Umbilical cord blood pH and risk factors for acidaemia in neonates in Kerman

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باهاء دم الحبل السري وعوامل الاختطار المتعلقة باحمضاض الدم في الولدان في كرمان

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الخلاصة: أُجريت دراسة استباقية شاملة لجميع القطاعات، لتحديد العلاقة والقيمة التكهنية لباهاء pH دم الحبل السري في تحرِّي النتائج الضائرة على الولدان. شملت الدراسة 400 رضيع ناضج مفرد، وُلدوا ولادة مهبلية أو قيصرية في مستشفى كرمان بجمهورية إيران الإسلامية في عام 2001. كان باهاء pH دم الحبل السري الوسطي 7.25 ± 0.14، وكان هناك 81 حالة تعاني من احمضاض الدم (الباهاء أقل من 7.1). وكان حَرَزُ أبغار عند الدقيقة الأولى والضائقة الجنينية ذَوَيْ علاقة مهمة إحصائياً بالاحمضاض. كما لوحظت علاقة يُعْتَدُّ بها إحصائياً بين السائل السَّلَوي amniotic المتلون بالعِقْي meconium وبين احمضاض الدم. وبرهن التحليل التحوُّفي اللوجستي على أن حَرَزَ أبغار الأقل من 7 بعد دقيقة واحدة، والسائل السَلَويَّ المتلوِّنَ بالعِقيْ، والضائقة الجنينية، تمثل عوامل اختطار يُعْتَدُّ بها إحصائياً لاحمضاض الدم لدى الولدان. بمعنى أن التغيرات الحمضية القاعدية ذات علاقة بالنتائج الضائرة اللاحقة في الولدان.

ABSTRACT A prospective cross-sectional study was carried out to determine the relationship and predictive value of umbilical cord blood pH for adverse neonatal outcomes. A total of 400 singleton term infants delivered by vaginal delivery or caesarean section were studied at a hospital in Kerman, Islamic Republic of Iran, in 2001. Mean (SD) umbilical cord blood pH was 7.25 ± 0.14 and 81 cases had acidaemia (pH < 7.1). Apgar score at 1 minute and fetal distress were significantly related to acidaemia. There was also a significant relation between meconium-stained amniotic fluid and acidaemia. Logistic regression analysis showed that Apgar score < 7 at 1 minute, meconium-stained amniotic fluid and fetal distress were significant risk factors for acidaemia in newborn infants. Umbilical cord blood acid–base alterations are related to subsequent adverse outcome events for neonates.

Le pH du sang de cordon ombilical et les facteurs de risque d'acidémie chez le nouveau-né à Kerman

RÉSUMÉ Une étude transversale prospective a été réalisée en vue de déterminer la relation et la valeur prédictive du pH du sang de cordon ombilical pour l'issue néonatale défavorable. Au total, 400 accouchements uniques à terme par voie basse ou par césarienne ont été étudiés en 2001dans un hôpital à Kerman (République islamique d'Iran). Le pH moyen (E.T.) du sang de cordon ombilical était de 7,25 ± 0,14 et 81 cas présentaient une acidémie (pH < 7,1). Le score d'Apgar à une minute de vie et la souffrance foetale étaient significativement associés à l'acidémie. Il y avait également une relation significative entre le liquide amniotique teinté de méconium et l'acidémie. L'analyse de régression logistique a montré qu'un score d'Apgar inférieur à 7 à une minute de vie, qu'un liquide amniotique teinté de méconium et que la souffrance fœtale étaient des facteurs de risque d'acidémie significatifs chez le nouveau-né. Les altérations acido-basiques du sang de cordon ombilical sont liées à des évènements ultérieurs ayant une issue défavorable pour le nouveau-né.

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Introduction

Umbilical cord blood pH is the best available criterion for determining fetal hypoxaemia during labour and making decisions about necessary care after birth [*1,2*]. Considerable effort has been expended to determine risk factors and the role of intrapartum asphyxia for adverse neonatal outcome [*3*]. Hypoxaemia is an arterial partial oxygen pressure less than normal. Hypoxaemia associated with ischaemia causes hypoxic–ischaemic encephalopathy in the fetus, leading to permanent lesions of the central nervous system. This may result in fetal mortality or later problems of cerebral palsy and mental retardation [*4,5*]. Arterial blood gases and blood cord pH are useful for measuring the degree of asphyxia and are also good criteria for assessing the likelihood of neonatal asphyxia and cerebral palsy [*6*].

Based on different studies, mean values of umbilical cord blood pH range from 7.25–7.28 [*7*]. In a study of 19 000 neonates, an umbilical cord blood pH 7.04–7.1 was considered the extreme of the normal range and pH < 7.1 as acidaemia [*7*]. Severe acidaemia is one of the symptoms of hypoxaemia. Therefore, hypoxic cases can be identified by measuring the umbilical cord blood pH and if it is raised, high pressure oxygen should be deployed in order to prevent cerebral lesions [*4*].

Studies so far have shown increased risk of several adverse outcome events in the preterm infant with evidence of acidaemia at birth, but some authors have demonstrated that umbilical cord gases have little value in the determination of infants at risk of adverse outcome [*8*].

The aim of this study was to determine the relationship, and predictive value, of umbilical cord artery blood pH in relation to adverse neonatal outcomes.

Method

The present study was a prospective cross-sectional study from 1 May 2001 to 30 April 2002. A sample of 400 neonates born in the delivery ward of Nik-Nafs Hospital, Kerman, Islamic Republic of Iran, was taken by selecting every other child born during the period of the study. The sample size was based on a pilot study of 30 newborns with 17% prevalence of acidaemia and the maximum error of 5% was determined as 395 subjects.

After admission for delivery, informed consent was taken from the pregnant women and they were enrolled in the study with the following inclusion criteria: singleton pregnancy, no underlying disease and gestational age of 38–42 weeks. The mother's age, gestational age, gravidity and any history of high-risk pregnancy with its reason and symptoms were recorded.

Immediately after the delivery of the fetus, the umbilical cord was clamped at a distance of 15–20 cm and 1 mL of umbilical cord arterial blood was aspirated with a heparinized syringe and delivered on ice to the hospital laboratory. Umbilical cord arterial blood pH was measured by a blood gas analyser (AVL Compact) and pH < 7.1 was considered as acidaemia [*2,9–11*].

After delivery, the cardiac and respiratory status of the fetus were evaluated and fetal distress was noted (defined as late deceleration or repeated early and variable deceleration of fetal heart beat). Apgar scores at 1 and 5 minutes and the neonate's birth weight were recorded. Meconium in the amniotic fluid and consistency of the meconium (thick or thin) was visually assessed and noted. All these measurements were done by the same researcher using the same measuring instruments.

Chi-squared analysis was used to determine the significance of differences be-

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tween groups. *SPSS*, version 11.5 was used for the analysis. Odds ratios were used for studying the risk of acidaemia from the variables measured. The Mantel–Haenszel model was used for evaluating the significance of odds ratios. After calculating the meaningful odds ratios in order to remove confounding factors, analyses were repeated using a logistic regression model.

Results

The mean birth weight of neonates was 3.28 (SD 0.32) kg and mean umbilical cord blood pH was 7.25 (SD 0.1). The mean gestational age was 38.8 (SD 1.4) weeks. The range of Apgar scores at 1 minute was 5–9 and at 5 minutes 7–10. Of the 400 neonates, 81 had acidaemia (umbilical cord arterial blood pH < 7.1).

Neonate weight and gestational age had no significant relationship with acidaemia ($P = 0.5$). However, there was a highly significant relationship between 1 minute Apgar score and acidaemia as 68% of neonates with acidaemia had Apgar score < 7 at 1 minute whereas only 1% of those with normal umbilical cord blood pH had Apgar score < 7 at 1 minute (Table 1). This difference was also observed in Apgar score at 5 minutes; that is, 51.8% of neonates with acidaemia had Apgar score < 7 at 5 minutes, compared with only 0.6% in neonates with normal pH ($P < 0.0001$). The odds ratio showed that neonates with Apgar score < 7 at 1 minute had a risk of acidaemia 222.8 times higher than neonates with Apgar score ≥ 7 ($P < 0.0001$) (Table 2).

Fetal distress had a highly significant relationship with acidaemia ($P < 0.0001$) and the risk of acidaemia in neonates with fetal distress was 7.7 times higher than neonates without fetal distress (Tables 1 and 2).

There was no significant relation between rate of normal vaginal delivery or caesarean section and acidaemia (Tables 1 and 2), and in the cases of caesarean section, there was no significant relation between the type of anaesthesia (general or epidural) and acidaemia.

The presence of meconium in the amniotic fluid had a highly significant relation with neonatal acidaemia; the risk of acidaemia was 5.8 times higher in neonates with meconium-stained amniotic fluid than those with clear fluid (Tables 1 and 2). Moreover, the concentration of meconium had a direct relation with acidaemia. In the 69 cases with meconium-stained amniotic fluid, the risk of acidaemia in those with thick meconium was 12.5 times higher (Tables 1 and 2).

Among the variables studied, the Apgar score at 1 minute, fetal distress and meconium-stained amniotic fluid had a significant relationship with the risk of acidaemia. Logistic regression analysis showed that each variable in the presence of 2 other variables was a risk factor for the occurrence of acidaemia. Based on the Mantel–Haenszel test, Apgar score < 7 at 1 minute, fetal distress and meconium-stained amniotic fluid were significant risk factors for neonatal acidaemia.

Discussion

Arterial blood gases and umbilical cord blood pH are valuable measures for determining hypoxaemia and for evaluating the extent of asphyxia in the newborn infant. The pH of normal umbilical cord blood varies across different studies. In the present study the mean value of 7.25 ± 0.1 was the same as Arikan et al. (7.25) [*12*] but dif-

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Table 1 **Association between umbilical cord blood pH and adverse outcomes for 400 singleton term neonates**

Outcome	Umbilical cord blood pH			Yates corrected χ^2
	Acidic No.	Normal No.	Total No.	
Apgar score at 1 min				
< 7	55	3	58	
≥ 7	26	316	342	
Total	81	319	400	χ^2 = 228.26, df = 1, ***P*** < 0.0001
Fetal distress				
Yes	32	25	57	
No	49	294	343	
Total	81	319	400	χ^2 = 50.46, df = 1, ***P*** < 0.0001
Type of delivery				
Caesarean	16	71	87	
Normal vaginal	65	248	203	
Total	81	319	400	χ^2 = 0.11, df = 1, ***P*** < 0.736
Meconium-stained amniotic fluid				
Yes	34	35	69	
No	47	284	331	
Total	81	319	400	χ^2 = 41.35, df = 1, ***P*** < 0.0001
Concentration of meconium				
Thick	23	5	28	
Thin	11	30	41	
Total	34	35	69	χ^2 = 18.21, df = 1, ***P*** < 0.0001

df = degrees of freedom.
Acidic = pH < 7.1.

Table 2 **Odds ratios for variables associated with acidaemia in 400 singleton term neonates**

Variable	OR	95% CI	Mantel–Haenszel χ^2
Apgar score at 1 min < 7	222.8	61.1–962.4	χ^2 = 233.04, ***P*** < 0.0001
Fetal distress	7.68	4.03–14.7	χ^2 =52.89, ***P*** < 0.0001
Caesarean section	0.86	0.45–1.63	χ^2 = 0.24, ***P*** < 0.626
Meconium-stained amniotic fluid	5.87	3.22–10.73	χ^2 = 43.39, ***P*** < 0.0001
Thick meconium	12.55	3.37–50	χ^2 = 20.07, ***P*** < 0.0001

OR = odds ratio.
CI = confidence interval.

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fered from Ramin et al. and Yeomans et al. (7.28) [*9,13,14*]. This difference may be because Yeomans et al. excluded all cases with fetal distress, meconium staining, twin pregnancy and diabetic mothers [*9*], and Ramin et al. studied cases with meconium-stained amniotic fluid and preterm neonates separately [*13,14*]. Although neonatal umbilical cord blood pH varies according to different conditions, it seems that there is no difference in blood pH between term and preterm neonates [*10,12,14*].

As for the relation of umbilical cord blood pH and acidaemia with meconium in the amniotic fluid there is disagreement among different studies. Yeomans et al. reported a higher rate of acidaemia in cases of meconium-stained amniotic fluid, and suggested a weak correlation between meconium-stained amniotic fluid and umbilical cord blood pH [*11*]. Ramin et al. reported no significant difference between neonates with meconium-stained amniotic fluid and normal amniotic fluid in both mean umbilical cord blood pH and acidaemia [*14*]. In the present study acidaemia was 5.87 times more likely in neonates with meconium-stained amniotic fluid with than in those with normal amniotic fluid.

There was no significant relation between birth weight and acidaemia and this is in line with the results of other studies [*10,13*]. There was also no significant relation between gestational age and acidaemia, a finding that agrees with other studies [*10,12,13*].

In our study, there was no difference between neonates born by caesarean section and those born by normal vaginal delivery in the occurrence of acidaemia. In a study performed in the United States, the mean umbilical cord blood pH was 7.22 in neonates born by elective caesarean, 7.2 in neonates born by caesarean following previous normal vaginal delivery and 7.4 in neonates born by normal vaginal delivery following previous caesarean. This difference was statistically significant ($P < 0.04$) [*15*]. Another study concluded that the umbilical cord blood pH of neonates born by vaginal delivery from the breech position was lower than that for those born from the cephalic position ($P < 0.01$). This may be due to longer labour and the higher degree of pressure on the umbilical cord for a fetus in the breech position [*16*].

In our study, an Apgar score less than 7 at 1 minute was a high risk factor for the occurrence of acidaemia (OR = 222.8). Valentin et al. found a significant correlation between Apgar score and umbilical cord blood pH [*17*]. But Hankins et al. in a study conducted on neonates with corioamnionitis concluded that this infection was not a risk factor for the occurrence of acidaemia and in spite of lower Apgar score in this group in comparison to the control group, the Apgar score itself was not an accurate criterion for birth asphyxia [*13*].

According to the results of the present study, fetal distress, Apgar score of less than 7 at 1 minute and meconium-stained amniotic fluid are risk factors of acidaemia. Each factor independently increased the risk of acidaemia. Based on a logistic regression model, each of these factors in the presence of 2 others significantly increased the risk of acidaemia. We conclude that these factors can be used clinically to predict the risk of acidaemia, leading to better management of this condition in neonates.

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