Virtual Lectures Planning Committee Disclosure Summary

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Listed below are individuals with control of the content of this program who have disclosed...

Relevant financial relationship(s) with industry:
None

No relevant financial relationship(s) with industry:
Brad Karon, M.D., Ph.D.– program speaker
Curtis Hanson, M.D. – program planning committee
Sharon Preuss – program planning committee
Bobbi Pritt, M.D., MSc, DTMH – program planning committee
Melissa Peterson – program planning committee

References to off-label and/or investigational usage(s) of pharmaceuticals or instruments in their presentation:
None
Demonstrating the Effect of Pre-Analytical Errors
Brad Karon, Tammy Tauferner, Amy Wockenfus, Lori Sorenson
Disclosures

Relevant Financial Relationship(s):
Nothing to Disclose

Off Label Usage:
Nothing to Disclose

Outline of activities

• Effect of air bubbles on blood gas results
  • Background information
  • Table top exercise, take your guess
• Effect of total parenteral nutrition (TPN) on pH and electrolytes
  • Background information
  • Table top exercise, take your guess
### Blood Gas Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>pH electrode</td>
</tr>
<tr>
<td>pO₂</td>
<td>Clark electrode</td>
</tr>
<tr>
<td>pCO₂</td>
<td>Severinghaus electrode</td>
</tr>
<tr>
<td>SO₂</td>
<td>Calculated based on pO₂</td>
</tr>
</tbody>
</table>

### Lung function (gas exchange)

[Diagram showing gas exchange between Lungs, Heart, and Body]
Oxygen saturation

- O2 binding to Hgb cooperative
- Dependent upon pH, DPG, temp, Hgb structure, pCO2

Evaluation of Hypoxemia

<table>
<thead>
<tr>
<th>Arterial pO$_2$</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;80 mm Hg</td>
<td>adequate oxygenation</td>
</tr>
<tr>
<td>60-80</td>
<td>mild hypoxemia</td>
</tr>
<tr>
<td>40-60</td>
<td>moderate hypoxemia</td>
</tr>
<tr>
<td>&lt;40</td>
<td>severe hypoxemia</td>
</tr>
<tr>
<td>SaO2 &gt; 94%</td>
<td></td>
</tr>
</tbody>
</table>
Acid Base Disorders

• Lungs--Acid regulation
  • Lungs (CO2)>>>kidneys (NH4+, H2PO4-)
  • Peripheral and central chemoreceptors respond to pH change
  • Increase or decrease respiratory rate

• Kidneys—Acid and Base regulation
  • Kidneys
  • Na/H exchange in renal tubules (NH4+, H2PO4-)
  • Reclamtion of HCO3 in proximal tubule (carbonic anhydrase formation of H2CO3)

Blood gas and acid-base assessment

• PaO2 and SaO2 use to assess for oxygenation
  • Gas exchange in lungs, ability to deliver O2 to tissue

• PaCO2 used to assess both acid-base balance and gas exchange ability of lungs
  • Exchange O2 for CO2 in lungs
  • Normal PaCO2 35-45 mm Hg

• pH used to assess for acid-base disorder
  • Normal pH 7.35-7.45
Pre-Analytical Variables—blood gas

• Air Bubbles
  • Dramatic effect on PaO₂
    • PaO₂ of room air: 158 mm Hg
    • For patients breathing room air (normal PaO₂ 80-100 mm Hg), air bubble falsely increases PaO₂
      • Could miss hypoxemia and therefore not treat
    • For patients getting supplemental oxygen (may have real PaO₂ > 158), air bubble may falsely decrease PaO₂ result
      • Difficulty trending and interpreting changes in oxygenation status

• Air Bubbles
  • Decreased PaCO₂
    • Change is less marked
  • Increased pH due to decrease in PaCO₂
  • Mixing enhances these changes
    • Air bubbles should be expelled within 2 minutes of collection and prior to mixing
    • Pneumatic tube lore related to mixing
  • Samples with obvious froth should be discarded
Blood gas air bubble exercise
Line draws and sample contamination

• Issues with line draws (central venous catheter, PICC, arterial line)
  • Hemolysis
  • Dilution
  • Heparin contamination (coagulation tests)
  • Analyte/drug contamination
    • Drugs given thru line
    • Heparin
    • Glucose, lipids, potassium, Mg, Phos, Calcium, others

Line draws and sample contamination

• Why draw blood specimens from indwelling lines
  • Patient comfort and convenience
  • Reduce burden on dedicated phlebotomy staff
  • More timely blood draws (relative to time ordered, time medication given, etc)
  • Difficult venous access
Guidelines

- CLSI GP41-A6: Procedures for the collection of diagnostic blood specimens by venipuncture
- Flush line (fluid being infused or heparin or other solution used to maintain patency)
- Discard 2x dwell volume non-coag tests, 5 mL or 6X dwell volume coag tests prior to sampling

Mayo current practice

- Discontinue all IV solutions 2 min
- 10 mL saline flush (adults)
- Discard 5 cc blood (adults)
  - If dextrose or TPN given thru lumen used to collect, waste 10-20 cc before collection (20 cc preferred if measuring glucose)
  - For any coag tests 10 cc minimum (either discard or drawn before coag tube)
  - Drug levels by line require provider approval with some exceptions (transplant, heme/onc)
- Draw blood samples using either (preferred) vacutainer or syringe
Common “funky” results from line draws

- Hemolyzed specimen
- Falsely elevated glucose
- Falsely elevated or decreased K
- Falsely elevated Mg, Phos or Ca
- Falsely decreased creatinine
- Falsely decreased hemoglobin/cell count
- Falsely decreased sodium

Mayo Experience with line draws

- Draws from PICC lines over-represented among contaminated specimens detected (mainly heparin)
- Draws from patients on total parenteral nutrition (TPN) over-represented among contaminated specimens detected (chemistries)
- Draws from patients on IV Mg/Ca/Phos replacement over-represented (Mg/Ca/Phos)
Mayo study of line draws

• 2 Hospital practices studied in 2007
• Asked to document waste volume, type of line, vacutainer vs. syringe, whether line used for infusion, whether infusion stopped

Mayo study of line draws

• Methodist Hospital
  • 541 line draws documented
  • All at least 5 cc discard volume
  • 0 contaminated specimens
Mayo Experience with line draws

- St Mary’s Hospital
  - 149 line draws documented
  - All 5 cc or more discard volume
  - 0 contaminated specimens

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Mayo Experience with line draws

- 690 line draws without a contaminated sample
- 84% vacutainer (Methodist) vs. 97% syringe (St Mary’s)
- If line being used no contamination as long as 2 min wait and 5 cc discard enforced
One approach

- All venous line draws: D/C all IV solutions 2 min, discard 5 cc
- No collections thru same lumen if glucose, TPN or lipid solution running
- If nursing finds discard volume comes easy thru syringe, use vacutainer for draw

Total parenteral nutrition (TPN) contamination

- In ICU TPN nutritional support very common
- TPN compounded for each individual patient
  - 15,000 mg/dL glucose
  - 41 mmol/L sodium
  - 16 mmol/L potassium
  - 30 mg/dL calcium
  - Vitamins, minerals, amino acids
- Is glucose alone enough to detect/suspect contamination with TPN?
TPN contamination experiment

Questions & Discussion