Umbilical venous blood gas analysis for neonatal assessment

Subhashchandra R. Daga*, Satish K. Kulkarni, Arti S. Sharma and Bela V. Verma

Department of Pediatrics, Cama and Albless Hospital, Mumbai, India

Received 2 June 2011

Revised 25 August 2011

Accepted 25 August 2011

Abstract. Umbilical venous pH is claimed to mirror fetal acid-base status. Importantly, it is easier to perform. The aim of this study is to : 1. Evaluate the umbilical venous blood gas (UVBG) profile of normal newborns and to compare UVBG in the following situations: presence or absence of asphyxia presence or absence of meconium-stained amniotic fluid presence or absence of respiratory distress; and in newborns that did and did not survive and 2. To study the peripheral venous blood gas (PVBG) profile of newborns that develop cardio-respiratory insufficiency (CRI). Venous blood gas (VBG) was performed in 961 newborns consecutively admitted to the neonatal nursery over one year and in 100 controls. PVBG was also performed in 370 admissions to the nursery that developed signs of CRI. Demographic, clinical and outcome data were collected. Mean UVBG parameters (pH, pCO₂, HCO₃, base deficit, pO₂ and SO₂%) were compared between different groups of newborns using t test. This study had ethical approval. Of the 3349 live births over one year, 961 (28.7%) needed intensive care. Of these, 123 (12.8%) died. All the mean cord gas parameters differed significantly between who died and who survived. Metabolic acidosis and hypoxemia were conspicuous on PVBG among babies with CRI. Except for PO₂ all the mean parameters of UVBG differed significantly with asphyxia and meconium-stained amniotic fluid. When similar comparison was made among newborns that did or that did not develop respiratory distress, the difference was significant for all the parameters except SO₂%. UVBG gives useful information about common neonatal morbidities and appears to be a useful tool for neonatal assessment. PVBG gives objective information about babies with CRI that may need special interventions.

Keywords: Neonatal assessment, cord blood gases, perinatal asphyxia, fetal distress, birth asphyxia, respiratory distress, meconium staining

1. Introduction

There are conflicting opinions about the significance of five perinatal findings felt to be indicators of asphyxia (meconium staining of the amniotic fluid, abnormal fetal heart rate patterns, acidotic fetal scalp blood gases, low Apgar scores, and acidotic cord blood gases). A review of the literature undertaken to determine the strength of association of each of these findings with adverse outcomes found that all studies contained methodological

problems. Yet, these indicators were found to have strong associations with one or more adverse outcomes such as perinatal death, low Apgar scores or cerebral palsy. The strength of the association (relative risk) was found to vary inversely with the prevalence of the outcome [1]. Intrapartum asphyxia, which can lead to neurological injuries, seizures and death [2], has been defined variously by taking in to consideration the following: 1. late decelerations on fetal monitoring, 2. meconium-stained amniotic fluid (MSAF), 3. delayed onset of respiration after birth, 4. arterial cord pH < 7.1, 5. Apgar score < 7 at 5 minutes, and 6. multi-organ damage [2]. Despite limitations, the most objective assessment of presence of intra partum asphyxia is metabolic acidosis in umbilical

*Corresponding author: Subhashchandra R. Daga, MIMER Medical College, Talegaon Dabhade-410507, India. Tel.: +91 02114 228532; Fax: +91 02114 223916; E-mail: subhashdaga@yahoo.com.

arterial blood at the time of birth [3]. Although it is the most commonly quoted figure, pH is not an ideal parameter for estimating the cumulative exposure to hypoxia. The base excess gives a more linear measure of degree of metabolic acid accumulation and is adjusted for variation in $p\text{CO}_2$. Thus, it allows assessment of mixed acidosis [4]. It is easier to sample from the umbilical vein, as it is larger. Therefore, we chose to study umbilical venous blood gas (UVBG), which is known to correlate well with arterial pH and Apgar scores [5], among normal newborns and among newborns with common morbidities.

2. Materials and methods

This study was conducted at a 560-bed public hospital in a developing country. We studied UVBG in 961 babies consecutively admitted to neonatal nursery over one year. The sample was collected in the labor room by a pediatric resident usually within 3 minutes after birth. Two clamps were placed across the cord, 10–12 cm from the umbilicus. The cord was divided between the clamps. The third clamp was placed 15–20 cm from the first set of clamps towards the placenta and the cord blood sample was collected between the clamps. The sample was preserved in ice in a heparinized polyethylene syringe. Blood gas analysis was performed by an automated machine, AVL 995.

Most admissions were made within 5 minutes of birth since criteria for neonatal intensive care unit (NICU) admission are well-defined and, labor room and operation theatre are adjacent to NICU. Late appearance of respiratory distress delayed admission to NICU in some cases. We also studied venous blood gas (VBG) profiles of 100 consecutively born controls i.e., babies born at term with birth weight 2.5 kg or more, with no asphyxia, or MSAF or respiratory distress (RD). Peripheral venous blood gas (PVBG) was performed in 370 NICU admissions with cardio-respiratory insufficiency (CRI). Diagnosis of CRI was made in presence of any of the following clinical features: tachypnea, chest in drawing, irregular respiration, cyanosis, mottling, weak pulsations and cool peripheries. We collected the following clinical and demographic information: birth weight, gestational age, asphyxia, MSAF, RD and outcome (died or discharged). Mean and standard deviation (SD) were obtained for various UVBG parameters among control group and among nursery admissions. Mean and SD were also obtained on PVBG parameters of 370 newborns that developed CRI. Means were compared by

applying t test in the following sub-groups: admissions, with and without RD, with and without MSAF, with and without asphyxia, and died vs. discharged. *P* value less than 0.05 was considered significant. This study had ethical clearance of staff council of the hospital in absence of an ethical committee.

3. Results

Of the 3349 live births, 961 (28.7%) babies were admitted to NICU, 123 (12.8%) died. Distribution of birth weight and gestational age is given in Tables 1 and 2. Mean and SD for various parameters in control group are given in Table 3. When UVBG parameters were compared between admissions with RD and controls, mean pH, $p\text{CO}_2$, HCO_3 , SO_2 and base deficit differed significantly (Table 4). The means of various parameters when compared among asphyxiated babies

Table 1
Birth weight distribution of subjects (n = 961)

Birth weight (g)	Frequency (no)	Percentage
Up to 999	15	1.6
1000 to 1500	80	8.3
1501 to 2000	186	19.3
2001 to 2500	262	27.3
More than 2501	418	43.5

Table 2
Gestational age distribution of subjects (n = 961)

Gestational age (week)	Frequency (no)	Percentage
Up to 27	11	1.1
28 to 30	33	3.4
31 to 32	33	3.4
33 to 34	127	13.2
35 to 36	207	21.5
More than 36	550	57.2

Table 3
Parameters of cord venous blood gas analysis in control group (n = 100)

Parameter	Mean	Standard deviation
pH	7.26	0.08
$p\text{CO}_2$ (mmHg)	44.74	9.94
$p\text{O}_2$ (mmHg)	28.05	11.83
HCO_3 (mmol/L)	19.45	3.32
% SO_2	42.52	19.66
Base deficit (mmol/L)	−8.42	4.39

Table 4

Means of different parameters of cord venous blood gas in control group and in babies with respiratory distress

Parameter	Controls (100)	Respiratory distress present (370)	t	Sig
pH	7.262	7.114	-12.575	0.00
pCO ₂ (mmHg)	45	55	5.376	0.00
PO ₂ (mmHg)	28	31	1.424	0.15
HCO ₃ (mmol/L)	19	17	-5.211	0.00
% SO ₂	43	36	-2.677	0.00
Base deficit (mmol/L)	-8	-11	-4.768	0.00

Table 5

Means of different parameters of cord venous blood gas in babies that required resuscitation and that did not

Parameter	Resuscitation required (230)	Resuscitation not required (732)	t	Sig
pH	7.07	7.19	-10.135	0.00
pCO ₂ (mmHg)	56	48	6.444	0.00
pO ₂ (mmHg)	27	28	1.198	0.23
HCO ₃ (mmol/L)	17	18	-3.599	0.00
% SO ₂	30	37	-4.299	0.00
Base deficit (mmol/L)	-12	-9	-5.290	0.00

Table 6

Means of different parameters of cord venous blood gas in controls and in babies with meconium stained amniotic fluid (MSAF)

Parameters	Died (123)	Survived (839)	t	Sig
pH	7.08	7.17	-5.331	0.00
pCO ₂ (mmHg)	55	49	-2.865	0.00
pO ₂ (mmHg)	29	28	1.145	0.25
HCO ₃ (mmol/L)	17	19	-3.169	0.00
% SO ₂	34	35	-0.454	0.65
Base deficit (mmol/L)	-12	-9	-4.370	0.00

and controls, and among babies born through MSAF and controls, differed significantly in all parameters except pO₂ (Tables 5 and 6). When the babies that died and those who survived were compared, pH, pCO₂, HCO₃ and base deficit were significantly different, whereas pO₂ and SO₂ were not (Table 7). PVBG values among babies with CRI revealed metabolic acidosis and hypoxia (Table 8).

Table 7

Means of different parameters of cord venous blood gas in babies that died and that survived

Parameters	Died (123)	Survived (839)	t	Sig
pH	7.08	7.17	-5.331	0.00
pCO ₂ (mmHg)	55	49	-2.865	0.00
pO ₂ (mmHg)	29	28	1.145	0.25
HCO ₃ (mmol/L)	17	19	-3.169	0.00
% SO ₂	34	35	-0.454	0.65
Base deficit (mmol/L)	-12	-9	-4.370	0.00

Table 8

Mean and standard deviation of different parameters of peripheral venous blood gas analysis when cardio respiratory insufficiency diagnosed (n = 370)

Parameter	Mean	Standard deviation
pH	7.24	0.12
pCO ₂ (mmHg)	36.04	11.56
pO ₂ (mmHg)	78.53	39.66
HCO ₃ (mmol/L)	15.63	6.33
% SO ₂	83.08	18.85
Base deficit (mmol/L)	-11.47	6.59

4. Discussion

Umbilical cord blood gas analysis can provide important information about the past, present and possibly the future condition of the infant. Among the umbilical vessels, arterial blood is an accurate measure of fetal acidosis since it represents blood coming from the fetus. Umbilical venous pH and umbilical arterial pH are significantly correlated [6]. It is easier to obtain an adequate venous blood sample than an adequate arterial sample, especially in relatively inexperienced hands and in places with frequently changing hands such as ours. Delay in taking blood samples after birth may lead to changes in the arterial blood gas values, whereas the venous values remain relatively constant [5]. Westgate et al. [6] reported on 1798 supposedly paired umbilical arterial and venous samples. They found that 350 (19.5%) samples were unreliable and suggested a mix up [6]. Taking in to consideration these facts, umbilical venous sampling may have some practical advantages especially in settings like ours.

D'Souza et al. [7] studied 453 term infants at birth. They observed that umbilical venous blood pH and

umbilical arterial blood pH were significantly related to each other ($r = 0.7447$, $P < 0.00001$). Huisjes and Aarnoudse [5] studied 1334 babies and found good correlation between venous and arterial pH, and the relationship between venous pH and Apgar scores was similar to that between arterial pH and Apgar scores. They also believed that in routine practice it is, even with a good technique, more often possible to obtain adequate venous sample than an adequate arterial sample [5].

In our study, asphyxiated babies and babies who developed RD had conspicuous mixed acidosis and hypoxia as reflected in their pH, pCO_2 , bicarbonates, base deficit and SO_2 values. Respiratory system involvement is known to be among the most common organ dysfunction following asphyxia. We found a significant difference in various parameters namely pH, pCO_2 , HCO_3 , $SO_2\%$ and base deficit when these babies with MSAF were compared with controls. When babies who died were compared with those who survived, pH, pCO_2 , bicarbonates and base deficit differed significantly in them. The babies with cardio-respiratory decompensation had metabolic acidosis and hypoxemia. We chose peripheral venous sample because these babies any way required peripheral venous access for special interventions. Yildizdas et al. [8] have shown that capillary, venous and arterial blood gas parameters are correlated.

Oxygen saturation of the cord blood has not been studied extensively for fetal monitoring. A preductal SaO_2 value of 30% might be a reasonable cut off level to detect fetal acidosis [9,10]. In our study, the difference in oxygen saturation among asphyxiated and non-asphyxiated babies and among babies with and without MSAF, was significant. McNamara et al. [11] showed a statistical correlation between preductal SpO_2 and umbilical vein SaO_2 , and between umbilical vein pH, umbilical artery SaO_2 and umbilical artery pH in humans at delivery. Most fetuses during labor are able to compensate moderate and even severe reductions in oxygenation, at least as reflected by umbilical oxygen saturation measurements at birth without significant acidosis developing. Newborn infants with thick meconium had lower pH or SaO_2 values [12].

In conclusion, umbilical venous blood gas analysis is a valuable tool for neonatal assessment although

umbilical arterial blood gas is a gold standard for assessment of fetal well-being. Umbilical venous blood gas can also be helpful in assessment of fetal well being. It is particularly useful in limited resource areas where presence of inexperienced and frequently changing hands is a common occurrence.

References

- [1] Bryce RL, Halperin ME, Sinclair JC. Association between indicators of perinatal asphyxia and adverse outcome in the term infant: a methodological review. *Neuroepidemiology* 1985;4: 24–38.
- [2] Cowan F, Rutherford M, Groenendaal F, Eken P, Mercuri E, Bydder GM, et al. Origin and timing of brain lesions in term infants with neonatal encephalopathy. *Lancet* 2003;361: 736–42.
- [3] American College of Obstetricians and Gynecologists, American Academy of Pediatrics. Criteria required to define an acute intrapartum hypoxic event as sufficient to cause cerebral palsy. In: Van Eerden P, Bernstein PS, editors. *Neonatal Encephalopathy and Cerebral Palsy*. Washington, DC: ACOG; 2003. p. 73–80.
- [4] Armstrong L, Stenson BJ. Use of umbilical cord blood gas analysis in the assessment of the newborn. *Arch Dis Child Fetal Neonatal Ed* 2007;92:430–4.
- [5] Huisjes HJ, Aarnoudse JG. Arterial or venous umbilical pH as a measure of neonatal morbidity? *Early Hum Dev* 1979; 3: 155–61.
- [6] Westgate J, Garibaldi JM, Greene KR. Umbilical cord blood gas analysis at delivery: a time for quality data. *Br J Obstet Gynaecol* 1994;101:1054–63.
- [7] D'Souza SW, Black P, Cadman J, Richards B. Umbilical venous blood pH: a useful aid in the diagnosis of asphyxia at birth. *Arch Dis Child* 1983;58:15–9.
- [8] Yildizdas D, Yapicioğlu H, Yilmaz HL, Sertdemir Y. Correlation of simultaneously obtained capillary, venous, and arterial blood gases of patients in a paediatric intensive care unit. *Arch Dis Child* 2004;89:176–80.
- [9] Dildy GA, Thorp JA, Yeast JD, Clark SL. The relationship between oxygen saturation and pH in umbilical blood: implications for intrapartum fetal oxygen saturation monitoring. *Am J Obstet Gynecol* 1996;175:682–7.
- [10] Richardson B, Nodwell A, Webster K, Alshimmiri M, Gagnon R, Natale R. Fetal oxygen saturation and fractional extraction at birth and the relationship to measures of acidosis. *Am J Obstet Gynecol* 1998;178:572–9.
- [11] McNamara H, Chung DC, Lilford R, Johnson N. Do fetal pulse oximetry readings at delivery correlate with cord blood oxygenation and acidaemia? *Br J Obstet Gynaecol* 1992; 99: 735–8.
- [12] Arikan GM, Scholz HS, Petru E, Haeusler MC, Haas J, Weiss PA. Cord blood oxygen saturation in vigorous infants at birth: what is normal? *BJOG* 2000;107:987–94.