Fetal Monitoring and Umbilical Cord Gases: What’s the Secret?

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Objectives

* The learner will be able to
  * describe the process for umbilical cord blood collection.
  * define the normal acid-base parameters of umbilical cord blood gases.
  * discuss the clinical value of determining acid-base parameters.
What is Hypoxia?

* Low levels of oxygen in the tissues
* Acidemia – state of low blood pH
* Acidosis – the process of becoming acidemic
* Birth asphyxia occurs when a baby doesn't receive enough oxygen before, during or just after birth

* Hypoxia, hypercapnia, and respiratory and/or metabolic acidemia
ACOG reports that fetal asphyxia occurs in 25 of 1000 live births and 15% of those are moderate to severe.
Assessing Fetal Well-Being

- Ultrasound
- Biophysical Profile (BPP)
- Doppler studies
- Electronic Fetal Monitor
- Umbilical Cord Blood Analysis
* “…a valuable but imperfect tool.”

(Clark, et al. 2017, p. 163)
Expected Outcomes

* Decrease incidence of cerebral palsy and intrapartum stillbirth
Actual Outcomes

- No difference # intrapartum stillbirth (one in 300)
- There were no differences in the incidence of CP
- Neonatal seizures decreased with EFM

- Continuous monitoring is associated with a significant increase in C/S and operative births
<table>
<thead>
<tr>
<th>Year</th>
<th>CD%</th>
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<tbody>
<tr>
<td>2015</td>
<td>32.0%</td>
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<td>2007</td>
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<td>1996</td>
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<td>1988</td>
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<td>1970</td>
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Unrealistically high expectations
Lack of standardization of FHR definitions until 1997/2008
Poor reliability for FHR interpretation
Failure to show the validity of FHR monitoring in detecting fetal asphyxia
* “... of infants born with metabolic acidemia, only approximately one-half could be identified potentially and have delivery expedited, even under ideal circumstances.”

(Clark, et al, 2017, p. 163)
Total Deceleration Area
Total Deceleration Area

(Cahill, et al., 2012)
Category I Strip
Category III Strip
Category III Strip
Parer et al. (2006) reported that only 24% of fetuses with Category III strips have metabolic acidemia.
Hypoxic Ischemic Encephalopathy

- Hypoxic (lack of oxygen)
- Ischemic (restricting blood flow)
- Encephalopathy (affecting the brain)

- Abnormalities during the last hour of fetal heart rate monitoring are poorly predictive of neonatal HIE
Hypoxic Ischemic Encephalopathy

“Hypoxic-ischemic encephalopathy is associated with significant increases in electronic fetal monitoring abnormalities, but the predictive ability to identify these conditions is low.”

Larma, et al., 2007
EFM Predicting Acidosis

* Specificity of 98.9%
  * Percent of healthy pts appearing healthy
* Sensitivity of 7.7%
  * Percent of unhealthy pts appearing unhealthy

Larma, et al., 2007
UCG’s are an important parameter in the decision for brain cooling.

Neonatal therapeutic hypothermia has been shown to help reduce significant brain damage in infants who suffered from lack of oxygen during labor/birth.
In 1958, James, et al. recognized the possibility of interpreting umbilical cord blood gases
ACOG Committee Opinion

- Intrapartum Event =/? Adverse Outcome
- All Non-elective cesareans deliveries
- 5- minute Apgar ≤ 3
- “Abnormal” Fetal Heart Rate Tracing
- Severe IUGR
- Intrapartum Fever
- Maternal Thyroid Disease
- Multiple Gestation
Clinical Relevance

* Cord blood analysis is the most objective way of assessing the fetal condition at birth
* Allows for differentiation of respiratory and metabolic acidemia
Normal Cord Gas Values

* pH >7.1
* pO2 > 20mmHg
* pCO2 < 60mmHg
* Bicarbonate >22mEq/L
* Base Excess >-12mEq/L
  * Base Deficit <12mEq/L

* (Adapted from AWHONN FHMPP, 2016)
Fetal neurologic injury does not occur without significant metabolic acidemia

* pH <7.0

ACOG, 2010
* Potential for Hydrogen (H+)
  * Increasing H+, decreasing pH
  * Decreasing H+, increasing pH

* Fetal Normal = > 7.10
* ACOG recommends= <7.0 for severe acidemia
pO2

* The amount of dissolved oxygen in the blood
* Normal umbilical gas values >20mmHg
- Dissolved carbon dioxide in the blood
- Normal umbilical gas value <60mmHg
  - Umbilical vein has lower pCO2
  - Umbilical artery has higher pCO2
 Buffering systems
  Circulating acids are neutralized
 Bicarbonate (HCO₃⁻) is the largest buffering system
The base excess is defined as the amount of H+ ions that would be required to return the pH of the blood to 7.35 expressed as a - number.

Indirect measurement of anaerobic metabolism.
* If you had a high H+ content in the blood (metabolic acidemia) it would take a very low amount to return to 7.35
Maternal oxygenation is compromised
  * Maternal cardiac disease
  * Reduced perfusion of the placenta
    * Preeclampsia
  * Delivery of oxygenated blood from the placenta to the fetus is impeded
    * Abruption, cord entanglement
Respiratory Acidemia

- CO₂ accumulates
  - pCO₂ > 60mmHg
- pH falls
- Develops quickly, clears quickly
  - Primary Apnea
"Hidden Acidemia"

- Delayed Cord Clamping (DCC)
- Reperfusion of the peripheral tissues causes CO2 to be released and can be detected in the umbilical artery
  - Decreased pH
  - Increased CO2
Absence of available $O_2$ the cells will shift into *anaerobic* metabolism which produces lactic acid as a byproduct.

- When lactic acid exceeds buffering capacity the result is metabolic acidemia
- Secondary apnea
Aerobic Respiration

O₂ → Metabolic Pot → CO₂
Glucose → Metabolic Pot → H₂O

38 ATP (Energy) → Heat (417 kcal)
Anaerobic Respiration

Glucose only → Metabolic Pot → Lactic acid

Metabolic Pot → 2 ATP (Energy)

Metabolic Pot → Heat (32 kcal)
Both necessary to ensure the biological validity of the samples obtained
Arterial vs. Venous Sample

- pH of the vein will always be higher than the artery (0.02)
- pCO2 of the vein will always be lower than the artery
Umbilical cord arterial pH is a measure of the fetal condition at birth.

Umbilical cord venous pH is a measure of maternal acid-base status and the condition of the placenta.
Respiratory, Metabolic or Mixed

* Respiratory acidemia
  * CO₂ greater than 60mmHg
* Metabolic acidemia
  * Bicarbonate <22mEq/L
  * Base Excess < -12mEq/L
* Mixed
  * All of the above
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<thead>
<tr>
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<th>Arterial</th>
<th>Venous</th>
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<tbody>
<tr>
<td>pH</td>
<td>7.10</td>
<td>7.16</td>
</tr>
<tr>
<td>pCO2</td>
<td>16</td>
<td>22</td>
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<tr>
<td>pO2</td>
<td>60</td>
<td>58</td>
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<tr>
<td>Bicarbonate</td>
<td>24</td>
<td>22</td>
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<tr>
<td>Base Excess</td>
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<td></td>
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<tr>
<td>BE</td>
<td>-10</td>
<td>-6</td>
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<tr>
<td></td>
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<td>Venous</td>
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<tr>
<td>----------------</td>
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<td>20</td>
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<tr>
<td>BE</td>
<td>-14</td>
<td>-10</td>
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A wide difference in values is often due to obstructed O2 delivery.

A small difference is most likely caused by impairment of maternal perfusion of the placenta.
Variable Decelerations
## Large UA-UV Difference

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<tr>
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<th>Arterial</th>
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<td>Bicarbonate</td>
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<tr>
<td>Base Excess</td>
<td>-21.2</td>
<td>-14.2</td>
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</table>
Late Decelerations
## Small UA-UV Difference

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<tbody>
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<td>18</td>
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<tr>
<td>Bicarbonate</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Base Excess</td>
<td>-22</td>
<td>-20</td>
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</table>
Double Clamped Cord Segment
Umbilical Artery Sampling
No Air in Sample
Wait Time & Transport

- Clamped cord good for 60 minutes at room temperature
- Stable in a plastic syringe for 30 minutes prior to sampling
- Transport at room temperature