Standard Monitors

Basic Anesthetic Monitoring

ASA Standards for Basic Anesthetic Monitoring

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

STANDARD II
“During all anesthetics, the patient’s oxygenation, ventilation, circulation, and temperature shall be continually evaluated.”

OXYGENATION
- F\textsubscript{2}O\textsubscript{2} Analyzer
- Pulse Oximetry

VENTILATION
- Capnography
- Disconnect alarm

CIRCULATION
- EKG
- Blood Pressure
- Pulse Oximetry

TEMPERATURE
- Temperature Probe

Pulse Oximetry

Terminology
- \( S_{O2} \) (Fractional Oximetry) = \( O_{2}Hb / (O_{2}Hb + Hb + MetHb + COHb) \)
- \( S_{O2} \) (Functional Oximetry/Pulse Oximetry) = \( O_{2}Hb / (O_{2}Hb + Hb) \)

Fundamentals
- The probe emits light at 660 nm (red, for Hb) and 940 nm (infrared, for \( O_{2}Hb \)); sensors detect the light absorbed at each wavelength.
- Photoplethysmography is used to identify arterial flow (alternating current = AC) and cancels out the absorption during non-pulsatile flow (direct current = DC); the patient is their own control!
- The S value is used to derive the \( S_{O2} \) (\( S = 1:1 \) ratio = \( S_{O2} 85\% \)).

Pearls
- Methemoglobin (MetHb) - Similar light absorption at 660 nm and 940 nm (1:1 ratio); at high levels, \( S_{O2} \) approaches 85%.
- Carboxyhemoglobin (COHb) - Similar absorbance to \( O_{2}Hb \). At 50% COHb, \( S_{O2} = 50\% \) on ABG, but \( S_{O2} \) may be 95%, thus producing a falsely HIGH \( S_{O2} \).
- Other factors producing a falsely LOW \( S_{O2} \) = dyes (methylene blue > indocyanine green > indigo carmine), blue nail polish, shivering, ambient light.
- Factors with NO EFFECT on \( S_{O2} \) = bilirubin, HbF, HbS, SuHb, acrylic nails, fluorescein dye.
- Cyanosis - clinically apparent with 3 g/dl desaturated Hb. At Hb = 15 g/dl, cyanosis occurs at \( S_{O2} = 80\% \); at Hb = 9 g/dl (i.e. anemia), cyanosis occurs at \( S_{O2} = 66\% \).
EKG

3-Electrode System
- Allows monitoring of Leads I, II, and III, but only one lead (i.e. electrode pair) can be examined at a time while the 3rd electrode serves as ground.
- Lead II is best for detecting P waves and sinus rhythm.

Modified 3-Electrode System
- If you have concerns for anterior wall ischemia, move L arm lead to V5 position, and monitor Lead I for ischemia.

5-Electrode System
- Four limb leads + V5 (left anterior axillary line, 5th ICS), allows monitoring of 7 leads simultaneously.
- V5 is 75% sensitive for detecting ischemic events; II + V5 is 80% sensitive; II + V4 + V5 together is 98% sensitive.

Noninvasive Blood Pressure
- Automated, microprocessor-assisted interpretation of oscillations in the NIBP cuff.
- MAP is primary measurement; SBP and DBP are derived from algorithms.
- Bladder should encircle ≥50% of extremity; width should be 20-50% greater than diameter of extremity.
- Cuff too small = falsely HIGH BP. Cuff too big = falsely LOW BP.

\[
\text{FYI:} \\
\text{MAP} = \frac{\text{SBP} + 2\text{DBP}}{3}
\]

Arterial Blood Pressure

Indications
- Moment-to-moment BP changes anticipated and rapid detection is vital.
- Planned pharmacologic or mechanical manipulation.
- Repeated blood sampling.
- Failure of NIBP.
- Supplementary diagnostic information (e.g. perfusion of dysrhythmic activity, volume status, IABP).

Transducer Setup
- Zeroing = exposes the transducer to air-fluid interface at any stopcock, thus establishing \( P_{atm} \) as the “zero” reference pressure.
- Leveling = assigns the zero reference point to a specific point on the patient, by convention, the transducer is “leveled” at the right atrium.

Effect of Patient & Transducer Position on BP Measurement

\[
\begin{array}{ccc}
\text{A} & \text{R} & \text{L} \\
\text{ABP} & 120/80 & 120/80 \\
\text{NIBP} & 120/80 & 120/80 \\
\text{B} & \text{R} & \text{L} \\
\text{ABP} & 120/80 & 120/80 \\
\text{NIBP} & 135/95 & 105/65 \\
\text{C} & \#1 & \#2 \\
\text{ABP} & 120/80 \\
\text{NIBP} & 120/80 & 105/65 \\
\text{D} & \#1 & \#2 \\
\text{10 cm H}_2\text{O} = 7.5 \text{ mm Hg}
\end{array}
\]

FYI:
- 10 cm H\(_2\)O = 7.5 mm Hg
Capnography

- Measures exhaled CO₂ (and other gases).
- Time delay exists due to length and volume of sample tube as well as sampling rate (50-500 ml/min).

**Capnogram Phases**

I. Dead space gas exhaled
II. Transition between airway and alveolar gas
III. Alveolar plateau
IV. Inspiration

**Example Traces**

A. Spontaneous ventilation
B. Mechanical ventilation
C. Prolonged exhalation (spontaneous)
D. Emphysema
E. Sample line leak
F. Exhausted CO₂ absorbant
G. Cardiogenic oscillations
H. Electrical noise

Temperature

Monitoring is required “when clinically significant changes in body temperature are intended, anticipated, or suspected.”

**Sites**

- Pulmonary artery = “Core” temperature (gold standard)
- Tympanic membrane - correlates well with core; approximates brain/hypothalamic temperature
- Esophagus - correlates well with core
- Nasopharyngeal - correlates well with core and brain temperature
- Rectal - not accurate (temp affected by LE venous return, enteric organisms, and stool insulation)
- Bladder - approximates core when urine flow is high
- Axillary - inaccurate; varies by skin perfusion
- Skin - inaccurate; varies by site
- Oropharynx – good estimate of core temperature; recent studies show correlation with tympanic and esophageal temperatures

References