laser ablation techniques:

- Denaturation of vein wall collagen by heat, leading to contraction and fibrous obliteration of the vein.

EVLT:

- Under local anesthesia and mild sedation, introduce a laser wire in the great or even short saphenous vein going all the way to the saphenofemoral junction by US guidance.
- The laser will burn the inside of the whole vein by pulling the wire the entire course of the vein.

Surgery:

- The *gold standard*. ☝
- Called *high ligation* and stripping of varicose or great saphenous vein.
- Make an incision in the groin area at the saphenofemoral junction, ligate the saphenofemoral junction.
- Introduce a wire in the great saphenous vein which will exit through an incision below the knee.
- Tie the vein to the wire at the bottom, the vein will be taken out by pulling it along with the wire through the opening below the knee
- The major complication:
  - Injury to the saphenous nerve leading to numbness of the medial aspect of the leg.

Compartment Syndrome (CS)

- Compartment means enclosed space.
- CS is a clinical syndrome where the compartment pressure exceeds the capillary filling pressure which results in reduction of tissue perfusion.
- Mostly affects the lower limb compartment.
- *sudden* increase in the bulk after ischemia (reperfusion)

Anatomy:

- The lower limb contains four compartments (anterior, lateral, superficial posterior and deep posterior) surrounded by tough fascia, in between these compartments are arteries, veins and nerves.
- In this syndrome there's no space for muscle expansion so the pressure will be increased.

Causes

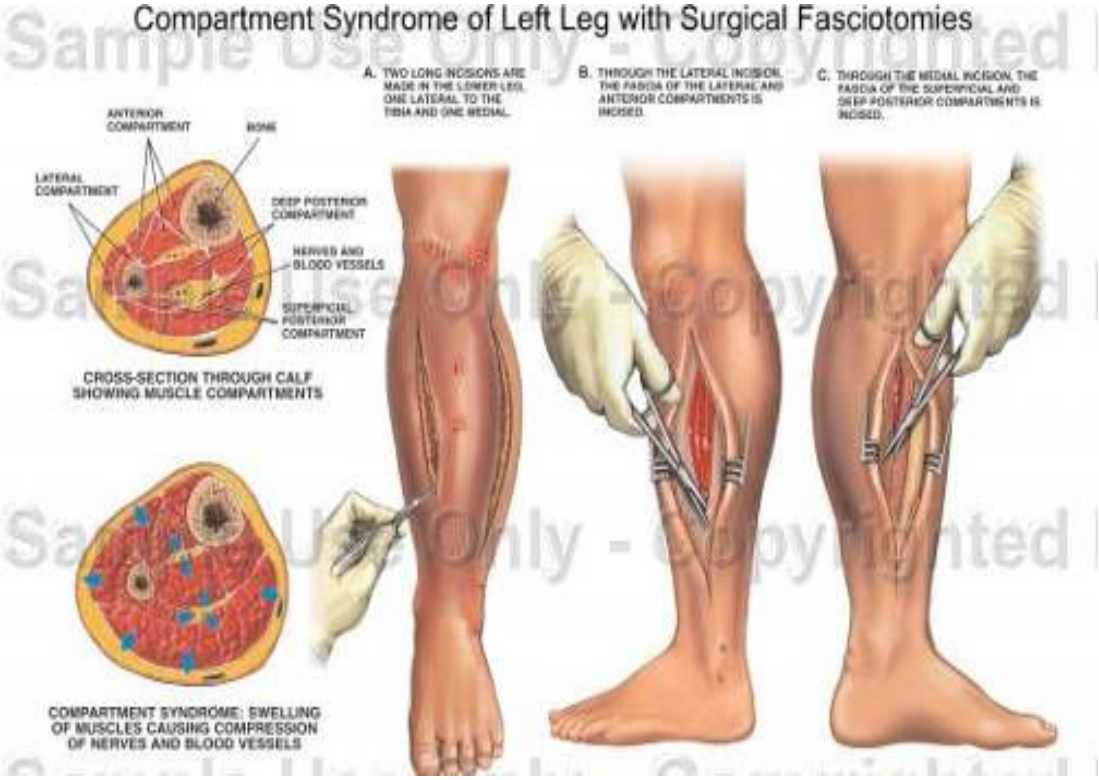
- External compression, e.g. tight cast.
- Increase in compartment volume:
  - Bleeding: blood volume increases compartment pressure.
  - Fracture: bone marrow escaping causing increased compartment pressure.
  - Ischemia: dead muscle cells increase in size by increased permeability to fluids causing increased compartment pressure.

Symptoms and signs:

- Tense compartment.
- Pain and tenderness at compartment muscles.
- Pulse *may or may not* be present. ☝

Treatment:

- Fasciotomy:
  - Open the skin till reaching the fascia and make cuts at each compartment with treating the underlying cause.
  - Types:
    a. Medial aspect fasciotomy; releases superficial posterior and deep posterior compartments.
    b. Lateral aspect fasciotomy; releases anterior and latral compartments.
- Reperfusion injury could happen when treating the patient, it's due to:
  - Hyperkalemia due to wash out of potassium from cells into the systemic circulation which could lead to cardiac arrest.
  - Acidosis because of accumulation of lactic acid formed by anaerobic metabolism of muscles hypoxemia.
  - Myoglobinemia: this myoglobin will precipitate in renal tubules causing myoglobinuria, which may lead to renal failure.



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Lymphedema

- Progressive, usually painless, swelling of an extremity that results from a decrease transport capacity of the lymphatic system.

Etiological classification:

- Primary:
  - Congenital (onset: less than 1 year of age).
  - Praecox (onset: 1 to 35 years of age).
  - Tarda (onset: after 35 years of age).
- Secondary to:
  - Filariasis.
  - Surgical procedure, i.e. lymph node dissection.
  - Tumor invasion.
  - Infection.
  - Trauma.

Signs:

- Leg swelling.
- Non pitting edema (opposite venous edema).
- Starts distally then advances proximally.
- It could be unilateral or bilateral.
- Dissection: secondary to procedure.
- Squaring of the toes and a hump in the dorsal aspect of the leg.

Investigation:

- Lymphoscintigraphy; measures the patency of the lymphatic system.

Treatment

- Mostly conservative by compression therapy.
- Surgical procedures are of poor outcome.

NOTE:

- *We should check the venous system by Duplex to check for any abnormalities then send the patient for lymphoscintigraphy.*

For extra reading
Lawrence's Essential of General Surgery
Chapter 23
464-470

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