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Effect of Noise on Neonatal Vital Data and Behavior in NICU

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Abstract High sound pressure levels may be harmful to the maturing newborns. Current guidelines suggest that the sound pressure levels within a neonatal intensive care unit should not exceed 45 dB. It is likely that environmental noise as well as the noise generated by the incubator fan and respiratory equipment may contribute to the total sound pressure levels. Knowledge of the contribution of each component and source is important to develop effective strategies to reduce noise within the incubator. **Aims:** To identify if there is any changes of neonatal response behaviors and their vital signs when newborns exposed to noise or not. The study included 100 newborns. All newborns included in the study were subjected to complete neurobehavioral assessment using Brazelton neonatal behavior scale before and after exposure to noise. Also they were subjected to measurement of vital signs before and after noise and we compared between them. We used sound level meter to measure level of noise that newborn exposed to in NICU. We measured level of noise at different times of days and nights and reported the mean of all measures. **Results:** We had found that noise exposure causes significant behavioral changes, and changes of all vital signs expect temperature. We had found difference between pre-term and full-term of their vital signs and behavior before and after noise exposure. **Conclusions:** The current study had shown that noise exposure in NICU has some negative drawbacks on vital signs and behavior of neonates.

Keywords Neonatal, Behavior, Noise

1. Introduction

Noise is any sound – independent of loudness – that may produce an undesired physiological or psychological effect in an individual. [1]

The goal for neonatal intensive care unit (NICU) is to provide an environment that promotes sleep, supports neonatal physiologic stability, and reduces potential adverse effects on the auditory development of newborn infants. [2]

There is a growing concern that such noise puts newborn at high risk for adverse health effects. Loud transient noise has negative short-term effects on the cardiovascular and respiratory systems of newborn infants. [3]

The NICU is often characterized by loud, unpredictable noise from extraneous sources such as alarms, ventilators, phones and staff conversation to which newborn infants are especially vulnerable. [4]

Some studies conclude that the average sound levels in a NICU ranges anywhere between 70 to 80 dB. The American Academy of Pediatrics (AAP) recommends a maximum safe noise level of 45 dB in a NICU. Failure to maintain noise levels under the maximum levels recommended by AAP may result in numerous adverse noise-induced health effects on premature babies as they are very fragile. [3]

Aim of the work:

The aims of this study were to:

- Identify sound characteristics in NICU that disrupt sleep, increase episodes of tachycardia, or desaturation and disrupt all vital data in newborn infants.
- Examine if there is any changes of neonatal response behaviors when newborns exposed to noise or not.
- Examine if there is any changes of vital signs when newborns exposed to noise or not.

Patients and methods:

The current study was designed as an interventional pre and posttest study with aim to evaluate the effect of noise exposure on vital signs (including heart rate, blood pressure, respiratory rate, temperature and oxygen saturation) and neonatal behavior among neonates admitted to NICU.

This study included 100 newborn chosen from Sayed Galal University Hospital, at period from February 2013 to January 2014 at different times of days and nights, and at different gestational age and birth weight. They were classified into two groups:

Group 1: 100 (males (70%) and 30% females) with more than half of them were preterm with gestational age less than 37 weeks (55%). This group not exposed to noise.

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Group 2: The same above newborn but after we exposed them to noise ranging from 60 – 130 dB for about 10 minute.

Inclusion criteria were:

1 – Mild neonatal jaundice (in phototherapy range).
2 – Mild neonatal sepsis
3 – Mild neonatal respiratory distress
4 – Growing baby include preterm and IUGR.

Exclusion criteria were:

1 – Sever neonatal sepsis.
2 – Hypoxic ischemic encephalopathy.
3 – Kernictrus or any CNS abnormality.
4 – Newborn on drugs affecting hearing such as aminoglycoside.

All newborn were subjected to the following:

1- History taking with special emphasis on gestational age, birth weight, maternal health, mode of delivery, consanguinity and type of feeding.

2- Detailed clinical examination to diagnose the presence of postnatal complications *e.g.* perinatal asphyxia, hemorrhage, malformations or suspected metabolic disease.

3- Measurement of vital sign (heart rate, respiratory rate, blood pressure, temperature, oxygen saturation) before and after noise and we compared between them.

4- Complete neurobehavioral assessment using brazelton neonatal behavior scale before and after exposure to noise and we compared between them.

Brazelton Neonatal Behavioral Assessment Scale (BNBAS) includes 27 behavioral items, each scored on 9-points scale and 16 elicited reflexes scored on 5-point scale. The infants neurobehavioral performance is summarized according to 7clusters including (social-interactive, motor behavior, state organization, regulation of state, habituation, autonomic stability and reflexes cluster). **(*Brazelton and Nugent., 1995*)**.

5- We used sound level meter to measure level of noise that newborn exposed to in NICU. We measured level of noise at different times of days and nights and reported the mean of all that measures.

We measured noise by sound level meter through putting sound level meter at the head of newborn and measured every sound alone by exclusion of other sounds. Note that newborn may be exposed to more than one sound. In our study newborns were exposed to noise ranging from 54 -83 dB for about 10 minute.

Table 1. Measurements of noise by sound level meter

Sounds in NICU	1	2	3	Mean ± SD
Incubator	54 dB	55 dB	59 dB	56 ± 2.65
Alarm of monitor	57 dB	63 dB	68 dB	62.67 ± 5.51
Nurses and doctors	69 dB	65 dB	74 dB	69.33 ± 4.51
Air conduction	50 dB	53 dB	58 dB	63.67 ± 4.04
Door of incubator	60 dB	60 dB	61 dB	60.33 ± 0.577
Door of NICU	80 dB	80 dB	83 dB	81 ± 1.732
Telephone	65 dB	69 dB	73 dB	69 ± 4

1 = First measurement 2 = Second measurement
3 = Third measurement

2. Results

Table 2. Vital signs before and after exposure to noise among studied neonates

Items	Before	After	p-value
Heart rate Mean ± SD	130.67 ± 12.39	136.49 ± 1.15	0.001*
Respiratory rate Mean ± SD	42.57 ± 0.63	46.49 ± 0.61	0.001*
Temperature Mean ± SD	36.85 ± 0.2	36.98 ± 0.2	0.8
Oxygen saturation Mean ± SD	96.19 ± 0.29	93.11 ± 0.43	0.001*
Systolic BP Mean ± SD	51.66 ± 1.02	53.62 ± 0.98	0.001*
Diastolic BP Mean ± SD	33.18 ± 5.09	35.17 ± 4.77	0.001*

*Statistically significant difference (p-value < 0.05).

There was significant increase of heart rate, respiratory rate, systolic and diastolic blood pressure. There was significant decrease of oxygen saturation among the studied neonates due to noise exposure. Only temperature didn't show significant change with noise exposure.

Table 3. Items of Brazelton neonatal behavior assessment scale before and after exposure to noise among studied neonates

		Before	After	p-value
Reflexes cluster	Mean ± SD	27.85 ± 0.89	35.7 ± 3.77	0.001*
Autonomic system cluster	Mean ± SD	22.06 ± 2.55	18.08 ± 2.92	0.001*
Habituation cluster	Mean ± SD	33.09 ± 2.44	28.46 ± 3.69	0.001*
State of regulation cluster	Mean ± SD	30.19 ± 2.93	25.48 ± 3.43	0.001*
State of organization cluster	Mean ± SD	29.95 ± 2.37	24.93 ± 2.66	0.001*
Motor system cluster	Mean ± SD	29.79 ± 2.59	24.08 ± 3.28	0.001*
Social interactive cluster	Mean ± SD	45.58 ± 2.75	37.01 ± 4.55	0.001*
Total score	Mean ± SD	218.51 ± 11.67	193.74 ± 16.59	0.001*

*Statistically significant difference (p-value < 0.05)

Table 4. Relation between total score of Brazelton neonatal behavior assessment scale after noise and baseline characteristics

Parameter		Total score after noise	
		Mean ± SD	**p-value**
Sex	Male	194.9 ±17.1	0.3 (NS)
	Female	190.9 ± 15.2	
Gestational age (weeks)	< 37 weeks	191.8 ±17.5	0.02
	≥ 37 weeks	196.1 ± 15.3	
Mode of delivery	NVD	193.3 ±16.2	0.8 (NS)
	CS	194.4 ± 17.3	
Addiction/caffeine intake by mother	No	194.9 ±16.9	0.3 (NS)
	Yes	191.6 ± 16.1	
Diseases during pregnancy	No	192.5 ±15.9	0.3 (NS)
	yes	196.7 ± 18.1	
History of jaundice	No	198 ±18.1	0.01*
	Yes	189.6 ± 13.9	
History of sepsis	No	192.1 ±13.9	0.3 (NS)
	Yes	196.3 ± 19.9	

*Statistically significant difference (p-value < 0.05)
NS: not statistically significant

The table revealed that neonates with neonatal jaundice were found to have significantly lower post exposure score denoting more severe impact of noise on these neonates. Also preterm was affected by noise more than full term denoting by lower post exposure score.

Table 5. The difference of vital signs between preterm and full term before and after noise

Vital Signs	Gestational age	N	Mean ± SD	P-Value
Heart rate Before noise	>= 37	45	130 ± 12.238	0.0467*
	< 37	55	131 ± 12.576	
After noise	>= 37	45	137 ± 10.987	0.0388*
	< 37	55	134 ± 11.934	
Respiratory rate Before noise	>= 37	45	44 ± 6.624	0.0319*
	< 37	55	41 ± 6.018	
After noise	>= 37	45	49 ± 5.839	0.0077*
	< 37	55	45 ± 6.058	
Temperature Before noise	>= 37	45	36.5 ± 0.25	0.82 (NS)
	< 37	55	36.8 ± 0.22	
After noise	>= 37	45	37.5 ± 0.22	0.074 (NS)
	< 37	55	37.0 ± 0.21	
Oxygen saturation Before noise	>= 37	45	96 ± 3.09	0.0041*
	< 37	55	95 ± 2.76	
After noise	>= 37	45	94 ± 5.83	0.0003*
	< 37	55	91 ± 2.49	
Systolic BP Before noise	>= 37	45	52 ± 10.93	0.0000*
	< 37	55	48 ± 8.08	
After noise	>= 37	45	58 ± 10.33	0.0000*
	< 37	55	51 ± 7.72	
Diastolic BP Before noise	>= 37	45	31 ± 4.40	0.0000*
	< 37	55	36 ± 4.18	
After noise	>= 37	45	36 ± 3.92	0.0000*
	< 37	55	38 ± 4.11	

*Statistically significant difference (p-value <0.05)
NS: not statistically significant

Table 6. The difference of Brazelton score between preterm and full Term neonates before and after noise

Brazelton Scores	Gestational age	N	Mean ± SD	P-Value
Total Brazelton Score After	>= 37	45	196.13 ± 15.32	0.02*
	< 37	55	191.782 ± 17.46	
Total Brazelton score before	>= 37	45	221.2 ± 9.2	0.04*
	< 37	55	216.31 ± 13.051	
Reflexes cluster after	>= 37	45	38.84 ± 3.056	0.029*
	< 37	55	36.40 ± 4.392	
Reflexes cluster before	>= 37	45	28.00 ± 0.000	0.01*
	< 37	55	27.73 ± 1.193	
Autonomic system cluster after	>= 37	45	18.2 ± 2.641	0.0097*
	< 37	55	18.09 ± 3.158	
Autonomic system cluster before	>= 37	45	22.4 ± S2.276	0.01*
	< 37	55	22.07 ± 2.775	
Habituation cluster after	>= 37	45	29.31 ± 3.604	0.036*
	< 37	55	27.76 ± 3.631	
Habituation cluster before	>= 37	45	33.71 ± 2.273	0.02*
	< 37	55	32.58 ± 2.470	
State of regulation cluster after	>= 37	45	26.40 ± 2.799	0.015*
	< 37	55	24.73 ± 3.734	
State of regulation cluster before	>= 37	45	30.89 ± 2.470	0.03*
	< 37	55	29.62 ± 3.159	
State of organisation cluster after	>= 37	45	24.87 ± 2.380	0.008*
	< 37	55	24.54 ± 2.890	
State of organisation cluster before	>= 37	45	30.18 ± 2.259	0.038*
	< 37	55	29.76 ± 2.464	
Moter system cluster after noise	>= 37	45	24.18 ± 3.339	0.035*
	< 37	55	24.00 ± 3.272	
Moter system cluster before noise	>= 37	45	30.11 ± 2.395	0.027*
	< 37	55	29.53 ± 2.748	
Social interactive cluster after noise	>= 37	45	38.47 ± 4.551	0.003*
	< 37	55	35.82 ± 4.221	
Social interactive cluster before noise	>= 37	45	46.27 ± 2.115	0.023*
	< 37	55	45.02 ± 3.076	

The vital signs of preterm were affected by noise more than full term, for example preterm infants have a higher resting heart rate and less cardiac acceleration after auditory stimulation than the full-term infants. Only temperature didn't show significant change with noise exposure.

The behavior of preterm was affected by noise more than full term, as shown by lower post exposure score of Brazelton of preterm than full term.

3. Discussion

As increasing numbers of survivors reach school age, more minor impairments cause concern; difficulties with attention, behavior, language performance, and academic skills are becoming apparent. [5]

It has been suggested that the persistence of these developmental problems may be associated with the NICU environment. [6]

One possibility is that the impairments emerging in school-age children may be the consequence of noise and light stimulation of the NICU environment exceeding the capacity of the preterm infant's central nervous system to cope with it. [7]

It is well documented that high noise levels are harmful to

preterm infants and result in increased physiologic stress. Even brief stimulation from alarms and telephones can result in an increase in autonomic response with a subsequent physiologic decline that puts the infant at risk for both bradycardia and hypoxic episodes. **Bremmer Byers, Kiehl (2003),** [8] Documented physiologic changes include apnea, bradycardia, alterations in sleep-wake states and fluctuations in heart rate, respiratory rate, blood pressure, and oxygen saturation. [9]

According to the current study, it was found that noise exposure causes significant increase of heart rate, respiratory rate, systolic and diastolic blood pressure (table 5). These findings are inconsistent with the available reports in the previous papers. [9], [8].

Wharrad and Davis (1997) [10] evaluated the heart rate response of 20 preterm and 22 full-term infants by presenting a five second stimulus of 80, 90, or 100 dB or no stimulus to each infant. They observed an increase in heart rate proportional to the intensity of stimulation in both groups, but saw a greater overall rise in the full-term infants, suggesting that the cardiovascular system becomes more responsive to auditory stimuli as it matures. Their results were consistent with current finding as we report significant difference of heart rate and respiratory rate changes in relation to gestational age of the studied neonates.

The current study had shown significant increase of systolic and diastolic blood pressure with noise exposure. Auditory stimulation may cause changes in blood pressure. Consistently, **Jurkovicova and Aghova (1989)** [11] assessed the change in blood pressure caused by high frequency and low-frequency acoustic stimulation in 30 low birth weight infants. They found that, in most infants, the stimulation resulted in an increase of the systolic and diastolic blood pressure of approximately 10 mmHg, which returned to baseline after about five minutes [12].

Inconsistent to the current findings, **Zahr and Balian (1995)** [13] found no significant effect on heart rate or respiratory rate. They investigated the cardiac and respiratory responses to noise and nursing intervention in 55 preterm infants (23 to 37 weeks gestational age) during two-hour observation periods in the morning and evening. The sound levels were not measured, but a bedside observer recorded any loud noise and the infant's response. No statistically significant effect of noise on heart rate or respiratory rate was noted during noisy periods [14].

Regarding effect of noise exposure on arterial oxygen saturation, the current study has shown that there was significant decrease of oxygen saturation among the studied neonates due to noise exposure. Consistently, **Long and colleagues** have reported that noises caused a decrease in oxygen saturation and an increase in heart rate plus a rise in respiratory rate [15].

Consistent findings regarding changes in oxygen saturation were also found by Johnson, who examined responses of 65 premature neonates to changes in environmental noise. Sound levels, oxygen saturations, and infant states were recorded every 2 minutes during three study conditions; prestudy neonate in incubator (10 minutes), neonate in incubator with acoustic foam placed in four corners (20 minutes), and post-study neonate in incubator with foam removed. With the foam in place, the average decrease in noise levels was 3.27 dB, oxygenation improved by more than 1 percent for all infants, and the effect was maintained for 10 minutes following the removal of the foam [14].

We had found that noise exposure causes significant behavioral changes as reported by comparing results of Brazelton neonatal behavior assessment scale before and after noise exposure. There were significant differences between pre and post exposure values concerning all items of the scale and the total score.

We had compared total **Brazelton** score after noise exposure according to neonatal characteristics which revealed that neonates with neonatal jaundice were found to have significantly lower post exposure score denoting more severe impact of noise on these neonates.

We had found difference between pre-term and full-term of their vital signs and behavior before and after noise exposure such as heart rate, we had found that the preterm infants have a higher resting heart rate and less cardiac acceleration after auditory stimulation than the full-term infants. We also had found that oxygen saturation of preterm is less than full-term before and after noise. Only temperature did not show any difference before and after noise.

4. Conclusions

1 - The current study had shown that noise exposure in NICU has some negative drawbacks on vital signs and behavior of neonates.
2- We had found significant changes of vital signs of newborns before and after noise.
3 - We had found significant changes of neonatal behavior before and after noise**.**
4 - Their was differences between preterm and full term of their vital signs and behavior before and after noise exposure.
5 - Neonates with neonatal jaundice had more severe impact of noise on these neonates.

Recommendations

Based on our results we recommend the following:

1. NICU environment is an important determinant of neonatal outcome in NICU.
2. Noise exposure in NICU should be evaluated routinely and reduced as much as possible.
3. Newborns with neonatal jaundice and preterm should be placed in the most quite place in NICU.
4. Doctors and other caregivers making morning rounds should discuss patient’s care plan away from the bedside of neonate.

5. All staff members involved in neonatal care will take a developmental care course that addressed the importance of management of the environment. The nurses should be educated about reducing conversation by the bedside.
6. All incubators should have acoustical foam placed in them to reduce the amount of noise inside the incubator.
7. In all NICU units, walls and trash cans should be padded and ceilings should have acoustic tiles.
8. Pregnant woman should work in quite place as fetus will be affected by noise.
9. All NICU doors and drawers should be padded.
10. Further studies that evaluate the long term effects of noise exposure on neural development should be conducted.

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