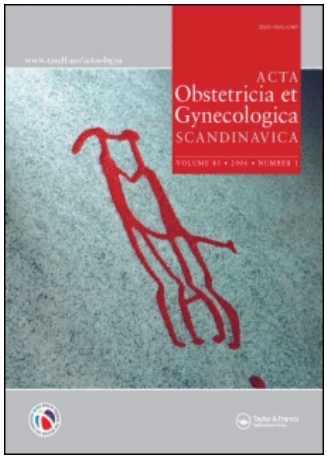

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Umbilical arterial pH levels after delivery and adult intelligence: a hospital-based study

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SHORT REPORT

Umbilical arterial pH levels after delivery and adult intelligence: a hospital-based study

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Key words: *Umbilical artery, pH, intelligence*

Introduction

The umbilical cord acid-base balance is widely used as a measure of fetal acidemia and the condition of the newborn. Routine measurement of the umbilical arterial pH has been recommended. Its clinical value, however, has been discussed controversially (1).

Various studies show severe fetal acidemia, i.e. an umbilical arterial pH <7, to be related to short-term neonatal morbidity and mortality. Only a few neonates, however, experience severe academia. Most neonates show umbilical arterial pH levels of ≥ 7. It seems reasonable to group these neonates into 2 categories: neonates with 'low normal' and those with 'normal' umbilical arterial pH levels. Few data are available regarding a potential cut-off value. Vandenbussche et al. suggested 7.12 as a cut-off value, separating the 'borderline' (7–7.11) from the 'normal' range (≥ 7.12) (1). To date, whether umbilical pH levels of >7 are associated with developmental outcome is unclear. The etiology of impaired intelligence caused by intrapartum asphyxia must be brain damage of hypoxic origin. In theory, severe hypoxia may occur at any time during delivery and may be of short duration, thus causing brain damage followed by a period of increased oxygen supply and a concomitant pH increase. In these situations, one would expect a correlation between the pH and later intelligence – even at subnormal and normal pH levels at the time of delivery.

Few studies have followed neonates to adulthood and correlated neonatal and/or perinatal parameters, i.e. Apgar scores, breastfeeding, etc., with adult intelligence (2,3). With respect to umbilical arterial pH, preliminary data suggest a 'dose-response' relationship between pH levels and intellectual outcome at early school age, i.e. the lower the pH, the worse the intellectual outcome (4). Whether umbilical arterial pH levels linearly correlate with intelligence is unknown. To the authors' knowledge, to date, no data are available linking umbilical arterial pH levels after delivery and adult intelligence. We, therefore, tested the hypothesis that umbilical artery pH levels ≥ 7 are correlated with adult intelligence.

Materials and methods

We performed a hospital-based study investigating the umbilical arterial pH levels of male newborns. We evaluated all male singleton births from 1 January 1983 to 31 December 1985 at the Department of

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Obstetrics and Gynecology, Landeskrankenhaus Bregenz, Bregenz, Austria. This hospital is a primary care facility serving a province in the Western part of Austria. Maternal and neonatal data were extracted from chart review. The local Institutional Review Board granted permission for this study. As clinical routine, two samples were taken from all umbilical cords; the lesser pH was seen as the umbilical arterial pH levels.

During the study period, a total of 1,907 male singleton neonates were delivered. Of those, 22 premature newborns <32 weeks were excluded, 89 had umbilical arterial pH levels <7, and 560 males were drafted elsewhere. Umbilical arterial pH levels in the males not drafted for unknown reasons or drafted elsewhere were not significantly different from the study group ($p = 0.8$). In total, 1,236 male newborns with umbilical arterial pH levels ≥7 were identified, who were delivered during the study period and attended the military draft at age 18. Neonatal and postnatal parameters were correlated with military draft reports at age 18.

In Austria, all males without severe mental or physical handicaps are required to appear before the draft board at the age of 18 years. The Austrian military uses various standardised tests assessing the draftees' performance on a Stanine scale (score range: 1–9, mean = 5) specifically designed to meet the needs of the Austrian military. The following parameters are investigated: overall performance, overall intelligence, technical understanding, concentration, operation accuracy, working speed, and eye-hand co-ordination. All available parameters on the socio-economic background, i.e. alcohol intake during pregnancy, smoking status during pregnancy, and parental social status were considered as possible confounders.

Values are given as means (SD). pH values were treated both as a continuous parameter and as dichotomous variables, i.e. 7–7.11 and ≥7.12. Parameters were compared using χ^2-test, Pearson's correlation analysis, and *t*-tests, where appropriate. A multivariate analysis was performed with 1-, 5-, 10-min Apgar scores, umbilical arterial pH levels, gestational week at delivery, and mode of delivery as independent parameters, and with all investigated performance parameters at age 18 as dependent parameters, *p*-values of <0.05 were considered statistically significant. For statistical analysis, we used the SPSS statistical software system (SPSS 11.0, SPSS Inc. Chicago, IL, USA).

Results

Mean maternal age at delivery was 28.9 (3.4) years. Some 83.1% of mothers were primigravidas at the time of the index delivery. Mean maternal weight at delivery was 72.2 (11.3) kg, and 9.4 and 7.3% of deliveries were cesarean sections and operative vaginal deliveries, respectively. Other maternal and neonatal characteristics broken down by umbilical artery pH are given in Table I.

The following performance parameters at age 18 were analysed: overall performance, overall intelligence, technical understanding, concentration, operation accuracy, working speed, and eye-hand co-ordination. Umbilical artery pH as a dichotomised variable, i.e. 7–7.11 versus ≥7.12, had no influence on any investigated outcome parameter (Table II). Furthermore, the following parameters were correlated with the investigated performance parameters at age 18: 1-, 5-, 10-min Apgar scores, umbilical arterial pH levels (continuous and dichotomised), gestational week at delivery, and mode of delivery. No significant associations were ascertained between any of these parameters and intelligence and performance status at age 18 in both a univariate and multivariate analysis.

Table I. Maternal and neonatal characteristics broken down by umbilical artery pH levels.

	Values		
Parameter	pH <7.12	pH ≥7.12	*p*
Gestational age at delivery (weeks)	39.7 (2.1)	39.8 (1.8)	0.8
Operative delivery rate (cesarean section, operative vaginal) (%)	27.8	13.7	0.03
Parity	1.1 (1.1)	1.1 (1.2)	0.6
% Of smokers in pregnancy	20	14.2	0.4
Birth weight (g)	3,442 (594)	3,453 (530)	0.9
Birth length (cm)	50.4 (2.7)	50.9 (2.3)	0.3
1-min Apgar score	7.1 (2.2)	8.4 (1.1)	<0.001
5-min Apgar score	9 (1.0)	9.7 (0.6)	<0.001
10-min Apgar score	9.5 (0.9)	9.9 (0.4)	<0.001

Values are given as absolute numbers or means (SD).

Table II. Intelligence performance parameters at age 18 broken down by umbilical artery pH values.

Parameter	Overall values	pH <7.12	pH ≥7.12	*p*
Overall performance	5.1 (1.8)	5.3 (2.1)	5.1 (1.9)	0.6
Overall intelligence	4.9 (1.8)	5.2 (2.0)	5.0 (1.8)	0.5
Technical understanding	5.0 (2.0)	5.1 (2.3)	5.0 (2.0)	0.7
Concentration	4.8 (1.8)	4.5 (2.1)	4.8 (1.8)	0.5
Operation accuracy	6.2 (1.9)	6.5 (2.3)	6.2 (1.9)	0.5
Working speed	3.9 (1.6)	3.9 (1.9)	3.8 (1.5)	0.7
Eye-hand co-ordination	5 (2.0)	5.5 (2.1)	5.0 (2.1)	0.3

Discussion

The measurement of the umbilical arterial pH after delivery is widely regarded as a more objective measure of neonatal well-being than the Apgar score (1). A low pH value is regarded as a reliable marker of fetal acidemia. Umbilical arterial pH levels are often seen as a benchmark for obstetrical care, and play an important role in obstetrical law suits.

In accordance with these perceptions, various studies demonstrated that severe acidemia, i.e. pH <7, is associated with an increased rate of neonatal morbidity. Few data, however, are available with respect to the clinical relevance of low normal and normal pH values (1). Preliminary data suggest that neonates with low normal pH values perform worse than controls (4). Such data, if confirmed in larger follow-up studies, might have the potential of changing obstetrical management. Therefore, we performed this present study investigating a series of more than 1,200 male Caucasians with umbilical value pH values ≥7. Interestingly, >80% of mothers were primigravidas at the time of the index delivery. This might reflect the increasing birth rate during the years investigated. Our data failed to show any association between umbilical artery pH levels and adult intelligence in all analysis performed. Furthermore, no linear correlation was noted between umbilical arterial pH levels and any investigated performance parameter.

Of note, our study has several limitations. (1) Draft records can be seen as relatively inadequate measure of adult intelligence. Data from draft reports have, however, been frequently used to measure intelligence and performance status in the absence of a more exact tool (3). (2) A scale from 1 to 9 can be seen as a crude measurement unable to detect subtle differences. (3) Our results are not corrected for demographic factors, such as education or single mother status. (4) Our study only includes male newborns. (5) Based on our study design, our study cannot compare 'borderline' and normal pH values to those <7. Of note, this was not the aim of the present study. (6) The test used by the Austrian military has been designed to serve its need and has not been scientifically validated. (7) In our series, we have a limited number of newborns ($n=37$) with low umbilical artery pH, i.e. <7.12. We can only hypothesise that, based on our data, a larger sample size would not yield different results. (8) Despite a relatively large sample size, a type II error cannot be fully excluded. Whether an even higher sample size could have shown significant results remains unclear. These shortcomings have to be kept in mind when interpreting the results of our study. The strengths of our study are the high number of participants, the long follow-up into young adulthood, and the ethnical and social homogeneity of the study population.

In conclusion, this is the first report investigating the association between umbilical arterial pH levels and adult intelligence. Our data fail to show an association between umbilical artery ≥7 and adult intelligence in a large series of male Caucasians. Our data argue against any long-term negative effects of low normal umbilical arterial pH levels. These data may have implications for the clinical relevance attributed to fetal acidemia and its weight in obstetric lawsuits.

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