ANESTHESIA MONITORING IN THE OPERATING ROOM AND ICU

Dr. Mustafa Alrabayah

Department of anesthesia and intensive care
The University of Jordan
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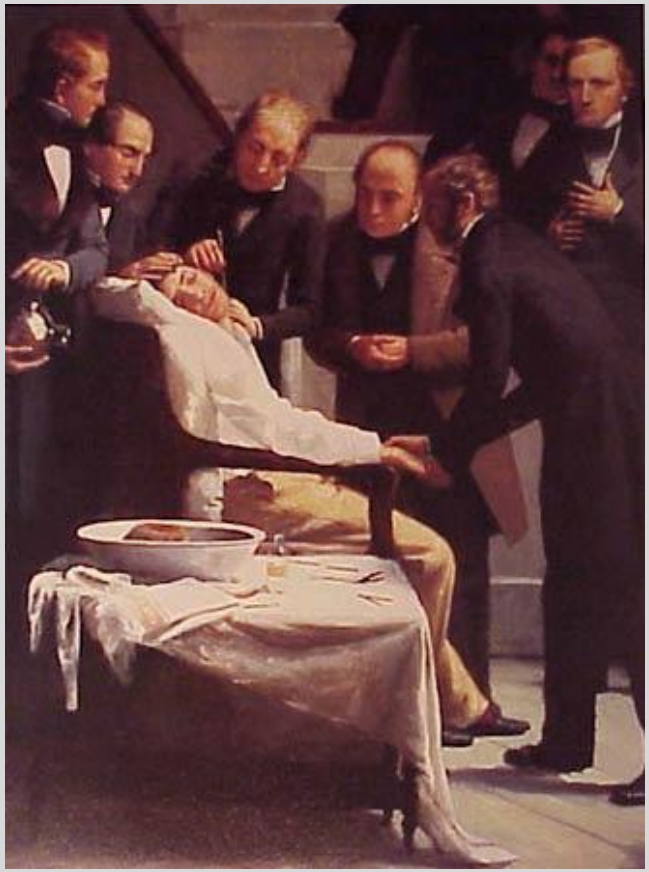
Monitoring In the Past

- Visual monitoring of respiration and overall clinical appearance
- Finger on pulse
- Blood pressure



Introduction

Why do we need intraoperative monitoring???

- To maintain the normal pt physiology & homeostasis throughout anesthesia and surgery:

  induction, maintenance & recovery

  as much as possible. To ensure the well being of the pt.
- Surgery is a very stressful condition → severe sympathetic stimulation, HTN, tachycardia, arrhythmias.
- Most drugs used for general & regional anesthesia cause hemodynamic instability, myocardial depression, hypotension & arrhythmias.
- Under GA the pt may be **hypo** or **hyperventilated** and may develop **hypothermia**.
- Blood loss → anemia, hypotension. So it is necessary to recognise when the pt is in need of blood transfusion (**transfusion point**).

Introduction

The most critical 2 times during anesthesia are:

INDUCTION - RECOVERY.

Exactly like "*flying a plane*" induction (= take off) & recovery (= landing).

The aim is to achieve a smooth induction , a smooth recovery & a smooth intraoperative course.

Introduction

Any monitor consists of:

1) Sensor for data collection.
2) System data analysis.
3) System for interpretation and display.

Introduction

Degree of invasiveness of monitoring

Noninvasive	ECG
Penetrating	ECHO (TEE)
Invasive	Arterial line, CVP
Highly invasive	Brain, PAC

Introduction

Limitation of monitoring

 Delay.

 Danger.

 Decrease skill.

 Doubt of results.

 Distracting set up.

ASA Monitoring Guidelines

STANDARD I

Qualified anesthesia personnel shall be present in the room throughout the conduct of all general anesthetics, regional anesthetics and monitored anesthesia care.

ASA Monitoring Guidelines

STANDARD II

During all anesthetics, the patient's oxygenation, ventilation, circulation and temperature shall be continually evaluated.

ASA Monitoring Guidelines

Oxygenation – FiO_2 analyzer + O_2 concentration alarm. Blood oxygenation – pulse oximetry

Ventilation – continuous capnography (expired Tidal Volume)

Circulation – EKG (minimum 3 leads, consider 5 for cardiac concerns), BP – minim q5 minutes

Temperature – some form of temperature probe

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

- Clinical monitors.
- Airway pressure measurement.
- Disconnection alarm.
- Stethoscope
- Spirometery.
- O2 monitoring.
- Co2 monitoring.
- Anesthetic gas analysis.
- H+ ions measurement.

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

- Peripheral pulse.
- Tissue perfusion.
- ECG.
- Arterial blood pressure.
- Central venous catheterization
- Pulmonary artery catheterization.
- Cardiac output measurement.
- TEE.
- Blood loss measurement.

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

- Temperature monitoring.
- Tissue oxygenation monitoring.
- Indirect calorimetry.
- Fluid & electrolyte status
- Blood gases & acid base status monitoring.

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

Peripheral nerve stimulation:

1) Single twitch.
2) Train of four twitches.
3) Tetanic stimulation.
4) Double burst stimulation.

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

- Arterial line
- Central venous pressure
- Pulmonary artery catheterization
- ICP monitoring

Respiratory system monitors

CVS monitors

Monitoring of metabolism

Neuromuscular Function

Invasive monitoring

CNS monitors

- Clinical monitoring.
- EEG.
- Evoked potentials.
- Cranial nerve monitoring.
- Cerebral blood flow
- cerebral oxygenation.
- depth of anesthesia.

How to select a monitor

Depend on

1) Aim.
2) Experience.
3) Type of anesthesia.
4) Facilities & availability.
5) Nature of surgery.
6) General condition of the patient.

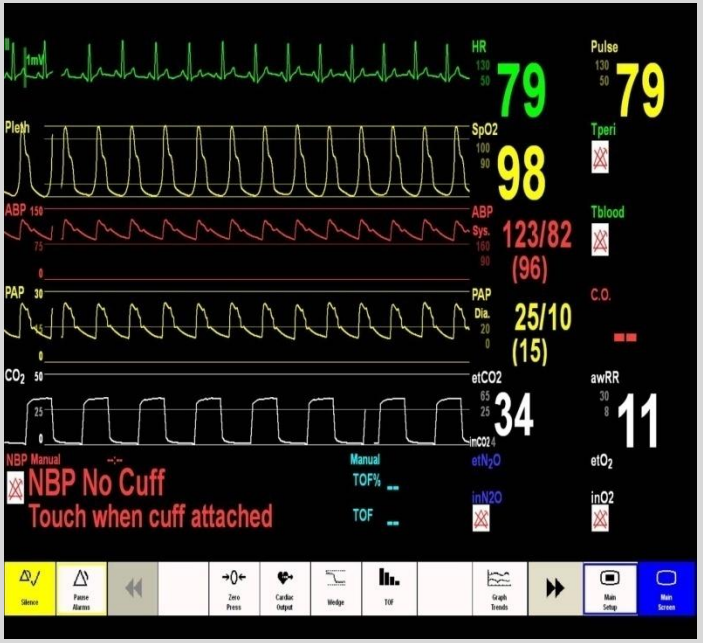
Respiratory system monitors

Oxygenation

Ensure adequate oxygen concentration *in inspired gas and blood*

Methods

- Exposure to assess color
- Inspired gas oxygen analyzer
- Pulse oximetry



Respiratory system monitors

O_2 monitoring

(1) Monitor O_2 delivery to the patient:

O_2 failure alarm.

O_2 conc. in the gas mixture

(2) Monitor O_2 delivery to the tissues

- Clinical monitoring:

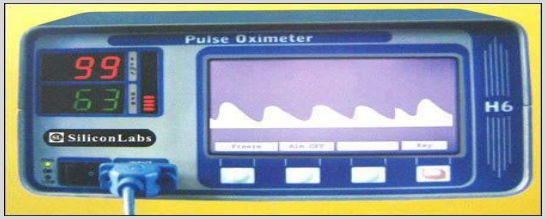
  cap. refilling, state of extremities…
- O_2 transport monitoring through measurement of:

  Hb level & SaO_2 & PaO_2
- O_2 uptake monitoring through:

  $S\bar{v}O_2$ by pulmonary artery oximetry.

  serum lactic acid level.

Respiratory system monitors



Pulse Oximetry

Definition: % of oxy-Hb / oxy + deoxy-Hb.

Timing of SpO2 monitoring: throughout the surgery:

before induction till after extubation & recovery.

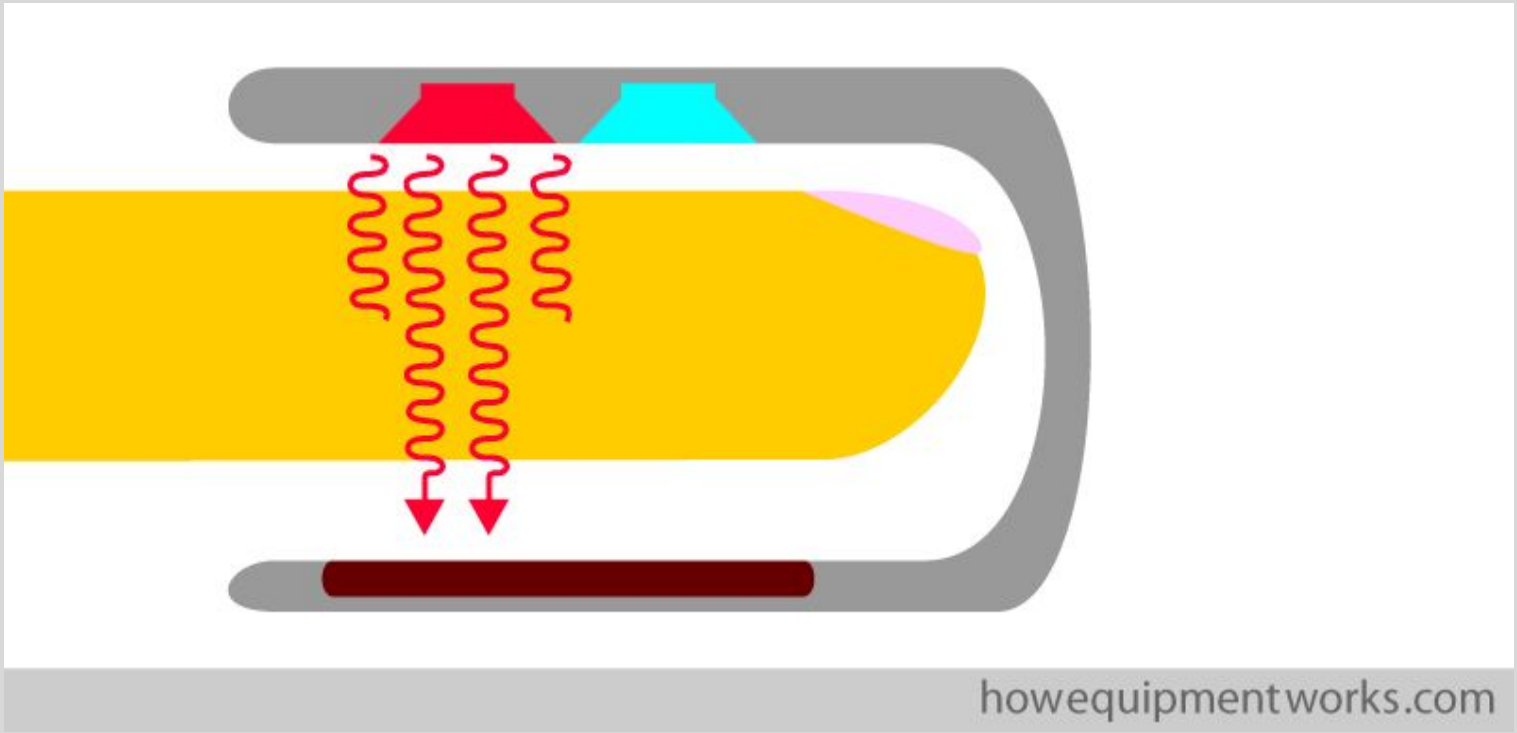
It is the LAST monitor to be removed off the pt before the pt is transferred outside the operating room to recovery room.

SpO2 monitoring should be continued in recovery room.

- Optical plethysmography
  - detects pulsatile changes in blood volume
- Spectrophotometry
  - measures pulsatile hemoglobin saturation

Respiratory system monitors

Pulse Oximetry



Respiratory system monitors

Pulse Oximetry

Value:

- SpO2: arterial O2 saturation (oxygenation of the pt).
- HR.
- Peripheral perfusion status (loss of waveform in hypoperfusion states: hypotension & cold extremeties).
- Gives an idea about the rhythm from the plethysmography wave (arterial waveform). (Cannot identify the type of arrhythmia but can recognize if irregularity is present).
- Cardiac arrest.

Respiratory system monitors

Pulse Oximetry

How to attach/apply saturation probe:

- To the finger or toe. The red light is applied to the nail.

  Nail polish and stains should be removed → false readings and artefacts

- Usually attached to the limb with the IV line (opposite the limb with the blood pressure cuff).

Respiratory system monitors

Pulse Oximetry

Readings:

- Normal person on room air (O2 = 21%) > 96%.
- Patient under GA (100% O2) = 98-100%.
- It is not accepted for O2 saturation to ↓ below 96% with 100% O2 under GA. Must search for a cause.
- < 90% = hypoxemia.
- < 85% = severe hypoxemia.

Respiratory system monitors

Pulse Oximetry

Inaccuracies occur when:

- Misplaced on the pts finger, slipped.
- Pt movement, shivering.
- Poor tissue perfusion (cold extremities)
- Poor tissue perfusion (hypotension & shock)
- Cardiac arrest.
- Interference…..
  - Intrinsic e.g. co-Hb, Met-Hb, I.V dyes, bilirubine, fetal Hb
  - Extrinsic e.g. motion, cautery, nail bed infection, polish……

Respiratory system monitors

Ventilation

Objective

ensure adequate ventilation of patient

Methods

qualitative clinical signs

- Chest excursion
- Observation of reservoir bag
- Auscultation of breath sounds

quantitative measurement

- End tidal carbon dioxide
- Volume of expired gas
- Airway pressure

Respiratory system monitors

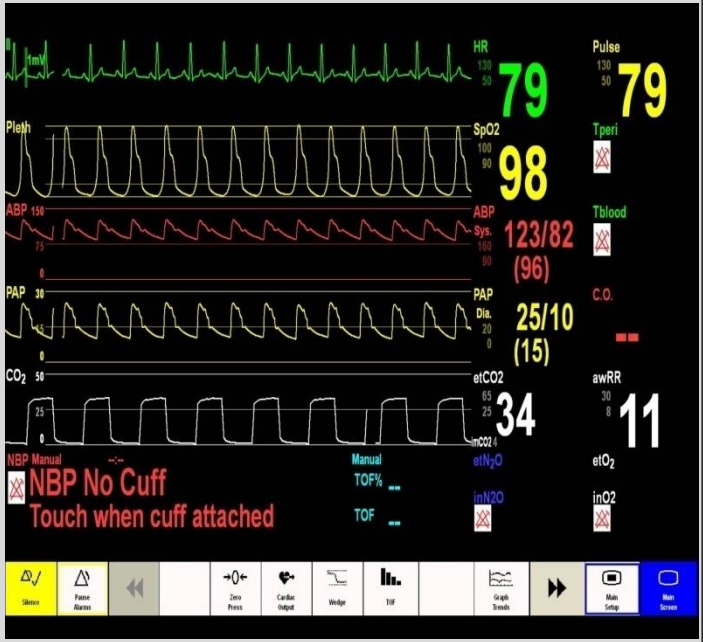
Capnography

- What is Capnography?

  Continuous CO2 measurement displayed as a <u>waveform</u> sampled from the patient's airway during ventilation.

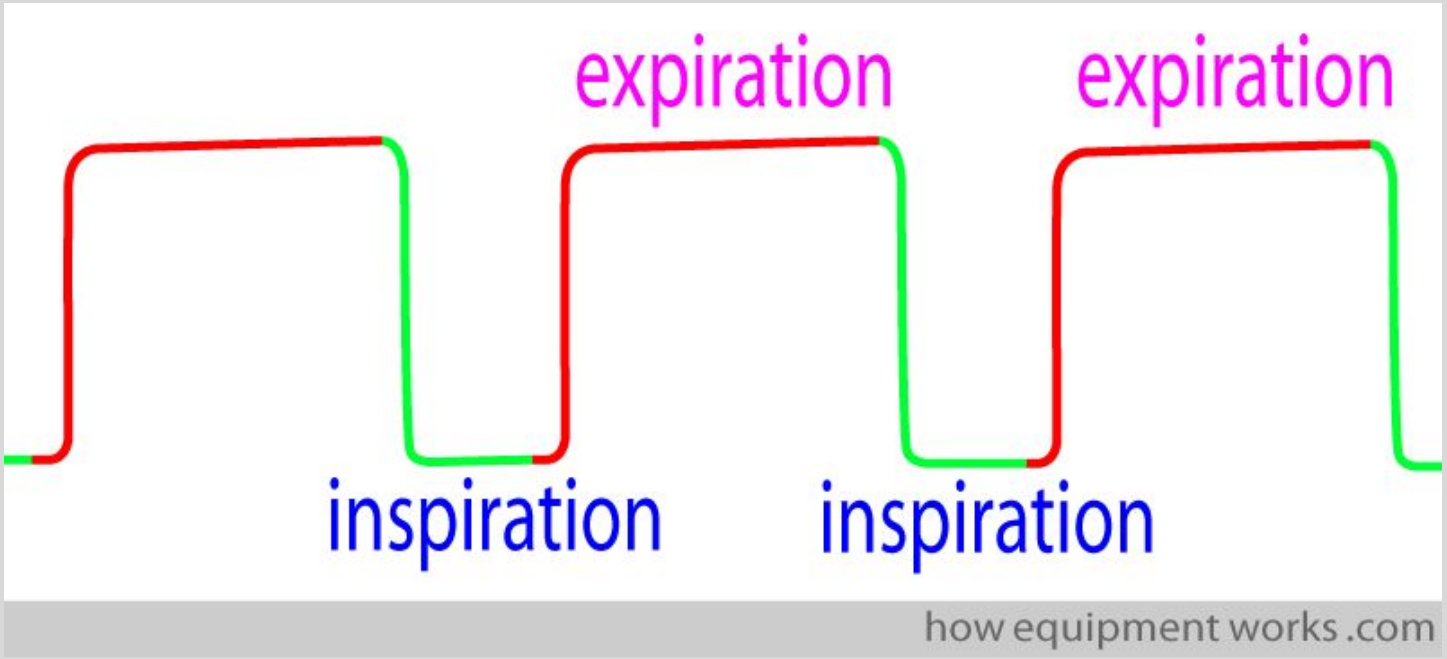
- What is EtCO2?

  A <u>point</u> on the capnogram. It is the final measurement at the endpoint of the pts expiration before inspiration begins again. It is usually the highest CO2 measurement during ventilation.



Respiratory system monitors

Capnography

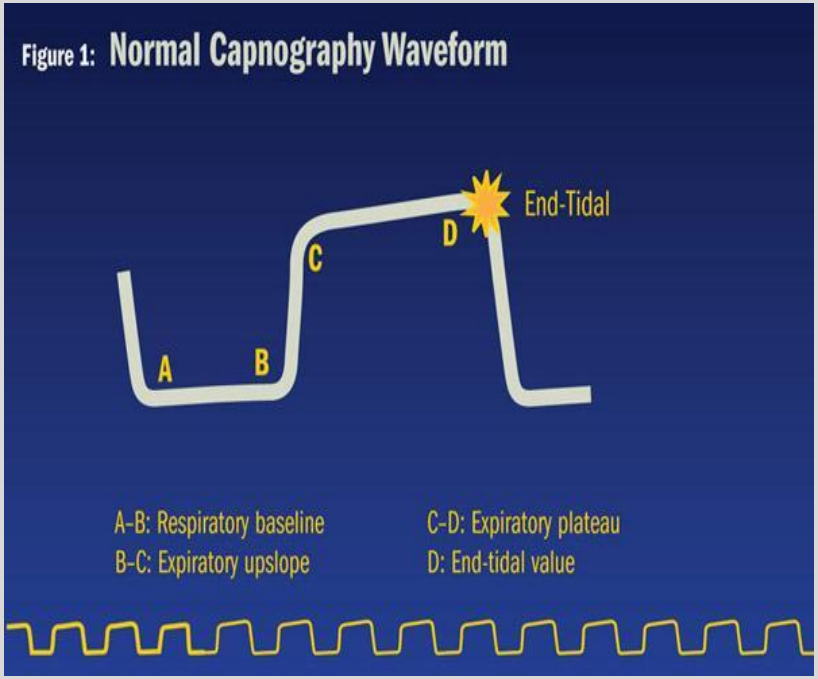


Respiratory system monitors

Capnography

Phases of the capnogram

- Balseline: A-B
- Upstroke: B-C
- Plateau: C-D
- End-tidal: point D
- Downstroke



Respiratory system monitors

Capnography

Normal range:

- 30-35 mmHg. (Usually lower than arterial $PaCO_2$ by 5-6 mmHg due to dilution by dead space ventilation).

Value (data gained from capnography & $ETCO_2$):

- ETT: esophageal intubation.
- Ventilation: hypo & hyperventilation, curare cleft (spontaneous breathing trials).
- Pulmonary perfusion: pulmonary embolism.
- Breathing circuit: disconnection, kink, leakage, obstruction, unidirectional valve dysfunction, rebreathing, exhausted soda lime.
- Cardiac arrest: adequacy of resuscitation during cardiac arrest, and prognostic value (outcome after cardiac arrest).
- Metabolic state of the patient.

CVS monitors

Circulation

Objective

- Ensure adequacy of circulatory function

Methods

- Continuous electrocardiogram monitoring
- Arterial blood pressure
- Heart rate

CVS monitors

ECG

Value:

- Heart rate.
- Rhythm (arrhythmias) usually best identified from lead II.
- Ischemic changes & ST segment analysis.

Timing of ECG monitoring:

Throughout the surgery: before induction until after extubation & recovery

Types & connections of ECG cables:

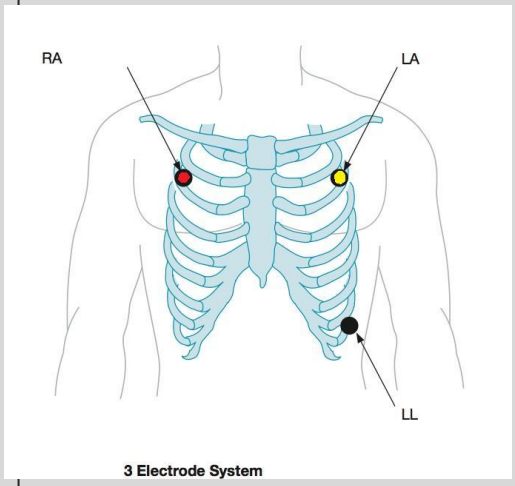
- 3-leads:
  Red=Right YeLLow=Left Black=Apex
  (can read leads: I, II, III)

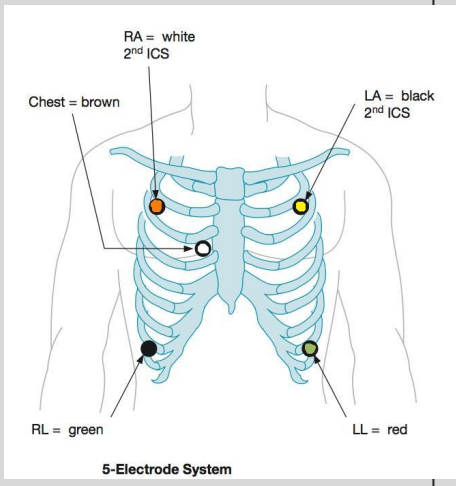
- 5-leads:
  Red=Right YeLLow=Left
  Black=under red Green=under yellow White=central
  (can read any of the 12 leads: I, II, III, avR, avL, avF, V1-V6).

CVS monitors

ECG

- 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





CVS monitors

ECG

RULES:

- QRS beep ON must be heard at all times. NO silent monitors.
- Cautery → artefacts in ECG (noise/ electrical interference) → check radial (peripheral) pulse
- Arrhythmias → check radial (peripheral) pulsations.

CVS monitors

Noninvasive Blood Pressure

- Methodology
  - Oscillometric algorithms
  - Automated

- Limitations
  - Cuff size
    - Cuff too small – Falsely High BP
    - Cuff too big – Falsely Low BP

CVS monitors

Noninvasive Blood Pressure

NIBP:
(non-invasive ABP monitoring = automated). Gives readings for:
systolic BP, diastolic BP & MAP

Value:
To avoid and manage extremes of hypotension & HTN.

Avoid ↓ MAP < 60 mmHg (for cerebral & renal perfusion)
Avoid ↓ diastolic pressor

Risks of HTN episodes:
(CVS): myocardial ischemia, pulmonary edema,
(CNS): hemorrhagic stoke, hypertensive encephalopathy.

While hypotensive episodes:
(CVS): myocardial ischemia,
(CNS): ischemic stroke, hypoperfusion state metabolic acidosis, delayed recovery, renal shutdown.

CVS monitors

Noninvasive Blood Pressure

Timing of BP monitoring:

throughout the surgery: before induction till after extubation & recovery.

Frequency of measurement:

- By default every 5 minutes.
- Every 3 minutes: immediately after spinal anesthesia, in conditions of hemodynamic instability, during hypotensive anesthesia.
- Every 10 minutes: eg. In awake pts under local anesthesia: "monitored anesthesia care" (minimal hemodynamic changes).

Monitoring of metabolism

Temperature

- Objective
  - Aid in maintaining appropriate body temperature
- Application
  - Readily available method to continuously monitor temperature if changes are *intended, anticipated or suspected*
- Monitoring sites
  - Tympanic
  - Esophagus
  - Bladder
  - Rectum
  - Blood (PA catheter)
  - Skin

Monitoring of metabolism

Temperature

- Normal heat loss during anesthesia averages 0.5-1 C per hour, but usually not more that 2-3 C
- Temperature below 34 C may lead to significant morbidity

(complications of hypothermia):

- Cardiac arrhythmias: VT & cardiac arrest.
- Myocardial depression.
- Delayed recovery (delays drug metabolism).
- Increased risk of infections.
- Metabolic acidosis (tissue hypoperfusion → anerobic glycolysis → lactic acidosis)
- Hyperkalemia
- Coagulopathy.

Neuromuscular Function

Evaluation of block

Peripheral nerve stimulation:

1) Single twitch.
2) Train of four twitches.
3) Tetanic stimulation.
4) Double burst stimulation.

Neuromuscular Function

Evaluation of Reversal of Blockade

- Clinical criteria

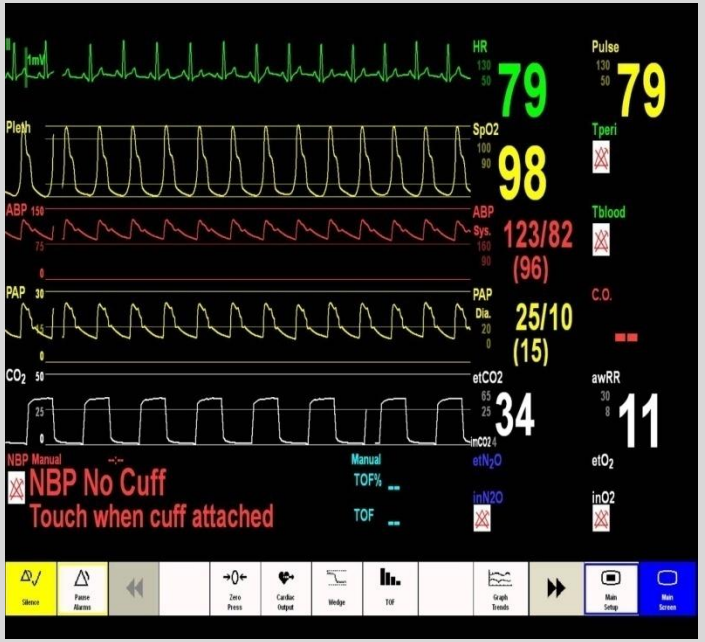
  - Head lift > 5 seconds
  - Sustained hand grip
  - Negative inspiratory force
    - At least -55 cmh_2o for adults
    - At least -32 cmh_2o for children
  - Vital capacity 15 ml/kg
  - Absence of nystagmus or diplopia

Invasive monitoring

Arterial line

Central venous pressure

Pulmonary artery catheter



Invasive monitoring

Arterial Line

IBP: (invasive arterial blood pressure monitoring)

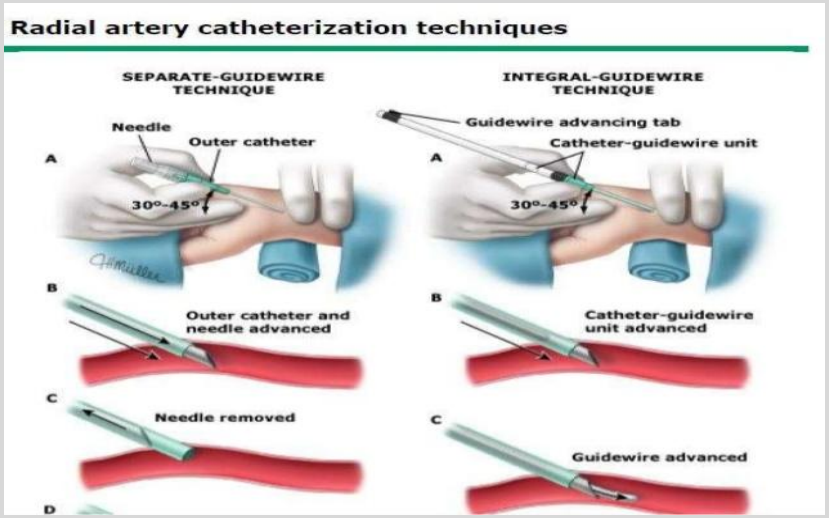
It is beat to beat monitoring of ABP via an arterial cannula.

Indications:

- Rapid moment to moment BP changes
- Frequent blood sampling
- Circulatory therapies: bypass, IABP, vasoactive drugs, deliberate hypotension
- Failure of indirect BP: burns, morbid obesity

Invasive monitoring

Arterial Line



Radial Artery Cannulation

- Technically easy
- Good collateral circulation of hand
- Complications uncommon

Invasive monitoring

Arterial Line

Alternative Sites

Brachial:

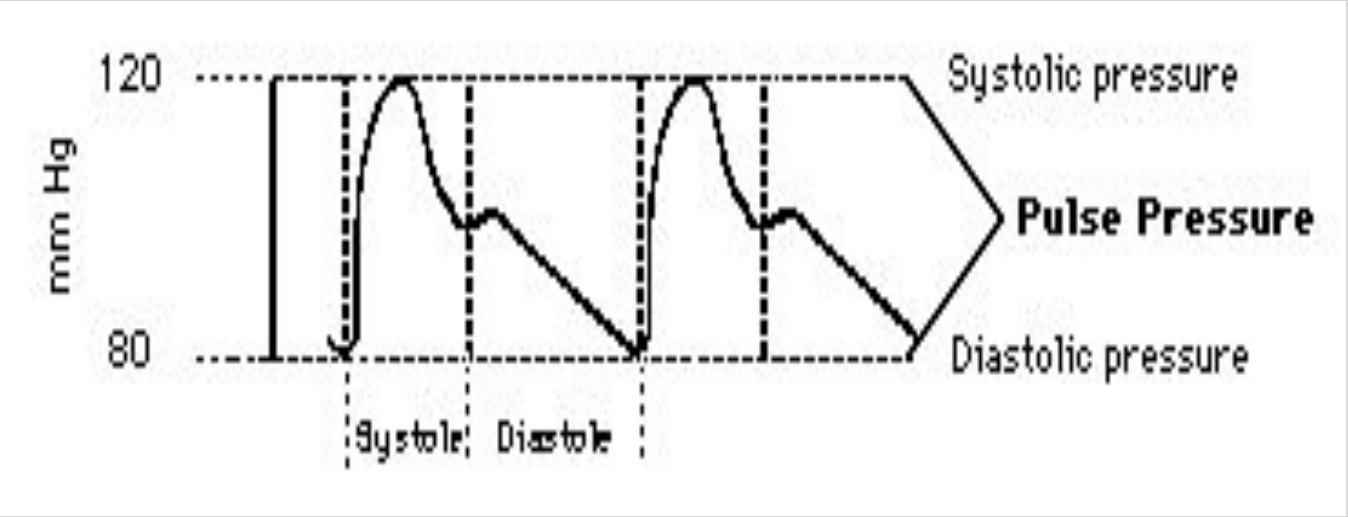
- Use longer catheter to traverse elbow joint
- Postop keep arm extended
- Collateral circulation not as good as hand

Femoral:

- Use guide-wire technique
- Puncture femoral artery below inguinal ligament (easier to compress, if required)

Invasive monitoring

Arterial Line



Invasive monitoring

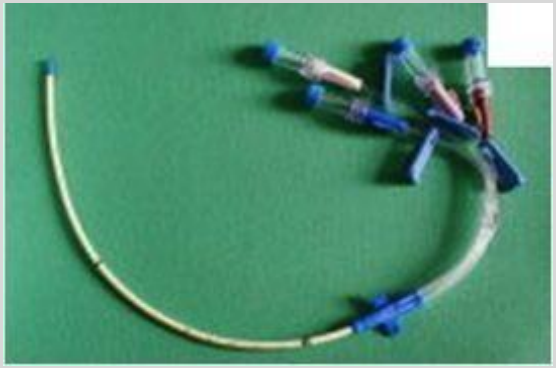
Arterial Line

Complications of arterial cannulation

- Hematoma.
- Vasospasm.
- Nerve damage
- Thrombosis.
- Embolization of air or thrombus.
- Skin necrosis, infection…..
- Disconnection and fatal blood loss…..

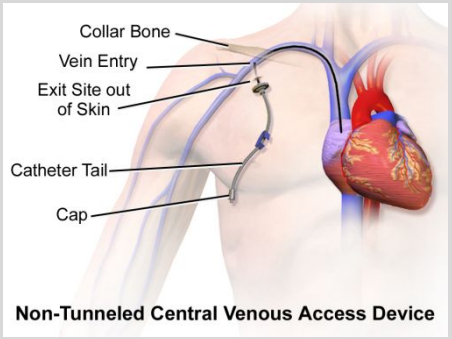
Invasive monitoring

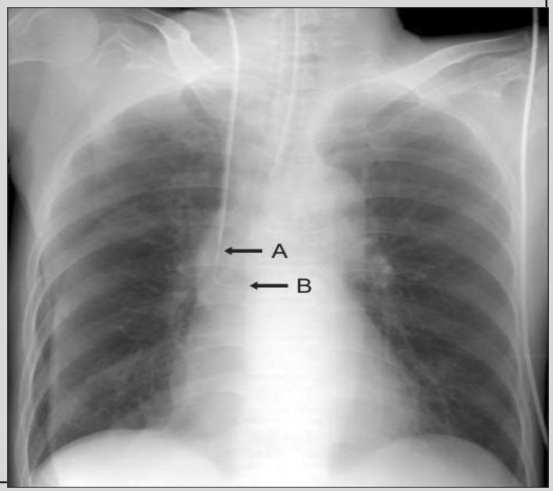
Central Venous Line



Indications:

- CVP monitoring
- Advanced CV disease + major operation
- Secure vascular access for drugs
- Secure access for fluids
- Inadequate peripheral IV access
- Pacer, Swan Ganz





Invasive monitoring

Central Venous Line

Advantages of RIJ

- Consistent, predictable anatomic location
- Readily identifiable landmarks
- Short straight course to SVC
- Easy intraop access for anesthesiologist at patient's head
- High success rate, 90-99%

Invasive monitoring

Central Venous Line

Alternative Sites

Subclavian:
- Easier to insert v. IJ if c-spine precautions
- Better patient comfort v. IJ
- Risk of pneumothorax - 2%

External jugular:
- Easy to cannulate if visible, no risk of pneumothorax
- 20%: cannot access central circulation

Femoral
- High infection rate
- No access for CVP readings

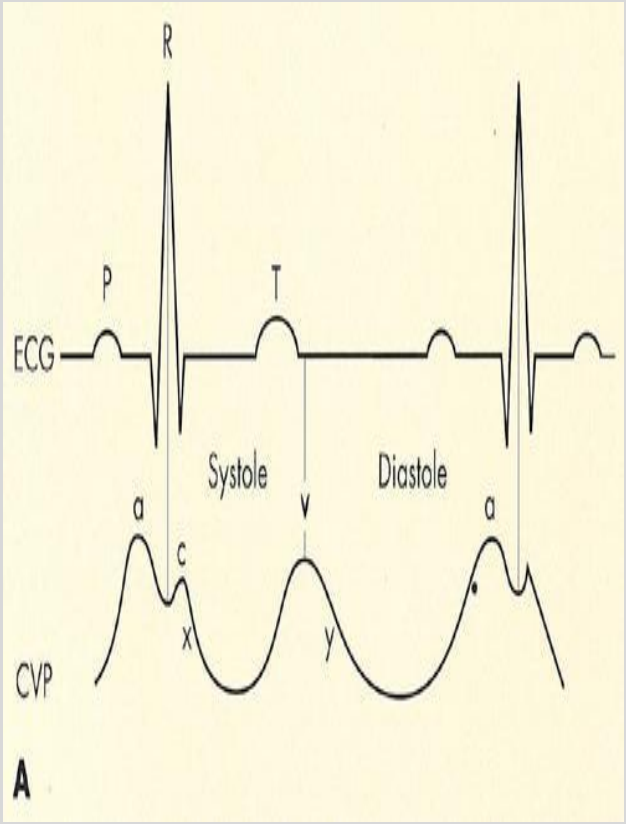
Invasive monitoring

Central Venous Line

- Reflects pressure at junction of vena cava + RA
- CVP is driving force for filling RA + RV
- CVP provides estimate of:
  - Intravascular blood volume
  - RV preload
- Measure at end-expiration

Invasive monitoring

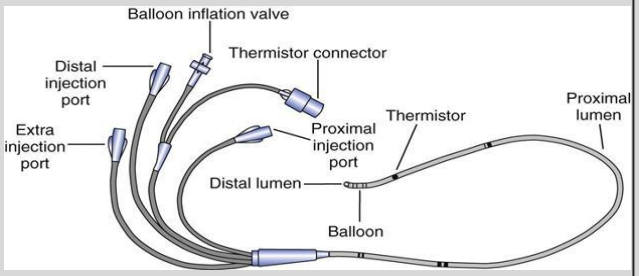
Central Venous Line



Component	Phase of Cycle	Event
a wave	End diastole	Atrial cont
c wave	Early systole	Isovol vent cont
x descent	Mid systole	Atrial relaxation
v wave	Late systole	Filling of atrium
y descent	Early diastole	Vent filling

Invasive monitoring

Pulmonary Artery Catheter

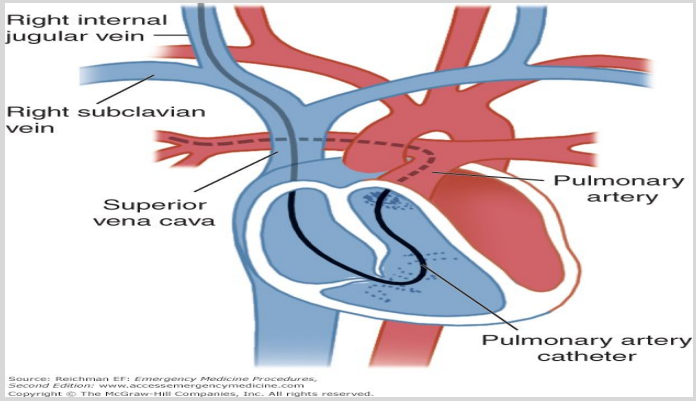


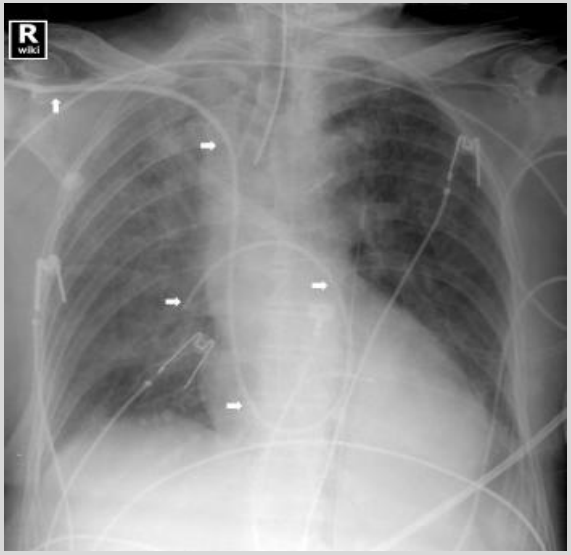
- Introduced by Swan + Ganz in 1970
- Allows accurate bedside measurement of important clinical variables:

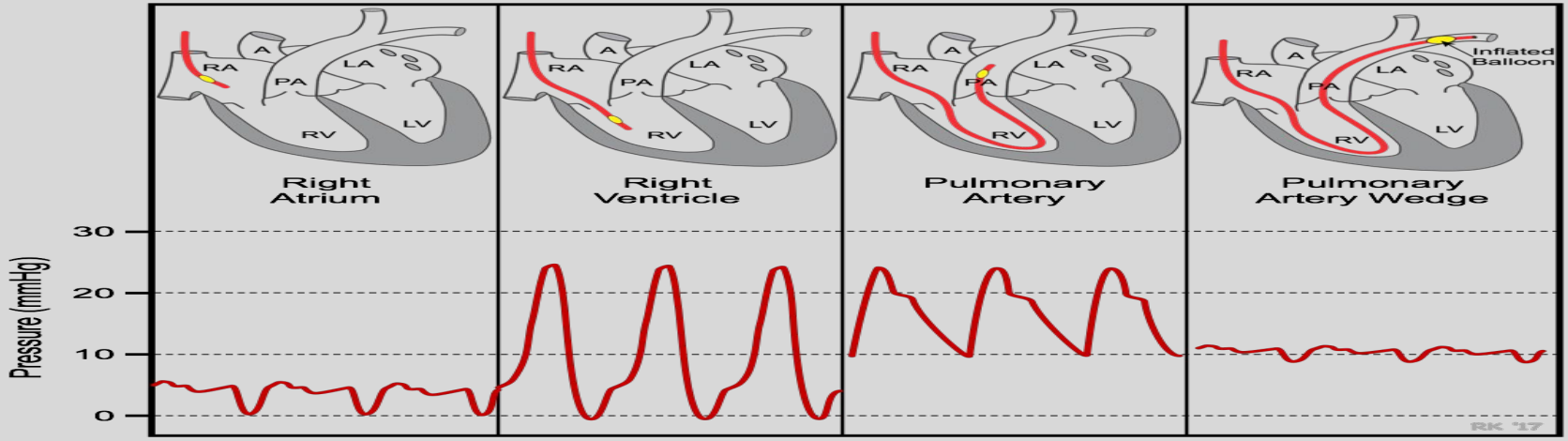
  CO, PAP, PCWP, CVP to estimate LV filling, guide fluid / vasoactive drug therapy and calculate core temp.

Invasive monitoring

Pulmonary Artery Catheter







Invasive monitoring

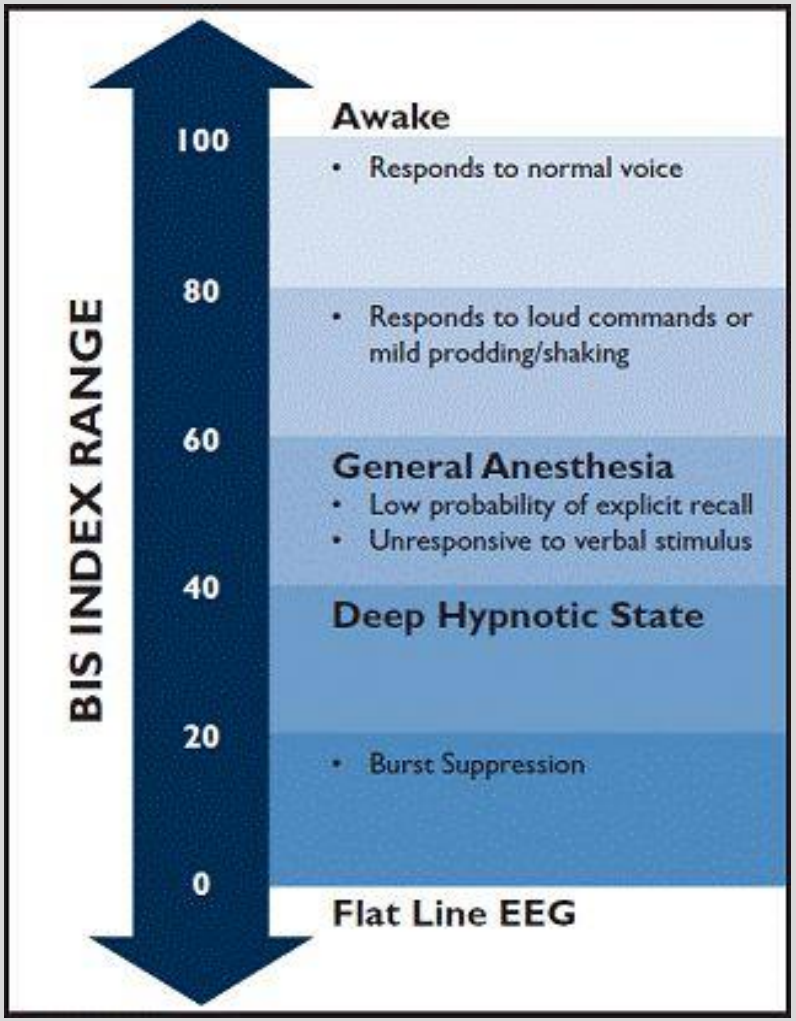
Pulmonary Artery Catheter

Complications

- Minor in 50%, e.g., arrhythmias
- Transient RBBB- 0.9-5%
  - External pacer if pre-existing LBBB
- Serious: 0.1-0.5%: pulmonary infarction, PA rupture (e.g., overwedge), endocarditis, structural heart damage
- Death: 0.016%

CNS monitors

- EEG analysis for frontal lobe
- Displayed as wave form and numbers



CNS monitors

Clinical monitoring:

Clinical monitoring:

Signs of pt awareness:

- Tachycardia.
- HTN.
- Movement (facial expression).
- Pupils dilated.
- Lacrimation.

Monitoring After Extubation & Recovery

BP:

- within 20% of baseline.

SpO2:

- > 92% on RA

Breathing:

- regular, adequate tidal volume.

Muscle power:

- sustained head elevation for 5 seconds, good hand grip, tongue protrusion.

Level of consciousness:

- 1) obeying orders 2) eye opening 3) purposeful movement.

MOST IMP: Pt MUST be able to protect his own airway.

:RULES NEVER to FORGET

NEVER start induction with a missing monitor: ECG, BP, SpO2.

NEVER remove any monitors before extubation & recovery.

NEVER ignore an alarm.

ALWAYS

- Remember that your clinical sense & judgement is better than & superior to any monitor.
- You are a doctor u are not a robot.
- The monitor is present to help you not to be ignored and not to cancel your brain.

QUESTIONS !!!