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RESEARCH ARTICLE

TO STUDY THE INCIDENCE OF SENSORINEURAL HEARING LOSS POST MENINGITIS IN NEONATES

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Abstract

Background: Post meningitis hearing impairment is an important public health problem. Neonatal meningitis is an important cause of mortality and morbidity in neonates in future life. An important consequence is hearing loss. Hearing plays a basic and important role in language, speech and intellectual development. Late detection causes irreversible stunting of the language development potential of the child. Early detection and intervention would help to maximize linguistic competence and literacy development for children who are deaf or hard of hearing. The study of brainstem evoked response audiometry provides an opportunity to evaluate the functional integrity of auditory pathway from inner ear to upper brainstem.

Aim: This study was conducted to determine the incidence of sensorineural hearing loss following meningitis in neonates.

Material and Methods: The present study was conducted in the Department of Pediatrics, Government Medical College Srinagar. All the patients,Term neonates with CSF culture proven bacterial meningitis. , were referred to the Department of ENT, SMHS Hospital Srinagar, of the institution for thorough ENT checkup, to exclude any ear pathology and BERA (Brainstem Evoked Response Audiometry).

Results: In our study total number of cases were 87. Majority of our studied children i.e. 47 (54%) were $\leq$ days of age whereas 40 (46%) children were 8-28 days of aged. The mean age of our study patients was 15.7$\pm$3.71.Out of 87 patients in our study, male predominance was observed with 55.2% males versus 44.8% females with a male to female ratio of 1.2:1. Hearing loss was observed in 11 (12.6%) of our study children.Bilateral hearing loss was seen in 5 of the 11 children (5.7%) while as unilateral hearing loss was observed in 6 of the 11 children (6.9%). Out of a total of 11 (12.6%) patients who had hearing loss, 6 (6.9%) were having mild hearing loss, followed by 3 (3.4%) children with profound hearing loss while as moderate and severe hearing loss was observed in 1 (1.1%) patients each.

Conclusion: Hearing loss is not a rare complication asociated with meningitis in neonates, early detection and appropriate treatment is needed to prevent language , speech and intellecual damage.

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Introduction:-

Post meningitis hearing impairment is an important public health problem. Neonatal meningitis is an important cause of mortality and morbidity in neonates in future life. An important consequence is hearing loss[1].

Hearing plays a basic and important role in language, speech and intellectual development.[2] A hearing impaired child develops psychological, social, educational and even cognitive problems.[3] as auditory deficit has major consequences on language and communication skills development.[4] This can happen even if the child is having partial hearing impairment and is not totally deaf.[5]

Late detection causes irreversible stunting of the language development potential of the child. Unfortunately, the average time between birth and the detection of congenital Sensorineural (SN) hearing loss is 2.5 years. Such delays may result in lower educational and employment levels in adulthood.[2]

Early detection and intervention would help to maximize linguistic competence and literacy development for children who are deaf or hard of hearing. The American Joint Committee on Infant Hearing recommended that audiological rehabilitation should begin within the first 6 months of life.[6]

The study of brainstem evoked response audiometry provides an opportunity to evaluate the functional integrity of auditory pathway from inner ear to upper brainstem.

Several studies have shown that early and adequate intervention of infants with congenital hearing loss minimizes future problems with speech and language development.[7] Hearing impairment has a devastating, detrimental and an invariably adverse impact on the development of newborns and the psychological well-being of their families.[8] Bacterial meningitis can cause deafness due to peripheral or central hearing loss. Bacterial meningitis causes lesions via immune, inflammatory, and ischaemic reactions, or by cerebral oedema.

Ossification of the organ of Corti is the most serious complication after bacterial meningitis. The organ of Corti can be damaged by inflammation with three successive stages: acute stage, fibrosis then ossification. Ossification after bacterial meningitis is reported in as many as 80% of cases [9]. The ossification process obliterates endolymph and perilymph spaces with more marked damage of the basal turn of the cochlea than the apex[10].

The 1994 Position Statement[11] recommended hearing screening of infants before 3 months of age for sensorineural and/or conductive hearing deficit and other high-risk factors (indicators) associated with them. However, some children may develop delayed-onset hearing loss[12] who are not identified by newborn screening programme. So, they recommended that infants identified with risk factors (indicators) associated with delayed onset hearing loss, are also to be brought under screening programme[11].

Measurement of the Auditory Brainstem Response (ABR) is considered the most sensitive method of assessing the auditory activity of neonates.[2]

Brainstem auditory evoked response (BAER) measures the electroencephalographic waves which are produced in response to click sounds of three electrodes placed on the infant's scalp by the auditory system[13]. This has been recommended for newborn hearing assessment because it is objective, correlates well with hearing, can detect mild and moderate hearing losses as well as severe to profound losses, permits ear specific information, has good performance statistics (sensitivity and specificity), is stable over time, is unaltered by sleep / sedation as the response is physiological, and can be done at any age[14].

The BAER occurs as a result of synchronous neural activity originating in the auditory nerve and brainstem pathways which usually arises in first 10 milliseconds of stimulus. It is produced by giving a click stimulus through headphones and recorded via surface electrodes applied to locations on the skull[15]. The responses are recorded as a graphic display with vertex positive peaks noted and designated as waves l-V. In infants waves I,III,V are easily identifiable. The absolute latencies as well as interpeak latencies are higher than adults. It is always prudent to record the response for at least 15 milliseconds instead of 10 milliseconds that is done for adults[16]. The waves are described in terms of amplitude and latency; the units used for them are milliseconds and micro volts, respectively[17].

The most prominent component of the response pattern is the wave V[17]. The five waveform peaks give information regarding hearing sensitivity for each ear[18]. It is worthwhile to mention here that BAER tests only electrophysiological integrity of auditory pathway from cochlea to midbrain and not a test for hearing per se, since it does not test conscious perception of sound[16].

Methods:-

The present study was conducted in the Department of Pediatrics, Government Medical College Srinagar. All the patients falling under inclusion criteria were referred to the Department of ENT, SMHS Hospital Srinagar, of the institution for thorough ENT checkup, to exclude any ear pathology and BERA (Brainstem Evoked Response Audiometry).

Inclusion Criteria

1. Term neonates with CSF culture proven bacterial meningitis.
2. Both hospital and community acquired.

Exclusion Criteria

1. Preterm
2. Clinically/empirically treated meningitis
3. Any other associated factor for hearing loss
4. birth weight <1500gm
5. in utero TORCH infection
6. hyperbillirubenemia requiring intervention
7. Family history of hereditary permenant childhood hearing loss
8. neonatal intensive care of more than 5 days or any other following regardless of stay; ECMO, assisted ventilation
9. any stigmata, neurodegenerative disorder and / or any syndromes associated with hearing loss

Craniofacial anomalies including those that involve the pinna, ear canal, ear tags, ear pits, temporal bone anomalies above 28 days at the time of presentation having atresia or stenosis of auditory tube or infected ears whose parents not willing to give consent

Infants with CSF culture proven bacterial meningitis underwent detailed history and thorough physical examination. The history included gestational age, sex, birth order, consanguinity, place of delivery, mode of delivery, perinatal history (asphyxia, meconium aspiration syndrome, resuscitation at birth, mechanical ventilation), obstetric history, family history, drug history followed by detailed examination and were recorded in predesigned proforma and treatment records in hospital (type of drug, dose of drug, duration of therapy) and all the baseline investigations were done (CBC, CRP, venous blood gas analysis, blood culture, USG cranium, LFT, KFT), CSF analysis obtained by lumbar puncture (colour, total WBC, Differential WBC, Total protein, Total sugar); CSF culture and sensitivity TORCH screening, CT head or MRI brain, if required. The neonates treated included in this study were CSF culture proven meningitis. In the study the antibiotics started were 3rd generation cephalosporin in combination with an aminoglycoside. The drugs were changed or an additional one added, if required, on the basis of CSF culture and sensitivity. Corticosteroids were administered to none of the patients. The treatment duration was a minimum period of 21 days and in case of complicated meningitis duration of treatment was prolonged. The infants were screened at 3 months of age in ENT department for any hearing impairment with proforma included.

As the BAER results are not affected by sedation or general anaesthesia for neonates who were awake, a 20 mg/kg of triclorfos was given orally for sedation. The morphology of the response and wave and interwave latencies were examined in respect to age-appropriate forms. An initial test using a stimulus intensity of 70 dB will be done. Failure to produce wave V indicates hearing impairment. If wave V was present, repeated tests at sequential reductions of 10 dB were established the hearing threshold. Intensity of 30dB was taken as normal threshold for wave V. Subsequently, the latency-intensity curve of wave V was studied, in addition to V-l interpeak interval. In sensorineural hearing impairment the latency-intensity curve of wave V shifts to the right and the slope becomes steeper.

Statistical Analysis

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as Mean±SD and categorical variables were summarized as frequencies and percentages. Graphically the data was presented by bar diagrams and pie diagrams. Shapiro–Wilk test and normal probability plot were used to test for normality of data. Normally distributed continuous variables were compared using student's independent t-test, and nonnormally distributed variables were analyzed using Mann-Whitney Utest. Chi-square test or Fisher's exact test, whichever appropriate, was employed for comparing categorical variables. A P-value of less than 0.05 was considered statistically significant. All P-values were two tailed.

Results And Observations:-

In our study total number of cases were 87. All these patients were referred to the Department of ENT, H&NS, SMHS hospital Srinagar of the institution for thorough ENT checkup, to exclude any ear pathology and BERA (Brainstem Evoked Response Audiometry).

Table 1:- Age distribution of study neonates.

Age (Days)	Number	Percentage
≤ 7 Days	47	54.0%
8-28 Days	40	46.0%
Total	87	100%
Mean±SD (Range)=15.7±3.71 (4 hours-28 Days)		

Majority of our studied children i.e. 47 (54%) were ≤ days of age whereas 40 (46%) children were 8-28 days of aged. The mean age of our study patients was 15.7±3.71. The youngest patient in our study was 4 hours old while as the eldest one was 28 days old.

Table 2:- Gender distribution of study neonates.

]Gender	Number	Percentage
Male	48	55.2
Female	39	44.8
Total	87	100

Out of 87 patients in our study, male predominance was observed with 55.2% males versus 44.8% females with a male to female ratio of 1.2:1.

Table 3:- Distribution of study neonates as per hearing loss.

Hearing Loss	Number	Percentage
Yes	11	12.6
No	76	87.4
Total	87	100

Hearing loss was observed in 11 (12.6%) of our study children.

Table 4:- Hearing loss as per gender in study neonates.

Gender	Number	Percentage
Male	6	6.9
Female	5	5.7
Total	11	12.6

Out of 11 children with hearing loss, 6 (6.9%) were males and 5 (5.7%) were females.

Table 5:- Laterality of hearing loss in study neonates.

Laterality	Number	Percentage

Unilateral hearing loss	6	6.9
Bilateral hearing loss	5	5.7
Total	11	12.6

Bilateral hearing loss was seen in 5 of the 11 children (5.7%) while as unilateral hearing loss was observed in 6 of the 11 children (6.9%).

Table 6:- Severity of hearing loss in study neonates.

Severity of hearing loss	Number	Percentage
Mild hearing loss (30-55dB)	6	6.9
Moderate (55-70dB)	1	1.1
Severe (70-90dB)	1	1.1
Profound (>90dB)	3	3.4
Total	11	12.6

Out of a total of 11 (12.6%) patients who had hearing loss, 6 (6.9%) were having mild hearing loss, followed by 3 (3.4%) children with profound hearing loss while as moderate and severe hearing loss was observed in 1 (1.1%) patients each.

Mild hearing loss (30-55dB); Moderate (55-70dB); Severe (70-90dB); Profound (>90dB)

Table 7:- Organism growth on CSF culture and sensitivity.

Organism	Frequency	Percentage
E coli	3	27.3
Kliebsiella	3	27.3
Pseudomonas	2	18.2
Listeria monocytogenes	1	9.1
Enterococcus	2	18.2
Total	11	100

Out of 11 neonates with hearing loss, E. coli was isolated on 3 (27.3%) CSF cultures, followed by Kliebsiella which was also isolated on 3 (27.3%) CSF cultures, pseudomonas 2 (18.2%), Entrococcus 2 (18.2%) and Listeria monocytogenes was isolated in 1 (9.1%) neonate on CSF culture.

Discussion:-

All children recovering from bacterial meningitis should be referred for audiological assessment.[19]

Hearing impairment after meningitis may have several different causes. Most likely is the effect of suppurative labyrinthitis, due to direct spread of the infection from the subarachnoid space through the cochlear aqueduct.[20] This leads to destruction of sensory structures and no recovery of hearing. On the other hand, a toxic or serous labyrinthitis is thought to be the mechanism responsible for partial and reversible losses.[21] Other possible mechanisms include direct nerve fibre damage[22] and secondary ischaemic damage.

Majority of our studied children i.e. 46 (54.0%) were $\leq$7 days of age followed by 40 (46.0%) patients were 8-28 days of age. The mean age of our study patients was 15.7$\pm$3.71. The youngest patient in our study was 4 hours old while as the eldest one was 28 days old. **Lin MC et al (2012)[23]** conducted a study on 156 neonates 105 (67.3%) were <1 week of age and 51 (32.7%) were >1 week of age.

In our study, there is male predominance with 55.2% males versus 44.8% females. Study conducted by **Lin MC et al (2012)**[23] also observed male preponderance. They included 156 neonates in which 96 (61.5% were males and 60 (38.45%) were females.

Zamani A and Zamani F (2005)[24] conducted a cross sectional study by non-randomized simple sampling method on 294 neonates in which 167 (56.8%) were males and 127 (43.2%) were females. **Karanja BW et al (2013)**[25] conducted a study on 83 children in which 49 (59%) were males and 34 (41%) were females.

The above studies are consistent with the observations of the present study.

Hearing loss was observed in 11 (12.6%) of our study children which was in accordance with the **Guiscafre H et al (1984)**[26] who studied 236 children with meningitis using brainstem auditory evoked responses and hearing loss was detected in 38 (16.1%) of their study patients and **Lin MC et al (2012)**[23] who conducted a study on 156 neonates in which hearing impairment was observed in 19 (12.2%).

Out of 11 children with hearing loss, 6 (6.9%) were males and 5 (5.7%) were females which is consistent with the study of **Cherian B et al (2002)**[27] who observed SNHL in 29.1% males and 25% females. **Karanja BW et al (2013)**[25] in their study observed hearing loss more in males than in females (55% versus 45%).

Bilateral hearing loss was seen in 5 of the 11 children (5.7%) while as unilateral hearing loss was observed in 6 of the 11 children (6.9%) which is consistent with the study done by **Guiscafre H et al (1984)**[26]**.** In their study 236 children with meningitis where the incidence of meningitis was 16.1% with unilateral hearing loss in 8.89% and bilateral hearing loss in 7.2%.

Out of a total of 11 (12.6%) patients who had hearing loss, 6 (6.9%) were having mild hearing loss, followed by 3 (3.4%) children with profound hearing loss while as moderate and severe hearing loss was observed in 1 (1.1%) patients each. Our study is consistent with the results obtained by **Rasmussen N et al (1991)**[28] who also found mild hearing loss in 12.7%, severe in 1.1% and profound in 4.2%.

Out of 11 neonates with hearing loss, 3 (27.3%) each had E. coli and Kliebsiella on CSF culture, followed by pseudomonas and Entrococcus in 2 (18.2%) neonates each while as Listeria monocytogenes was isolated in 1 (9.1%) neonate on CSF culture. **Lin MC et al (2012)**[23] conducted a study on 156 neonates with meningitis. In their study,

Group B streptococci was isolated in CSF culture in 61 patients, E. coli in 32 patients, Group A streptococci in 10, Enterococcus in 8, Enterobacter cloacae in 8, C meningosepticum in 7, Klebsiella pneumoniae in 6, Proteus mirabilus in 5, Streptococcus bovis in 4, Stretpococcus morbillorm in 3, haemophilus parainfluenzae, Alcaligenes, Nieseria meningitides were isolated in 2 patients each, Salmonella, Pseudomonas aeruginosa, Acinectobacter, Plesiomonas, Bacteroid fragilis and Streptococcus sanguis in were isolated in 1 patient each, which is not consistent with the findings of the present study. The reason could be the far bigger sample size in their study, also the pathogen for neonatal sepsis varies from region to region.

Conclusion:-

1. Postmeningitic hearing impairment is an important public health problem with implications for both paediatric and audiology services.
2. Hearing loss disrupts the development of communication skills, particularly in children who have not fully developed speech and language. This disruption is an important sequela of bacterial meningitis, justifying the effort of early identification to enable appropriate rehabilitation to begin as soon as possible.
3. Since the risk of sensorineural hearing loss is significant in neonates and children with meningitis, it is recommended that BERA be recorded in all, so that early intervention is possible. Parents and teachers must identity the children with any degree of hearing impairment, even if it is too mild for hearing aids to be beneficial.

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