Original Article

OTO ACOUSTIC EMISSION TEST AMONG HIGH RISK NEONATES IN TERTIARY CARE HOSPITALS

Dr. V. Y. Kshirsagar[1], Dr. Shailesh B. Patil[2]

[1] Professor & Head, Department of Pediatrics, Krishna Institute of Medical Sciences, Krishna Institute of Medical Sciences Deemed to be University, Karad.
[2] Assistant Prof., Department of Pediatrics, Krishna Institute of Medical Sciences, Krishna Institute of Medical Sciences Deemed to be University, Karad.
Email: drkshirsagarvy@yahoo.com

DOI: 10.47750/pnr.2022.13.S02.74

Abstract

Detecting hearing impairment before 6 months of age and appropriate treatment provides the best choice maximizing the critical period of hearing and thereby availing the resources to improve hearing and verbal communication skills. On the other hand late detection and treatment, leave such children with poor speech development and school achievement. Programmes that focus on detecting hearing disabilities at an early age of child help in improving the overall development of the child in cognitive, motor and social domains.[4]

Introduction

The prevalence of hearing impairment in India in newborns in various studies is 1 to 6 per 1000 newborns screened. 50% of neonates with hearing impairment have associated high risk factors like birth asphyxia, low birth weight, pre term gestation, TORCH and other intra uterine infections, use of oto toxic drugs in neonatal period, hyperbilirubinemia requiring exchange transfusion, family history of sensory neural hearing impairment, mechanical ventilation > 5 days and sepsis.[1,2]

We performed this study to evaluate the possible burden of hearing disability in high risk neonates at a tertiary care hospital. We screened newborns with some high risk factors using Oto Acoustic Emissions (OAE) twice. Those who would test positive for hearing impairment in both OAE screenings, we confirmed and determined the degree of deafness in the neonates by BERA test

Aims and Objectives

AIM:

To determine the incidence of hearing impairment using oto acoustic emission test among high risk neonates in a tertiary care hospital.

Objectives:

Primary Objective

To determine the incidence of Hearing impairment using oto acoustic emission test among high risk neonates in a tertiary care hospital

Secondary Objective

To confirm hearing impairment detected by OAE with BERA

Review of Literature

Earliest known examples of skeletal evidence associated with hearing loss in humans dates back to more than 10000 year. In Shinidar Cave, Iraqi Kudristan, neanderthal skeleton dating back to 45,000 to 35000 years old had external bony exostosis occluding ear canals and mummy of Pum 2, had perforated ear drum

As recorded by Alsion Alkin (University Of Sheffied), congenital deaf Roman child from Britain, was found buried face down in stone coffin, capped with roof tiles in ancient past.

In 1982, two additional risk factors were added (bacterial meningitis and birth asphyxia including low Apgar scores) and included the recommendation for physiologic screening of high-risk infants. At that time, the Committee did not recommend any specific device, although many programs were successfully utilizing automated ABR for newborn screening. Despite efforts and endorsements, the growth of high-risk screening in the United States was very slow. In 1984, high-risk hearing registries only included an estimated 15 percent of the nation's newborn population and it is likely, that less than half of those infants had their hearing assessed. Other weaknesses identified that a restricted risk register will miss approximately 50 percent of infants with hearing impairment.

In year 1994- The JCIH Position statement recommended that "all infants with hearing impairment should be identified before 3 months of age and receive intervention by 6 months of age."

In year 1999- The American Academy of Pediatrics endorsed

Universal newborn hearing screening and detection of hearing impairment before three months of age and intervention services initiated by six months of age.

2000- The JCIH, USA Year 2000 Position Statement issued Principles and Guidelines for Early Hearing Detection and Intervention Programs.

In 2006, the HHS Secretary's Advisory Committee on Heritable Disorders in Newborns and Children (SACHDNC) IN USA included newborn hearing as one of the conditions to be included in their Recommended Uniform Screening Panel (RUSP).

With growing research evidence, in 2007 United States Preventive Services Task Force (USPSTF) recommended screening of hearing impairment in all newborn infants." By 2010, 43 states enacted legislative statutes or written regulatory language related to universal newborn hearing screening.

In 2018, Health Level 7 (HL7) approved the Early Hearing Detection and Intervention (EHDI) Implementation Guide as a Normative Standard to be followed by all the states in USA.

Less than a decade after the first description of the ABR, its application in newborn hearing screening was introduced by Schulman-Galambos and Galambos in year 1979. Indeed, the ABR appeared to be ideally suited for newborn hearing screening. It could be reliably recorded in newborn and even premature infants [Hecox and Galambos, 1974; Schulman Galambos and Galambos, 1975]; the response demonstrated a specific and predictable maturational course as proved by Hecox and Galambos in 1974; Starr et al in 1977; Gorga et al in1987; the response demonstrated an acceptable correlation between ABR threshold and behavioral audiometric results as proved by Kileny and Magathan in 1987; Hyde et al in1990.[10]

Numerous investigators have reported results of A-ABR in UNIVERSAL NEW BORN HEARING SCREENING [Mason and Herrmann, 1998; Mehl and Thomson, 1998; 2002; Prieve et al., 2000; Norton et al., 2000b]. Studies have ranged from controlled research protocols [Norton et al., 2000b] to clinical implementation comparisons

[Prieve et al., 2000] to population-based clinical practice [Mason and Herrmann, 1998; Mehl and Thomson, 1998; 2002].

Despite these methodological limitations, follow-up of infants screened by A- ABR demonstrates good test performance in identifying infants with moderate or greater degrees of hearing impairment (test sensitivity) as well as passing infants with normal hearing (test specificity).[10]

Norton and colleagues described screening outcomes for OAEs, and A-ABR. They reported that all three tests performed almost equally well in predicting hearing status based on area under the receiver operating characteristic curve (best OAE screening performance was obtained with stimulus intensity of 65/50 dB). Test sensitivity for all three measures increased as degree of hearing impairment increased. Several investigators have reported that OAEs result in a higher fail rate than A-ABR, especially within the first 24 hours of birth [Doyle et al., 1997; Vohr et al., 2001b]. This higher refer rate affects programmatic cost of screening by OAEs. As noted previously, both Gorga and his colleagues [Gorga et al., 2001] and Vohr and her colleagues [Vohr et al., 2001] calculate that programmatic costs of OAE and A-ABR screening are comparable when higher refer rates from OAE screening are taken into account.

In a study conducted by Dr.Jose.O et al in NICU, department of pediatrics, T.D.Govt. Medical College, Alappuzha in 2014titled "Assessment of Hearing Impairment Using Brainstem Evoked Response Audiometry (BERA) In Neonates with Various Otonoxious Risk Factors" 270 newborns with risk factors for hearing impairment were subjected to BERA initially with90 dB and subsequently stimuli at decreasing frequencies i.e. 75, 60, 45 dB were presented to each ear at an intensity of 90dB hearing level. An infant was considered as passed the test if wave V was present at 30 dB in both ears or in one ear at 30 dB and in the other at 45dB. Out of the 270 newborns, BERA was found to be impaired in 48 cases with increased hearing threshold, remaining 222 neonates had normal hearing threshold of 30dB bilaterally and 45dB in one ear and 30 dB in the other ear. Very low birth weight babies with impaired hearing was 25%, hyperbilirubinaemia in exchange range having hearing impairment were 45%, newborns with sepsis and hearing impairment were 32.5% It was concluded by the authors that proportion of newborn with impaired BERA was high in high risk newborn when compared to all neonates put together. Sepsis, very low birth weight and hyper bilirubinaemia in exchange range were found to have significant hearing impairment.[12]

Meyer et al performed multi centric study from October 1995 through November 1997 at 5 pediatric hospitals in the Federal Republic of Germany Hearing screening in high-risk neonates was done using BERA which revealed a total of 5% of infants had abnormal BERA. Significant risk factors were familial hearing impairment, bacterial sepsis, and craniofacial abnormalities. In contrast, very low birth weight and complications of prematurity were not independent risk factors for abnormal screening results in this study population. This change in the risk profile for neonatal hearing impairment in a high-risk population as speculated by the authors is to be related to improvement in perinatal and neonatal care.[16]

A child's hearing impairment should therefore be identified as early in life as possible so that he or she can receive timely and appropriate intervention. The interventions will then take full advantage of the plasticity of child's developing nervous system optimizing his or her social, emotional, psychological and academic development.[19,20,21]

New Born Hearing Screening In India:23

India being a developing nation and an resource limited setting the challenge of implementing NEW BORN HEARING SCREENING in India has to face several important challenges foremost being the scarcity of audiologists and the lack of infrastructure able to reach the 72% of the population which resides in rural areas[23]

Of the 350 government-run hospitals with tertiary care facilities only 120 have diagnostic and rehabilitation facilities for early detection of hearing impairment. Significant numbers of private centers offer facilities for audiological evaluation; however, they are not uniformly available across the country. Additionally, there is a

strong contrast in the demand for human resource versus capacity, as the ratio of the combined number of audiologists and audiometricians to population has been reported to be 1: 500,000.[23]

EXTERNAL ACOUSTIC (AUDITORY) CANAL:

It is divided into outer Cartilaginous Part and inner bony part

TYMPANIC MEMBRANE OR THE DRUMHEAD

It forms the partition between the external acoustic canal and the middle ear.

Tympanic membrane can be divided into two parts:

1. **Pars Tensa**

It forms most of tympanic membrane. Its periphery is thickened to form a fibrocartilaginous ring called *annulus tympanicus*, which fits in the tympanic sulcus. The central part of pars tensa is tented inwards at the level of the tip of malleus and is called *umbo.* A bright cone of light can be seen radiating from the tip of malleus to the periphery in the anteroinferior quadrant

2. **Pars Flaccida (Shrapnell's Membrane)**

This is situated above the lateral process of malleus between the notch of Rivinus and the anterior and posterior malleal folds (earlier called malleolar folds). It is not so taut and may appear slightly pinkish

THE INTERNAL EAR

The internal ear or the labyrinth is an important organ of hearing and balance. It consists of a bony and a membranous labyrinth. The membranous labyrinth is filled with a clear fluid called *endolymph* while the space between membranous and bony labyrinths is filled with perilymph.

BONY LABYRINTH

It consists of three parts: the vestibule, the semicircular canals and the cochlea.

1. **Vestibule.** It is the central chamber of the labyrinth. In its lateral wall lies the oval window. The inside of its medial wall presents two recesses, a *spherical recess*, which lodges the saccule, and an *elliptical recess*, which lodges the utricle. Below the elliptical recess is the opening of aqueduct of vestibule through which passes the endolymphatic duct. In the posterosuperior part of vestibule are the five openings of semicircular canals

2. **Semicircular Canals. Mainly concerned with the balance**

3. **cochlea.** The bony cochlea is a coiled tube making 2.5 to 2.75 turns round a central pyramid of bone called *modiolus*. The base of modiolus is directed towards internal acoustic meatus and transmits vessels and nerves to the cochlea.

DEVELOPMENT OF EAR[24]

Auricle – Around 6th week of embryonic life, a series of 6 tubercles appear around the first branchial cleft. They coalesce to form the auricle. Tragus develops from the tubercle of first arch while rest of pinna develops from the

remaining five tubercles of the second arch.
External Auditory Meatus – It develops from the first branchial cleft. By 16th week of embryonic life, cells proliferate from the bottom of ectodermal cleft and form a meatal plug. Recanalisation of this plug forms the epithelial lining of the bony meatus.

Tympanic Membrane – It develops from all the 3 germinal layers. Outer epithelial layer is formed by the ectoderm, inner mucosal layer by the endoderm and the middle fibrous layer by the mesoderm.

Middle Ear Cleft – The Eustachian tube, tympanic cavity, attic, antrum and mastoid air cells develop from the first and second pharyngeal pouches. Malleus and Incus are derived from mesoderm of the first arch while the Stapes from the second arch.

Inner Ear –Ectoderm in the region of hind brain thickens to form an auditory placode which is invaginated to form the auditory vesicle or otocyst. This differentiates into the endolymphatic duct and sac; the utricle, semicircular ducts; and saccule and the cochlea

Hearing Loss –Causes[8]
The causes fall into three basic categories.
Genetically inherited hearing loss accounts for approximately 50% of all cases. 70% are autosomal recessive, 15% autosomal dominant and 15% with other types of transmission. The most common genetic cause of hearing impairment is a mutation in the **connexin 26 gene**, located on chromosome **13q11-12.**Deletion of **mitochondrial gene 12SrRNA, A1555G is associated with a predisposition for hearing impairment after exposure to aminoglycoside antibiotics. The majority of these are non-syndromic**. The other cases are syndromic. In this type there are other clinical manifestations along with the hearing impairment. Usher syndrome is an example of a syndrome that includes hearing impairment.

In approximately 25% of childhood hearing loss, a **nongenetic** cause is identified. **Hearing impairment is thought to be secondary to injury to the developing auditory system in the intrapartum or perinatal period.**

The injury may be due to infection, hypoxia, ischaemia, metabolic disease, ototoxic medication or hyperbilirubinemia. Congenital Cytomegalovirus infection is the most common cause of nonhereditary sensory neural hearing impairment globally. Approximately 1% of all infants worldwide are born with CMV infection[42].Of these 10% have clinical signs of infection at birth(small for gestational age, hepatosplenomegaly, jaundice, thrombocytopenia, neutropenia, intracranial calcification, skin rash) and 50 -60% of these infants develop hearing impairment[42].**Hearing impairment also develops in 10 – 15% of those who are asymptomatic at birth. Sensory neural deafness is the single most common finding among infants with Congenital Rubella Syndrome (when maternal infection occurs before 11 weeks of gestation).** In the remaining 25%of all there is no identifiable cause.

OTOACOUSTIC EMISSIONS (OAE)
OTO acoustic emissions were first described by KEMP in 1978.In healthy cochlea, vibration of hair cells in response to noise generates acoustic energy known as OAE .An OAE is a weak echo type inaudible sound emitted by the ear soon after an audible sound is perceived .The OAE measures stimulated acoustic energy generated in cochlea (inner ear) that travels through the middle ear into the ear canal where it is sensed with a miniature microphone. OAE is very sensitive, noninvasive, cost and time effective making it an ideal screening method.[27]

OAE testing therefore measures the integrity of inner ear. Persons with normal hearing produce emissions. Those with hearing impairment greater than 25 – 30 decibels do not. OAEs can detect blockage in outer canal, middle ear fluid or damage to outer hair cells in the cochlea.

What Happens If An Infant Does Not Pass The Screening?[30,31,32,33]
Infants who do not pass the first screening by OAE are subjected to second screening by OAE after one month.

Rescreening reduces the false positive rates[31].

If second screening of OAE after interval of 6 weeks is also abnormal, then the infant is subjected to BERA(Task Force on newborn and infant hearing) and then referred for follow-up audiological (electrophysiologic measure of threshold using, frequency specific stimuli) and medical evaluations. These evaluations confirm the presence of hearing impairment; determine the type, nature, and (whenever possible) the cause of the hearing impairment; and help to identify options for treatment. Intervention for hearing impairment must be initiated before 6 months of age.

SENSITIVITY AND SPECIFICITY27,34
Sensitivity of OAE is 80 – 98% and that of BERA is 98-100%. Both methods have specificity >90%.

TEST LIMITATIONS27
OAE relies on a functionally normal outer, middle and inner ear and BERA in addition relies on functional lower auditory pathway.

As the stimuli for both tests are introduced via external ear canal, debris in the canal or middle ear fluid can affect accuracy of test. In particular, OAE testing may be affected by amniotic fluid in the ear canal when testing is done in the first 48 hours after birth.

Materials and Methods

Source of Data:
Neonates having high risk factors either born in department of Gynecology and Obstetrics, KIMSDU, Karad or born outside and are referred to NICU, department of pediatrics, KIMSDU, Karad during the study period of December 2017 to September 2019

STUDY DESIGN:
Prospective study

TYPE OF STUDY:
Prospective, observational, cross sectional study

SAMPLE SIZE:
P=5.9% i.e. normal q= 94.1 %
$N = 4pq/L^2 = 4*5.9*94.1/5^2 = 2221/25 = 87$
A total of 92 neonates with some of the high risk factors were studied

INCLUSION CRITERIA:

- Inborn neonates with some of the high risk factors.
- Out borns with some of the high risk factors referred to NICU, Dept Of Pediatrics KIMS , Karad
- The above neonates were tested only after stabilization and proper assessment
- This study comprised of neonates with following high risk factors
- BIRTH ASPHYXIA
- LOW BIRTH WEIGHT
- PRE TERM GESTATION
- TORCH AND / OR OTHER INTRA UTERINE INFECTION
- USE OF OTO TOXIC DRUGS IN NEONATE
- HYPERBILIRUBINEMIA REQUIRING EXCHANGE TRANSFUSION

- FAMILY HISTORY OF SENSORY NEURAL HEARING impairment
- MECHANICAL VENTILATION > 5 DAYS :
- SEPSIS

EXCLUSION CRITERIA:

- Those who are not willing to give consent.
- Normal healthy neonates without any risk factors
- neonates born with anotia
- Unstable and very sick neonates who cannot be shifted outside nicu for OAE testing

METHOD OF EXAMINATION

- Approval from research and ethics committee was obtained
- Parents or the grandparents or care takers of the neonates with high risk factors were informed about the study and motivated to undergo the screening program. An informed consent was taken from the parent/guardian
- Using a pre tested questionnaire risk factors were identified
- Although we recorded various maternal factors like preeclampsia with magnesium sulphate administration , hypothyroidism , placenta previa we could not get any literature which proves association between these maternal factors and hearing loss in neonates so we didn`t mention these in results.
- Neonates with high risk factors underwent hearing assessment after 48 hrs of life and within one month of age using OAE as the initial screening. Before performing OAE first stage screening it was ensured none of the babies had debris in both ears.
- Neonates who failed the initial screening were tested again with OAE at six weeks of life during the first immunization visit. Before performing OAE second stage screening it was ensured none of the babies had ear infection or debris in both ears. This was done in the Department of Otolaryngology KIMS KARAD
- Infants who failed the screening with OAE twice were subjected to BERA evaluation. The BERA evaluation was done on the same day on which 2nd OAE screening was done. All neonates with abnormalities were advised detailed ENT audio logical evaluation and auditory rehabilitation

Observation, Analysis and Results

Either inborn or out born Neonates with high risk factors were subjected to hearing assessment after 48 hrs of life but within one month of age using OAE as the first level of screening.

Infants who failed both the screenings with OAE were subjected to BERA evaluation

- This study comprised of 92 neonates with following high risk factors
- BIRTH ASPHYXIA
- LOW BIRTH WEIGHT
- PRE TERM GESTATION
- TORCH AND INTRA UTERINE INFECTION
- USE OF OTO TOXIC DRUGS IN NEONATE
- HYPERBILIRUBINEMIA REQUIRING EXCHANGE TRANSFUSION
- FAMILY HISTORY OF SENSORY NEURAL HEARING impairment
- MECHANICAL VENTILATION > 5 DAYS :
- SEPSIS
- These 92 neonates with some of the above high risk factors were subjected to OAE testing. The age of the study group ranged between 3 days to 28 days. The gestational age of the neonates studied ranged between 28 to 40 weeks. Birth weight varied between 900grams and 3800 grams. 1 neonate was excluded from study after the first screening test due to lost to follow up.

Table 1: Demographic Characteristics Of Study Population

ENROLLED	92
COMPLETED STUDY	91
DROP OUT	01

There were 92 new borns in our study out of whom 1 neonate was lost to follow up. Rest all completed the study.

Table 2: Showing Number of Neonates Who Were Inborn and Number of Neonates Who Were Out Born:

	NUMBER	**PERCENT**
INBORN	85	92.39%
OUT BORN	7	7.61%
TOTAL	92	100%

There were 92 new borns in our study out of these 7 neonates were outborn

Neonates Who Had Very Low Birth Weight As A Risk Factor:

Table 9: Showing Data Regarding Neonates Who Had Very Low Birth Weight As A Risk Factor

	First stage screening by OAE	**Second stage screening by OAE**	**Screening by BERA**
No of babies screened	47	04/05 <As one baby was lost to follow up >	02
No of babies who passed in the screening	42	02	01
No of babies with impairment in both ears	04	02	01
No of babies with impairment in one ear	01	00	00
Total No of babies who failed and eligible to undergo next stage hearing assesment	05	02	

- In our study there were 47 neonates with very low birth weight. Out of these 47 neonates, 42 neonates passed and 5 neonates failed in **FIRST STAGE OAE SCREENING**

Out of 48 NEONATES WHO WERE PRE TERM (includes all babies whose gestational age was less than 37 weeks irrespective of their birth weight) other risk factors noted are as follows :

Ototoxic drugs	13
LBW	47
Mechanical Ventilation	2
Sepsis	7
Hyperbilirubinemia	1
Birth Asphyxia	1

Out of 48 pre-term neonates other risk factors noted were Ototoxic drugs were administered in 13 , 47 had low birth weight ,2 received Mechanical Ventilation ,7 had Sepsis , 1 baby had hyperbillirubinemia requiring exchange transfusion, 1 had birth asphyxia

Neonates Who Were Administered Ototoxic Drugs:

Table 14: Showing Data Regarding Neonates Who Were Administered Ototoxic Drugs

	First stage screening by OAE	**Second stage screening by OAE**	**Screening by BERA**
No of babies screened	54	07/08 <as one baby was lost to follow up >	05
No of babies who passed in the screening	46	02	02
No of babies with impairment in both ears	06	04	03
No of babies with impairment in one ear	02	01	00
Total No of babies who failed and eligible to undergo next stage hearing assessment	08	05	

- In our study there were 54 neonates who were administered oto toxic drugs. Out of these 54 neonates , 46 neonates passed and 8 neonates failed in **FIRST STAGE OAE SCREENING**
- Out of these 8 neonates, 7 neonates underwent **SECOND STAGE OAE SCREENING** as 1 was lost to follow up and the results of **SECOND STAGE OAE SCREENING** of these 7 babies showed 5 had failed and 2 had passed

Neonates Who Received Mechanical Ventilation > 5 Days:

Table 18: Showing Data Regarding Neonates Who Received Mechanical Ventilation > 5 Days

	First stage screening by OAE	**Second stage screening by OAE**	**Screening by BERA**
No of babies screened	03	02	02
No of babies who passed in the screening	01	00	01
No of babies with impairment in both ears	02	02	01
No of babies with impairment in one ear	00	00	00
Total No of babies who failed and eligible to undergo next stage hearing assessment	02	02	

- In our study there were 3 neonates who underwent MECHANICAL VENTILATION > 5 DAYS. Out of these 3, 1 neonate passed and 2 neonates failed in the FIRST STAGE OAE SCREENING. These 2 neonates were found to have bilateral hearing impairment
- Both neonates were detected to have b/l hearing impairment in SECOND STAGE OAE SCREENING also.
- Both neonates were further tested by BERA which showed one neonate had mild hearing impairment in both ears and the other neonate had normal BERA.
- These neonates were twins and also had multiple risk factors in form of administration of ototoxic drugs ,birth weight less than 1 kg and were provided mechanical ventilation for more than 5 days for RDS

Table 27 Comparison Between Risk Factors Of Babies Found To Have U/L Hearing Impairment And B/L Hearing Impairment In Second Stage OAE:

RISK FACTORS NOTED AMONG BABIES WITH U/L HEARING LOSS	RISK FACTORS NOTED AMONG BABIES WITH B/L HEARING LOSS
1 ototoxic drugs, sepsis	1 :Birth Asphyxia, Ototoxic drugs, Preterm, Birth Weight >1 kg, Ototoxic drugs, clinical sepsis 2: preterm, birth weight <1kg, ototoxic drugs, culture positive sepsis, Mechanical ventilation >5 days 3 :ototoxic drugs, hyperbillirubinemia, culture positive sepsis, mechanical ventilation >5 days

It is found that babies with u/l hearing loss in second stage OAE had less number of risk factors (2) when compared to babies with b/l hearing loss (4 or more)

Table 28: Characteristics Of Babies Who Failed In First Stage OAE Screening:

RISK FACTORS	**FIRST STAGE OAE SCREENING**	**SECOND STAGE OAE SCREENING**	**BERA**
Preterm, Birth Weight >1 kg, Ototoxic drugs, clinical sepsis	Fail	Pass	
Birth Asphyxia, Ototoxic drugs,	Fail	Fail	Mild To Moderate Hearing Impairment
Preterm, Birth Weight >1 kg, Ototoxic drugs, clinical sepsis	Fail	Lost To F/Up	
Ototoxic drugs	Fail (Rt Ear) Pass (Lt Ear)	Pass(B/L Ears)	
preterm, birth weight >1kg, ante natal risk factor	Fail (Rt Ear) Pass (Lt Ear)	Pass(B/L Ears)	
ototoxic drugs, sepsis pneumonia	pass (Rt Ear) Fail (Lt Ear)	pass (Rt Ear) Fail (Lt Ear)	pass
preterm, birth weight <1kg, ototoxic drugs, cuture positive sepsis, Mechanical ventilation >5 days	Fail	Fail	Mild Hearing Impairment

preterm, birth weight <1kg, ototoxic drugs, culture positive sepsis, Mechanical ventilation >5 days	Fail	Fail	Pass
ototoxic drugs, hyperbillirubinemia, culture positive sepsis , mechanical ventilation >5 days	Fail	Fail	Profound Hearing Impairment

Discussion

This study comprises of 92 neonates who had high risk factors. These 92 babies were subjected to OAE testing. Out of these 92, **9(9 .8 %)** babies failed after the first screening.1(11.1%)baby lost for follow up after the first screening test. Thus, 8 underwent 2 nd OAE testing 3 out of 8 (37.5%) babies passed the second screening by OAE. 5 out of 8 babies(62.5%) failed after second screening by OAE and were subjected to BERA. Totally 5 babies were subjected to BERA . 3 babies had abnormal BERA(3.2%). All the babies who had persistent OAE failure and abnormal BERA had multiple risk factors . All those babies with single risk factor passed OAE stage 1, except one neonates who showed unilateral hearing impairment but subsequently on OAE stage 2 this neonate passed the test

Neonates Who Had Hyper bilirubinemia Requiring Exchange Transfusion As A Risk Factor

- In our study 7 neonates had **HYPER BILIRUBINEMIA REQUIRING EXCHANGE TRANSFUSION**. Out of these 7, 6 neonate passed and 1 neonate failed in **FIRST STAGE OAE SCREENING.** This neonate was found to have hearing impairment in both ears
- This neonate was detected to have b/l hearing impairment in **SECOND STAGE OAE SCREENING** as well
- This neonate was further tested by BERA which concluded profound hearing impairment in both ears
- This neonate also had other risk factors in form of administration of ototoxic drugs and culture positive sepsis and neonatal convulsion.
- These 7 neonates with Hyperbilirubinemia had other risk factors like Ototoxic drugs were administered in all 7 ,1 is preterm , 3 had Sepsis.
- In study done by O Jose et al[12] after performing multiple logistic regression analysis they found sepsis is the single most important adverse factor for hearing impairment. They detected 21% of their 73 cases are having hearing impairment. The prevalence in their study being much higher than our study. Probable reason for this is they have included only neonates with culture positive sepsis where as we included neonates with clinical , probable and culture positive sepsis
- Study done by Khairy et al[14] also found sepsis as a important risk factor. They have screened 260 neonates out of whom 78 neonates had hearing impairment. The prevalence in their study being much higher than our study. Probable reason for this is they have included more number of pre-term neonates (70 %) than we included (50%) in our study.

Neonates Who Had Family History Of Sensory Neuronal Hearing Impairment

In our study two babies who had family history of **SENSO NEURAL HEARING LOSS** were screened and both passed the first screening by OAE.

In study done by Prasad et al[1] who screened 27 babies who had family history of sensoryneural hearing loss were screened and only one baby had persistent OAE failure

Conclusion

- From this study of 92 high risk new born babies tested with two staged OAE for detection of hearing impairment, 5.4% new borns had hearing impairment detected.

- Of the 9 risk factors screened, Our observation indicate that FAMILY HISTORY OF SENSORY NEURAL HEARING LOSS AND INTRA UTERINE TORCH INFECTION are only 2 risk factors that are NOT frequently associated with hearing impairment. However VLBW infants, SEPSIS, Hyperbilirubinemia, Mechanical ventilation >5 days, those who received Ototoxic drugs, prematurity, Birth asphyxia are frequently associated with hearing impairment.

Limitations

- Our study focused on high risk infants .High risk infants constitute only 50% of all neonates with hearing impairment. The other 50% who do not have some of the high risk factors would go undetected at birth by this approach as neonates who do not have any of the high risk factors were not included in this study .

- All high risk neonates require hearing assessment every 6 months upto 3 years of age. This follow up was not included in our study

Bibliography

1. Prasad Kumar, Adhisivam B, Vishnu Bhat B, Bharathi B, Febi Francis, Nivedita Mondal ,Screening for Hearing Impairment among High Risk Neonates– Experience from A Tertiary Care Center. Department of Neonatology, JIPMER, Pondicherry 605 006, India, Curr Pediatr Res 2016; 20 (1&2): 43-46 ISSN 0971-9032

2. Nagapoornima P, A Ramesh, Srilakshmi, Rao Suman, Patricia P L, Gore Madhuri et al. Universal Hearing Screening. Indian J Pediatr 2007; 74 (6): 545- 9.

3. Report No. 485: Disabled Persons in India, July-December 2002. NSS 58th Round. National Sample Survey Organisation. Ministry of Statistics and Programme Implementation. Government of India; December, 2003

4. Dora Jerina Jose, Rejee Ebenezer Renjit and Sajilal Manonmony Prevalence of hearing impairment among high risk neonates- A hospital based screening Study. International Journal of Biomedical and Advance Research 2016; 7(3): 131-134. 131 IJBAR (2016) 07 (03). www.ssjournals.com

5. Report by NIH , USA which can be assessed at following link https://report.nih.gov/nihfactsheets/ViewFactSheet.aspx?csid=104&key=N

6. Abraham Paul, Chhaya Prasad, Ss Kamath, Samir Dalwai, Mkc Nair And Waheeda Pagarkar Consensus statement of the indian academy of pediatrics on newborn hearing screening Indian Pediatrics , Volume 54 ,August 15, 2017

7. Dr.Jaideep Bhatt, Dr.Laltanpuia Chhangte, Accuracy of OAE and BERA to detect the incidence of hearing loss in newborn. International Journal of Scientific and Research Publications, Volume 5, Issue6, June 2015.

8. Nelson text book of pediatrics 20th edition

9. Statement on history of universal new born hearing screening by cdc , USA which can be assessed at following link https://stacks.cdc.gov/view/cdc/55989/cdc_55989_DS1.pdf?

10. Deborah Hayes, Screening Methods: Current Status, Mental Retardation And Developmental Disabilities Research Reviews 9: 65–72 (2003)

11. Dr.D.Suchitra, Dr.P.Nagaveni, Dr.C.Rukesh Chary, Hearing Assessment In Asphyxiated Term Neonates in a Tertiary, Care Hospital, IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), Volume 16, Issue 6 Ver. XI (June. 2017), PP 24-29.

12. Dr.Jose.O Dr.Sreelatha. P. R Dr Rani R Nath Assessment of Hearing Impairment Using Brainstem Evoked Response Audiometry (BERA) In Neonates with Various Otonoxious Risk Factors IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) e-ISSN: 2279-0853, p-ISSN:2279- 0861.Volume 16, Issue 3 Ver. II (March. 2017), PP 25-33

13. P. Nagapoornima, A. Ramesh, Srilakshmi, S. Rao,P.L. Patricia, M. Gore, M. Dominic and Swarnarekha, "Uni- versal Hearing Screening " India Journal ofPediatrics, Vol.74,No.6,2007,pp.545-549

14. Khairy et al Hearing Impairment Among High-Risk Newborns Admitted To A Tertiary Neonatal Intensive Care Unit .DOI: 10.1080/14767058.2017.1326902 the journal of maternal fetal and neonatal medicine volume 31 -2018 issue 13

15. . Wang CH1, Yang CY2, Lien R1, Chu SM1, Hsu JF1, Fu RH1, Chiang MC1..Prevalence and independent risk factors for hearing impairment among very low birth weight infants Int J Pediatr Otorhinolaryngol. 2017 Feb; 93:123- 127. doi: 10.1016/j.ijporl.2016.12.029.

16. Christiane Meyer, Neonatal Screening for Hearing Disorders in Infants at Risk: Incidence, Risk Factors, and Follow-up American Academy of Pediatrics Journal 1998 MD DOI: 10.1542/peds.104.4.900

17. Universal hearing screening in Illinois 2003-2004, published report of Illinois Dept of Public health, Division of Epidemiologic studies, August 2006,1-11.

18. Facts released by who regarding hearing loss which can be accessed at following link https://www.who.int/news-room/fact-sheets/detail/deafness- and-hearing-impairment

19. Kumudha J. Follow up of high risk neonates. Indian Journal of Practical Pediatrics. 2009; 11(4) : 329-36

20. Christine Yoshinaga-Itano, Allison L. Sedey, Diane K. Coulter and Albert L. Mehl. Language of Early- and Later-identified Children With Hearing Impairment. Pediatrics1998; 102; 1161-1171.

21. Andrew P. McGrath, Betty Vohr and Courtney A.O'Neil. Medicine & health/rhodeisland.2010.93 (5): 42-44.

22. Kittrell and Arjmand. The age of diagnosis of sensorineural Hearing impairment in children. 1997. International Journal of Pediatric Otorhinolaryngology; 40:97-106

23. Ramkumar, Vidya. (2017). A Review Of Neonatal Hearing Screening Practices In India. Journal of Hearing Science. 7. 9-15. 10.17430/902592.

24. P L Dhingra diseases of Ear, Nose and Throat - 2nd edition.

25. Jane E.Stewart and Jeffrey W.Stolz. Manual of Neonatal Care - 6th edition: pages644-647

26. O Edward. Tympanometry .Am Fam Physician. 2004 ;70(9): 1713-20

27. Harvey Coates and Kim Gifkins. Newborn hearing screening. Aust Prescr 2003; 26 :82-4

28. Olusanya BO, Newton VE. Global burden of childhood hearing impairment and disease control priorities for developing countries. Lancet 2007;14:1314-7

29. Sharma P, Chhangani NP, Meena KR, Jora R, Sharma N, Gupta BD. Brainstem evoked response audiometry (BAER) in neonates with hyperbilirubinemia. Indian J Pediatr. 2006May; 73(5):413-6.

30. Abraham paul K. Hearing impairment in neonates and infants: Need for early detection and intervention. Pediatrics Today Vol.XII No.4 July-August 2009: 157-160.

31. Heinemann M, Bohnert A. Hearing screening in newborn infant. Comparative studies and cost analysis with different instruments. Laryngorhinootologie.2000 Aug; 79(8):453-8.

32. White, K. R., and Maxon, A. B. Universal screening for infant hearing impairment: simple, beneficial, and presently justified. International Journal of Pediatric Otorhinolaryngology, 32 (1995) 201-211

33. Abdullah A, Hazim M Y S, Almyzan A, Jamilah A G, RoslinS, Ann M T, et al. Newborn hearing screening: experience in a Malaysian hospital. Singapore Med J 2006;47(1):60-64

34. Article from medscape can be accessed at following link https://emedicine.medscape.com/article/836277-overview#a4

35. Christine Ohl, Liliane E Dornier, Cecile Czajka, Jean-Claude Chobaut andLaurent Tavernier. International Journal o f Paediatric Otorhino Laryngology.73 (2009) 1691-1695.

36. Baran Acar , Emre Ocak , Mehtap Acar, Deniz Kocaöz, Comparison of risk factors in newborn hearing screening in a developing country , The Turkish Journal of Pediatrics 2015; 57: 334-338

37. Goderis J, De Leenheer E, Smets K, Van Hoecke H, Keymeulen A, Dhooge I Hearing loss and congenital CMV infection: a systematic review.. Pediatric journal 2014 Nov;134(5):972-82. doi: 10.1542/peds.2014-1173

38. Kruthika Thangavelu, Kyriakos Martaki, Silke Fabian, Mahima Venkateswaran, Bernhard Roth, Dirk Beutner, Ruth Lang-Roth, Prevalence and risk factors for hearing impairment in high-risk neonates in Germany, Acta Pædiatrica, May 2019 ISSN 0803-5253 DOI:10.1111/apa.14837.