Umbilical cord blood acid–base analysis

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Introduction

- Fetal assessment with cordocentesis in antepartum, fetal scalp sampling in intrapartum, umbilical cord blood sampling in immediately after birth

- Umbilical cord blood gas levels are believed to be the best representation of the fetal acid–base status immediately before birth compared to fetal heart rate tracing or fetal scalp PH
Fetal acid–base physiology

- The fetus has both aerobic and anaerobic metabolism
- The fetus produces both volatile (carbonic acid) and nonvolatile acids (non carbonic or organic acid)
Carbonic acid

- The fetus produces carbonic acid (H2CO3) during oxidative metabolism (aerobic glycolysis).

- The rate of CO2 production, in turn, is equivalent to fetal oxygen consumption.

- Carbonic acid dissociates to water and CO2, which readily diffuses across the placenta. Diffusion of CO2 across the placenta is facilitated by a lower pCO2 in the mother during pregnancy, secondary to hyperventilation.
Organic acid

- Organic acids result from fetal anaerobic metabolism. Unlike carbonic acid, organic acid are cleared very slowly across the placenta. Metabolic acidemia develops when the primary buffer, bicarbonate (HCO3), as well as other buffers decrease to the critical level.

- The most important organic acids are lactic acid and ketoacids.
Buffers

- The two major buffers are bicarbonate and hemoglobin

- Other buffers: inorganic phosphate, erythrocyte bicarbonate, and albumin

- The placenta also plays a significant role in helping to maintain a bicarbonate pool and buffering the fetus against changes in maternal pH or blood gas status.
**Factor affecting fetal acid-base physiology**

Maternal perfusion of the placenta

- Preeclampsia
- Heart, renal or pulmonary disease
- Chronic HTN, severe anemia, diabetes, hypotension

**Obstetric complication**

- Placental abruption
- Cord prolapse

**Fetal factors**

- GA, infection, anemia, myocardial depression
Indication for fetal acid–base analysis

1. An abnormal fetal heart rate tracing
2. Operative deliveries for suspected fetal compromise
3. A low 5 minute APGAR score
4. All non elective cesareans
5. Sever IUGR
6. Intrapartum fever
7. Multiple pregnancy
8. Maternal thyroid dysfunction
TECHNIQUE

1. Double clamp an umbilical cord segment immediately after birth

2. Obtain a blood sample with a syringe flushed with heparin

3. A paired sampling of the artery and vein may prevent a dispute over the accuracy of arterial sampling

4. If the neonate appears vigorous, then the clamped cord segment can be discarded

5. The cord segment is appropriate for sampling anytime within 60 minutes from birth

1. Blood is appropriate for analysis anytime within 60 minutes from sampling
Time of sampling

- PH decreases 0.05 at 30 min
- PH decreases 0.087 at 60 min
- PH decreases 0.12 at 90 min in clamped cord
# Cord blood normal values

<table>
<thead>
<tr>
<th></th>
<th>Venous cord blood</th>
<th>Arterial cord blood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PH</strong></td>
<td>7.25-7.45</td>
<td>7.18-7.38</td>
</tr>
<tr>
<td><strong>PCO2 (mmHG)</strong></td>
<td>26.8-49.2</td>
<td>32.2-65.8</td>
</tr>
<tr>
<td><strong>PO2 (mmHG)</strong></td>
<td>17.2-40.8</td>
<td>5.6-30.8</td>
</tr>
<tr>
<td><strong>HCO3</strong></td>
<td>15.8-24.2</td>
<td>17-27</td>
</tr>
<tr>
<td><strong>Base Excess</strong></td>
<td>0_ -8</td>
<td>0_ -8</td>
</tr>
</tbody>
</table>
Sampling from artery, vein or both

- Sampling of two vessels is not affordable
- Sampling from both is to ensure that the sample is arterial
- Comparing results of UA and UV can help to distinguish between different causes of acidosis
- PH should be at least 0.02 units and unit less in artery than vein
- PCO2 should be at least 4mmHG higher in the artery
- If reported Pao2 is >31mmHG it is highly likely to be venous sample
- Air bubble in sample: increasing PH & po2, decreasing pco2

- Too much heparin in sample: increasing acidosis due to acidotic properties of heparin
UA sampling with delay cord clamping

- Delayed cord clamping: decreasing PH, BE, HCO₃, increasing lactate & pco₂ (hidden acidosis)
- DCC is not indicated for non-vigorous babies
- Sampling from pulsating UA & UV unclamped cord (with expert staff)
- DCC up to 2 min have no or little effect
Test results

- PH/PCO2/PO2 are measured
- Bicarbonate /O2saturation/ base excess or base deficit are calculated
- The most useful indexes for interpretation of acid base state and prognosis are the PH and BE
Test results

- Risk of low PH(<7): 3.7/1000 live birth
- Majority of newborn with UA PH less than 7 have uncomplicated neonatal course
- In one study: 93 neonate with PH <7
  - 97.8% : no HIE
  - 89.2% : not need CPR
Acidosis

- Acidosis is well tolerated by the fetus without sequelae until it becomes very severe.
- Serious adverse sequelae in the newborn period are unusual with umbilical cord PH greater than 7 or BE less than \(-12\)
- Infant with cord PH above 7, have no adverse effect of acidosis on cognitive function.
Acidosis

- Once severe acidosis is present, the likelihood of adverse sequelae rises sharply with worsening acidosis.
- Goodwin et al found that HIE occurred in:
  - 12% of infants with cord PH < 7
  - 33% with cord PH < 6.9
  - 60% with cord PH < 6.8
  - 80% with cord PH < 6.7
Acidosis

- PH less than 7
- BE more than −12
- PH is not an ideal parameter for estimating the cumulative exposure to hypoxia because it does not give a linear measure of acid accumulation
- BE is better and has more linear relation with degree of hypoxia
Decreased concentration of buffers (e.g., bicarbonate) associated with metabolic acidosis is reported as BD.

BD is helpful for distinguishing whether UA acidosis is metabolic or respiratory.
Base Deficit

- BD equal or more than 12 is threshold for predicting increased risk of moderate to severe complication

- BD 12_16 : 10% risk of moderate to severe complication

- BD >16 : 40% risk of severe complication
Base Deficit

- BD value is impacted by the fetal fluid compartment sample (blood or ECF)
- Choice of algorithm
- Brand of blood gas analyser
Isolated fetal respiratory acidosis

- Decreased PH/increased CO2/NL bicarb
- Short time impairment of utero placental or feto placental circulation
- The time of insult is no more than 20–30 min
- Seldom is associated with adverse outcomes
THIS IS NOT TRUE:

- In mixed acidosis we can estimate PH before acute insult

- For each 10 mmHg increment in pCO2 from normal (neonatal pco2 at birth time :50) PH rises 0.08 unit
Other factors influencing cord

- Prolonged second stage of labor
- Second twin
- Uterine hyper stimulation
- Regional anesthesia: spinal block
Effect of labor

- Normal second stage of labor changed BE 1 mmol/L/hr
- Moderate to severe variable FHR deceleration changed BE 1 mmol/L/30 min
- Late or atypical variable deceleration can change BE 1 mmol/L/6–15 min
- Acute uterine rupture with fetal bradycardia changed BE 1 mmol/L/2–3 min
Chorioamnionitis, with or without funisitis does not appear to influence cord PH.

Although placental infection is associated with cerebral palsy in both term and preterm infants, the mechanism appears to be large independent of hypoxia-ischemia.
Restriction of cord blood flow

- Both UA & UV gases could then be normal despite severe intra partum asphyxia.
- Fetal death with normal cord gases could also occur with fetal cardiac arrest.
- In cases of intrapartum stillbirth and in infants who are in very poor condition at birth and who require considerable resuscitation, normal PH do not exclude acute intrapartum asphyxia.
- A blood gas sample taken from the infant soon after birth would be expected to show marked acidosis if there had been cord obstruction. (reperfusion acidosis)
Restriction of cord blood flow

- If the obstruction to the umbilical vessels was sudden and complete and this persisted until the moment of delivery or until fetal death then the cord gases sampled at birth would give a snapshot of the fetal acid–base balance prior to the obstruction
Short or long lasting hypoxia

- High BD in artery and normal BD in vein: short lasting hypoxia
  
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<thead>
<tr>
<th></th>
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<th>Vein</th>
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<tbody>
<tr>
<td>PH</td>
<td>7.01</td>
<td>7.27</td>
</tr>
<tr>
<td>Co2</td>
<td>8.82</td>
<td>5.14</td>
</tr>
<tr>
<td>BD</td>
<td>12.8</td>
<td>8.0</td>
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- High BD in artery and vein: long lasting hypoxia

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Whereas cord blood analysis provides a static measurement, longitudinal measurement of acid-base status after birth may be useful in prognosis.

Casey et al found that infants in whom acidosis (PH<7.20) persisted 2 h beyond delivery had a poorer outcome than those in whom acidosis had resolved.

Persisting lactic acidosis is associated with severe encephalopathy and may be a reflection of the presence and severity of seizures.
Arterial to venous differences are small where there is impairment of the maternal perfusion of the placenta, such as in cases of abruption.

In a comparative study between infants born after cord prolapse and those born after placental abruption,
Cord blood lactate

- Lactate measured in umbilical cord blood samples is almost entirely fetal in origin.

- Correlate with both PH and BE. Routine assessment of cord blood lactate is not recommended given the poor predictive value of newborn long term outcome.
summary

1. Umbilical cord blood gas analysis is now recommended in all high risk deliveries.
2. Umbilical cord blood gas analysis is assumed to give a picture of the acid base balance at the moment of birth when the cord is clamped.
3. This is a legal protection for intrapartum asphyxia.
summary

- Test results:
  - Normal
  - Acidosis:
    - respiratory acidosis
    - mixed acidosis
    - metabolic acidosis
- PH less than 7 & BE greater than 12 are important
- BE is very important but in acidotic setting