Fetal Acid Base Status and Umbilical Cord Sampling

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Part I:
Some Background
Intra-uterine Event as Causative of CP

- Cord pH < 7.00 and base excess of > 12
- Early onset neonatal encephalopathy
- Spastic quadriplegia or dyskinetic CP
- Exclusion of other identifiable causes

All four must be present before an intrauterine hypoxic event can be considered as a cause of CP

Neonatal Encephalopathy and Cerebral Palsy. ACOG and AAP. 2003
Five Criteria that COLLECTIVELY Suggest an Intra-partum Causative Event

- A sentinel hypoxic event occurring immediately before or during labor
- Previously described abnormal monitor patterns*, usually after a sentinel event
- Apgar scores < 4, beyond 5 minutes
- Onset of multi system involvement w/i 3 days of birth
- Early imaging studies that show non focal cerebral abnormality

* Sustained bradycardia, absent variability + persistent late or variable decelerations

Contrary evidence would therefore exclude an injurious intrapartum event

Neonatal Encephalopathy and Cerebral Palsy. ACOG and AAP. 2003
What is Normal Acid Base Status?

Table 2. Placental and Umbilical Cord Blood Measurements

<table>
<thead>
<tr>
<th></th>
<th>Vein</th>
<th>Artery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Umbilical</td>
<td>Placental</td>
</tr>
<tr>
<td>Po₂ (mmHg)</td>
<td>28.7 ± 5.9</td>
<td>26.8 ± 5.7</td>
</tr>
<tr>
<td>Pco₂ (mmHg)</td>
<td>41.1 ± 7.2</td>
<td>41.1 ± 9.3</td>
</tr>
<tr>
<td>pH</td>
<td>7.35 ± 0.05</td>
<td>7.34 ± 0.05</td>
</tr>
<tr>
<td>Base excess (mM)</td>
<td>-3.3 ± 2.3</td>
<td>-3.4 ± 2.2</td>
</tr>
<tr>
<td>O₂ saturation (%)</td>
<td>63.3 ± 13.9</td>
<td>59.1 ± 15.1</td>
</tr>
<tr>
<td>Hb (g/L)</td>
<td>160 ± 22 (48)</td>
<td>163 ± 23 (46)</td>
</tr>
</tbody>
</table>

NS, not significant; Hb, hemoglobin.

Values are mean ± standard deviation and (number of patients or measurements). Significance is based on paired data.

Doesn’t really change over wide range of gestational ages

Even in Lowest pH Group
Only 10.3% had low Apgar and
Two Thirds Admitted to Normal Nursery

<table>
<thead>
<tr>
<th>pH</th>
<th>N</th>
<th>%</th>
<th>Apgar (\leq 3) at five min</th>
<th>NND</th>
<th>Seizures</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 7.00</td>
<td>87</td>
<td>2.50%</td>
<td>10.30%</td>
<td>8%</td>
<td>12.60%</td>
</tr>
<tr>
<td>7.00 - 7.04</td>
<td>95</td>
<td>2.70%</td>
<td>1.10%</td>
<td>1.10%</td>
<td>4.20%</td>
</tr>
<tr>
<td>7.05 - 7.09</td>
<td>290</td>
<td>8.30%</td>
<td>0.30%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7.10 - 7.14</td>
<td>798</td>
<td>22.80%</td>
<td>0</td>
<td>0.40%</td>
<td>0.30%</td>
</tr>
<tr>
<td>7.15 - 7.19</td>
<td>2236</td>
<td>63.80%</td>
<td>0.04%</td>
<td>0.10%</td>
<td>0.20%</td>
</tr>
</tbody>
</table>

3,506

Confirms poor correlation of low 5 minutes Apgar score and low pH
18 Ways to Have an Acidemic Baby

- Abruption
- Birth Asphyxia
- Chorioamnionitis
- Congenital Anomaly
- Decreased F.M.
- End Stage Bradycardia
- F.M. abnormalities
- Instrument Deliveries
- Meconium Aspiration Syndrome
- Prolonged Labor
- Quick Perk Up Baby
- Shoulder Dystocia
- Splenic Artery Aneurysm
- Substance Abuse
- Twin B Delivery Problems
- Unclear
- Uterine Rupture
- Version
Part II: Sampling Umbilical Cord Gases, Specifically Arterial

Why Do It?
Lofty: Umbilical cord blood analysis for evaluation of the newborn’s acid-base status immediately after delivery is the most objective way of assessing fetal metabolic condition at birth. Allows distinguishing between respiratory and metabolic acidosis.

Less lofty, but realistic: required by some insurance companies, hospital policies, etc

Practical: the more frequently you do it, the better you get at doing it right
And

Umbilical artery cord blood obtained promptly after delivery accurately reflects fetal acid-base status at birth. Umbilical vein cord blood does not!

Severe cord blood acidemia (pH < 7.00) is an essential criterion for the diagnosis of intra-partum asphyxia.....

And the converse: the absence of metabolic acidemia precludes acidemia as a causative factor in CP

Let me repeat: A normal umbilical artery blood gas analysis may serve as solid evidence against any alleged association between intrapartum events and poor neonatal outcome
But, there is a “catch,” as there are two vessels and only one is the artery.

If cord sampling is performed upon a single vessel, it often is tempting to go for the easy vessel. Sadly that one is the umbilical vein, not the artery. And it is close to useless! The vein’s blood acid-base status, in isolation, neither assists in the care of the neonate nor cannot it be used to defend care.
Solution to the Problem

• Always draw two samples
• From different but closely adjacent blood vessels
• One inevitably will be the artery
• The big easy-to-draw-from is vessel is always the vein
• The differences in PCO2 (always higher in the artery) and pH (always lower in the artery) will indicate from which vessel the samples were obtained, regardless of how the sample may be erroneously labeled

• Obtain the umbilical artery sample first, then the umbilical vein sample
Warning! It is easy to contaminate the sample with ambient air! So, if you see bubbles in the liquid, discard it and try again.

Minimal sample size = 0.2 cc's. Remove air from syringe. Seal with cap provided. Label with Baby Name / MR number.

NO BUBBLES of O2
Umbilical Cord (arterial and venous blood gases) …1990-1999, term, no anomalies, Caucasian

Fetal umbilical cord oxygen levels......Lackman F et al. Am J Ob Gyneco 2001;185:674-82

<table>
<thead>
<tr>
<th></th>
<th>FGR (n=495 and 464)</th>
<th>bFGR (n=1333 and 1253)</th>
<th>AGA (n=19,253 and 18,376)</th>
<th>bLGA (n=2019 and 1959)</th>
<th>LGA (n=1062 and 1043)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Umbilical vein</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{PO}_2$ (mm Hg)</td>
<td>$25.6 \pm 8.0^*$</td>
<td>$26.7 \pm 6.6^*$</td>
<td>$28.3 \pm 6.7$</td>
<td>$28.8 \pm 6.4^*$</td>
<td>$29.2 \pm 7.2^*$</td>
</tr>
<tr>
<td>$\text{PCO}_2$ (mm Hg)</td>
<td>$41.9 \pm 7.2^*$</td>
<td>$40.7 \pm 7.4^*$</td>
<td>$39.0 \pm 6.5$</td>
<td>$39.0 \pm 6.1$</td>
<td>$39.9 \pm 6.6^*$</td>
</tr>
<tr>
<td>pH</td>
<td>$7.32 \pm 0.06^*$</td>
<td>$7.33 \pm 0.06^*$</td>
<td>$7.85 \pm 0.06$</td>
<td>$7.35 \pm 0.05$</td>
<td>$7.35 \pm 0.06$</td>
</tr>
<tr>
<td>Base excess (mmol/L)</td>
<td>$-4.6 \pm 2.5^*$</td>
<td>$-4.3 \pm 2.4^*$</td>
<td>$-3.9 \pm 2.3$</td>
<td>$-3.7 \pm 2.2^*$</td>
<td>$-3.8 \pm 2.3$</td>
</tr>
<tr>
<td>Oxygen saturation (%)</td>
<td>$56.2 \pm 17.1^*$</td>
<td>$59.9 \pm 16.5^*$</td>
<td>$64.4 \pm 15.1$</td>
<td>$65.8 \pm 14.1^*$</td>
<td>$65.7 \pm 14.8^*$</td>
</tr>
<tr>
<td><strong>Umbilical artery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{PO}_2$ (mm Hg)</td>
<td>$13.8 \pm 4.9^*$</td>
<td>$14.8 \pm 5.3^*$</td>
<td>$15.7 \pm 5.3$</td>
<td>$15.7 \pm 5.4$</td>
<td>$15.8 \pm 5.4$</td>
</tr>
<tr>
<td>$\text{PCO}_2$ (mm Hg)</td>
<td>$55.4 \pm 9.6^*$</td>
<td>$54.3 \pm 9.2^*$</td>
<td>$53.5 \pm 8.8$</td>
<td>$54.2 \pm 9.2^*$</td>
<td>$55.2 \pm 9.3^*$</td>
</tr>
<tr>
<td>pH</td>
<td>$7.24 \pm 0.07^*$</td>
<td>$7.25 \pm 0.07^*$</td>
<td>$7.26 \pm 0.07$</td>
<td>$7.26 \pm 0.07$</td>
<td>$7.25 \pm 0.06$</td>
</tr>
<tr>
<td>Base excess (mmol/L)</td>
<td>$-5.3 \pm 3.1^*$</td>
<td>$-5.0 \pm 3.0^*$</td>
<td>$-4.7 \pm 2.9$</td>
<td>$-4.5 \pm 2.9^*$</td>
<td>$-4.4 \pm 2.8^*$</td>
</tr>
<tr>
<td>Oxygen saturation (%)</td>
<td>$19.9 \pm 13.6^*$</td>
<td>$23.1 \pm 14.9^*$</td>
<td>$25.8 \pm 15.4$</td>
<td>$25.8 \pm 15.3$</td>
<td>$26.0 \pm 15.0$</td>
</tr>
<tr>
<td>Fractional oxygen extraction</td>
<td>$0.65 \pm 0.19^*$</td>
<td>$0.62 \pm 0.20^*$</td>
<td>$0.61 \pm 0.20$</td>
<td>$0.61 \pm 0.20$</td>
<td>$0.61 \pm 0.19$</td>
</tr>
</tbody>
</table>

Data presented as mean ± SD; n values shown for vein and then for artery.

*P < .001 versus AGA group adjusting for the confounding effects of mode of delivery, nuchal cord status, maternal hypertension, and maternal diabetes.

†P < .05.

‡P < .01.
Above and Below Certain Values, sample must have come from a specific vessel or was contaminated by air bubbles.

pH values here just cannot be from the artery.

Fig 2. Umbilical vein (closed triangle) and artery (open triangle) pH and base excess values for the birth weight categories as indicated. Statistical significance between groups was determined with the AGA group as reference against the other 4 groups and adjusting for the confounding effects of mode of delivery, nuchal cord status, maternal hypertension, and maternal diabetes.
Above and Below Certain Values, sample must have come from a specific vessel or was contaminated by air bubbles.

Similarly, O2 values above this area cannot come from an uncontaminated arterial sample.

**Fig 1.** Umbilical vein (closed triangle) and artery (open triangle) PO2 and PCO2 values for the birth weight categories as indicated. Statistical significance between groups was determined with the AGA group as reference against the other 4 groups and adjusting for the confounding effects of mode of delivery, nuchal cord status, maternal hypertension, and maternal diabetes.
But What if Those Present in the OR/DR Just Cannot Get Two Samples

1. Irrational, but Human Nature: Fake it…..just send one sample, hope for the best, label it the artery…. then shrug your shoulders when the useless result come back. This won’t work more than once.

2. Rational, but requires intellectual courage: obtain a delayed sample
Accuracy of Delayed Sampling

• Aim of Study: To determine the accuracy of delayed arterial gas sampling

• Methodology: Population: singleton, NSD, C/S, high risk, 30 in each group;

• Method: cord double clamped, then placenta delivered; paired (artery and vein) samples taken within 5 min, then 30, 60, 90 minutes

• Cord and placenta were clamped over the sampling sites

• 23 gauge needles, pre-heparinized syringes, analyzed w/i 15 minutes

• Adrienne L, Philip B: Arch D Child. 2007;92:281-285
Cord Arterial pH changes per delivery group

Note….statistically similar rate of fall of pH for each delivery group irrespective of starting point
Placental Arterial pH Changes Over Time

Figure 3: Placenta arterial pH changes over time for each delivery group. *p = 0.05 when comparing time 0 values for all three groups. NVD, normal vaginal delivery.
Cord Arterial Base Excess Changes Over Time per Each Group

Figure 5. Cord arterial base excess changes over time for each delivery group. *p<0.001 when comparing time 0 values for all three groups. NVD, normal vaginal delivery.
Cord and Placental Arterial Base Excess Changes Over Time

Mean cord vs placenta pH 7.207 vs 7.240; base excess -7 mmol/l vs 6.3 mmol/l; CO2 57.2 mm Hg vs 52.4…….. All differences stat signif

Cord arterial base excess decreased over time (became more negative) and fell at a similar rate to that of the placental arterial base excess
Placental Base Excess Changes Over Time per Each Group

Figure 6. Placenta arterial base excess changes over time for each delivery group. *p=0.001 when comparing time 0 values for all three groups. NVD, normal vaginal delivery.
**The Bottom Line**

**What is already known on this topic**

- The umbilical cord arterial acid-base status is a measure of the condition of the neonate at birth and abnormal findings may indicate the occurrence of an acute intrapartum hypoxic event.
- Blood samples taken for acid-base status remain stable in a plastic syringe for up to 30 min before analysis.

**What this study adds**

- The arterial pH and base excess from a clamped umbilical cord at room temperature is not stable after birth but falls over time. We have provided data to be able to estimate the values at birth with reasonable confidence to enable delayed samples to still be useful clinically.
- The arterial pH and base excess rate of fall over time is similar for all types of deliveries despite differing values at birth.