

Association between Acid-Base Balance and Asphyxia in Newborn Infants

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ABSTRACT We performed a prospective study on the association between acid-base balance and asphyxia based on Apgar scores in 45 newborn babies admitted to the Division of Perinatology, Pirngadi Hospital, Medan, from January 1 to February 28, 1993. Blood gas analysis was done on blood obtained from umbilical artery. Based on 1st and 5th minutes Apgar scores, 40 (88.9%) and 21 babies (46.7%), respectively, had asphyxia. Relation to acid-base balance was determined with the sensitivity of the 5th minute Apgar score in predicting acidotic states. It was found that Apgar score had sensitivity of 57.7% and specificity of 68.4% in predicting the acidotic states. Apgar score of > 7 was unable to exclude the possible acidosis in 45% of cases (negative predictive value 54.1%). Gestational age had no influence on Apgar Scores. Apgar score was more sensitive to eliminate suspected acidosis in term neonates than in preterms. We recommend to perform umbilical arterial blood gas analysis to determine acidotic state in high risk newborn infants. [*Paediatr Indones* 1994; 34:38-43]

Introduction

Neonatal asphyxia is a state of failure in breathing spontaneously and regularly in the first minutes after birth. This is an emergency situation in which immediate management is important to protect the

neonates from death or illness.^{1,2} Hypoxia and hypercarbia will result in metabolic acidosis and respiratory acidosis.^{2,3} Analysis of blood sample obtained from umbilical artery to determine acidotic state in high and non-high risk newborns is routinely performed in many centers.^{4,5} However, some centers still use Apgar score to detect asphyxia.^{1,2,4}

Apgar score was first introduced by Dr. Virginia Apgar in 1952 and has been

considered as an effective method in the assessment of neonatal status.^{2,5} Recently, many studies have questioned the accuracy of Apgar score in detecting asphyxia in neonates. Some investigators have demonstrated that low Apgar score may not predict the presence of asphyxia. In other words, Apgar score is not sufficiently accurate in assessing the severity of resultant asphyxia.^{5,6} Conversely, other authors report a good correlation between acid-base balance and Apgar score in newborn infants.⁷

A number of reports suggest that Apgar score is influenced also by gestational age. More mature infants will produce better Apgar score, although the presence of asphyxia may not completely be eliminated.⁸⁻¹⁰

The purpose of this study was to assess the sensitivity of Apgar score in predicting acidotic state in neonates with asphyxia, and to find out the association between Apgar score and gestational age and its relation to acidotic state.

Methods

The study was done prospectively in all newborn infants admitted to the Division of Perinatology, Pirngadi Hospital, Medan, during two months (January 1, to February 28, 1993).

Apgar scores were measured at the first and fifth minutes after birth by the attending obstetrician. Airway suction and tactile stimulus were performed in all newborn infants. All asphyxiated neonates, based on the fifth minute Apgar score, were referred immediately to the Division Perinatology for follow up. Arte-

rial blood sample was obtained immediately before intervention, e.g., resuscitation or injections of drug or fluid. Half a milliliter of blood was obtained from umbilical artery by using a sterile non-pyrogenic 2.5 ml disposable syringe which had been cleaned by heparin. Blood sample was put immediately into an ice-box and sent to the laboratory. Blood gas was analyzed by using a Blood Gas Analyzer Corning 158, with the confidence level of 95%. Because the assessment could be done only at working hours, cases referred after hours were excluded. Samples were grouped according to Apgar scores of 1st and 5th minutes. Infants with Apgar score of less than 7 were assigned in the asphyxiated group, and those with score of more than 7 were assigned in the normal group. The relation to acidotic state was determined by Apgar score at minute 5. Acidotic state was determined by pH and base deficit as seen in the result of blood gas analysis; pH of less than 7.2 and/or base deficit of more than 10 mmol/L determined the acidotic state.

Gestational age was determined based on the last menstrual period, and subsequently confirmed by physical maturation. Gestational age of less than 37 weeks was regarded as preterm; 37-42 weeks as term, and more than 42 weeks as post term.

The accuracy of Apgar score in determining acidosis was represented by sensitivity, specificity, positive predictive value, and negative predictive value, with their corresponding 95% confidence intervals. Statistical analyses were performed using Chi square and Wilcoxon rank sum tests.

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Results

During the study period, 76 babies were referred to the Division of Pediatric Perinatology, Pirngadi Hospital, Medan. Of them, 45 babies (59.2%) were eligible for the study. In those 45 babies, significant difference was found between Apgar score of minutes 1 and 5 (Table 1). At minute 1, approximately 90% of the total infants had Apgar score of less than 7, while at minute 5, 21 (46%) infants had Apgar score of less than 7.

There was no significant difference in the method of delivery between asphyxiated or non-asphyxiated infants (Table 2). Most of deliveries (37.7%) were spontaneous, while Caesarean section ranked the second (35.5%). The birth weight and gestational age in group with Apgar score of 7 or more were relatively higher compared with those in group with Apgar of less than 7, but this difference was not statistically significant.

Table 3 shows that acidosis was found in 26 of 45 infants, giving the prevalence of 57.7%. Out of 21 infants with Apgar score of less than 7, 15 were acidotic ('true positive'), and 6 were not acidotic ('false positive'). Thirteen out of 24 infants with Apgar score of 7 or more were not acidotic ('true negative'), while 11 infants were acidotic ('false negative'). Thus the sensitivity of Apgar score in predicting acidotic state was 57.7%, while its specificity was 68.4%. The negative predictive value of Apgar score (54.1%) was lower than the positive predictive value (71.4%). In other words, the possibility of acidosis in a neonate could not be eliminated with sufficient confidence by the Apgar score of more than 7.

Table 4 discloses that low Apgar score was higher in preterm than in term infants, but the difference was not statistically significant.

The percentage of acidosis was higher in preterm (76.9%) than in term infants (53.1%). When we divided infants into preterm and term groups, it was found that values for preterm and term infants, respectively, were: sensitivity: 60.0 vs. 52.9%, specificity: 33.3 vs 73.3%, positive predictive value: 75.0 vs 69.2%, and negative predictive value: 20.0 vs 57.9%. Broad confidence intervals were observed in each value, however. See Tables 5 and 6.

Discussion

The association between asphyxia based on Apgar score and acidosis in neonates has been studied by Wahyoeningsih et al.⁷ In 11 newborn babies delivered with Caesarean section, they found the correlation between Apgar score and acid-base balance. However, their study did not describe how close the correlation was. Besides, they did not describe how sensitive the Apgar score could explain the acidosis in newborn babies.⁷

Sykes⁵ concluded that Apgar score was not accurate in detecting the degree of asphyxia in newborn babies, in addition to its failure in determining the severity of the acidosis. In their prospective study on 1210 newborns, they found 73% of babies with Apgar score of 7 or more at the 1st minute, and 86% at the 5th minute, suffered from severe acidosis. Only 21% of the babies with Apgar score of less than 7 at the 1st minute,

Table 1. Comparison between the proportion of asphyxia at first and fifth minute in 45 infants

Apgar score	First minute	Fifth minute
< 7	40 (88.9%)	21 (46.7%)
> 7	5 (11.1%)	24 (53.3%)
Total	45 (100%)	45 (100%)

χ^2 (Mc Nemar) = 8.65, df=1, $p < 0.05$

Table 2. Comparison between some clinical characteristics of asphyxiated and non-asphyxiated infants

	Apgar < 7		Apgar 7+	
	n = 21	n = 24		
Mode of delivery*				
- Spontaneous	8	9		
- Caesarean Section	6	10		
- Vacuum Extract	4	4		
- Manual Aid	3	3		
BW (g)**, Median	2,800	2,875		
GA age (wk)**, Median	38	39		

* $p > 0.05$ (Chi-square test); ** $p > 0.05$ (Wilcoxon rank-sum test); BW = body weight; GA = gestational age

Table 3. Accuracy of Apgar score to acidosis

Apgar score	Acidosis		Total
	Yes	No	
< 7	15	6	21
> 7	11	13	24
Total	26	19	45

Prevalence of acidosis = 57.7 %
Sensitivity = 57.7% (95%CI 36.9;76.6)
Specificity = 68.4% (95%CI 43.4;87.4)
Positive predictive value = 71.4% (95%CI 47.8;88.7)
Negative predictive value = 54.1% (95%CI 32.8-74.4)

Table 4. Relation between gestational age and Apgar score

Gestational age (wks)	Apgar < 7	Apgar > 7	Total
< 37	8	5	13
37-42	13	17	30
> 42	0	2	2
Total	21	24	45

$\chi^2 = 3.04$; df = 2; $p = 0.219$

Table 5. Accuracy of Apgar score to acidosis in infants of < 37 weeks gestational age

Apgar score	Acidosis		Total
	Positive	Negative	
< 7	6	2	8
7+	4	1	5
Total	10	3	13

Prevalence of acidosis = 76.9%
Sensitivity = 60.0% (95%CI 0.26;87.8)
Specificity = 33.3% (95%CI 8.4;90.6)
Positive predictive value = 75.0% (95%CI 34.9;96.8)
Negative predictive value = 20.0% (95%CI 5.0-71.6)

Table 6. Accuracy of Apgar score to acidosis in infants with gestational age 37-42 weeks

Apgar score	Acidosis		Total
	Yes	No	
< 7	9	4	13
7+	8	11	19
Total	17	15	32

Prevalence of acidosis = 53.1 %
Sensitivity = 52.9% (95%CI 27.8;77.0)
Specificity = 73.3% (95%CI 44.9;92.2)
Positive predictive value = 69.2% (95%CI 38.6;90.9)
Negative predictive value = 57.9% (95%CI 33.5;79.7)

and 19% at the 5th minute, had 'true-positive' severe acidosis. They used umbilical arterial blood immediately after birth for analyzing blood gas.⁵

With different approach, in this study we found that there was an association between Apgar score and acidotic state as seen from the positive predictive value of 71.4%, indicating that if the Apgar score was less than 7, then the possibility that a baby was acidotic was 71.4%. However, the negative predictive value of the test was low (54.1%). It means that the possibility of acidosis failed to be eliminated by Apgar score of more than 7 was 45.9%. The sensitivity and specificity of Apgar score were also low, namely 57.7% and 68.4%, respectively.

Goldenberg et al¹⁰ reported an association between gestational age and Apgar score. They found that the lower gestational age, the lower Apgar score, although the acid-base balance was normal. Catlin et al⁸ report similar results. They suggest that from five components of Apgar score, skin-color appearance is the weakest component that might cause the deviation of Apgar score in determining acidosis, especially in preterm infants. This is supported by Crawford and co-workers⁶ who demonstrate that all components, except skin-color appearance have a good correlation to acid-base balance.

In our study, we found that the proportion of asphyxia (Apgar score of less than 7) was greater in preterm (8/13) than in term (13/32); but the difference was not statistically significant. This might be due to the limited number of cases studied. The sensitivity of Apgar score in determining acidosis in both

preterm (60.0%) and term (52.9%) infants were not very different. However, Apgar score of 7 or more in term infants appeared to be better (specificity 73.3%, negative predictive value 57.9%) in eliminating the possibility of acidosis than that in preterms (specificity 33.3%, negative predictive value 20.0%). We did not determine the correlation between Apgar components and acid-base balance.

Although this study used a different approach, our results agree with the previous studies that Apgar score is insufficiently sensitive or specific in predicting the state of acidosis. There seemed to be only a weak association between acid-base balance and asphyxia as measured by Apgar score. Therefore, the interpretation of Apgar score must be done carefully. Careful clinical observation is necessary after birth, and if possible, blood gas analysis should be done.

All of our results, i.e. sensitivity, specificity, and predictive values had a broad 95% confidence intervals, however. This was due to the limited number of patients, especially in subgroup analysis. More studies involving sufficient subjects are recommended, before final conclusions could be established. With that deficiency in mind we tentatively conclude the following:

1. Apgar score seemed to be inaccurate in predicting acidosis in newborn infants. Apgar score of more than 7 was not sufficient to eliminate the possibility of acidosis.
2. The influence of gestational age to Apgar score is unclear.
3. Apgar score of 7 or more was better in eliminating the possibility of acidosis in term than in preterm infants.

4. Routine blood gas analysis should be done in high risk newborn infants.

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