Journal of Pediatric Nursing (2016) **31**, e149–e154

Sound Environments Surrounding Preterm Infants Within an Occupied Closed Incubator

Aya Shimizu MSN[a,*], **Hiroya Matsuo PhD**[b]

[a]*Department of Nursing, Graduate School of Health Sciences, Kobe University, Hyogo, Japan*
[b]*Department of International Health, Graduate School of Health Sciences, Kobe University, Hyogo, Japan*

Received 16 April 2015; revised 18 October 2015; accepted 18 October 2015

Key words:
Preterm infants;
Sound;
Environment;
Frequency analysis;
Developmental care

Purpose: Preterm infants often exhibit functional disorders due to the stressful environment in the neonatal intensive care unit (NICU). The sound pressure level (SPL) in the NICU is often much higher than the levels recommended by the American Academy of Pediatrics. Our study aims to describe the SPL and sound frequency levels surrounding preterm infants within closed incubators that utilize high frequency oscillation (HFO) or nasal directional positive airway pressure (nasal-DPAP) respiratory settings.
Design and Methods: This is a descriptive research study of eight preterm infants (corrected age < 33 weeks) exposed to the equipment when placed in an incubator. The actual noise levels were observed and the results were compared to the recommendations made by neonatal experts.
Results: Increased noise levels, which have reported to affect neonates' ability to self-regulate, could increase the risk of developing attention deficit disorder, and may result in tachycardia, bradycardia, increased intracranial pressure, and hypoxia.
Conclusion and Practice implications: The care provider should closely assess for adverse effects of higher sound levels generated by different modes of respiratory support and take measures to ensure that preterm infants are protected from exposure to noise exceeding the optimal safe levels.

RECENT ADVANCES IN neonatal medical treatment and nursing have significantly reduced the mortality rate from 55.3% (1980) to 15.2% (2000) in extremely low birth weight infants (500 g to 999 g) and from 20.7% (1980) to 3.8% (2000) in very low birth weight infants in Japan (Horiuchi, Itani, & Ohno, 2002). Some preterm infants survive but develop functional disorders because of the stressful environments in the neonatal intensive care unit (NICU). Several studies have shown that a stressful environment could interfere with the neonates' ability to self-regulate and could increase the risk of developing attention-deficit hyperactivity disorder (ADHD) later in life (Brown, 2009; Schieve et al., 2010). In particular, sudden, jarring, or transient sounds may cause an unstable physiological state, resulting in tachycardia, bradycardia, increased intracranial pressure, and hypoxia (Brown, 2009). Thus, improving the acoustic environment will encourage natural growth and development in neonates.

For almost two decades, in America as well as in Japan, the sound pressure level (SPL) in NICUs has remained much higher than the levels recommended by the American Academy of Pediatrics (AAP) (American Academy of Pediatrics, 1997; Graven, 2000; Thomas, 1989; Thomas & Uran, 2007) and the Recommended Standard for Newborn ICU Design (Smith & White, 2001; White, 1999; White, Smith, & Shepley, 2013). According to both guidelines, the hourly equivalent continuous sound level (Leq) should be kept at less than 45 A-weighted decibels (dBa), and the hourly maximum sound level (Lmax) should be maintained at less

* Corresponding author: Aya Shimizu, MSN.
E-mail address: ashimizu@penguin.kobe-u.ac.jp.

http://dx.doi.org/10.1016/j.pedn.2015.10.011
0882-5963/

than 65 dBa. Most studies that have evaluated SPL have determined that the ventilator equipment, supplemental oxygen therapy, and bed types are the major contributors to noises in the NICU (Berens & Weigle, 1995, 1997; Thomas & Martin, 2000; Byers, Waugh, & Lowman, 2006; Lasky & Williams, 2009; Knutson, 2013; Wang et al., 2014). In addition, the AAP guidelines (1997) do not address the issue of appropriate sound frequency level (SFL). Some studies have shown that the SFL range after birth is possibly higher than that in the womb; sounds are possibly muted in-utero because of the amniotic fluid (Krueger, Horesh, & Crosland, 2012). The SFL was measured both inside and outside the closed incubator and was seen to affect the autonomic nervous system (Kellam & Bhatia, 2008, 2009; Livera et al., 2008). There is, however, a lack of reports that evaluate both SPL and SFL within occupied closed incubators, and determine to what sounds infants are actually being exposed.

In this study, we aimed to describe the SPL and SFL in the preterm infants on respiratory support in the following areas a) beside the respirator (outside), b) near the neonate's head inside the incubator with opened windows, and c) near the neonate's head inside the incubator with closed windows.

Methods

An observational study was conducted to measure the sounds within closed incubators occupied by preterm infants. The present study was approved by the ethics committee of our university. The recruitment extended from September 2013 to May 2014.

NICU Environment

NICU

In the present study, the NICU (level-III) consisted of a 21-bed unit in a large general hospital in Osaka, Japan. This study was conducted only in the rooms for infants who were attached to more medical equipment.

Medical Equipment

Neonates in the NICU were cared for in a closed incubator and respiratory support was provided with a mechanical ventilator. All neonates were placed in the same type of incubator (Atom Infant Incubator V-2100G, Atom Medical, Tokyo, Japan). The mechanical ventilator was selected depending on each infant's respiratory setting requirements. The Dräger Babylog® VN500 (Drägerwerk AG & Co. KGaA, Lübeck, Germany) was used for high frequency oscillation (HFO), and the Infant Flow® SiPAP™ (CareFusion, CA, USA) was used for the nasal directional positive airway pressure (nasal-DPAP) setting.

Study Protocol

The sound levels were measured after consent was obtained from the parents whose preterm infants were enrolled at 30 weeks of age (corrected age). A nurse manager was recruited to explain this study to the parents of the infants who met the following selection criteria: neonates with a gestational age of less than 28 weeks at birth (estimated by date of confinement, in turn based on fetal ultrasound during pregnancy) and neonates occupying a closed incubator. Parents signed an informed consent document that described the purpose of the study, methods, and expectations before starting the study. After the parents provided consent, the sound scaling was conducted at least twice, at approximately 2-week intervals. However the infants with serious physical problems such as intraventricular hemorrhage or sepsis were not included in the study because the participating hospital had agreed to consider the sentiments of their families. All the neonates were less than 33 weeks of corrected age during the course of the study.

This study was conducted during the daytime shift. The nurse in charge or one of the researchers placed a covered microphone to collect data regarding the sound levels a) outside beside the respirator, and near the baby's head both b) inside the incubator with open windows and c) inside the incubator with closed windows. The total recording time was determined depending on the intubation time, as indicated by the chief doctor. Each sound recording was paused during the routine patient care activities. After collection, the recordings were analyzed in a laboratory. Based on the results of frequency analysis, the SPL and SPF were determined.

Subjects

Seven families (including one family with twins) agreed to participate in this study. A total of 19 measurement times were scheduled for the 8 preterm infants; however, the dataset of 17 measurement times (HFO, n = 8; nasal-DPAP, n = 9; total measurement duration = 31 h 23 min) was analyzed because the measurement was cancelled twice due to serious physical condition of the infant on observation. The SPL was analyzed with all sound recorded regardless of the microphone location. On the other hand, the SFL was analyzed only with the sound recorded when the windows within the occupied incubators remained closed for continuous 15 minutes, which is the longest duration to analyze the SFL by the sound level meter.

Table 1 shows the demographic characteristic comparisons for both the ventilator groups (HFO and nasal-DPAP). The gestational age at birth and corrected age at observation ranged from 22 to 28 weeks and 27 to 32 weeks, respectively. The mean gestational age at birth, corrected age at birth, and infant body weight at observation were significantly different between the HFO group and the nasal-DPAP group, (gestational age at birth: 23.3 ± 1.2 vs. 26.0 ± 2.9 weeks, $p < 0.05$; corrected age at observation: 29.4 ± 1.9 vs. 31.4 ± 0.7 weeks, $p < 0.01$; infant body weight at observation: 838.0 ± 191.7 vs. 1052. 8 ± 177.0 g, $p < 0.01$).

Measurements

The sound within the closed incubator was recorded by a sound level meter of international standards, the LA-5560 K, which was calibrated by professionals before this study, with