The effect of ambient noise in the NICU on cerebral oxygenation in preterm neonates on high flow oxygen therapy

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ABSTRACT

In this early pilot study, we sought to determine if the alteration in these physiologic effects in premature infants in response to ambient noise in the NICU could be assessed evaluating cerebral blood saturation. Three premature infants, on high flow nasal cannula oxygen support (HFNC), at less than 34 weeks of gestation were included in the study. Three variables were used to evaluate sound levels due to AAP and EPA guidelines; Leq,1h, L10,1h and Lmax,1min.

All of the patients studied were found to be exposed to statistically significant noise levels (above recommendation) throughout all of the time periods measured. Noise levels were found to be similarly elevated during the 1 am and 3 pm time periods as well, though not as much as compared to the 7 am measure. A statistically significant difference was found within every patient’s rSO2 levels in both hemispheres, but also in the absolute differences of rSO2. Positive significant statistical correlations were found between the average rSO2 and Leq,1h (p=0.14), Lmax,1min (p=0.18), L10,1h (p=0.15). Significant negative correlations were found between the absolute difference levels and Lmax,1min (p=0.3), and L10,1h (p=0.18). This data highlights the need for further study as to the potential impact of noise on the cerebral physiology of premature infants. Further research is needed to assess the potential long-term side effects of environmental noise on the premature infant’s brain.

Key words: noise, infant, new-born, neonatology, noise measurement

INTRODUCTION

Throughout their lifetimes, humans interact with their environment. The in utero foetus is well protected by the womb and experiences low frequency sounds (as the womb has a protective and adaptive function), meaning full term infants have the opportunity and possibility to identify the maternal voice against background sounds. In such a nurturing and confined environment, they achieve proper neurosensory development. (1) In contrast, the premature infant, prior to 37 weeks of gestational age, spends their first months in the Neonatal Intensive Care Unit (NICU) environment, which is often a harsh, invasive and noisy environment at a time of physiologic immaturity, making them especially vulnerable to NICU environmental stress that can often continue. (2) They also have an increased need for long term intensive care, which makes them more sensitive to the negative effects of the NICU. (1) According to its definition, noise is undesirable sound and sound is vibration in a medium, usually air. When these vibrations occur at high levels sound may become harmful. “Level of sounds are characterized by intensity, loudness, frequency, periodicity and duration; the loudness of sound can be measured in units called decibels (dB).” (1) The United States (US) Environmental Protection Agency (EPA) recommends sound levels for hospital environments at a maximum of 45 dB during daytime hours and 35 dB during night time hours. Additionally, to protect the wellbeing and health in hospitals, the American Academy of Pediatrics (AAP) Sound Study Group established criteria for noise in the NICU, recommending that overall continuous sound in bed space and patient care area should not exceed an hourly loudness equivalent (Leq,1h ) of 45 dB(A), hourly sound levels should not exceed 50 dB(A) 10% of the time (L10,1h) and should not exceed one-second maximum level (Lmax,1min) of 65 dB(A) [3]. “These recommendation have been reviewed and endorsed by the Council of International Neonatal Nurses as well as the Institute for Family Centred Care.” (1) Despite these recommendations, previous research has shown that NICUs and Intensive Care Units sound levels frequently exceed the EPA and AAP recommended
Although there is a similarity to pulse oximetry, NIRS technology is used to monitor regional oxyhaemoglobin and deoxyhaemoglobin oxygenation through the measurement of light. It is used to assess microcirculatory tissue transparency to near-infrared non-invasive technique relying on the relationship between light absorption and tissue oxygenation. Near infrared spectroscopy (NIRS) is a developmental or neurological delays. (8)

Noise in cerebral oxygenation, going from sleep to wake, periods of apnoea. (7) Noise can also contribute to cochlear damage, especially since the capability of shutting down the sensory surface.

Negative effects of increased sound levels can have long implications for the neonate, especially since the capability of shutting off of environmental stimuli differs between premature and full-term infants. Previous research studies have shown that premature infants change their behavioural state in response to noise. Environmental noise can cause agitation and be a major source of stressful stimulations. (6) The preterm infant is more likely to abruptly fluctuate of blood pressure, heart rate, respirations, oxygen saturation, decreases in cerebral oxygenation, going from sleep to wake, periods of apnoea. (7) Noise also can contribute to cochlear damage, language and hearing delays. Often these conditions result in behavioural changes that can be detected long after discharge as developmental or neurological delays. (8)

Near infrared spectroscopy (NIRS) is a non-invasive technique relying on the relative tissue transparency to near-infrared light. It is used to assess microcirculatory oxygenation through the measurement of oxyhaemoglobin and deoxyhaemoglobin concentrations. Cerebral oximetry is based on NIRS technology to monitor regional cerebral oxygen saturation (rsO2). (9, 10) Although there is a similarity to pulse oximetry, cerebral oximetry monitors measures the nonpulsatile signal component reflecting tissue circulation. (11) A great advantage of NIRS monitoring is in producing real time data at the bedside, which allow continuous monitoring of the changes in cerebral oxygenation. In the paediatric population, a promising use has been found in various surgical and anaesthesiology procedures, monitoring neurodevelopmental outcomes etc. (12-16)

In this early pilot study, we sought to determine if the alteration in these physiologic effects in premature infants in response to ambient noise in the NICU could be assessed evaluating cerebral blood saturation.

The aims of the study are stated in the following hypotheses:

1. Premature infants are exposed to elevated levels of noise beyond standard recommendations
2. Elevated noise levels in the NICU will result in changes in rsO2, indicating increased stress to the child

MATERIALS AND METHODS

Our research was accepted by our institution’s ethical committee, and informed consents were obtained from all research participant’s parents or guardians. This pilot study is a part of an ongoing larger project on the effect of noise on premature infants. Three male premature infants, on high flow nasal cannula oxygen support (HFNC), born with less than 34 weeks of gestation were included in the study. A brain ultrasound excluded congenital brain malformations. The first subject was a premature infant born with 29 +5 weeks of gestation, birth weight 1,395 g and APGAR 10/10. The other two were twins, gestational age of 33 weeks, APGAR score 6/6, birth weight 2,466 g, and 1,994 g, APGAR score 2/6, respectively. The study was performed in the NICU of the Paediatric Clinic, University Hospital in Osijek. All infants were in the same incubator model Dräger Caleo.

Sound was measured using sound meter Brüel & Kjær, Denmark, model 2250 L. The instrument was certified to meet the specification of the manufacturer and was calibrated in a controlled environment using a standard with values traceable to the National Institute of Standards. The sampling rate of noise collection was 10 seconds, which were further averaged to achieve one minute data. Readings were taken using A-weighted levels and slow meter responses, a procedure that filters sound according to the frequency response of a human ear, which helps the sound meter recording to map more closely the sound pressure.

The study protocol required that sound levels be measured for 24 hours. For this study purpose, three different time intervals lasting one hour were chosen for analysis. The first time period was the one with the most intensive work, at the beginning of the day shift, between 7 AM and 8 AM. The second one during the early afternoon between 3 PM and 4 PM, and the third one during the night hours between 1 AM and 2 AM.

Three variables were used to evaluate sound levels due to AAP and EPA guidelines. The first variable Leq,1h , measures the steady state dB(A) noise during a 1-hour period. Leq,1h measures the dB(A) sound level that is exceeded 10 percent of the time over the upper limit of the set range during a 24-hour period. Lmax,1min measures the maximum sound level of one second duration during a one minute period.

To monitor the cerebral oxygenation, a INVOS 5100c (INVOS oximeter, Covidien Corporation, Boulder, CO) was used. INVOS is device which allows non-invasive monitoring placing sensors to the skin surface. The obtained values were recorded every 6 seconds, which were further averaged for a 1 minute time interval to allow a consistent analysis with the sound levels data.

The data was analysed with the R software (www.r-project.org). The normality of the distributions of numerical variables was assessed using the Kolmogorov Smirnov test. If the data did not meet the assumption of normality, the values were descriptively presented with median and interquartile range. Differences between more groups were assessed with the Friedman’s and Kruskal Wallis test, followed by Tukey’s post hoc test. The Spearman’s rank correlation test was used to test the associations between variables. P values less than 0.05 were considered statistically significant.

RESULTS

The first objective of this research was to assess different noise levels and brain oximetry in premature children according to three different time levels. The results of our findings are summarized in Tables 1. and 2. All of the patients studied were found to be exposed to statistically significant noise levels (above recommendation) throughout all of the time periods measured. The medians of the highest Leq,1h...
Further analysis was to assess the correlations between noise levels and rSO2. Positive significant statistical correlations were found between the average rSO2 and Leq1h (p=0.014), Lmax1min (p=0.18), and L10,1h (p=0.15). Significant negative correlations were found between the absolute difference levels and Lmax1min (p=0.03), and L10,1h (p=0.18). (Table 2.)

**DISCUSSION**

The aim of an NICU is to provide an environment that replaces the womb as much as possible, and insure optimal conditions for normal development. According to previous research, the sound levels in NICUs are above recommended standards. (17) The purpose of this study was to examine noise levels during day and night shifts, and to evaluate the impact on cerebral physiology. We hypothesized and found a significant relationship between environmental noise and cerebral oximetry. The main findings of this study would suggest that there is a positive correlation between noise levels and brain oximetry. All variables Leq1h, L10,1h and Lmax1min were above recommended standards suggested by the AAP and EPA. We can assume that Leq1h exceeded the recommended <50 dB(A) at 7 am because that is the time of nursing and physician reports. Precedent work monitoring cerebral oxygenation has been done on infants undergoing extracorporeal membrane oxygenation, cardiac surgery and resuscitation. To our best knowledge, this is the very first study relating cerebral oxygenation and environmental noise in the NICU. Elevated brain oximetry is an indirect measure of increased brain blood flow and
may be an indication of increased stress. Moreover, a change in cerebral oxygenation was shown in the reduction of the absolute differences between the left and right hemispheres where there should be normal variability. (18, 19) Acute exposure to higher noise causes a stress response which increases heart rate, blood pressure and cardiac output. (20 – 22) Premature infants are especially at risk for intraventricular haemorrhage, due to their lack of cerebral blood flow autoregulation. (23) We found that increased noise levels lead to decreased variability highlighting a worsening of an already compromised autoregulation.

CONCLUSION

Although this research lacks the sample size for a better generalization of our results, these preliminary findings suggest that more attention may need to be given to noise reduction in the NICU. This data highlights the need for further study as to the potential impact of noise on the cerebral physiology of premature infants. Questions still remain and further research is also needed to assess the potential long-term side effects of environmental noise on a premature infant's brain.

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