MEDICINE NEET SS

CRITICAL CARE

CONTENT

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.

→

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

Skin mottling :

Important predictor of adverse outcome.

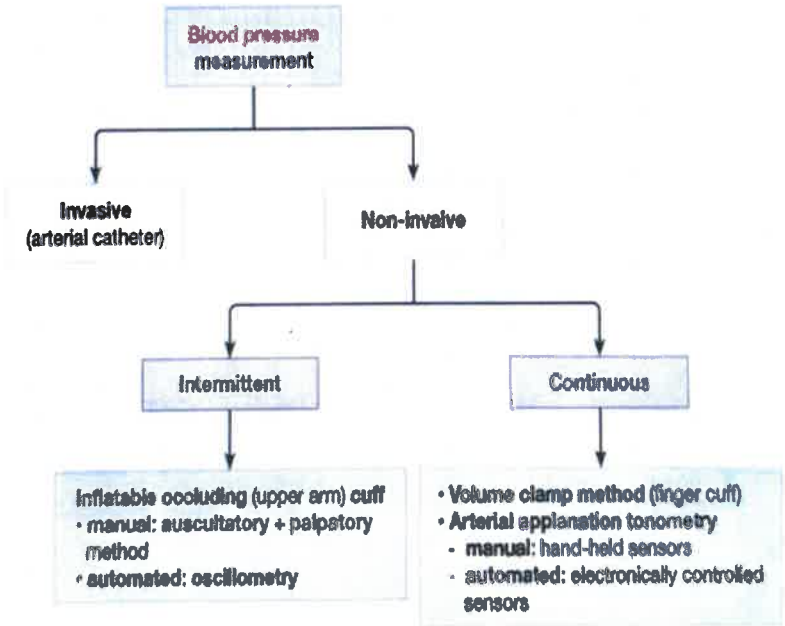
- Score 0 : No mottling.
- Score 1 : Small area of mottling, localised to centre of knee.
- Score 2 : modest mottling area that does not extend beyond superior border of kneecap.

- 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 systolic pressure. • Then gradually deflates. • MAP : pressure at peak amplitude of arterial pulsations. • SBP & DBP : Derived from proprietary formulas (rate of change of pressure pulsations).

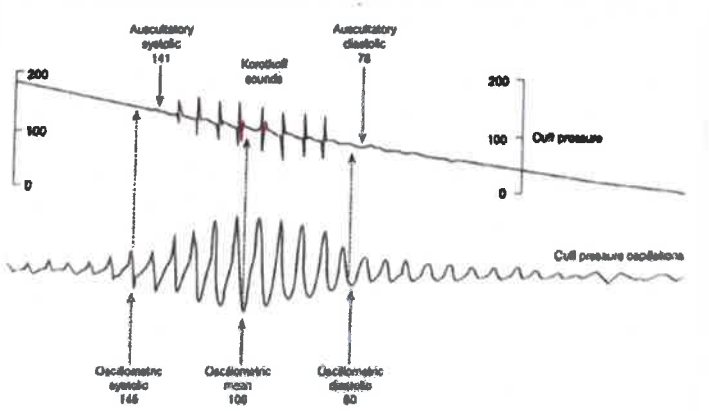
Cuff Size :

- 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

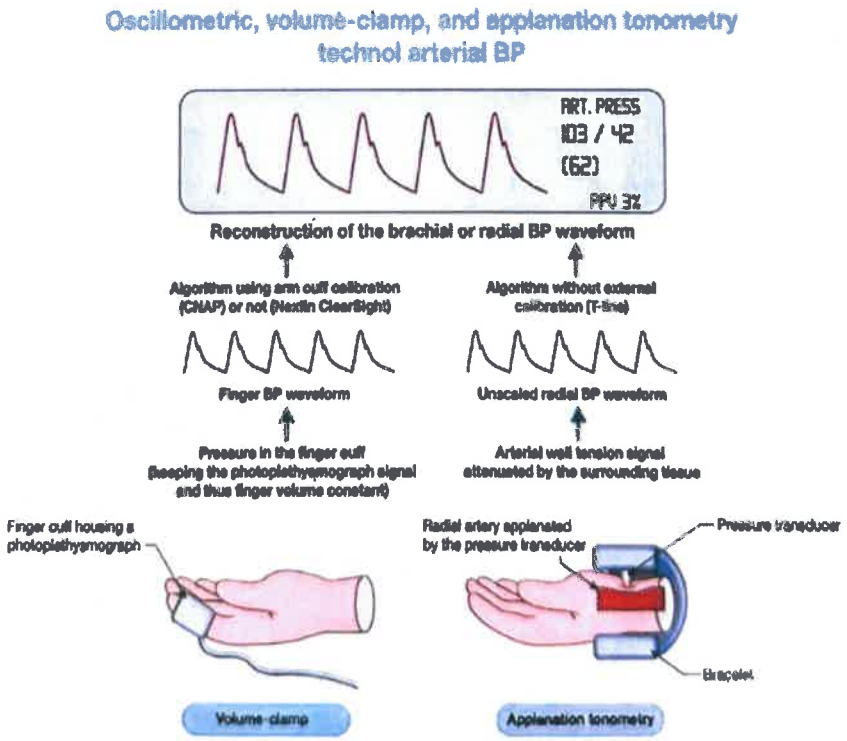
Volume clamp method (finger cuff) :

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

B

T- line system : Based on applanation tonometry :

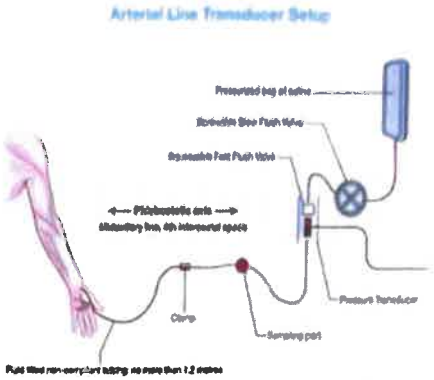
- Radial artery applanation :
- A pressure sensor applied over radial artery :
  - Gently compresses artery : Applanates.
- The sensor is automatically moves over radial artery until optimal waveform is recorded.
- External applanation leads to reconstruction of BP waveform.
- mean BP measured directly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



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.

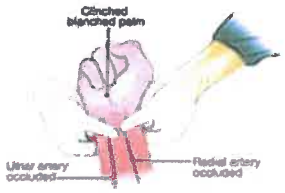
- Unstable blood pressure/severe hypotension.
- Use of rapidly acting vasoactive drugs : Vasodilators, vasopressors, inotropes.
- Frequent sampling of arterial blood.

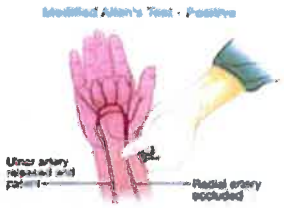
Relative contraindications : Invasive arterial pressure monitoring.

- 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%).





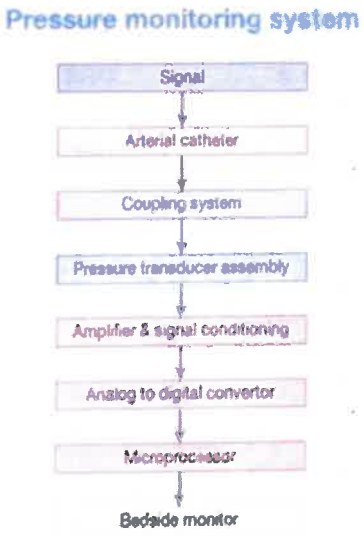
Common sites :

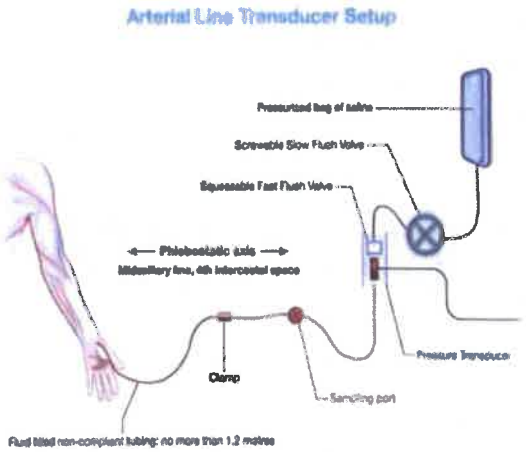
1. Radial.
2. Femoral.
3. Dorsalis pedis.
4. Posterior tibial.

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 :





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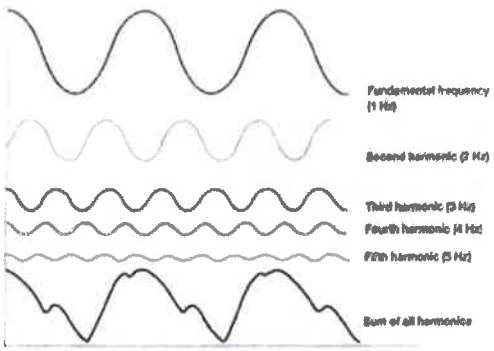
- Arterial waveform is a composite of many waveforms of increasing frequencies (harmonics).
- 8-10 harmonics.



Natural frequency :

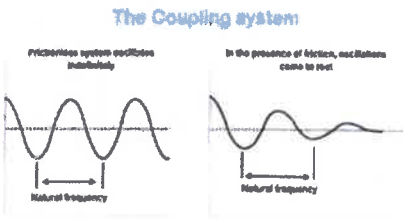
- Frequency at which a system oscillates.

Maximum diameter
Minimum length
Low Compliance

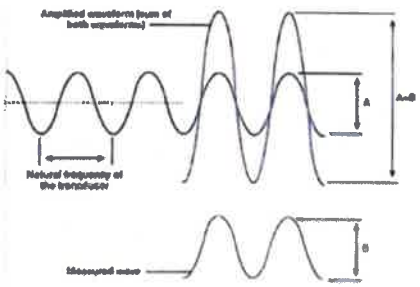
$$\text{Natural frequency } f_n = \frac{1}{2\pi}\sqrt{\frac{\pi D^2}{4\rho L}\cdot\frac{\triangle P}{\triangle V}}$$

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 :

Damping :

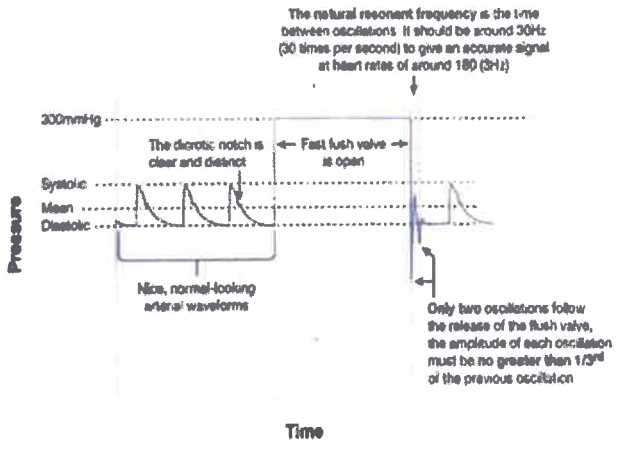
- Absorption of energy (amplitude) of oscillations :
  - Decreases amplitude of waves.
  - Reduces natural frequency of a system.
- Transducer system must be adequately damped :
  - Amplitude should not change due to resonance.
- Diameter of the tubing has the greatest effect on damping.
- Damping increases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

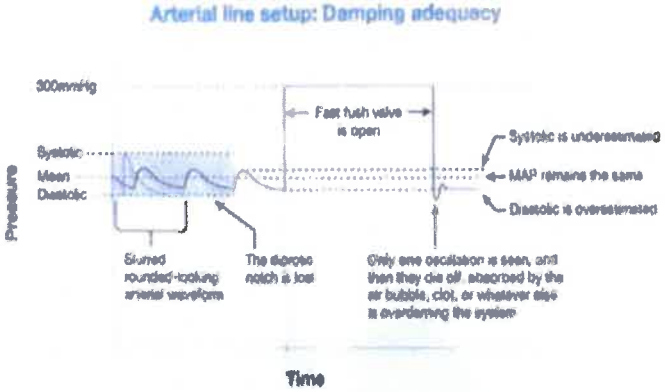
Dynamic response :

- Ability of the system to accurately reproduce hemodynamic waveform.

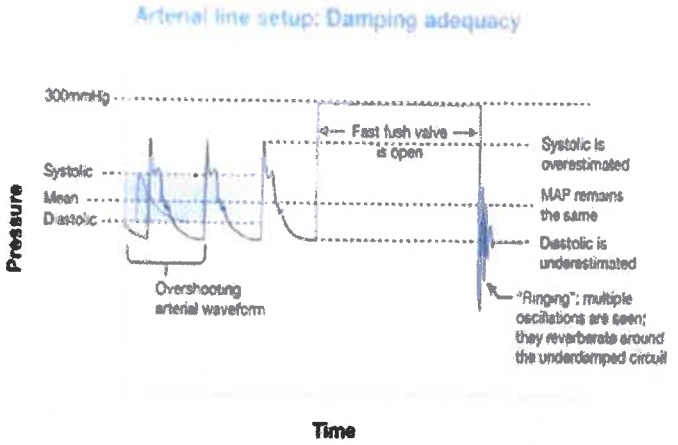
Natural frequency	Damping coefficient
should be > highest frequency of the incoming pulsatile signal	How quickly an oscillating fluid filled system comes to rest
> 24Hz needed	Fast flush test

Arterial line setup : Damping adequacy



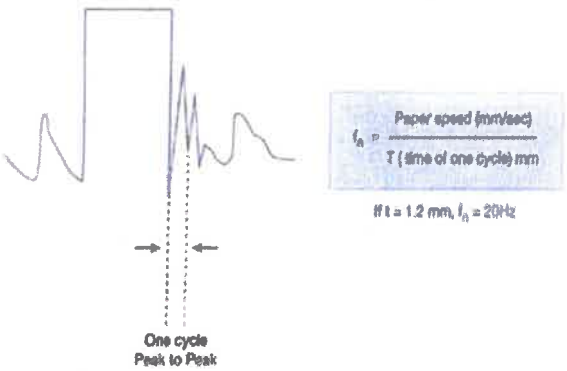


Clots, kinks, air bubbles, low compliant tubings, loose connection

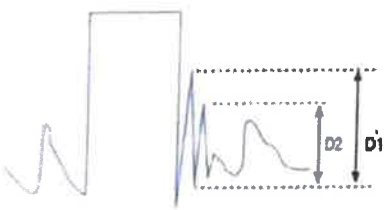


Long tubing, hyperdynamic circulation, tachycardia, hypertension, atherosclerosis

Determining fn :

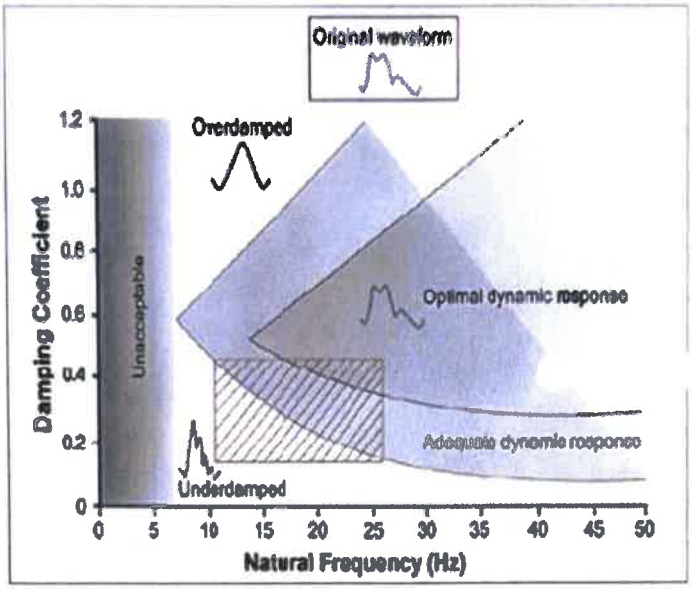


Amplitude Ratio :



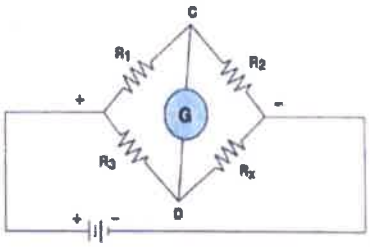
Amp Ratio (D2/D1)	Damping coefficient
0.9	0.034
0.8	0.071
0.7	0.113
0.6	0.160
0.5	0.215
0.4	0.280
0.3	0.358
0.2	0.456
0.1	0.591
0.05	0.690

Arterial line setup : dynamic response

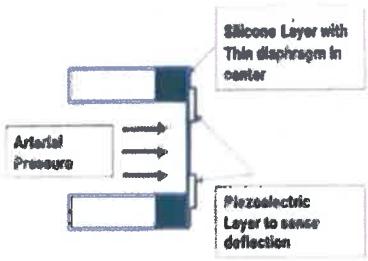


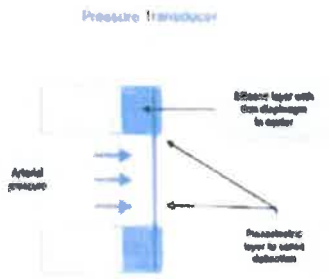
Pressure transducer :

- A transducer is a device which converts energy from one form to another :
  - Pressure into electrical energy.
- It acts on the principle of Wheatstone bridge.
- Wheatstone bridge : Electrical circuit with one unknown resistor.



- Piezoresistive strain gauges is used to complete the circuit.
- Wheatstone bridge used to measure the unknown resistance (of strain gauge).
- Resistance of unknown resistor is determined by pressure.





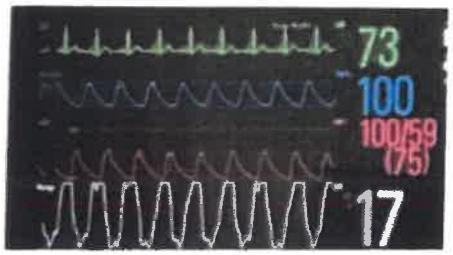
Arterial pulse waveform : Components

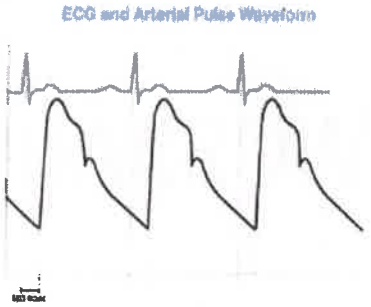
- Systolic phase : Rapid increase in pressure to a peak.
  - Begins with opening of aortic valve.
  - Corresponds to LV ejection.

- Dicrotic notch :
  - Closure of aortic valve.
- Diastolic phase :
- Run-off of blood into peripheral circulation.

Arterial pulse waveform : Analysis

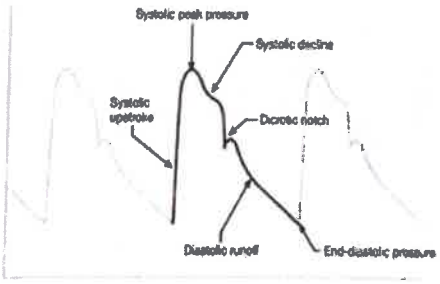
- On ECG, R wave signals beginning of systole.
- Systolic upstroke does not occur immediately following systole.
- There is 160-180 millisecond delay.





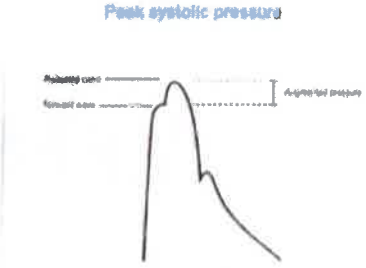
Systolic upstroke :

- Represents ventricular ejection.
- Corresponds to peak aortic blood flow.
- Factors influencing aortic flow rates affect it :
  - Contractility.
  - Aortic valve flow.
  - Peripheral resistance.



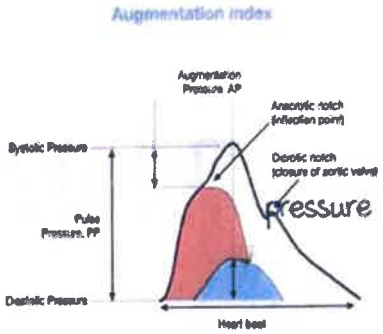
Peak systolic pressure :

- Maximum pressure in central arteries generated during systolic ejection.
- Major contributions :
  - LV contraction.
  - Central arterial compliance.
  - Reflected pressure wave.



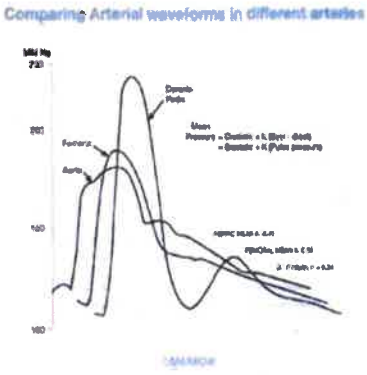
Augmentation index :

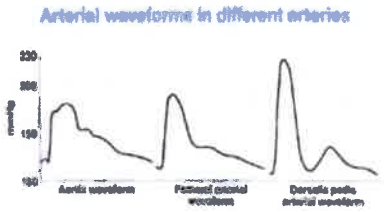
- Wave reflected from periphery to central aorta augments aortic pressure.
- It is a measure of systemic arterial stiffness.
- Calculated as ratio of augmentation to pulse pressure.



Distal systolic pulse amplification :

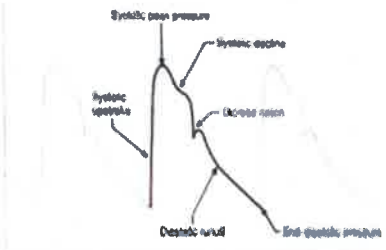
- Demonstrates change in systolic pressure on moving further from aortic root.
- Due to action of reflected waves on systolic pressure.
- Accumulating more of reflected pressure waves on top of systolic peak.





Systolic decline :

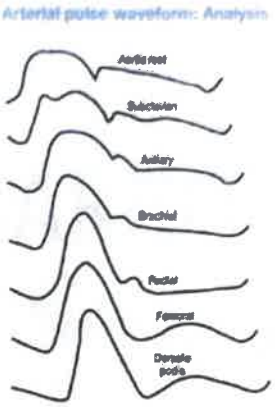
- Rapid decline in pressure as ventricular contraction ceases.
- Efflux of blood from central arterial compartment is faster than influx of blood from left ventricle.
- more rapid: Left ventricular outflow tract obstruction.



Arterial pulse waveform : Analysis

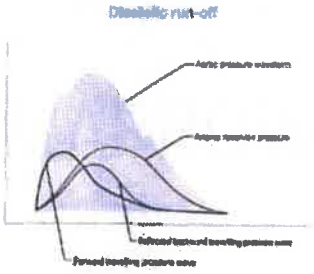
Dicrotic notch

As aortic valve closes, there is a sudden increase in pressure



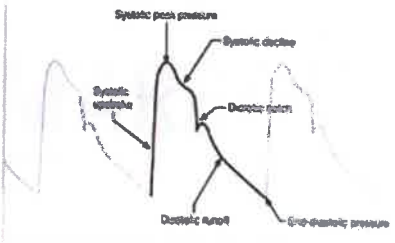
Diastolic run-off :

- Drop in pressure after aortic valve has closed.
- No flow from the LV :
  - But pressure does not drop suddenly; decreases gradually.
  - Due to reservoir effect of aorta.
- Shape of reservoir pressure depends on characteristics of reservoir.

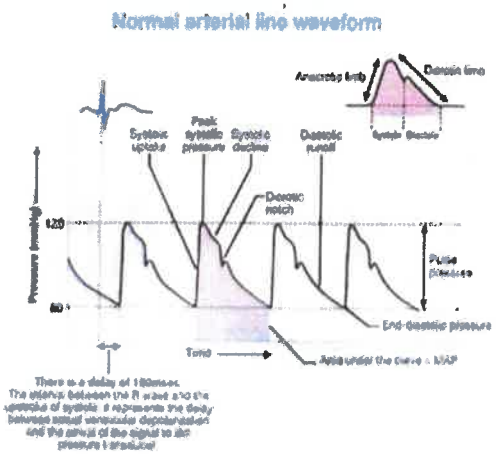


End diastolic pressure :

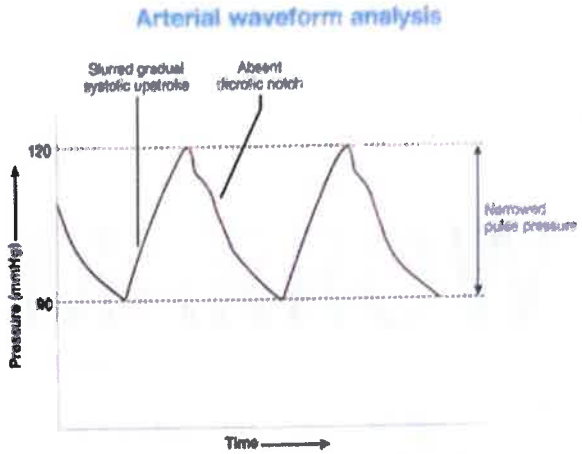
- Pressure exerted by vascular tree back upon aortic valve.
- Non-compliant vessels will raise it.
- Vasoplegic patient : Low diastolic pressure.



Normal arterial line waveform :



Arterial waveform analysis : Cardiac dysfunction

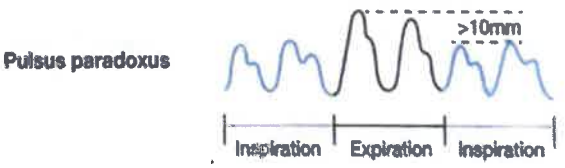


Pulsus alternans :

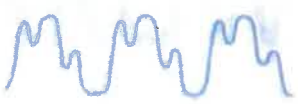
Alteration of beats with higher & lower pulse pressures indicative of severe left ventricular dysfunction.

Pulsus paradoxus :

Exaggerated inspiratory fall in systolic blood pressure >10 mm Hg.

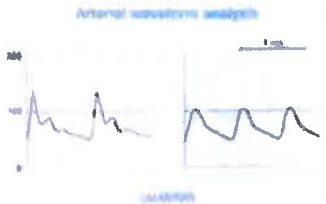


Aortic Regurgitation



Bisferiens pulse

HOCM



"Spike and dome"

CENTRAL VENOUS LINE AND CVP MEASUREMENT

Need of CVP lines

00:00:33

- Physical examination of the neck veins has been a fundamental aspect of cardiovascular assessment.
- The bedside diagnosis of low, normal, or high CVP is often inaccurate, particularly in critically ill patients.
- Direct measurement of CVP is necessary in hemodynamically unstable patients & those undergoing major operations.
- SSG (2014) deemphasized the role of CVP as a marker of fluid responsiveness.

Introduction

- It is the pressure in thoracic veins near right atrium.
- Major determinant of filling pressure/ Preload of RV.
- Preload = End diastolic volume.
- Assumptions :
  - Linear relationship between Ventricular volume & Pressure.
  - This relationship is constant.
  - LV end diastolic pressure correlates with Atrial Pr / CVP.
- CVP measures filling pressure of the right ventricle (RV).
- CVP measures the interplay of the :
  1. Circulating blood volume.
  2. Venous tone.
  3. Right ventricular function.

Indications for central venous cannulation :

- CVP monitoring.
- Temporary HD.
- Aspiration of air emboli
- Drug administration :
  - Concentrated vasoactive drugs.
  - RPN.
  - Chemotherapy.
  - Prolonged antibiotic therapy (e.g., endocarditis).

Arterial waveform : Information

- From measurements :
  - Heart rate.
  - Systolic pressure.
  - Diastolic pressure.
  - mean arterial pressure.
  - Pulse pressure.
  - Changes in amplitude with respiration.

- From waveform shape :
  - Slope of anacrotic limb : Aortic valve & LVOT flow.
  - Slurred/collapsing wave : AS.
  - Rapid systolic decline : LVOTO.
  - Low dicrotic notch : Poor peripheral resistance.
  - Quality of dicrotic notch : Damping coefficient.