



Non Invasive Vascular Tests:

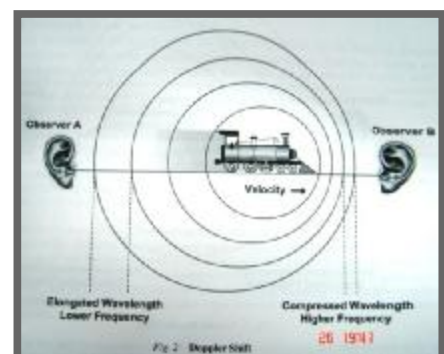
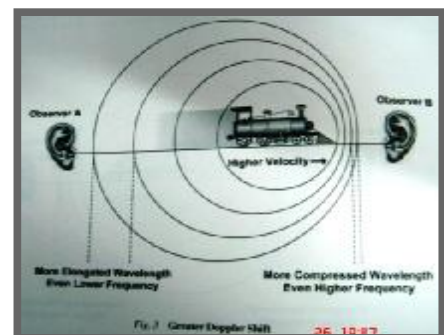
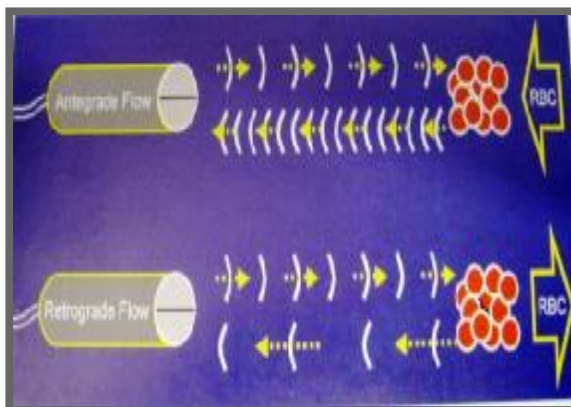
- Utilizes instrument – Doppler Ultrasound.
- Sound –longitudinal mechanical wav of any frequency.
- Audible Sound range 20-20,000 cycles/sec 20Hz-20 k Hz
- Ultrasound-‘Ultra’ means ‘Above’ human hearing - >20,000 cyc/sec(20kHz).
- Diagnostic Ultrasound –2MHz-12MHz (2million-12million cyc/sec).

Doppler ultrasound-based on principle of Doppler effect/shift:

- Ultrasound interaction with stationary object.
 - Ø No frequency change.
 - Ø No Doppler effect or shift.
- Ultrasound encounters moving object
 - Ø Doppler Effect or Shift occurs.
 - Ø Change perceived frequency of ultrasound emitted by moving object.

In clinical practice – moving targets RBC traveling with in the blood vessel

Source & Receiver of sound – Ultrasound Transducer

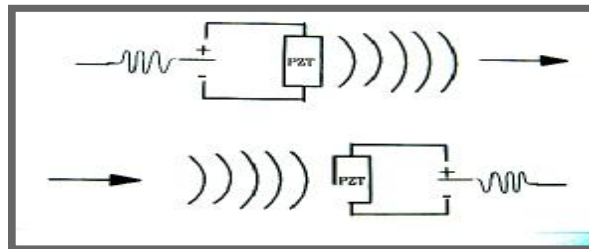




Transducer – device converts one form of energy to another :

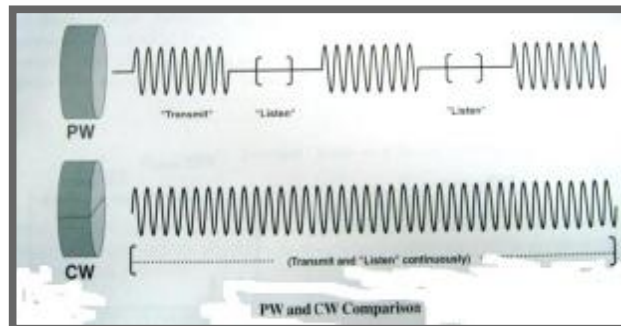
Ultrasound Transducer:

- 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)



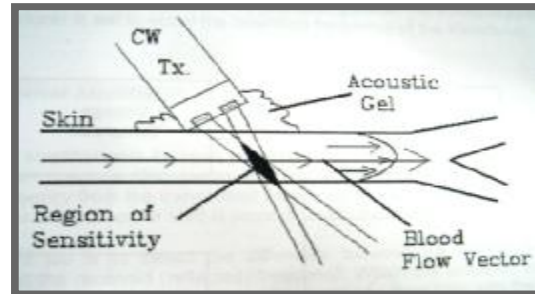
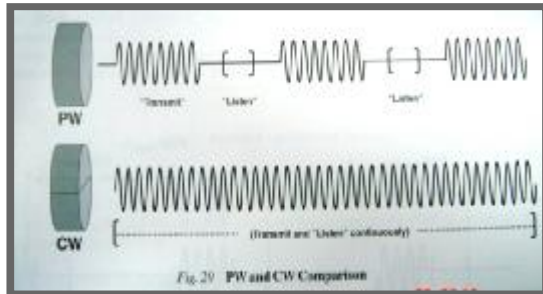


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Continuous Wave Doppler:



Doppler transducer Transmit continuously ultrasound & Receive simultaneously.

■ Have two Piezoelectric crystals, one Transmit & other Receive.

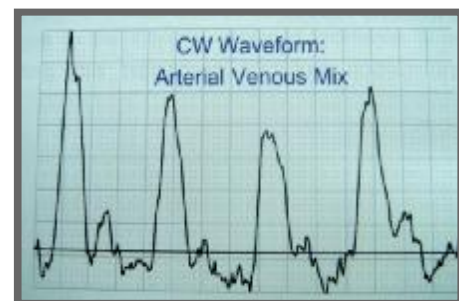
■ Advantage :

Ø magnitude of detectable velocity – limitless.

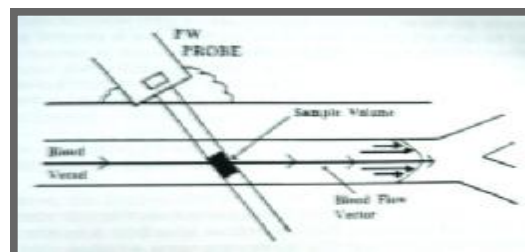
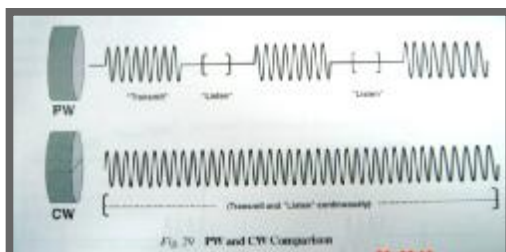
■ Disadvantage :

Ø Not specific for depth

Ø Detects any & all vessels in beam path.



Pulse Wave Doppler :





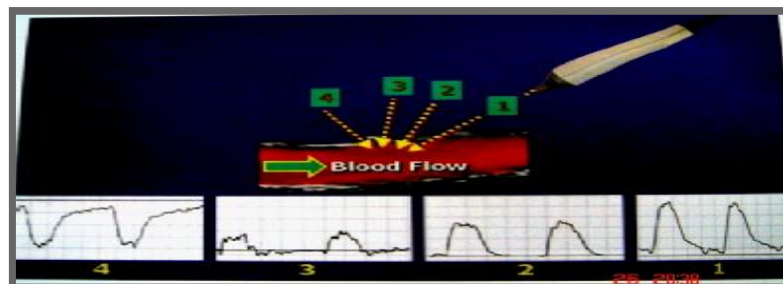
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- Single piezoelectric crystal – both transmission & reception.
- Alternate pulses On & Off.
- Transmit pulse – system waits – pulse travels to sample volume (specific area) – echo pulse returns
- Advantages
 - Specific for depth & range.
 - No mixture of signals like CW Doppler.
- Disadvantage
 - 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'
- Smaller Doppler angle higher the frequency shift.
- Optimal Doppler signals –transducer angle 45-60 towards direction of flow.

Arterial Assessment – Doppler ultrasound :

- Audible interpretation
 - Ø Waveform analysis
 - Ø Hand held Doppler
- Normal Peripheral
 - Ø arterial Doppler signal
 - Ø TRIPHASIC



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TRIPHASIC ARTERIAL SIGNAL :

■ 1st sound – phase

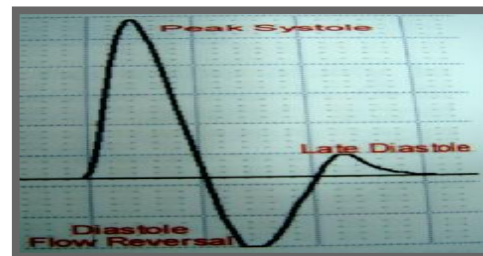
large, high velocity, forward flow, systolic component.

■ 2nd sound – phase

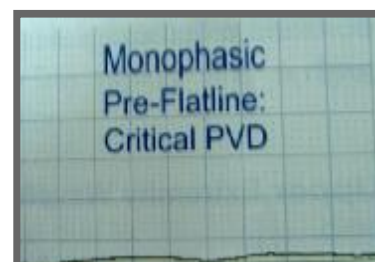
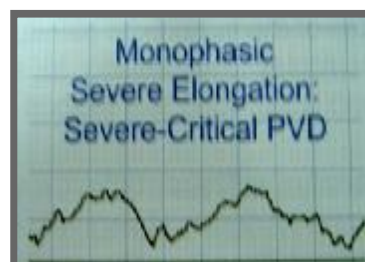
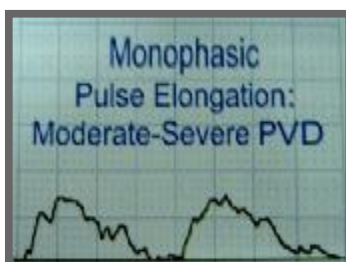
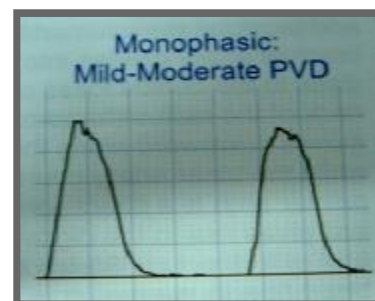
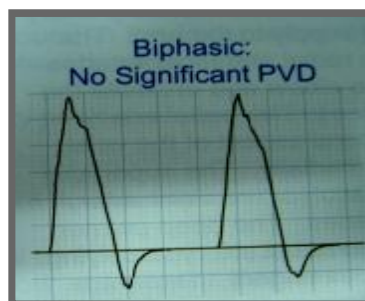
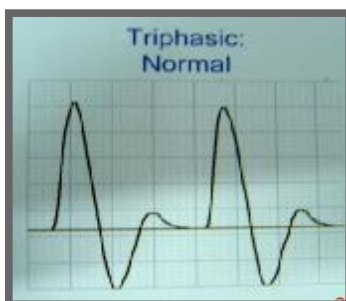
smaller reverse flow early diastole

■ 3rd sound – phase

smaller forward flow late diastole



Audible interpretation & Wave form analysis:





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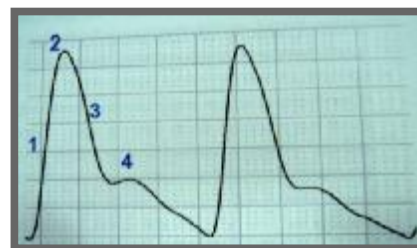
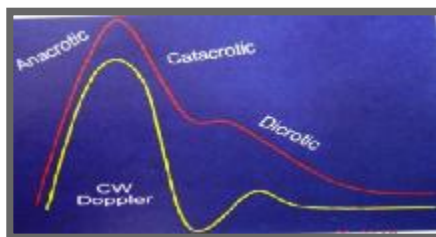
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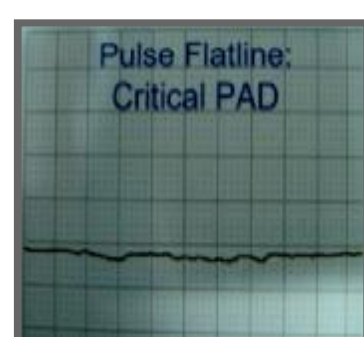
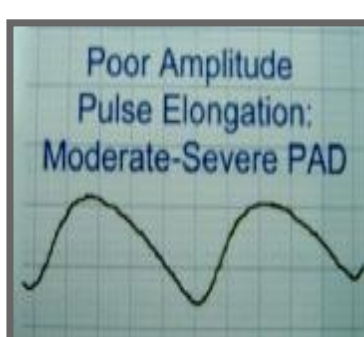
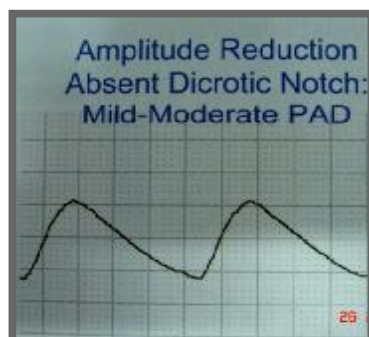
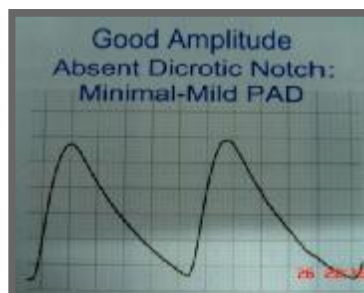
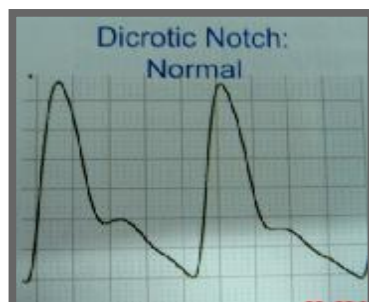
PVR (Pulse Volume Recording) :

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 .



PVR (Pulse Volume Recording) :





Arterial Pressure measurements :

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 & waveforms – low ABI.
- Stress testing – severity of claudication & to rule out pseudoclaudication

Contraindication to pressure measurements :

- Acute DVT
- Bandages & casts
- Ulceration
- Trauma
- Surgical site .

Ankle Brachial Index (ABI) :

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





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- Record bilateral systolic brachial pressure & systolic Ankle pressure (dorsalis pedis & post.tib art)
- Interpretation-Ratio highest ankle to brachial pressure.

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



Toe Pressure :

- Normal toe pressure – 2/3rd systolic ankle pressure
- Plethysmographic device –records changes in volume (used as sensor).
- Inflate cuff above 2/3rd of ankle pressure.
- BP cuff (2.5cm) around base of toe.
- Gradual deflate until arterial tracing demonstrate return of pulsatile flow – recorded as systolic toe pressure.

Segmental Pressure :

- 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



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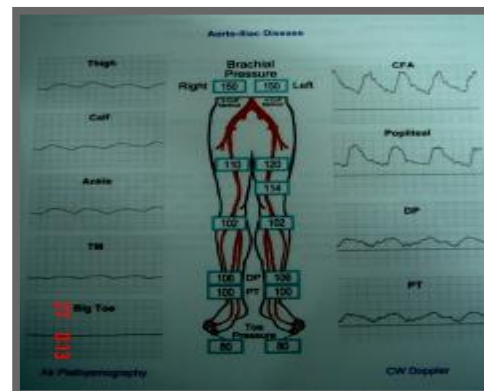
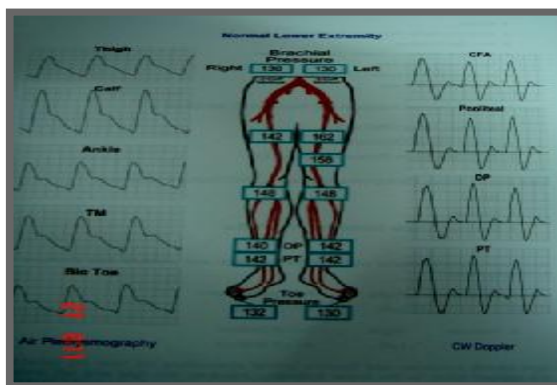
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Segmental Pressure

- Gradient >30mmofHg

Hemodynamically significant disease between adjacent levels.



Exercise Test (StressTest):

- Thread mill 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 & arm.
- Walk at 2mph at 12% gradient-5mnts or point claudication symptoms.
- Return supine position & measure ankle pressure 30secs & 1mnt post exercise.
- Measure till baseline pressure recovered.



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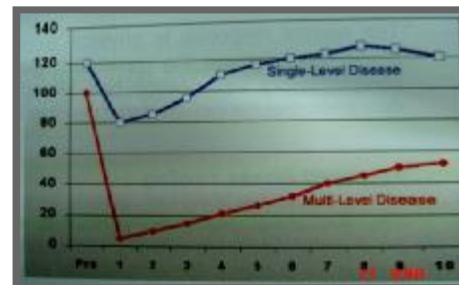
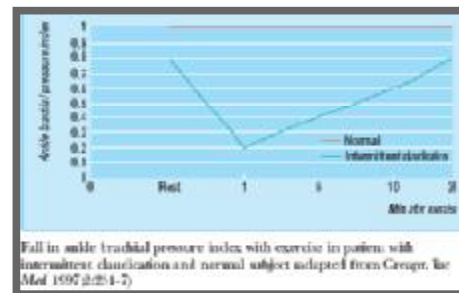
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Note:

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

Interpretation:

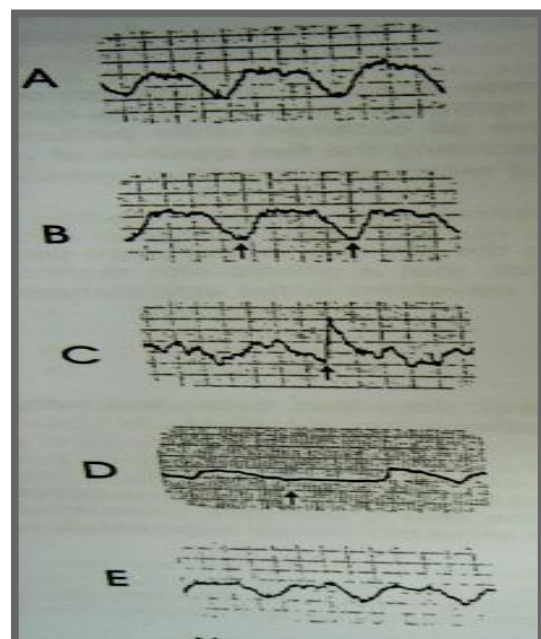
- Normal :no drop in ankle pressure.
- Minimal disease: pressure returns to baseline in 2mnts
- Single level disease
pressure returns to baseline in 3-5mnts.
- Multi level disease
pressure returns to baseline >10mnts



Doppler assessment of Veins :

Five qualities of normal Venous flow:

- A - Spontaneity
- B - Phasicity
- C - Augmentation
- D - Valvular competence
- E - Non pulsatility





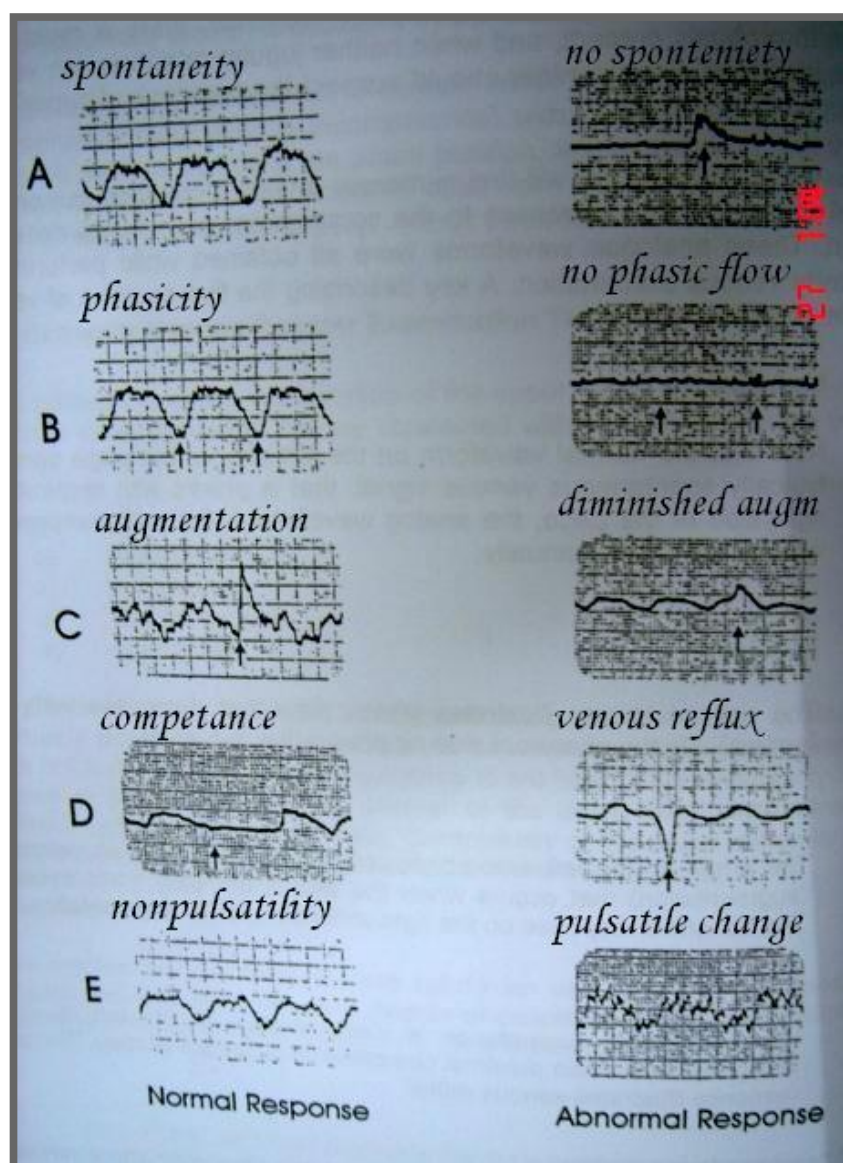
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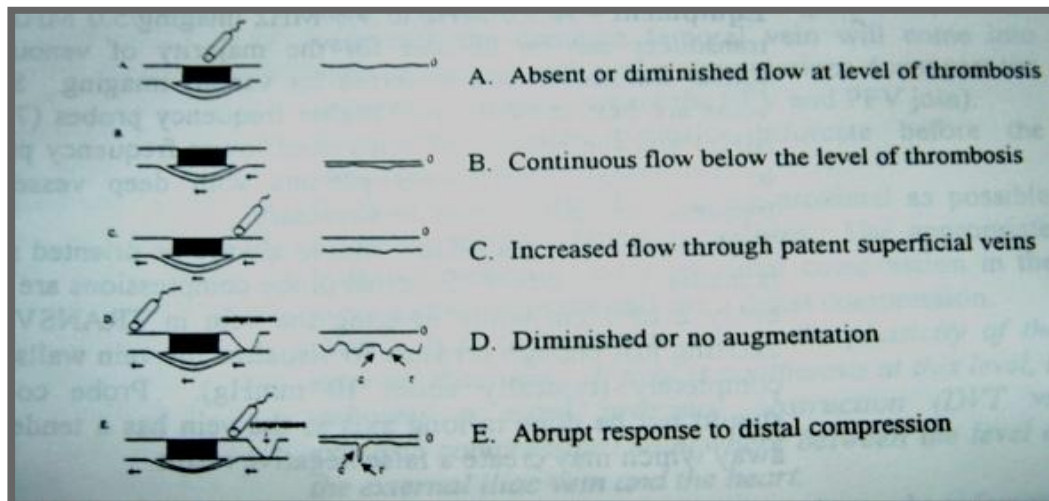
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■ In cases of DVT :

- Normal five qualities of
- Venous flow are lost





Ultrasound Imaging :

Imaging Principles

Amplitude mode

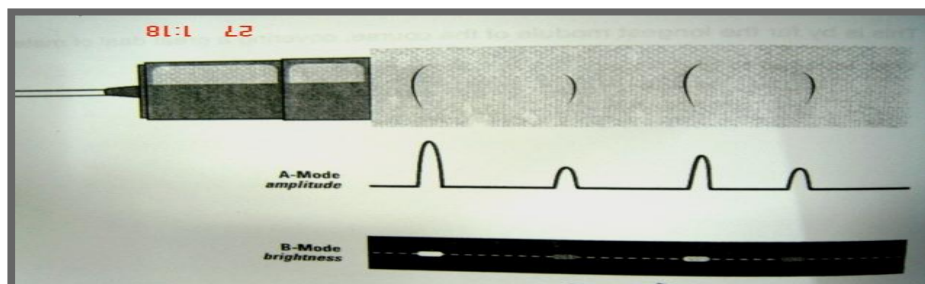
(A-mode)

method of presenting returning echoes of US on a display Screen .

- displayed as vertical deflections or spikes, projecting from baseline.
- Stronger echoes-higher amplitude signals .

B-mode :

- Brightness mode Returning echoes displayed as series of dots.
- Position of each dot corresponds to distance from the sound source .
- Brightness corresponds to amplitude of returning echo – Gray scale intensity.





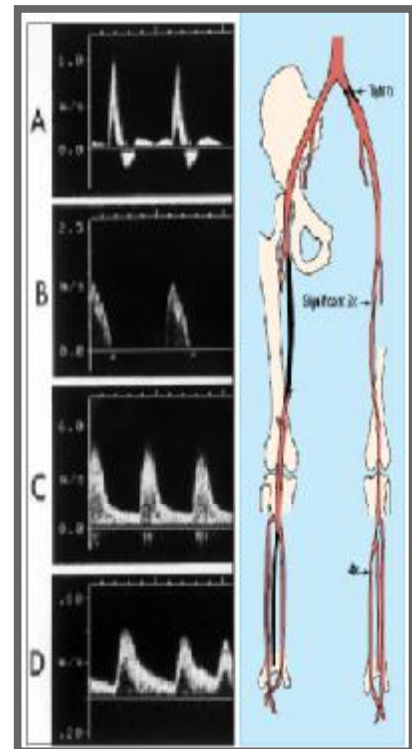
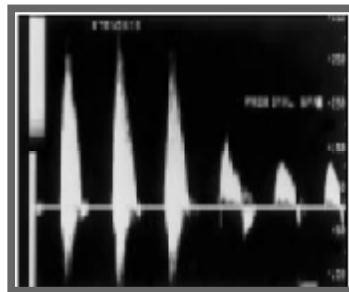
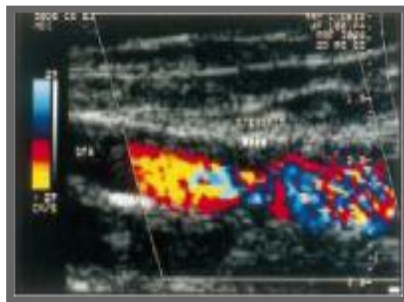
Duplex Scan :

- Combination of B-mode imaging with pulsed Doppler US – gives both anatomical & physiological information of vascular system .
- Addition of colour frequency mapping – Colour Duplex imaging .

Uses of colour duplex imaging:

Arterial duplex :

- Identify obstructive or aneurysmal atherosclerotic disease
 - Ø peripheral arteries
 - Ø carotid arteries
 - Ø renal & visceral arteries
- Surveillance of by pass grafts.



Venous Duplex :

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



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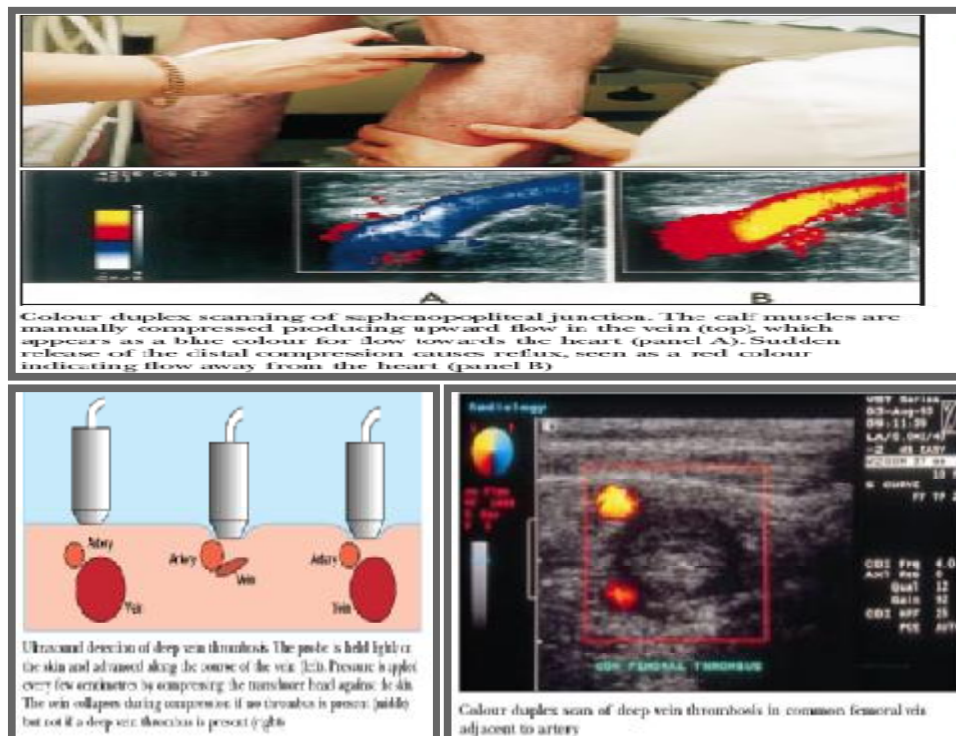
Criteria for Duplex examn. Of venous system :

Normal

- Easily compressible
- Should be echo free
- Normal valve motion
- Normal Doppler signals

Abnormal (DVT)

- Non compressible
- Echogenic thrombus in vein
- Incompetant valves
- Absent Doppler signals





Arteriography :

- Gold Standard.
- Good resolution.
- Seldinger technique .
- Access –commonly femoral artery & brachial artery .
- Inject iodinated contrast.
- Two types of contrast :
 - Ionic or high osmolar
 - Non ionic or low osmolar .

Ionic or High Osmolar Contrast :

- Water soluble
- Hypertonic, osmolality 5-10 times of blood.
- Causes discomfort at injection site.
- More nephrotoxic.

Non Ionic or Low Osmolar Contrast:

- Has same no of iodine ions ,no cations
- Osmolality 1/3rd of high osmolar contrast
- Still hypertonic twice that of plasma.
- Less nephrotoxic
- More expensive



Complications :

Local:

- Hemorrhage
- Thrombosis
- Pseudo aneurysm
- AV fistula
- Intimal dissection
- Embolization

General:

- Renal – nephrotoxicity
- Cardiac- hypertension, arrhythmias, CCF.
- Neurological – Carotid angiogram – TIA stroke, convulsions.
- Pulmonary-bronchospasm, pulm edema.

Allergic reaction to contrast :

- Minor – nausea, vomiting, head ache, chills, fever, itching.
- Intermediate - hypotension. urticaria, bronchospasm.
- Major-anaphylaxis, pul edema, laryngeal edema

Venogram :

- Ascending Venography
- Descending Venography



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 .

Decending venogram :

- Indication:
 - To distinguish primary deep venous valvular incompetence from thrombotic disease.
 - Identify level of deep venous reflux & morphology of venous valves.

Venographic categories of Deep vein reflux :

- Grade 0 – normal valve function noreflux
- 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.



Lymphedema :

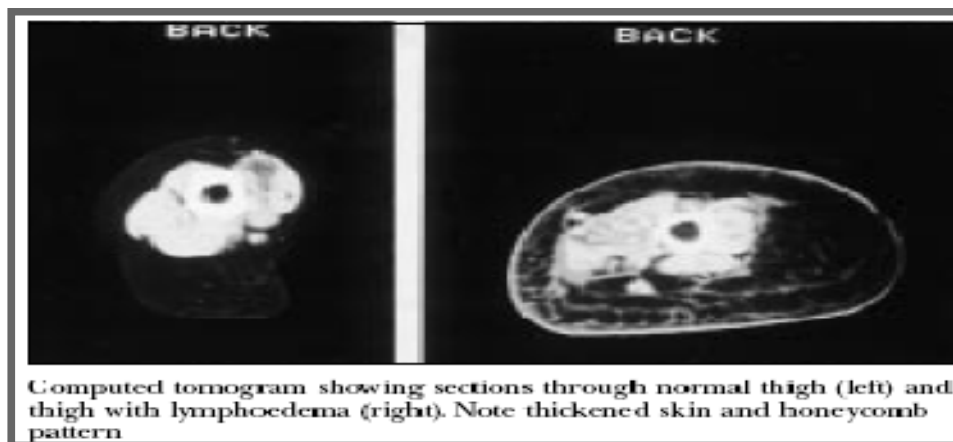
- Minimal invasive investigation to identify edema of lymphatic origin
- Lymphoscintigraphy
- CT & MRI

Lymphoscintigraphy:

- Isotope Lymphography
 - Radiolabelled Colloid or Protein injected 1st web of foot .
 - Gama Camera monitoring of tracer uptake.
- 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.

CT & MRI :

Honeycomb pattern in the subcutaneous compartment, characteristic of lymphedema .



Computed tomogram showing sections through normal thigh (left) and thigh with lymphoedema (right). Note thickened skin and honeycomb pattern



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Direct contrast X Ray lymphography :

- Lymphangiography
- 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.

Other Modalities of Vascular Investigations :

- CT, CTAngiogram .
- MRI, MRAngiogram .

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