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Early exposure to maternal voice: Effects on preterm infants development

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ABSTRACT

Background: Preterm infants complete their development in Neonatal Intensive Care Unit being exposed to environmental stimuli that lead to the early maturation of the sensory systems. It is known that the fetus perceives sounds and reacts to them with movements since the 26th–28th week of gestational age. Maternal voice represents a source of sensory stimulation for the fetus.
Aims: To investigate the effect of the exposure to maternal voice, administered by bone conduction, on preterm infants autonomic and neurobehavioral development.
Study design: Longitudinal, explorative, case control study.
Subjects: 71 preterm infants with birth weight <1500 g, born adequate for gestational age Outcome measures: vital and neurobehavioral parameters at term, neurofunctional assessment at 3 and 6 months of corrected age.
Results: Infants in the treatment group had lower heart rate values and a higher proportion of stable skin color at each study point as compared to the control group. The scores in the visual attention performance and in the quality of the general movements at term were better in the treatment group than in the control one. Neurofunctional assessment score at 3 months of corrected age was higher in the treatment group whereas no difference between the two groups was detected at 6 months of corrected age.
Conclusions: Early exposure to maternal voice exerts a beneficial effect on preterm infants autonomic and neurobehavioral development.

1. Introduction

During intrauterine life the fetus experiences an extremely rapid cerebral growth and neurosensorial maturation. The quality of the experiences undertaken before birth may influence the fetal neurological development both in terms of structural and functional modifications.

Preterm infants are at high risk for developing adverse short and long-term developmental outcomes [1,2]. Disorders have been linked not only to the immaturity of the cerebral structures but also to the sudden interruption of the physiological development of cerebral structures due to preterm birth [3–5]. Preterm infants actually complete their development being exposed to continous adverse environmental stimuli (light, noise, electromagnetic fields, drugs, inadequate manipulations, temperature etc.) during hospital stay [6–9]. Indeed Neonatal Intensive Care (NICU) environment largely differs from that of the protective womb. In addition, the preterm infant is much more sensible and vulnerable than the term one. With regard to the development of the auditory system, exposition to NICU stimuli has been reported to cause an advanced progression of the infant's sensory systems maturation and to deeply affect the cortex functional organization [10].

It is widely acknowledged that the fetus perceives sounds and reacts to them with movements since the 26th–28th week of gestational age (GA) [11]. The sounds perceivable in the environment of a pregnant woman penetrate the tissues and fluids surrounding the fetal head, stimulating the inner ear through a bone conduction route [12]. The sound pressure into the amniotic fluid induces skull vibrations which are transmitted directly into the contents of the cranial cavity and from there into the cochlear fluids, presumably by fluid channels connecting them [13]. It can be therefore speculated that the exposure of preterm infants to maternal voice through bone conduction may mimic the prevalent method of operation of the fetal auditory system.

Developmental Care (DC) is any NICU intervention undertaken to improve neurodevelopmental outcome. It includes NICU design,

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nursing routines, nursing care plan, management of pain, feeding methods and parental involvement [14]. DC aims to provide an extrauterine environment which positively supports and influences the newborn development [15]. Indeed early interventions may significantly influence the well-being of the infant and his/her parents, reducing the negative effects of prematurity [2].

Maternal voice represents a unique source of sensory stimulation for the fetus and exerts a positive acustic stimuli for its correct development. The exposure to maternal voice within preterm infant's sound environment may therefore contribute to provide the infant a more comfortable and secure surrounding. Few studies addressed the effect of the exposure to maternal voice on preterm infant's development reporting inconsistent results. Some authors did report potentially positive developmental effects (i.e. the development of more adaptative responses such as a greater decrease in heart rates and higher oxygen saturation rates) whereas other did not [16–21].

To our knowledge, there are no data available concerning the effect of the exposure to maternal voice administered by bone conduction on preterm infants development.

The aim of the present study was to investigate the effect of the exposure to maternal voice, administered by bone conduction, on preterm infants autonomic and neurobehavioral development. The hypothesis to be tested was that preterm infants exposed to the stimulation of maternal voice would show better autonomic and neurobehavioral parameters during the intervention period and a better neurobehavioral performance during the first six months of corrected age (CA) than preterm infants that have not been exposed to maternal voice.

2. Materials & methods

We conducted a prospective, longitudinal, explorative, case control study. Infants were scheduled to be prospectively followed up to the sixth month of CA. CA was calculated, up to 24 months of life, from the chronological age adjusted for gestational age that is, for the number of weeks different from the expected 40 weeks.

The study design was approved by the departmental ethics committee and written informed consent was obtained from all the infants' parents.

3. Study population

Of all the 405 consecutive infants admitted to NICU, Fondazione IRCCS, Ospedale Maggiore Policlinico, between 2008 and 2012, 87 infants entered the study. The inclusion criteria were: birth weight (BW) <1500 g, being adequate for gestational age (AGA; birth weight ≥10 percentile according to Fenton's growth chart) [22], spontaneous breathing with saturation >=95%, heart rate (HR) between 140 and 170 bpm during the last 48 h, normal cerebral ultrasound. The exclusion criteria were the presence of major congenital malformations, severe neurosensorial deficits (i.e. retinopathy of prematurity, hypoacusia), gastrointestinal, brain and cardiac diseases, chronic lung disease, infections. Infants were enrolled when they had achieved 29 weeks of GA. The enrolment period lasted 5 years due to the strict elegibility criteria of the study protocol that allowed the enrolment of around 15 infants per year.The reason for choosing such strict elegibility criteria relied on the fact that we aimed to explore the effect of the exposure to maternal voice on infants not affected by pathologic conditions that could per se negatively affect the autonomic and neurobehavioral development.

For each infant enrolled to receive the intervention, the next consecutive infant, matched for BW (±100 gr) and GA (±1 week), that fulfilled the inclusion criteria was enrolled as control.

Infants belonging to the intervention group underwent three sessions of exposure to maternal voice recorded in agreement with the American Academy of Pediatrics [23,24] that recommends the following safe sound levels within the NICU: hourly leq of 50 dB; hourly L10 of 55 dB; and 1-second duration Lmax < 70 dB. The passages were played back at 48 dB. Intervention took place daily and lasted 21 days for each infant. A neurobehavioral observation per day during one of the three sessions was also performed. We decided to perform the neurobehavioral observation in the evening time, when the NICU noise levels were lower.

Infants belonging to the control group were not exposed to maternal voice. However, they also underwent one neurobehavioral observation session in the evening time during which the vital parameters were collected (see paragraph below).

Enrolled infants, both in the intervention and in the control group, further underwent a follow up neurobehavioral assessment at 40 weeks, 3 and 6 months of CA.

According to our internal nutritional procedure, enrolled infants, both in the intervention and in the control group, were on continuous enteral feeding. Parents were allowed to come into NICU 24 h/24.

3.1. Intervention procedure

Intervention procedure started at GA between 30 and 32 weeks. Three sessions were performed daily (every eight hours). A transducer Oticon model BC461 bone conductor (BC461, 116Ω, 8.8 mH @ 1 kHz, mechanicaly unloaded, 13Ω DC), device that converts an electrical signal of low frequency in a magnetic vibration, was applied to the wrist of every infant of the intervention group in order to restore the perception of sound through bone conduction [25–27]. The reason for choosing the wrist rather than the skull relies on the fact that its application is more accessible and easy in the premature newborn. The mother's voice was trasmitted through the transducer while reading passages of the “Little Prince” by Antoine de Saint Exupéry. The voice was filtered according to the method by A. Tomatis [28,29] using a system composed of two equalizers (mod. dbX Graphic equalizer 1231) in which the deep frequencies had been attenuated by 60 dB, preserving those superior to 6000–8000 Hz. High frequencies were preserved in order to reproduce the original characteristics of maternal voice as perceived in the womb. We applied the protocol for infant's observation at the beginning, in the middle and at the end of the intervention procedure.

3.2. Parameters collected during the intervention period

For each child the following parameters were collected from medical records: GA and BW, weight at term, days of hospitalization, week of achievement of spontaneous suckling and independent feeding.

3.2.1. Vital parameters

HR and oxygen saturation (SpO_2) of enrolled infants were monitored continuously.

For analysis, HR and oxygen saturation (SpO2) of infants in the intervention group were recorded over 1 minute during one of the three listening sessions of the day at three different stages: at the beginning (before exposure), in the middle (15° min) and at the end of intervention (30° min). The same parameters were collected for every infant belonging to the control group.

3.2.2. Neurobehavioral and autonomic parameters

Neurobehavioral assessment investigated the presence of tremors and changes in skin color and the quality of spontaneous motor activity. According to item 56 of the Neonatal Intensive Care Unit Network Neurobehavioral Scale (NNNS) [30], tremors were defined as “absent” (score = 1, 2 or 3), “occasional” (score = 4, 5 or 6) and “frequent” (score = 7, 8 or 9). Spontaneus motor activity was defined as “poor” (score = 1 or 2), “good” (score = 3, 4 or 5) and “hyperkinetic” (score = 6), according to item 54 of the NNNS. Changes in skin color were defined as “mottling”, “cyanosis” and “paling” according to item 58 of the NNNS. The behavioral states using Prechtl's grading [31] were recorded. For analysis, active awake state and quiet awake state were grouped and named “wakefulness”.