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Umbilical Cord pH is Associated With Infant Cardiac Psychophysiology

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Abstract

A prospective longitudinal study relating obstetric factors to persisting heart rate alterations in infants was performed. 101 mature AGA - infants were examined at two weeks, two months, four months of age. Basic heart rate and short-term heart rate variability were assessed at each appointment. Infants delivered by caesarean section did not differ psychophysiological from infants delivered spontaneously. Infants with lower umbilical pH. however, showed a consistently higher heart rate (p=0.01) at 4 months postnatal, also, they had a lower short-term heart rate variability (RMSSD) (p=0.006).

The results are discussed in view of the data existing for chronic placental dysfunction causing persistent alterations in infant heart rate, indicating that not only infants small for gestational age, but also infants suffering from acute perinatal hypoxia may be at risk of developing a metabolic syndrome or developmental alterations associated with persisting psycho-physiological disturbances.

Keywords: Child Cardiac Physiology; Perinatal Hypoxia; Umbilical Cord

Introduction

Recent research shows associations between prenatal stress, cortisol and infant temperament [1-2]. As well as pre- peri and postnatal complications [3]. Furthermore, a correlation between child temperament and cardiac activity has been reported [4-5]. Basic foetal and infant cardiac activity provides indexes of both parasympathetic and sympathetic activity [6]. Several investigators have reported minimal preservation of variation in cardiac measures over the first months of life [7-8]. Others reported a general enhancement of parasympathetic tone and a decrease in sympathetic activity [9-10]. Also described some stability of cardiac measurers over the first months of life. Madison and Coworkers identified a stability of heart rate from 30 weeks' postconceptional age to 3 weeks postpartum. Infant cardiac activity has recently been proposed to predict infant temperament and behavioural inhibition [11-12]. As it se ems to indicate sympathetic arousal, thereby reflecting individual differences in stimulus reactivity. Infants with higher heart rate at the age of 6 weeks generally seem to be more apprehensive and avoidant towards novel stimuli Vice versa short-term heart rate variability has become a marker of vagal tone and parasympathetic activity and is also being discussed as an indicator of infant emotion regulation, with higher heart rate variability reflecting higher vagal tone and a better capacity for self-regulation and a more stable and positive mood in infants [13-14]. Lowered short-term heart rate variability also seems to be associated with aversive reactions towards novel stimuli [15]. Moderate Stability of vagal tone over the first years of life has been reported [16]. The common denominator of behavioural and autonomic data seems to be located in the CNS [17]. argues for the critical influence of the amygdala and its projections to motor and autonomic sites via hypothalamus, striatum, central grey and medulla. It has been postulated that infants differ in the reactivity of these limbic sites that monitor cardiac and motor responses. So far these differences have been attributed to temperamental or dispositional genetic tendencies [18]. In short, beat to beat intervals of infant heart rate and time-domain analysis of its variability seems to be a relevant indicator of autonomic balance. Autonomic balance itself is controlled by limbic sites and is also related to infant behaviour and emotionality, underlining the necessity to analyse the factors influencing infant heart rate and heart rate variability as factors potentially being relevant for behavioural development. In light of the facts, that cardiac physiology as a marker of autonomic balance is strongly related to infant emotionality and behavioural reactivity, it seems crucial to address the question whether autonomic balance can be influenced by external factors. Field and co-workers [19].

provided evidence of a more rapid and less variable heart rate in neonates and older infants of depressed mothers, indicating an autonomic shift toward a sympathetic activation. So far, it has been impossible to empirically differentiate, whether this activation is a reaction to an environmental stress (maternal depression) or a genetic trait.

Another string of research has confirmed persistently elevated heart rate as a consequence of sympathetic arousal in infants born small for gestational age and related this to the risk of developing a ,metabolic syndrome with higher blood pressure [20-24]. elevated blood sugar and heart rate potentially resulting in cardiac disease and diabetes (Barkers Hypothesis). As cognitive disturbances in SGA-Infants have never been identified and emotional development in these children so far has not been consistently analysed, to date the psycho-physiological alterations seem to be the only obvious consequences of intrauterine malnutrition resulting from chronic placental insufficiency. So far the explanation for this phenomenon is derived from malnutrition causing altered glucose tolerance and a basic state of ‚stress ‘manifesting itself by the cardiac alterations described above.

Prenatal stress and its impact on human infants receive increasing scientific attention in recent years. The foci of primary interest are attentional organization [25-27], temperament and developmental consequences affecting infant growth [28-30]. As foetal stress seems to be the cause of psycho-physiological alterations not only chronic placental dysfunction but also other conditions resulting in foetal distress might bear the risk of resulting in a persistently altered cardiac physiology [31]. The existence of these findings and the postulate, that autonomic balance is a marker of infant behaviour leads to the postulate that prenatal events could potentially influence infant and toddler behavioural development as well.

Therefore, the question whether pre- and perinatal events less severe and more common than chronic placental dysfunction or acute asphyxia might also influence autonomic balance seems to be of crucial importance, since autonomic balance has been identified as a major influence on physical and behavioural development. A deeper understanding of all the factors influencing infant personality seems to be mandatory in order to establish efficient preventive strategies e.g. by parent counselling. The hypothesis analysed in this longitudinal study was whether higher infant basic heart rate, lower short-term- heart rate variability or slower cardiac habituation might contribute to infant anxiety disposition and could therefore be a relevant factor for infant behavioural development. This hypothesis seems to be of crucial relevance regarding the necessity to further understand regular early infant development and the earliest origins of psychopathology. In this study 101 mother infant pairs were examined starting from “2 weeks until 14 months” postnatal age. Basic infant heart rate and heart rate variability and habituation to an acoustic stimulus was assessed via ECG at 2 weeks, 2 months, 4 months and 14 months. Maternal heart rate, heart rate variability and habituation was measured when infants were 2 months of age.

Methods

Subject

The sample consisted of 101 mother-infant pairs born to a volunteer sample of healthy Caesarean mothers recruited through the four major local obstetric units. The women were between the ages of 25 and 45 (M=33,3 years) None smoked or drank more than an occasional glass of wine or beer during pregnancy and all had full-term deliveries. Infants were above 2500 grams of weight in order to exclude SGA-infants. Medium infant weight was 3497 grams. APGAR-Scores were above 7 and the third APGAR-Score had to be nine at least in order to exclude severe perinatal asphyxia. 45% of infants were girls. 81 percent of mothers had a college degree, 19% a high school degree. All mothers were in a partnership with the infant’s father. The subjects were seen in the laboratory when the infant was 2 weeks, two months, four months and fourteen months of age.

Procedures for Cardiac Variables

In study 1 Mothers came to the laboratory when their infants were fed and rested. Electrodes were applied to the infant’s chest. A bio bench psycho-physiological monitor was used to collect the infants ECG during a quiet baseline episode. A cardiac waveform was digitized and recorded every millisecond. Post-processing software extracted the inter beat intervals by identifying a parameterized sequence of waveform features. The mean heart period and heart period standard deviation were calculated. Standard deviation was assessed by calculation of standard deviation of the mean of heart period over a period of 1 minute (SDNN) or as the mean of standard deviation of adjacent intervals over a period of 1 minute (RMSSD) in order to obtain two different indexes of parasympathetic activity.

Results

Umbilical Cord pH

Mean umbilical cord pH of the total sample was 7,270. In infants delivered by primary (planned) caesarean section umbilical cord pH was highest, while infants born via forceps or vacuum extraction had the lowest umbilical cord pH as an indicator of their perinatal hypoxia. For the relationship between birth modalities and cardiac activity in the first 4 months see (Table 1) No significant

associations were found. Assessment of the association between umbilical cord pH and early infant heart rate rendered a significant result insofar, as umbilical pH predicted a significantly lower basic heart rate as well as a higher RMSSD. The results were calculated by Spearman Rank Correlation and are shown in (Table 2).

	2 Weeks		6 Weeks		4 Months	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Spontaneous						
Heart rate	147,7	13,4	149,3	14,4	144,7	11,6
RMSSD*	10,0	6,3	9,1	5,3	10,4	5,5
SDNN*	24,5	12,4	22,1	11,5	22,2	8,9
Vacuum						
Heart Rate	131,6	19,8	145,7	8,5	138,8	4,6
RMSSD*	22,4	17,9	7,6	1,9	11,2	4,3
SDNN*	53,7	19,4	13,4	4,4	24,5	12,1
C-section						
Heart rate	144,8	11,8	151,7	14,3	147,4	11,0
RMSSD*	12,1	7,6	7,8	4,04	9,5	4,1
SDNN*	26.9	10,9	19,2	10,3	20,4	7,9
*RMSSD= Root Mean Square of Successive Differences, *SDNN= Standard Deviation of NN-Intervals.						

Table 1: Means and SD of heart rate and heart rate variability at two and six weeks in children delivered spontaneously, by vacuum extraction and by C-Section.

	2 Weeks		6 Weeks		4 Months	
	Corr	p	Corr	p	Corr	p
Umbilical pH						
Heart rate	-0.21	0.01	-0.16	0.05	-23	0.01
RMSSD*	0.19	0.02	0.17	0.04	. 24	0.005

Table 2: Means and SD of heart rate and heart rate variability at two and six weeks as well as 4 months in children in association with umbilical pH.

Conclusions

Perinatal hypoxia as measured by umbilical cord pH can have longer lasting effects on child physiology until at least 4 months postnatal. Further studies on this relationship are warranted.

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