Monitoring Critically Ill Patients

Vital basics on vital signs and signs that are vital...

Brandon Masi Parker OMS IV POPPF
DidacticsOnline
Topics:
- Vitals
- Pulse Oximetry
- Blood Gases
- End-tidal CO₂
Vitals

– Heart rate
– Respiratory rate
– Temp
– Blood pressure
Heart rate

- The autonomic nervous system is the primary regulator of heart rate in healthy pt.
- 50% of critically ill patients will present with normal HR
HR variability

- Heart rate variability (HRV) measurements provide a method for assessing cardiac autonomic function and for predicting cardiac death and sustained ventricular arrhythmias in pts. with CAD.
  - The autonomic nervous system has an important role in the triggering or sustaining of malignant ventricular arrhythmias, particularly after myocardial infarction.
  - **Myocardial ischemia** → increase afferent cardiac sympathetic firing → reflexes that increase efferent cardiac sympathetic neural activity while decreasing efferent vagal activity.
  - Release of norepinephrine from sympathetic nerves and high extracellular potassium concentrations in ischemic regions → regional heterogeneity of depolarization and repolarization → reentrant activity and the precipitation of ventricular fibrillation.
  - HR variability is inversely related to the production of many inflammatory markers.
Respiratory rate

• Ensure accuracy
• Insight to respiratory drive
• Insight to metabolic status

• Minute ventilation $\rightarrow$ actual ventilation
  – Clinically assess tidal volume
Temperature

- Rectal, vagina, or otic = 37.5 °C (99.5 °F)
- Oral = 36.8 °C (98.2 °F)
- Axillary = 36.5 °C (97.7 °F)

- Oral about 0.4 °C (0.7 °F) lower than rectal
  – influenced by drinking, chewing, smoking, and breathing with the mouth open
Blood pressure

• Aims to represent perfusion of organs
• Commonly measured with MAP and Pulse pressure
Pulse Pressure

• Pulse Pressure: SP-DP
• Low/Narrow:
  – Decreased stroke volume
• High/wide:
  – Increase in SV
    • Physiologic in stress and exercise (increase SV and decrease TPR)
  – A high pulse pressure with bradycardia and an irregular breathing pattern = Cushing's triad
MAP

- MAP: \((CO \times SVR) + CVP\)
  - \(DP + \frac{1}{3}(SP-DP)\) or \(DP + \frac{1}{3}PP\)
  - \(\frac{2}{3}DP + \frac{1}{3}SP\)

- Noninvasive can underestimate by 2-12 mmHg
- MAP is unreliable predictor of blood flow and CO
Perfusion

• Cardiac index = CO/BSA
  – Warm toe = sufficient cardiac index and global perfusion
• Cardiac power = MAP x CO
Pulse Oximetry
Pulse ox

- **PaO$_2$**: *partial pressure* of O$_2$ in arterial blood--ABG.

**SaO$_2$**: *oxygen saturation* is the percentage of hemoglobin molecules which are oxygenated (oxyhemoglobin) in arterial blood.-- pulse ox

<table>
<thead>
<tr>
<th>PaO$_2$</th>
<th>SaO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>70 (74.9)</td>
</tr>
<tr>
<td>50</td>
<td>80 (85)</td>
</tr>
<tr>
<td>60</td>
<td>90 (90.6)</td>
</tr>
</tbody>
</table>
Pulse ox calibration

• Finger probes are calibrated in subjects with \( \text{SaO}_2 \) from 100-75%.
  – Figures are extrapolated below 75% and accuracy suffers.

• Calibrated with normal Hg, Temp and pH which can all effect \( \text{SaO}_2 \).
  – Pulse ox still considered accurate with very low Hg but questionable with pH and Temp changes.
Pulse ox waveform

• Artifactual changes or a diminished arterial pulse may be evident in this waveform, and repositioning the probe may improve the signal.

• Good waveform = more trust in pulse ox reading.

• Although waveform is real time the saturation figure is not.
Pulse oximetry latency

- Lag time of finger pulse oximeter primarily determined by blood flow and is approx. 30 seconds in a healthy person (Ding).
- With decreased blood flow lag time can increase to over 2 minutes (Mateer).
  - Vasoconstriction/hypothermia/low flow state
  - Very dangerous at steep part of curve
Blood Gases
Blood gas

• Traditionally ventilation and acid base status is assessed via ABG.
• In VBG this can be closely estimated by looking at PvCO₂, pH, and HC0₃
  – Lactate can also be measured via VBG as long as in blood gas analyzer
VBG as estimate of ABG

- **Central/Mixed VBG**
  - pH: 0.03-0.05 < ABG
  - PCO$_2$: 4-5 mmHg > ABG
  - HC0$_3$: equivalent

- **Peripheral VBG**
  - pH: 0.02-0.04 < ABG
  - PCO$_2$: 3-8 mmHg > ABG
  - HC0$_3$: 1-2 meq/L > ABG
Blood gases in shock patients

• ABG- Alkalotic or neutral
  – Low CO₂
  – Little to no interaction with acidotic tissues

• VBG- Acidotic
  – High CO₂
  – Little to no interaction with lungs (ventilation)
End-tidal CO₂
End-tidal CO₂

**ETCO₂ ≠ PaCO₂**

- **ETCO₂** can predict **PaCO₂** with an intrinsic and predictable *underestimation* in *healthy* pts.
- In critically ill pts. we can assume:

  \[ PaCO₂ ≥ ETCO₂ \]

- Gradient between PaCO₂ and ETCO₂ is determined by shunt and dead space
End-tidal CO$_2$

- Parameter measuring **ventilation** and **cardiac output**
- In healthy patients it primarily measures ventilation
  - With decreasing CO the measurement becomes more dependent on the perfusion of the lungs and thus measures CO > ventilation
End tidal CO$_2$

- Measure of ventilation and cardiac output

Graph showing End Tidal CO2 against CO reduction from baseline with lines indicating ventilation and cardiac output.
Summary

• Vitals
  – Vital but always in context

• Pulse Oximetry
  – Looking in the past

• Blood Gases
  – $\text{VBG} \approx \text{ABG}$ in non-shock patients

• End-tidal CO2
  – Measures primarily CO after a significant drop in CO
Resources

• Assali AR, Herz I, Vaturi M, Adler Y, Solodky A, Birnbaum Y, Sclarovsky S. Electrocardiographie criteria for predicting the culprit artery in inferior wall acute myocardial infarction. *Am. J. Cardiol.* 84(1); 87-9
• Levin T, Goldstein JA. Right ventricular myocardial infarction. *UpToDate*
• Reeder GS, Kennedy HL, Rosenson RS. Overview of the acute management of ST elevation myocardial infarction. *UpToDate*
• Ryan TJ, Reeder GS. Initial evaluation and management of suspected acute coronary syndrome in the emergency department. *UpToDate*
• Weingart S. Physiology of oxygenation. *Emcrit audio podcast*