MONITORING

DR S PAPAIKONOMOU

MONITORING

- Latin verb – ***monere*** : warn
- Standards by ASA 1986
- Standard I : Constant presence of the anaesthetist

  No mechanical or electrical device can replace the anaesthetist (pilot). Information requires clinical interpretation
- Standard II : Continually evaluating the patient's oxygenation, ventilation, circulation and temperature
- Meticulous record-keeping

- Details of preoperative assessment including drug history
- Cardiovascular variables, including heart rate, arterial pressure, CVP and urine output
- Respiratory variables, including ventilator settings, airway pressures and FiO_2
- Details of apparatus employed
- Dosages of all drugs, including the concentration of N_2O and volatile agent employed
- Details of all i.v. fluids
- Volume of blood loss
- Any problems or difficulties encountered
- Postoperative instructions

CARDIOVASCULAR

- Stethoscope
- Electrocardiography
- Arterial Blood Pressure
- Pulse
- Central Venous Pressure
- Pulmonary Artery Pressure
- Urine Output
- Blood Loss
- Transoesophageal Echocardiography (TEE)

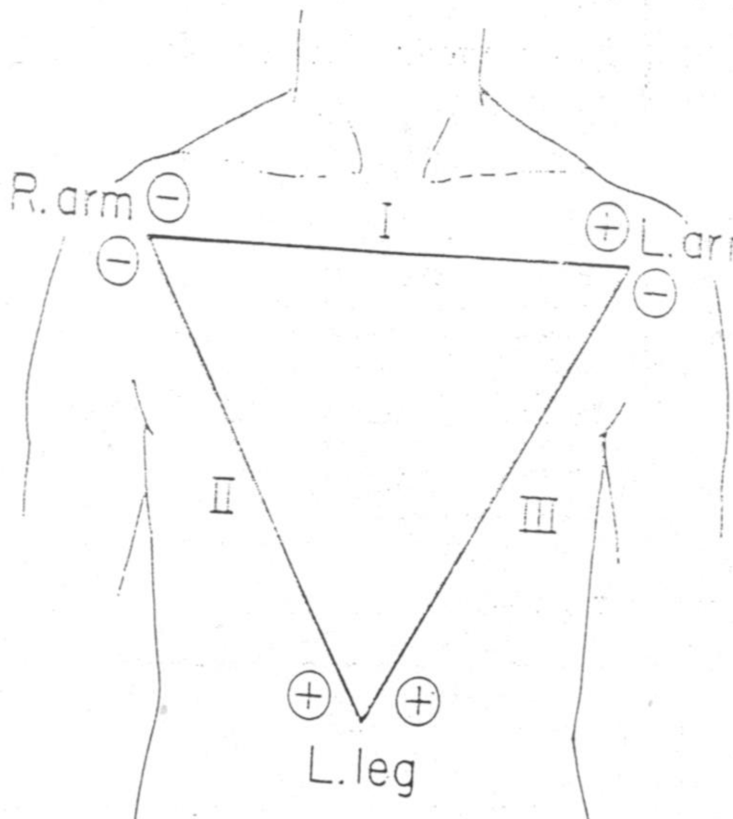
ELECTROCARDIOGRAPHY

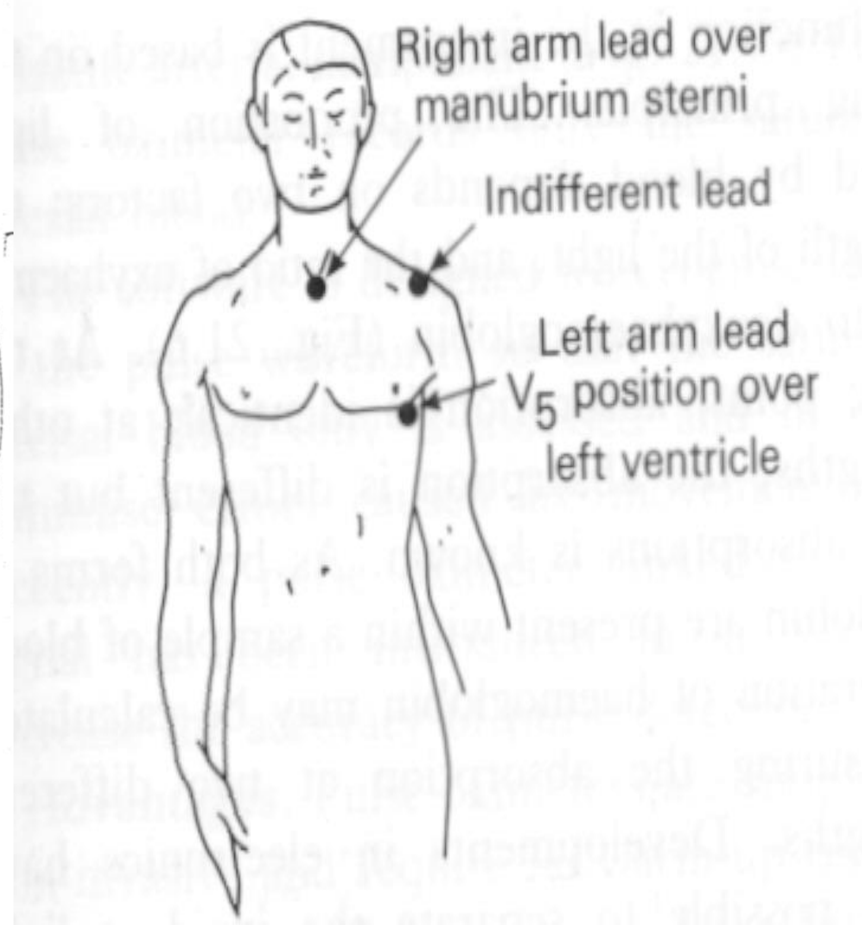
- Its use allows the detection of dysrhythmias, myocardial ischaemia, conduction abnormalities, pacemaker malfunction and electrolyte disturbances
- Idea of electrical activity, not cardiac output
- The patient may have an electrical rhythm and no pulse!
- The ECG contacts the patient’s body through silver chloride electrodes
- Conductive gel lowers the skins electrical resistance, which can be further decreased by cleansing the site with alcohol

- In theatre only one standard lead is used to transmit the ECG, so it is not possible to diagnose details of disturbances that may be present
- The peak of the QRS complexes are transmitted as an audible signal and the actual ECG trace is projected on the screen continuously
- The use of this monitor does not preclude the use of the pre-operative 12-lead ECG
- Patient or lead-wire movement, electrocautery and faulty electrodes can simulate dysrhythmias
- Lead selection determines the diagnostic sensitivity of the ECG

- The electrical axis of lead II parallels the atria, resulting in the greatest P wave voltage. This orientation enhances the diagnosis of dysrhythmia
- The CM_5 lead configuration reveals more readily ST segment changes produced by left ventricular ischaemia

Lead II and CM5





BLOOD PRESSURE

- Measurement of arterial blood pressure is mandatory during anaesthesia in all patients
- It is an indirect method of estimating adequacy of cardiac output

  Cardiac output = arterial pressure X

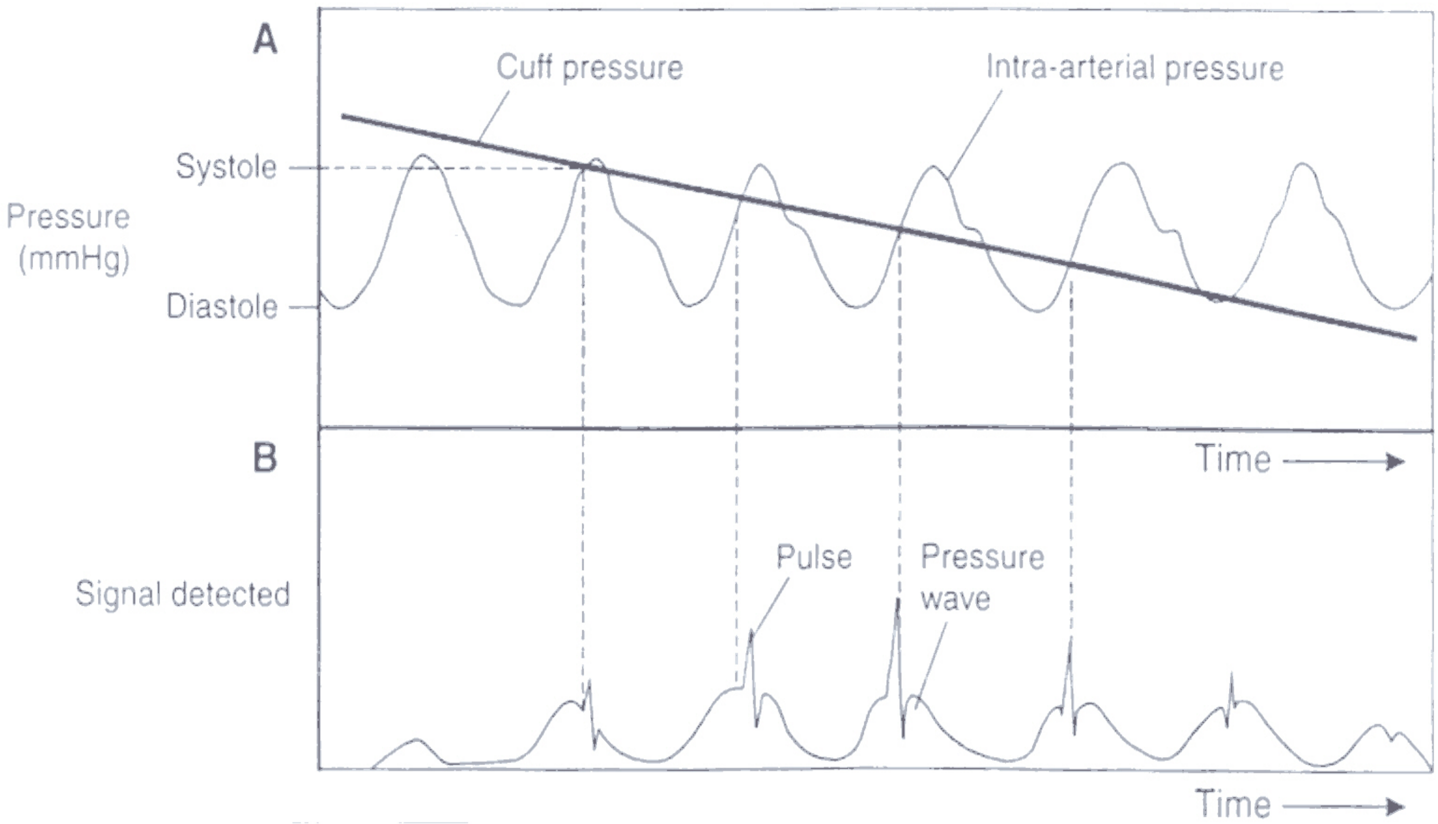
  peripheral vascular resistance

- Methods: Non-invasive (indirect) NIBP

  oscillometry

  Invasive (direct)

NIBP - oscillometry



INVASIVE

- Indications
  Continuous BP measurement required
  Elective hypotension
  Wide intraoperative BP swings expected
  Multiple arterial blood gas analysis
- Contraindications
  Arteries without collateral blood flow
  Vascular insufficiency (Raynauds disease)

- Techniques

  Cannulation of radial artery of non-dominant hand preferred (Alan test) or dorsalis pedis

  Connection to mechanical electric transducer to display waveform (zero- table height)

  Seldinger's technique – guidewire cannulation

- Complications

  Hematoma and skin necrosis

  Vasospasm and arterial thrombi → ischemia

  Nerve damage

  Sepsis

  Unintentional intra-arterial injection of drugs

  Cerebral air embolism

  Aneurysm and arteriovenous fistula

PULSE

- The clinical importance was already established in the time of Hippocrates and after 2000 years is still accepted as an important parameter
- The rate, rhythm, volume and character is important
- Hippocrates palpated the artery and counted the beats, but in the modern age we can use a photoelectric cell connected to the finger to pick up these pulsations

Pulse oximetry is based on several facts

- The colour of blood is a function of oxygen saturation
- Electromagnetic energy is passed through the extremity and is then detected by a photodetector (spectrophotometry)
- Energy of two wavelengths is transmitted : red 660nm and near infrared 940nm
- The absorption by oxy Hb and deoxy Hb is different but the ratio of absorption is known, so saturation of Hb may be calculated
- This intensity waxes and wanes with each heartbeat (plethysmography)

- Pulse oximetry combines the technology of plethysmography and spectrophotometry
- The software is designed to recognize the shape of the pulse waveform so that the saturation of arterial blood only is assessed

Errors in pulse oximetry

- The most serious limitation is the errors caused by abnormal substances in the blood with absorption spectra that interfere with that of normal Hb
- The most common are the dyshaemoglobins:

  carboxy Hb and met Hb
- At high Met Hb, measured SaO_2 approaches 85% independent of actual blood oxygenation
- Reduced amplitude of pulsation

Pulse oximeters are simple to use and non-invasive and provide an overall assessment of the integrity of all the systems involved in delivering oxygen to the tissue

1. Oxygen supply to the patient
2. Oxygen uptake by the lungs
3. Oxygen delivery to the tissues via the circulatory system

Oxygen flux (DO_2)

DO_2 = QT X CaO_2

QT = cardiac output

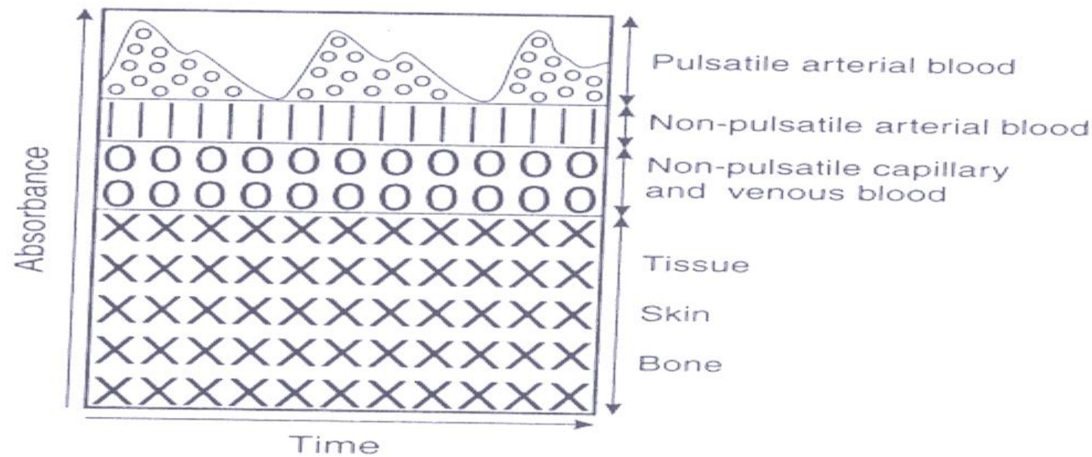
= Stroke volume X HR

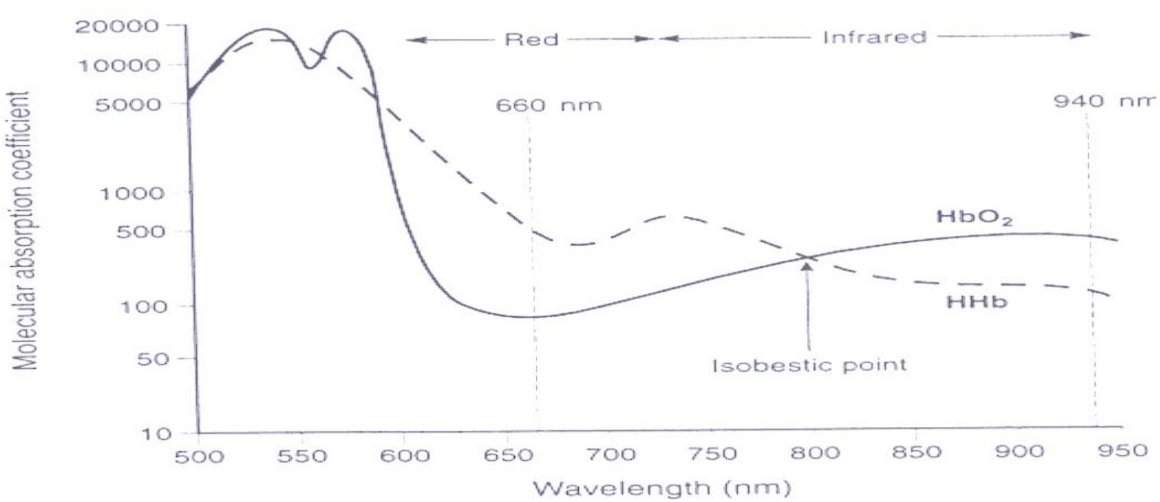
= 70ml X 72 ~ 5l/ min

CaO_2 = 200ml/l

DO_2 = 1l/min

Absorption spectra of Hb





CENTRAL VENOUS PRESSURE

- Cardiac output is based on the Frank-starling mechanism where force of contraction is determined by the initial fiber length and the ability of the cardiac muscle to contract at a given initial fiber length. (stroke volume)
- We do not measure stroke volume so pressure is used as a surrogate
- The placement of a **c**entral **v**enous **c**atheter with its tip in the lower SVC or RA thus provides valuable information concerning the *volume status* of the circulation (preload)

- Infusion of drugs & hyperalimentation
- Aspiration of air embolism
- Insertion of trancutaneous pacing leads
- Venous access in patients with poor veins

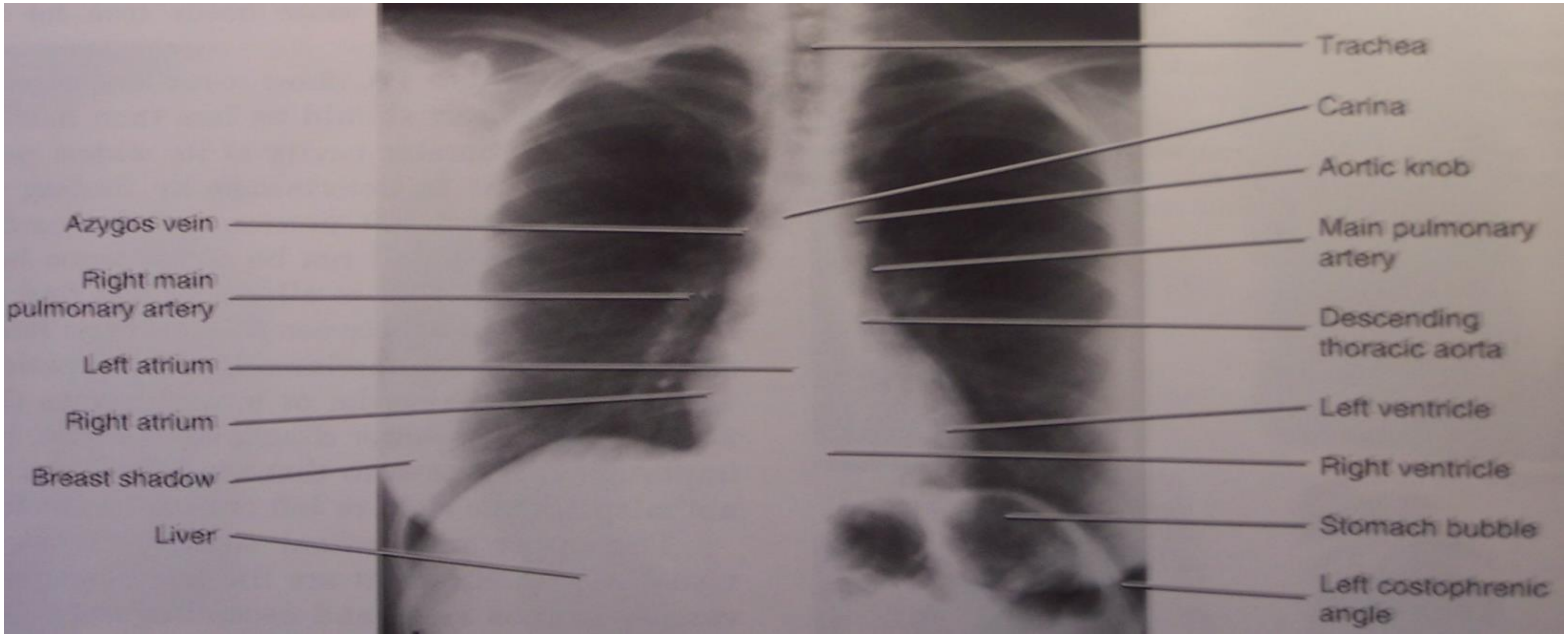
<u>Contraindications</u>

- Anticoagulation
- Tumors in right atrium

<u>Technique</u>

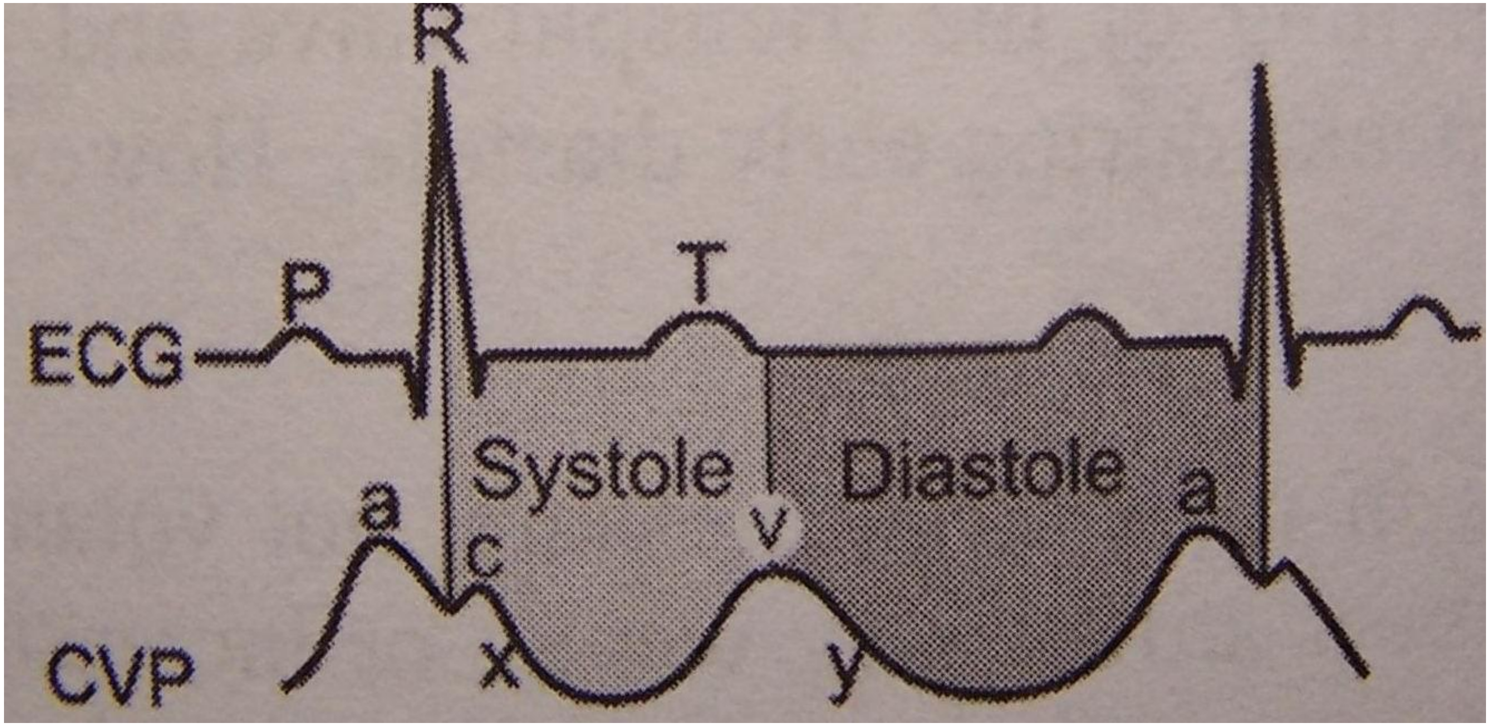
- Aseptic
- Cannulate subclavian or internal jugular
- Catheter tip at junction of SVC & RA (CXR)
- Read values at chest height of RA at end expiration

Where should the tip be?



Always intrathoracic, in SVC
Parallel to vessel wall
Below inferior border of clavicle, above the carina
Surface anatomy – above manubrio-sternal junction

Normal CVP waveform

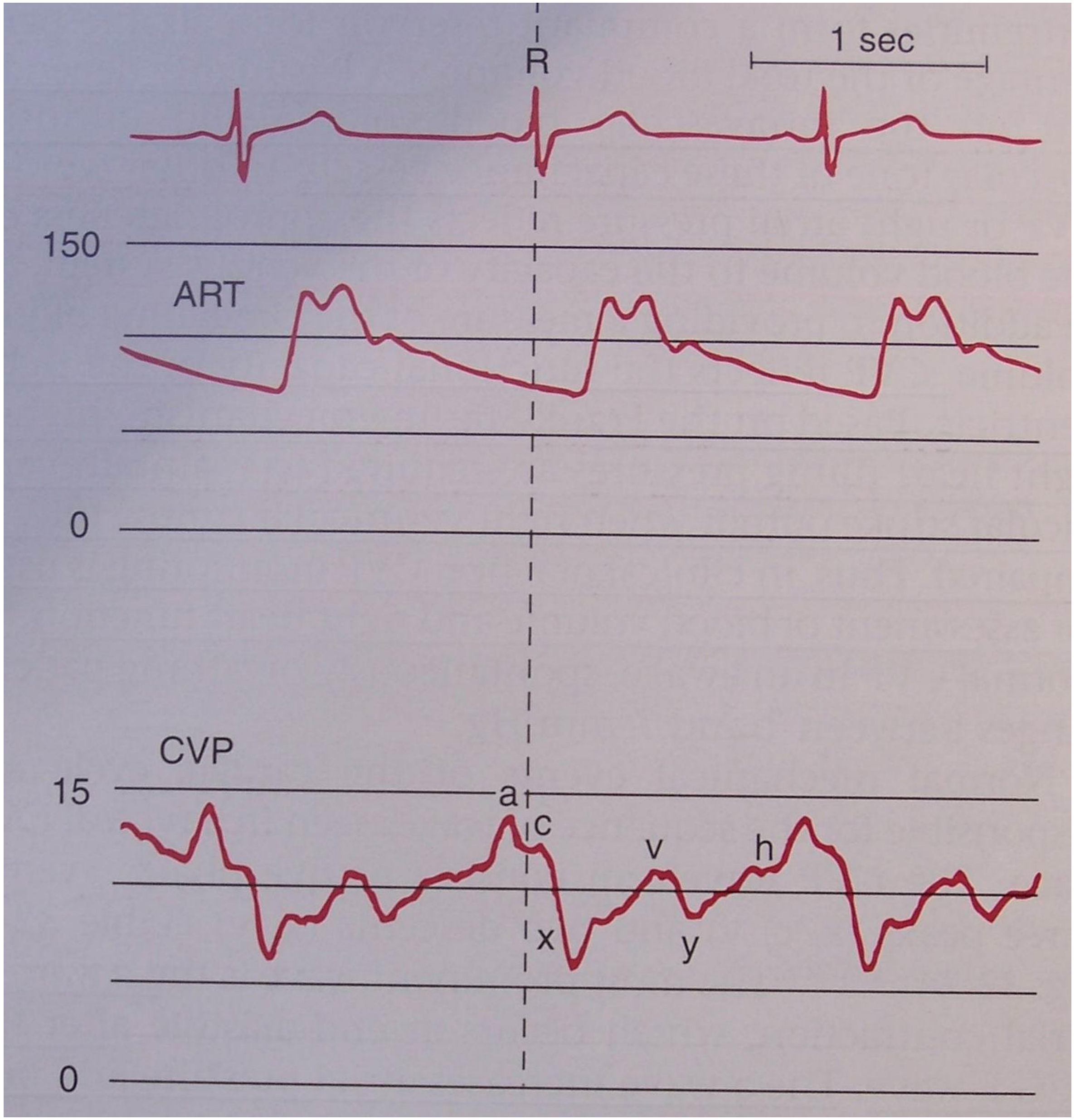


CVP waveform

- a wave = atrial contraction, absent in AF
- c wave = tricuspid valve elevation in early ventricle contraction
- v wave = venous return against a closed tricuspid valve, giant v wave in tricuspid regurgitation, large in RV ischemia, constrictive pericarditis or cardiac tamponade

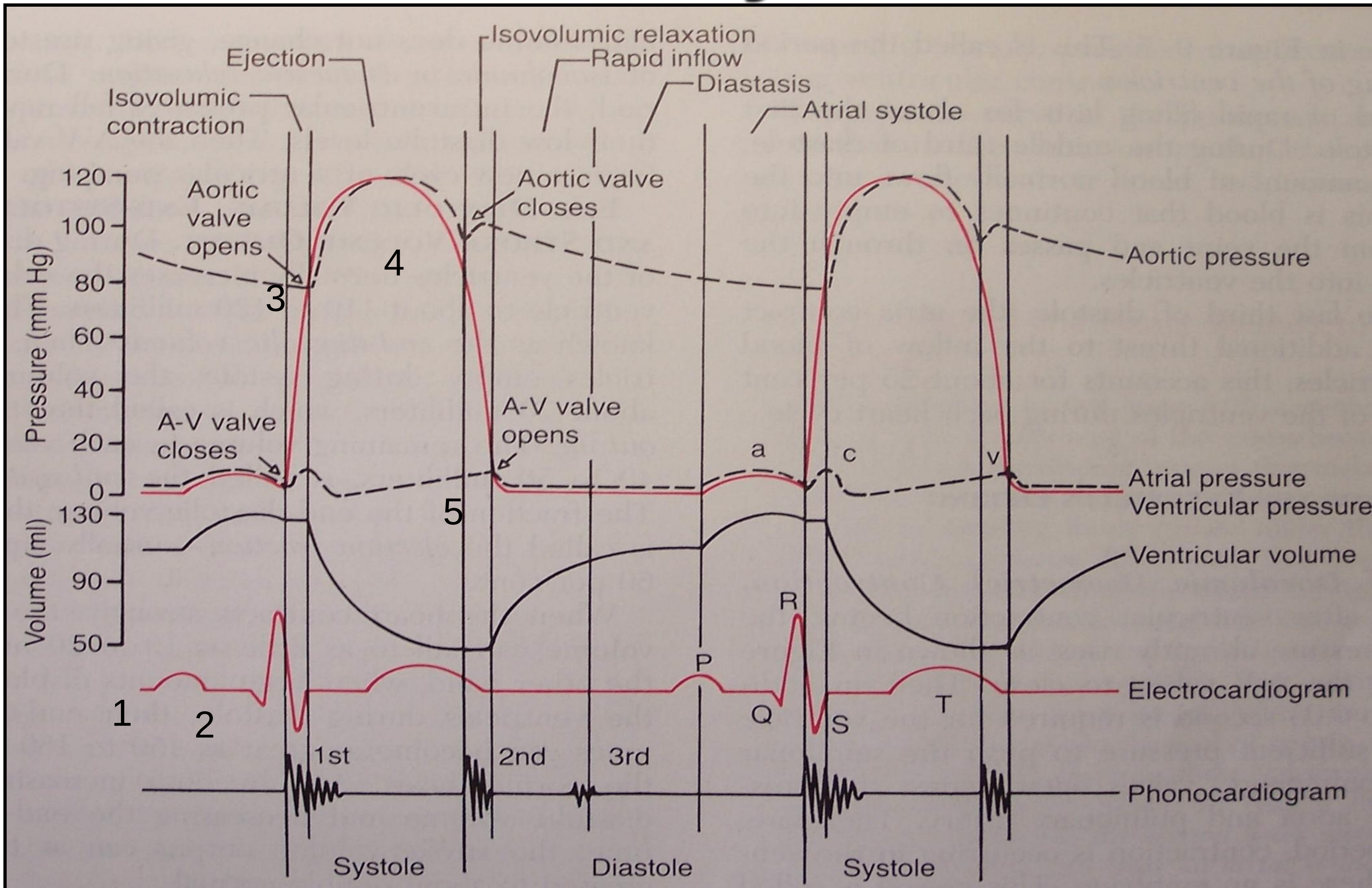
m or w wave – when a & v wave fuse due to decrease in RV compliance with ↑ in CVP

- x & y descent = downward displacement of ventricle during systole & tricuspid valve opening during diastole



R
1 sec
150
ART
0
CVP
15
a
c
v
h
x
y
0

Cardiac cycle



PULMONARY ARTERY PRESSURE

- In the normal individual CVP measurement provides a reasonably accurate estimate of the filling pressures of both R & L atria. In some situations not, and infusion of fluids or inotropic agents titrated against CVP may not result in optimum cardiac function.
  - LV failure with pulmonary oedema
  - Interstitial pulmonary oedema of any cause
  - Chronic pulmonary disease
  - Valvular heart disease

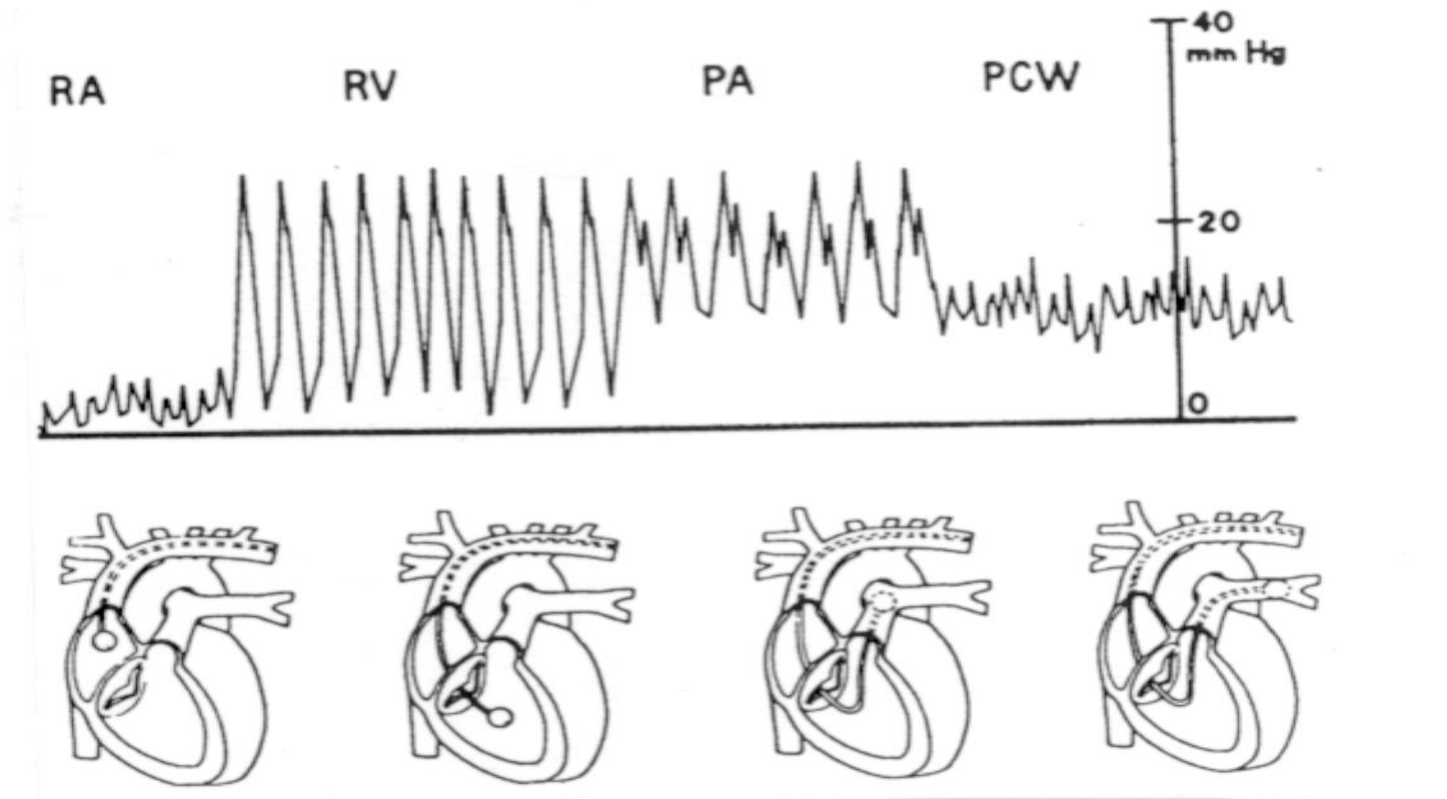
Contraindications

- Inexperience
- Left bundle branch block
- Wolf-Parkinson-White syndrome

Complications

- Sepsis
- Arrhythmias on insertion
- Knotting of the catheter in the RV
- Pulmonary infarction
- Pulmonary artery rupture
- Balloon rupture

PA catheter



URINE OUTPUT

- Adequacy of renal perfusion may be inferred from the volume of urine produced. The kidney is the only organ whose function may be monitored directly in this way. Adequate production of urine implies that perfusion of other vital organs is likely to be adequate.

<u>Indications</u>

- Major surgery - vascular, cardiac, neuro, orth
- Major trauma, massive fluid or blood loss
- Renal or hepatic failure
- Post-op difficult voiding (epidural)

<u>Aim</u>: **0.5-1.0 ml/kg/hour**

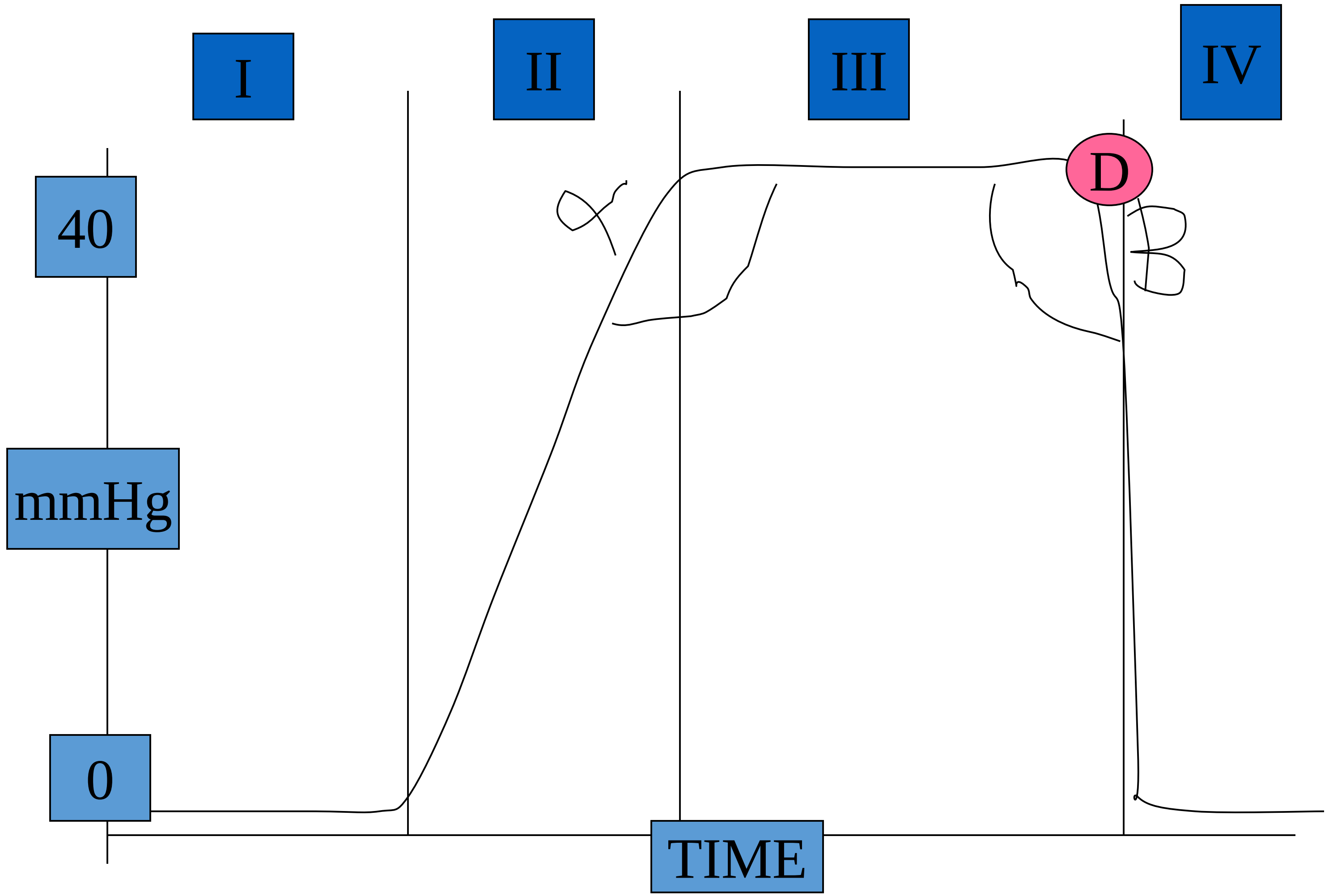
RESPIRATORY

- Clinical: Pt colour, RR, chest movement
- Monitoring oxygen delivery
  - To the patient
  - To the tissues
- Monitoring carbon dioxide – Capnograph
- Airway pressures
- Other gas delivery and excretion

CAPNOGRAPHY

- Monitor of end-expiratory CO_2 *$Pe'CO_2$*
- Normal range 35-45 mmHg
- $Pe'CO_2$ correlates well with $PaCO_2$ in patients who have no significant pulmonary disease.
- The normal $PaCO_2$ - $Pe'CO_2$ gradient is approximately 5 mmHg
- Measured by the ability of CO_2 to absorb infrared light

Capnogram



- **I Respiratory Baseline**, beginning of expiration, CO_2 free gas from anatomical and apparatus dead space
- **II Expiratory upstroke**, mixing of dead space and alveolar gas
- **III Alveolar plateau**, CO_2 rich gas from alveoli
- **IV Inspiration**, sudden down stroke and return to baseline

Indications

- To provide evidence of correct placement of tracheal tube. Rapid diagnosis of oesophageal intubation
- For routine monitoring of the adequacy of ventilation and the effects of IPPV
- To detect rebreathing
- To detect air, fat or pulmonary embolism; a sudden drop in $PeCO_2$ occurs as a result of increased deadspace
- To detect malignant hyperthermia; a progressive increase in $Pe'CO_2$ and temp. is produced by increased muscle metabolism
- To ensure normocapnia

Airway pressure

<u>Causes of excessive elevation</u>

- Kinking
- Overinflation of tracheal tube cuff
- Secretions, blood
- Pneumothorax
- Bronchospasm
- Inadequate muscle relaxation

TEMPERATURE

- The commonest method of measuring pt temperature is still by use of a mercury in glass clinical thermometer
- However, remote-reading is much more convenient with the anaesthetized patient
- Hypothermia defined as a body temperature less than 36°C, occurs frequently during anaesthesia and surgery
- Redistribution of heat from warm central compartments to cooler peripheral tissues from anaesthetic induced vasodilation explains most of the initial drop in temperature

Maintaining normothermia

- Operating room temperature is the most critical factor influencing heat loss because it determines the rate at which metabolic heat is lost by radiation, conduction and evaporation from the surgical incision
- Passive insulation to the skin surface
- Airway heating and humidification
- Warm intravenous fluids
- Overhead heaters
- The most effective warming system is forced air blankets (Bair Hugger)

NEUROLOGIC

- Neuromuscular monitoring
- Nerve mapping for nerve blocks
- Evoked potential monitoring
  (visual, auditory, sensory, motor)
- Bispectral index monitoring
- Entropy

Neuromuscular monitoring

- Because of the variation in patient sensitivity to neuromuscular blockade, the neuromuscular function of all patients receiving muscle relaxants should be monitored
- Furthermore, it can help to locate nerves to be blocked by regional anaesthesia

<u>Technique</u>

- A peripheral nerve stimulator delivers a current of variable frequency to a pair of electrodes placed over a peripheral motor nerve

- It consists of a battery powered pulse generator of sufficient output voltage to cause depolarization of a nerve passing subcutaneously when the electrodes are applied to the skin surface
- The output must be low enough that no direct damage is caused and that skeletal muscle is not caused to contract directly, other than due to depolarization of the nerve supplying it
- The evoked mechanical or electrical response of the innervated muscle is observed
- Ulnar N stimulation of the adductor pollices muscle and facial N stimulation of the orbicularis oculi are most commonly monitored

- To deliver a supra-maximal stimulation to the underlying nerve, peripheral nerve stimulators must be capable of generating a 50 mA current across a 1000-ohm lead. This current is quite uncomfortable for an awake patient!

Clinical considerations

- The degree of neuromuscular blockade is monitored by applying various patterns of electrical stimulation
- All stimuli are 200 µsec in duration, of square wave pattern, and equal current intensity
- **Twitch-tetanus-twitch.** A train of single shocks given at a rate of not more than 1 every 3s is followed by a tetanic train (50Hz) for 3s and the train of single shocks is repeated. Four basic patterns

- ***Normal response:*** twitch response followed by strong sustained tetanic contraction and no potentiation of the post-tetanic twitches as compared with the pretetanic twitches
- ***Total block***. No responses
- ***Partial depolarising block.*** The twitch responses are weak followed by a weak but sustained tetanic contraction. There is no post-tetanic potentiation.
- ***Partial non-depolarising block.*** The initial twitch responses are weak, the tetanic train evokes a contraction which fades rapidly and the post-tetanic twitches are markedly potentiated compared with the pretetanic twitches. A similar pattern is seen in myasthenia gravis.

- **Train-of-four** stimulation denotes four successive twitches in 2 sec (2Hz), each 0,2 msec long
- The twitches in a train-of-four pattern progressively fade as relaxation increases
- The ratio of the response of the first and fourth twitch is a sensitive indicator of non-depolarizing muscle relaxation. The train-of-four ratio is calculated as the ratio of the force generated by the 4th contraction compared with the force of the 1st contraction; a force transducer is required
- Disappearance of the fourth twitch represents a 75% block, the third twitch an 80% block, and the second twitch a 90% block

- **Post-tetanic twitch.** The nerve is stimulated at 50Hz for 5s followed by twitches after 3s at a frequency of 1Hz. The number of post-tetanic stimuli which evoke detectable twitches is counted. The ability of tetanic stimulation during a partial non-depolarizing block to increase the evoked response may be due to increase in Ach mobilization. There are usually about 12-20 before the train-of-four count detects the first response. Reversal of block is usually easy if the post-tetanic count is more than 10.
- **Double-burst stimulation.** Consists of three short bursts followed 750 msec later by another 3 or 2 bursts ($DBS_{3,3}$ $DBS_{3,2}$) Fade is more obvious and less painful

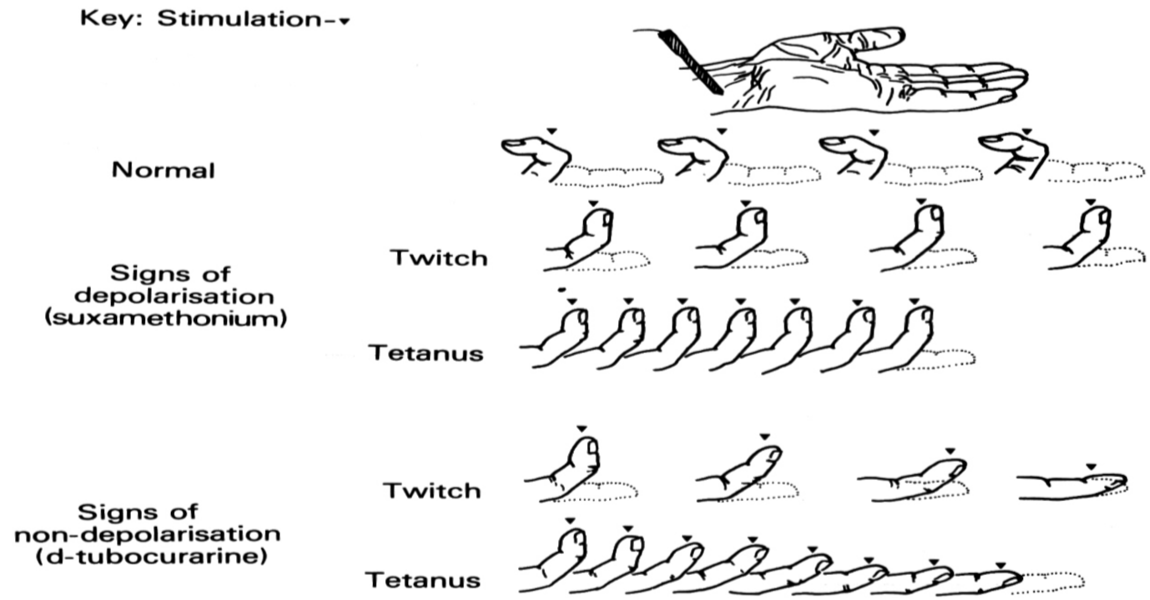
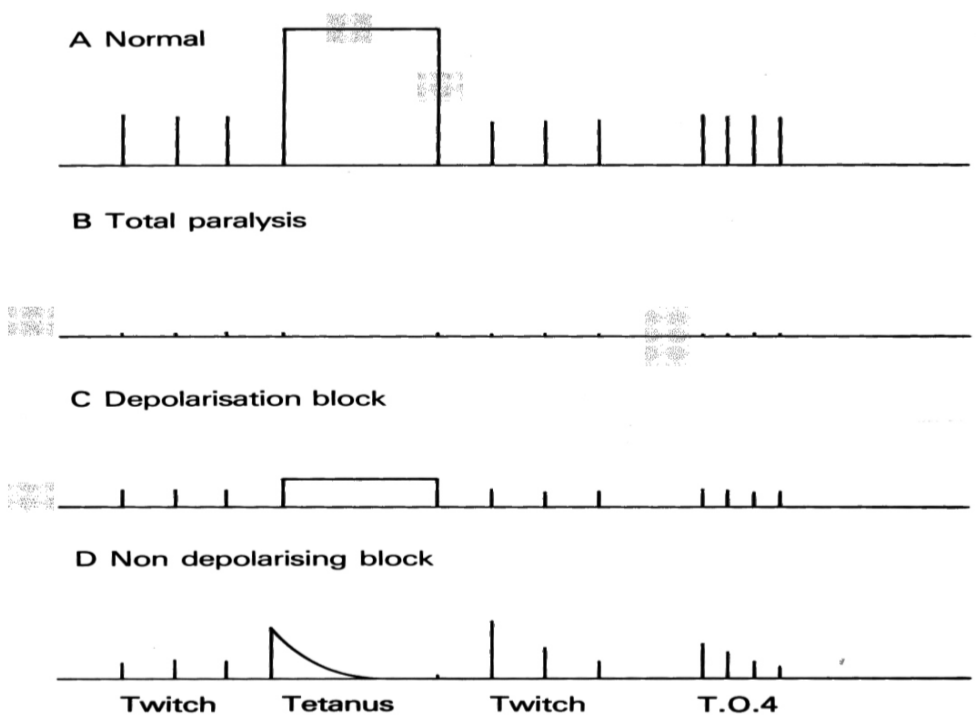
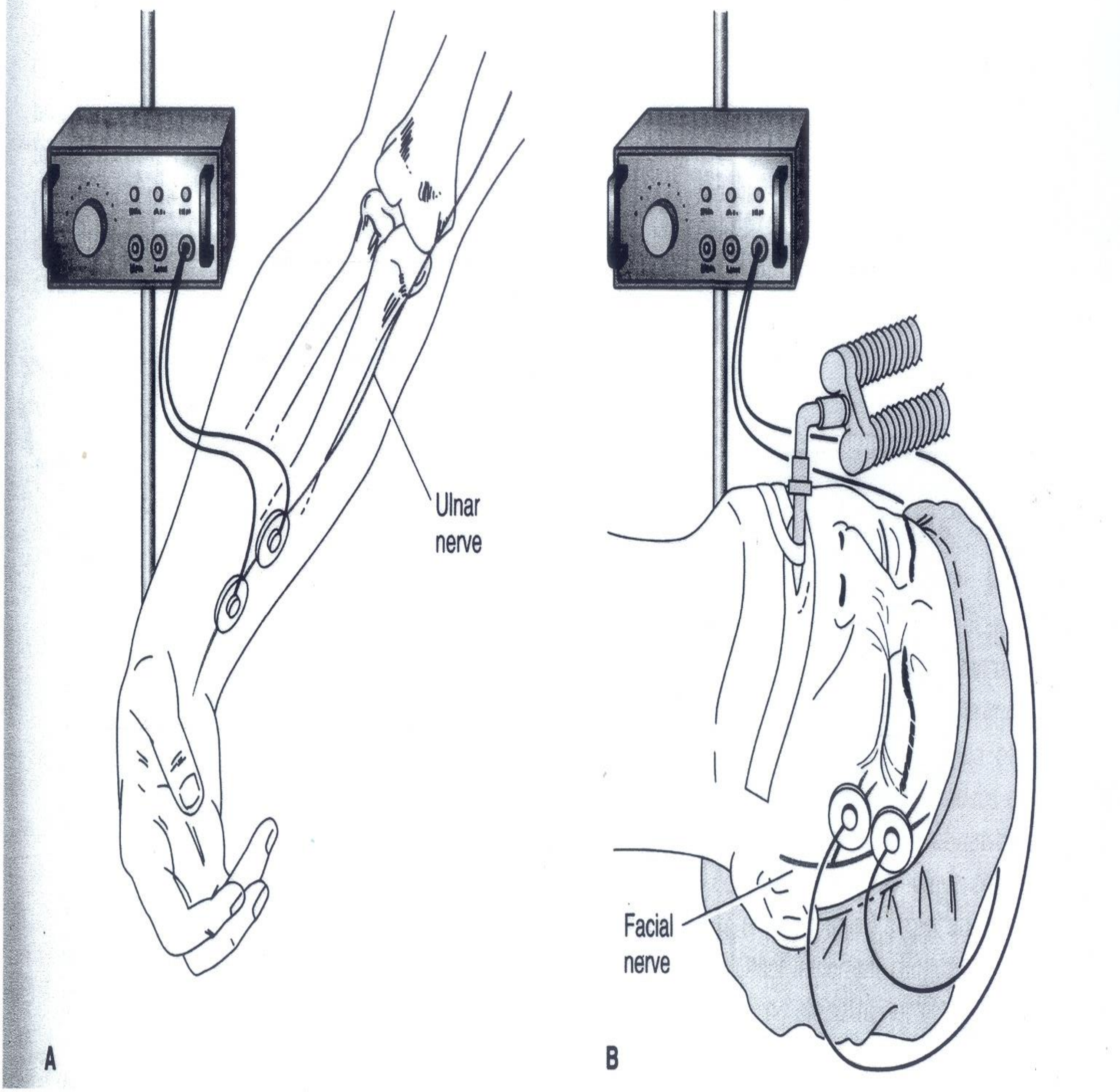


Fig. 12.3 Effects of single twitch and tetanic stimulation assessed by observation of finger movement.




Ulnar
nerve
Facial
nerve
A
B

Depth of anaesthesia

- Current anaesthetic techniques, using muscle relaxants, opioids, and β-blockers~ periods of intraoperative awareness are not always heralded by sympathetic nervous system stimulation.
- Traumatic intraoperative recall (with pain) 0,03%
- Predominantly young healthy females for C/S
- GA creates 2 specific behaviors:
  - Unresponsiveness (surgical immobility)
  - Oblivion (unconsciousness and amnesia)
- Memory: explicit and implicit