Anatomy & Physiology of the Peripheral Venous System

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Main Physiological Functions

- Return of Venous Blood back to the Heart
- Thermoregulation
- Storage of blood
    - 70% of blood stored in the venous system
- Regulation of cardiac output

Thermoregulation

- Vasoconstrictor fibres supply the SVS
- Heat response:
    - Removal of vasoconstriction
    - Cooler blood diverted towards skin helping in heat dissipation
- Cold response:
    - Constriction of arterioles and superficial veins
    - This allows heat conservation by diverting venous blood through the perforators into the deep veins which lie closer to the arteries

The Physiology of Venous Return

- As arterial blood flows into the leg, distal superficial veins constantly fill
- Venous Blood is regularly emptied from the superficial system into the deep venous system via the SFJ, SPJ and perforators
- This blood is then returned to the right side of the heart through one-way valves by calf muscle contraction.
- Venous Return occurs uphill against gravity, against fluctuating thoraco-abdominal pressures and sometimes in the face of additional back-pressures such as CCF.
- The process of Venous Return depends on the patency of the flow circuit and on the normal functioning of the Calf Muscle Pump and Venous Valves

Valvular System

- 'One-way', Bi-cuspid
- These valves permit blood flow from superficial to deep (foot is only exception) and from distal to proximal
- Located every few centimeters in veins below the CFV
- Located in Perforators and at Major Junctions (SFJ, SPJ)
- Made up of thin sheets of collagen/smooth muscle, covered by endothelium

Calf Muscle Pump and Ambulatory Venous Pressure (AVP)

- When calf muscles are at rest, deep veins expand and blood is drawn in from the superficial veins.
- Venous Refilling occurs via arterial inflow (VRT 25-30 s).
- Normal Resting Supine Venous Pressure in the foot is approximately 80-100 mmHg.
- With calf-muscle contraction, blood is forced up the deep veins
- Foot Pump also contributes.
- The immediate post-AVP is about 20% of the resting supine venous pressure.

Venous Pathophysiology

- **Chronic Venous Insufficiency** is caused by either impaired venous outflow or abnormal (retrograde) venous inflow.
- Chronic Venous Hypertension occurs when the AVP is persistently elevated
- Exercise can no longer empty the leg of blood and thereby decrease AVP.
- Failure of this normal process, leads to a persistently elevated venous pressure despite ambulation.
- This subsequently results in Chronic Venous Hypertension.
- Any condition that increases venous inflow or impedes venous outflow will result in a persistently elevated venous pressure during or immediately after ambulation.

Calf Muscle Pump Failure

- CMP failure leads to incomplete emptying of venous blood from the leg and hence an increase in post AVP
- Muscle Atrophy

- bed rest and immobility (plaster casts)
- muscle injury
- deliberate dieting, malnutrition, malabsorptive states, eating disorders
- Neuromuscular causes – neuropathies, MND, nerve injuries, neuralgias
- Malignancy (pancreatic, stomach, lung, etc...)
- Chronic Infection (HIV, TB)
- CCF
- Endocrine Causes (Hyperthyroidism, Addisons, Cushings)
- Arthritic (OA, Rheumatoid)
- Seven Masquerades (Depression, Diabetes, Drugs, Anaemia, Thyroid, etc...)

- Prolonged Standing

Deep Venous Obstruction

- Thrombotic
  - Spontaneous
  - Induced
  - Hereditary
  - Acquired
- Non-thrombotic
  - Diaphragm-like membrane

    (Kilken et al, 2004)
  - Fibrous Tissue compressing DVS (KTS)
  - Tumour

1. Mesenchymal Chondrosarcoma

   (Kim et al., 2003)
2. Primary Venous Leiomyosarcoma

   (Zhang & Wang, 2006)
3. Primary Malignant Lymphoma

   (Rulli et al., 2002)
4. Popliteal Vein Compression

Valvular Incompetence

- Deep Incompetence

  - primary valve agenesis (?KTS)

  - Prior Valve damage

  - direct trauma

  - dilation with 2ndary valve failure

- Perforator Incompetence

  - trauma

  - secondary to deep vein obstruction

- Superficial Incompetence

Valve Failure

- Gravitational Hydrostatic Pressure

  (prolonged standing)

- Congenital Weakness of valves

- thrombophlebitis

- trauma

- hormonal influences

Superficial Venous System

Great Saphenous Vein

- Originates in Medial Foot as part of dorsal venous arch
- Continues proximally , along the medial aspect of the foot as the medial marginal vein of the foot
- GSV then passes anterior to the medial malleolus
- Ascends along the tibial edge of the medial calf to cross the knee.
- Lies within a fascial compartment (not as large and well defined as in the thigh)
- From the upper calf to the groin, the GSV lies within a very clearly defined fascial compartment (superficial and deep fascial fascia) known as the “saphenous eye”’.
- Typical normal GSV is 3-4 mm in diameter
- Usually has 10-20 valves

Saphenous Nerve and it’s association with the GSV

- Very close association with the “Saphenous Nerve”, in the lower leg, which may be injured during surgical stripping/EVLT/UGS
- Saphenous Nerve is the largest branch of the Femoral Nerve and is purely sensory, supplying the anteromedial and posteromedial aspects of the lower leg.

Sapheno-Femoral Junction

- The GSV terminates into the SFJ (a short segment that receives multiple tributaries)
- There is a constant terminal valve 1-2 mm distal to the termination of the GSV
- There is a preterminal valve a further 2 cm distal which marks the distal area of the SFJ – this is the upper limit for EVLT.

GSV Tributaries

- Anterior Accessory Saphenous Vein
- Posterior Accessory Saphenous Vein (PASV)
- Anterior Thigh Circumflex Vein (ATCV)
- Posterior Accessory GSV of leg (aka Posterior Arch Vein)
- Anterior Accessory GSV of leg
- Communicating Branch with SSV, usually via another tributary.

Small Saphenous Vein

- Drains the Postero-Lateral Aspect of the Leg and lateral aspect of the foot.
- Originates in the lateral foot as part of the dorsal venous arch.
- Ascends proximally behind the lateral malleolus as continuation of lateral marginal vein of foot
- Frequently terminates at the popliteal vein, but this may vary.
- The SSV lies for its entire length in an inter-fascial compartment defined by the deep muscular fascia and superficial fascia.
- The distal compartment appears on ultrasound as an “Egyptian eye”

- The proximal compartment is defined by the medial and lateral heads of gastrocnemius and the superficial fascia
- Sural Nerve intimately associated in distal 1/3
- Medial Cutaneous Sural nerve in upper 2/3s
- 9-12 valves

Sural Nerve and its association with the SSV

- Sural Nerve is formed in the distal portion of the leg by the union of the Medial Sural Cutaneous Nerve (branch of tibial nerve) and a Peroneal Communicating Branch. In 20%, the peroneal communicating branch may be absent. The Lateral Sural Cutaneous Nerve may also contribute.
- Although the sural nerve is considered to be a sensory nerve, motor fibres have been found in 4.5% of cases. (*Amoiridis G, Schols L, Ameridis N, Przuntek H. **Motor fibers in the sural nerve of humans**. Neurology 1997;49:1725-8)*
- The Sural Nerve is intimately associated with the SSV in the distal calf. It lies lateral to the SSV in the distal leg.
- Injury to the sural nerve following surgery can cause permanent lateral leg/foot paraesthesia
- Care must also be taken with EVLT – in the lower third of the leg.

Thigh Extension of the SSV

- Confirmed by ultrasound
- Present in 95% of limbs
- Lies deep to the fascia of the posterior thigh
- 4 distinct patterns

1. Continue as single vein to the Gluteal area
2. Join FV via post. or post.lateral perforator
3. Divide into many muscular or s/c branches
4. Connect to the PTCV which then connects to the GSV. This complex of veins (TE + PTCV) is termed Giacomini Vein.

Termination of the SSV – 3 possible variations

1. SSV joins popliteal vein at the SPJ, joins deep veins at higher level via TE, or joins GSV via Giacomini
2. SSV continues as TE/Giacomini but communicates with popliteal vein via small anastamosis
3. There may be no connection to the popliteal or deep veins. Hence, SSV continues as TE or Giacomini Vein

Sapheno-Popliteal Junction

- Position of the SPJ is highly variable
- Most often situated within 2-4 cm above the knee crease, but above this level in 25%
- SSV joins popliteal vein from the posterior aspect in 15%, postero-medial in 30%, lateral in 42% and antero-lateral in 1%
- Terminal SSV has a terminal valve in close proximity to the popliteal vein and a pre-terminal valve just below the depart of the TE of the SSV

Tributaries of the SSV

- Subcutaneous tributaries pierce the superficial fascia
- Common tributary seen on regular U/S is the so called "***popliteal fossa perforating vein***"**.** First described by Dodd
- Runs s/c along post.aspect of calf and popliteal fossa, sometimes parallel to SSV
- Typically forms a separate junction with the popliteal vein, usually lateral to the SPJ
- Communicating branch with GSV or its tributaries

Lateral Venous System

- aka Lateral Subdermic Venous System or Albanese system
- May represent the remnant of the embryonic lateral marginal vein
- Extremely common and accounts for large % of phlebologist's practice
- Normal flow is paradoxically downwards from proximal thigh into lateral thigh and lateral knee perforators.
- Reflux commonly occurs via these perforators
- Small percentage occur via incompetent ATCV/GSV

Perforators

- Perforators act as alternative pathways from superficial to deep
- They pass through anatomical defects in the deep fascia and join directly with deep veins of the thigh or calf
- They usually contain one way bicuspid valves that allow blood flow from superficial to deep
- All perforators are accompanied by an artery

GSV System Perforators

- Perforators of the femoral canal (formally Dodd) connect the GSV to the Femoral Vein.
- Para-tibial Perforators (formally Sherman in the lower and mid leg and Boyd in the upper leg) connect the GSV or its tributaries to the Posterior Tibial Veins.
- Posterior Tibial Vein Perforators (formally Cockett's) are divided into upper, middle and lower and connect the Posterior Arch Vein to the Posterior Tibial Veins.
- Anterior Leg Perforators (pierce the Anterior Tibial compartment to connect the ant. GSV tributaries to the anterior tibial veins.

SSV System Perforators

- Soleal Perforators – perf. of May
- Para-Achillean Perforators – perf. of Bassi

Deep Veins of the Calf

- Intra-muscular
  (venous sinusoids within the corresponding muscle, coalesce to form these veins. In most cases, these are paired and run with a corresponding artery)

  - soleal, gastrocnemius

- Inter-muscular veins
  (these veins are all paired and run with their accompanying artery)

  - peroneal, post. tibial, ant. tibial

- Outflow tract

  - popliteal vein

Deep Veins of the Thigh

- Popliteal vein
- Femoral Vein (not to be referred to as the Superficial Femoral Vein)
- Deep Femoral Vein (aka Profunda Femoris Vein)
- Common Femoral Vein
- External Iliac Vein

Important Nerves for Phlebologists to consider:

- Saphenous Nerve
- Sural Nerve
- Sciatic Nerve
- Common Peroneal Nerve

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