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### RESEARCH ARTICLE

#### A STUDY OF PREVALENCE OF HEARING IMPAIRMENT BY OTOACOUSTIC EMISSIONS IN NEONATES AT GOVERNMENT RAJAJI HOSPITAL.

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#### Abstract

**Aims and Objectives:** To determine the prevalence of hearing impairment in at risk neonates admitted in tertiary level teaching hospital and to determine distribution of common risk factors in newborns with hearing loss. **Materials and Methods:** It was a prospective study over a period of one year. We screened high risk neonates for hearing impairment using portable transient evoked otoacoustic emissions (TEOAE) before discharge from the hospital. Follow up transient evoked automated otoacoustic emissions (TEOAE) was performed after four weeks in cases where initial testing gave refer response. Babies who tested refer on the follow-up were subjected for BERA testing and hearing impairment was confirmed. **Results:** A total of 110 cases comprising 39 males (35.5%) and 71 females (64.5%) were enrolled and studied. 45 cases (40.9%) were preterm, 30 cases (27.3 %) were low birth weight, 20 cases (18.2%) were having perinatal asphyxia with Apgar score of less than 6 at fifth minute, 9 cases (8.2%) had hyperbilirubinemia requiring exchange transfusion, 6 cases (5.5%) had sepsis. In the first visit, with 110 neonates and 220 test ears, OAE was tested. 84 neonates (76.36%) had both ears pass response, while 26 neonates (23.63%) had refer response (10 males and 16 females). Hearing loss had no statistical relationship with gender ( $p=0.978$ ). 2 neonates did not appear for follow up visit. 2<sup>nd</sup> OAE was tested after 4 weeks of initial testing. Out of 24 neonates with refer response in second visit, 8 were preterm neonates, 5 had prenatal asphyxia, 5 had received exchange transfusion for hyperbilirubinemia, 2 had low birth weight and 1 had sepsis. BERA was done for neonates with refer response even in the second visit and hearing impairment was confirmed. **Conclusion:** To conclude, prevalence of hearing impairment in at risk neonates are preterm neonates (40.3%), low birth weight (27.3%), perinatal asphyxia (18.2%), hyperbilirubinemia requiring exchange transfusion (8.2%), sepsis (5.5%). The prevalence of hearing impairment was more in neonates with hyperbilirubinemia requiring exchange transfusion than other risk factors. Most newborns with a detected hearing loss can be identified based on the risk factors. Thus, a targeted approach for hearing screening may be more feasible in resource limited settings.

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**Introduction:-**

Hearing deficit prevalence is 1.5 to 2.6 per 1000 live births (WHO). Four in every 1000 children suffer from severe to profound hearing loss in India. Over 100,000 babies are born with hearing deficiency every year in our country. It can be either unilateral or bilateral. Any degree of hearing loss should be considered for further evaluation. Early intervention, as young as 6 months is the key.<sup>[4,5]</sup>

Hearing assessment is a tool to determine an individual's hearing status, while a screening is a pass/fail tool to determine whether a full assessment is warranted. Screening programs for hearing impairment may be either "universal" or "high risk" population based<sup>[7]</sup>.

Studies have shown that early auditory deprivation impairs with the development of neural structures necessary for hearing. The goal of early identification and intervention is to minimize this adverse effect. Neonatal and infant screening programs using otoacoustic (OAE) emission and auditory brain stem response (ABR) have been established worldwide for this purpose.

Studies show that children who received intervention have better cognition than those without. Before the implementation of hearing screening program, it was advised to only test those newborn who have significant risk factors for hearing loss. It is indeed a big challenge to provide special education, vocational training and employment to this large population. The gravity of this problem can only be tackled if available infrastructure is used to mainstream hearing impaired people in regular education, vocational training and employment, by attending to hearing loss on time and instituting appropriate remedial measures.

Kemp introduced Otoacoustic Emissions (OAE) measurement for newborn screening. OAE is sensitive, non-invasive, cost and time effective, making it an ideal screening method<sup>[8]</sup>. In a normally functioning cochlea, the outer hair cell emits 'echoes' back which are measured as OAE recorded in the external ear canal by a small, sensitive microphone connected to microcomputer<sup>[9]</sup>.

**Aims And Objectives:-**

1. To determine the prevalence of hearing impairment in at risk neonates
2. To determine distribution of common risk factors in newborns with hearing loss.
3. Early detection leading to early intervention
4. Improving speech and language acquisitions

Significant hearing loss is one of the most common health problems present at birth and, if undetected, will impede speech, language, and cognitive development. Early detection, intervention, treatment and rehabilitation prevent the consequences of neonatal hearing.

The statement of the Joint Committee on Infant Hearing (1994), supported by the American Academy of Pediatrics (AAP), endorses the goal of universal detection of hearing loss in infants before 3 months of age, with appropriate intervention no later than 6 months of age. Infant distraction test has the disadvantage that it cannot be performed until 6 months of age<sup>[10]</sup>.

**Materials And Methods:-**

This study was a hospital based prospective study undertaken in the department of Otorhinolaryngology, Government Rajaji Hospital, Madurai; a tertiary care referral hospital.. The study was done over a period of one year from August 2016 to July 2017. Ethical committee clearance was given by the hospital ethical committee. Since my study was hearing assessment in neonates, sought help from Department of Paediatrics, Government Rajaji Hospital, Madurai. Informed consent was taken from the parents and the guardians after explaining to them, the purpose of the study.

**Sampling Frame:-**

The sample size of the study group comprised of the 110 neonates between the age of 1 and 28 days selected by consecutive sampling method who were considered to be high risk patients as described below for hearing loss:

1. Prematurity
2. Perinatal asphyxia determined by APGAR less than 6 at 5 minutes
3. Birth weight (<1500gm)
4. Hyperbilirubinemia requiring exchange transfusion
5. Culture positive neonatal sepsis
6. Family History of hereditary childhood sensorineural hearing loss

Neonates with malformed ear, middle ear pathology and birth injuries were excluded from the study.

### **Methodology:-**

The case history and clinical examination including otoscopy was done thoroughly for all 110 cases. After getting informed and written consent from parents, neonates are subjected to primary screening with transient evoked otoacoustic emission testing before discharge from hospital.

If initial screening result falls under refer criteria, repeat TEOAE after 4 weeks is suggested.

If the repeat TEOAE result falls under refer criteria, confirmative evaluation with BERA was done.

The neonatal hearing screening was carried out by portable transient evoked automated otoacoustic emissions (OAE) before discharge from the hospital. OAE was carried out in both ears using a portable device which uses click stimuli involving frequency bands between 1,500 Hz and 3,800 Hz. The click is presented at an intensity of 75 to 83 dB SPL. The response was considered positive (passed) when the otoacoustic emissions captured were 6 dB higher than the noise. No further test are to be done for neonates who have their otoacoustic emissions under pass criteria. The parents of newborns who had met the pass criteria were informed regarding the delayed-onset hearing impairment and follow-up of their children regarding hearing loss was recommended. They were not called back for screening again as this implementation did not exist in our screening program.

If there was no clear emission in either ear, infants undergo secondary testing with the OAE. In absence of emissions in secondary OAE, infants were advised to have brainstem evoked response audiometry (BERA) tested.

Measurement of BERA produced by a series of clicks at 45, 90 and 110 dB NHL was made via three scalp electrodes, an averaging computer, and a printer.

The presence and latency of the ABR were determined by a trained observer. Screening was done by two trained audiologists under the supervision of an otorhinolaryngologist.

### **Informations Collected During The Study:-**

1. Gestational age at birth
2. Birth weight
3. APGAR Score at 5'
4. Blood investigations including Total, direct and indirect Bilirubin, C reactive protein
5. Otoscopic examination
6. Tympanometry
7. Transient evoked otoacoustic emission testing
8. Brainstem Evoked Auditory Response

This study included preterm babies according to WHO definition<sup>[17]</sup>. World Health Organization has defined preterm as babies born alive before 37 weeks of pregnancy are completed. There are sub-categories of preterm birth, based on gestational age:

1. Extremely preterm (<28 weeks)
2. Very preterm (28 to <32 weeks)
3. Moderate to late preterm (32 to <37 weeks).

**Neonatal birth weight:-**

Birth weight of less than 1500g was considered as the risk factor in the study. Low birth weight (LBW) is defined by the World Health Organisation as a birth of a live born infant of 2,499 g or less, regardless of gestational age. Very low birth weight (VLBW), is birth weight less than 1500 g (3 pounds 5 ounces), extremely low birth weight (ELBW), birth weight is less than 1000 g (2 pounds 3 ounces). Normal weight at term delivery is 2500–4200 g (5 pounds 8 ounces – 9 pounds 4 ounces).

**Perinatal Asphyxia:-**

Perinatal asphyxia, neonatal asphyxia or birth asphyxia is the medical condition resulting from deprivation of oxygen to a newborn infant that lasts long enough during the birth process to cause physical harm, usually to the brain. Hypoxic damage can occur to most of the infant's organs (heart, lungs, liver, gut, kidneys), but brain damage is of most concern and perhaps the least likely to quickly or completely heal. In more pronounced cases, an infant will survive, but with damage to the brain manifested as either mental, such as developmental delay or intellectual disability, or physical, such as spasticity.

It results most commonly from a drop in maternal blood pressure or some other substantial interference with blood flow to the infant's brain during delivery. This can occur due to inadequate circulation or perfusion, impaired respiratory effort, or inadequate ventilation. Perinatal asphyxia happens in 2 to 10 per 1000 newborns that are born at term, and more for those that are born prematurely. WHO estimates that 4 million neonatal deaths occur yearly due to birth asphyxia, representing 38% of deaths of children under 5 years of age.<sup>[18]</sup>

Neonates with Apgar score of less than 4 at one minute or less than 6 at fifth minute were taken for this study.

Apgar score is a method to quickly summarize the health of newborn children. Dr. Virginia Apgar, an anesthesiologist at NewYork–Presbyterian Hospital, developed the score in 1952 in order to quantify the effects of obstetric anesthesia on babies<sup>[16]</sup>.

The Apgar scale is determined by evaluating the newborn baby on five simple criteria on a scale from zero to two, then summing up the five values thus obtained. The resulting Apgar score ranges from zero to 10. The five criteria are summarized using words chosen to form an acronym (Appearance, Pulse, Grimace, Activity, Respiration) The test is generally done at one and five minutes after birth, and may be repeated later if the score is and remains low. Scores 7 and above are generally normal, 4 to 6 fairly low, and 3 and below are generally regarded as critically low.

A low score on the one-minute test may show that the neonate requires medical attention<sup>[4]</sup> but does not necessarily indicate a long-term problem, particularly if the score improves at the five-minute test. An Apgar score that remains below 3 at later times—such as 10, 15, or 30 minutes—may indicate longer-term neurological damage, including a small but significant increase in the risk of cerebral palsy. However, the Apgar test's purpose is to determine quickly whether a newborn needs immediate medical care.

**Neonates with hyperbilirubinemia at a serum level requiring exchange transfusion:-**

An exchange transfusion involves removing aliquots of patient blood and replacing with donor blood in order to remove abnormal blood components and circulating toxins whilst maintaining adequate circulating blood volume. It is primarily performed to remove antibodies and excess bilirubin in isoimmune disease, the incidence of exchange transfusion is decreasing secondary to the prevention, and improved prenatal management of alloimmune haemolytic disease and improvements in the management of neonatal hyperbilirubinemia.

A total serum bilirubin level at or above the exchange transfusion level should be considered a medical emergency and intensive phototherapy should be commenced immediately<sup>[19]</sup>.

**Otoscope examination:-**

The otoscopic exam is performed by gently pulling the auricle upward and backward. In children, the auricle should be pulled downward and backward. This process will move the acoustic meatus in line with the canal. Hold the otoscope like a pen/pencil and use the little finger area as a fulcrum. This prevents injury if the patient turn suddenly.

1. Inspect the external auditory canal.
2. Evaluate tympanic membrane

3. Note the color (red, white, yellow) and translucency (transparent, opaque) and position (retracted, neutral or bulging) of the drum
4. Identify the pars tensa with its cone of light, the handle and short process of malleus, and the anterior and posterior folds of the pars flaccida and position of the malleus handle.

Since an intact tympanic membrane is necessary for conducting cochlear echoes, otoscopic examination is a must before OAE testing.

**Tympanometry:-**

Tympanometry is an examination used to test the condition of the middle ear and mobility of the tympanic membrane and the conduction bones by creating variations of air pressure in the ear canal.

Tympanometry is an objective test of middle-ear function.

**Otoacoustic emission:-**

An otoacoustic emission (OAE) is a low-level sound emitted by the cochlea either spontaneously or evoked by an auditory stimulus.

When sound stimulates the cochlea, the outer hair cells vibrate. The vibration produces a nearly inaudible sound that echoes back into the middle ear. The sound can be measured with a small probe inserted into the ear canal.

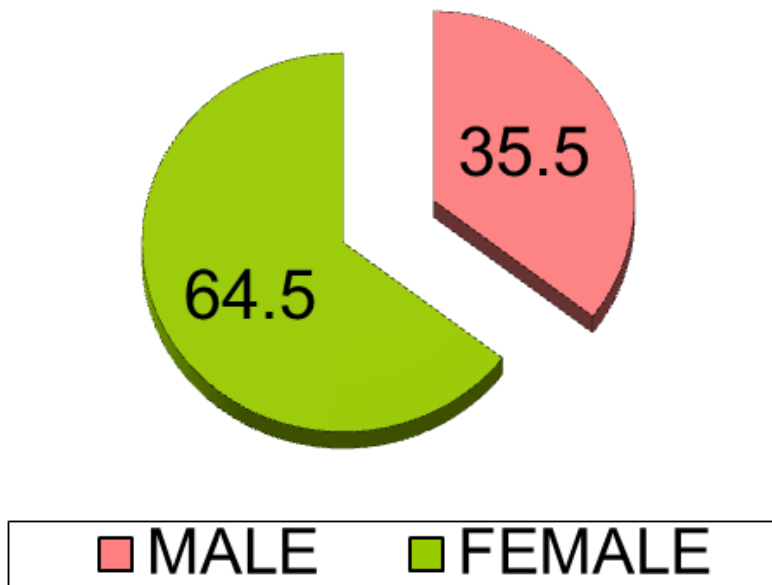
**Statistical Analysis:-**

The data obtained was tabulated and the variables were analyzed for their association with the outcome by applying the Fisher's exact test, Chi-square test, correlational analysis and calculation of p-value and Odd's ratio.

**Observations And Results:-**

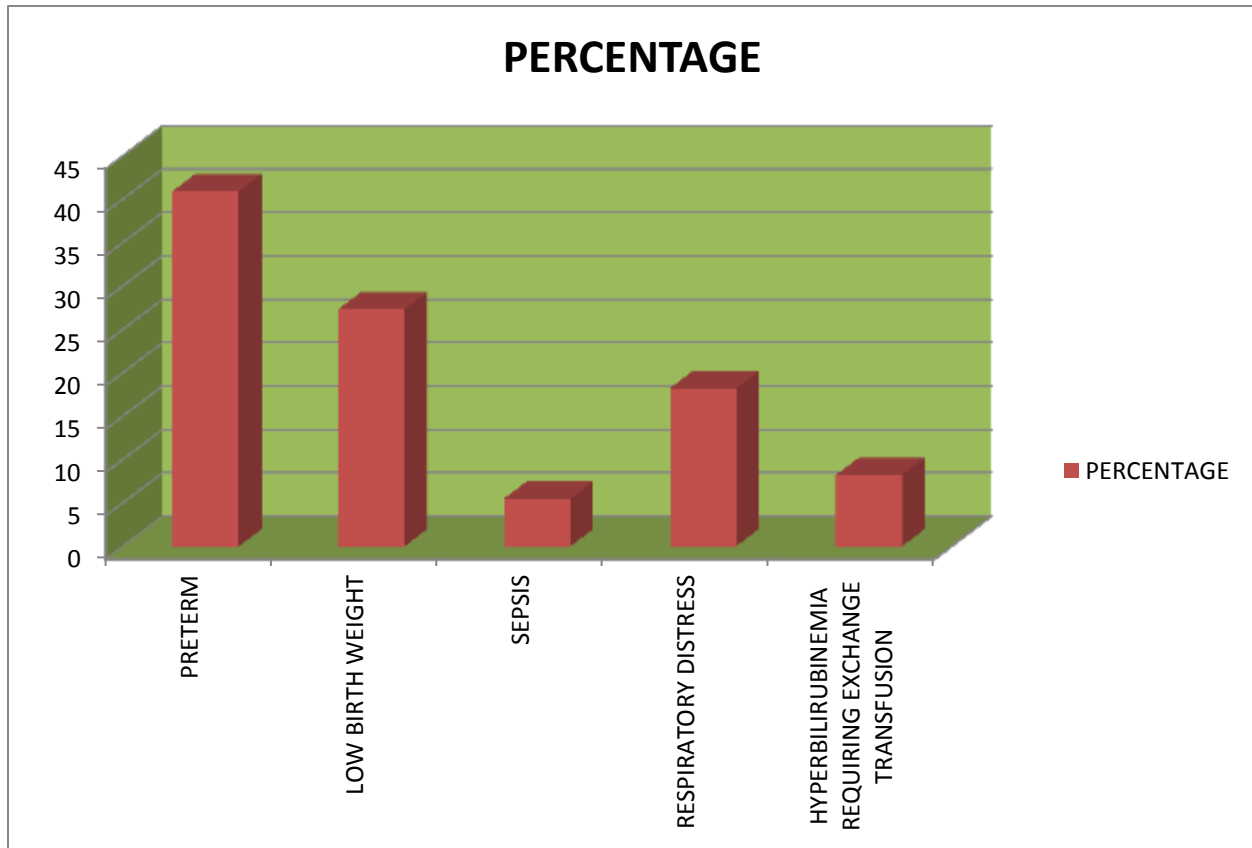
A total of 110 cases comprising 39 males (35.5%) and 71 females (64.5%) were enrolled and studied.

## SEX DISTRIBUTION



SEX	Percentage
MALE	39
FEMALE	71
TOTAL	100.0

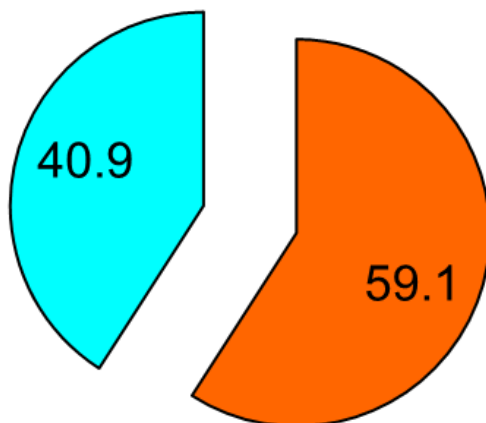
Out of 110 cases, 45 cases (40.9%) were preterm, 30 cases (27.3 %) were low birth weight, 20 cases (18.2%) were having perinatal asphyxia with Apgar score of less less than 6 at fifth minute, 9 cases (8.2%) had hyperbilirubinemia requiring exchange transfusion, 6 cases (5.5%) had sepsis.



Out of 110, 10 males and 16 females had hearing loss (initial OAE testing). A total of 21 neonates, 7 males and 14 females had hearing loss on follow up OAE and BERA. Hearing loss had no statistical relationship with gender (p=0.978).

75 (68.2%) neonates in the age group of 11 to 20 days, 23 (20.9%) neonates in the age group of more than 20 days, 12 (10.9%) neonates in the age group of less than 10 days were tested for OAE.

## GESTATION AT BIRTH



■ TERM      ■ PRETERM

45 out of 110 (59.1%) neonates were preterm and 65 out of 110 (40.1%) neonates were term. 30 neonates (27.3%) had birth weight less than 1500g, 80 neonates (72.7%) had normal birth weight.

BIRTH WEIGHT	No.of cases
LOW BIRTH WEIGHT	30
NORMAL BIRTH WEIGHT	80
Total	110

20 neonates (18.2%) had history of perinatal asphyxia and 90 neonates had no history of perinatal asphyxia.

PERINATAL ASPHYXIA	No.of cases
PRESENT	20
ABSENT	90
TOTAL	110

9 neonates (8.2%) had received exchange transfusion for hyperbilirubinemia; 101 neonates had normal serum bilirubin levels and did not any transfusion. 6 neonates (5.5%) had sepsis and raised C reactive protein.

HYPERBILIRUBINEMIA	No.of cases
REQUIRING EXCHANGE TRANSFUSION	9
NOT REQUIRING EXCHANGE TRANSFUSION	101
Total	110

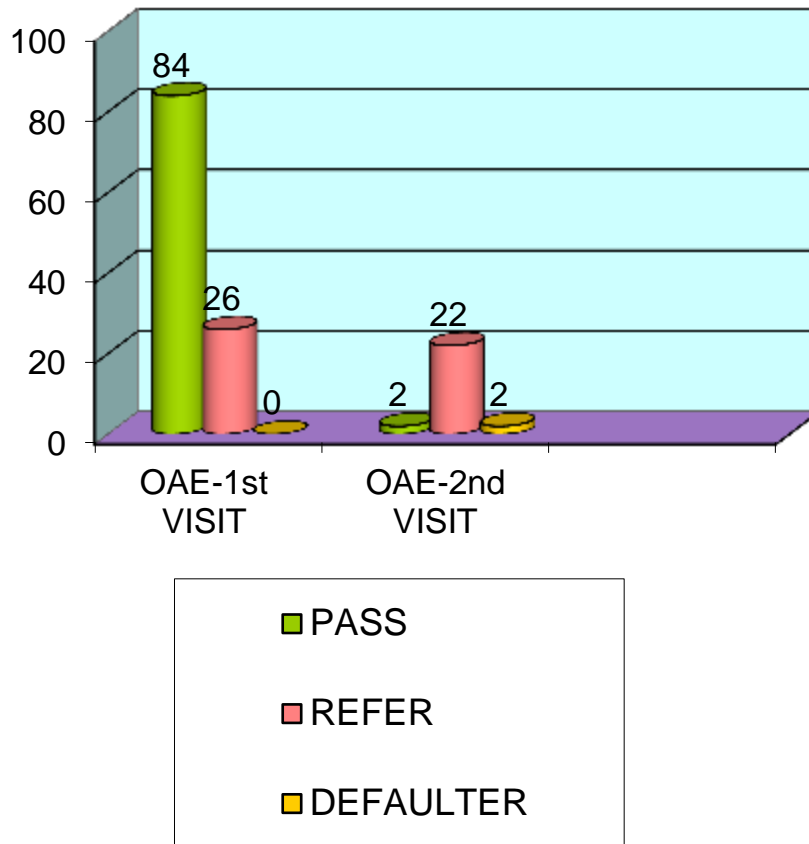
SEPSIS	No.of cases
PRESENT	6
ABSENT	104
TOTAL	110

Preterm, low birth weight, perinatal asphyxia were the major risk factors occurring in 40.9%, 27.3% and 18.2% at risk neonates respectively. None of the study neonates had family history of hearing loss.

VISIT	OAE-1st VISIT	OAE-2nd VISIT
PASS	84	2
REFER	26	22
DEFAULTER	0	2

In the first visit, with 110 neonates and 220 test ears, OAE was tested. 84 neonates (76.36%) had both ears pass response, while 26 neonates (23.63% ) had refer response. 2 neonates did not appear for follow up visit. 2<sup>nd</sup> OAE was tested after 4 weeks of initial testing. Out of 24 neonates who visited the second time, 22 had refer response and 2 neonates had pass response.

### VISIT DISTRIBUTION



Out of 24 neonates with refer response in second visit, 7 were preterm neonates, 6 had prenatal asphyxia, 5 had received exchange transfusion for hyperbilirubinemia, 2 had low birth weight and 2 had sepsis. The parents of neonates who had pass response in the first visit, were educated about late onset hearing impairment. BERA was done for neonates with refer response even in the second visit and hearing impairment was confirmed.

**Distribution Of Cases With Refer Criteria:-**

PRETERM	8
LOW BIRTH WEIGHT	2
RESPIRATORY DISTRESS	5
HYPERBILIRUBINEMIA REQUIRING EXCHANGE TRANSFUSION	5
SEPSIS	1

In this study, prevalence of risk factors in neonates are preterm, low birth weight, perinatal asphyxia, hyperbilirubinemia requiring exchange transfusion and sepsis in decreasing order. The prevalence of hearing impairment was more in neonates with hyperbilirubinemia requiring exchange transfusion followed in order by perinatal asphyxia, preterm, low birth weight and sepsis.

Distribution of cases	NO OF CASES	PERCENTAGE
Preterm	45	40.9
Low birth weight	30	27.3
Perinatal asphyxia	20	18.2
Hyperbilirubinemia requiring exchange transfusion	9	8.2
Sepsis	6	5.5

Risk factors	No of cases participated in the study	No of cases with refer response	hearing loss prevalence
Preterm	45	8	17
Low birth weight	30	2	10
Perinatal asphyxia	20	5	25
Hyperbilirubinemia requiring exchange transfusion	9	5	55
Sepsis	6	1	16

### Discussion:-

This study represents an initial attempt for implementing new-born hearing screening program in our hospital. In this study 110 at risk neonates were screened for hearing loss using OAE. 26 neonates tested abnormal in the initial screening procedure, which could be confirmed in 22 infants (20%) on follow-up. This implies a significant increase in hearing impairment in high risk neonates. Similar results have been obtained in the studies done by A Zamani et al., (8%) and Alwan M Maisoun et al., (13.5%)<sup>[20]</sup>. However, Christiane Meyer et al., found hearing impairment in 5.3%<sup>[21]</sup>. The higher incidence in our study could be due to smaller sample size or because of severity of illness in our study population.

M AL-Harbi et al., found sepsis/meningitis and intraventricular haemorrhage as significant risk factors for hearing impairment<sup>[23]</sup>. Christiane Meyer et al., reported craniofacial anomalies, familial hearing disorders and bacterial meningitis as significant factors associated with pathologic BAER<sup>[21]</sup>. Similar findings were reported by AL-Harbi M et al., and KY Chan et al.,<sup>[23,24]</sup>.

In our study use of preterm, perinatal asphyxia and hyperbilirubinemia were the major risk factors in study neonates, which is consistent with the study conducted by A Zamani et al.,<sup>[20]</sup>. In the study by Christiane Meyer et al., ototoxic medication and birth weight <1500gm were the major risk factors<sup>[21]</sup>. The difference can be attributed to the relatively low survival rate of low birth infants in our set-up. Higher percentage of hyperbilirubinemia requiring exchange transfusion in our study is due to poor follow-up of neonates with blood group incompatibilities.

In our study, two neonates had initial refer response turned into pass response on follow up studies. This transient abnormality can be due to the presence of middle ear effusion seen in ventilated babies. Similar findings have been reported by Hulya Bilgen et al.<sup>[22]</sup>.

In our study 5 out of 9 neonates with hyperbilirubinemia requiring exchange transfusion had refer in 2<sup>nd</sup> OAE and abnormal BERA which is supported by the study conducted by A Zamani et al.,<sup>[20]</sup>, hyperbilirubinemia was the main cause of hearing loss. The transient BERA abnormalities in infants with hyperbilirubinemia has been earlier reported by VK Agrawal et al.,<sup>[25]</sup>.

Infant hearing screening was started in the USA more than 30 years ago by (Downs and Sterritt, 1964) using behavioral audiometric 'arousal' technique. High rates of false positives and false negatives were detected, according to the Joint Committee On Infant Hearing, and recommended the alternative use of audiometry tests for infants with high-risk criteria. Low sensitivity and specificity in conventional screening procedures such as the arousal technique apparatus render the technique suitable for screening only and not for diagnostic procedures. In 1988 Screening for hearing impairment in infancy in most districts in the United Kingdom was done with infant distraction test (IDT) at 7 to 8 months of age, a targeted high risk babies Johnson et al., (1990) reported the distraction test was sensitive (91%) but non-specific (82%) in the high-risk population. The effectiveness of the screening program was limited. Recently, the use of TEOAEs together with ABR was shown to be reliable and high sensitivity and specificity in universal hearing screening programs. The two techniques (TEOAEs and ABR)

showing maximal promise as universal screening tools for the newborn, each has its unique advantages and disadvantages (Geert De Ceulaer et al., 1999).

#### **Limitations Of The Study:-**

Small sample size is one of the limitations in our study. Further studies are needed with larger sample size to more accurately highlight the importance of hearing assessment in high risk newborn babies. Furthermore, other risk factors like duration of NICU stay, meningitis, malformations, ototoxic drug administration could not be evaluated.

#### **Conclusion:-**

To conclude, prevalence of hearing impairment in at risk neonates are preterm neonates (40.3%), low birth weight (27.3%), perinatal asphyxia (18.2%) , hyperbilirubinemia requiring exchange transfusion (8.2%), sepsis (5.5%). Hence emphasizes the importance of screening for hearing impairment in such high risk newborns. The prevalence of hearing impairment was more in neonates with hyperbilirubinemia requiring exchange transfusion than other risk factors. The study highlights that although universal hearing screening programs are warranted; most newborns with a detected hearing loss can be identified based on the risk factors. Thus, a targeted approach for hearing screening may be more feasible in resource limited settings.

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