BASIC PATIENT MONITORING

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Learning objectives

What you should know

- Principles of monitoring methods
- Indications of each method
- Contraindications
- Limitations of each method
- Normal values and measured parameters

What you should do

- Use correctly every means and technique of monitoring

Pulse oximetry

Definition

Pulse oximetry is a continuous, non-invasive and indirect method of measuring oxygen saturation in the hemoglobin and peripheral pulse.

Principles of functioning – how it works

This method relies on two principles: spectrophotometry and plethysmography.

- Spectrophotometry is based on the Beer-Lambert law that states that at a constant hemoglobin concentration the intensity of light transmitted through the tissues is a logarithm function of the oxygen saturation of hemoglobin. In other words, the absorption of light is proportional with the concentration of the substance that absorbs light.
- Blood contains four forms of hemoglobin, each absorbing light differently (different light wave): oxihemoglobin, reduced hemoglobin, methemhemoglobin and carboxyhemoglobin. Oxihemoglobin absoarbs light more in the infrared specter (±910–940 nm), while reduce hemoglobin in the red specter (±660 nm). To mention that pulse oxymetry only indicates functional saturation, namely:

$$SaO_2 = \frac{HbO_2}{HbO_2 - \text{Hb reduced}} \times 100$$

- Fractional saturation refers to the report of oxygenated hemoglobin to all hemoglobin species and is achieved through co-oximetry, using several lights of various wave lengths. Oxihemoglobin percentage is measured by determining the infrared / red light ratio.
- In order to do this the pulse oximeter is based on two major components: leds that emit various wave-length lights and a photodetector cell that absorbs the light.
- To mention that the light absorbed is measured from the pulsating site onto which it is applied, during systole. This is possible by plethysmography, used for differentiating the pulsing signals (arterial) from the non-pulsing ones (venous or tissular). During diastole the absorption is due to other tissues such as muscles, bones, skin, veins.

Placement sites of the sensor

- Finger (most frequent)
- Ear lobe
- Nasal septum
- Forehead
- On the palm or sole (in newborn, infants and young children)

Figure 1.
Pulse oximeter placed on the finger

Indications

- To detect and prevent hypoxemia
- Is part of standard monitoring recommended by all professional organizations for all patients submitted to anesthesia or sedation before and after an operation
- For all the patients in intensive care who receive oxygen supplement.
- Management of airways
- Within cardio-pulmonary resuscitation
- In patients with lung and heart diseases
- In intoxications with various inhalation substances (careful regarding limitations)

Normal values

Normal values are over 95%.

Limitations

- In case of hypoxia the values indicated by the pulse oximeter may be flawed. Thus, at a saturation below 70% the practioner cannot rely on these values
- The sensor is sensitive to movement. For example shivering may alter the recording by increasing the distance between the emitting diode and the receptor cell
- Nail polish may decrease the saturation value. Also, long or false nails may interfere with the sensor, by difficulty of positioning or erroneous results
- Environmental light may also interfere with the sensor. False higher values may be found if Xenon, fluorescent or optical fiber light sources are interposed. On the other hand, infrared light may determine a false low value
- Tissue hypoperfusion may affect the recording by decreasing the pulse signal. This happens mainly in states of shocl, but also in impaired circulation (a simple example is when the blood pressure cuff on the same extremity as the pulse oximeter is inflated).
- Hypothermia and the onset of peripheral constriction affects the pulse component and may lead to false or even absent signal
- Dyshemoglobinemia. Methemglobinemia that occurs in patients under certain medication (antibiotics, local anesthetic, cyanides, bromites, metoclopramide etc.) May cause false higher results because its wave length is similar to that absorbed by oxygenated hemoglobin; carboxihemoglobin may also cause falsely increased readings
- Patients with hyperlipidemia or receiving infusions high in lipids may have false low values
- Intravascular administration of stains. For example methyl blue used in the treatment of methemglobinemia absorbs light on 670 nm wave length, thus lowering the value on the pulse oximeter
- Electrocautery used in surgical operations may interfere with pulse oximeter if the sensor receives its waves.

Incidents and accidents

- Decubitus-induced injuries or even burns may occur is the sensor is left too long in the same place.

ECG standard monitoring

Definition

Continuous ECG monitoring is realized through electrodes attached to the skin that record heart impulses and transforms them into electric signals transmitted and processed for the monitor screen.

Standard monitoring refers to the recording of limbs derivations, namely: DI, DII, DIII, avl, avf, avr.

Where sensors may be placed

- Red electrode
  - On the upper right limb
  - On the right shoulder
  - At chest level, upper right side
- Yellow electrode
  - Upper left limb
  - Left shoulder
  - Chest – upper left side
- Green electrode
  - Lower left limb
  - Chest level, lower left side
- Black electrode
  - Lower right limb
- Chest – lower right side
  - Being a neuter electrode, it has the role of minimizing interferences
  - Some devices may not have it

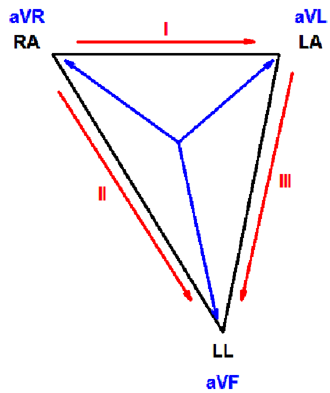

Figure 2.
Diagram of the electrodes placement

Indications

Continuous ECG monitoring is part of standard monitoring recommended for all patients to undergo anesthesia and those in ICU, especially in:

Patients with heart diseases

- Patients with hemodynamic instability
- Patients with rhythm disturbances
- Patients to undergo an invasive procedure

- Patients predisposed to rhythm disturbances, such as those with hydro-electrolytes

Limitations

- Signal recording is altered by movement
- Recording may be low in case of high chest impedance, such as: pilosity, something between heart and electrodes (hemo- or pneumothorax).

Incidents and accidents

Decubitus-induced injuries caused by ECG electrode cables.

Non-invasive measurement of blood pressure

Definition

Blood pressure is the pressure blood exerts on the arterial walls.

In the following we shall only refer to automatic BP monitoring, manual measurement being covered elsewhere.

Principle of functioning

Non-invasive automatic measurement of BP is based on oscillometry. This method used a cuff that occludes blood flow in a peripheral artery (when cuff is inflated), then measuring the fluctuations in the blood vessel given by the arterial pulsations as the cuff deflates.

Systolic pressure is approximated when oscillations may be perceived at a maximum cuff inflation, average pressure when the oscillation amplitude is maximal, while diastolic pressure is estimated at a minimally inflated cuff.

Thus, during cuff deflation each pulse wave generates a pressure oscillation that is transmitted through the connecting tube and recorded by a transducer in the central unit of the monitor.

Where to apply the cuff

- On the arm (most common)
- On the forearm or the wrist
- On the calf – to compress the posterior tibial artery
- On the thigh – compression of the popliteal artery

Keep in mind that the more distal the cuff placement, the tendency is for the systolic pressure to increase and the diastolic one to decrease.

Important notes

It is important to observe certain rules before measuring blood pressure:

- The patient must have rested at least 3-5 minutes before measurement
- Take the BP several times in order to increase accuracy
- Position the cuff at heart level if you measure it from the arm
- Use a cuff adapted to the patient: the cuff should cover 2/3 of the arm length. There are cuffs specially made for different body weights
- According to the American Society of Cardiology, the cuff width should be at least 40% of the arm length and length 80% of the arm circumference, or twice its width
- On the first measurement take BP in both arms. A difference bigger than 20 mmhg should require additional investigations.

Indications

- All patients submitted to an anesthetic procedure should have their BP taken every 5 minutes (recommendation of the American Society of Anesthesia)
- All patients in the ICU who hemodynamically unstable
- Within routine monitoring of a patient undergoing overall objective assessment.

Reference values

According to the recent guidelines of the European Society of Cardiology, *normal values* of arterial tension are under 130 mmhg for systolic (SAT) and under 85 for diastolic (DAT).

Pathological values are:

- Normally high BP: SAT: 130 – 139 mmhg or DAT: 85-89 mmhg
- Arterial hypertension (AHT) grade 1: SAT: 140 – 159 mmhg or DAT: 90 – 99 mmhg
- AHT grade 2: SAT: 160 – 179 mmhg or DAT: 100 – 109 mmhg
- HTA grade 3: SAT ≥ 180 mmhg or DAT ≥ 110 mmhg

Limitations

- It is very important to use the right cuff size
- A cuff larger than necessary will measure a false low BP and in reverse a small cuff will overestimate BP
- It is very important that the patient should not move during the procedure, because movements may be perceived as oscillations and readings will be flawed
- Atherosclerosis may limit accuracy because of vessel wall rigidity
- Atrial fibrillation or other rhythm disturbances may induce false values
- Hypotension may lead to an underestimation of BP

Materials necessary

- Monitor with a module for non-invasive measurement of BP and cuffs of various sizes.

Incidents and accidents

- Decubitus-induced lesions or incidents caused by the cable attached to the cuff
- Ischemia or peripheral nerves disturbances if BP is taken too often at the same site or if the cuff is forgotten inflated

Measurement of temperature

Definition

The temperature emitted by the body and its changes in a critical patient may be associated with high rates of morbidity and mortality. Moreover, an abnormal temperature may be the first clinical sign of an infection, inflammation, neurological disease or drug poisoning. Therefore its measurement is of major importance.

Principle of functioning

Electronic thermometers transform recorded temperature into an electric signal that will be displayed on the monitor screen. This is achieved by two systems: thermocouples and thermoresistors.

- Thermocouples consist of the junction between twp metals with different properties. Voltage changes in the junction may be precisely correlated with temperature. The thermocouple should be calibrated according to a second thermocouple with a constant temperature

- Thermistors are formed of oxides of semiconductive metals in which electrical resistance is changed inversely with temperature. Semiconductors measure temperature due to the fact that voltage changes between the base and emitting source is temperature dependent, while the current recorded by the silicone resistor is constant.

Sites where temperature can be measured

- Sublingual
  - Limitations:
    - Variations if the patient ingested cold or hot liquids
    - In tachypnea the temperature will be falsely lowered.
    - Unsuitable for continuous measurement.
- Armpit (subaxillary)
  - Limitations:
    - Though some studies report good measurements of central temperature, others report different values from the tympanic values: 1.5 – 1.9ºc
    - Reduced accuracy compared to other sites, mainly because of difficult maintenance of a constant position of the sensor
- Rectal
  - The best accepted location for measuring central temperature
  - Before introducing the sensor, rectal touch should be performed, as feces may tamper with readings
  - The values are more accurate with a higher placement of the sensor in the rectum, preferably over 10 cm.
  - Limitations:
    - The response to changes of central temperature takes longer than in other locations
- Esophagus
  - It is usually 0.6ºc lower than the rectal one.
  - Because of large vessels nearby, this locations responds quickly to changes of central temperature
  - Limitations:

        - Recorded temperature may vary according to the sensor position.
- Tympan
    - Often used in neurosurgery or in patients with cerebral diseases because it reflects best brain temperature.
    - Limitations:
        - Higher risk of tympan perforation.
        - Great variability compared to central temperature
- Urinary bladder
    - The sensor is inserted through a Foley catheter.
    - Used especially in patients submitted to targeted management of post-resuscitation temperature
    - One of the most reproducible measuring sites

Indications

Continuous temperature monitoring is part of standard monitoring in all patients undergoing anesthesia or in the ICU:

- Patients with hemodynamic instability
- Patients suspected of having infections or inflammations

Normal values

- Normal central temperature varies between 36.4 – 37.9ºc. Fever is considered as such at over 38.3ºc.
- Hypothermia is a decrease of central temperature below 35ºc and is classified by current resuscitation guidelines as follows:
    - Mild: 35 – 32ºc
    - Moderate: 32 – 28ºc
    - Severe: 28 – 24ºc
    - Cardio-respiratory arrest or decreased circulation: <24ºc
    - Death caused by hypothermia at a temperature below 13.7ºc
- Peripheral temperature varies between 36 and 37.5ºc. Fever is considered as such at over 38ºc.

Materials necessary

- Electric thermometer connected to the monitor

Incidents and accidents

- Cables may tighten around limbs and cause stasis or ischemic injuries

- Thermometers may break or get stuck at the measuring sites.

Assessment / self-assessment form

For each monitoring method:

Stage / Criterion	**Correct**	**Incorrect**
Indications		
Principle		
Limitations		
Monitoring sites		
Correct mounting		
Reference values		
Listing of possible incidents		