

L13-Vascular Investigations



Surgery Team
MED 433

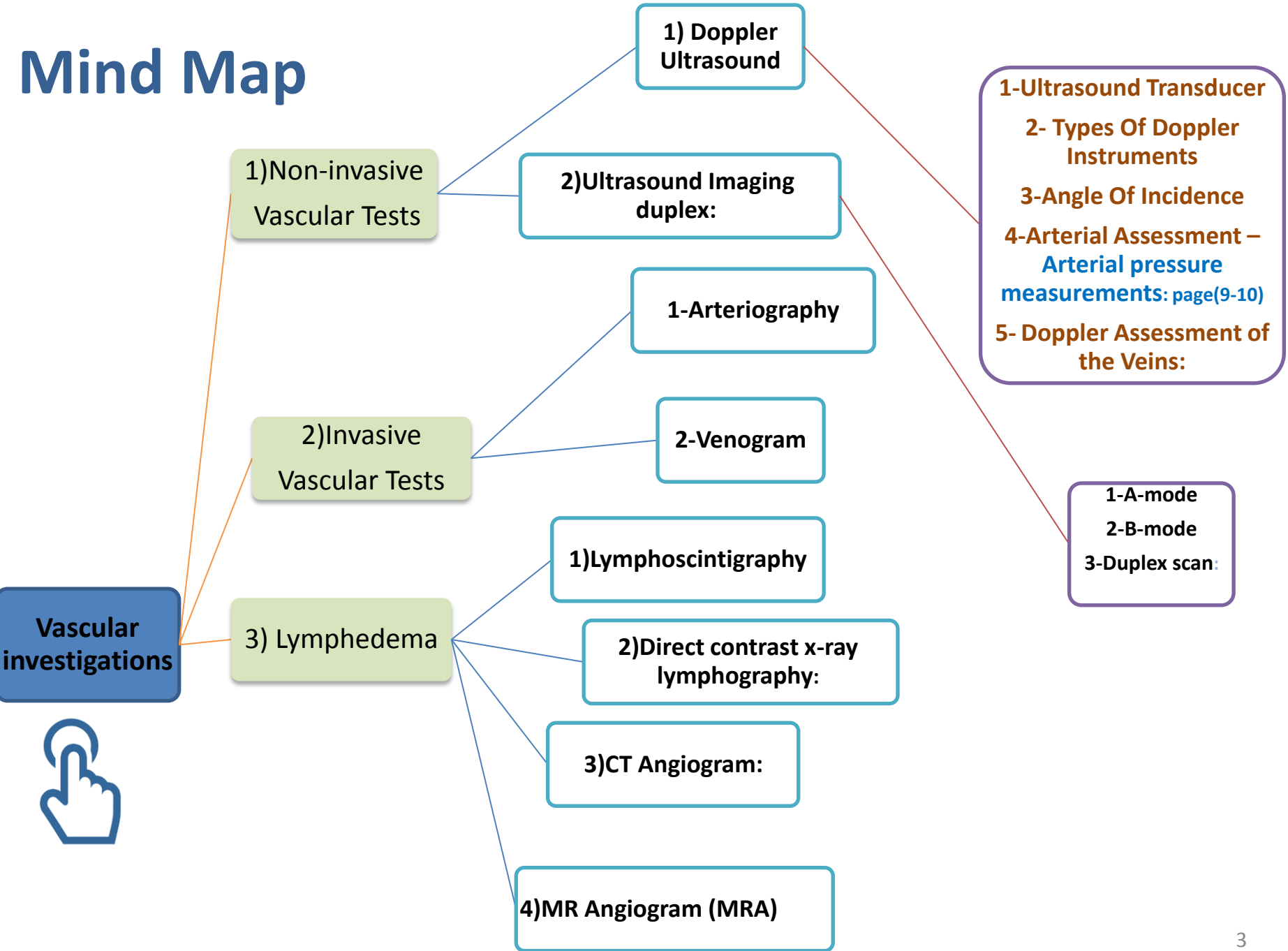


Objectives :

Color Index: Slides & Raslan's () | **Doctor's Notes** | Extra Explanation | **Additional**

This work is based on doctor's Slides +Notes and Raslan's only (Does not include the book)

Mind Map



Introduction:

- Blood vessels are a series of tubes that are used to pump blood throughout the body.
- There are 3 types of blood vessels: **arteries**, **veins** and **lymphatics**.
- Arteries carry oxygen rich blood away from the heart to every part of the body, including the brain, kidneys, intestine, arms, legs and heart itself. When a disease occurs in the arteries, it's called arterial disease.
- Blood flows back to the heart from all parts of the body through veins. When disease occurs in the veins, it's called venous disease.
- Fluids return from the skin and other tissues to the veins through lymphatics.

Vascular Diseases:

Arterial diseases: such as aortic dissection which is caused by a tear in the inner layer of the aortic wall and then blood will flow between the layers and separate them or arterial occlusion. A lot of patients come with arterial occlusive diseases.

- **Acute:** ischemia
- **Chronic:** intermittent claudication or dilatation (arterial aneurysmal disease)...Etc.
- **Venous diseases:** deep vein thrombosis commonly referred to as “DVT”,

occurs when a blood clot, or thrombus, develops in the large veins of the legs or pelvic area, or chronic venous insufficiency which is an inclusive term for vascular malformations, vascular tumors, and other congenital vascular defects. The more commonly used term, Chronic Venous Insufficiency (CVI), implies abnormally formed blood vessels that one is born with... etc.

1) Non Invasive Vascular Tests:

- Utilizes instrument; Utilizes the sound energy (Arterial and venous flow)
- Doppler Ultrasound.
- Sound –longitudinal mechanical wave of any frequency.
- Audible Sound range 20-20,000 cycles/sec [?]. 20Hz-20kHz.
- Ultrasound-'Ultra' means 'Above' human hearing - >20,000 cycle/sec(20kHz).
- **Diagnostic Ultrasound –2MHz-12MHz** (2million-12million cycle/sec)

1) Doppler ultrasound:

Ultrasound interaction with stationary object

- No frequency change.
- No Doppler Effect or shift.
- Sound won't be heard.

Ultrasound encounters moving object:

- Doppler Effect or Shift occurs.
- Change perceived frequency of ultrasound emitted by moving object.
- Sound will be heard (3 voices)

❖ **In clinical practice: moving targets RBC traveling with in the blood vessel.**



Source & Receiver
of sound:
ultrasound
transducer

Ultrasound Transducer

- Transducer: device converts one form of energy to another.
- Ultrasound Transducer:
- Use piezoelectric crystals.
- Converts Electro potential energy (voltage) into Mechanical vibration (ultrasound) & Mechanical vibration into Voltage

Types Of Doppler Instruments

Continuous Wave (CW)	Pulsed Wave (PW)
<ul style="list-style-type: none"> • Doppler transducer Transmits continuously ultrasound & Receive simultaneously. • Have two Piezoelectric crystals, one Transmit X & other Receive Y 	<ul style="list-style-type: none"> • Single piezoelectric crystal – both transmission & reception. • Alternate pulses On & Off. • Transmit pulse – system waits – pulse travels to sample volume (specific area) – echo pulse returns
Advantages:	
Magnitude of detectable velocity-Limitless	Specific for depth and range. No mixture of signals like CW Doppler. (it is more advanced)
Disadvantages:	
Not specific for depth Detects any & all vessels in beam path	Limited maximum detectable velocity unlimited for CW Doppler.

Angle Of Incidence

- Doppler or frequency shift is what we hear & see on graphic display.
- Affected by 'angle of flow' or 'angle of incidence'
- The smaller the Doppler angle, the higher the frequency shift.
- **Optimal Doppler signals: transducer angle 45-60 towards direction of flow**

Arterial Assessment – Doppler Ultrasound

- Audible interpretation
 1. Waveform analysis.
 2. Hand held Doppler.
- **Normal Peripheral Arterial Doppler signal: TRIPHASIC**

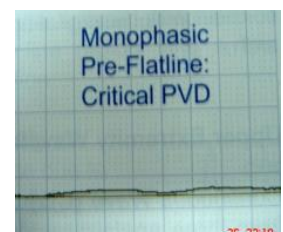
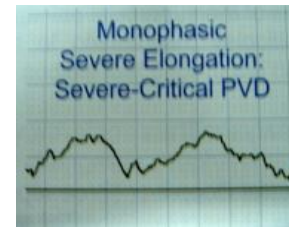
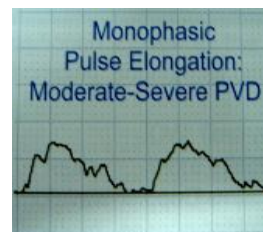
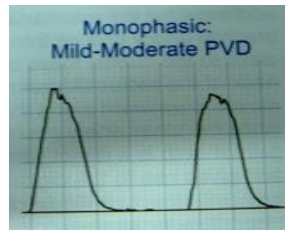
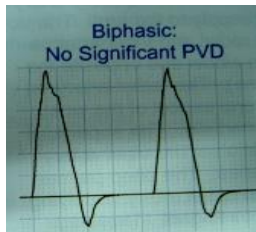
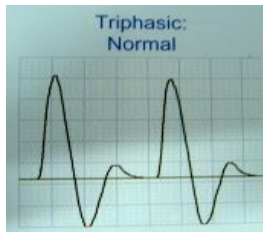
Triphasic arterial signal:

1st sound – phase: large, high velocity, forward flow, **systolic component.**

2nd sound – phase: smaller **reverse flow early diastole.**

3rd sound – phase: smaller **forward flow late diastole.**

Audible interpretation & Wave form analysis:



PVR (Pulse Volume Recording): Normal PVR:

- 1) Brisk systolic upstroke Anacrotic limb.
- 2) Sharp systolic peak.
- 3) Gradual down stroke Catacrotic limb.
- 4) **Dicrotic notch**: reflective wave-during diastole normal peripheral resistance.

Arterial pressure measurements: More details in the next slide

❖ Used For Peripheral arterial occlusive disease .

- Sequence of pressure measurement tests:
 - ◆ Systolic Brachial & Ankle pressure at rest.
 - ◆ Calculation of ABI.
 - ◆ Toe pressure-non compressible tibial arts.
 - ◆ Segmental pressure and waveforms: low ABI.
 - ◆ Stress testing: severity of claudication & to R/O pseudo-claudication.
- Contraindication to pressure measurements:
 - Acute DVT; closure of veins makes it worse.
 - Bandages & casts
 - Ulceration
 - Trauma
 - Surgical site

A) Ankle Brachial Index (ABI):

High Sensitivity And Specificity

Easiest, Cost Effective, Initial Test To Screen For PAOD

Important

- **Before the test Consider :**

- a) Patient supine arms at sides.
- b) Basal state (10mnts pretest rest).
- c) CW Doppler ultrasound.
- d) Appropriate size pressure cuffs.

- **When testing :**

- a) Record bilateral systolic brachial pressure & systolic Ankle pressure (dorsalis pedis & posterior tibial artery)
- b) Interpretation-Ratio highest ankle to brachial pressure.

-ABI and relation to PAOD :Easiest, Cost Effective, Initial test to screen for PAOD. Can be performed in office. 95% sensitivity & 99% Specificity for detection of PAOD. Reduction in ABI correlates with severity of PAOD

- **ABI & Relation to PAOD:**

- 0.97 -1.25 Normal
- 0.75 – 0.96 Mild PAOD
- 0,50 – 0.74 Moderate
- <0.5 Severe
- <0.3 Critical
- >1.5 Vessels non compressible (in diabetes ,renal failure and elderly bcuz the arteries are calcified insetead we do Toe pressure)

B) Toe Pressure

Important

- ❖ This test is done if the ABI showed very high values → like in diabetic patient.
- ❖ Normal toe pressure – 2/3rd systolic ankle pressure (if the Ankle pressure is 120, Toe is 80)
- ❖ Plethysmographic device –it records changes in volume (It is used as a sensor) .
- ❖ Inflate cuff above 2/3rd of ankle pressure.
- ❖ BP cuff (2.5cm) around the base of the toe.
- ❖ Gradual deflate until arterial tracing demonstrate return of pulsatile flow – recorded as ₉ systolic toe pressure.

C) Segmental Pressures

Important

- ❖ Drop in ABI at rest or post exercise indicates hemodynamically significant disease proximal to cuff.
 - ❖ Segmental pressure measurement – localizes the diseased arterial segment.
 - ❖ Pressure difference between two adjacent segments **<20mm of Hg is Normal**
 - ❖ **Gradient >30mm of Hg - Hemodynamically significant disease between adjacent levels**
- Due to the significant drop between two segments e.g. from 120 to 90 (narrowing pressure which is caused by occlusion)

D) Exercise (Stress) Test

Important

- ❖ Treadmill stress test.
- ❖ Reactive hyperemia stress test.
- ❖ Assess functional limitation **due to PAOD**
- ❖ Differentiates PAOD – Pseudoclaudication Ex; neurogenic claudication.
- ❖ Resting ankle & brachial pressures.
- ❖ Pressure cuffs secured in place –ankle and arm.
- ❖ Walk at 2mph at 12% gradient-5mnts or point claudication symptoms.
- ❖ Return supine position & measure ankle pressure 30 seconds and 1 minute post exercise. Measure till baseline pressure is recovered.

We Note :

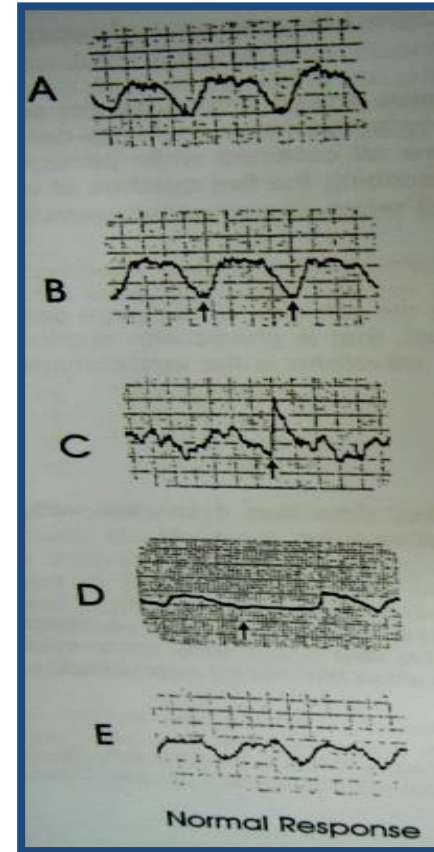
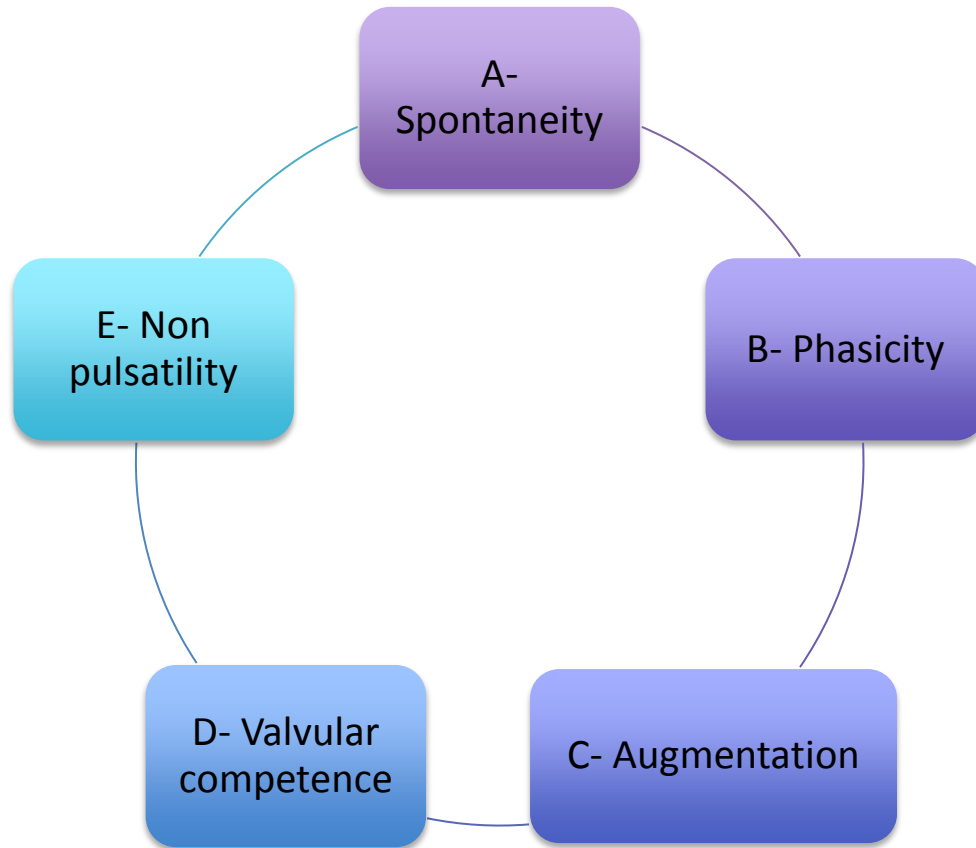
- Duration of exercise.
- Distance walked.
- Symptoms prevented by exercise.

Interpretation:

- Normal: no drop in ankle pressure.
- Minimal disease pressure returns to baseline in 2 minutes.
- Single level disease: pressure returns to baseline in 3-5 minutes.
- Multi-level disease: pressure returns to baseline >10 minutes.

Doppler Assessment of the Veins:

The five qualities of normal venous flow:



→ In DVT, ALL five qualities are lost!

2)Ultrasound Imaging duplex:

A-mode:

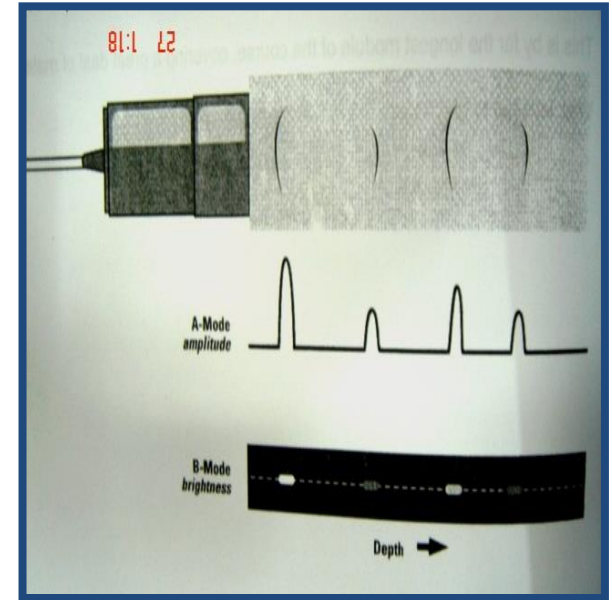
- Also known as amplitude mode
- Displayed as **vertical deflections** or spikes from the baseline
- Stronger echoes → higher amplitude signals

B-mode:

- Also known as brightness mode
- Displayed as a series of **dots**
- The position of each dot corresponds to the distance from the sound source
- Brightness corresponds to the amplitude of returning echo
→ **Gray-scale intensity**
- Gives gray and white

Duplex scan:

- A combination of B-mode and pulsed doppler US
- Gives both anatomical and physiological information regarding the vascular system
- **Adding color frequency mapping → Color duplex imaging.**



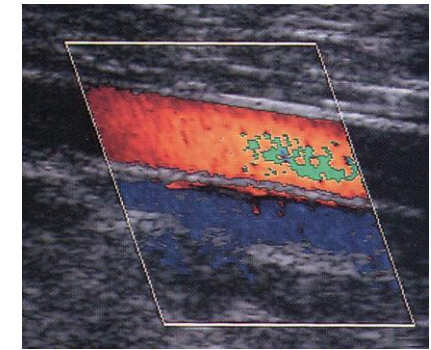
Uses of color duplex imaging:

Arterial:

- Identify obstructive or aneurysmal atherosclerotic disease
- peripheral arteries
- carotid arteries
- renal & visceral arteries
- Surveillance of bypass grafts

Venous:

- Diagnosis of DVT
- Assessing competence of deep vein valves.
- Superficial venous reflux & identifying Sapheno-Femoral & Popliteal Junction refluxes.
- Preoperative mapping of saphenous vein

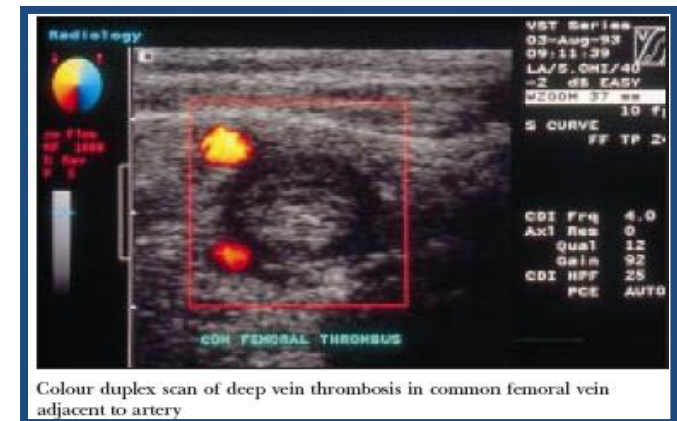


Assignment of color hues based on direction and magnitude of frequency shift

Criteria for duplex examination of the venous system:

Normal	Abnormal (DVT)
- Easily compressible	- Non-compressible
- Should be echo-free	- Thrombus within a vein
- Normal valve function	- Incompetent valves
- Normal doppler signals	- Absent doppler signals

Extra note: With increasing stenosis in a vessel, the peak systolic velocity (Δf) increases and spectral broadening (turbulence) appears
 → **higher velocity of blood flow with stenosis**
 To say an aneurysm is so, it must be at least 50% dilated



Colour duplex scan of deep vein thrombosis in common femoral vein adjacent to artery

2) Invasive Vascular Tests:

1) Arteriography:

- Gold standard
- Good resolution
- Seldinger technique
- Access → commonly femoral or brachial artery
- Injection of iodinated contrast
- Two types of contrast: ionic (high osmolar) or non ionic (low osmolar)

Types of contrast:

Ionic or high osmolar

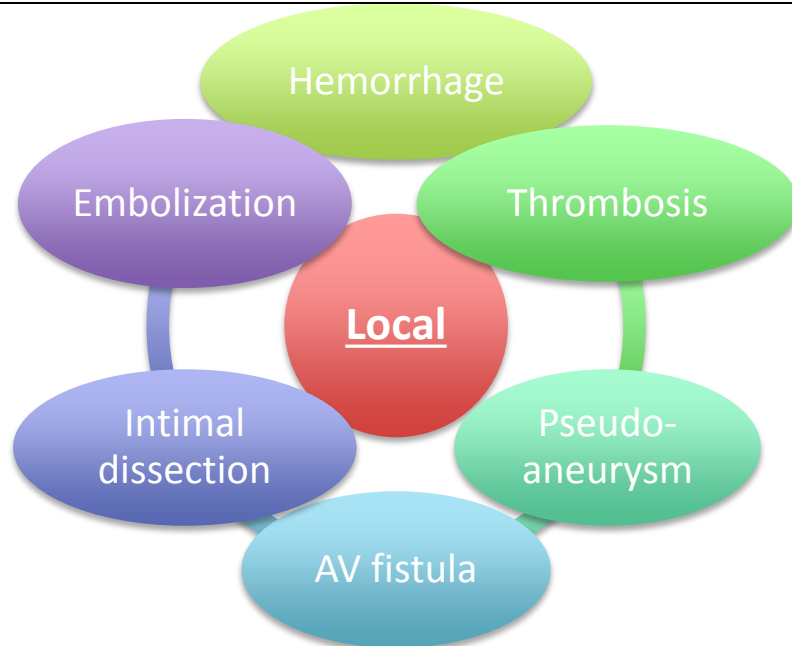
- Water soluble
- Hypertonic, osmolality 5-10 times blood
- Causes discomfort at injection site (phlebitis)
- **More nephrotoxic**
- More complications

Nonionic or low osmolar

- More commonly used
- Has same number of iodine ions with no cations
- Osmolality is 1/3rd that of the high osmolar contrast medium
- Still hypertonic (twice that of the plasma)
- Less nephrotoxic
- More expensive

Complications:

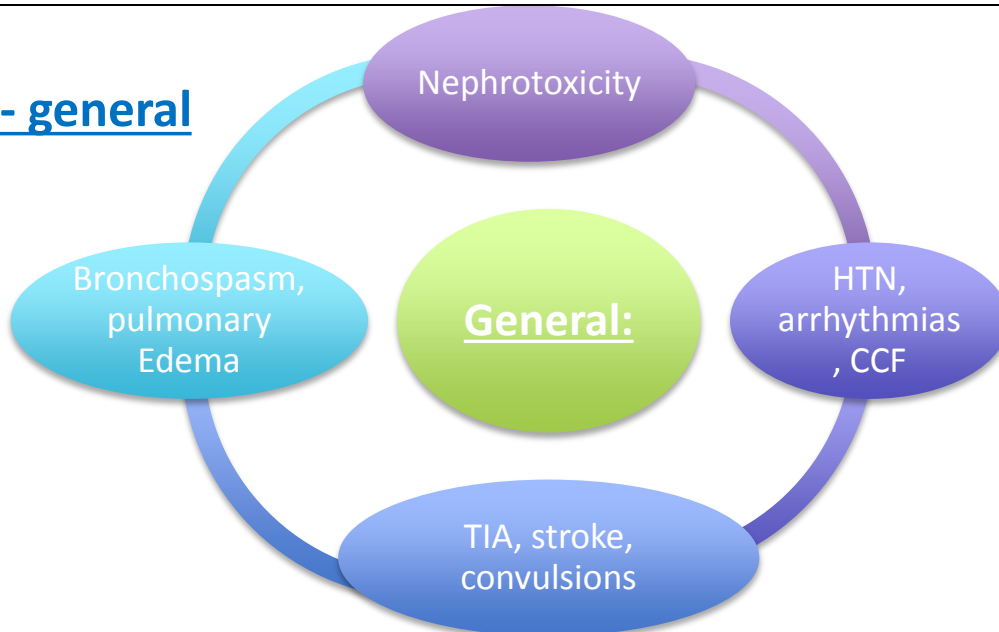
1-Local



Note: The complications are very important!!

- pseudo-aneurysm: a pulsatile swelling around an artery due to leakage of blood, but NO true dilation of a vessel and does NOT involve all three vessel layers!

2- general



3- Allergic reactions:

Minor	Moderate	Major
N/V, headache, fever, chills, itching	Hypotension, urticaria, bronchospasm	Anaphylaxis, pulmonary edema, laryngeal edema

4- Nephrotoxicity:

- 3rd cause of ARF in hospitalized patients
- Mild reversible rise in serum creatinine –ESRD & Death
- Risk Factors – DM, RI, Age, CCF, dehydration.

2) Venography:

1- Ascending venography:

- Relatively invasive study
- Requires painful venipuncture
- Injection of **iodinated contrast**
- Exposure to **radiation**
- Indication: High clinical suspicion of DVT with negative or equivocal non invasive vascular tests.
- Gives information about anatomy & patency of deep veins & locates the incompetent perforators veins.
- Inject about 40-60 ml of contrast into superficial foot arch veins & tourniquet tied above ankle to visualize deep veins.
- Complications: thrombophlebitis + previous ones mentioned

2- Descending venography:

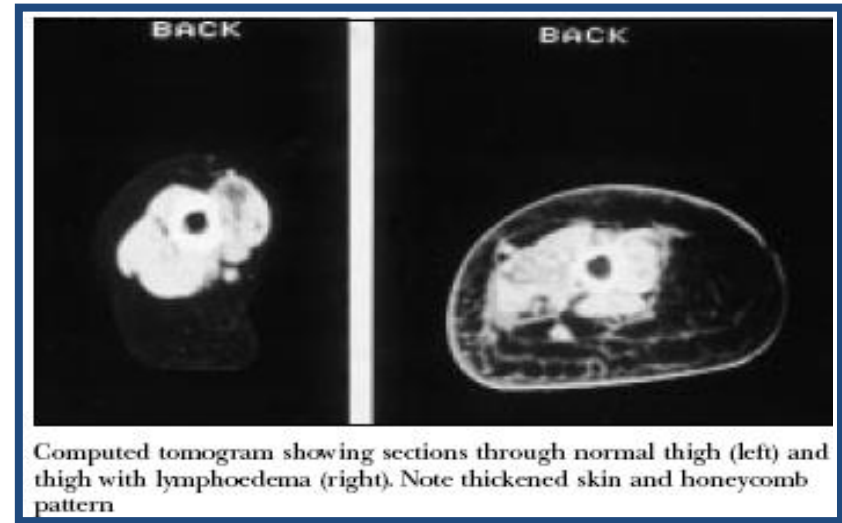
- Indication: To assess the competency of the valves → To distinguish primary deep venous valvular incompetence in the deep system from thrombotic disease.
- Identify level of deep venous reflux & morphology of venous valves.
- Place in IVC, then inject and ask patient to do maneuver to increase intra abdominal pressure
- **Venographic categories of Deep vein reflux:**
 - Grade 0** – normal valve function no reflux
 - Grade 1** – minimal reflux confined to upper thigh
 - Grade 2** – extensive reflux reach lower thigh
 - Grade 3** – extensive reflux reach to calf level
 - Grade 4** – no valvular competence immediate reflux distally to calf.

3) Lymphedema

- Abnormal accumulation of lymph in the limbs either due to maldevelopment (primary) or secondary to lymph obstruction
- Secondary causes include: trauma, infection, filariasis, post-phlebitis, irradiation, malignancy, allergy
- Minimally invasive investigations to identify edema of the lymphatic origin: lymphoscintigraphy, CT, or MRI.
- The first one done usually is Lymphoscintigraphy.
- The principle in treatment is to increase lymphatic return
- Treatment: bypass → lymphovenous shunting

1) Lymphoscintigraphy

- Isotope Lymphography: Radiolabelled Colloid or Protein injected 1st web of foot - Gamma Camera monitoring of tracer uptake. (**Most commonly used** → minimally invasive)
- Measurement of tracer uptake within the lymph nodes after a defined interval → distinguishes lymph edema from edema of non lymphatic origin.
- Appearance of tracer outside the main lymph routes – dermal back flow indicates lymph reflux & proximal obstruction
- Poor transit of isotope from injection site – suggest hypoplasia of lymphatics
- **Honeycomb pattern** in the **subcutaneous compartment**, characteristic of lymphedema
- Complications: infections, sepsis, lymphangiosarcoma



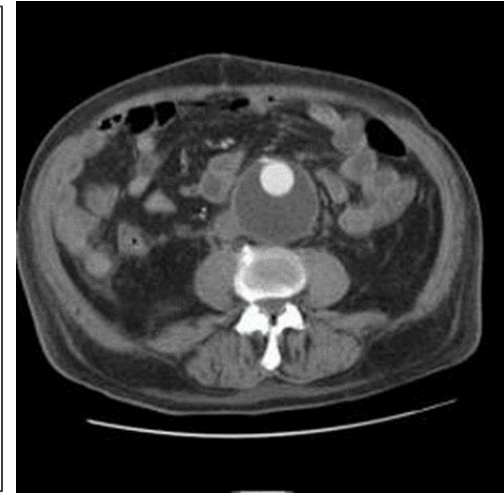
Lymphoscintigraphy:

2) Direct contrast x-ray lymphography:

- Not commonly used anymore
- Invasive
- lymph vessels identified by injecting vital dyes & lymph vessel cannulated.
- Lipiodol contrast directly injected
- Normal limb shows opacification of 5-15 main lymph vessels as converge to inguinal lymph nodes.
- Lymphatic obstruction-contrast refluxes into dermal network – dermal backflow.

3)CT Angiogram:

- Utilizes contrast but still considered minimally invasive
- Rapid & Minimally invasive
- Arterial vasculature can be evaluated from multiple angles & planes
- Provides soft tissue details useful in defining pathologies outside vessel lumen, Aneurysms, Dissections, Wall thickening, or Arterial Entrapment.
- Primary imaging modality in pre-operative planning & follow up AAA
- Limitations: Radiation dose - Contrast induced nephrotoxicity - Diminished accuracy in heavy calcification



4)MR Angiogram (MRA):

- There are two types: contrast enhanced, and non-contrast enhanced
- Limitations: Scan artefacts, in Renal Impairment, Gadolinium contrast, nephrogenic systemic fibrosis, Metal implants, Claustrophobia

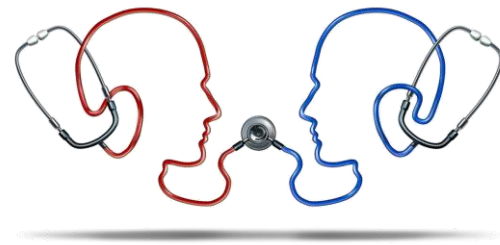
Important notes (from Raslan):



Person with abdominal aortic aneurysm , what's the best for diagnostic and surveillance purposes? → noninvasive ultra sound or duplex.

- ❖ For follow up of aneurysm, which is 3 cm →US
- ❖ Start treating aneurysm when it's 5cm because larger has higher incidence of rupture, less than that don't treat just follow up with US.
- ❖ For following up after an open surgery (Endovascular Repair) EVR →CT
- ❖ Person with abdominal aortic aneurysm ,what's the best for therapeutic and plan management purposes? →CT
- ❖ Local diseases causing Limb swelling →DVT, chronic venous insufficiency, lymphedema.
- ❖ For DVT, chronic venous insufficiency →diagnosed by US or duplex US.
- ❖ To assess or diagnose lymphatic vessels or lymphedema →lymphoscintigraphy (not lymphangiography) sometimes MRI magnetic resonant angiogram (minimal invasive)
- ❖ MRV →venogram (not used because it needs a special software).

Important cases by the doctor:



1. 60 year old patient with rest pain and gangrene of the big toe, his ABI > 1.5 with absent Pulses, what is the best next step?

Answer : Toe pressure

2. 70 year old patient with intermittant claudication in the right lower limb, on examination Normal pulses and normal ABI , to rule out PAOD we do?

Answer: Exercise test

3. 70 year old smoker, come to you with pulsatile abdomen , what is the best modality to do?

Answer: Arterial duplex

4. 65 year old comes with weakness of the right lower limb, can't move and can't speak, On examination he had bruite what is the next step?

Answer : Duplex scan

Summary

- non-invasive methods include doppler U/S and color duplex U/S
- **Optimal Doppler signals:** transducer angle 45-60 towards direction of flow.
- Arteries normally have a triphasic doppler signal
- Arterial pressure in the limbs is measured by ABI, and in diabetics, older patients, those with unclear readings, and those with renal failure, we use the toe pressure for a more accurate result as the vessel would be incompressible.
- Segmental pressure is used to LOCALIZE the diseased segment
- In duplex scans, blood flows higher in diseased segments (stenotic ones)
- The gold standard for arteries is: ARTERIOGRAPHY, and the gold standard for veins: VENOGRAPHY. Both of which utilize contrast!
- Lymphoscintigraphy is the 1st test in assessing the lymphatic system.



MCQs

1. **In non-invasive assessment of peripheral arterial disease, the following is an appropriate candidate for exercise test:**

- a. Patient with rest pain in the foot
- b. Patient with intermittent claudication and normal resting ABI
- c. Patient with venous ulcer
- d. Patient with resting ABI of <0.4
- e. Patient with acute ischemia

2. **15-year old girl presented with progressive painless unilateral leg swelling:**

- a. Most likely cause is chronic venous insufficiency
- b. Most likely cause is primary lymphedema
- c. Patient needs arteriogram to confirm diagnosis
- d. Is due to secondary lymphedema
- e. Common treatment is lymphatic bypass surgery

3. **50-year old male patient with swelling, pigmentation and ulceration around the ankle:**

- a. Most likely cause is chronic lower limb ischemia
- b. Needs arteriogram for diagnosis and management
- c. Needs non-invasive assessment by Doppler and duplex for obstruction and
- d. valvular incompetence of the venous system
- e. Brown skin pigmentation is due to excess of melanocyte activity in the skin
- f. Usually managed by amputation of limb

4. **30 year old female , 26 weeks pregnant has painful swollen and pale left leg and her pedal pulses are well felt:**

- a. Arteriogram is indicated because of pale left leg
- b. Optimal initial diagnostic test is venous duplex examination
- c. Appropriate treatment would be warfarin
- d. Venography should be the initial diagnostic test
- e. Heparin is contraindicated in this patient

5. **50 year old diabetic male smoker present with rest pain and gangrene of the 1st toe, the following statement are correct:**

- a. ABI in the above patient is the ratio of ankle diastolic pressure to brachial
- b. diastolic pressure
- c. ABI in normal person is <0.9
- d. The above patient has critical ischemia and usually ABI <0.4
- e. Calcification of arteries in this patient can give very give ABI results
- f. Always ABI is measured in standing position

6. **In vascular investigations:**

- a. Doppler is used only for arterial investigations
- b. Duplex scan can be used to evaluate the lymphatic system
- c. Vascular Investigations
- d. Bleeding is a common cause of death with venogram
- e. None of the above is true

7. **Venous system of the lower limb:**

- a. Consists of superficial, middle and deep systems
- b. No connection between its parts
- c. Superficial femoral and profunda veins join to form the common femoral vein
- d. Great saphenous vein starts posterior to the medial malleolus



MCQs

8. A 32 year old woman presented to the clinic with thickening skin of her medial aspect of the leg, which was associated with dermatitis and hyperpigmentation. Which type of presentation is this?
- Telangictasia
 - Lipodermatosclerosis
 - Healed ulcer
 - Active venous ulcer
9. Evaluation does not include which of the following tools?
- Doppler
 - Duplex
 - Venogram
 - AVP
10. All of the following can treat the previous case except:
- Stocking
 - Endovenous laser ablation
 - Endovenous laser therapy
 - Surgical ligation

Thank You..

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