

# 430 SURGERY TEAM



## Vascular Investigations

**Maysoon AlHaizan**

Green: Doctor's notes & explanation during the lecture.

Blue: Further explanation & team's notes.

Red: important notes.

## VASCULAR DISEASE IS THE TERM THAT DESCRIBES BLOOD VESSEL DISEASES:

Blood vessels are the series of tubes that are used to pump blood throughout the body. There are three 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, intestines, kidneys, arms, legs and the heart itself. When disease occurs in the arteries, it is called arterial disease. Veins return blood back to the heart from all parts of the body. When disease occurs in the veins, it is called venous disease. Lymphatics are a third type of blood vessel that returns fluid from the skin and other tissues to the veins.

### Vascular diseases :

- **Arterial:** such as **Aortic dissection** which is caused when the inner layer of the aortic wall tears and then peels or separates away from the next layer or **arterial occlusion**.. a lot of patients come with arterial occlusive diseases) **acute:** ischemia , **chronic:** intermittent claudication or **dilatation (arterial aneurysmal disease)** .. etc.
- **Venous: 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 all-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.
- **Lymphatic**

### Types of investigations:

- Invasive in vascular surgery invasive procedures are the gold standard
- Non invasive

### Non-Invasive Vascular Tests

Utilizes instrument: Utilizes the sound energy

#### 1) Doppler Ultrasound:

- Sound: longitudinal mechanical wave of any frequency.
- **Audible Sound:** ranges from **20-20,000** cycles/sec. (20Hz-20kHz)
- **Ultrasound:** 'Ultra' means 'above' human hearing >20,000 cyc/sec. (20kHz).
- **Diagnostic Ultrasound:** **2MHz-12MHz.** (2million - 12million cyc/sec).  
More frequency → less penetration of the tissue e.g. for superficial structures  
More frequency → better resolution

Less frequency → deeper penetration of the tissue e.g. abdominal investigation.

Less frequency → lesser resolution

**Doppler ultrasound is based on principle of Doppler effect/shift:**

Normally blood vessels contain moving blood if there's a block it'll stop moving

- **Ultrasound interaction with stationary object:**

No frequency change.

No Doppler effect or shift.

Sound won't be heard

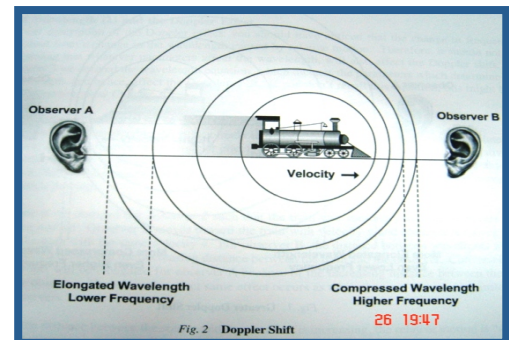
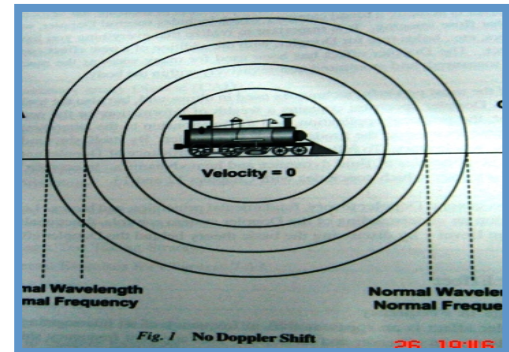
- **Ultrasound encounters moving object:**

Doppler Effect or Shift occurs.

Change perceived frequency of

Ultrasound emitted by moving object.

Sound will be heard ( 3 voices )

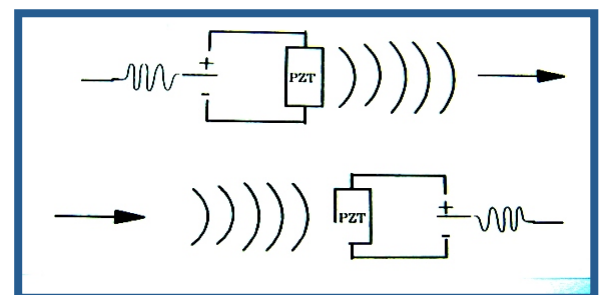
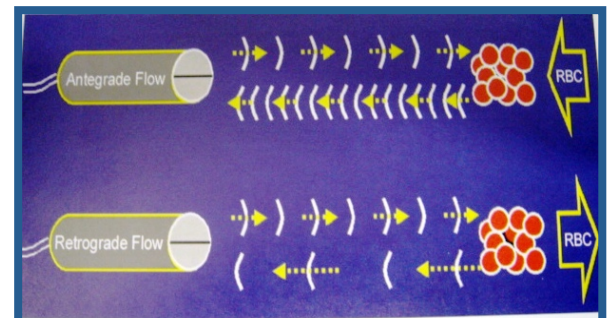


**In clinical practice:** moving targets are **RBC's** traveling with in the blood vessel

We transmit X frequency and receive Y frequency.. These are utilized to know if blood is moving properly or no.

**Source & Receiver of sound:** Ultrasound Transducer uses the crystals that have the ability to change the form of energy from electrical to mechanical or ultrasound.

**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
- Pulse wave

**Continuous Wave (CW)** the pocket Doppler the one the doctor used.

- Doppler transducer Transmit continuously ultrasound & Receive simultaneously.
- Have **two piezoelectric crystals**, one Transmit **X** & other Receive **Y**.

#### Advantage

- Magnitude of detectable velocity, limitless.

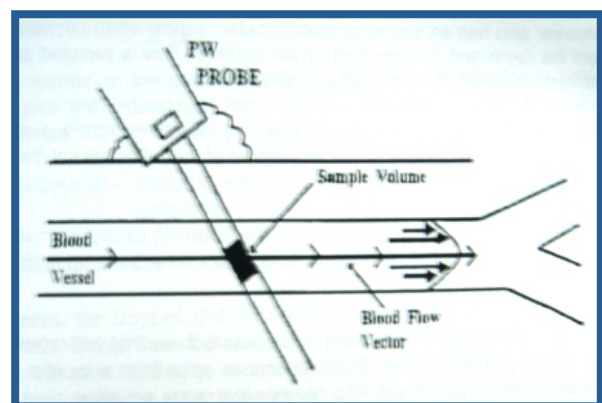
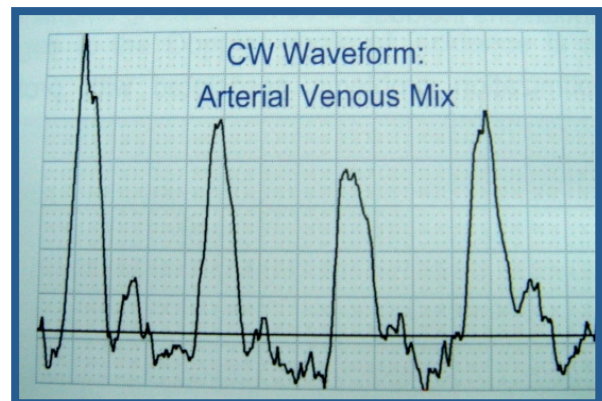
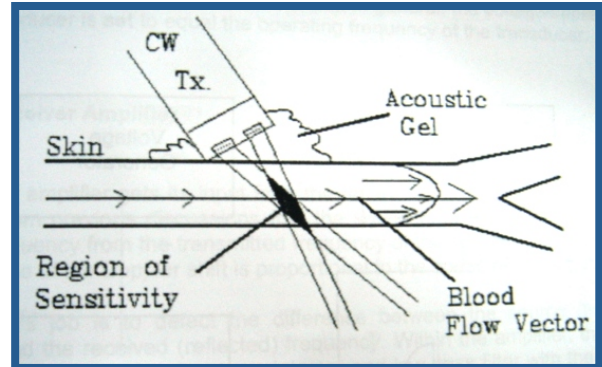
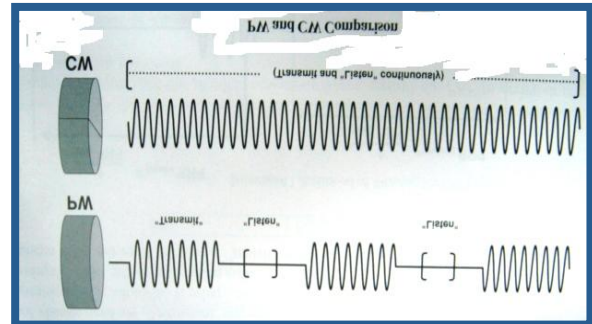
#### Disadvantage

- **Not specific for depth**
- **Detects any & all vessels in beam path.**

It's not specific; it does not give a specific area or structural picture of the vessels. It only gives the anatomical location in general.  
(Gives a rough idea)

**Pulsed Wave (PW)** more advanced

- **Single piezoelectric crystal** – both transmission & reception.
- Alternate pulses On & Off.
- Transmit pulse – system waits – pulse travels to sample volume (specific area) – echo pulse returns

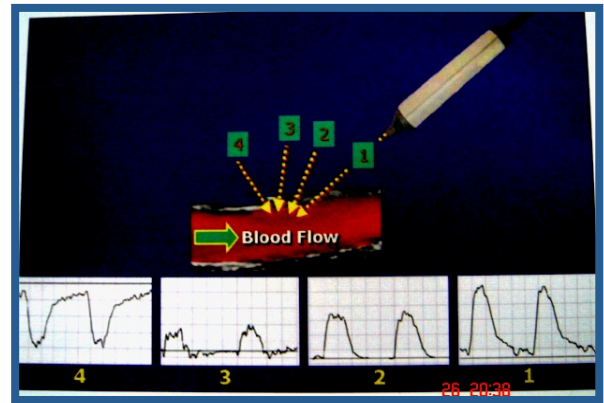




### Angle of Incidence

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

The smaller the angle the higher the frequency

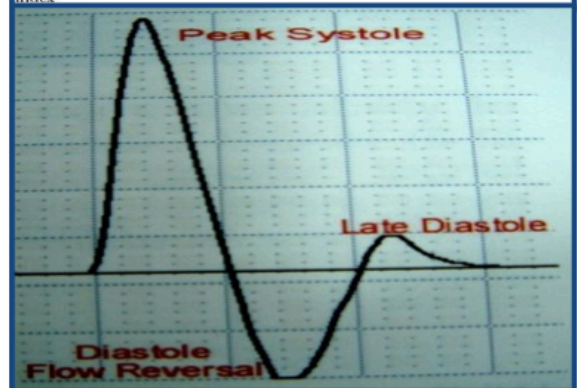


### Arterial Assessment - Doppler ultrasound:

- ***Audible interpretation***  
Use Waveform analysis  
Hand held Doppler
- ***Normal Peripheral***  
Arterial Doppler signal



Handheld pencil Doppler being used to measure ankle brachial pressure index

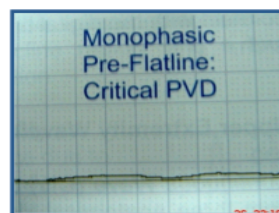
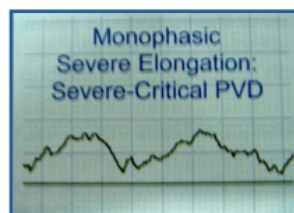
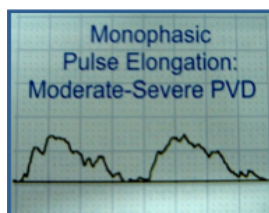
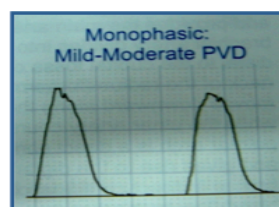
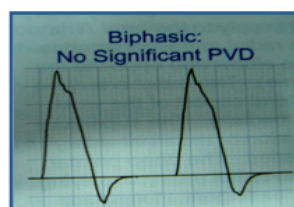
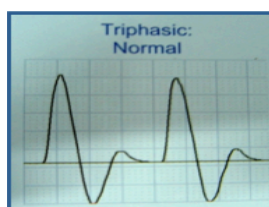


### TRIPHASIC

#### **TRIPHASIC ARTERIAL SIGNAL**

- **1<sup>st</sup> sound** – phase large, high velocity, forward flow, **systolic** component.
- **2<sup>nd</sup> sound** – phase smaller reverse flow early **diastole**
- **3<sup>rd</sup> sound** – phase smaller forward flow late **diastole**

### *Audible interpretation & Wave form analysis:*



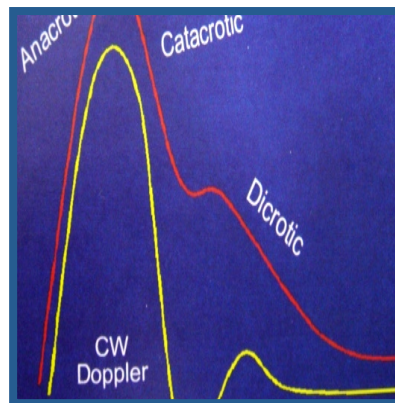
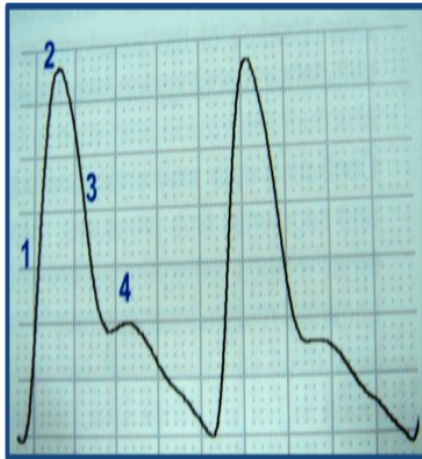
Triphasic : normal

Monophasic :  
peripheral arterial  
disease

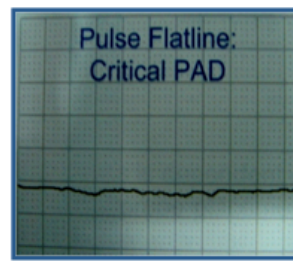
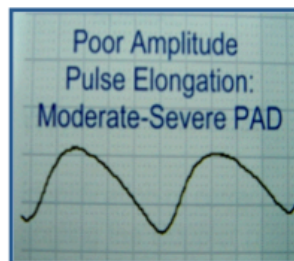
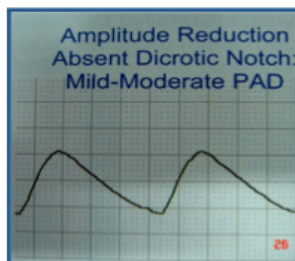
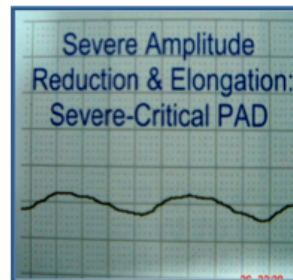
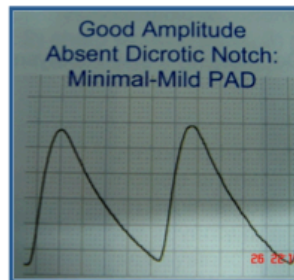
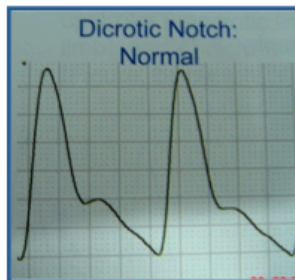
## PVR (Pulse Volume Recording)

### **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:

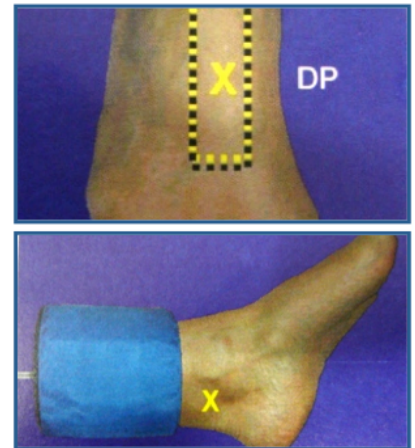
For Peripheral arterial occlusive disease.

### *Sequence of pressure measurement tests:*

- Systolic Brachial & Ankle pressure at rest
- **Calculation of ABI**
- Toe pressure-non compressible tibial arts
- Segmental pressure & waveforms – low ABI.
- Stress testing – severity of claudication & to rule out pseudoclaudication

### *Contraindication to pressure measurements:*

- Acute DVT closure of veins makes it worse
- Bandages & casts
- Ulceration
- Trauma
- Surgical site



**Ankle Brachial Index (ABI) : it's the ratio of ankle systolic pressure to brachial systolic pressure**  
**Ankle pressure is higher than the brachial pressure due to Gravity**

### *Before testing:*

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



### *When testing:*

- 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 (mcq)**
- 0.75 – 0.96 Mild PAOD
- 0,50 – 0.74 Moderate



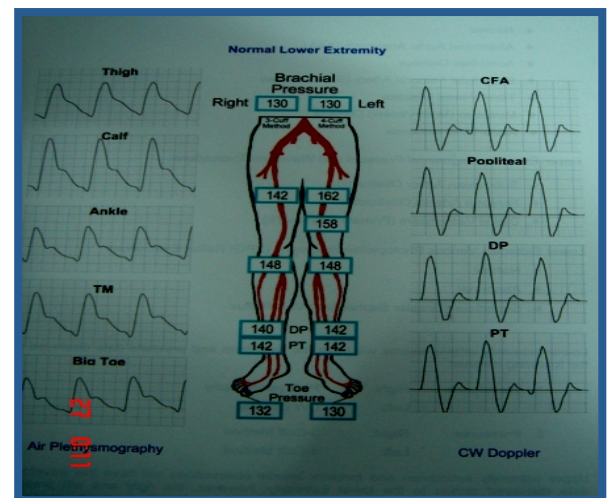
- <0.5      Severe
- <0.3      **Critical**
- >1.5      **Vessels non compressible ( DM , elderly , renal failure arteries are calcified )**

### Toe Pressure:

- **Normal toe pressure 2/3<sup>rd</sup> systolic ankle pressure**
- Plethysmographic device –records changes in volume (used as sensor).
- Inflate cuff above 2/3<sup>rd</sup> 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

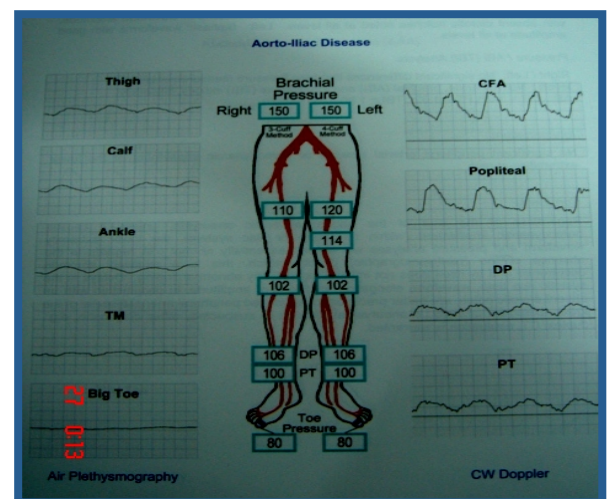
### Segmental Pressure:

- 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**



- **Gradient >30mmofHg**

**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)



**Exercise Test (Stress Test) :** same principle as ECG, measure at rest and at stress.

- 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

**Note: imp**

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

### Interpretation:

- **Normal:**

No drop in ankle pressure.

- **Minimal disease:**

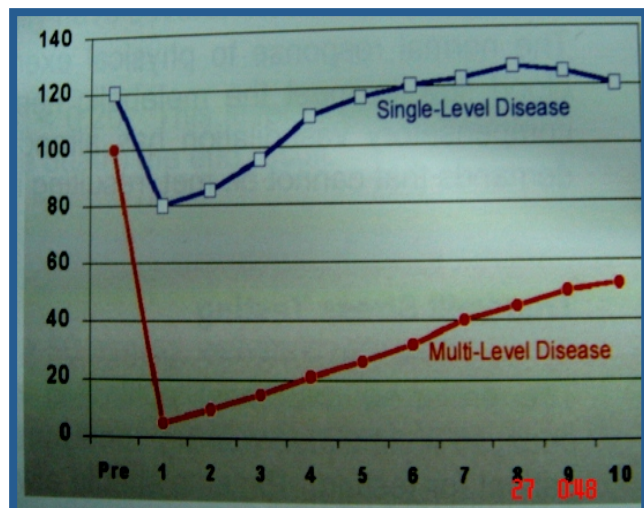
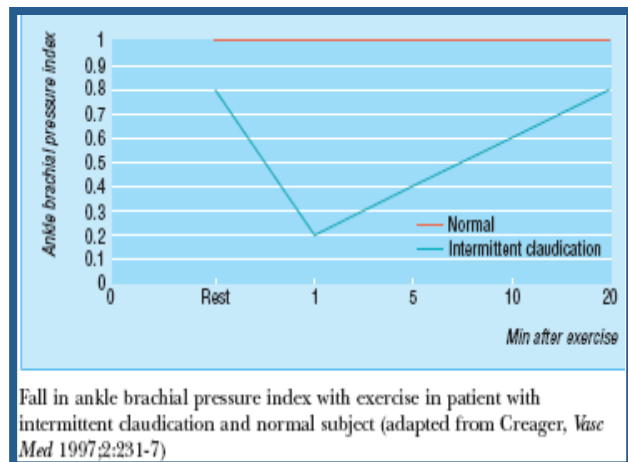
Pressure returns to baseline in 2mnts

- **Single level disease**

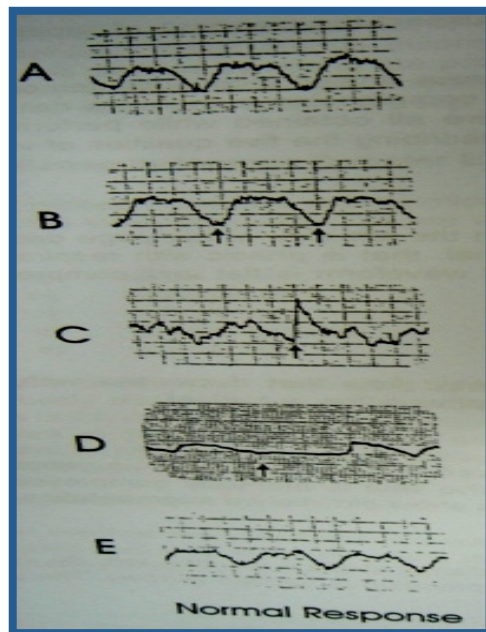
Pressure returns to baseline in 3-5mnts.

- **Multi level disease**

Pressure returns to baseline >10mnts



## Doppler assessment of Veins:

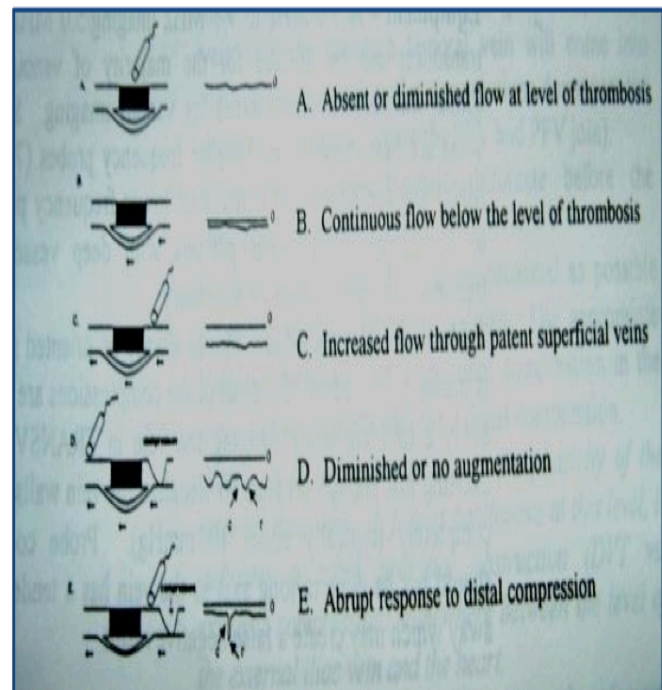
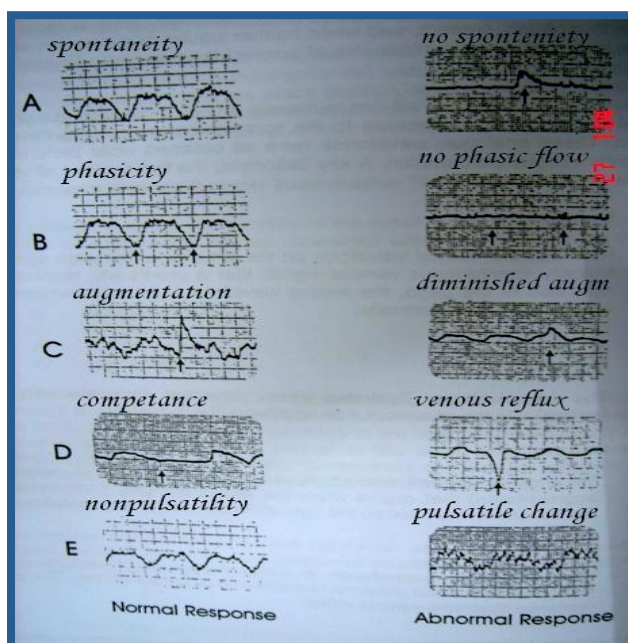


### **Five qualities of normal Venous flow:**

- A : Spontaneity ..
- B : Phasicity .. With respiration it changes because in inspiration no flow because there's no venous return, expiration increases in venous flow.
- C : Augmentation
- D : Valvular competence
- E : Non pulsatility Arterial flow: pulsatile triphasic like while Venous flow: wind like

### **In cases of DVT:**

Normal five qualities of venous flow **are lost .. because the vein is closed there will be no sound ..**



**second non-invasive ..**

## 2) Ultrasound Imaging Duplex

### Imaging Principles

Amplitude mode (A-mode) method of presenting returning echoes of US on a display screen

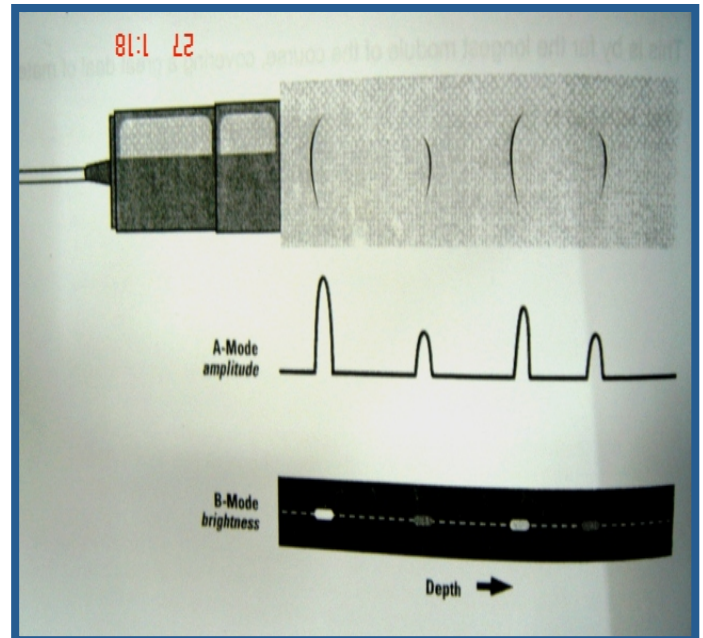
#### **A-mode:**

- 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 → **duplex scan**
- Addition of **color** frequency mapping → **Color Duplex imaging**

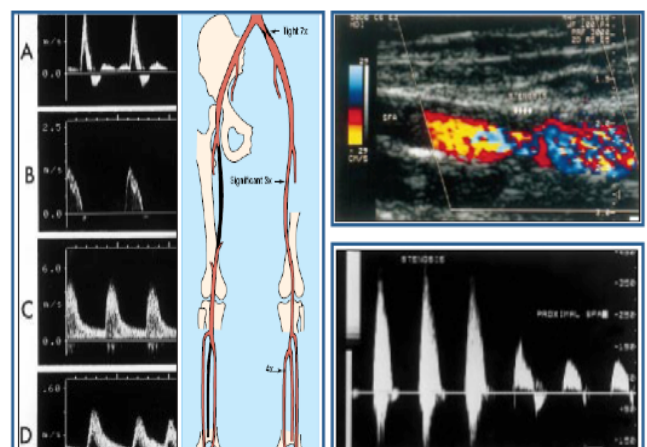
#### **Uses of color duplex imaging:**

##### **1) Arterial:**

##### **A. Identify obstructive or aneurysmal atherosclerotic disease**

- Peripheral arteries
- Carotid arteries
- Renal & visceral arteries

##### **B. Surveillance of by pass grafts.**



## 2) 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

### Criteria for Duplex examination Of venous system:

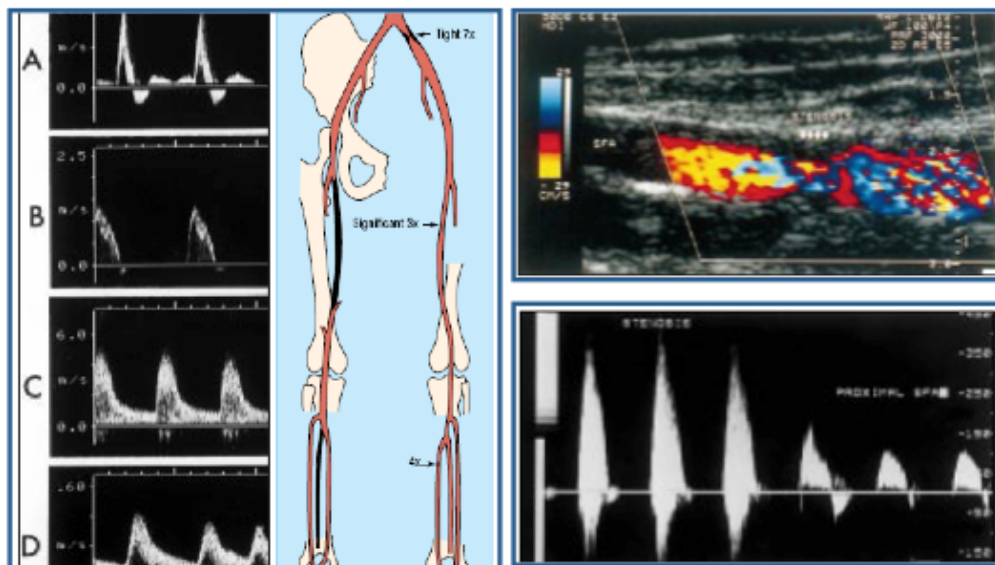
#### Normal:

- Easy compressible
- Should be echo free
- Normal valve motion
- Normal Doppler signal

#### Abnormal (DVT)

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

### Venous duplex :



### INVASIVE INVESTIGATIONS

#### Arteriography:

- Gold Standard.
- Good resolution.
- Seldinger technique
- Access → commonly femoral artery & brachial artery easiest accessible artery , least complications with larger arteries , never access small arteries .



- Inject iodinated contrast **into the catheter you inserted in the large artery**
- **Two types of contrast**
  - A. Ionic or high osmolar
  - B. 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. More complications**

***Non Ionic or Low Osmolar Contrast : commonly used***

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

***Complications: very important!***

***Local:***

- Hemorrhage
- Thrombosis
- Pseudo-aneurysm **is a pulsatile swelling around the artery due to leaking of blood no dilatation of vessel.**
- 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, headache, chills, fever, itching.
- Intermediate - hypotension. urticaria, bronchospasm.
- Major-anaphylaxis, pulm edema, laryngeal edema

Venogram : we do when we're not sure of US results

***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. (Dooplex)
- 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:** same as previous + thrombophlebitis

***Descending Venography:***

***Indication:*** to assess the competency of the valves

- 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 : more advanced to know***

- **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.

Lymphedema:

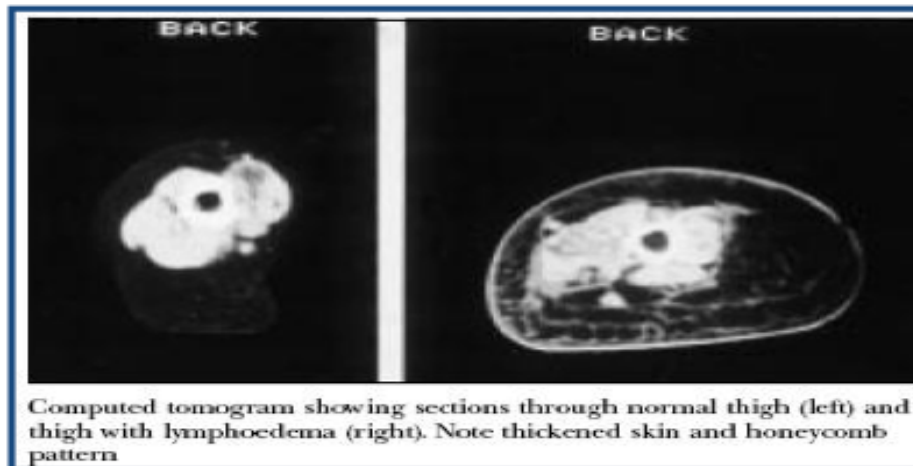
Accumulation of lymph in the limbs

Minimal invasive investigation to identify edema of lymphatic origin

## ***Lymphoscintigraphy***

### ***CT & MRI***

Honeycomb pattern in the subcutaneous compartment, characteristic of lymphedema



### ***Lymphoscintigraphy : asses the lymphedema by 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

### ***Direct contrast X Ray lymphography***

- Lymphangiography **not used now**
- 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*** **minimally invasive procedures**

- CT, CT Angiogram
- MRI, MR Angiogram

### **Important notes :**

Person with abdominal aortic **aneurysm** what's the best for **diagnostic and surveillance** purpose → non-invasive 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** purpose → **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 diagnosis lymphatic vessels or lymphedema** → **lymphoscintigraphy** (not lyphangiography) sometimes MRA magnetic resonant angiogram (minimal invasive )

MRV → venogram (not used because it needs a special software)

Best of luck