Early Human Development (2008) **84**, 37–41

available at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/earlhumdev

The association between cord pH at birth and intellectual function in childhood

Elena Svirko [a], **Jane Mellanby** [a,*], **Lawrence Impey** [b]

[a] *Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD, UK*
[b] *Department of Fetal Medicine, John Radcliffe Hospital, Oxford OX3 9DU, UK*

Accepted 10 February 2007

KEYWORDS
Cord pH;
Non-verbal intelligence;
Reading;
Acidosis

Abstract

Background: Acidemia at birth is very common but little is known about its long-term consequences.
Aim: To determine if pH at birth is related to established tests of intellectual function.
Subjects: School children aged 6–8, for whom obstetric data were available, who had been delivered after labour at term, and had an umbilical cord arterial pH>7.00 (i.e. that was not extremely acidemic).
Study design/outcomes: Retrospective cohort study correlating birth and arterial pH data with childhood tests for non-verbal intelligence, grammar comprehension and literacy.
Methods: Relationships between pH and cognitive measures were analysed with parametric correlations. Partial correlations were used to examine these relationships, controlling for possible confounding factors.
Results: Arterial pH was significantly negatively correlated with literacy ($p=0.001$) and with non-verbal intelligence ($p=0.033$).
Conclusions: Lower arterial pH is associated with higher scores on literacy and non-verbal intelligence tests at ages 6–8. This is unlikely to be a chance finding and is further evidence that acidemia in isolation should not be considered an adverse outcome. Further research on the relationship between labour and long-term cognitive measures is required.

1. Introduction

The processes of pregnancy and parturition have long-term implications for both mother and fetus. However, many end-points in perinatal research are short-term and of little significance, such as Apgar scores or 'fetal distress'. Alternatively, research concentrates on risk factors for death or severe morbidity. There are few data on the association between pregnancy events and more subtle long-term outcomes.

These limitations apply particularly to hypoxia in labour. This accounts for a small, commonly over-estimated, though important percentage of severely handicapped children [1], yet its detection is the principal aim of intrapartum fetal monitoring, where scalp pH assessment is advised if electronic monitoring of the heart rate appears abnormal. If the scalp pH (capillary sample) is less than 7.20 'fetal distress' is diagnosed

* Corresponding author.
E-mail address: Jane.mellanby@psy.ox.ac.uk (J. Mellanby).

0378-3782/$ - see front matter © 2007 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.earlhumdev.2007.02.002

and immediate delivery is recommended; if the pH is less than 7.25, the sample should be repeated (NICE Guidelines; www.nice.org.uk). Deliveries for 'fetal distress' account for 22% of all caesarean sections in the UK [2].

In fact, severe neonatal sequelae appear to be increased only with an arterial pH level below 7.00 [3]. The vast majority, therefore, of babies delivered as an emergency for 'fetal distress' have an apparently normal outcome since the recommended threshold for intervention encompasses neonates with far less severe cord acidemia. Whether lesser degrees of acidemia have less immediate or subclinical long-term effects is largely unknown. Nevertheless, even mild acidemia is considered an adverse outcome and has even been used as such in clinical trials [4].

The aim of this study was to investigate whether intellectual achievement in early childhood is related to cord arterial pH at birth.

2. Methods

This is a retrospective cohort study of children who have undergone intelligence, literacy and grammar understanding tests, for whom obstetric data were available. The cohort constituted children who were involved in a longitudinal project in three Oxfordshire primary schools investigating factors that predict literacy development with a view to constructing future improvement and remediation programmes. Parental consent for participation was obtained. Children were assessed in years 1–3 (at ages 6–8). Approximately 90% of children entering year 1 of each school were tested, the exceptions being the result of children moving from the area or persistent illness or because the parents declined testing. The exact numbers of these excluded children are unavailable. The schools informed the parents of the study and obtained consent. The results of these tests were then cross referenced with the details of their births. Ethics committee approval for this was obtained in September 2005.

2.1. The tests of intellectual achievement

The assessments comprised tests of non-verbal intelligence (Naglieri non-verbal ability, NNAT) [5], grammar comprehension (Test for Comprehension of Grammar, TROG; [6]), and literacy (Wechsler Objective Reading Dimensions, WORD; [7]). The NNAT was performed at age 6–8 years. It is derived from Raven's Progressive matrices and mainly involves completing complex pattern grids from a choice of 5 possible pieces. TROG, assessed at age 5–7 years, uses a multiple choice pictorial format where the child has to select one of four pictures that illustrate a particular grammatical relationship given orally as a sentence. The WORD test was administered at age 6–8 years. It comprises 3 parts: single word reading, spelling (a list of words delivered orally in sentences), and a reading comprehension exercise (where specific questions are asked after reading a short text). With all three tests, the results are calculated as an age-standardized score.

2.2. Birth and cord data

In the local hospital, details of all deliveries from 1989 to the present day are prospectively recorded in a database (OXMAT). This includes obstetric and socio-economic data and cord gas analysis. The latter is performed in approximately 50% of deliveries: it is not usually undertaken at elective caesarean sections, deliveries outside hospital, or where the birth attendant is too busy. After determination of the children's hospital numbers, an anonymised copy of OXMAT was searched to see if details of their birth were recorded. All children tested were included in the analysis if their details, including cord pH values, were available.

Umbilical cord blood analysis is undertaken using a 1 ml heparinised syringe, withdrawing blood from the umbilical artery of a section of the cord that is clamped immediately after delivery of the baby. Analysis is performed immediately and entered directly by the midwife into OXMAT. The distribution of values in OXMAT corresponds to accepted and published ranges.

Socio-economic status was assessed at the time of delivery according to the Registrar General classification. Where two parents were coded, the higher one was used (Class: 1 = Professional, 2 = Managerial and Technical, 3 = Skilled, both manual and non-manual, 4 = Partly skilled, 5 = Unskilled. Class 9 = Armed forces. Members of class 9 were allocated to classes 1 to 5 according to the rank in the armed forces.).

2.3. Statistics

Analyses were carried out using SPSS 13.0. Kolmogorov–Smirnov tests were performed to test the normality of variables. All variables passed the normality assumption except WORD Reading scores and duration of labour. Appropriate transformations were performed on these measures to make them normally distributed. The transformed scores were used in the analyses.

Relationships between cord arterial pH and cognitive measures were analysed with parametric correlations. Partial correlations were used to examine these relationships, controlling for possible confounding factors. Simple regressions were performed to determine how cord arterial pH predicts different aspects of literacy.

3. Results

Results of at least one of the three educational tests were available for 563 children. Approximately half had data available in OXMAT (Table 1). Eleven births were excluded because the gestation was earlier than 36 weeks; a further 13 were excluded because they had been delivered by elective, pre-labour caesarean section. Of the remainder, approximately half of the children had cord pH data available. This corresponds with the 50% cord gas collection rate in OXMAT. Cord data were available for 116, 113 and 87 children undergoing TROG, NNAT and WORD respectively. The mean cord arterial pH value was 7.20 (range 6.86 to 7.37; SD 0.090). Children tested had similar scores irrespective of whether their details were in the database (Table 1), but if cord analysis was not taken the mean (total) WORD scores were slightly higher.

Including those children with an arterial pH$<$7.00, there was a significant negative correlation between increasing cord gas arterial pH and literacy, as measured by WORD test.