Monitoring In Anesthesia
In general we do monitoring for many things:

1. **Oxygenation**: we monitor it [Clinically](#) through patient color and pulse oximetry and [Quantitively](#) by using oxygen analyzer, equipped with an audible low oxygen concentration alarm.

2. **Temperature**: Continuous temperature measurements monitoring is [mandatory](#) if changes in temperature are [suspected](#).

3. **Circulation**: we monitor it [Clinically](#) through pulse palpation, heart auscultation and monitoring intra-arterial pressure or oximetry and [Quantitively](#) by using ECG signals and arterial blood pressure measurements every 5 min.

4. **Ventilation**: [Clinically](#), we monitor it through a correctly positioned endotracheal tube, also observing chest expansion, and breath sounds over both lungs, [Quantitively](#) by ETCO2 analysis, and by Arterial blood gas analysis for assessing both oxygen and ventilation.
**Pulse Oximetry:**

A non-invasive method for monitoring person’s oxygen saturation (So2), though its reading of So2 isn’t always identical to reading through **ABG analysis**, which is the invasive method, but it consider a **safe, convenient, noninvasive and not expensive method for monitoring So2**.

**Timing of SpO2 monitoring**: Before intubation >> Throughout the surgery >> After extubation and Recovery.
Con’t...

• Allows beat to beat analysis of oxygenation.
• Red and Infra-red light frequencies transmitted through a translucent portion. (finger-tip or earlobe)
• Depends on differences in light absorption between oxyHb and deoxyHb.
• Microprocessors then analyze amount of light absorbed by the 2 wavelengths, comparing measured values, then determining concentrations of oxygenated and deoxygenated forms through only arterial blood
Con’t …

- It is uncertain when there is severe vasoconstriction, due to the reduced pulsatile component of the signal, also in shock or cold extremities.

- It is uncertain with certain hemoglobin:
  1. when carboxyhemoglobin is present, it overestimates SaO2
  2. when methemoglobin is present, at an SaO2 > 85%, it underestimates the saturation.

- It progressively under-reads the saturation as the hemoglobin falls (but it is not affected by polycythemia).

- It is affected by extraneous light.

- It is uncertain when there is excessive movement of the patient.
Con’t...

Pulse oximetry give us many information:

• **SpO2**: arterial O2 saturation (oxygenation of the pt).
• **HR**.
• Peripheral perfusion status
  
  **Example**: loss of waveform in hypoperfusion states: hypotension and cold extremities.

• Give an idea about the rhythm from plethysmography wave (arterial waveform), Cannot identify the type of arrhythmia but can recognize it if irregularity is present.
• Cardiac arrest

**Note**: The pulse oximeter is not an indicator of the adequacy of alveolar ventilation
ECG monitoring:

This is easily applied and gives information on heart rate and rhythm, and may warn of the presence of ischemia and acute disturbances of certain electrolytes (e.g. potassium and calcium).

**Timing of ECG monitoring:** Before intubation >> Throughout the surgery >> After extubation and Recovery.
Con’t…

• It can be monitored using three leads applied to the Right shoulder (Red), the Left shoulder (yellow) and the left lower chest (green), to give a tracing equivalent to standard lead II of the 12-lead ECG.

• Many ECG monitors now use five electrodes placed on the anterior chest to allow all the standard leads and V5 to be displayed.

• **Note**: The ECG alone gives no information on the adequacy of the cardiac output and it must be remembered that it is **possible to have a virtually normal ECG in the absence of any cardiac output**.
• Identification of P waves in lead 2 and its association with the QRS complex is useful in distinguishing a sinus rhythm from other rhythms.

• Analysis of ST segment is used as an indicator of MI.
  
  eg: Depression : ischemia / Elevation : infarction

• Over 85% of ischemic events can be detected by monitoring ST segment of leads 2 and V5.

• QRS beep ON must be heard at all times, NO silent monitors.

• Note: Remember that your clinical judgement is much more superior to the monitor So always Check peripheral pulsations.
Blood pressure monitoring:

- **Non invasive blood pressure monitoring**: This is the most common method of obtaining the patient’s blood pressure during anesthesia and surgery.
- A pneumatic cuff with a width **40%** of the arm circumference must be used and the internal inflatable bladder should encircle at least half the arm. If the cuff is **too small**, the blood pressure will be overestimated, and if it is **too large** it will be underestimated.
Con’t...

- **NIBP** can give rapid and accurate ($\pm 9$ mmHg) readings for: systolic BP, diastolic BP and MAP

$$\text{Mean Arterial Pressure (MAP)} = \text{DBP} + \frac{1}{3} (\text{SBP} – \text{DBP})$$

- Goal of NIBP monitoring: Avoid and Manage of severe Hypotension or Hypertension.

- Risk of **Hypotension** episodes:
  - myocardial ischemia, ischemic stroke, hypoperfusion state, metabolic acidosis, delayed recovery, renal shutdown

- Risk of **Hypertension** episodes:
  - myocardial ischemia, pulmonary edema, hemorrhagic stroke, hypertensive encephalopathy.
Non-invasive BP measurement provides either intermittent or continuous readings, **For intermittent**:  
- By default every 5 minutes.  
- Every 3 minutes: immediately after spinal anesthesia, in conditions of hemodynamic instability, during hypotensive anesthesia.  
- Every 10 minutes: In awake patient under local anesthesia.

- Heart rate is also determined and displayed.
Con’t...

- **Invasive blood pressure monitoring (Arterial BP):**

**Indications:**
- Rapid moment to moment BP changes
- Frequent blood sampling
- Major surgeries (cardiac, thoracic, vascular)
- Circulatory therapies: vasoactive drugs, deliberate hypotension
- Failure of indirect BP: burns, morbid obesity
- Sever metabolic abnormalities
- Major trauma

**The radial artery at the wrist is the most common site for an arterial catheter. Alternatives are femoral, brachial and dorsalis pedis.**
Con’t...

- Complications of arterial cannulation
  - Hematoma.
  - Vasospasm.
  - Thrombosis.
  - Embolization of air or thrombus.
  - Skin necrosis infection.
  - Nerve damage.
  - Disconnection and fatal blood loss
Central Venous line and Pressure (CVP)

- This is measured by inserting a catheter via a central vein, usually the internal jugular or subclavian, so that its tip lies at the junction of the superior vena cava and right atrium.

- It is then connected via a fluid-filled tube to a transducer that converts the pressure signal to an electrical signal.

- Then, this is amplified and displayed as both a waveform and pressure.
Con’t…

• Loss of circulating volume will reduce venous return to the heart, diastolic filling and preload, and be reflected as a low or falling CVP.

• CVP is usually monitored in operations during which there is the potential for **major fluid shifts** (e.g. prolonged abdominal surgery) or **blood loss** (e.g. major orthopaedic and trauma surgery).

• CVP is driving force for filling RA + RV.

• Central Venous Pressure (CVP): 1-10 mmHg
Con’t...

Internal jugular vein

- Advantages of Internal jugular vein
  - Internal jugular vein lies in groove between sternal and clavicular heads of sternocleidomastoid muscle, it’s lateral and slightly anterior to carotid artery So it is readily identifiable landmark
  - Short straight course to SVC.
  - Easy intra OP access for anesthesiologist at patient’s head
  - High success rate **90-99%**

- Complications of Internal jugular vein?
Con’t...

• **Subclavian vein:**
  • Easier to insert *Vs IJV*
  • Better patient comfort *Vs IJV*.
  • Higher Risk of pneumothorax 2%

• **External jugular:**
  • Easy to cannulate if visible.
  • no risk of pneumothorax,
  • high risk of bleeding.
  • 20% : cannot access central circulation
Ventilation monitoring:

- As we known before we must monitor a patient to ensure adequate ventilation of the patient.

  **Clinically**, we monitor it through a correctly positioned endotracheal tube, also observing chest expansion, and breath sounds over both lungs.

  **Quantitively** by capnography and ETCO2 analysis, and by Arterial blood gas analysis for assessing both oxygen and ventilation.
• **What is Capnography?**

Continuous CO2 measurement displayed as a waveform sampled from the patient’s airway during ventilation.

• **What is EtCO2?**

A point on the capnogram.

It is the final measurement at the endpoint of the patient’s expiration before inspiration begins.

It is usually the highest CO2 measurement during ventilation.
Con’t...

- Phases of the capnogram:
  - Inspiratory baseline
  - Expiratory Upstroke
  - Expiratory Plateau
  - End-tidal (EtCO2)
  - Expiratory Downstroke

Con’t...

• Applications:
  • confirmation of intubation
  • monitoring for circuit disconnection
  • identification of airway obstruction
  • rebreathing/metabolic monitoring
• Normal range: 35-45 mmHg.
• Value (data gained from capnography & ETCO2):
• Endo tachial tube: 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).
Monitoring Temperature

Objective
- aid in maintaining appropriate body temperature

Application
- readily available method to continuously monitor temperature if changes are intended, anticipated or suspected

Methods
- thermostat
- temperature sensitive chemical reactions
• Potential heat loss or risk of hyperthermia necessitates continuous temperature monitoring
• Normal heat loss during anesthesia averages 0.5 - 1 C per hour, but usually not more than 2 - 3 C
• Temperature below 34C may lead to significant morbidity
• Hypothermia develops when thermoregulation fails to control balance of metabolic heat production and environment heat loss
• Normal response to heat loss is impaired during anesthesia
• Those at high risk are elderly, burn patients, neonates, spinal cord injuries
Con’t...

Monitoring Sites

• Tympanic
• Esophagus
• Rectum
• Nasopharynx
• Blood (PA catheter)
• Skin
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 and judgement is better than and superior to any monitor.

You are a doctor you are not a robot, the monitor is present to help you not to be ignored and not to cancel your brain.
cyanosis

• Bluish discoloration of the skin and mucous membranes due to the high levels of deoxygenated hemoglobin or its derivatives, including methemoglobin and sulfhemoglobin.

• Defined as the presence of 5 gm/dL of deoxygenated hemoglobin.

  - Hb level = 15 gm/dL, 5 gm/dL release O2
  which leaves 10 gm/dL of oxyhemoglobin
  -SaO2 = OxyHb / (OxyHb + DeoxyHb)
  = 10 / (10 + 5)
  = 66%
  -SAO2 of 66% corresponds to PaO2 of 35mmHg.
• In severely anemic patients, oxygen saturation at which cyanosis is
detectable will be lower than in normal patients.
  - Hb level = 10 gm/dL, 5 gm/dL release O2
  - SaO2 = OxyHb / (oxyHb + DeoxyHb)
    = 5 / (5 + 5)
    = 50%
  - SAO2 of 50% corresponds to PaO2 of only 27 mmHg.

• Under optimal conditions, the earliest that cyanosis can be
  appreciated is at an oxygen saturation of 85%(PaO2 of 55mmHg).

• At a SaO2 of 70% (PaO2 of 40mmHg) most clinicians will be able
to detect cyanosis.
O2-Hb dissociation curve
• Sigmoidal in character- describes the relationship between oxygen tension (PaO2) and binding (saturation).

• When PaO2 is low (PaO2<60%), the hemoglobin affinity to oxygen falls rapidly, explaining the sharp sloping.

• Shifting in the curve is a normal process depending on the site of circulation.
  • Right shift : Hb releases oxygen to tissues; muscles and placenta, more rapidly.
  • Left shift: Hb has a higher affinity for oxygen in the lungs
  • Causes of shifting Include changes in PaCO2, Ph, temperature and [2,3 DPG].

• The lowest acceptable O2 saturation level is 90%
## Conditions Affecting Oxygen Carrying Capacity: Oxygen Hb Dissociation Curves

<table>
<thead>
<tr>
<th></th>
<th><strong>left shift</strong> (high affinity for $O_2$)</th>
<th><strong>right shift</strong> (low affinity for $O_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>2,3-DPG</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>$p(CO_2)$</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>$p(CO)$</td>
<td>increase</td>
<td>decrease</td>
</tr>
<tr>
<td>pH (Bohr effect)</td>
<td>increase (alkalosis)</td>
<td>decrease (acidosis)</td>
</tr>
<tr>
<td>type of haemoglobin</td>
<td>fetal haemoglobin</td>
<td>adult haemoglobin</td>
</tr>
</tbody>
</table>

2,3-DPG = 2,3-diphosphoglycerate

- **Remember:**
  - Left shift = less oxygen to the tissues = tissue hypoxia
  - Right shift = more oxygen to the tissues
monitored parameters

• Vital signs:
  • Heart rate
  • Heart rhythm
  • Respiratory rate and depth
  • Mucous membrane color and skin appearance
  • Capillary refill time
  • Pulse strength
  • Blood pressure
  • Body temperature

• Best indicator for the patients wellbeing
• Reflexes
  • Involuntary response to stimulus
  • Palpebral, corneal, pedal, swallowing, laryngeal, and papillary light reflexes
  • Indicators of anesthetic depth.

• Parameters offer predictable responses to anesthesia at various depths.

• May be affected by drugs, disease, or individual response variation.

• Monitor anesthetized patients as often as possible; continuously is ideal.
# Normal adult parameters in general anesthesia

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic Blood Pressure</td>
<td>SBP</td>
<td>mmHg</td>
</tr>
<tr>
<td>Diastolic Blood Pressure</td>
<td>DBP</td>
<td>mmHg</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>HR</td>
<td>bpm</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>RR</td>
<td>rpm</td>
</tr>
<tr>
<td>Oxygen sat. by oximetry</td>
<td>SpO₂</td>
<td>%</td>
</tr>
<tr>
<td>End Tidal CO₂ tension</td>
<td>ETCO₂</td>
<td>mmHg</td>
</tr>
<tr>
<td>Skin appearance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Urine Production</td>
<td></td>
<td>ml.kg⁻¹.min⁻¹</td>
</tr>
<tr>
<td>Measurement</td>
<td>Value 1</td>
<td>Value 2</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Central Venous Pressure</td>
<td>CVP</td>
<td>1 – 10</td>
</tr>
<tr>
<td>Pulmonary Artery Pressure</td>
<td>PAP PCWP</td>
<td>10 – 20</td>
</tr>
<tr>
<td>Pulmonary Capillary Wedge pressure</td>
<td>PCWP</td>
<td>5 – 15</td>
</tr>
<tr>
<td>Mixed venous oxygen saturation</td>
<td>SvO2</td>
<td>75</td>
</tr>
<tr>
<td>Cardiac Output</td>
<td>CO</td>
<td>4.5 – 6</td>
</tr>
<tr>
<td>Mean Arterial Pressure</td>
<td>MAP</td>
<td>80 – 120</td>
</tr>
</tbody>
</table>

*MAP = DBP + 1/3 (SBP – DBP)*