Umbilical cord blood erythroblast count as an index of intrauterine hypoxia

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Abstract
The relation of umbilical cord blood arterial pH, Apgar score, leucocyte count, and erythroblast count at delivery with the diagnosis of fetal distress in labour was studied prospectively in three groups of singleton pregnancies delivering at term vaginally (55 infants), by elective caesarean section (39 infants), or by emergency caesarean section for abnormal intrapartum fetal heart rate patterns (55 infants). In the emergency caesarean section group the umbilical cord blood arterial pH was significantly lower and the leucocyte and erythroblast counts were higher than in the elective caesarean section group. Comparison of the emergency caesarean section and spontaneous vaginal delivery groups showed significant differences for pH and erythroblast count, but not for leucocyte count. In the spontaneous vaginal delivery group erythroblastosis was associated with umbilical cord blood pH, whereas leucocytosis was associated with the length of labour. The five minute Apgar score was >7 in all infants. This study suggests that leucocytosis is a non-specific response of the fetus to labour, whereas erythroblastosis reflects fetal tissue hypoxia.

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Labour is associated with an increase in the number of erythroblasts and leucocytes in umbilical cord blood.1,2 Antenatal studies of pregnancies complicated by severe intrauterine growth retardation and red blood cell isomunisation have suggested that erythroblastosis may be the consequence of fetal tissue hypoxia.3–5 In contrast, the fetal leucocyte count in these disorders is decreased.6,7 The aim of this study is to investigate whether the erythroblastosis and leucocytosis associated with labour are the consequence of intrauterine fetal tissue hypoxia or a non-specific response to labour.

Patients and methods
Three groups of singleton pregnancies delivering at term were examined: (a) those delivered by elective caesarean section (39 infants) for reasons such as breech presentation, previous caesarean section, placenta previa, or unstable fetal lie; (b) those delivered by emergency caesarean section (55 infants) for presumed fetal distress because of abnormal intrapartum fetal heart rate patterns (baseline tachycardia or bradycardia and non-reactive decelerative pattern) with or without fetal scalp blood sampling; and (c) spontaneous vaginal deliveries after induced or spontaneous onset of labour. Data on the former two groups were collected over a three month period. Subsequently, data were collected from 55 consecutive spontaneous vaginal deliveries to examine the effect of labour on the measured variables.

At delivery the umbilical cord was double clamped and umbilical arterial blood was collected into heparinised syringes for the measurement of pH (Radiometer ABL 330, Copenhagen, Denmark). Cord blood was also collected into isotonic edetic acid solution and the total nucleated cell count was determined with a Coulter stacker automated cytometer (Coulter Electronics, Luton). Blood films were stained by the May–Grüwald-Giemsa method and the number of erythroblasts per 100 leucocytes was counted. The absolute erythroblast count (×10⁹/l) was calculated.

STATISTICAL ANALYSIS
Mann-Whitney U tests were used to determine the significance of any differences in data between the various groups of infants. In the spontaneous vaginal delivery group linear regression analysis was used to determine the significance of any associations between blood pH, leucocyte count, and erythroblast count and the duration of labour. Multiple regression analysis was used to determine the contribution

<table>
<thead>
<tr>
<th>Gestational age (weeks)</th>
<th>ELCS (n=39)</th>
<th>SVD (n=55)</th>
<th>EMCS (n=55)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>38 (37–41.3)</td>
<td>36–43 (36–43)</td>
<td>36–43 (36–43)</td>
<td>ELCS: SVD: p&lt;0.01</td>
<td>ELCS: EMCS: p=0.001</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3320 (2460–4160)</td>
<td>3400 (2100–4700)</td>
<td>3410 (1980–5160)</td>
<td>No significant difference</td>
</tr>
<tr>
<td>Length of labour (hours)</td>
<td>7.26 (7.08–7.37)</td>
<td>7.26 (7.00–7.38)</td>
<td>7.22 (6.91–7.40)</td>
<td>ELCS: SVD: p&lt;0.01</td>
</tr>
<tr>
<td>Umbilical cord blood arterial pH</td>
<td>0.30 (0.00–0.49)</td>
<td>0.75 (0.00–0.5)</td>
<td>1.00 (0.00–0.15)</td>
<td>ELCS: SVD: p&lt;0.01</td>
</tr>
<tr>
<td>Erythroblast count (×10⁹/l)</td>
<td>10.6 (6.2–17.7)</td>
<td>13.8 (7.25–48.0)</td>
<td>13.5 (4.2–40.3)</td>
<td>SVD: EMCS: p=0.001</td>
</tr>
<tr>
<td>Leucocyte count (×10⁹/l)</td>
<td>ELCS: SVD: p&lt;0.01</td>
<td>ELCS: EMCS: p&lt;0.01</td>
<td>ELCS: SVD: p&lt;0.01</td>
<td>ELCS: EMCS: p&lt;0.01</td>
</tr>
</tbody>
</table>
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Results

Gestational age, birth weight, duration of labour (time interval between the onset of painful regular uterine contractions and delivery), umbilical cord blood arterial pH, leucocyte count, and erythroblast count in the three groups of infants are shown in the table and fig 1. In all instances the five minute Apgar score was ≥7. In the groups experiencing labour (spontaneous vaginal delivery and emergency caesarean section) the leucocyte and erythroblast counts were significantly higher than in the non-labour (elective caesarean section) group, but umbilical cord blood pH was significantly decreased only in the emergency caesarean section group (table).

In the spontaneous vaginal delivery group there were significant associations between cord blood leucocyte count and the duration of labour (fig 2: r=0.309; p<0.05) and between the erythroblast count and umbilical cord blood pH (fig 3: r=−0.543; p<0.0001). There was no significant association between the duration of labour and either the erythroblast count (r=0.143) or umbilical cord blood pH (r=−0.229), or between the leucocyte count and umbilical cord blood pH (r=−0.208).

In the total population umbilical cord blood pH was significantly associated with erythroblast (r=−0.401; p<0.0001) and leucocyte counts (r=−0.273; p<0.001). Multiple regression analysis, however, showed that after correcting for the presence or absence of labour only the erythroblast count contributed significantly in explaining the variance in umbilical cord blood pH (erythroblast count: r=−0.011, SE=0.003, t=−3.38, p<0.001; leucocyte count: r=−0.001, SE=0.001, t=−0.53; leucocyte count: r=−0.002, SE=0.002, t=−1.32).

Discussion

The finding of this prospective study that labour is associated with fetal leucocytosis and erythroblastosis is compatible with previously published data. Although the leucocyte
count was higher in the pregnancies with in- 
partum fetal distress necessitating emergency 
caesarean section than in those delivered by 
elective caesarean section, there was no signifi-
cant difference between the emergency 
caesarean section and spontaneous vaginal 
delivery groups. Furthermore, in the sponta-
taneous vaginal delivery group the degree of 
leucocytosis was related to the length of labour 
but not to fetal acidaemia. These findings 
suggest that leucocytosis is likely to be a non-
specific response to labour.

In contrast with leucocytosis, erythroblasto-
sis may be the consequence of fetal tissue hypoxia 
either before or during labour. Thus the highest 
erthroblast counts were observed in pregnan-
cies complicated by intrapartum fetal distress 
necessitating emergency caesarean section and 
the magnitude of erythroblastosis was 
associated with the degree of fetal acidaemia.

Blood pH in samples obtained from the 
umbilical cord at delivery are susceptible to 
acute changes during labour and is a poor pre-
dictor of neonatal morbidity or long term 
handicap.8-9 In contrast, plasma erythropoeti-
in is a good measure of tissue oxygenation and 
increases only when physiological compensa-
tory mechanisms such as cardiovascular 
responses do not prevent tissue hypoxia.10,11 
Furthermore, the increase in plasma erythro-
poietin is better correlated with erythroblast 
count than with pH.4,5 In this respect the degree 
of erythroblastosis may be a better index of 
hypoxic tissue damage than blood pH. Indeed, 
previous retrospective studies in premature 
and term infants have shown that cord blood 
erthroblast count at delivery is a better 
predictor than pH of neonatal morbidity.2,12 

The significance of the hypoxic insult to the 
erthroblastemic fetus remains to be estab-
lished in long term neurodevelopmental stud-
ies. Furthermore, the value of erythroblast 
estimation as a method of intrapartum fetal 
monitoring, by the use of fetal scalp blood 
sampling, needs to be evaluated.

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