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The Effect of Invasive and Non-Invasive Ventilation on Neonatal Hearing Impairment

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ABSTRACT

Background: The incidence of hearing loss in neonates is 2-4 cases in every 1000 live births. Hearing loss, especially in mild and moderate forms, may not be recognized before the second year, but may produce great defects in conversational abilities.

Objective: The aim of the present study was to assess the hearing impairment with invasive and non-invasive ventilation in Zagazig University Hospitals.

Patients and methods: This was a retrospective cohort study of preterm infants attending in neonatal intensive care unit (NICU) of Zagazig University hospital in the period of time between February 2021 and August 2021. The studied population included thirty preterm infants. Visual examination of the external auditory meatus and tympanic membrane was performed using a Welch Allyn Halogen Otoscope. **Results:** There was non-significant difference between the studied groups regarding gender, gestational age, or birth weight. There was significant increase in cesarean (CS) mode in nasal continuous positive airway pressure (NCPAP) group (86.7%) compared to 40% in synchronized intermittent mandatory ventilation (SIMV) group. On the other hand, there was non-significant difference between them regarding presence of maternal risk factors. About 50% of patients underwent NCPAP, while the other 50% underwent SIMV. The duration ranged from 7 to 13 days with mean 9.03 days. The Apgar at 1, 5 and 10 minutes and Down score; all were significantly lower in SIMV group. In each group, there was significant increase in Apgar score over time.

Conclusion: There was no significant effect of invasive ventilation (SIMV) and non-invasive ventilation (NCPAP) on auditory function of preterm infants.

Keywords: Hearing Loss; Invasive Ventilation; Neonates, Non-Invasive Ventilation.

INTRODUCTION

Hearing impairment in children across the world constitutes a particularly serious obstacle to their optimal development and education, including language acquisition. Neonatal hearing loss has a prevalence that is more than twice that of other newborn disorders such as congenital hypothyroidism and phenylketonuria [(1)]. It has been estimated that bilateral sensorineural hearing loss (SNHL) occurs in approximately 1.86 of 1000 newborns. The prevalence of bilateral severe SNHL was previously reported to be 9.7% in neonates who survived with a very low birth weight (1500 g) and 16.7% in neonates who survived after neonatal seizure [(2)].

There have been reports suggesting that prematurity itself is a cause of neonatal published incidence of SNHL in neonates with extremely low birth weight. Ten (3.0%) out of 337 such neonates were documented to have a hearing impairment. Of these, one infant (0.3%) showed bilateral moderate-to severe SNHL, while the other nine infants (2.7%) turned out to have conductive hearing loss. SNHL [(3)]. Low gestational age (GA) and low birth weight resulted in a higher rate of no response to transient-evoked otoacoustic emission: the odds ratios for an abnormal transient-evoked otoacoustic emission result were 1.76 and 1.58, respectively, in neonates with < 30 weeks of gestation and birth weight < 1500 g. Finally, a statistically significant difference in the prevalence of SNHL was observed between normal full-term neonates and premature neonates (0.82% vs. 3.1%) [(4)].

In light of this higher prevalence of SNHL among premature neonates, several researchers tried to delineate factors related to prematurity that contributed to the increased risk of SNHL. Of neonatal factors, hyperbilirubinemia, surgical ligation of patent ductus arteriosus [(5)], and respiratory status (duration of ventilation and oxygen treatment) appeared to be associated with significant SNHL [(6)]. However, although a number of maternal conditions have been reported to be associated with preterm birth (e.g. intrauterine infection and preeclampsia), little information is available concerning maternal risk factors for the development of SNHL. In particular, several reports provided somewhat contradictory results with regard to the role of histological chorioamnionitis in the development of SNHL [(7)].

Therefore, this study aimed to assess the hearing impairment with invasive and non-invasive ventilation in Zagazig University Hospital. Also, to determine the incidence and risk factors associated with hearing impairment among newborns in a tertiary care center.

PATIENTS AND METHODS

This was a retrospective cohort study of preterm infants attending in NICU of Zagazig University hospital in the period of time between February 2021 and August 2021. The studied population included thirty preterm infants.

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These infants were classified into two groups: Group I: 15 preterm infants (50%) underwent non-invasive ventilation (NCPAP) and **Group II:** 15 preterm infants (50%) underwent invasive ventilation (SIMV).

Inclusion criteria: All singleton infants born alive at 23 to 37 weeks of gestation who: (1) Survived for at least 30 days after birth, and (2) Ventilated by non-invasive and invasive ventilation.
Exclusion criteria: Premature with congenital anomalies.

Operational design:

All patients were subjected to the full history taking :- (prenatal- natal- postnatal) including GA calculated based on the last menstrual period and Ballard score, date of admission, duration and date of discharge) and ventilation (type of ventilation, duration of ventilation) [8].

The following maternal factors were assessed: maternal age, parity, causes of preterm birth, mode of delivery; antenatal use of medications; and clinical diagnosis of chorioamnionitis. Natal/ postnatal characteristics including GA at birth, birth weight, sex, Apgar scores at 1 minute, 5 and 10 minutes [9].

Abnormalities of the placenta, use of surfactant, use of mechanical ventilation, Down score on admission, early-onset neonatal sepsis, respiratory distress syndrome (RDS), bronchopulmonary dysplasia (BPD), intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL), necrotizing enterocolitis (NEC), and seizure were assessed. Physical examination included vital sign, cardiac, chest, abdominal and neurological examination.

Audiological examination: All patients were subjected to emission after 1 week from discharge from neonatal care unit, then all were subjected to emission and auditory brainstem response (ABR) after 3 weeks then the patients who have failed or partial passed emission, or have hearing loss (HL) at ABR were subjected to ABR and emission after 3 months.

Equipment:

(1) Transient evoked 0toacoustic emission testing (TEAOE): (IOL 96 OTODYNAMIC)

TEAOE amplitudes and signal to noise ratio in 5 frequency bands were measured in both ears of subjects using a diagnostic OAE analyzer (Otodynamics ILO V6).

Tested children must be asleep to limit their movements. Normal sleep after feed was used. The OAE probe was fitted with appropriate sized ear tip and sealed the external ear canal. The probe fit was confirmed with the in the ear calibration by the software. TEOAEs were elicited using non-linear click sounds of 100 μs presented at an intensity level of 80 dBSPL with 260 presentations of click and recorded over a frequency band of 1000- 4000 Hz. The stability of the stimulus was maintained at ≥80% and reproducibility level of ≥70%. The overall amplitude of the TEOAE spectrum and TEOAE amplitudes at five frequency bands (1, 1.4, 2, 2.8 and 4 kHz) were determined. OAEs were considered present in a band when the signal to noise ratio (SNR) in that band equaled or exceeded 3 dB and were considered as absent when the SNR was below 3 dB.

(2) Auditory brain stem response (ABR): Otometric (Ics chater Ep200)

ABR was done for all patients using OTOMETRICS. The skin was prepared by use of abrasive gel in order to lower the skin impedance, which had to be below 5 KOhm. Electrodes were placed on both mastoids and on the forehead. Infants were tested during normal sleep. ABR was recorded ipsilaterally with the positive recording electrode on the forehead, the reference electrode on the ipsilateral mastoid and the ground electrode on the contralateral mastoid. Rarefaction click stimuli were presented at 80 dBnHL, at a rate of 21.1/sec, through TDH-49p headphones. A total number of 1024 of sweeps were obtained and a low pass filter with cut off frequency 3000 Hz and a high pass filter with cut off frequency 100 Hz were used. ABRs were obtained initially at 80 dBnHL, with two trials were obtained at each test level. A 10-dB decrement was used to determine threshold. Threshold was determined at the lowest level at which an ABR wave V was present as determined.

(3) Tympanometry: (MADSEN zodiac 901)

Ethical consideration:

The study was approved by the Ethical Committee of Zagazig Faculty of Medicine. An informed consent was obtained from the parents of all the patients in this research. Every parent received an explanation for the purpose of the study. All given data were used for the current medical research only. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

Data were analyzed using Microsoft Excel software. Data were then imported into the Statistical Package for the Social Sciences (SPSS version 18.0) software for analysis. Quantitative data were expressed as means and standard of deviation (SD) and were compared by independent "t" test. Qualitative data were expressed as frequency and percentage and were compared by Chi square (X^2) test. Monte Carlo test was used to calculate the maternal risk factors. P value was set at $P < 0.05$ for significant results and < 0.001 for high significant result.

RESULTS

The present study showed non-significant difference between the studied groups regarding gender, gestational age, or birth weight **(Table 1)**.

Table (1): Comparison between the studied groups according to demographic data

Parameter	Group		p
	NCPAP group	SIMV group	
	N=15 (%)	N=15 (%)	
Gender:			
Female	8 (53.3)	8 (53.3)	>0.999
Male	7 (46.7)	7 (46.7)	
Gestational age:			
Mean ± SD	32.13 ± 1.96	31.87 ± 1.51	0.679
Birth weight:			
Mean ± SD	1.67 ± 0.43	1.51 ± 0.21	0.233

There was significant increase in CS mode in NCPAP group compared to SIMV group. On the other hand, there was non-significant difference between them regarding presence of maternal risk factors **(Table 2)**.

Table (2): Comparison between the studied groups according to mode of delivery and maternal risk factors

Parameter	Group		P
	NCPAP group	SIMV group	
	N=15 (%)	N=15 (%)	
Mode of delivery:			
CS	13 (86.7)	6 (40)	0.008*
NVD	2 (13.3)	9 (60)	
Maternal risk factor			
Maternal hypertens	5 (33.3)	4 (26.7)	
Bleeding	2 (13.3)	1 (6.7)	0.333
PROM	6 (40)	10 (66.7)	
PROM+antental bleeding	2 (13.3)	0 (0)	

*: significant

There was about 50% of patients underwent NCPAP while the other 50% underwent SIMV **(Table 3).**

Table (3): Distribution of the studied patients according to type and duration of ventilation

	N=30	%
Type of ventilation:		
NCPAP	15	50
SIMV	15	50
Duration		
Mean ± SD	9.03 ± 1.81	
Range	7 – 13	

The Apgar at 1, 5 and 10 minutes and Down score, all were significantly lower in SIMV group. In each group, there was significant increase in Apgar score over time **(Table 4).**

Table (4): Comparison between the studied groups according to APGAR and Down score

Parameter	Group		P	
	NCPAP group (N=15)	SIMV group (N=15)		
	Mean ± SD	Mean ± SD		
Apgar 1	7.93 ± 0.59	7.13 ± 0.35		<0.001**
Apgar 5	8.8 ± 0.41	8.13 ± 0.35	4.752	<0.001**
Apgar 10	9.4 ± 0.74	8.6 ± 0.63	3.191	<0.001**
P	<0.001**	<0.001**		
Down score on admission	6.67 ± 0.49	4.87 ± 0.64	8.663	<0.001**

*: significant, **: highly significant

There was significant increase in duration of admission in SIMV group, while there was non-significant difference between them regarding duration of intervention **(Table 5).**

Table (5): Comparison between the studied groups according to duration of admission and intervention

Parameter	Group		P
	NCPAP group (N=15)	SIMV group (N=15)	
	Mean ± SD	Mean ± SD	
Duration of admission	30.27 ± 5.52	38.53 ± 6.62	<0.001**
Duration of intervention	21.73 ± 4.85	18.73 ± 3.41	0.06

**: highly significant

There was non-significant difference between the studied groups regarding complications. Sepsis occurred in 13.3% in both of those underwent NCPAP and SIMV **(Table 6).**

Table (6) Comparison between the studied groups according to complications

Parameter	Group		p
	NCPAP group	SIMV group	
	N=15 (%)	N=15 (%)	
Complications:			
No	13 (86.7)	13 (86.7)	0.39
Yes	2 (13.3)	2 (13.3)	

DISCUSSION

Preterm neonates are exposed to multiple sources of acoustic trauma during their stay in the neonatal intensive care unit (NICU). Of particular importance is noise created by life-support equipment like the isolette, alarms from vital sign monitors and ventilators. The incidence of hearing loss has been directly correlated with the method and the length of ventilation used for managing respiratory distress in preterm neonates [(10)].

Noninvasive ventilation like nasal continuous positive pressure (NCPAP) is increasingly used as alternative ventilatory modality since its use is associated with lower pulmonary morbidity when compared to mechanical positive pressure ventilation. NCPAP is associated with a decrease in bronchopulmonary dysplasia without increase in other morbidities in preterm neonates [(5)]. The use of neonatal CPAP is increasing, especially > 32 weeks gestation and among non-tertiary hospitals [(6)].

Despite these advantages, concerns remain regarding significantly higher noise exposure to preterm newborns managed by NCPAP as compared to those who are either receiving no respiratory support or managed by mechanical ventilation. Two-thirds of the neonates on bubble NCPAP are exposed to more than 90 dB of noise, which is significantly higher than the maximum acceptable noise level of 45 dB [(11)].

Our results revealed that there was no difference between study of both groups (group I and group II) regarding gestational age, length of hospital stay, birth weight, sex, mode of delivery and Apgar score and Down score. Similar to our results **Yoshikawa *et al.*** [(12)] investigated the incidence of neonatal hearing loss in a neonatal intensive care unit and found that there were non-significant differences between the study and control groups in NICU regarding to birth weight, gestational age, and respiratory status such as Apgar score. In Disagreement to our results, **Kountakis *et al.*** [(13)], in their prospective study found that risk factors for hearing loss in neonates included length of stay in the intensive care unit, however they included also many other factors that were present in their population and not found in our population like; respiratory distress syndrome, retrolental fibroplasia, asphyxia, meconium aspiration, neurodegenerative disorders, chromosomal abnormalities, drug and alcohol abuse by the mother, maternal diabetes, multiple births, and lack of prenatal care.

In our study, there was statically non-significant difference regarding to development of sepsis and sepsis has no effect on hearing. Unsimilar to our results, **Yilmaz *et al.*** [(14)] revealed the proven sepsis group (group 1B), the effect of blood transfusion on hearing loss was higher. In this group, the increased frequency of anemia-induced transfusion and the disruption of tissue oxygen due to anemia may be related to hearing loss.

CONCLUSION

There is no significant effect of invasive ventilation (SIMV) and noninvasive ventilation (NCPAP) on auditory function of preterm infants.

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