HEMODYNAMIC MONITORING-PART I

Introduction 00:00:16

- Body here Cardiovascular organ dysfunction : 2nd most common organ dysfunction.
- Continuously observing changes in physiologic variables :
  1. To monitor organ function.
  2. For prompt therapeutic interventions.
  3. To evaluate response to therapeutic interventions.
- Monitoring per se not improve patient outcomes.
- Timely applied right interventions can do.

Assessing global and regional perfusion 00:01:19

Initial steps :

1. Clinical assessment.
2. Basic monitoring and assessment of global perfusion.
3. Preload monitoring and fluid responsiveness.

Advanced monitoring measures :

1. Cardiac output monitoring.
2. Assessment of cardiac contractility.
3. Assessment of tissue perfusion.

Step 1 : Clinical assessment

- Thirst.
- Cold extremities.
- Poor peripheral pulses.
- Impaired capillary refill.

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- Tachypnoea, tachycardia.
- Confusion.
- Altered skin perfusion.
- Oliguria.

Skin mottling :

Important predictor of adverse outcome.

- Score 0 : No mottling.
- Score 1 : Small area of mottling, localised to centre of knee.
- Score 2 : Modest mottling area that does not extend beyond superior border of kneecap.

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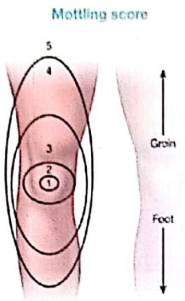
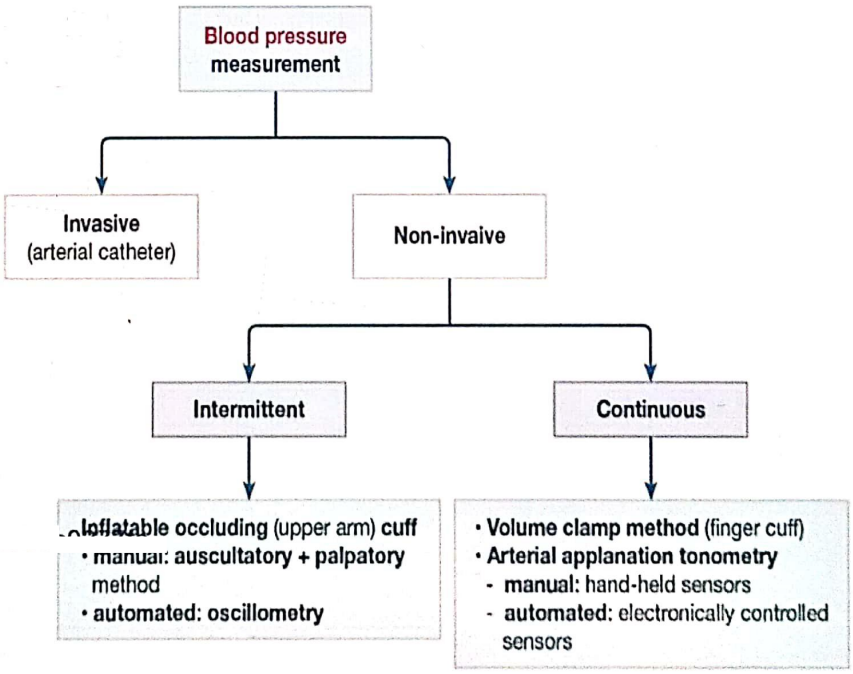
- Score 3 : Mild mottling area that does not extend beyond the mid-thigh.
- Score 4 : Severe mottling area, not going beyond the groin fold.
- Score 5 : Extremely severe mottling area, extending beyond groin fold.



Step 2 : Basic monitoring and assessment of global perfusion :

- 12 lead ECG.
- Blood pressure : Non invasive and Invasive.
- Pulse oximetry (SpO_2).
- Lactate levels.
- Biochemical variables.

Blood pressure monitoring :



NIBP : Intermittent

Manual intermittent	Automated intermittent
• Described by KOROTKOW 1905. • Sphygmomanometer, cuff, and stethoscope. • Auscultating sounds generated by turbulent arterial blood flow beyond cuff. • Systolic : First Korotkoff sound. • Diastolic : Before disappearance.	• Based on oscillometry. • Cuff is coupled to an oscillometer. • The cuff inflates above sustolic pressure. • Then gradually deflates. • MAP : pressure at peak amplitude of arterial pulsations. • SBP & DBP : Derived from proprietary formulas (rate of change of pressure pulsations).

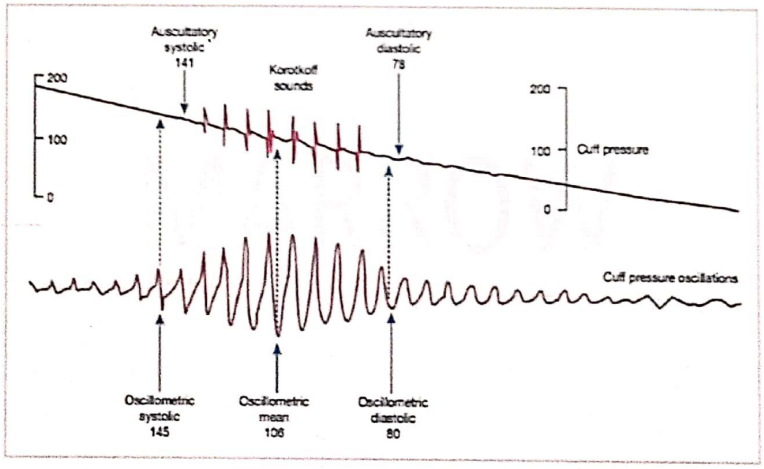
Cuff Size :

- Bladder length : 80% of arm circumference.
- Bladder width : 40% of arm circumference.
- Midline of cuff bladder should be positioned over the arterial pulsation.

BP Cuff size

Patient	Recommended cuff size
Adults (by arm circumference)	
22 to 26 cm	12 x 22 cm (small adult)
27 to 34 cm	16 x 30 cm (adult)
35 to 44 cm	16 x 36 cm (large adult)
45 to 52 cm	16 x 42 cm (adult thigh)

Comparison of blood pressure measurements via Korotkoff sounds and oscillometry :



CNAP : Continuous noninvasive arterial pressure

Volume clamp method (finger cuff) :

- Inflatable finger cuff with infrared plethysmography & monitor.
- Adjusts its pressure multiple times per second to finger artery constant.
- Produce a brachial arterial waveform.

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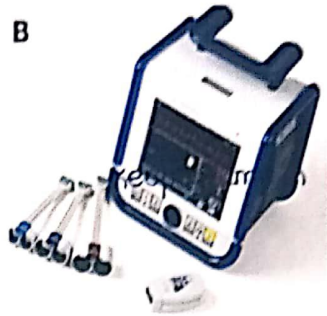
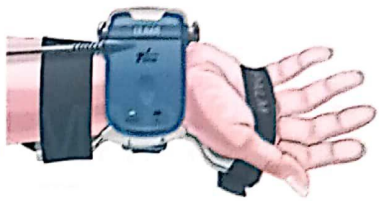
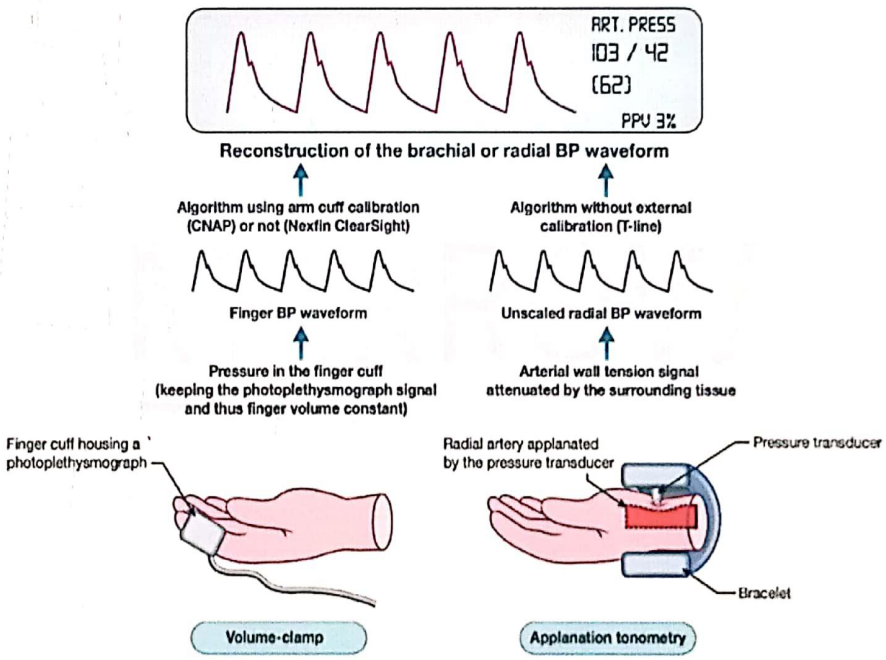


T- line system : Based on applanation tonometry :

- Radial artery applanation :
- A pressure sensor applied over radial artery :
  - Gently compresses artery : Applanates.
- The sensor is automatically moves over radial artery until optimal waveform is recorded.
- External applanation leads to reconstruction of BP waveform.
- mean BP measured directly (optimal waveform).



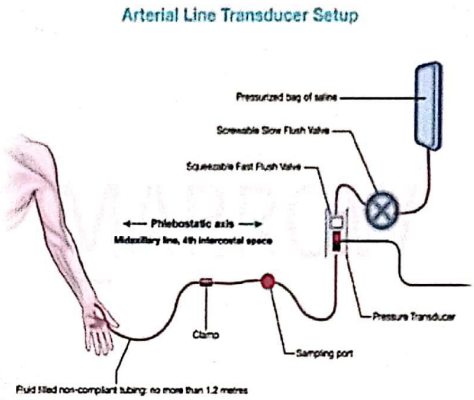
Oscillometric, volume-clamp, and applanation tonometry . technol arterial BP



Invasive blood pressure :

- Gold standard for BP monitoring :
  - Arterial cannulation.
  - Continuous pressure transduction.
  - Waveform display.

- Conventions :
  - Pressures expressed as mmHg.
  - Referenced to phlebostatic axis.
  - Zeroed to ambient pressure.



Invasive blood pressure : Indications.

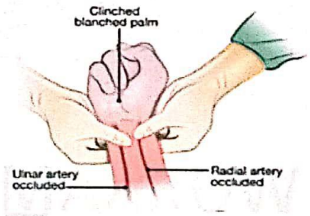
- Unstable blood pressure/severe hypotension.
- Use of rapidly acting vasoactive drugs : Vasodilators, vasopressors, inotropes.
- Frequent sampling of arterial blood.

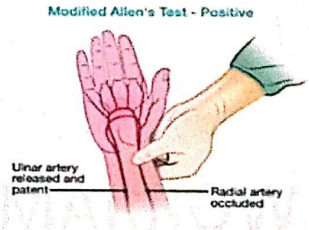
Relative contraindications : Invasive arterial pressure monitoring.

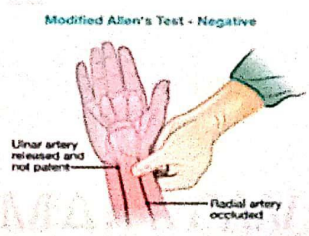
- Anticipation of thrombolytic therapy.
- Severe peripheral vascular disease preventing catheter insertion.
- Vascular anomalies : AV fistula, local aneurysm, local haematoma, Raynaud's disease.
- Lack of collateral blood flow distally (e.g. radial artery previously used for coronary artery bypass surgery).

Modified Allen test :

- Used to assess adequacy of collateral circulation.
- Reduced collateral flow when palm remains pale > 6 to 10 seconds.
- Disadvantage : Sensitivity (70-80%).







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Common sites :

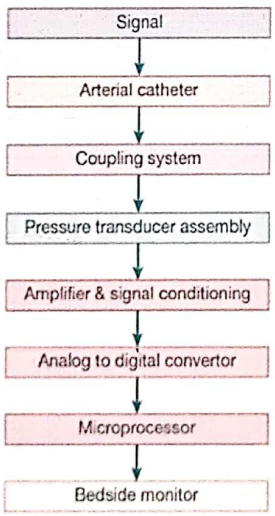
1. Radial.
2. Femoral.
3. Dorsalis pedis.
4. Posterior tibial.

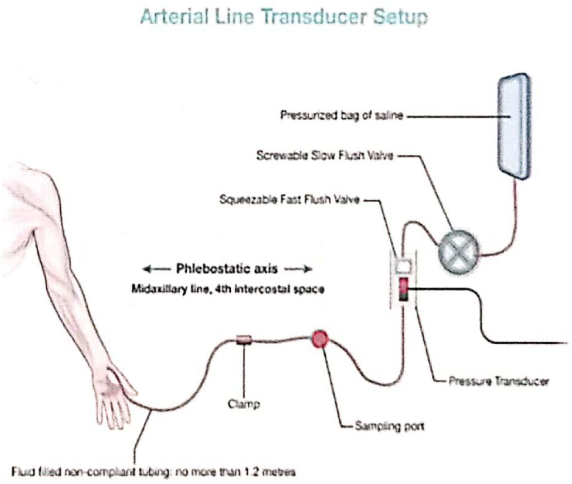
Complications of Direct Arterial Pressure Monitoring

Distal ischemia, pseudoaneurysm, arteriovenous fistula
Hemorrhage
Arterial embolization
Infection
Peripheral neuropathy
Misinterpretation of data
Misuse of equipment

Pressure Monitoring System :

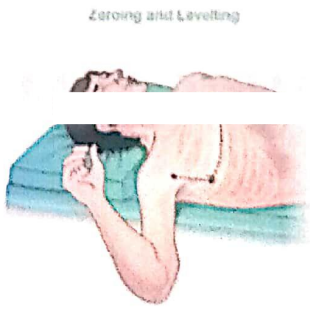
Pressure monitoring system





Zeroing & Levelling :

- At level of the right atrium : Levelling.
- Opening the transducer stopcock to atmosphere.
- Stopcock at level of midaxillary line 4th ICS : Flavostatic axis.
- With the stopcock open, monitor displays 0.



Fourier analysis of a complex waveform

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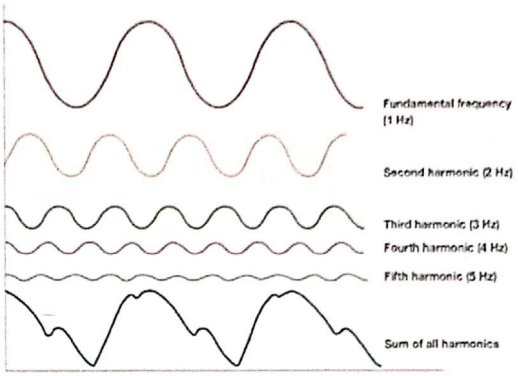
- Arterial waveform is a composite of many waveforms of increasing frequencies (harmonics).
- 8-10 harmonics.

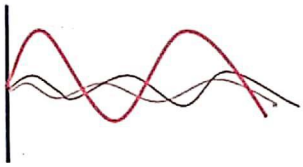


Natural frequency :

- Frequency at which a system oscillates.

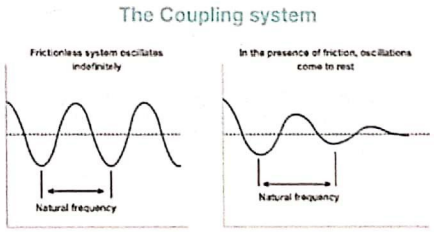
  Maximum diameter
  Minimum length
  Low Compliance

$$\text{Natural frequency } f_n = \frac{1}{2\pi}\sqrt{\frac{\pi D^2}{4\rho L}\cdot\frac{\triangle P}{\triangle V}}$$

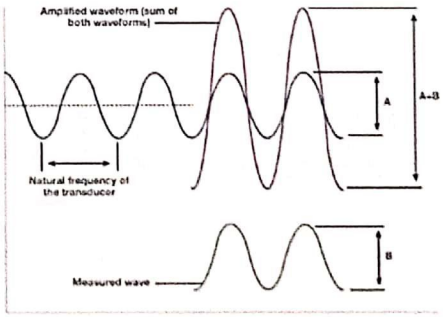


The Coupling system :

- Fluid between artery and transducer acts as simple harmonic oscillator :
  - Analogous to a pendulum.
  - When the pendulum is displaced, it undergoes simple harmonic motion : it oscillates around the equilibrium point.



- Resonance : Amplification of a signal
  - When it's frequency is close to natural frequency of a system.



- If natural frequency of pressure transducer matches with each peak of arterial pressure wave :
  - Increase amplitude of the measured values.
- Transducer system must have a natural frequency well above the 8th harmonic frequency of a rapid pulse :

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Damping :

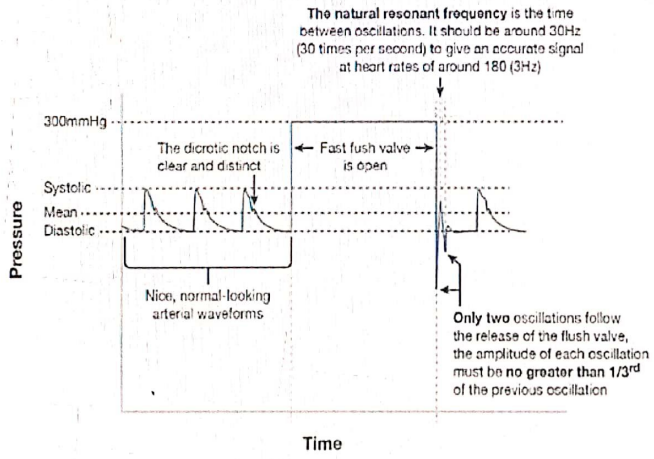
- Absorption of energy (amplitude) of oscillations :
  - Decreases amplitude of waves.
  - Reduces natural frequency of a system.
- Transducer system must be adequately damped :
  - Amplitude should not change due to resonance.
- Diameter of the tubing has the greatest effect on damping.
- Damping increases by third power of any decrease in tubing diameter.

Dynamic response :

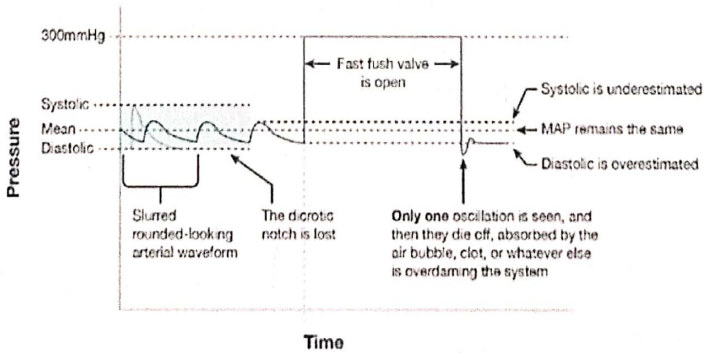
- Ability of the system to accurately reproduce hemodynamic waveform.

Natural frequency	Damping coefficient:
should be > highest frequency of the incoming pulsatile signal	How quickly an oscillating fluid filled system comes to rest
> 24Hz needed	**Fast flush test**

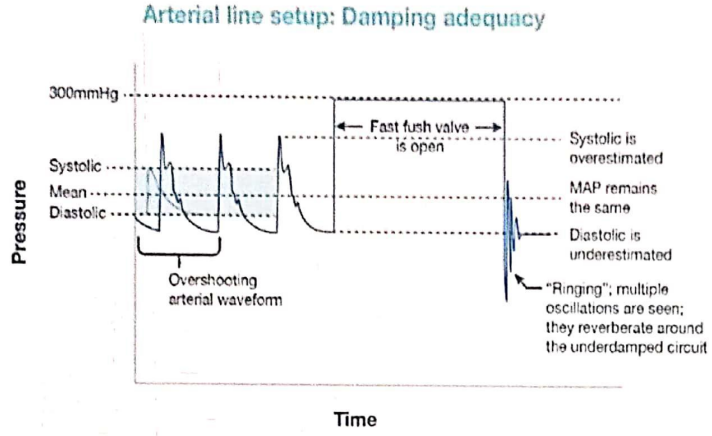
Arterial line setup : Damping adequacy



Arterial line setup: Damping adequacy

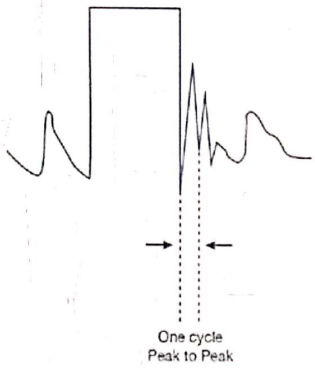


Clots, kinks, air bubbles, low compliant tubings, loose connection



Long tubing, hyperdynamic circulation, tachycardia, hypertension, atherosclerosis

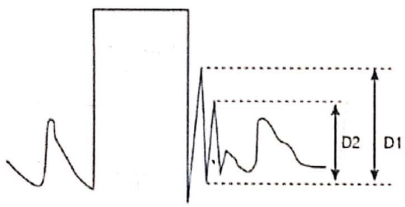
Determining fn :



$$f_n = \frac{\text{Paper speed (mm/sec)}}{\text{T (time of one cycle) mm}}$$

If t = 1.2 mm, f_n –

Amplitude Ratio :



Amp Ratio (D2/D1)	Damping coefficient
0.9	0.034
0.8	0.071
0.7	0.113
0.6	0.160
0.5	0.215
0.4	0.280
0.3	0.358
0.2	0.456
0.1	0.591
0.05	0.690