

# NEET SS ANESTHESIA

*Updated Notes 2026*



## CRITICAL CARE PART-1



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## HEMODYNAMIC MONITORING : I

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Cardiovascular organ dysfunction : 2<sup>nd</sup> most common organ dysfunction.

Continuously observing changes in physiologic variables :

- To monitor organ function.
- For prompt therapeutic interventions.
- To evaluate response to therapeutic interventions.

monitoring per se does not improve patient outcomes.

Timely applied right interventions can cause improvement in outcomes.

### Assessing global and regional perfusion

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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.

- |   |   |  |
|---|---|--|
| <ul style="list-style-type: none"> <li>• Thirst.</li> <li>• Cold extremities.</li> <li>• Poor peripheral pulses.</li> <li>• Impaired capillary refill.</li> </ul> | → | <ul style="list-style-type: none"> <li>• Tachypnoea, tachycardia.</li> <li>• Confusion.</li> <li>• Altered skin perfusion.</li> <li>• Oliguria.</li> </ul> |
|---|---|--|

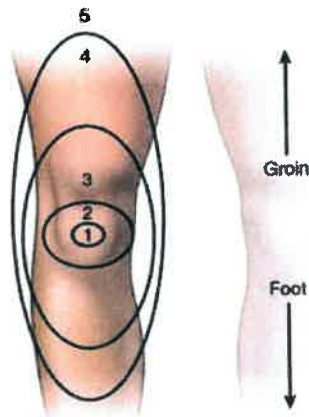
Skin mottling :

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.

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### Mottling score



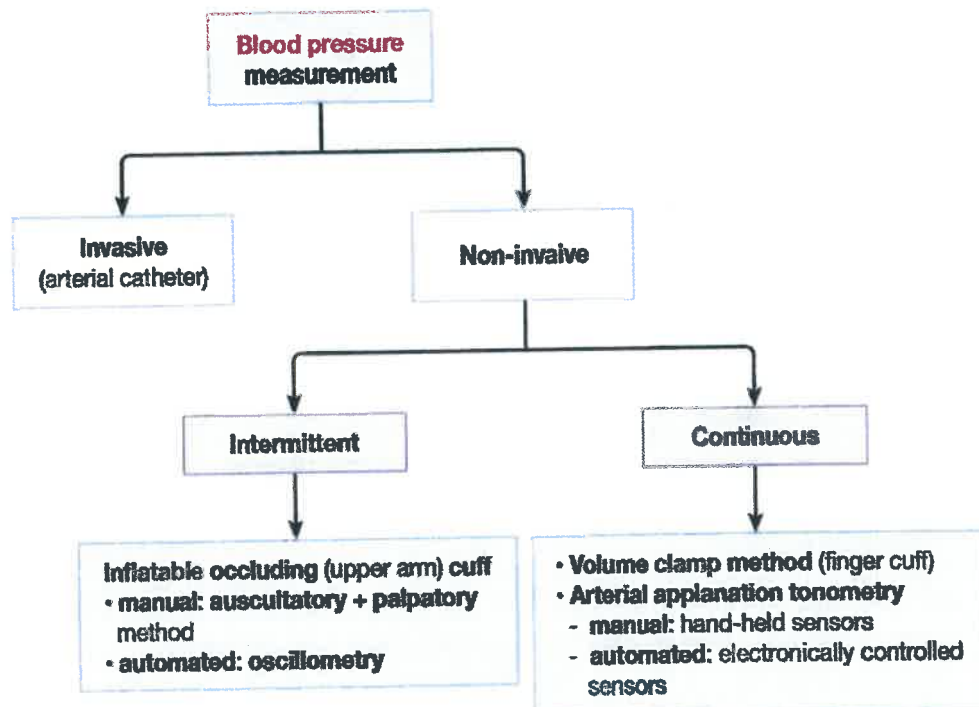
GRADE 2 MOTTLING



### 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 :



NIOP : Intermittent.

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Manual intermittent	Automated intermittent
<ul style="list-style-type: none"> <li>• Described by Korotkoff in 1905.</li> <li>• Sphygmomanometer, cuff, and stethoscope needed.</li> <li>• Auscultating sounds generated by turbulent arterial blood flow beyond cuff.</li> <li>• Systolic : First Korotkoff sound.</li> <li>• Diastolic : Before disappearance.</li> </ul>	<ul style="list-style-type: none"> <li>• Based on oscillometry.</li> <li>• Cuff is coupled to an oscillometer.</li> <li>• The cuff inflated above systolic pressure → Then gradually deflates.</li> <li>• MAP : pressure at peak amplitude of arterial pulsations.</li> <li>• SBP &amp; DBP : Derived from proprietary formulas (Rate of change of pressure pulsations).</li> </ul>

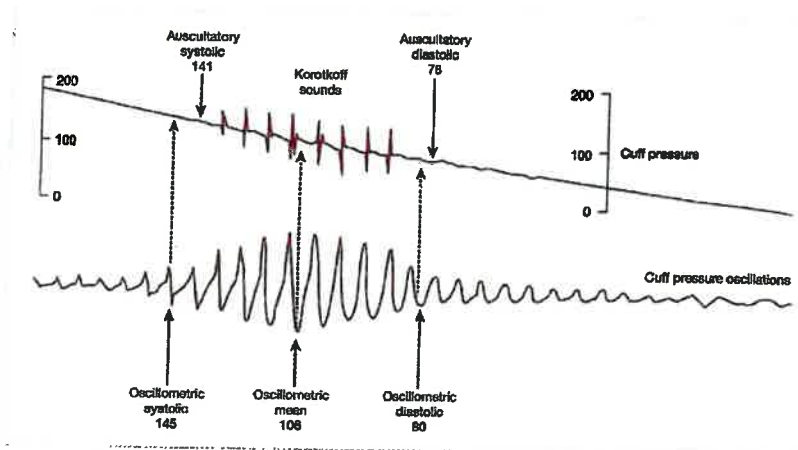
Cuff Size :

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

Patient	Recommended cuff size
<b>Adults (by arm circumference)</b>	
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)

BP cuff size

Comparison of blood pressure measurements via Korotkoff sounds and oscillometry :



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Non invasive :

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 keep volume in finger artery constant.
- Produce a brachial arterial waveform.



T- line system :

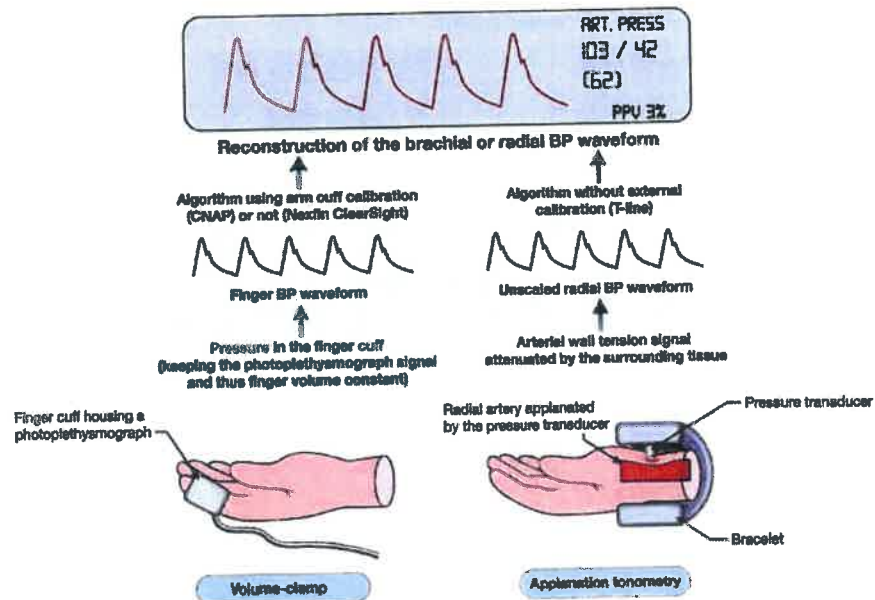
Based on applanation tonometry.

- 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).

T-line system: Based on applanation tonometry



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



Invasive blood pressure :

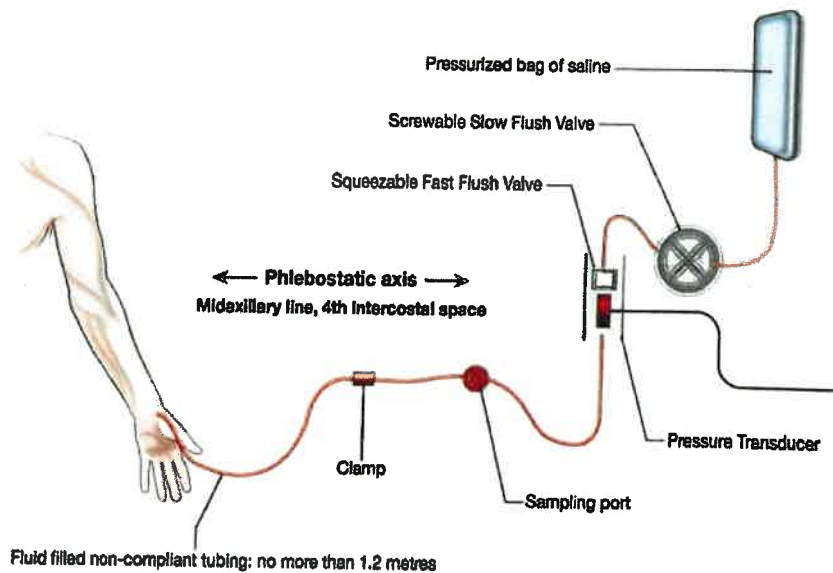
- Gold standard for BP monitoring :
  - Arterial cannulation.
  - Continuous pressure transduction.
  - waveform display.

- Conventions :

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

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### Arterial Line Transducer Setup



#### Indications :

- unstable blood pressure/severe hypotension.
- use of rapidly acting vasoactive drugs : vasodilators, vasopressors, inotropes.
- Frequent sampling of arterial blood.

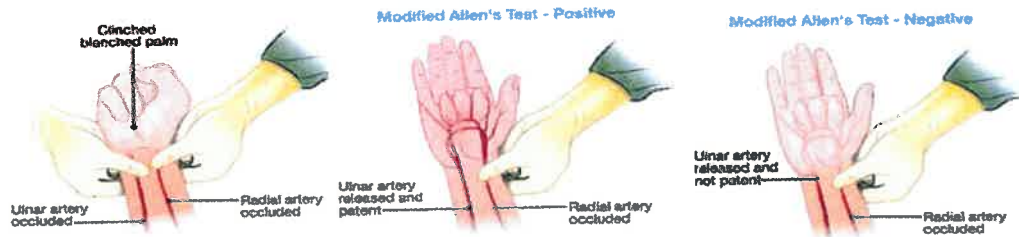
#### Relative contraindications for invasive arterial pressure monitoring :

- 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 (Eg : 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 :

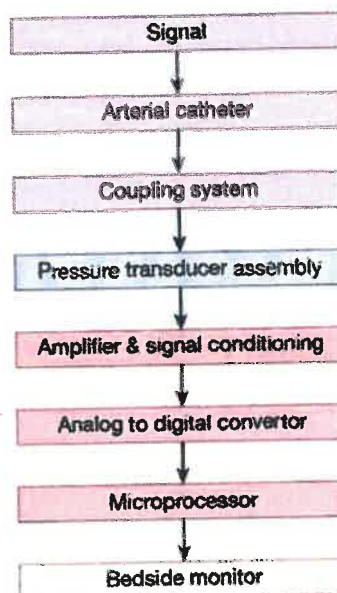
1. Radial.
2. Femoral.
3. Dorsalis pedis.
4. Posterior tibial.

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 :**

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



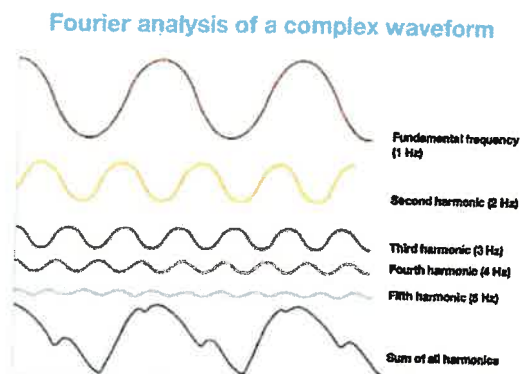
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**Physics of arterial waveform**

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**Fourier analysis of complex waveform :**

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

**Natural frequency :**

Frequency at which a system oscillates.

$$\text{Natural frequency } f_n = \frac{1}{2\pi} \sqrt{\frac{\pi D^3}{4\rho L} \cdot \frac{\Delta P}{\Delta V}}$$

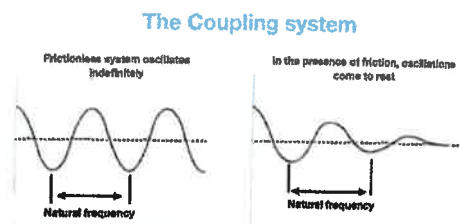
Dependent on :

- maximum diameter.
- minimum length.
- Low compliance.

**The coupling system :**

Fluid between artery and transducer acts as simple harmonic oscillator :

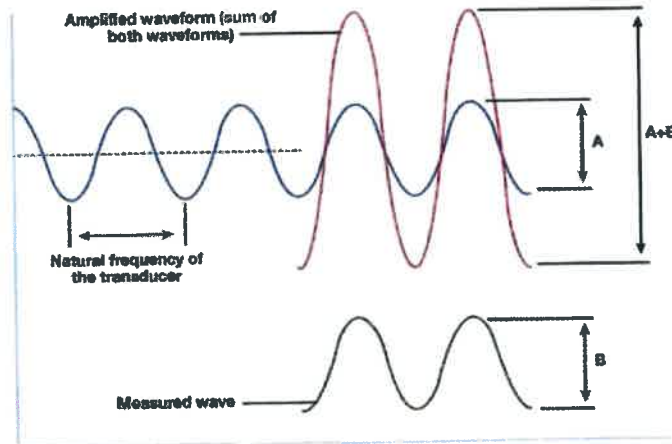
- Analogous to a pendulum.
- When the pendulum is displaced, it undergoes simple harmonic motion it oscillates around the equilibrium point.



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

### The Coupling 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 8<sup>th</sup> harmonic frequency of a rapid pulse :  $>24\text{Hz}$  (Taking HR upto 180/min).

### Damping :

- Absorption of energy (Amplitude) of oscillations :
  - Decreases amplitude of waves.
  - Reduces natural frequency of a system.
- 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.

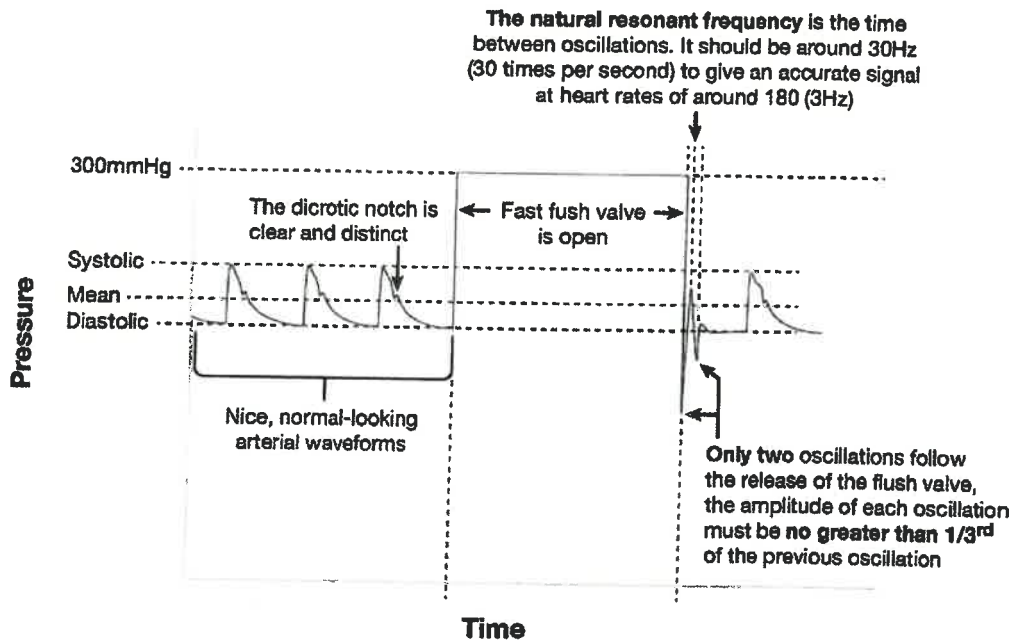
### Damping coefficient :

To assess how quickly an oscillating fluid filled system comes to rest.

Test : **Fast flush test.**

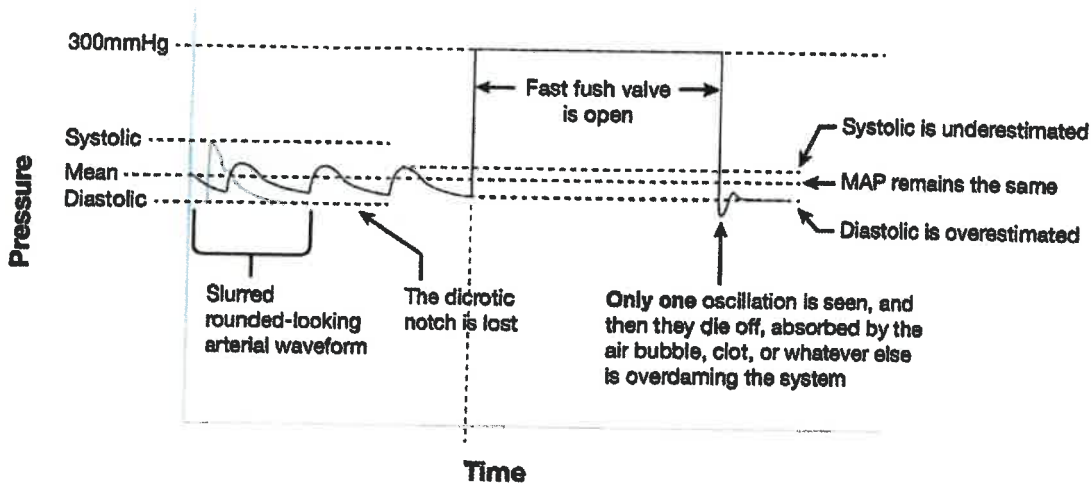
Arterial line setup : Damping adequacy.

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Over damped system :

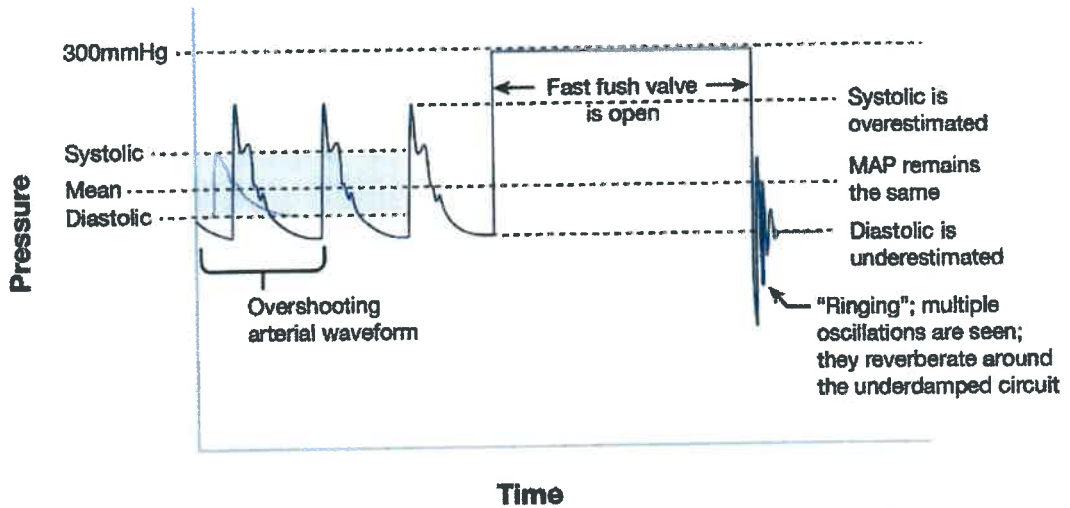
Arterial line setup: Damping adequacy



Occurs in cases of : Clots, kinks, air bubbles, low compliant tubings, loose connection.

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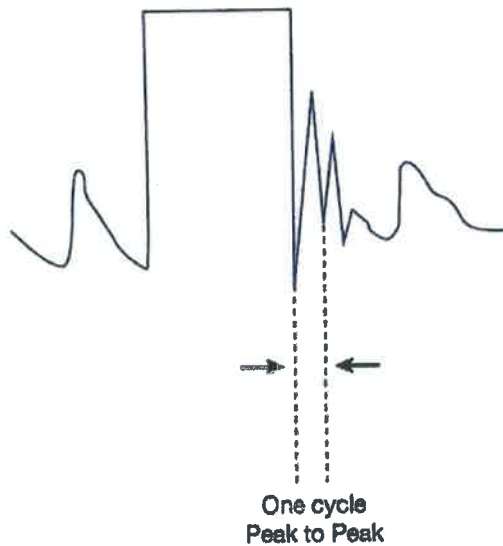
Underdamped system :



Occurs in : Long tubing, hyperdynamic circulation, tachycardia, hypertension, atherosclerosis.

Determining frequency of a system :

### Determining $f_n$



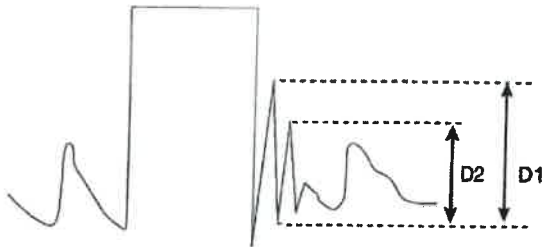
$$f_n = \frac{\text{Paper speed (mm/sec)}}{T \text{ (time of one cycle) mm}}$$

If  $t = 1.2 \text{ mm}$ ,  $f_n = 20\text{Hz}$

**Amplitude ratio :**

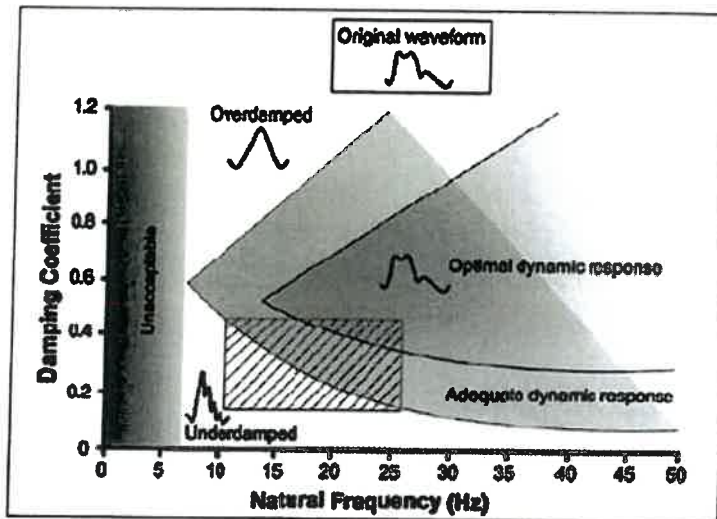
Height of waves generated following a fast flush test.

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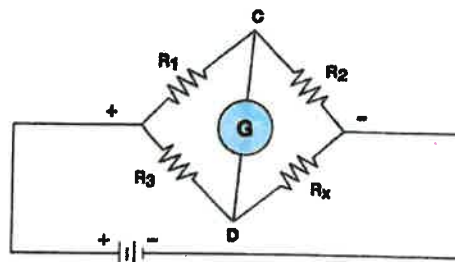
Amp Ratio (D2/D1)	Damping coefficient
0.9	0.034
0.8	0.071
0.7	0.113
0.6	0.160
0.5	0.215
0.4	0.280
0.3	0.358
0.2	0.456
0.1	0.591
0.05	0.690

**Arterial line setup : Dynamic response.**



**Pressure transducer :**

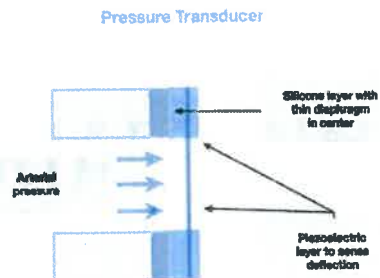
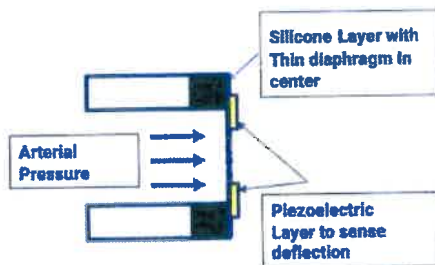
- A transducer is a device which converts energy from one form to another : Pressure into electrical energy.
- It acts on the principle of wheatstone bridge.
- wheatstone bridge : electrical circuit with one unknown resistor.



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Mechanism :

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

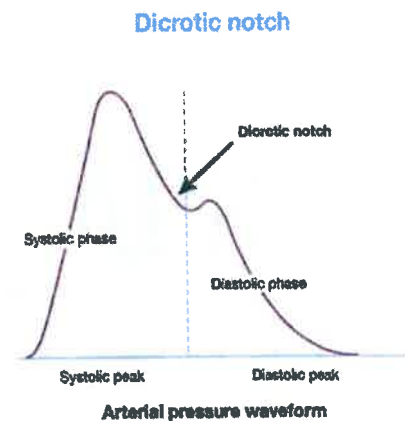


## Components of arterial pulse waveform

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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.



Analysis :

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

