MONITORING DURING AND AFTER ANESTHESIA

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Monitoring

Harvey Williams Cushing

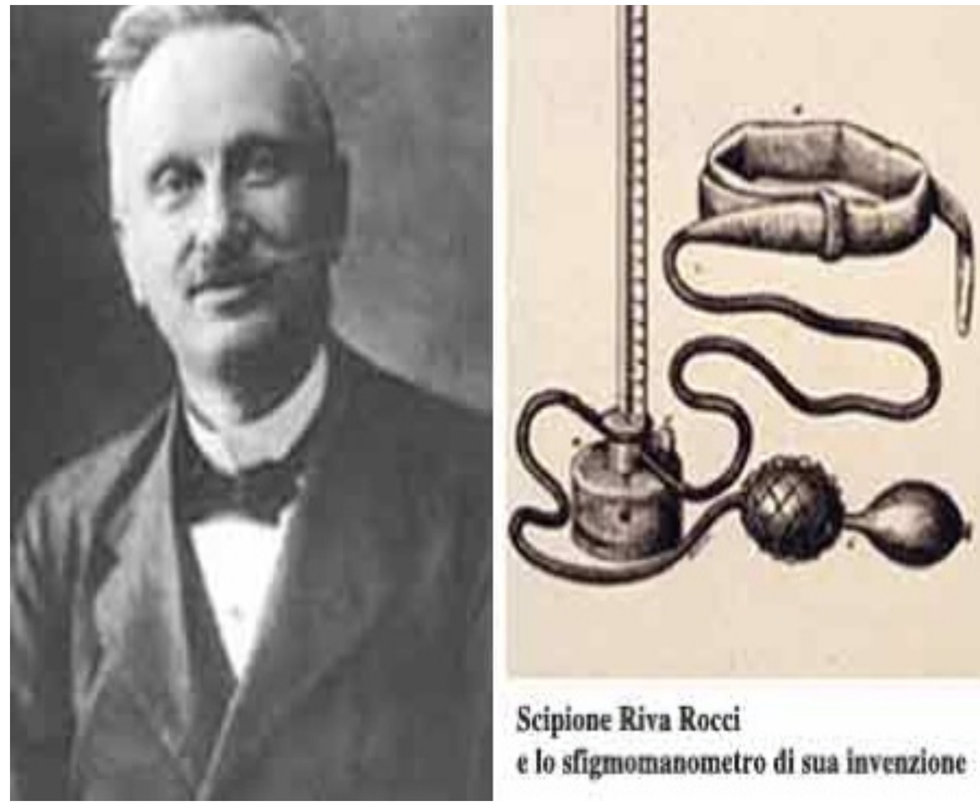
Not just a famous neurosurgeon …
but the father of anesthesia monitoring

- In 1894 at the Massachusetts General Hospital he invented and popularized the anesthetic chart - observed respiratory rate and palpated pulse rate
- In 1901 added blood pressure measurement by Riva Rocci sphygmomanometry
- In 1903 with Dr. S. Griffith Davis also added respiratory rate and heart rate as auscultated by precordial stethoscope
- Emphasized the relationship between vital signs and neurosurgical events *(increased intracranial pressure leads to hypertension and bradycardia)*

www.m.endocrinediseases.org/adrenal/cushings.shtml

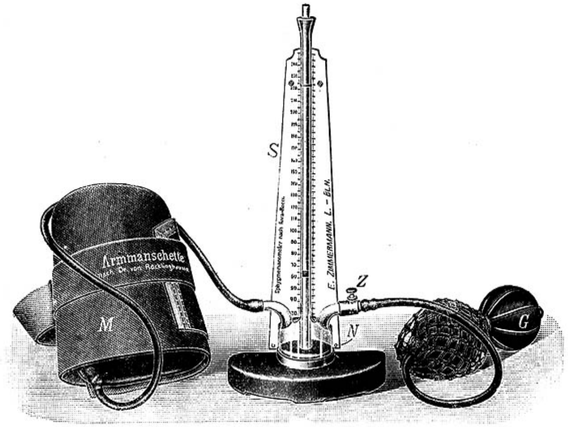
Riva – Rocci shygmomamanometer („puls pressure meter”)

- Invented in 1896 by Italian inetrnist and pediatrician
- A rubber cuff to wrapp around the patient’s arm. Cuff inflated with a rubber bulb
- Pulse palpation on the wrist
- Pressure in the cuff was measured by the height of the mercury in the vertical glass tube
- Only systolic blood-pressure



www.cesarearezzo.it/site/?m=201401

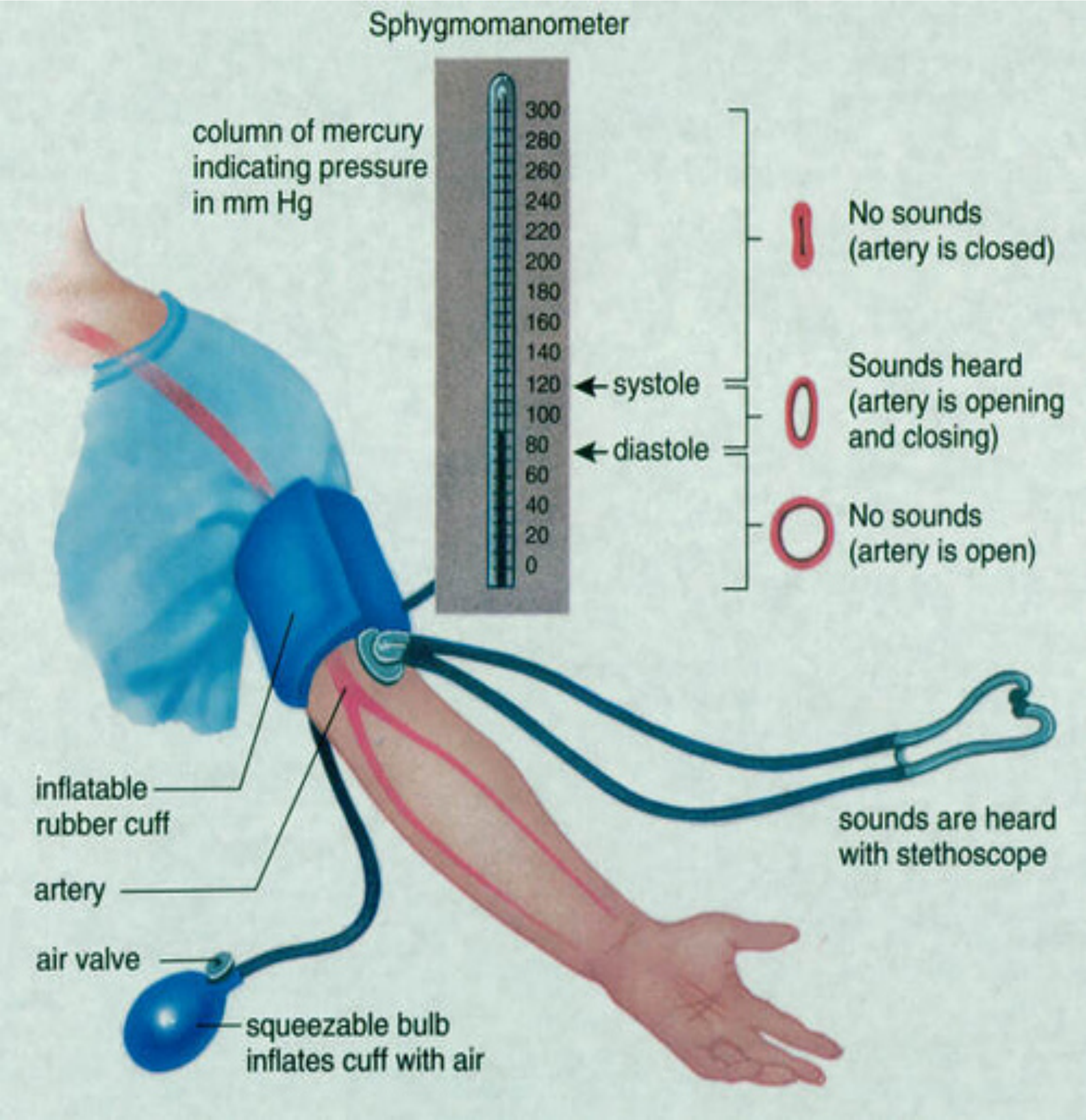
Sphygmomanometer



http://vlp.mpiwg-berlin.mpg.de/vlpimages/images/img3572.jpg

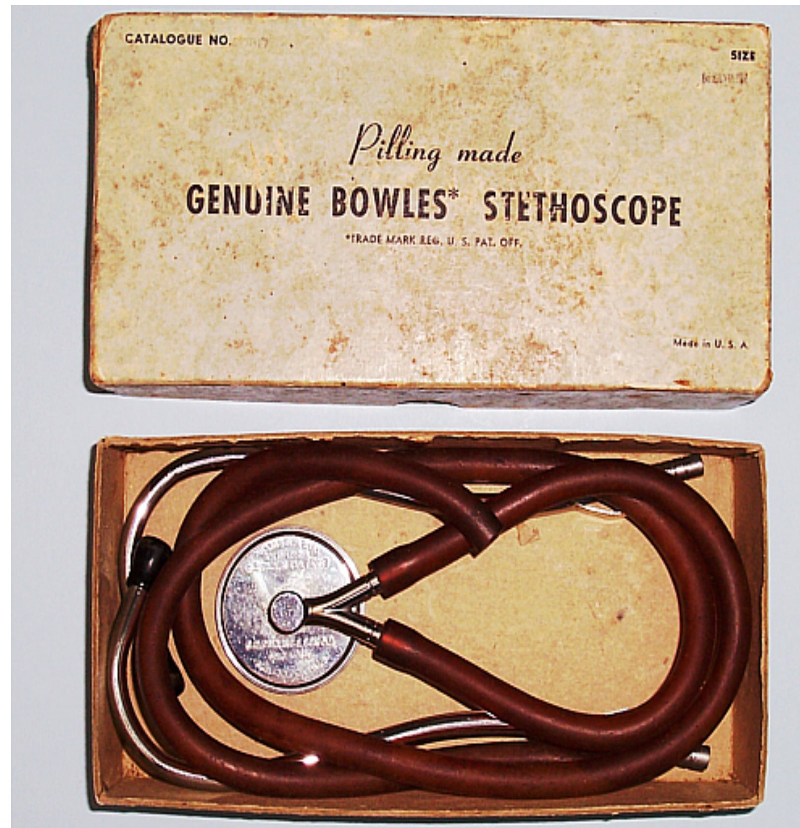
www.shopping.indiatimes.com

www.mortonmedical.co.uk



Sphygmomanometer
column of mercury indicating pressure in mm Hg
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
systole
diastole
No sounds (artery is closed)
Sounds heard (artery is opening and closing)
No sounds (artery is open)
inflatable rubber cuff
artery
air valve
squeezable bulb inflates cuff with air
sounds are heard with stethoscope

Bowles Precordial Stethoscope



www.antiquemed.com

What is the value of knowing this?

- To understand & appreciate the value of <u>clinical monitoring</u>
- <u>To remember the rule:</u> your clinical judgment/assessment is much BETTER & much more VALUABLE than the digital monitor
- To appreciate that modern monitors have made life much easier for us. They are present to make monitoring easier for us NOT to be omited or ignored

Monitoring in the Present

- Standardized basic monitoring requirements (guidelines) from the ASA (American Society of Anesthesiologists), CAS (Canadian Anesthesiologists' Society) and other national societies
- Many integrated monitors available
- Many special purpose monitors available
- Many problems with existing monitors (e.g., cost, complexity, reliability, artifacts)

American Society of Anesthesiology (ASA) Standards for Basic Anesthetic Monitoring

last amended 2011

Standard I

- Qualified personnel shall be present in the operating room throughout all:
  - General Anesthetics
  - Regional Anesthetics
  - Monitored Anesthesia Care

- Because of the rapid changes in patient status during anesthesia, qualified personnel shell be continuously present to monitor the patient and provide anesthesia care

Standard II

- During all anesthetics the following parameters will be continually evaluated:
  - Oxygenation
    - oxygen analyzer, oximeter
  - Ventilation
    - capnography, ventilation alarms
  - Circulation ECG, blood pressure
  - Temperature

Observe

Color of a patient

Chest movements

Color & amount of blood in operative field

Oxygenation

- Objective
  - ensure adequate oxygen concentration in the inspired gas and the blood
- Methods
  - inspired gas: oxygen analyzer with alarms to measure the concentration of oxygen (GA)
  - **<u>Pulse oximetry</u>**

Oxygenation

Puls oximetry

Inspired gas, oxygen analyzer

Pulse Oximetry

Simply to use

Non invasive

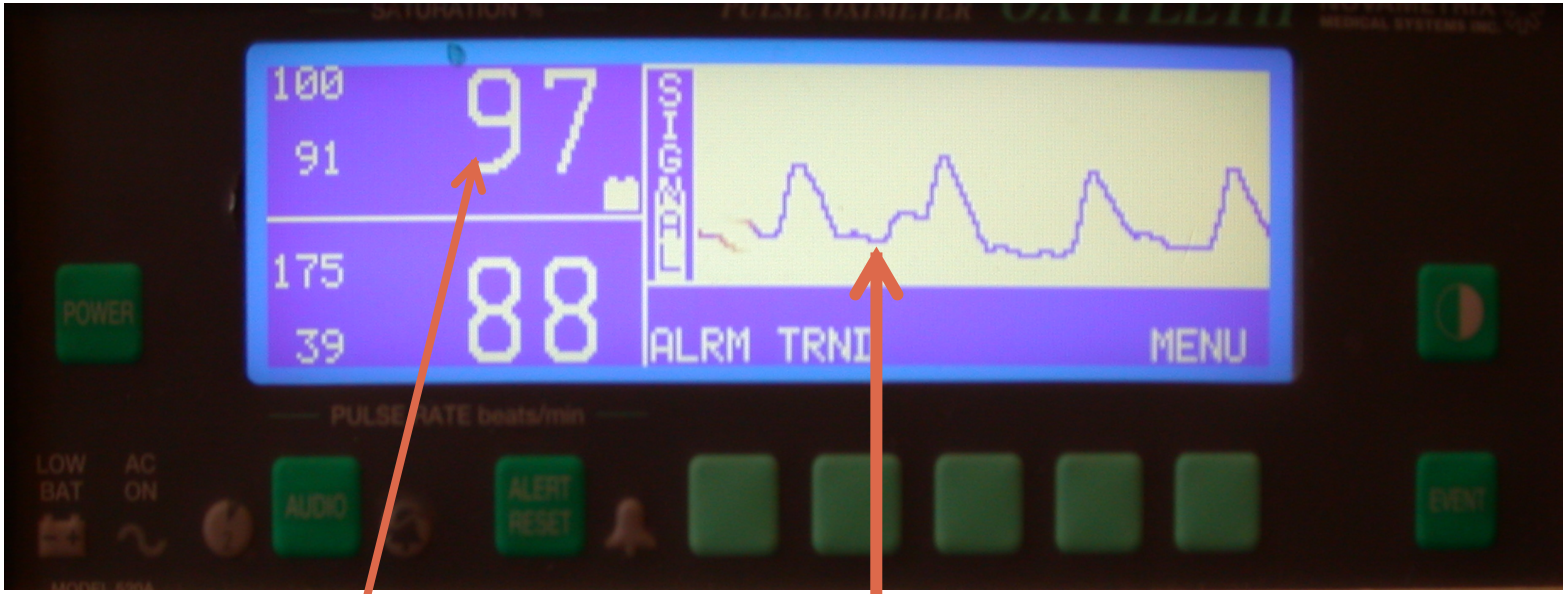
No warm up time

Not affected by pigmented skin

Pulse Oximetry

- Optical plethysmography
  - detects pulsatile changes in blood volume
- Spectrophotometry
  - measures pulsatile hemoglobin saturation
- Assumptions
  - all pulsation is arterial

Pulse Oximeter



spectrophotometry

plethysmography

Pulse oximetry probe

Attached to:

- Finger
- Ear lobe
- Nasal bridge
- Wrapped around a digit

Two light emitting diodes (red &infra-red light)

- Single detector on the opposite side

Pulse oximetry disadvanteges

<u>Read inaccurately in the presence of</u>

- High concentration of carboxyhemoglobin, methemoglobin & bilirubin
- Hypothermia
- Severe hypotension (shock)

Ventilation

- Objective
  - ensure adequate ventilation of patient
- Methods

<u>clinical signs</u>

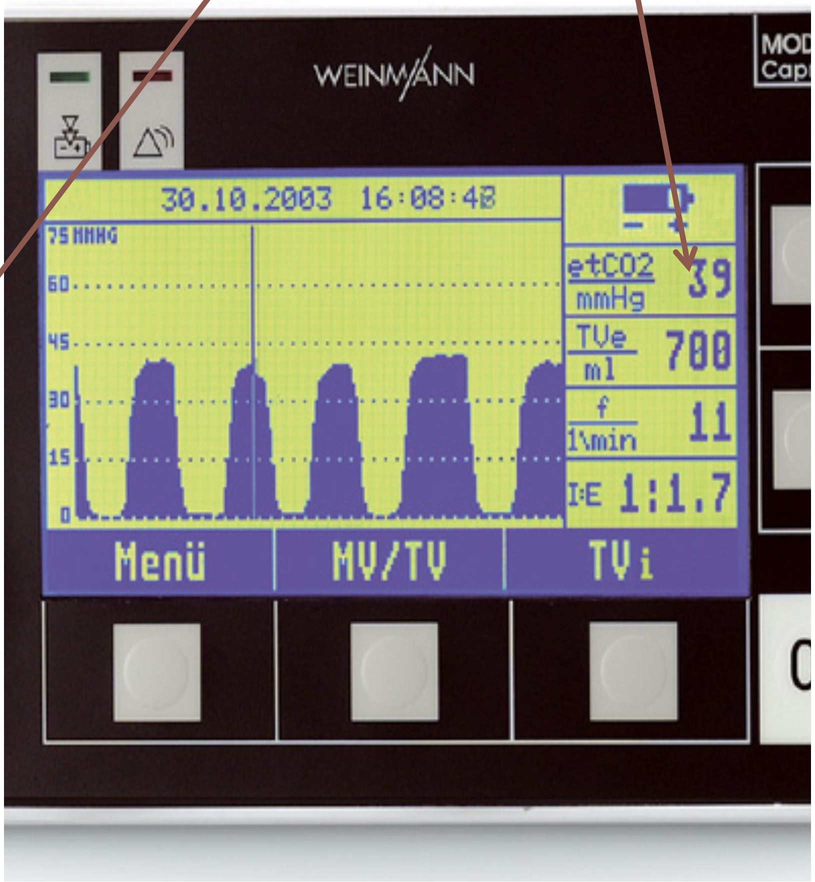
- chest excursion
- observation of reservoir bag
- auscultation of breath sounds

<u>measurement</u>

- end tidal carbon dioxide
- volume of expired gas
- continuous circuit disconnect monitor for mechanical ventilation

Capnography

ET CO2



Capnography

- Identification of carbon dioxide in the expired gas
- Continual end-tidal carbon dioxide analysis, in use from the time of endotracheal tube/laryngeal mask placement until extubation/removal

Applications

- confirmation of intubation
- monitoring for circuit disconnection
- identification of airway obstruction
- rebreathing/metabolic monitoring

Capnography

- Et CO_2 correlates well with $PaCO_2$ in the absence of pulmonary disease
- $PaCO_2$ = 40mm Hg = etCO_2 = 35 mm Hg

Circulation

- Objective
  - ensure adequacy of circulatory function
- Methods
  - **continuous electrocardiogram monitoring**
  - **arterial blood pressure and heart rate q 5 min**
  - during GA one additional continual parameter

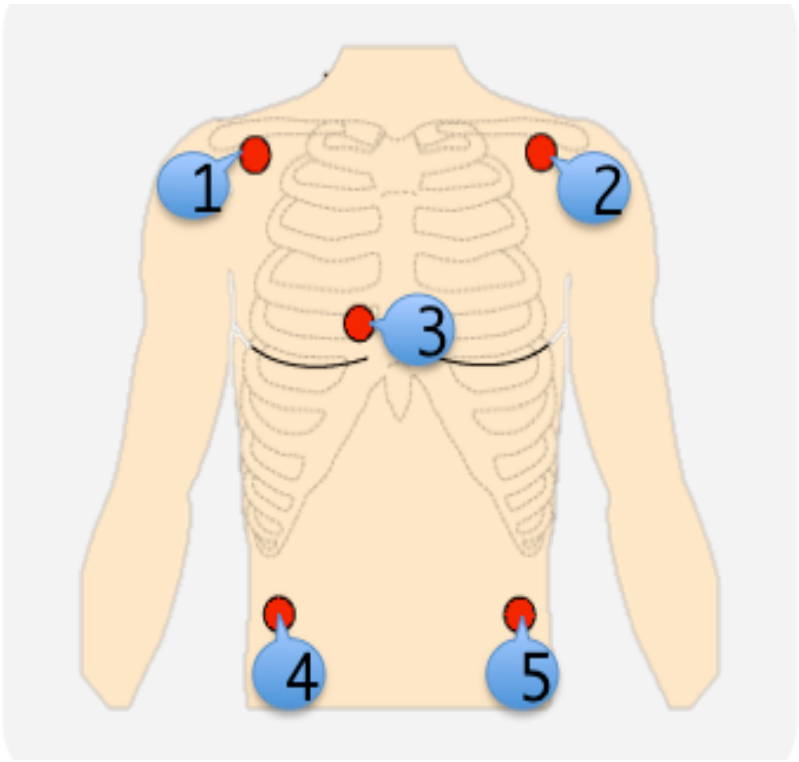
- palpation of pulse
- auscultation of breath sounds
- intra-arterial pressure trace
- doppler peripheral pulse
- pulse plethysmography
- pulse oximetry

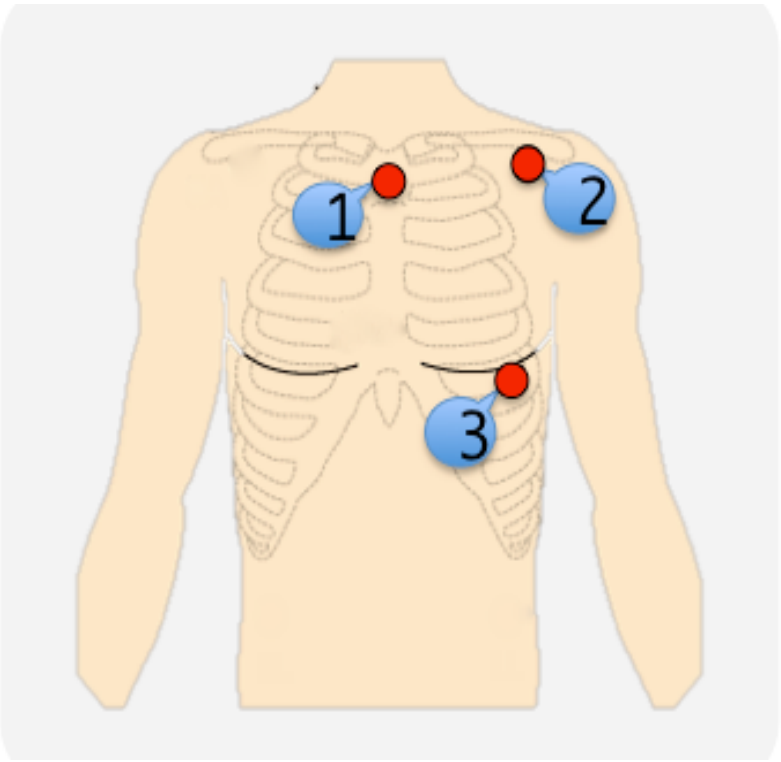
Electrocardiogram

- 3 vs. 5 electrode system
  - three versus seven leads for diagnostic purposes
- Heart rate measurement
  - R wave counting (any lead)
- Ischemia Monitoring
  - lead II and V_5 are 90% sensitive
  - lead II, V_5 and V_4 up to 98% sensitive
- Arrhythmia monitoring
  - lead II for supraventricular arrhythmias
  - all leads for ventricular arrhythmias

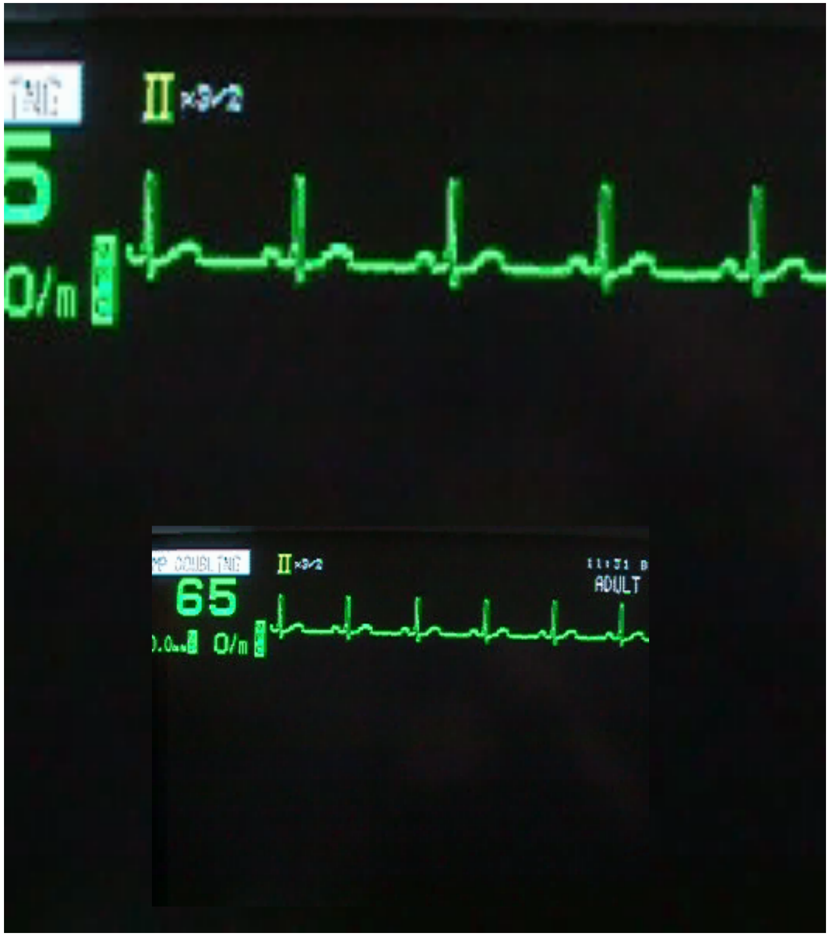
Electrodes placement

Practice standards for electrocardiographic monitoring in hospital settings. An American Heart Association Scientific Statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young





Electrocardiogram



Noninvasive Blood Pressure NIBP

- Methodology
  - oscillometric algorithms
  - automated
  - reproducible
- Limitations
  - cuff size
    - oversize erroneously low measurements
    - to small erroneously high

Temperature

- Objective
  - aid in maintaining appropriate body temperature
- Application
  - readily available method to continuously monitor temperature if changes are intended, anticipated or suspected
- Methods
  - thermistor
  - temperature sensitive chemical reactions
  - location

Temperature Monitoring

Rationale for use

- detect/prevent hypothermia
- monitor deliberate hypothermia
- adjunct to diagnosing MH
- monitoring in cooling/ rewarming (special procedures –post CPR states)

Sites

- Esophageal
- Nasopharyngeal
- Axillary
- Rectal
- Bladder
- Blood

Additional monitoring

Fluid balance

- bladder catheter, accurate measurement of urine output,
- insensible water loss from the respiratory tract,
- evaluation of blood loss
- fluid loss through the wound - perspiration,

Additional monitoring

- Neuromuscular Function - evaluation of reversal of blockade
- Depth of anesthesia
- Blood tests

Neuromuscular Function
Evaluation of Reversal of Blockade

Clinical Criteria

- head lift > 5 seconds
- sustained hand grip
- negative inspiratory force
  - at least -55 cmH_2O for adults
  - at least -32 cmH_2O for children
- vital capacity 15 ml/kg
- absence of nystagmus or diplopia

Neuromuscular Function
Evaluation of Reversal of Blockade

The recommendations for application of neuromuscular monitoring is based on:

- Variable individual response to muscle relaxants
- Narrow therapeutic window (no detectable block until 75-85% of receptors are occupied and paralysis is complete at 90-95% receptor occupancy)

Monitoring permits administration of NMBs such that optimal surgical relaxation is achieved and yet the block reverses spontaneously or reverse reliably and quickly with antagonists

When only clinical criteria are used up to 42% of the patients are inadequately reverse upon arrival to the recovery room.

Residual neuromuscular block is a major risk factor for many critical events (ventilatory insufficiency, hypoxemia, pulmonary infections)

Neuromuscular Function
Evaluation of Reversal of Blockade

The most satisfactory method for reliable monitoring neuromuscular function is the stimulation of an appropriate nerve using a peripheral nerve stimulator and observation of avoked response in the muscle

Methods:

- Electromyography - based on measurement of the compound action potential
- Mechanomyography - based on isometric measurements
- **Acceleromyography** – most popular- based on Newton’s 2nd law of motion, force =mass x acceleration

ANESTHESIOLOGY
The Journal of the American Society of Anesthesiologists, Inc.

From: Acceleromyography for Use in Scientific and Clinical Practice:A Systematic Review of the Evidence

Anesthesiology. 2008;108(6):1117-1140. doi:10.1097/ALN.0b013e318173f62f

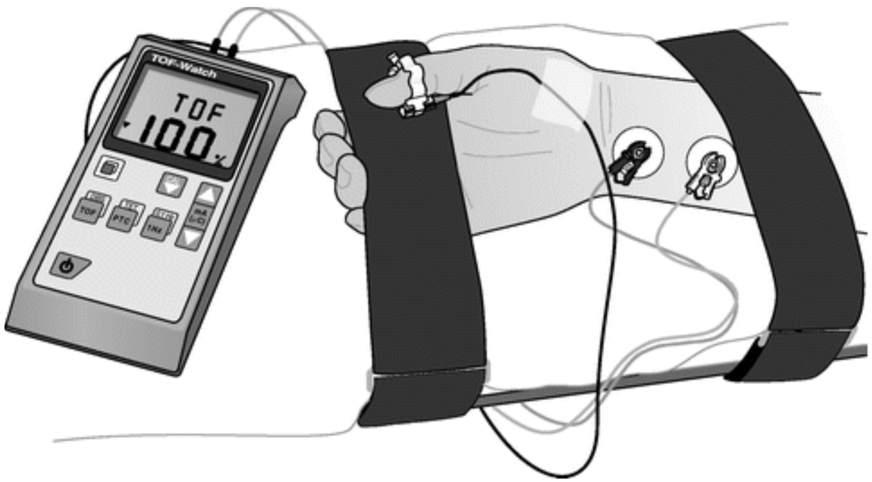


Figure Legend:

Fig. 1. The setup of acceleromyography. Two electrodes are placed above the ulnar nerve, and the response to nerve stimulation is measured using a small piezoelectrode acceleration transducer distally placed on the volar site of the thumb.

Monitoring the depth of anethesia

- The incidence of unintended awareness may be higher than commonly perceived at around 1:660 anaesthetics.
- Neuromuscular blocking drugs remain the most commonly implicated risk factor for unintended awareness.
- An adequate administration rate of anaesthetic drugs (MAC>0.7 for volatile agents) should be maintained and the haemodynamic consequences of anaesthesia should be dealt with separately. Benzodiazepines do not prevent awareness or recall.
- Depth of anaesthesia monitors may be helpful, particularly for TIVA, but may not be better than close attention to end-tidal volatile agent concentration.

Monitoring the depth of anethesia

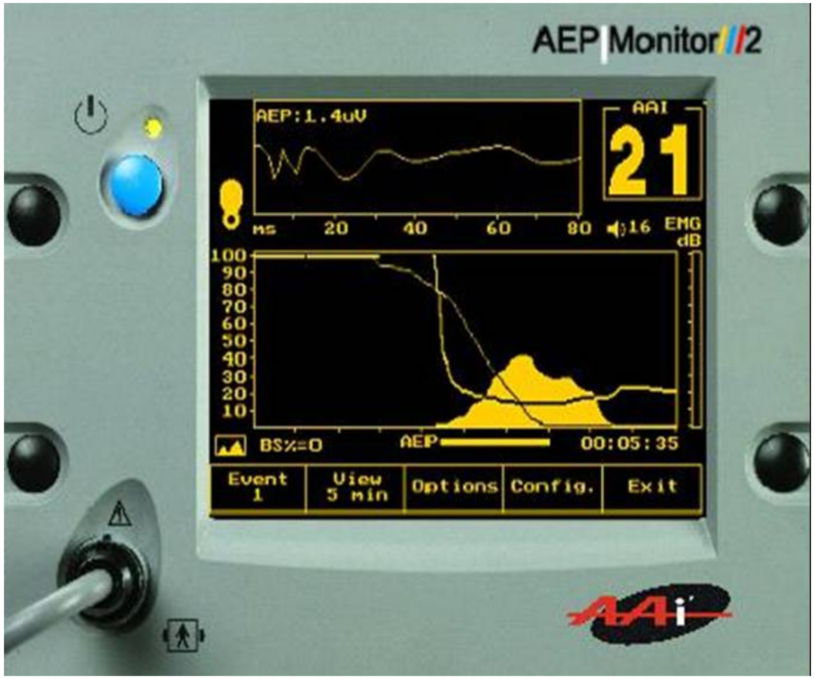
- Bispectral index (BIS) Narcotrend, and M-Entropy -

- use the processed spontaneous EEG to provide a measure of the degree of cortical suppression.

- The aepEX device

- uses auditory-evoked potentials (AEP) to derive the depth of anaesthesia.

Depth of Anesthesia



BIS

Blood tests

- Glucose
- Ions
- Arterial blood gases
- Cardiac tests
- Liver, kidney function
- Hematology – RBC, HBG, PLT, Coagulation
- Tromboelastometry

Invasive monitoring

- Invasive blood pressure (BP) monitoring
- Measurement of central venous pressure (CVP)
- Hemodynamic monitoring
- Intracranial pressure (ICP) measurement

Continous, Invasive Blood Pressure

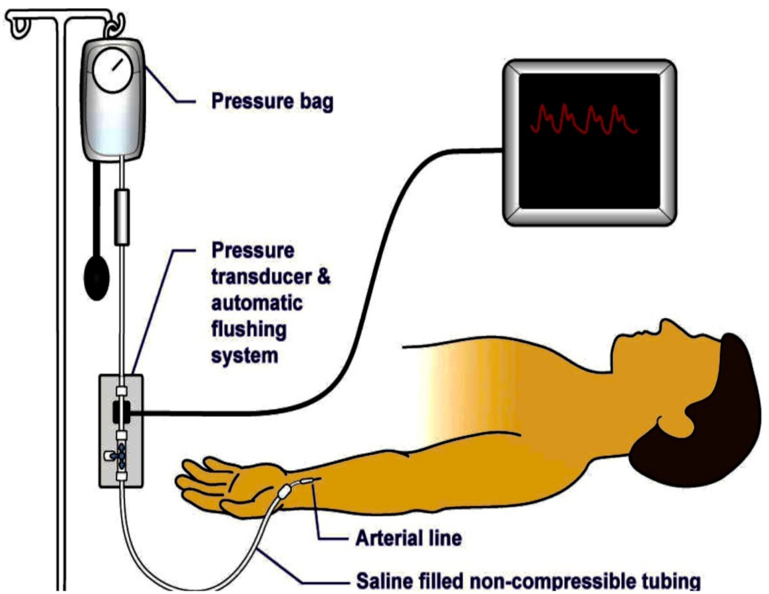
- This is the gold standard of blood pressure measurement giving accurate beat-to-beat information.
- In general, systolic pressure will be slightly higher and diastolic pressure slightly lower (5 - 10 mm Hg) than non-invasive measurements.

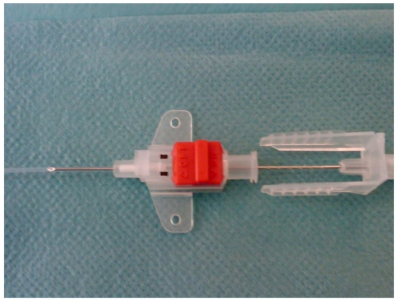
Continous, Invasive Blood Pressure

<u>It is useful</u>:

- When rapid changes in blood pressure are anticipated (due to cardiovascular instability, large fluid shifts or pharmacological effects)
- When non-invasive blood pressure monitoring is not possible or likely to be inaccurate (obesity, arrhythmias such as atrial fibrillation, non-pulsatile blood flow during cardiopulmonary bypass).
- When long-term measurement in sick patients is required as it avoids the problem of repeated cuff inflation (causing localized tissue damage)
- Allows repetitive sampling for blood gases and laboratory analysis.

Continous, Invasive Blood Pressure





- Intra-arterial cannula;
- Tubing (incorporating an infusion system);
- Transducer;
- Microprocessor and display screen;
- Mechanism for zeroing and calibration

Central Venous Pressure CVP

It is a pressure of blood in thoracic vena cava near the right atrium

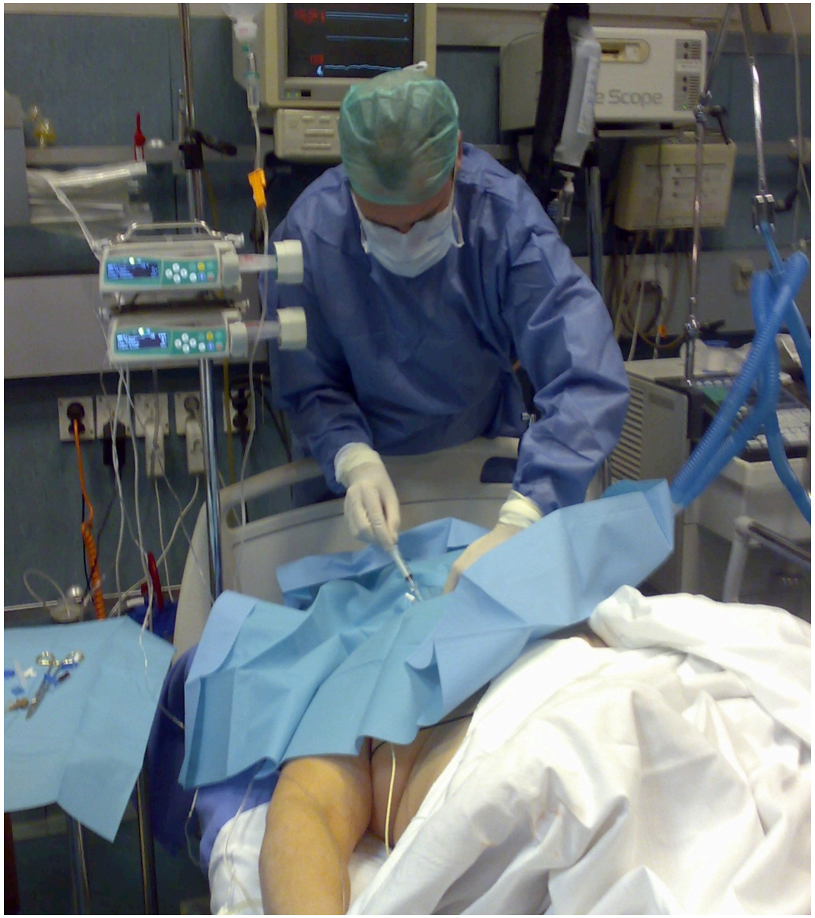
It reflects the amount of blood returning to the heart and ability of the heart to pump the blood into the arterial system

Indications:

- Patients requiring resuscitation by infusion of fluids or blood
- Patients requiring catecholamine infusion

Central Venous Pressure CVP

- We usually need central venous catheter,
- Most often placed through
- internal jugular veins,
- subclavian veins
- femoral veins
- (sometimes via brachial veins)



Central Venous Pressure CVP

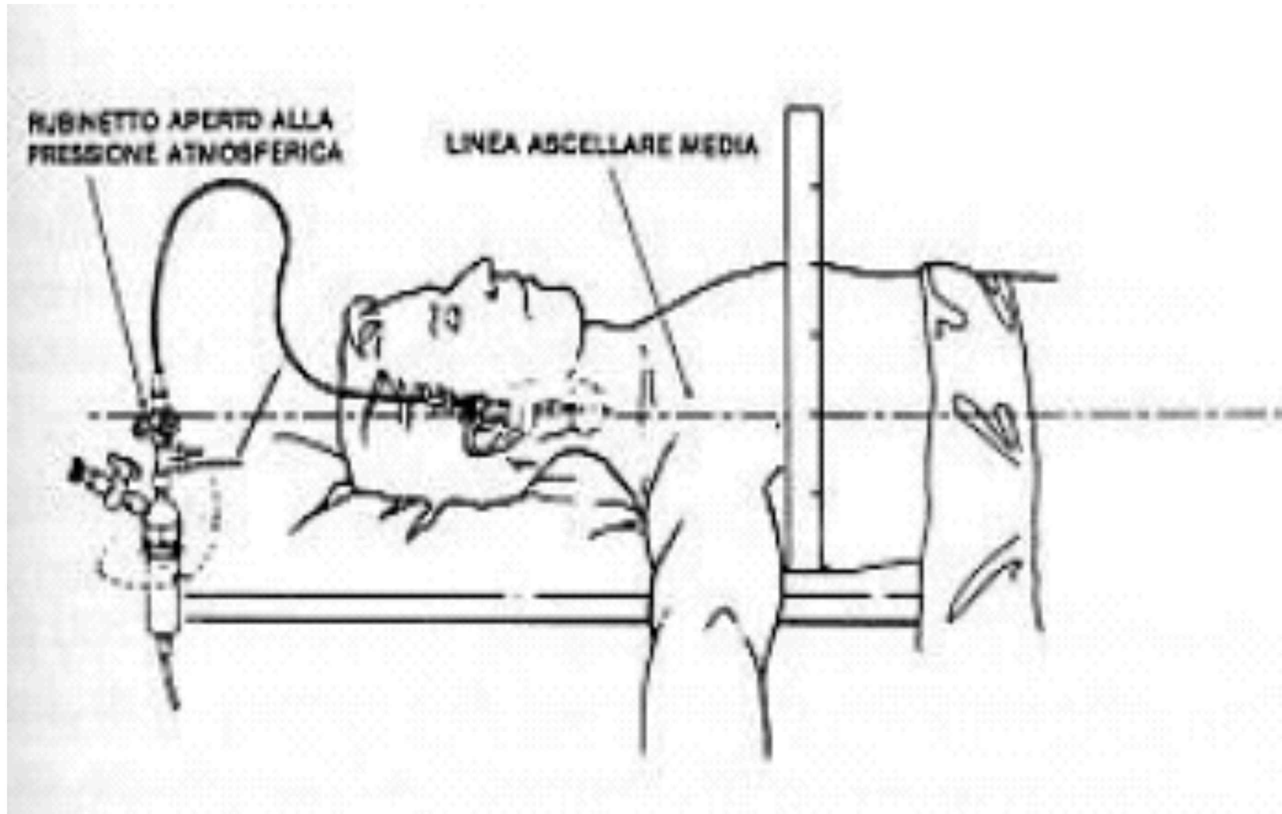
Reference point

RIGHT ATRIUM

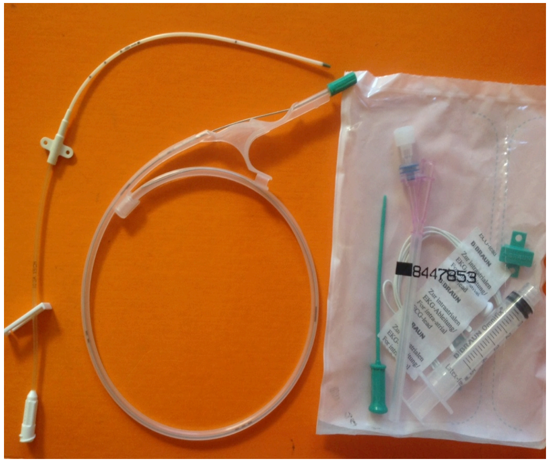
=

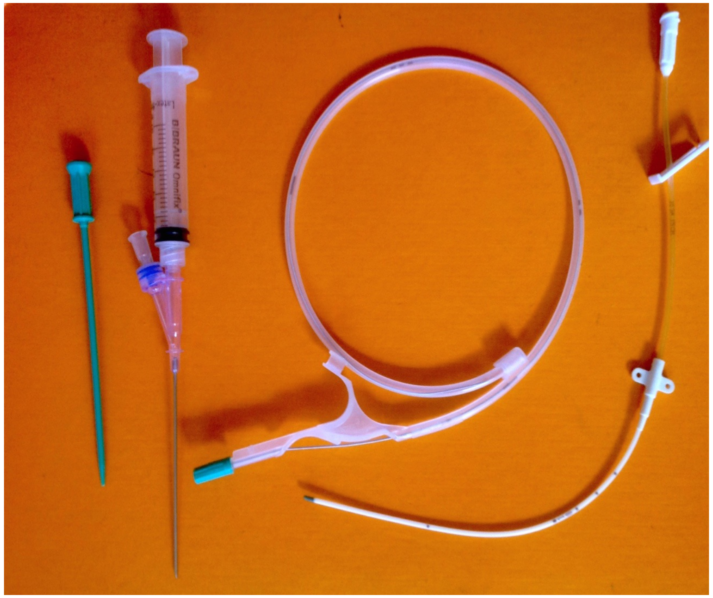
"Mean Axillary Line"

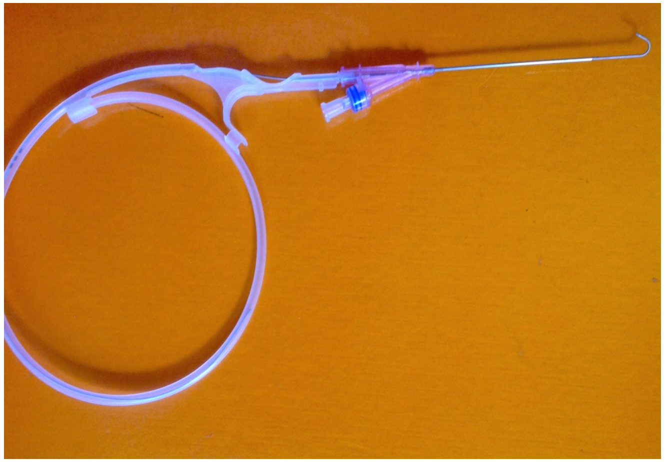
Supine position



Central venous catheter



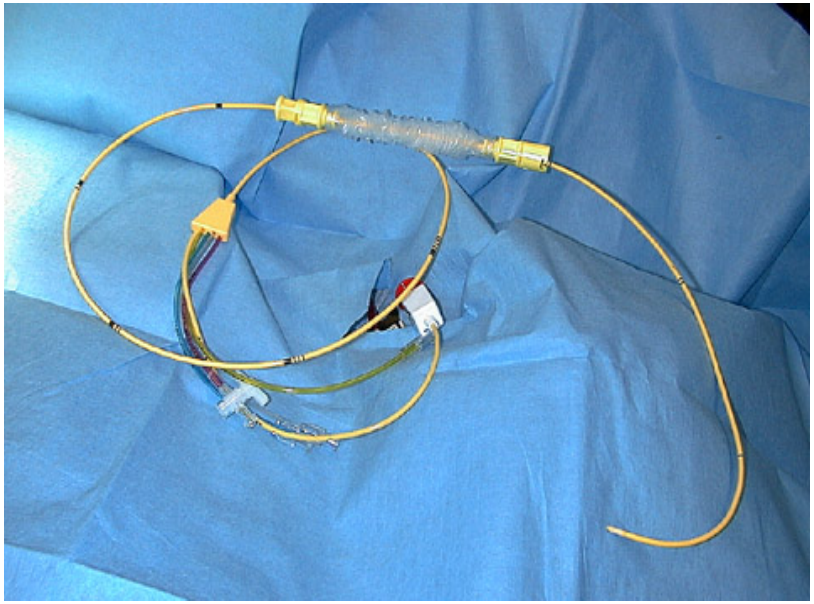




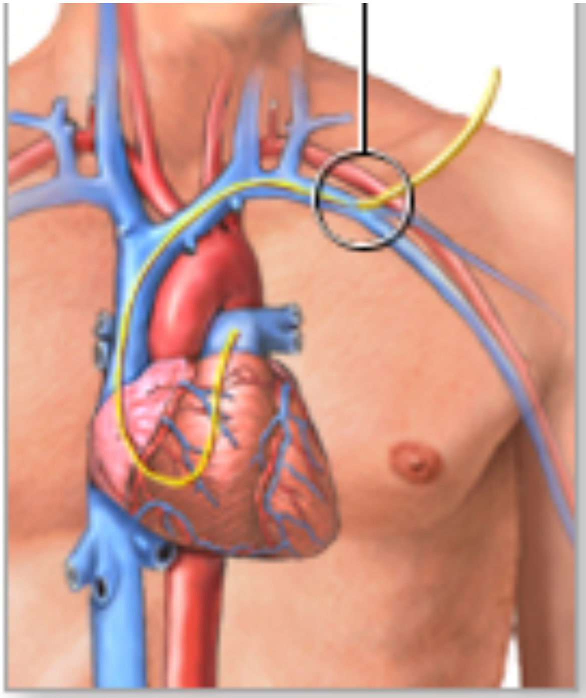
Invasive hemodynamic monitoring Cardiac Output Measurements

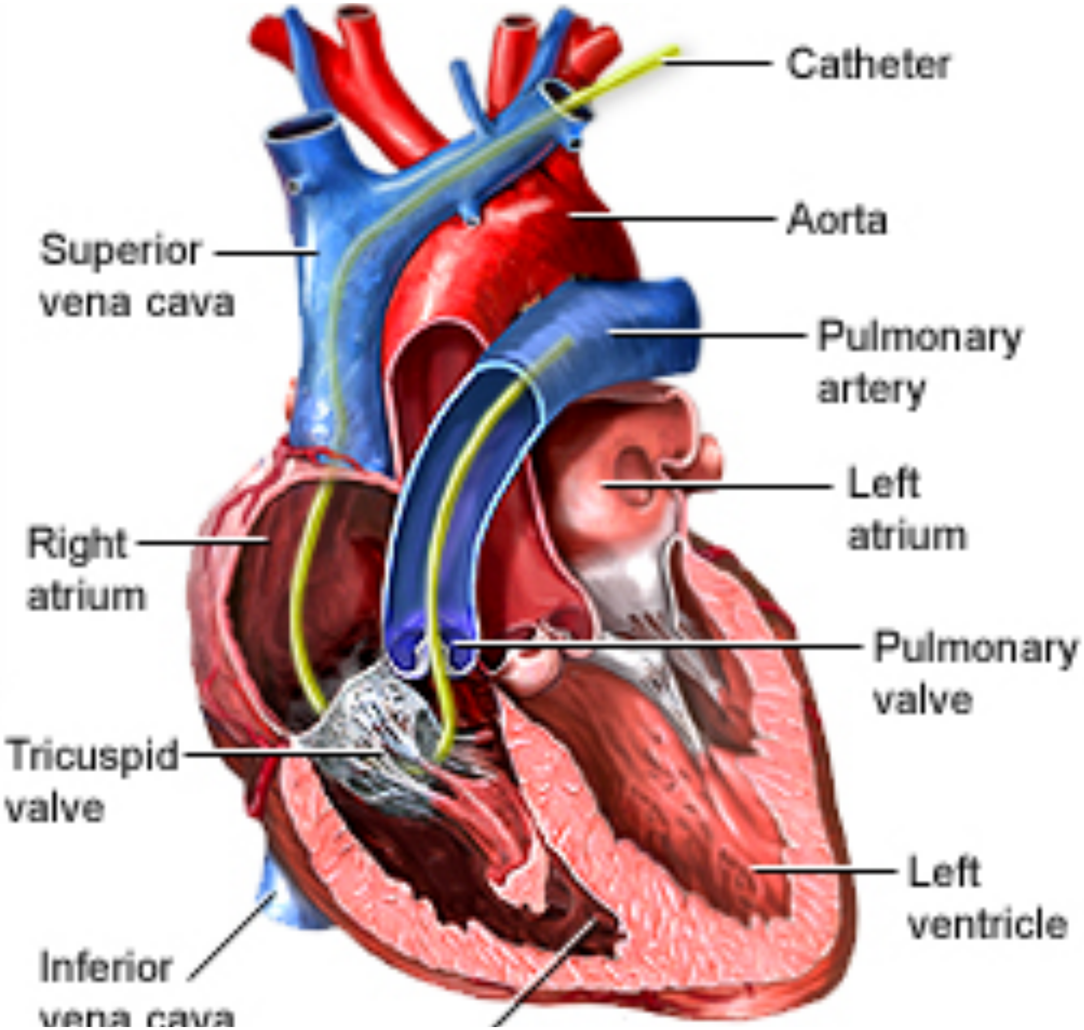
Pulmonary artery catheter

The PAC was the clinical standard for cardiac output monitoring for more than 20 years and the technique has been extensively investigated



Pulmonary artery catheter





Pulmonary artery catheter - right heart catherisation

The catheter is introduced through a large vein

- Internal jugular
- Subclavian
- Femoral

It is threaded through the atrium of the heart, right ventricle and subsequently into the pulmonary artery

Pulmonary artery catheter

It allows:

- Continuous cardiac output monitoring (CO)
- Central temperature monitoring
- Measurement of pulmonary artery pressure
- Measurement of mixed venous saturation
- Indirect monitoring of the pressure in the left atrium (CVP)
- Left ventricular end diastolic pressure (PCWP)

Minimaly invasive hemodynamic monitoring

- Transesophageal doppler
- Pulse pressure analysis – requires a catheter placed in the artery preferably femoral and very often a central venous line (PiCCO,Vigileo)
- Bioimpendance - cardiac output is continuously estimated using skin electrodes or electrodes mounted on an endo - tracheal tube
- Applied Fick principle – Partial CO2 rebreathing - this technique may be applied in a precisely defined clinical setting to mechanically ventilated patients only.

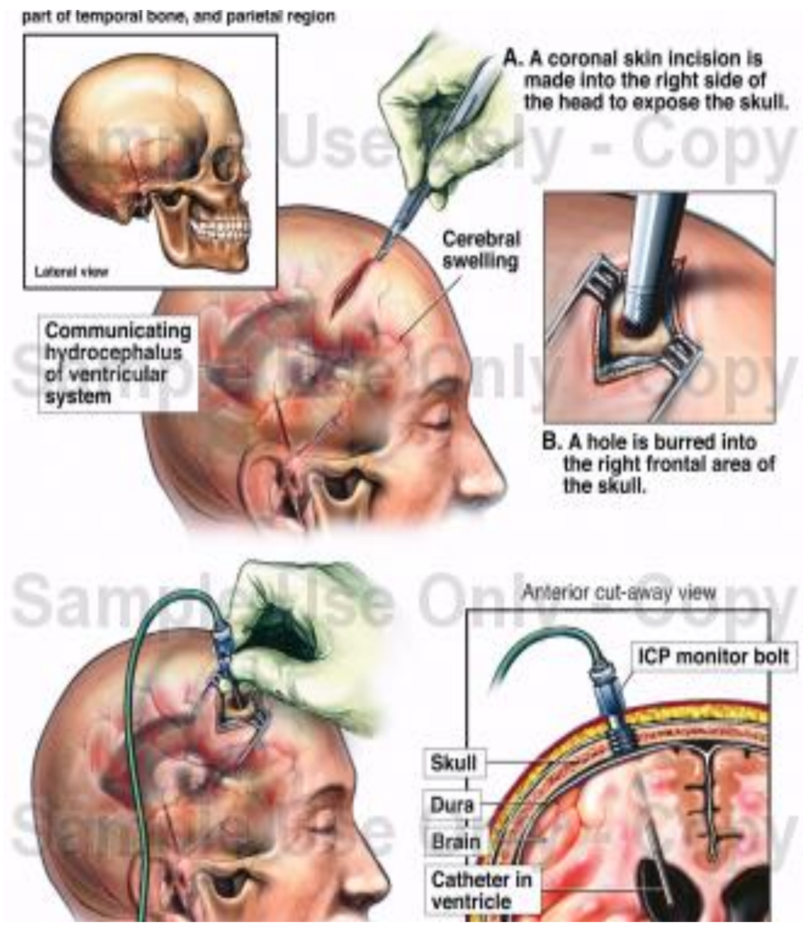
Intracranial pressure ICP

Elevated intracranial pressure (ICP) is seen in head trauma

1. Hydrocephalus
2. Intracranial tumors
3. Hepatic encephalopathy
4. Cerebral edema

Intractable elevated ICP can lead to death or devastating neurological damage either by reducing cerebral perfusion pressure (CPP) and causing cerebral ischemia or by compressing and causing herniation of the brainstream or other vital structures Prompt recognition is crucial in order to intervene appropriately

Intracranial pressure ICP



There are three ways to monitor intracranial pressure (in the skull).

1. Intraventricular catheter
2. Subdural screw
3. Epidural sensor

Post anesthesia care

All patients who have received general anesthesia, regional anesthesia or monitored anesthesia care should receive appropriate postanesthesia management

Postanesthesia Care Unit (PACU)

Transport to the PACU

The patient should be:

- Accompanied by a member of the anesthesia care team who is knowledgeable about the patient’s condition
- Continually evaluated and treated with monitoring and support appropriate to the patient’s condition

During transport the anesthetist remains at the head part of the patient

PACU

- The patient’s condition should be re-evaluated upon arrival to the PACU and then continually observed
- Methods of monitoring appropriate to the medical condition of the patient
- Particular attention should be given to monitoring oxygenation, ventilation, circulation. Level of consciousness and temperature

Discharge from PACU

The 'modified' Aldrete Post anesthesia Score > 9 pts

oxygenation	2	1	0
	SpO2 > 92% on room air	SpO2 > 90% on oxygen	SpO2 < 90% on oxygen
respiration	2	1	0
	Breathes deeply and coughs freely	Dyspneic, shallow or limited breathing	Apnea
circulation	2	1	0
	BP ± 20 mmHg of normal	BP ± 20 – 50 mmHg of normal	BP more than ± 50 mmHg of normal
consciousness	2	1	0
	Fully awake	Arousable on calling	Not responsive
activity	2	1	0
	Moves all extremities	Moves two extremities	No movement