Cord Blood Lactate and pH Values at Term and Perinatal Outcome: A Retrospective Cohort Study

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Abstract

Objective: To examine the relationship between newborn umbilical cord blood lactate and pH levels, mode of delivery and short-term neonatal outcome.

Materials and methods: Umbilical cord arterial and venous lactate and pH values, mode of delivery, birth weight, gestational age, Apgar scores were extracted from the Obstetrix database at Nepean Hospital in Sydney. More than 7400 newborn cord blood gases were available for analysis.

Results: Gestational age ranged from 37 to 43 weeks (mean 39.7 weeks). The highest mean arterial cord lactate values were noted among babies delivered instrumentally (5.1 mmol/L). Infants who had a normal vaginal delivery had the second highest levels (4.3 mmol/L), followed by infants delivered by emergency caesarean section (3.9 mmol/L). The lowest lactate values were noted in deliveries by elective caesarean section (3.2 mmol/L). Cord arterial lactate levels were significantly higher among infants born with low Apgar scores (7.02 mmol/L vs 4.0 mmol/L, P < 0.001). Newborns with raised cord arterial lactate were significant more likely to have low Apgar scores (OR 4.8, 2.4-9.9), whereas low arterial cord pH was slightly less significant (OR = 3.6). High arterial cord lactate was a significant predictor of admission to NICU (OR 2.9, 2.1 – 4.1). ROC analysis suggests that lactate and pH are virtually equivalent in their correlation with adverse neonatal outcome.

Conclusions: Cord lactate and pH levels are significantly related to the mode of delivery. Cord arterial lactate is equivalent to cord arterial pH in predicting adverse neonatal outcomes, with limited sensitivity and specificity.

Introduction

Umbilical cord blood analysis supplies important information about a newborns’ biochemical status prior to delivery. In the fetus, metabolic acidemia develops when oxygen deprivation is of sufficient duration and magnitude to require anaerobic metabolism for cellular energy needs (1). Excessive lactate accumulation may contribute to damage to the vital organs.

Levels of lactate and pH in fetal scalp blood have been shown to be comparable in predicting perinatal outcome (2), and possibly more sensitive than pH in predicting low Apgar scores and hypoxic ischemic encephalopathy (3,4). A significant practical advantage is that lactate requires less blood and fewer scalp incisions; the technique is faster and less likely to be unsuccessful (5).

Measuring umbilical artery lactate level is regarded as an efficient and accurate technique for the diagnosis of fetal distress (6,7). The aim of this study is to evaluate neonatal cord blood lactate and pH in relation to the mode of delivery, and to test the hypothesis that lactate is a better predictor of poor neonatal outcome at term.

Materials and methods

Approval from our local ethics committee was obtained prior to commencing the project. Umbilical cord blood gas analysis at birth has been a routine procedure at our hospital for all deliveries for many years. Shortly after delivery, the umbilical cord is double-clamped. Arterial and venous umbilical cord blood is sampled in two separate pre-heparinised syringes and usually analysed within 30 minutes. These results are entered in our computerized obstetric database together with other relevant information such as gestational age, birth weight, mode of delivery, Apgar scores, duration of labour and admission to neonatal intensive care (NICU).

Cases extracted from the database included 9360 live, singleton newborns born after 37 weeks gestation, from October 2004 to September 2007. Of these, 7442 had complete cord blood acid-base values for analysis. Cases with incomplete data were excluded from the analysis. Variables studied included umbilical cord arterial and venous lactate and pH values, mode of delivery, birth weight, gestational age, Apgar scores and admission to NICU. A low Apgar score was defined as less than 7 at five minutes.

All statistical analyses were carried out using SPSS for Windows software. Correlation coefficients were
calculated using Spearman’s method. Logistic regression analysis was used to estimate the adjusted odds ratios for predictors of low 5-minute Apgar scores, and admission to NICU. A high lactate value was defined as greater than the 90th percentile, whereas a low pH value was defined as below the 10th percentile. Receiver-operator characteristic curves with areas under the curve were estimated for both pH and lactate in relation to low 5-minute Apgars and admission to NICU. Optimal cut-off levels were estimated on the basis of the highest Youden index.

Results

The gestational age of the neonates ranged from 37 to 43 weeks (mean 39.7). The mean birth weight was 3467 g (SD 498 g). Normal delivery occurred for 64% of cases, caesarean section was required in 29%, instrumental delivery in 8%. Male infants accounted for 52.3% of births. About 0.8% (57 cases) had low 5-minute Apgar score and 4.4% (326 cases) required admission to NICU.

In a separate subgroup analysis, the characteristics of the excluded infants with missing acid-base data were compared to those without missing data. There were no significant differences in mean birth weight and gestational age, but a slightly higher percentage of females had missing data (21.2% vs 19.1%, P< 0.05).

There were highly significant negative correlations between cord lactate and pH, both in arterial blood (R = -0.57, P<0.001) and venous blood (R = -0.37, P < 0.001). A weak but statistically significant positive correlation was noted between gestational age and lactate, which was not found in cases delivered by elective caesarean section.

The cord lactate and pH values according to mode of delivery are shown in table 1. The highest mean arterial cord lactate values were noted among babies delivered instrumentally (5.03 mmol/L). Infants who had a normal vaginal delivery had the second highest levels (4.31 mmol/L). These were followed by infants delivered by emergency caesarean section (3.90 mmol/L). The lowest lactate values were noted among babies delivered by elective caesarean section (3.24 mmol/L). Similar trends were noted for cord arterial pH values.

Cord arterial lactate levels were significantly higher among infants born with low Apgar scores (6.58 mmol/L vs 3.96 mmol/L, P < 0.001). Logistic regression analysis (tables 2 and 3) showed that, at term, a high arterial cord lactate to be a highly significant predictor of low Apgar scores (OR 4.82, P< 0.0001), whereas a low arterial cord pH was less significant (OR = 3.61). Likewise, a high arterial cord lactate level was a significant predictor of admission to NICU ( OR 2.91, P< 0.0001) whereas arterial cord pH was slightly less important (OR 2.72, P< 0.001).

Receiver-operator curve analysis (table 4) suggests that both arterial pH and lactate are very similar in predicting adverse neonatal outcomes, being more closely correlated with low Apgar scores (AUC 0.76) than admission to NICU (AUC 0.66). With cord arterial lactate, the optimal cut-off point for predicting either low 5-minutes Apgar scores or admission to NICU was 5.75, with a sensitivity of 61% and specificity of 86% for the former, whereas for admission to NICU the sensitivity was 39% with a specificity of 86%.

Discussion

Lactate is an important energy source for the heart, brain and skeletal muscle; fetal levels are higher than maternal levels. The placenta is an important site for clearance of fetal lactate, especially during hypoxia. Transplacental maternal transfer is not regarded to be a significant source of fetal lactate (8).

Our results indicate that it is normal for a fetus in labour to develop a mild metabolic acidosis from increased anaerobic metabolism. However, increased lactate production is not specific of increased anaerobic metabolism (9) but may also arise from maternal glucose administration, beta-mimetic drugs and the fetal intrapartum catecholamine surge (10). Hence raised levels may not always be indicative of intrapartum asphyxia.

Our data suggest that cord arterial lactate performs as well as cord pH in predicting adverse neonatal outcomes. In a randomised controlled trial, Wiberg-Itzel and colleagues (11) found no significant differences in the performance of scalp lactate compared with scalp pH in terms of clinical outcome measures. However, Gjerris and colleagues (12) suggested that lactate in arterial umbilical cord blood might be a more correct indicator of fetal asphyxia at delivery than pH.

We demonstrated in our study that the highest mean arterial cord lactate values were among babies delivered instrumentally and this further supports the results of a small study by Borruto and colleagues (13). The lowest values were noted among newborns delivered by elective caesarean sections, which is consistent with the lack of stress from labour.

Our optimal cut-off point for cord arterial lactate of 5.75 mmol/l is significantly higher than the 4.2 mmol/l
advocated for scalp lactate values (14), and this may be due to the rise that takes place in the second stage of labour. There may also be an additional rise secondary to the delay from time of delivery to the time the sample is analysed (15). It is however significantly lower than the cut-off of 8.0 mmol/l suggested by Gjerris and colleagues (12); in their study the “gold standard” was a low base excess, whereas we used clinical indicators.

Previous work has shown that arterial and venous umbilical cord lactate increase significantly with advancing gestational age (10). This effect was also noted in our total population, but it was absent in the subgroup of women delivered by elective caesarean section. This suggests that the overall increase noted in labouring women may be due increased levels of intra-partum hypoxia at more advanced gestations.

The main limitation of our study is the variable and undocumented time interval from collection of the specimens to biochemical analysis. On average, this is likely to overestimate the lactate values, and it would also artificially increase the variance of for this variable. Cord pH has been shown not to be affected by this delay (15), but lactate could rise by 3.2 mmol/l over 40 minutes.

Our results suggest that cord arterial pH and lactate are equivalent in their limited correlation with poor neonatal outcome at term, and that the mode of delivery has significant impact on their levels. Their sensitivities and specificities are poor, and this has been shown to be the case even in high risk cases (5).

References

## Table 1 Cord blood lactate (mmol/L) and acid-base in relation to the mode of delivery

<table>
<thead>
<tr>
<th>Mode of delivery</th>
<th>Normal vaginal</th>
<th>CS: Elective</th>
<th>CS: Emergent</th>
<th>Instrumental vaginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial lactate</td>
<td>4.33 (1.92)</td>
<td>3.11 (1.25)</td>
<td>3.90 (1.8)</td>
<td>5.06 (1.84)</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>7.29 (0.10)</td>
<td>7.27 (0.06)</td>
<td>7.27 (0.06)</td>
<td>7.25 (0.08)</td>
</tr>
<tr>
<td>Arterial BE</td>
<td>-0.42 (4.50)</td>
<td>-0.37 (2.92)</td>
<td>-0.035 (3.80)</td>
<td>-0.009 (5.16)</td>
</tr>
<tr>
<td>Venous lactate</td>
<td>3.81 (1.59)</td>
<td>2.66 (1.06)</td>
<td>3.50 (1.70)</td>
<td>4.41 (1.67)</td>
</tr>
<tr>
<td>Venous pH</td>
<td>7.36 (0.07)</td>
<td>7.33 (0.05)</td>
<td>7.32 (0.06)</td>
<td>7.32 (0.06)</td>
</tr>
<tr>
<td>Venous BE</td>
<td>-0.47 (4.40)</td>
<td>-0.33 (2.56)</td>
<td>-0.15 (3.73)</td>
<td>0.07 (5.1)</td>
</tr>
</tbody>
</table>
Illustration 2

Table 2 Arterial lactate and pH as predictors of low Apgar scores.

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial lactate &gt; 6.4</td>
<td>4.82</td>
<td>2.36 - 9.88</td>
</tr>
<tr>
<td>Arterial pH &lt; 7.18</td>
<td>3.61</td>
<td>1.77 - 7.36</td>
</tr>
<tr>
<td>Gestational age (week)</td>
<td>0.98</td>
<td>0.77 - 1.26</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.43</td>
<td>0.83 - 2.47</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>0.99</td>
<td>0.99 - 1.00</td>
</tr>
</tbody>
</table>
Illustration 3

Table 3 Arterial lactate and pH as predictors of admission to NICU.

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial lactate &gt; 6.4</td>
<td>2.91</td>
<td>2.08 – 4.06</td>
</tr>
<tr>
<td>Arterial pH &lt; 7.18</td>
<td>2.72</td>
<td>1.94 – 3.80</td>
</tr>
<tr>
<td>Gestational age (week)</td>
<td>0.73</td>
<td>0.65 – 0.80</td>
</tr>
</tbody>
</table>
Table 4 ROC analysis for arterial lactate and pH as predictors of low 5-minute Apgar scores and adm

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low Apgars</th>
<th>Admission to NICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial lactate</td>
<td>0.76 (0.037)</td>
<td>0.66 (0.018)</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>0.75 (0.038)</td>
<td>0.67 (0.017)</td>
</tr>
</tbody>
</table>
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