

Umbilical Cord Blood Gas Analysis at Delivery

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ABSTRACT

Background: Umbilical cord blood gas values are better indicators of perinatal asphyxia than Apgar scores. However, the reported normal range of umbilical blood gas values vary greatly in the literature. The aim of this prospective study was to establish the normal range of umbilical cord blood gas values in our labour ward.

Methods and Results: Umbilical cord blood gas from 153 vaginal deliveries and 52 Caesarean sections for indication other than fetal distress were evaluated. In our labour ward, the mean and standard deviation of umbilical artery pH were 7.21 and 0.08 for vaginal deliveries and 7.22 and 0.07 for Caesarean sections respectively. The mean and standard deviation for umbilical artery base deficit were 5.08 and 3.85 for vaginal deliveries and 4.09 and 3.07 for Caesarean sections respectively.

Conclusion: In conclusion, pH of 7.05 is the statistical lower limit of umbilical artery pH in our labour ward and is a good cut-off value to indicate perinatal asphyxia. Five cases with abnormal umbilical artery pH (< 7.05) were also analysed and discussed.

Keywords: normal range of umbilical cord blood gas values, umbilical artery pH (UApH), base deficit in extracellular fluid component (BDefc), perinatal asphyxia

INTRODUCTION

In Singapore, most obstetric units use Apgar score as the indicator of neonatal condition at birth. However, Apgar score is not a good indicator of perinatal asphyxia⁽¹⁻³⁾, and can be influenced by other factors eg. prematurity, maternal sedation with opioids, aspiration of mucus or meconium etc. In contrast, umbilical cord blood gas values are more objective in the assessment of fetal oxygenation at delivery^(1, 4-7).

Measurement of acid base status of umbilical cord blood after delivery is recommended by the 1994 American College of Obstetrics and Gynaecology Committee Opinion on Obstetric Practice and the 1993 Royal College of Obstetrics and Gynaecology Study Group on Intrapartum Fetal Surveillance⁽⁸⁾.

It is an objective measure of fetal response to labour and can exclude intrapartum hypoxia as a proximate cause of neonatal depression.

Before we start to use umbilical cord blood gas values routinely as an indicator of antepartum and intrapartum care, establishment of normal range of blood gas values in our labour ward is important, rather than relying on results from other centres which may reflect different labour ward practices. Moreover, the reported normal range of umbilical artery pH value varies greatly^(1, 9-13). This study defines the normal range of blood gas values in our labour ward.

After the normal range in our labour ward was established, during a subsequent 6-month period, we followed-up on 5 cases with statistically abnormal umbilical artery pH and examined the significance of some of the blood gas parameters.

MATERIALS AND METHODS

During the periods from 21 March to 11 April 1994 and 21 June to 8 July 1994, 205 umbilical cord blood gas results were evaluated. Of these, 153 newborns were delivered vaginally and 52 newborns were delivered by Caesarean section.

Immediately after delivery, a segment of umbilical cord was isolated between cord clamps. The umbilical artery and vein were serially punctured with a 14 gauge needle and the blood was collected into a pre-heparinised capillary tube by capillary action. The blood gas values were analysed with AVL 995 blood gas analyser within 30 minutes of delivery.

AVL 995 analyser measures pH, pCO₂, pO₂ and calculates HCO₃⁻, Base deficit (blood) and Base deficit in the extracellular fluid compartment (BD ecf) from the measured parameters.

Pregnancies of less than 34 or more than 42 completed weeks of gestation and pregnancies with growth retardation or fetal anomalies were excluded. Fetuses with significant fetal heart rate abnormalities during the first stage of labour were also excluded.

All infants evaluated had at least a 10-minute CTG segment of recorded fetal heart during the second stage.

The arterial and venous blood gas values were examined immediately after analysis. Those results with arterial pH and pO₂ higher than venous pH and pO₂ or arterial pCO₂ lower than venous pCO₂ were excluded from analysis.

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After the normal range of umbilical cord blood gas parameters were established, selective umbilical cord blood gas sampling was performed by some of the clinicians in our Unit over a six-month period. The purpose of the exercise was to collect cases with statistically abnormal umbilical cord pH to examine the significance of abnormal cord blood gas parameters to neonatal outcome.

During this period, the indications to perform blood gas analysis were:

- 1) Fetal distress:- eg. persistent late deceleration, severe variable deceleration with reduced baseline variability, scalp blood pH less than or equal to 7.25, thick meconium stained liquor or no liquor, cord prolapse, severe bradycardia;
- 2) Antepartum haemorrhage;
- 3) Estimated fetal weight less than or equal to 1.5kg;
- 4) Estimated gestation less than or equal to 34 weeks;
- 5) Assisted breech delivery;
- 6) Poorly controlled IDDM;
- 7) Severe pre-eclampsia or eclampsia;
- 8) Suspected fetal anomalies;
- 9) Transverse or oblique lie at Caesarean section,
- 10) Multiple pregnancy

Both umbilical artery and vein were sampled and the blood gas parameters recorded. All those cases with abnormal umbilical artery pH less than 7.05 (mean - 2SD in our series) were retrospectively analysed with regards to their antenatal events, intrapartum management and neonatal outcome.

RESULTS

Of the 153 vaginal deliveries, delivery was spontaneous for 141 patients but required assistance in 12 patients (forceps 9 cases, vacuum 3 cases). Of the 52 Caesarean sections, 25 were performed electively and 27 were done as emergency for indications other than fetal distress.

The period of gestation of the newborns ranged from 34 - 42 weeks with a mean of 37.2 weeks. Their birth-weights ranged from 1625 to 4215g with a mean of 3112g. One minute Apgar scores ranged from 5 to 9 with a mean of 8.89. Five-minute Apgar scores were all 9.

The means and standard deviations for umbilical arterial pH, pCO₂, bicarbonate and base deficit in the extracellular fluid compartment (BDecf) for both vaginal deliveries and Caesarean sections are tabled in Table I.

The means and standard deviations for umbilical vein pH, pCO₂, bicarbonate and BDecf for vaginal deliveries and Caesarean sections are given in Table II.

Over the subsequent six-month period when we performed selective umbilical cord blood gas sampling for high risk pregnancies and cases with clinical indications of fetal distress, we performed a total of 69 blood gas analyses. Five cases had umbilical arterial pH < 7.05. Unfortunately, all 5 cases had umbilical artery pH less than 7.00. Hence the effect of lesser degree of acidosis could not be illustrated from our study.

The other 64 cases with umbilical artery pH ≥ 7.05 had 5-minute Apgar score of ≥ 8 with an uneventful neonatal course.

The clinical scenarios of the 5 cases with abnormal umbilical artery pH are presented below and the blood gas results with probable etiology are tabulated in Table III.

Case 1

A 35-year-old gravida 4 para 2 presented at 37 weeks amenorrhoea with abruptio placentae. Cardiotocogram showed bradycardia with poor baseline variability. Emergency LSCS was done. Retroplacental clot was formed covering 50% of placental surface. A baby girl weighing 2670g with Apgar scores of 9 at 1 and 5 minutes was delivered. The baby did well though afflicted with some transient tachypnoea of newborn and neonatal jaundice and was discharged on day 12. At 4-month follow-up, her developmental milestones were normal.

Case 2

A 33-year-old gravida 1 para 0 presented at 42 weeks with prolonged rupture of membrane for 3 days. Cardiotocogram showed tachycardia with poor baseline variability. Emergency LSCS was done. Liquor was scanty and foul smelling. A baby boy weighing 2740g with Apgar scores of 1 and 9 at 1 and 5 minutes respectively was delivered. The boy was resuscitated with bag and mask and had mild respiratory distress. He was discharged on day 11 and had normal milestones at 4-month follow-up.

Table I – The means and standard deviations for umbilical artery pH, pCO₂, bicarbonate and base deficit in extracellular fluid compartment (Bdecf) for both vaginal deliveries and caesarean sections

	Vaginal Deliveries		LSCS	
	Mean	SD	Mean	SD
UApH	7.21	0.08	7.22	0.07
UABDecf	5.08	3.85	4.09	3.07
UApCO ₂	55.52	12.35	58.21	9.31
UAHCO ₃	21.45	2.80	24.14	5.39

Table II – The means and standard deviations for umbilical vein pH, pCO₂, bicarbonate and base deficit in extracellular fluid compartment (Bdecf) for both vaginal deliveries and caesarean sections

	Vaginal Deliveries		LSCS	
	Mean	SD	Mean	SD
UVpH	7.30	0.06	7.27	0.06
UVBDecf	3.82	3.29	3.70	2.49
UVpCO ₂	47.72	8.05	50.14	8.54
UVHCO ₃	20.33	2.45	22.86	5.16

Table III – Five cases of abnormal umbilical cord blood gas parameters and probable etiology

Cases	1	2	3	4	5
uApH	6.983	6.922	6.972	6.681	6.688
uApCO ₂	94.5	72.4	90.9	128.7	121.6
uABD	7.7	15.5	11.7	24.1	24.6
uVpH	7.034	7.119	7.237		6.71
uVpCO ₂	81.5	50.3	51.7		116.2
uVBD	6.6	9.1	4.7		24.0
Probable etiology	Abruptio	? Cord compression	Cord compression (thick meconium stained liquor)	Abruptio	Uterine rupture
Hospital stay (days)	12	11	5	38	Died day 99

Table IV – Reported normal range of umbilical arterial pH in other studies

Author	No of patients	Mean UA pH	SD	Mean – 2 SD
Sykes et al ⁽¹⁾	899	7.20	0.08	7.04
Eskes et al ⁽⁹⁾	4667	7.23	0.07	7.09
Perkins R et al ⁽¹⁰⁾	3183	7.31	0.08	7.15
Yeomans et al ⁽¹¹⁾	146	7.28	0.05	7.18
Clark et al ⁽¹³⁾	39	7.22	0.06	7.10
Koch and Wendel ⁽¹²⁾	27	7.24	0.06	7.12
Westgate ⁽⁷⁾	1448	7.27 (median)	–	7.06(2.5th %tile)

Case 3

A 20-year-old primigravida was admitted in labour at 37 weeks. A cardiotocogram showed baseline tachycardia, poor baseline variability and late decelerations. An emergency LSCS was performed. Thick meconium stained liquor was seen. The baby boy weighed 2.9 kg and his Apgar score was 8 at 1 minute and 9 at 5 minutes. He did not develop meconium aspiration and was discharged on day 5 of life.

Case 4

A 30-year-old gravida 4 para 3 presented at 34 weeks with continuous abdominal pain and antepartum haemorrhage. Doppler was negative but bedside ultrasound examination showed feeble heart beat at about 40 beats/minute. An emergency LSCS was performed. Liquor was heavily blood stained. About 600 mLs of clots was found retroplacentally. A baby boy weighing 1500g was delivered. His Apgar scores were 0 at 1 minute and 2 at 5 minutes. The baby was intubated. Neonatal problems included hypotension requiring dopamine support, stage 2 hypoxic ischaemic encephalopathy, neonatal seizure needing phenobarbitone for 1 week and grade 4 Hyaline membrane disease. The baby was discharged on day 38 of birth. At 4 months, he had no seizures, was able to raise his head from prone position and was “babbling and cooing” at the time of consultation.

Case 5

A 26-year-old lady gravida 2 para 1 with 1 previous LSCS, was admitted in labour at 37 weeks. Epidural anaesthesia was administered and labour was augmented with syntocinon. At second stage of labour, CTG showed prolonged bradycardia. Vacuum assisted delivery was performed. Subsequently, a diagnosis of uterine rupture was made. The baby's Apgar score was 0 at 1 minute and 2 at 5 minutes. The baby was intubated but developed hypoxic ischaemic encephalopathy with spastic diplegia and opisthotonic posturing, Swiss cheese periventricular leukomalacia, and was ventilator-dependent. The baby was extubated and died at 99 days of life.

DISCUSSION

Umbilical cord blood gas values reflect the last moment of fetal oxygenation and acid base balance prior to delivery. Severe fetal acidemia is associated with increased perinatal mortality and increased risk of subsequent impaired neurological development.

Compared to mean arterial pH of 7.40 in adults, neonates are definitely acidotic at birth. However, certain degree of acidosis is physiological and is not harmful to the newborn. What then constitutes significant acidosis?

It is obvious from Table IV that there is no consensus in the literature on what constitutes

acidosis. If we take mean - 2 standard deviation as abnormal, the reported lower limit of normal uAph ranges from 7.04 - 7.18.

In our study, statistically lower limit of uAph (mean - 2SD) is 7.05 for vaginal deliveries. This is in agreement with larger series of Sykes et al and Westgate et al^(1, 7). In most studies trying to correlate uAph with neonatal outcome, the level of pH chosen to indicate acidosis was too high. This may explain the lack of strong correlation between uAph and outcome⁽¹⁵⁾.

We found that the isolation of a segment of umbilical cord immediately after delivery is logistically easier for labour ward staff. Before our study, we performed consecutive measurements on clamped segments of umbilical cord at 0, 15, 30, 45 and 60 minutes of birth and found that clamped segments of umbilical cord are stable for blood gas analysis of up to 30 - 45 minutes of birth. These results concurred with Duerbeck's⁽¹⁶⁾ who found that a clamped segment of cord is stable for blood gas assessment for at least 60 minutes after delivery.

Whether umbilical cord blood gas analysis needs to be routinely performed for all deliveries is controversial. If logistically feasible, routine sampling for all cases is ideal, but this increases costs for the patient. Another approach will be to routinely isolate segments of umbilical cord at birth. If the newborn is active with a good Apgar scores and there are no other clinical indications to perform blood gas analysis (eg. prematurity, vaginal breech delivery, meconium stained liquor etc), the umbilical cord can be discarded.

It is important to obtain a paired arterial venous sample of umbilical cord blood for a few reasons:-

1. To ensure that separate vessels have been sampled. In a recent study by Westgate et al, 25% of results had to be discarded because some vessels had been sampled twice or the vessels were transposed. If only the umbilical artery was sampled, the labour ward personnel may inadvertently sample umbilical vein, giving a less acidotic blood gas picture.
2. Arterial-venous difference of blood gas parameters may indicate (i) the etiology of fetal acidosis (eg. large arteriovenous difference in BDecf can be due to cord entanglement) and (ii) the duration of hypoxic insult.

What we define in our study is the statistical normal range of blood gas parameters. It is not necessarily true that a statistically abnormal pH must cause a significant, pathological insult to the newborn. The significance of various levels of acidosis need to be clarified in long term neuro-behavioural follow-up studies of significantly acidotic newborns. This study is not possible unless such newborns are identified by selective paired cord blood gas assessments.

What are the parameters to look at in an umbilical cord blood gas results other than umbilical artery pH? We think umbilical artery BDecf and arterial venous difference in BDecf are

two important parameters. Base deficit in the extracellular fluid compartment is less affected by elevated CO₂ level in the newborn compared to the blood compartment. As the newborn is usually hypercapnoeic at birth, BDecf is a better parameter to quantitate metabolic acidosis than BD blood⁽¹⁷⁾.

In the presence of similar umbilical artery pH, metabolic acidosis (with elevated BDecf is more significant than respiratory acidosis. Cases 1 and 2 in our small series had approximately similar umbilical artery pH but case 1 had a predominantly respiratory acidosis while case 2 had a greater metabolic-acidosis component. This may partially explain why the newborn in case 2 was less active at delivery. Very high BDecf indicates significant metabolic acidosis and the outcome is usually sub-optimal, eg. cases 4 and 5.

Umbilical arterial and venous difference in BDecf is markedly higher in cases where cord entanglement is the etiology of acidosis (eg. cases 2 and 3). Other studies also had the same observation^(17, 18).

In acute hypoxic insult of short duration, fetal and placental blood may not have sufficient time to equilibrate and this may be reflected in a large arterial-venous difference in BDecf. However, in long-standing hypoxic insult, lactic acid produced by the baby was given time to be removed across the placenta to saturate the placental extracellular fluid compartment. In such cases eg. case 5, the arterial-venous difference in pH and BDecf are low and the neonatal outcome is usually dismal.

In conclusion, we are sure that umbilical cord blood gas analysis is useful to ascertain whether a particular case of fetal compromise is due to "perinatal asphyxia". Selectively paired umbilical cord blood gas analysis, when properly done and correctly interpreted offers insight into metabolic events occurring in the perinatal period and enables the obstetricians to learn from individual patient. It also provides the neonatologists with a baseline of the neonate's metabolic condition. A good blood gas in a depressed newborn should alert the neonatologist to search more diligently for other causes of neonatal depression eg. sepsis, trauma or congenital abnormalities. It also provides an objective measure for the evaluation of antepartum and intrapartum care.

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1400 - 1430 hours	Old versus New Macrolides Ti Teow Yee Assoc Professor, Department of Pharmacology, NUS Assoc Consultant, Department of Medicine, NUH
1430 - 1500 hours	Coffee Break
1530 - 1600 hours	Prophylaxis for Cerebrovascular Disorders Dr Richard Chan Consultant Neurologist Department of Medicine, NUH
1600 - 1630 hours	Benzodiazepines: Problems to Anticipate Dr Tan Chay Hoon Senior Lecturer, Department of Pharmacology Assoc Consultant, Psychological Medicine, NUH
1700 - 1730 hours	Questions and Answers

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