Non-Invasive Oxygen Monitoring
Pulse Oximetry & Conjunctival Oxygen Monitoring

OBJECTIVES
• At the end of this module, the student will be able to…
  • define terms associated with pulse oximetry.
  • explain the theory of operation of a pulse oximeter.
  • differentiate between functional and fractional saturation.
  • list the indications, limitations, advantages, disadvantages and contraindications for use of a pulse oximeter.

OBJECTIVES
• At the end of this module, the student should be able to…
  • list some of the things that affect the accuracy of a pulse oximeter.
  • explain when co-oximetry would be more appropriate than pulse oximetry.
  • describe patient application for each of the noninvasive monitors.

ASSIGNMENTS
• Read:
  • Egan Chapter 16, pgs. 377 – 383
  • AARC Clinical Practice Guidelines - Pulse Oximetry
  • Articles on Pulse Oximetry (look on website)

Circle of Oxygenation

Hypoxia Develops Rapidly

from Hanning, “Oximetry and Anaesthetic Practice”, 1985
Pulse Oximetry

The Fifth Vital Sign

Oxygen Content
• The total amount of oxygen present in arterial blood.
  • Dissolved oxygen (PaO₂)
  • Attached to hemoglobin (SaO₂)
    • Measured by co-oximeter
    • Estimated by pulse oximeter
    • Calculated by blood gas analyzer
  • Actual amount of hemoglobin (Hb)

Oxygen Carrying Capacity

The Science behind Oximetry
• Spectrophotometry
  • Lambert-Beer Law
  • Light Transmission Spectra and Oximetry
  • Light Emitting Diode (LED) technology
  • Optical Plethysmography

Spectrophotometry
• Spectrophotometry is the measurement of the amount of light that is absorbed as it passes through a substance.
  • Reflected
  • Absorbed
  • Transmitted
• Spectrophotometry is an application of Beer’s (Beer-Lambert) law.

Absorption Spectrum
Wavelength Selection

- Two wavelengths are selected for analysis.
  - A red light at about 660 nanometers (nm).
  - An infrared light at about 940 nanometers.
- So how do we get such specific measurements?

Light Emitting Diode Technology

- A pulse oximeter sensor is made up of two different parts:
  - A light emitting diode
  - A photodetector

Misalignment of the sensor by inserting finger too far.

Optical Plethysmography

- Plethysmography is the measurement of changes in volume in a particular part of the body.
- Originally designed to measure vascular perfusion.
- Changes in volume at a site is due to the pulsation of arterial blood.

Output signal generated by pulse oximeter. Saturation is based on the ratio of light absorption during pulsatile and baseline phases.
Functional vs. Fractional Saturation

- S\textsubscript{PO2} \neq S\textsubscript{AO2}
- Functional Saturation (S\textsubscript{PO2})
- Fractional Saturation (S\textsubscript{AO2})

Measurement vs. Monitoring

- Measurement: A one time snapshot. Example: ABG sample or a “spot-check” S\textsubscript{PO2}.
- Monitoring: Ongoing measurements. Example: Continuous pulse oximetry

Golden Rule For Safety Monitors

- A Safety Monitor must be:
  - SAFE
  - ACCURATE
  - RELIABLE
  - CONVENIENT

  “Always detect danger”
  and
  “No false goodness”

Technical Limitations

- Calibration Assumptions
- Optical Interference
- Absorption Interference
- Signal Artifact

Calibration Assumptions

- Calibration curves
- Accuracy range

Optical Interference

- Ambient Light
- Optical Shunt
- Optical Cross-Talk
- Edema
Absorption Interference

- Anemia
- Skin Pigmentation
- Nail Polish
- Carbon Monoxide
- Methemoglobin
- Intravascular Dyes

Signal Artifact

- Artifact can cause errors in measurement.
- Artifact may obscure the signal

Causes:
- Low perfusion
- Hypotension
- Cold
- Motion Artifact

The Solution?

- Improvements in technology that:
  - Improve the signal to noise ratio present in low perfusion.
  - Improve the ability of the oximeter to “read” through motion.

Sensor Application

- Properly place sensor.
- Single use sensor are meant for a single patient.
- Use sensor as designed.

Patient Application - Sites

- Adults & children
  - Finger
  - Toe
  - Ear lobe
  - Cheek
  - Tongue
  - Nose
- Small children & babies
  - Wrist
  - Upper arm
  - Across foot
Pulse oximetry probes

Reporting Results

• Four things to verify prior to reporting results:
  • Waveform
  • Signal strength
  • Heart rate
  • Clinical Correlation

Plethysmograph – Pulse oximeter tracing

Contraindications (relative)

• When arterial blood gases are indicated for measurement of pH or PaCO₂.

• When CO-oximetry is indicated for evaluation of total hemoglobin and abnormal hemoglobins
  • HbCO%
  • HbMet%
Maintenance

• Pulse oximeters usually do a self-check when they are first turned on.

• They do not require regular routine manual calibration.

• Wipe probe and monitor with an alcohol soaked cloth between patients.

Conjunctival

• **Principles of Operation**
  
  • A sensor is inserted under the eyelid.
  
  • It contains a Clark PO₂ electrode similar to a blood gas analyzer.
  
  • It is used mainly in to OR for short-term application.
  
  • Conjunctival PO₂ is reported and correlates to the arterial PaO₂.