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Original Article

Paediatrics Section

Noise Levels of Invasive and Non Invasive Respiratory Support used in Neonatal Intensive Care Unit of Northern India: A Cross-sectional Study

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ABSTRACT

Introduction: The average noise level exposure inside Neonatal Intensive Care Unit (NICU) is more than the recommended guidelines. The source of noise exposure inside NICU is multifactorial. There is need of studies to assess the noise levels of respiratory equipment used inside the NICU.

Aim: To assess the noise levels of invasive versus non invasive and respiratory support in preterm neonates admitted to NICU.

Materials and Methods: This cross-sectional descriptive study was done in NICU of a tertiary health care center of Sanjay Gandhi Postgraduate Institute, Lucknow, Uttar Pradesh, India over one year duration from December 2019 to December 2020. A sample of 85 eligible neonates without major congenital anomalies (26-36+6 weeks gestation) was enroled in this study after obtaining informed consent from parents. The noise levels of Heated Humidified High Flow Nasal Cannula (HHHFNC), Continuous Positive Airway Pressure (CPAP), conventional ventilation and High-Frequency Ventilation (HFV) were measured using a sound level meter for a period of first 24 hours of life. The median sound level from non invasive ventilation is compared with invasive ventilation. The continuous variables were expressed as median with range, while categorical data were expressed as frequencies and percentages.

Results: A total of 85 neonates were enroled majority of them were born in 32-34 weeks of gestation and were with birth weight of 1501-2500 grams. The sound level exposure of HHHFNC support was 56.1 dB (52.6-60 dB) from warmer and 47.3 dB (44.6-50.8 dB) from the incubator. The median sound level exposure per hour of bubble CPAP was 59 dB (55.2-61.9 dB) with warmer and 51.4 dB (47-55 dB) with incubator. The median sound level exposure per hour of the conventional ventilator was 60 dB (57.4-63.9 dB) with warmer and 53 dB (50.2-56.1 dB) with incubator. The median sound level exposure per hour of high-frequency ventilator was 69.1 dB (66.3-71.8 dB) with warmer and 67.3 dB (66.2-68.9 dB) with incubator.

Conclusion: Non invasive ventilation (HHHFNC and bubble CPAP) was less noisy than invasive ventilation. The lowest measured noise exposure was higher than the American Academy of Paediatrics (AAP) recommendation of 45 dB, even after isolation with physical barrier.

Keywords: Continuous positive airway pressure, High flow nasal cannula, Ventilation

INTRODUCTION

The foetus response to sound is observed as early as 26-28 weeks of gestation [1]. But there is a difference in the level of sound exposure between in-utero versus ex-utero environment, NICU. The AAP recommends that the average sound level inside NICU should not exceed 45 dB and the maximum level of transient sound not be more than 65 dB [2]. Noise more than the recommended range can produce changes in vital parameters, apnoea, hypoxia, hearing loss and neurodevelopmental impairment [3,4]. But in most NICU, the average sound level exposure is more than the suggested threshold [5,6]. Hence, a consensus committee on design standards of NICU (2020), suggested guidelines to reduce the noise level inside the NICU [7].

The main obstacle against the successful implementation of these guidelines is the multifactorial source of sound exposure inside the NICU. According to published literature the sound exposure inside modern incubators might be harmful and more than the recommended standard [8]. The noise generated from HFNC and CPAP have been found to be far more than the AAP recommendation and less noisy devices were needed [9].

Most of these published studies were in-vitro and neonate mankind was used in the methodology [10,11]. There is paucity of in-vivo NICU studies among preterm neonates.

Hence, the aim of the present study was to assess the noise exposure from invasive and non invasive respiratory support among preterm neonates admitted in the NICU.

MATERIALS AND METHODS

This cross-sectional descriptive study was done in NICU of a tertiary health care center of Sanjay Gandhi Postgraduate Institute, Lucknow, Uttar Pradesh, India over one year duration from December 2019 to December 2020. The study was approved by the Institutional Ethics Committee (PGI/BE/44/2020).

Inclusion and Exclusion criteria: Neonates of gestational age 26-36+6 weeks of gestation requiring any kind of respiratory support inside the NICU were enrolled in the study after obtaining informed consent. Neonates with major congenital malformations such as congenital heart diseases (duct dependant), organ malformation, neural tube defects and major surgical conditions were excluded.

Procedure

The average admission of preterm neonates in our NICU was 100±20 per year and authors noted that 60% of these neonates required non invasive ventilation and 40% required invasive ventilation. All sequentially admitted neonates requiring respiratory support were included. The recruited 85 neonates were divided into two groups:

- Invasive ventilation (35 neonates) and
- Non invasive ventilation (50 neonates).

In order to reduce the noise interference from NICU environment, the enroled neonates were isolated inside the NICU by physical barriers (incubators/curtains/well-spaced beds). The measured median basal noise level was 33 dB (30-35 dB) when unoccupied or vacant (measured before routine NICU fumigation), due to acoustic properties of enclosed study place inside NICU.

The noise exposure of enroled neonates was continuously monitored using sound level meter (TSL-06SPD, Tunix corporation, India) for a total duration of 24 hours, with same settings for all neonates (A/C weighted frequency measurements, the accuracy of +1.5 dB and resolution of 0.1 dB). The sound meter was placed on an open neonatal warmer or incubator with the microphone suspended 5-10 inches above the neonate's head. Care was taken to minimise the effect of vibration due to surrounding equipment. Twenty-four discrete sound decibels were measured on hourly basis. The median sound decibel per hour for 24 hours was included in the data analysis. Staff nurses were trained on the proper measurement to ensure uniformity in data collection. The collected data was cross-checked with the data stored in the internal memory of the sound level meter.

The neonates enroled in the study were treated according to the unit protocol [12]. The neonates were treated by Doctorate of Medicine (DM) Senior residents (Neonatology) in consultation with faculties of the department. We use open care system, double-walled incubator, HHHFNC (Fisher&Paykel), bubble CPAP (Babypap, Fanem model), ventilator (Acutronic, Fabian model) and high-frequency ventilator (Stephanie, Sophie) for neonatal care. The ventilator parameters varied according to the neonate's respiratory requirement. Data on gestational age, weight, and gender were recorded for each neonate at the time of enrolment.

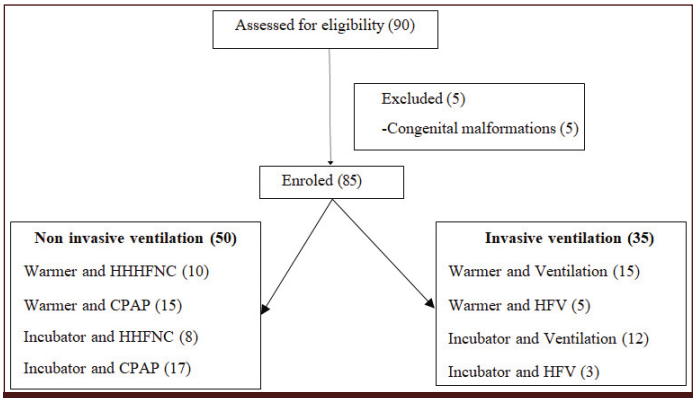
STATISTICAL ANALYSIS

Statistical analysis was done using Statistical Package for Social Sciences version 19.0 (SPSS Inc., Chicago, IL). The continuous variables were expressed as mean with standard deviation, while categorical data were expressed as frequencies and percentage.

RESULTS

Strobe chart showing the enrolment [Table/Fig-1]. The baseline parameters were shown in [Table/Fig-2]. Most of the enroled neonates were 32-34 weeks of gestation and birth weight of 1501-2500 grams.

The median sound levels measured were shown in [Table/Fig-3]. Among the 85 neonates enroled in the study, the median sound level exposure was 56.1 dB (52.6-60 dB) from warmer with HHHFNC support and 47.3 dB (44.6-50.8 dB) from the incubator with HHHFNC support. The median sound level exposure per hour was 59 dB (55.2-61.9 dB) from bubble CPAP with warmer, 60 dB (57.4-63.9 dB) from the conventional ventilator with warmer and 69.1 dB (66.3-71.8 dB) from the high-frequency ventilator with warmer. The median sound level exposure per hour was 51.4 dB (47-55 dB) from bubble CPAP with incubator, 53 dB (50.2-56.1 dB) from conventional ventilator with incubator and 67.3 dB (66.2-68.9 dB) from high-frequency ventilator with incubator.



[Table/Fig-1]: Strobe chart.

Characteristics	n (%)
Gender	
Male	56 (65.8%)
Female	29 (34.1%)
Gestational age (in weeks)	
26-27+6	7 (8.2%)
28-29+6	11 (12.9%)
30-31+6	16 (18.8%)
32-33+6	30 (35.2%)
34-36+6	21 (24.7%)
Birth weight (in grams)	
<800	1 (1.1%)
801-1000	5 (5.8%)
1001-1250	17 (20%)
1251-1500	21 (24.7%)
1501-2500	31 (36.4%)
>2501	10 (11.7%)

[Table/Fig-2]: Baseline parameters.

Respiratory support	n (%)	Median with range (dB)
Non invasive ventilation		
Warmer and HHHFNC	10 (12%)	56.1 (52.6-60)
Incubator and HHHFNC	8 (9%)	47.3 (44.6-50.8)
Warmer and CPAP	15 (18%)	59 (55.2-61.9)
Incubator and CPAP	17 (20%)	51.4 (47-55)
Invasive ventilation		
Warmer and conventional ventilation	15 (18%)	60.6 (57.4-63.9)
Incubator and conventional ventilation	12 (14%)	53 (50.2-56.1)
Warmer and HFV	5 (6%)	69.1 (66.3-71.8)
Incubator and HFV	3 (3%)	67.3 (66.2-68.9)

[Table/Fig-3]: Sound exposure of neonates with various levels of supportive care.
HHHFNC: Heated humidified high flow nasal cannula; CPAP: Continuous positive airway pressure; HFV: High frequency ventilator

DISCUSSION

In this descriptive study, authors assessed the noise levels of various respiratory supports used in NICU. The median decibel sound noted in the first 24 hours of life was used for comparison. The sound measurement inside NICU is affected by multiple factors

[13]. The lowest possible sound was generated from non invasive ventilation support using HHHFNC. The highest possible sound was generated from invasive ventilation support using HFV. The respiratory care using incubators was associated with reduced sound when compared to the open care system.

The authors noted that measured sound level was more than the AAP recommendation of 45 dB. Matook SA et al., measured the sound levels inside NICU and noted that the average sound levels were more than 45 dB almost all parts of the day [14]. In another study by Krueger C et al., measured sound levels at multiple locations inside NICU were never below the recommendation range [15]. Hence, the elevated sound levels are a major concern among most NICU across the world. The exposure to sound levels is not uniform for all neonates admitted in NICU.

Heated Humidified Cannula and CPAP are the major non invasive respiratory support inside NICU. In this study, the median sound range from HHFNC devices was 47.3 dB with incubator and 56.1 dB with open care system. Roberts CT et al., compared the sound levels between HHFNC and CPAP devices across various gas flows. HHFNC was noted to be less noisy in the study compared to CPAP [16]. Another in-vitro study by König K et al., showed HHFNC was noisier than CPAP devices. Vapotherm HFNC generated the highest noise levels, measuring 81.2-91.4 dB with increasing flow. Fisher and Paykel HFNC noise levels were between 78.8 and 81.2 dB. The CPAP device generated the lowest noise levels between 73.9 and 77.4 dB [9]. Hence, the major determination of noise generated from non invasive respiratory support was the gas flows and the pressure generated by the devices. High flow cannula and CPAP at low flow rates generated the low noise levels inside NICU.

In the present study, the median sound levels of CPAP was 59 dB (warmer) and 51 dB (incubator) respectively. Kirchner L et al., studied the noise levels between continuous flow and constant flow CPAP devices. Conventional CPAP generators (55 dB) work more quietly than the currently available jet CPAP generators (83 dB) [17]. The higher flow rates in the CPAP devices were the major source of noise generation [10]. Surenthiran SS et al., noted that sound measured at postnasal spaces of neonates with CPAP at high flows were more than conventional ventilator [18]. The high sound measured at postnasal space was associated with cochlear damage.

In this study the HFV with warmer (69.1 dB) and with incubator (67.3 dB) was noisier among the respiratory support used inside NICU. Goldstein J et al., compared the noise generated from different high frequency ventilators. The Drager ventilator was the quietest with average sound of 49.8±0.49 dB [19]. The observed difference was due to the bench study type and the ventilator settings between the studies. Noise levels were highest for the SensorMedics and the Babylog (70 dB and 62 dB, respectively) [20].

The sound exposure of respiratory support devices with the incubator was less than that of the open care system. The median sound level exposure per hour was 51.4 dB (47-55 dB) from bubble CPAP with incubator, 53 dB (50.2-56.1 dB) from conventional ventilator with incubator and 67.3 dB (66.2-68.9 dB) from HFV with incubator. Parra J et al., noted that the sound inside the incubators was more than the room (+8 dBA) [21]. The sound levels inside incubators were affected by the sound frequency and the motor characteristics [22]. Monson BB et al., noted that low frequency sounds were louder inside incubators when compared to the high frequency sounds [23]. The presence of sound absorbing panels was associated with reduced reverberating effects within incubators [24].

In this study, it was observed that noise exposure inside NICU was more than the recommendation. Non invasive ventilation support (HHFNC) was less noisy when compared to invasive ventilation. Quality improvement initiatives have significantly reduced the basal noise levels of NICU [25]. The alteration of the NICU acoustic environment such as sound absorbing walls and windows was associated with reduction in baseline noise levels inside NICU [26]. The use of earmuffs among preterm neonates was associated with reduced behavioural changes in the neonates and increased the sleep duration [27,28]. Hence, infant ICU should develop and maintain a program of noise control and abatement in order to operate within the recommended permissible noise criteria [29].

The noise levels of various respiratory equipments used inside NICU was compared. But other sources of sound/noise inside NICU were not considered in the study. The reproducibility of the data will be affected by multiple considerations in the methodology [30].

Limitation(s)

The effect of sound level on mortality and morbidity was not commented on due to the limited sample size and multiple confounders.

CONCLUSION(S)

Non invasive ventilation (HHHFNC and bubble CPAP) was less noisy than invasive ventilation. The lowest measured noise exposure was higher than the AAP recommendation of 45 dB, even after isolation with physical barrier. Further studies involving large sample size, correlation to the outcome and long term follow-up of preterm neonates are needed.

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