Umbilical-Cord Blood Gas Analysis in Obstetrical Practice

Webinar - Wednesday, July 1, 2015

Jan Stener Jørgensen, MD, PhD
Head of Obstetrics
Professor of Clinical Obstetrics
Odense University Hospital
University of Southern Denmark
Umbilical-Cord Blood Gas Analysis
- A reliable method to describe fetal oxygenation
- and possible birth asphyxia
Fetal asphyxia

- Asphyxia (from Greek) means no “pulse”

- Usual definition: insufficient oxygen ($O_2$) supply/uptake and insufficient carbondioxide ($CO_2$) exchange.

- This definition is less useful in daily clinical life, as fetal $pO_2$ is always low in the interuterine life and during labour
Fetal asphyxia

– Accordingly, better described and defined by

• Apgar scores

• Fetal acid-base status at birth
  - Umbilical-Cord Blood Gas Analysis
At the end of the day it is all about the presence or absence of oxygen (O2)
Who discovered oxygen first?

"Hard-luck Scheele" made a number of chemical discoveries - before others who are generally given the credit for it.
... but here is where fetal surveillance started...
Intrapartum fetal surveillance

- **1821** First auscultation of FHR
  - Kergaradec, Geneve

- **1833** Observations on obstetric auscultation
  - Kennedy, Dublin

- **1897** Spasticity might arise in fetal life
  - Freud, Wien
Intrapartum fetal surveillance

- **1906** First fetal ECG
  - *Cremer, Germany*

- **1908** First fetal phonocardiogram
  - *Hoffbauer Weiss, Germany*

- **1958** CTG / EFM
  - *Hon, USA*

- **1958** First Umbilical Cord Blood Gas Analysis
  - *James, USA (N.Z.)*
THE ACID-BASE STATUS OF HUMAN INFANTS IN RELATION TO BIRTH ASPHYXIA AND THE ONSET OF RESPIRATION

L. S. James, M.B. (N.Z.), I. M. Weisbrot, M.D.,* C. E. Prince, M.D.,**
D. A. Holaday, M.D., and V. Apgar, M.D.
New York, N. Y.
Intrapartum fetal surveillance

• 1961 scalp-pH  *Saling, Berlin*

• 1968 scalp-lactate  *Monti, Milan*

• 1974 continuous tissue-pH  *Stamm, Lausanne*

• 1978 transcutaneous pO₂ and pCO₂  *Huch, Marburg*
Clinical purpose of cord blood gas analysis

- Determine neonatal acid-base status at birth for the detection of birth asphyxia
- Possible assessment tool to document quality of care within obstetrical units
- Documentation of neonatal acid base status at birth in case of litigation towards obstetricians, midwives or obstetrical departments

Facts & figures

Globally, 4 - 9 million neonates suffer from asphyxia each year [1]

1.2 million neonates die from birth asphyxia and about the same number develop severe disabilities [1]

29% of global neonatal deaths are caused by birth asphyxia [1]

Umbilical-Cord Blood Gas Analysis (UCBGA) provides important information about the past, present and – to some degree – future condition of the newborn infant.

Now recommended in all high-risk deliveries by both ACOG and RCOG.

In many countries, like in Denmark, and in many centres UCBGA is now a routine procedure following all deliveries.
• **UCBGA** is of increasing clinical importance, and in many countries (like in the US and UK) also of medicolegal importance

Clinicians should be familiar with:

• the background to interpret the blood gas values
• the practice to obtain the samples
Clinicians should be familiar with:

- Maternal – fetal gas exchange
- Development of asphyxia
- Normal and pathological values of cord blood gases
- Factors influencing the blood gases
- Evaluation and interpretation of fetal acidosis
Clinicians should be familiar with:

- Respiratory acidosis and metabolic acidosis
- Significance of different combinations of acidosis and Apgar scores
- Factors influencing the umbilical cord blood gases
- Arterio-venous differences and their significance
Clinicians should be familiar with:

- Different prognostic features
- Sampling procedures
- Storage
Placental anatomy and physiology

Cord *artery* blood reflects fetal acid-base status whereas the *vein blood* reflects the oxygen (and nutritional) supply form the placenta.

Preferably parameters derived from both cord *artery* and *vein blood* are used to assess neonatal condition at delivery.

One large cord *vein* carries oxygenated blood and nutrient to the fetus.

Two small cord *arteries* carry deoxygenated blood and waste products (CO2) from the fetus.
Understanding gas exchange during labour

- Adequate supply of oxygenated maternal blood reaching placenta
- Gas exchange across placenta
- Supply of oxygenated blood to fetus through open umbilical vein
- Sufficient metabolic reserve in fetus to withstand “hypoxic effect” of uterine contractions

Brain damage
- Long-term neurological disorders – cerebral palsy
- Neonatal death

Impairment may lead to risk of birth asphyxia
What can cause foetal hypoxia/asphyxia:

<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal hypotension</td>
<td>Utero-placental flow ↑</td>
</tr>
<tr>
<td>- supine position, anaesthesia,</td>
<td></td>
</tr>
<tr>
<td>vasodilation (epidural)</td>
<td></td>
</tr>
<tr>
<td>Maternal hypoventilation</td>
<td>Maternal $pO_2$ / $SO_2$ ↓</td>
</tr>
<tr>
<td>- apnoe /eclampsia</td>
<td></td>
</tr>
<tr>
<td>Maternal cathecolamines ↑</td>
<td>Utero-placental flow ↓</td>
</tr>
<tr>
<td>(adrenalin)</td>
<td>(from animal experiments)</td>
</tr>
<tr>
<td>fear, pain, stress</td>
<td></td>
</tr>
</tbody>
</table>
What can cause foetal hypoxia/asphyxia:

**Cause:**

- Uterine hypertonia
  - hyperstimulation
  - overefficient uterine activity

- Cord compression
  - oligohydramnios, (maternal) position, breech, cord entanglement, nuchal cord prolapse

- Placental abruption / insufficiency

**Effect:**

- Utero-placental flow ↓

- Foeto-placental flow ↓
  - decreased/blocked O₂/CO₂ exchange
Cord entanglement, a knot – or rather ”a tie”

Protective amniotic (sac) fluid
Asphyxia during labour $pO_2$
Asphyxia during labour pCO$_2$
Asphyxia during labour pH
Asphyxia during labour SBE, lactate
Asphyxia during labour

- Pre-acidotic
- Respiratory acidosis
- Metabolic acidosis

Parameters:
- pO2
- pCO2
- SBE
- Lactat
- pH

Stages:
- Normal
- Stress
- Distress
Aerobic metabolism

O₂ → Glucogène → Energy (38 ATP) → H₂O, CO₂ → Activity → Growth
Glucogene → Lactate
Glucogene → Energy
Energy → 2 ATP
2 ATP → Basal Activity
Fetal physiology during labour

Pre-acidotic period

- Increasing oxygen utilisation (Bohr effect)
- Decreasing activity
### Fetal physiology during labour – preacidotic period

#### Blodgas-værdier

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.282</td>
<td></td>
</tr>
<tr>
<td>$pCO_2$</td>
<td>5.85</td>
<td>kPa</td>
</tr>
<tr>
<td>$pO_2$</td>
<td>3.97</td>
<td>kPa</td>
</tr>
</tbody>
</table>

#### Syre-Base-status

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>cHCO$_3$(P)$_c$</td>
<td>20.0</td>
<td>mmol/L</td>
</tr>
<tr>
<td>cHCO$_3$(P)$_c$</td>
<td>21.4</td>
<td>mmol/L</td>
</tr>
<tr>
<td>ABE$_c$</td>
<td>-6.1</td>
<td>mmol/L</td>
</tr>
<tr>
<td>SBE$_c$</td>
<td>-5.5</td>
<td>mmol/L</td>
</tr>
<tr>
<td>cHCO$_3$(P, st)$_c$</td>
<td>18.7</td>
<td>mmol/L</td>
</tr>
</tbody>
</table>

#### Oximetri-værdier

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>cHb</td>
<td>8.6</td>
</tr>
<tr>
<td>FO$_2$Hb</td>
<td>0.598</td>
</tr>
<tr>
<td>FMetHb</td>
<td>0.008</td>
</tr>
<tr>
<td>FCO$_2$Hb</td>
<td>0.008</td>
</tr>
<tr>
<td>$sO_2$</td>
<td>0.608</td>
</tr>
</tbody>
</table>

#### Elektrolyt-værdier

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>cK$^+$</td>
<td>4.4</td>
</tr>
<tr>
<td>cNa$^+$</td>
<td>134</td>
</tr>
<tr>
<td>cCa$^{2+}$</td>
<td>1.47</td>
</tr>
</tbody>
</table>

#### Beregnede værdier

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>cCa$^{2+}(7.4)_c$</td>
<td>1.38</td>
</tr>
</tbody>
</table>

#### Metabolit-værdier

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>cLac</td>
<td>3.5</td>
</tr>
</tbody>
</table>

#### Noter

Advarsel: Der er detekteret og korrigeret for HbF

Udskrevet: 16:21 2002-09-19
Fetal physiology during labour

Respiratory (hypercapnic) acidosis

- release of stress hormones
- redistribution of foetal blood flow
- anaerobic metabolism in peripheral tissue
Fetal physiology during labour - Respiratory acidosis

<table>
<thead>
<tr>
<th>Blodgas-værdier</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7,16</td>
<td></td>
</tr>
<tr>
<td>pCO₂</td>
<td>9,20 kPa</td>
<td></td>
</tr>
<tr>
<td>pO₂</td>
<td>0,14 kPa</td>
<td></td>
</tr>
<tr>
<td>Syre-Base-status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cHCO₃⁻ (P)</td>
<td>21,3 mmol/L</td>
<td></td>
</tr>
<tr>
<td>ctCO₂(P)</td>
<td>23,4 mmol/L</td>
<td></td>
</tr>
<tr>
<td>ABEc</td>
<td>-10,5 mmol/L</td>
<td></td>
</tr>
<tr>
<td>SBEc</td>
<td>-6,8 mmol/L</td>
<td></td>
</tr>
<tr>
<td>cHCO₃⁻ (P,st)</td>
<td>14,4 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Oximetri-værdier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cHb</td>
<td>11,1 mmol/L</td>
<td></td>
</tr>
<tr>
<td>FO₂Hb</td>
<td>0,035 mmol/L</td>
<td></td>
</tr>
<tr>
<td>FMetHb</td>
<td>0,012 mmol/L</td>
<td></td>
</tr>
<tr>
<td>FCOHb</td>
<td>0,003 mmol/L</td>
<td></td>
</tr>
<tr>
<td>sO₂</td>
<td>0,036 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Elektrolyt-værdier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cK⁺</td>
<td>4,3 mmol/L</td>
<td></td>
</tr>
<tr>
<td>cNa⁺</td>
<td>134 mmol/L</td>
<td></td>
</tr>
<tr>
<td>cCa²⁺</td>
<td>1,55 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Beregnede værdier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cCa²⁺(7,4)</td>
<td>1,31 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Metabolit-værdier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cLac</td>
<td>11,0 mmol/L</td>
<td></td>
</tr>
</tbody>
</table>

Noter
- Ca (7,4) kan ikke benyttes

Udskrevet 21:20 2003-03-09
Metabolic acidosis

- anaerobic metabolism in vital organs
- risk of heart and brain failure
Fetal physiology during labour - metabolic acidosis

Blood gas values:
- **pH**: 6.904
- **pCO₂**: 13.5 kPa
- **pO₂**: 0.01 kPa

Base status:
- **cHCO₃(P)c**: 19.0 mmol/L
- **ctCO₂(P)c**: 22.1 mmol/L
- **ABE_c**: -19.8 mmol/L
- **SBE_c**: -12.4 mmol/L
- **cHCO₃(P,st)c**: 9.5 mmol/L

Oximetry values:
- **ctHb**: 10.9 mmol/L
- **FO₂Hb**: 0.018
- **FMetHb**: 0.013
- **FCOHb**: 0.011
- **sO₂**: 0.018

Electrolyte values:
- **cK⁺**: 6.1 mmol/L
- **cNa⁺**: 135 mmol/L
- **cCa⁴⁺**: 1.66 mmol/L

Calculated values:
- **cCa⁴⁺ (7.4)c**: 1.22 mmol/L

Metabolite value:
- **cLac**: 15 mmol/L
Normal and pathological values of cord blood gasses

Table 1  Studies reporting umbilical cord values for term and preterm infants

<table>
<thead>
<tr>
<th>Author</th>
<th>pH</th>
<th>Base excess (mmol/l)</th>
<th>Pco2 (kPa)</th>
<th>P02 (kPa)</th>
<th>pH</th>
<th>Base excess (mmol/l)</th>
<th>Pco2 (kPa)</th>
<th>P02 (kPa)</th>
<th>Number</th>
<th>Population studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vity et al 2004</td>
<td>7.24</td>
<td>-5.6 (3.0)</td>
<td>7.05 (1.33)</td>
<td>2.26 (0.8)</td>
<td>7.33</td>
<td>-4.5 (2.4)</td>
<td>5.45 (0.93)</td>
<td>3.86 (0.93)</td>
<td>20456</td>
<td>Term non-anomalous singletons</td>
</tr>
<tr>
<td>Helwig et al 1996</td>
<td>7.26</td>
<td>-4.0 (3.0)</td>
<td>7.49 (1.44)</td>
<td>2.33 (0.92)</td>
<td>7.34</td>
<td>-3.0 (3.0)</td>
<td>5.45 (0.93)</td>
<td>3.80 (0.97)</td>
<td>15073</td>
<td>All gestations, all delivery types, Apgar &gt;7</td>
</tr>
<tr>
<td>Thorp et al 1989</td>
<td>7.24</td>
<td>-3.6 (2.7)</td>
<td>6.69 (1.48)</td>
<td>2.45 (1.09)</td>
<td>7.32</td>
<td>-2.9 (2.4)</td>
<td>5.41 (1.05)</td>
<td>3.79 (1.02)</td>
<td>1694a1820v</td>
<td>Term, nullipara, SOL, all delivery types</td>
</tr>
<tr>
<td>Riley and Johnson 1993</td>
<td>7.27</td>
<td>-2.7 (2.8)</td>
<td>7.05 (1.33)</td>
<td>2.53 (1.05)</td>
<td>7.33</td>
<td>-2.6 (2.5)</td>
<td>5.77 (1.1)</td>
<td>3.88 (1.29)</td>
<td>1393a1526v</td>
<td>Term singleton infants, vaginal delivery</td>
</tr>
<tr>
<td>Dickinson et al 1992</td>
<td>7.26</td>
<td>-3.2 (2.9)</td>
<td>7.05 (1.33)</td>
<td>2.53 (1.05)</td>
<td>7.33</td>
<td>-2.6 (2.5)</td>
<td>5.77 (1.1)</td>
<td>3.88 (1.29)</td>
<td>1393a1526v</td>
<td>Term singleton infants, vaginal delivery</td>
</tr>
</tbody>
</table>

Data are presented as mean (SD). Arterial (a) and venous (v) sample numbers are given separately where available. CTG, cardiotocogram; SOL, spontaneous onset of labour; SVD, spontaneous vertex delivery.

Umbilical artery
- pH: 7.24-7.27
- BE (mmol/l): -2.7 - -5.6
- pCO2 (kPa): 6.69-7.49
- pO2: 2.26-2.45

Umbilical vein
- pH: 7.32-7.34
- BE (mmol/l): -2.4 - -4.5
- pCO2 (kPa): 5.54 – 5.83
- pO2: 3.79 – 3.88
... values in mm Hg, Lactate - and human adult values for comparison

Table I. Median ranges for umbilical cord blood gas, base excess and lactate values [8].

<table>
<thead>
<tr>
<th></th>
<th>Umbilical Artery (n =12,345)</th>
<th>Umbilical Vein (n =12,345)</th>
<th>Adult artery (non-cord) blood values (for comparison only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH median</td>
<td>7.27</td>
<td>7.35</td>
<td>7.40</td>
</tr>
<tr>
<td>$pO_2$ median (kPa)</td>
<td>2.2</td>
<td>3.7</td>
<td>12.0</td>
</tr>
<tr>
<td>$pO_2$ median (mm Hg)</td>
<td>16.3</td>
<td>27.9</td>
<td>90</td>
</tr>
<tr>
<td>$pCO_2$ median (kPa)</td>
<td>7.3</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td>$pCO_2$ median (mmHg)</td>
<td>55.1</td>
<td>40.4</td>
<td>40</td>
</tr>
<tr>
<td>Base excess (mmol/L)</td>
<td>-3.00</td>
<td>-3.00</td>
<td>0</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>3.7</td>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

Factors influencing the UC blood gases

- Mode of delivery
- Gestational age
- Parity
- Fetal presentation (Breech)
- Cord entanglement
- Oligohydramnios
- Multiple pregnancies
- Regional anesthesia
- (Fever – chorionamnitis)
Umbilical cord blood gas analysis at delivery: a time for quality data

Jennifer Westgate Lecturer/Honorary Senior Registrar, Jonathan M. Garibaldi Research Assistant, Keith R. Greene Consultant/Honorary Senior Lecturer

Perinatal Research Group, Postgraduate Medical School, Department of Obstetrics, Derriford Hospital, Plymouth

Conclusions Both artery and vein cord samples must be taken and the results screened to ensure separate vessels have been sampled. Interpretation of the results requires the examination of PCO$_2$ and base deficit of the extracellular fluid from each vessel as well as the pH. Confusion about the value of cord gas measurements may be due to the use of erroneous data and inadequate definitions of acidosis which do not differentiate between respiratory and metabolic components.
Verifying that both cord artery - and vein sample was obtained

Blood from both cord artery and cord vein should preferably be collected and analyzed

To validate that a sample form cord artery has truly been obtained:

- Arterio-venous (A-V) differences for:
  - pH > 0.02
  - pCO$_2$ > 0.5 kPa/3.75 mmHg

Insight into cause of acid-base disturbance

Interpretation of low and high A-V differences – in relation to acidosis and aphyxia

• A wide difference between umbilical artery and vein blood gas values is often due to an obstructed cord as for instance ”nuchal cord” (Martin)

• A small difference is most likely caused by impairment of maternal perfusion of the placenta as in case of placental abruption (Johnson)

• When UcA-pH < 7.0 : The magnitude of A-V difference in pCO2 is directly correlated to the risk of developing HIE (Belai)
For prognostic value -

- It is of outmost importance to sample both arterial and venous blood for bloodgasses – when the newborn is depressed, as...

  - normal UcV blood gasses in the case of an obstructed umbilical cord

  - could "hide" a severe acidosis with a high risk of an adverse outcome

Interpretation of low and high A-V differences – in relation to acidosis and aphyxia
Normal Cord Blood pH (both artery and vein) at birth does not entirely exclude acute intrapartum asphyxia:

- Sudden an total obstruction of cord vessels
- Sudden fetal cardiac arrest
- In these cases blood gasses taken post partum would reveal severe acidosis
What is severe fetal acidosis?

Most authors agree on pH < 7.0 as severe acidosis.

Prevalence: 0.4 – 1 %

Low pH in combination with other abnormal clinical patterns (e.g. cardio-pulmonary) is associated with high risk of poor long-term outcome.

This also counts for pathological intrapartum findings.
<table>
<thead>
<tr>
<th></th>
<th>Seizures</th>
<th>No Seizures</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.84 ± 0.12</td>
<td>6.89 ± 0.11</td>
<td>NS</td>
</tr>
<tr>
<td>BD</td>
<td>-18.1 ± 9.1</td>
<td>-16.6 ± 6.1</td>
<td>NS</td>
</tr>
<tr>
<td>Baseline FHR</td>
<td>143 ± 11</td>
<td>146 ± 16</td>
<td>NS</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>56%</td>
<td>84%</td>
<td>'0.06'</td>
</tr>
<tr>
<td>Decelerations</td>
<td>36, 32%</td>
<td>50, 52%</td>
<td>NS</td>
</tr>
<tr>
<td>Accelerations</td>
<td>24%</td>
<td>48%</td>
<td>NS</td>
</tr>
<tr>
<td>Min/absent variab.</td>
<td>64%</td>
<td>36%</td>
<td>'0.08'</td>
</tr>
<tr>
<td>Duration abnormal</td>
<td>72 ± 12 min</td>
<td>36 ± 18 min</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Low pH - but normal Apgar scores:

• Short period of acidosis (most likely respiratory)
• Fair prognosis
Normal pH - but low Apgar scores:

- Chronically sick child
  - no hypoxia during the last part of the delivery
- Earlier condition of e.g. hypoxia, infection, malformation or prematurity
- Prognosis - depending on the cause
• Significance of different combinations of acidosis and Apgar scores

Low Apgar scores - and low pH:

• Severe asphyxia - of a certain duration
  - during labour
  (most likely metabolic acidosis)

• Prognosis: pH – but also BE (lactate)
  is of prognostic importance
pH is no ideal measure for cumulative exposure to acidosis due to anaerobic metabolism

- pH is logarithmic (not linear) - directly correlated to pCO2 accumulation
- Base excess provides a more linear measure of the accumulation of metabolic acid
  - adjusted for pCO2
• Sampling procedures
• Storage
The cord blood sampling should be performed by *either* method 1 *or* method 2:

**Method 1:**
The cord blood sample must be collected immediately and within one minute after delivery of the neonate.

So, the blood is collected before the placenta is delivered and before the cord is clamped and separated from the neonate [27]

**Method 2:**
A segment of the cord must be isolated immediately and within one minute after delivery of the neonate.

When the cord and placenta are separated from the neonate, the cord segment is placed on the delivery table.

The cord blood sample must be collected within 60 minutes after delivery [27-29]

For method 1 and 2 the collection should be performed as follows:
For method 1 and 2 the collection should be performed as follows:

Collect the cord artery sample first. Push the plunger down as far as it can go. Insert the cannula parallel to the artery; pull the plunger for collection of the cord artery blood sample.

Then collect the cord vein sample. Push the plunger down as far as it can go. Insert the cannula parallel to the vein; pull the plunger for collection of the cord vein blood sample.
Delayed cord clamping

In recent years there has been increasing acceptance of delaying the cord clamping procedure by 2-3 minutes after delivery for the benefit of placental blood transfusion (extra blood volume) to the neonate [39].

A recent Cochrane review of studies in this area concluded that the benefit to the neonate associated with delayed cord clamping (higher birth weight, increased hemoglobin concentration and iron reserves) outweighs the increased risk of jaundice. It states that a more liberal approach to delayed cord clamping is warranted [39]. The policy of delayed cord clamping clearly poses a potential problem for accurate assessment of neonatal acid-base status at the moment of delivery, because of the “hidden acidosis” phenomenon (see section

A solution to this problem has been validated by the results of two recent clinical studies [30, 40]. The solution, which is standard practice in some units, is to sample blood directly from the still pulsating unclamped umbilical cord, at the moment of delivery, rather than from a separated clamped cord segment. This way there is no risk of “hidden acidosis” and the neonate can take advantage of the delayed clamping.
Storage

- Double-clamped (10 cm) piece of cord
  - or in syringe

- On ice – for up to 60 minutes
Asphyxia - prognosis

- Apgar score - by it self - has a poor prognostic value

- Both the Apgar score - as well as pH / BE - should be used to more precisely predict the prognosis at birth
Asphyxia – prognosis
Does pH correlate to long term outcome?

Strength of association between umbilical cord pH and perinatal and long term outcomes: systematic review and meta-analysis

Gemma L Malin, clinical research fellow,1 Rachel K Morris, clinical research fellow,1 Khalid S Khan, professor of obstetrics, gynaecology, and clinical epidemiology1 2

Cite this as: BMJ 2010;340:c1471
### No of true positives or true negatives/No with event

<table>
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**Subgroup meta-analysis**

- **High risk population (11 studies)**: 3959
  - Test for heterogeneity: $I^2=35.1\%$, $P=0.118$
- **Unselected population (4 studies)**: 466 406
  - Test for heterogeneity: $I^2=0.0\%$, $P=0.985$
- **High quality studies (7 studies)**: 2946
  - Test for heterogeneity: $I^2=10.0\%$, $P=0.278$
- **Low or medium quality studies (8 studies)**: 466 419
  - Test for heterogeneity: $I^2=71.7\%$, $P=0.001$
- Overall: $I^2=61.0\%$, Harbord: no small study effects, $P=0.111$

**Fig 2** Association of low arterial cord pH with neonatal mortality. EPI=estimated predictive interval
Association of low arterial cord pH - with neonatal morbidity
Association of low arterial cord pH with cerebral palsy

<table>
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<th>Study</th>
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Test for heterogeneity: $I^2=0.0\%, P=0.777$
**WHAT IS ALREADY KNOWN ON THIS TOPIC**

Umbilical cord pH at birth is frequently used to measure perinatal asphyxia.

Neonatal and childhood mortality and morbidity, including cerebral palsy, are often attributed to fetal acidosis, as defined by a low cord pH at birth.

Existing reports of the association between cord pH and adverse outcome are conflicting.

**WHAT THIS STUDY ADDS**

Low cord pH is substantially associated with neonatal mortality and morbidity and cerebral palsy in childhood.

These outcomes justify the increased surveillance of infants born with a low cord pH.

Further research is, however, needed to explore the cost effectiveness of doing this test in all neonates.

### Conclusions and practice implications

Cord pH is currently assessed in infants believed to be at high risk for neonatal asphyxia. Our results suggest, however, that the strength of association with cord pH and outcome is not limited to this high risk population. Therefore future research should assess the use of cord pH across neonatal populations, particularly exploring the cost effectiveness of testing all neonates.
Conclusions and practice implications

Cord pH is currently assessed in infants believed to be at high risk for neonatal asphyxia. Our results suggest, however, that the strength of association with cord pH and outcome is not limited to this high risk population. Therefore future research should assess the use of cord pH across neonatal populations, particularly exploring the cost effectiveness of testing all neonates.
Intrapartum fetal surveillance

- **CTG/EFM:**
  - Introduced world-wide after 1970 without proper evidence
    - Intention and expectation was to get rid of CP due to intrapartum asphyxia
    - Low specificity causing high CS-rate
    - FBS was introduced meanwhile, and was found to increase the specificity
History of Biochemical Monitoring of the Fetus During Labor

Archiv für Gynäkologie 197, 108—122 (1962)

Aus der Städtischen Frauenklinik und Hebammenlehranstalt Berlin-Neukölln (Ärztlicher Direktor: Dr. E. Jung)

Neues Vorgehen zur Untersuchung des Kindes unter der Geburt*
Einführung, Technik und Grundlagen

Von
Erich Saling
Mit 7 Textabbildungen
(Eingegangen am 10. April 1961)
Fetal Scalp Sampling (FBS)

FIG. 1.—Amnioscopy. Inset shows introduction of the instrument. Below, the instrument in place with the obturator withdrawn.
FBS
NB: suction by mouth

Fig. 2.—Foetal blood sampling. The presenting part has been pricked, and a drop of blood is about to be sucked into a heparinized tube, held in special forceps.
Normal values:

Scalp-pH is slowly decreasing during normal labour, with values between 7.45 og 7.25 (Weber 79)

No upper limits of normal scalp-pH have been described
Scalp-blood sampling
FBS (pH)

pH decrease during normal labour:
(Weber 79)

- I. stage: 0.016 pH unit per hour
- II. stage: 0.11 pH unit per hour
Scalp-blood sampling
FBS (pH)

- By **anoxia** (no oxygen supply at all)
  - e.g. total umbilical cord compression

- pH drops by **0.04 pH unit per min**!
  - e.g. from 7.20 ⇒ 6.80 in 10 minutes

*(Myers 72)*
Scalp-pH – Intrauterine rescuscitation

- pH < 7.20

  - Incipient acidosis
    Risk of developing asphyxia

  - Consider intrauterine rescuscitation (tocolysis)

  - Continue CTG in theatre, if improvement after IUR – avoid general anaesthesia

  - Deliver the baby
Scalp-pH – Acidosis - Hypoxia

- **Hypoxia** ⇒ **Acidosis**
  - $\text{CO}_2$ accumulation
  - Anaerobic metabolism, accumulation of lactate

- Low scalp-pH ⇒ low cord-pH

- Hence, scalp-pH can predict fetal acidosis
Scalp-blood sampling
FBS (pH)

• Low pH is connected with fetal hypoxia

but

• So far, no single study has proven better neonatal outcome, nor decreased incidence of cerebral palsy - by the use of scalp-pH

“…..the pan-galactical trial”
• Special conditions to consider:
  – Prematurity (< 34 weeks)
  – Chorionamnitis
• Conclusion:
  
  – scalp-pH in comb. with CTG is the mainstay
  
  – at present no other (and for sure - no better) supplement with CTG
Fetal scalp and umbilical artery blood lactate measured with a new test strip method

L. NORDSTRÖM
B. PERSSSON
Associate Professor
St. Görans Pediatric Hospital
Karolinska Institutet, Sweden

ABSTRACT
Objective  To compare the measurement of lactate in fetal scalp and umbilical artery blood by a new dry reagent strip method with a commercially available enzymatic method using plasma (Monotest).
Design    Comparative study.
Umbilical cord blood lactate: A valuable tool in the assessment of fetal metabolic acidosis

Anne Cathrine Gjerris a,*, Jette Stær-Jensen a, Jan Stener Jørgensen b, Thomas Bergholt a, Carsten Nickelsen a

a Department of Obstetrics and Gynaecology, Hvidovre University Hospital, 2100 Copenhagen, Denmark
b Department of Obstetrics and Gynaecology, Odense University Hospital, Odense, Denmark

umbilical cord arterial blood samples from 2554 singleton deliveries

Conclusion: Lactate in arterial umbilical cord blood might be a more direct and accordingly more correct indicator of fetal asphyxia at delivery than pH and SBE (or ABE). Its potential as a predictor of neonatal outcome needs to be evaluated in future studies.
• UCBGA is recommended in high-risk deliveries, but ought to be after ALL deliveries – since early intervention can be considered (e.g. cooling)

• Optimal interpretation only when both art. and ven. samples are obtained - after immediate double clamping of segment of umbilical cord.

• Low pH in vigourous newborns has a fair prognosis, - whereas non-vigourous newborns with pH<7.0 are at high risk of HIE

• SR+MA: Even in low risk populations, low pH is substantially associated with neonatal morbidity and mortality - and later cerebral palsy

• Scalp-pH (FBS) is gold standard in conjunction with CTG as monitor of fetal wellbeing during labour

• Lactate in both FBS and in UCBGA may be the future

• Most important take home messages