# Umbilical Artery Blood Gas and Lactate in Healthy Newborns

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**Abstract**

This study aimed to establish the normal range of umbilical artery pH, $pCO_2$, base deficit and lactate in normal term and preterm newborn. Umbilical artery pH, $pCO_2$, base deficit and lactate was measured in 637 newborn babies. The study included 555 babies at term with Apgar score equal to or more than 7 at 5 minutes, not requiring assisted ventilation and not admitted to the neonatal unit (NNU), as well as 47 preterm babies with Apgar score equal to or more than 7 at 5 minutes who were admitted to the NNU for observation only because of prematurity. Data was presented as mean and SD. Statistical analysis was done by *t*-test and simple linear regression analysis. In the newborn at term mean umbilical artery blood gas and lactate were as follows; pH = 7.25 (±0.08), $pCO_2$ = 45.66 (±1.88) mmHg, base deficit = 7.69 (±3.88) mEq/L, lactate = 2.96 (±1.8) mMol/L. In preterm newborn the values were; pH = 7.25 (±0.04), $pCO_2$ = 51.78 (±13.00) mmHg, base deficit= 5.29 (±1.87) mEq/L, lactate = 2.55 (±1.87) mMol/L. The range of umbilical artery blood gas and lactate parameters in term and preterm fetuses with good neonatal outcome were derived. There was a statistically significant difference in $pCO_2$ and base deficit between term and preterm newborn. There was no linear correlation between lactate, pH, $pCO_2$, base deficit and fetal glucose respectively in term or preterm infants.

**Key word :** Umbilical Artery, Blood Gas, Lactate, Newborns

Assessment of newborn status has traditionally based on the Apgar scoring system(1). However, the system depends on subjective interpretation and may be affected by many factors. For example, Apgar score may be low in a non-asphyxiated preterm baby if the mother is given sedation.

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Assessment of acid-base status of the newborn at birth is valuable because it may give us information about hypoxia in the baby, which may have a long term effect. James et al first reported the relationship between abnormal blood gas and low Apgar score[2] but recent studies have shown that acidotic babies may not have low Apgar score[3-5]. Thus, measurement of acid-base status may be a useful adjunct to evaluate the condition of new born babies.

Acidosis is divided into respiratory, metabolic and mixed types. Respiratory acidosis can be transient and results from accumulation of $CO_2$. This can be cleared quickly and is usually transient and harmless to the fetus. If oxygen falls to a level at which the fetus fails to compensate, this will lead to anaerobic metabolism, with lactate and $H^+$ ion as end products. Accumulation of lactate and $H^+$ ion will lead to metabolic acidosis.

Metabolic acidosis represents tissue hypoxia and is associated with risk of vital organ damage. pH alone may not discriminate between metabolic and respiratory acidosis. Lactate levels or $pCO_2$ together with pH to calculate base deficit (BD) may be necessary for discrimination. Thus, it is of value to measure umbilical artery blood gas and lactate level to evaluate new born status.

This study aimed to establish the reference range in umbilical artery blood gas and lactate for healthy term and preterm babies in our population and to correlate the various indicies to each other and to compare the results observed in the two groups.

## MATERIAL AND METHOD

During the study period, from January 1996 to December1996, 637 newborn babies, who were service cases, were delivered at National University Hospital, Singapore. Five hundred and eighty six of them were term babies and 51 were preterm. In order to establish the normal range of umbilical artery blood gas and lactate of term babies, only babies delivered at or after 37 weeks amenorrhea with Apgar score equal to or more than 7 at 5 minutes and who did not require assisted ventilation and were not admitted to the NNU (Neonatal Unit) were included in this study. Preterm babies included those delivered before 37 weeks amenorrhea with Apgar score at 5 minutes equal to or more than 7 and who were not admitted to the NNU or those who were admitted to the NNU because of prematurity. Based on our study criteria,555 term and 47 preterm babies were included in this study.

For blood gas and lactate investigations, a segment of umbilical cord was doubly clamped immediately after delivery. Clamps were placed near the cut end of the umbilical cord so arteries and vein could be identified. Blood was drawn from an umbilical artery into a 2 ml heparinized syringe. We did not investigate blood chemistry in the umbilical vein because it comes from the placental bed which represents a newborn status poorer than umbilical artery flow from the baby itself. Blood gas was analyzed by an automatic pH-blood gas analyzer (Compact 2 blood gas analyzer; AVL medical instruments AG, Switzerland) in the labor ward. Lactate levels were measured by the single-use teststrip method using an enzymecoated electrode and meter (Accusport, Boehringer Manheim, Germany). Glucose was measured by RefloluxII. (Boehringer Manheim, Germany). These measurements were performed in the labor ward within 5 minutes after birth.

All data collection was completed soon after delivery. Calculation and statistical analysis was performed using the SPSS for Window version 6.0 statistical software package. All data were presented as means and one standard deviation (SD). Group comparisons between term and preterm infants were done using Student's *t*-test. Statistical significance was considered when p-value was less than 0.05. Correlation was calculated by simple linear regression analysis.

## RESULTS

Five hundred and fifty-five term and 47 preterm newborns met the inclusion criteria. Mean birth weight of term babies in this study was 3146.2±427.5 (±1 SD) grams which was the same as the mean birth weight of normal term babies in the National University Hospital. Mean birth weight of preterm babies was 1720.4±458.3 grams. Gestation ranged from 25 to 36 weeks with a mean gestation of 32.3 (± 3.0) weeks. Of the total population, 18.4 per cent of babies were delivered by cesarean section and 11.4 per cent had operative vaginal delivery whilst 70.3 per cent had a normal vaginal delivery. Table 1 summarizes the mean and standard deviation for pH, $pCO_2$, base deficit (extracellular fluid compartment), fetal glucose, maternal glucose and lactate from the umbilical artery of normal term and preterm newborns. Comparison of blood gas and lactate value of term and preterm newborns showed

**Table 1. Normal umbilical artery blood gas and lactate in normal term and preterm newborns.**

| | Term mean ± SD | Preterm mean ± SD | p value | 95% confident interval |
|---|---|---|---|---|
| Birthweight (grams) | 3146.20 ± 427.50 | 1720.40 ± 458.34 | <0.05 | 1293.67, 1560.56 |
| pH | 7.25 ± 0.08 | 7.25 ± 0.04 | 0.69 | -0.02, 0.03 |
| $pCO_2$ (mmHg) | 45.66 ± 12.88 | 51.78 ± 13.00 | <0.05 | -10.10, -2.09 |
| Base excess (mEq/L) | -7.69 ± 3.88 | -5.29 ± 5.11 | <0.05 | -3.65, -1.41 |
| Fetal glucose (mMol/L) | 3.79 ± 1.28 | 3.94 ± 1.26 | 0.47 | -0.54, 0.25 |
| Maternal glucose (mMol/L) | 5.05 ± 2.10 | 5.44 ± 1.87 | 0.27 | -1.08, 0.30 |
| Lactate (mMol/L) | 2.96 ± 1.79 | 2.55 ± 1.08 | 0.14 | -0.13, 0.96 |

statistically significant differences in $pCO_2$ and base deficit between term and preterm newborns (P-value <0.05). There were no significant differences in pH, lactate, and glucose between the two groups.

We used simple linear regression analysis to describe the relationship between the measured variables. Lactate concentration was used as the dependent variable. pH, $pCO_2$, base deficit, and glucose were used as independent variables. Analysis revealed that there was no linear correlation between lactate and pH ($R^2$=0.1), $PCO_2$ ($R^2$=0.03), base deficit ($R^2$=0.03) or fetal glucose ($R^2$=0.02).

## DISCUSSION

The Apgar score has been widely used for diagnosis of fetal asphyxia since 1953[1]. However, it is subjective and can be influenced by many factors other than hypoxia. The Apgar score may be low in a nonhypoxic baby if the mother was given sedation. Immature development of muscle tone and reflex may cause low Apgar score although the babies are not asphyxiated[6,7].

In recent years, acid-base balance has been widely studied because it reflects hypoxic events during labor and delivery[2-5]. Many of these studies have shown that acid-base status and Apgar score do not have good correlation[3-5]. pH is a good indicator of acidosis but it can not differentiate metabolic acidosis from respiratory acidosis. Lactate is an end product of anaerobic metabolism which is associated with tissue hypoxia. Measurement of blood lactate and base deficit may better reflect the metabolic status of the newborns.

Traditionally, fetal acidemia has been defined as an umbilical artery pH < 7.2[8,9]. However, many babies at term,with an umbilical artery pH < 7.2 have a normal Apgar score and no significant neonatal complications[10,11]. Recently, many papers have suggested that a cut off value for diagnosis of significant acidemia should be pH <7.0 (11-13). However, the normal range for blood lactate that may provide the cut off value for diagnosis of fetal asphyxia has still not been determined[14,15].

Newborns delivered after 37 weeks amenorrhea who were not admitted to the NNU and with an Apgar score equal to or more than 7 at 5 minutes were included in this study. Mean value of umbilical artery pH in this group was 7.25±0.08 (6.69-7.56) which is similar to that of most other studies[15-18]. Mean $pCO_2$ was 45.66 (±12.88) mmHg which is lower than other studies[15-18]. Mean base deficit was 7.68 (±3.88) mEq/L which is higher than that obtained in studies by Riley et al[17] and Ramin et al[18] but is similar to the value obtained by Westgren et al[19] (Table 2). In this study, we calculated the base deficit for extracellular fluid and measured the values for blood lactate.

We compared blood gas and lactate concentrations between term and preterm newborn babies by using unpaired *t*-test (Table 1). There was a statistically significant difference in $pCO_2$ and base deficit between term and preterm babies. The $pCO_2$ was significantly lower but the base deficit was significantly higher in term babies. Length of labor can alter the blood gas values and is probably the cause of this difference[20,21]. Fifty six per cent of preterm babies were delivered by caesarean section with two thirds of them had emergency operation while only 15 per cent of term babies were delivered by caesarean section. However, pH and blood glucose did not show any statistically significant difference. Although mean lactate concentration in preterm was lower than in term new born,

**Table 2. Normal range of umbilical artery blood gas and lactate in term newborns in different population.**

| | Chanrachakul* (n=555) | Shirey[15] (n=85) | Westgren[19] (n=3301) | Riley[18] (n=3522) | Ramin[17] (n=1292) | Yeoman[16] (n=146) |
|---|---|---|---|---|---|---|
| pH | 7.25 ± 0.08 | 7.28 ± 0.06 | 7.27 ± 0.09 | 7.27 ± 0.07 | 7.28 ± 0.07 | 7.28 ± 0.05 |
| $pCO_2$ (mmHg) | 45.66 ± 12.88 | NA | 46 ± 13 | 50.3 ± 11.1 | 49.9 ± 14.2 | 49.2 ± 8.4 |
| Base excess (mEq/L) | -7.69 ± 3.88 | NA | -6.62 ± 3.92 | -2.7 ± 2.8 | -3.6 ± 2.8 | NA |
| Lactate (mmol/L) | 2.96 ± 1.79 | 2.98 ± 1.40 | 1.87 ± 0.94 | NA | NA | NA |

* Present series

**Table 3. Normal range of umbilical artery blood gas and lactate in preterm newborns in different population.**

| | Chanrachakul* (n=47) | Riley[18] (n=1015) | Dickinson[20] (n=949) | Ramin[17] (n=77) |
|---|---|---|---|---|
| pH | 7.25 ± 0.04 | 7.28 ± 0.09 | 7.27 ± 0.07 | 7.29 ± 0.07 |
| $pCO_2$ (mmHg) | 51.78 ± 13.00 | 50.2 ± 12.3 | 51.6 ± 9.4 | 49.2 ± 9.0 |
| Base excess (meq/L) | -5.29 ± 5.11 | -2.5 ± 3 | -3.0 ± 2.5 | -3.3 ± 2.4 |
| Lactate (mmol/L) | 2.55 ± 1.87 | NA | NA | NA |

* Present series

the difference was not statistically significant. Lactate concentration did not show linear correlation with pH, $pCO_2$, base deficit or fetal glucose level on regression analysis. The variation of value in normal babies may be too small to show the correlation.

Previous studies have shown that umbilical artery blood gas in term and preterm babies is similar[17-19,22]. However, in some of these studies [17,22], babies born prematurely included those with a low Apgar score and other complications other than prematurity. In this study, we included only those preterm babies with an Apgar score equal to or more than 7 at 5 minutes and who were admitted to the NNU for observation because of prematurity. In the preterm group, mean umbilical artery pH was 7.25±0.04 (7.11-7.34) which was similar to that of babies at term. However, the mean umbilical artery pH in the preterm group of this study was lower than that of other studies[17,18] (Table 3). Mean $pCO_2$ of preterm babies was higher than the Ramin et al and Riley et al studies[17,18] but lower than the study of Dickerson et al[22]. The previous studies did not measure lactate concentration in preterm babies.

When we compared blood chemistry of the healthy newborn babies to the babies who did not meet the inclusion criteria, there was statistical difference in lactate in the term group and no statistical difference in the preterm group. However, the number of babies who did not fulfil the inclusion criteria (Apgar score <7, requiring assisted ventilation or admission to the NNU) was small. Larger samples are needed to compare the difference between these two groups.

The data from these two groups of 555 term and 47 preterm infants provide a normal reference range of umbilical artery pH, $pCO_2$, base deficit and lactate in babies born with good outcome in our population. The two standard deviations from mean should be used as the reference for healthy newborn babies.This data may be helpful for evaluation of fetal asphyxia in term and preterm newborn.

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# ค่าก๊าซในเลือดและแล็คเตท ของเส้นเลือดแดงสายสะดือ ในทารกแรกเกิดปกติ

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รายงานการศึกษาค่า blood gas และ lactate ของ umbilical artery ในทารกแรกเกิดครบกำหนด 555 คน และทารกคลอดก่อนกำหนด 47 คน ซึ่งมีค่า Apgar score ที่ 5 นาที มากกว่าหรือเท่ากับ 7, ไม่ใช้เครื่องช่วยหายใจหรือไม่จำเป็นต้องเข้ารับการรักษาใน NICU ยกเว้นการดูอาการในกรณีที่เป็นทารกคลอดก่อนกำหนด

ในทารกคลอดครบกำหนด ค่าเฉลี่ยของ umbilical artery blood gas และ lactate เป็นดังนี้ : pH = 7.25 (± 0.08), $pCO_2$ = 45.66 (± 1.88) mmHg, base deficit = 7.69 (± 3.88) mEq/L, lactate = 2.96 (± 1.8) mMol/L ในทารกคลอดก่อนกำหนด ค่าเฉลี่ยของ umbilical artery blood gas และ lactate เป็นดังนี้ : pH = 7.25 (± 0.04), $pCO_2$ = 51.78 (± 13.00) mmHg, base deficit = 5.29 ± (1.87) mEq/L, lactate = 2.55 (± 1.87) mMol/L

ค่า $pCO_2$, base deficit ของทารกคลอดครบกำหนดและทารกคลอดก่อนกำหนดมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ แต่ไม่พบความสัมพันธ์แบบเส้นตรง (linear correlation) ระหว่างค่า lactate กับ pH, $pCO_2$, base deficit และ fetal glucose ทั้งในทารกคลอดครบกำหนด และคลอดก่อนกำหนด

**คำสำคัญ** : ก๊าซในเลือด, แล็คเตท, เส้นเลือดแดงสายสะดือ, ทารกแรกเกิด

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