Neonatal/Pediatric Cardiopulmonary Care

Assessment of Oxygenation and Ventilation

Blood Gases

Blood Gas Analysis
- Infants can make dramatic changes in status very quickly
- Very difficult to base therapeutic decisions simply on observation, esp. when it comes to oxygenation & ventilation
- Keep in mind:
  - Small premie may only have 100 ml of blood volume
  - Frequent blood sampling can deplete blood supply in a hurry
Indications for Blood Gas

- Any neonate showing signs of respiratory distress
- Any neonate whose clinical course, appearance, VS or condition has changed for no obvious reason
  - Don’t wait for blood gas to treat
- 15-30 min after vent setting or FIO2 changes
- Once NB is on vent & stabilized -- BG regularly

Blood Gas Sources

- Umbilical Artery Catheter (UAC)
  - Preferred method:
    - No pain
    - Easily obtained
  - If R→L shunt exists (PA→aorta) through PDA
    - PtcO2 on right chest or SpO2 on right arm + UAC to compare PaO2
    - Normally: right = preductal
    - UAC = postductal
    - if R→L d.a. open - right arm PaO2 will be higher than UAC

Blood Gas Sources

- UAC
  - Problem with UAC if d.a. open: PaO2 does not reflect PaO2 of blood going to head, heart
  - Raising PaO2 in response to low PaO2 from UAC may raise PaO2 to head, heart to dangerous levels
Oxygenation & Ventilation

Blood Gas Sources

• Procedure
  – Withdraw 2-2.5 ml blood slowly
  – ABG syringe placed on stopcock
  – Sample withdrawn
  – Reinsert 1st 2-2.5 ml blood
  – Analyze

Blood Gas Sources

• Radial artery catheter
  – Indwelling
  – Useful alternative to UAC when UAC can't be put in or has to be removed
  – Results are preductal if on right
  – Hazards
    • Infection
    • Air embolism
    • Arterial occlusion
    • Infiltration of fluids
    • Nerve damage

Blood Gas Sources

• Radial arterial puncture
  – Compared to UAC are fairly difficult to obtain
  – Can’t palpate artery - done blind
  – Helps to use transillumination under wrist
  – Inflicts too much damage to do often
  – Hazards
    • Infection
    • Bleeding
    • Nerve damage
    • Embolism
    • Hematoma
Blood Gas Sources

- Capillary sampling
  - Used after UAC removed or can’t get one in
  - Less hazardous & more easily obtained than arterial punctures
  - Reliable in assessing pH and PaCO₂
  - Is not reliable in assessing PaO₂
    - Must be determined by SpO₂ or TC
    - Unreliable correlation between PaO₂ & PaCO₂
    - If Pco₂ < 70 mmHg - PaO₂ = Pco₂
    - If Pco₂ > 70 mmHg - PaO₂ may be very high

Blood Gas Sources

- Capillary sampling - Indications
  - Need BG & arterial access is not available
  - TC, PO, capnography readings are abnormal
  - Assessment of patient following initiation or change in therapy
  - Change in patient status
  - Monitor severity or progression of disease process

Blood Gas Sources

- Capillary sampling - Contraindications
  - Need for direct analysis of arterial blood
  - Patients < 24 hrs old - poor correlation to PaO₂
    - Decreased O₂ due to open d.a.
    - Hypoxia (vasoconstriction → poor peripheral perfusion)
    - Hypothermia (vasoconstriction → poor peripheral perfusion)
    - Hypercarbia (vasoconstriction → poor peripheral perfusion)
  - Polycythemia
Blood Gas Sources

• Capillary sampling - Areas to avoid
  – Fingers of neonates
  – Previous puncture sights
  – Inflamed, swollen, areas
  – Areas of infection
  – Posterior curvature of heel
  – Heel of any walking patient
  – Site of posterior tibial artery

Blood Gas Sources

• Capillary sampling - Technique
  – Heel heated 45° X 5-7 min
  – Heel wiped with antiseptic pad
  – Puncture made
  – Should bleed freely
    • NO “milking”!!
    • NO “kneading”!!
  – No air bubbles in capillary tube

Blood Gas Sources

• Capillary sampling - Complications (usually related to improper technique)
  • Puncture heel bone  • Bruising
  • Infection  • Scarring
  • Burns  • Tibial a. laceration
  • Hematoma  • Pain
  • Nerve damage  • Bleeding
  • Inappropriate pt. mgnt. by relying on P<sub>O</sub><sub>2</sub>
Blood Gas Sources

- Pedi patients
  - All info same except can do heel or finger stick
  - Arterial sticks done in this order
    - Radial
    - Brachial
    - Temporal, Dorsalis pedis
    - Femoral

ABG Assessment

- The big difference between neonates & pedi is what are normal or safe values

- Remember - really aren’t normal values for neonates - values change over 1st hrs & days of life with changes in lung function and cardiac shunts

Normal ABGs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Neonates</th>
<th>Pediatrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{PaO}_2$</td>
<td>50 - 70 mmHg</td>
<td>85 - 100 mmHg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55 - 80 mmHg (5,000 ft)</td>
</tr>
<tr>
<td>$\text{PaCO}_2$</td>
<td>35 - 45 mmHg (chronic disease: &lt;60 mmHg)</td>
<td></td>
</tr>
<tr>
<td>$\text{pH}$</td>
<td>7.35 - 7.45 safe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.30 - 7.50 acceptable</td>
<td></td>
</tr>
</tbody>
</table>
Transcutaneous Monitoring

TCM Basic Concepts

- Are drawbacks to traditional methods of assessing ABGs
  - Freq blood sampling depletes supply
  - Only shows status at time of sampling & may be invalid within minutes as fast as neonates change
- Ideal to monitor constantly without causing pain or blood loss
- TCM offers 1 method

TCM Design & Mechanics

- Measures O₂ diffusing through skin
- Uses same electrode as in ABG machine only smaller - what electrode??
- Electrode is heated
  1. Changes lipid structure of skin allowing faster diffusion
  2. Causes vasodilation arterializing blood
  3. Shifts oxyhemoglobin dissociation curve to right enhancing release of oxygen from RBC
TCM Design & Mechanics

- Temperature regulated by thermistor
  - 42-44°C
- Relatively new technology: O₂ & CO₂ on same electrode
- Result is monitor placed on skin surface that give a continual readout of O₂ & CO₂ tensions that are reliable

TCM Design & Mechanics

- Correlation to ABG values
  - \( P_{TC}O_2 < PaO_2 \)
    - Perhaps TCM is measuring tissue O₂
  - \( P_{TC}CO_2 = PaCO_2 \)
    - CO₂ diffuses faster
    - Surface area of Severinghaus electrode > Clark electrode

TCM Clinical Uses

- Main advantage is ability to trend
  - Even though \( P_{TC}O_2 \neq PaO_2 \), difference is stable
- Factors that cause \( P_{TC}O_2 < PaO_2 \) are factors that decrease tissue perfusion
  - shock
  - hypothermia
  - cyanotic heart disease
  - acidosis
  - skin edema
  - Tolazoline delivery
  - anemia
  - \( PaO_2 > 100 \)
Oxygenation & Ventilation

TCM Clinical Uses

• Detection of shunt
  – Usually R→L shunt through Ductus arteriosus
    • PA → aorta, i.e. unoxygenated blood → oxygenated blood thereby ↓ SaO₂
  – Place 1 electrode on right shoulder which is fed by preductal subclavian artery
  – 1 electrode on lower abdomen or thigh fed by postductal descending aorta
  – When shoulder PaO₂ > lower extremity PaO₂ = d.a. is open

TCM Clinical Uses

• Indicator of skin perfusion
  – Some monitors can track the power required to heat the sensor to the preset temp
  – Changes in skin perfusion will show as changes in the amount of power required to maintain probe temp
    • As perfusion increases, blood carries heat away more rapidly requiring more power to maintain temp

TCM Limitations

1. TCM may underestimate PaO₂ in
   • Hyperoxemia
   • Compromised hemodynamic status
   • Pressure on electrode
   • Chronic lung disease
2. Inappropriate temp of electrode may adversely affect performance of monitor
TCM Limitations

3. Performance decreased if electrode placed over poorly perfused sites
   - Distal extremities
   - Bony areas
   - Place electrode over
     - Abdomen
     - Upper thorax
     - Inner thighs

4. Heated electrode can cause burns, blistering
   - Especially if poor perfusion to site
   - Change site q2-3 hrs
5. Should have periodic correlation with ABGs
6. Requires proper application, warm-up time, calibration

TCM Complications & Hazards

- Thermal injury (greatest hazard)
- Stickies used to hold electrode in place can injure skin when removed
  - Change site q2-3 hrs
  - Velcro straps or Coban wraps
- Total reliance on TCM without periodic ABGs
Pulse Oximetry

PO Basic Concepts
• Utilizes light absorption to calculate saturation of hemoglobin
• Ideal locations
  – Toe
  – Finger
  – Ear
  – Foot
  – Wrist

PO Basic Concepts
• Operation

Light emitting diode (infrared + red)
Wrist
Toe
Foot
Finger
Ear
Photodetector
PO Basic Concepts

- Operation
  - Oxyhemoglobin and deoxyhemoglobin are distinctly different in their capability to absorb infrared and red light
  - Processor calculates oxygen saturation by comparing the ratio of infrared to red light absorbed

PO Clinical Uses

- Advantages
  - Requires no warm-up time
  - Accurate
  - Non-invasive, non-heated

- Disadvantages
  - External light (heat lamps, phototherapy lights) can interfere with light detector
  - Inaccuracies seen with heavy skin pigment
  - Change site q8h to prevent skin breakdown and pressure sores

Capnography
Basic Concepts

• Measurement of exhaled CO₂

• Uses spectrophotometry or infrared absorption to determine $P_{Et}CO₂$

Basic Concepts

Metabolism produces CO₂ → $PvCO₂$ → 46 mmHg → Lungs

Arterial blood leaving lungs has $PaCO₂$ of 40 mmHg (if lungs well perfused)

Removal of CO₂ from alveoli by ventilation

• Unfortunately, patients do not possess healthy, well-perfused lungs

Basic Concepts

• So what happens in diseased lungs?

** The basis for understanding $P_{Et}CO₂$ monitoring is that the results ultimately reflect changes in pulmonary perfusion**
Effect of V/Q Imbalances

- Deadspace ventilation (V>P, V w/o P)
  - Has the greatest effect on $P_{ET}CO_2$
  - If no or little CO$_2$ brought to alveoli → ↓$P_{ET}CO_2$
  - While PaCO$_2$ normal → ↑$P_{aET}CO_2$
- Causes of increased VD
  - Pulmonary emboli
  - High vent press &/or PEEP
  - Anything that decreases pulmonary blood flow
  - Anything that decreases Q_T

Effect of V/Q Imbalances

- Shunts don’t affect $P_{ET}CO_2$

Limitations of Capnography

- Does not reflect any info on oxygenation
- Can only show a change in patient condition, not an improvement or deterioration . . . .
Oxygenation & Ventilation

Limitations of Capnography

- Improved ventilation
- Worsening V/Q
- Improved V/Q
- ↓ min ventilation
- ↓ V,D
- ↓ Q,T
- ↑ V,D
- ↑ P,ET,CO₂
- ↓ P,ET,CO₂
- BAD
- GOOD

How To Assess Patient

1. Perform ABG
2. Determine P(a-ET)CO₂
3. If P(a-ET)CO₂ ≤ 5 mmHg =
4. Means P,ET,CO₂ =
5. If P(a-ET)CO₂ > 5 mmHg =
6. P,ET,CO₂ ≠

Problems

- P(a-ET)CO₂ = 2 mmHg  P,ET,CO₂ = 52 mmHg
- What do we know?
Oxygenation & Ventilation

Problems

• $P_{(a-ET)}CO_2 \cdot 14 \text{ mmHg}$  $P_{ET}CO_2 \cdot 22 \text{ mmHg}$

• What do we know?

Problems

• $P_{(a-ET)}CO_2 \cdot 2 \text{ mmHg}$  $P_{ET}CO_2 \cdot 32 \text{ mmHg}$

• What do we know?