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CORRELATION BETWEEN BEHAVIOURAL OBSERVATION AUDIOMETRY AND AUDITORY BRAINSTEM RESPONSE THRESHOLDS IN CHILDREN

Objective:
To correlate the behavioural observation audiometry (BOA) and auditory brainstem response (ABR) thresholds in children up to 5 years of age.

Material & methods:
Prospective study was conducted between January 2013 to December 2014 at Ganesh Man Singh Memorial Academy (GMSMA) of ENT and Head Neck studies, Institute of Medicine, Tribhuvan University Teaching Hospital, Kathmandu, Nepal. One hundred and seven children up to 5 years of age were included. All children underwent behavioural observation audiometry followed by auditory brainstem response. Thresholds were correlated using Spearman rank correlation test.

Result:
Positive predictive value and sensitivity of BOA was 87.5% and 93.9 % respectively. Behavioural and auditory brainstem response threshold had good agreement in 59.8 % children. Behavioural observation audiometry had significant correlation with auditory brainstem response thresholds ($p< 0.001$).

Conclusion:
Behavioural observation audiometry correlated well with auditory brainstem response thresholds in children up to 5 years of age. BOA can be used as an initial hearing screening in children.

Key words: Behavioural audiometry, Auditory brainstem response

INTRODUCTION:

Hearing loss is one of the most common congenital anomalies, affecting approximately 1-3 infants per thousand live births.[1,2] Early detection and management can prevent further disabilities in speech language and cognitive development. Hearing assessment is difficult in children as they lack sufficient cognitive and motor abilities to provide accurate audiogram as in adults. Universal newborn hearing screening programme using otoacoustic emission and auditory brainstem response is implemented in many developed countries but developing countries like Nepal still face obstacles regarding cost of screening, lack of equipment and trained manpower. Auditory brainstem response (ABR) is preferred in children as it provides objective measure of hearing threshold and is unaffected by consciousness, sleep state or sedation.[3] It is useful in uncooperative children and those with mental retardation. However, ABR is expensive, time consuming and not available everywhere in developing countries like Nepal. Behavioural observation audiometry (BOA) uses observation of behavioural response (such as startle, eye widening, grimace, cessation of sucking or distraction) in response to auditory stimuli. It is commonly used as initial screening measure in our country as it is inexpensive and readily available in peripheral hospital setting. This study aims to determine if behavioural observation audiometry threshold are consistent with auditory brainstem threshold in children.

MATERIALS AND METHODS:

A prospective study was carried out in GMSMA ENT Head & Neck Studies, IOM, TUTH Kathmandu, Nepal between January 2013 to December 2014. One hundred and seven children visiting outpatient department up to 5 years of age were included. Indication of hearing screening were complaint of delayed speech and language development and high risk newborn (defined according to Joint Committee on Infant Hearing position statement 2007)[4] referred for hearing screening. Children with middle ear disease (chronic otitis media, otitis media with effusion and congenital ear anomaly were excluded. Parents were counseled and verbal consent was taken. After ear examination and wax clearance if present, all children underwent behavioural observation audiometry (BOA) in three sittings using sound field stimuli of pure tone frequency range 500Hz, 1kHz and 4kHz. BOA was performed using infant audiometer S-II, Nagashima medical equipments, Japan, calibrated according to American National Standardization institute (ANSI),2004 standards. Age appropriate behavioural response were observed such as startle, eye widening, grimace, cessation of sucking or distraction and conditioned behavioural response like throwing the pebble for cooperative child. Average of three measurements were taken. Results were given as normal hearing (<40dB), mild hearing impairment (40-55 dB), moderate hearing impairment (56-70 dB), severe (71-90dB) and profound hearing impairment (>90 dB). Next, ABR was done in all children under sedation with oral chloralhydrate solution using 2000 click stimulus in 2-4kHz range at 20.1 click per second. ABR was done with Interacoustic EP 25, Denmark (calibrated ANSI, 2004 standards) . Results were given as normal hearing (<30dB, mild hearing impairment (30-55 dB), moderate hearing impairment (56-70 dB), severe (71-90 db) and profound hearing impairment (>90 dB). Data were analysed using SPSS version 21. Correlation coefficient was measured using Spearman rank correlation test. P value < 0.05 was considered significant.

RESULTS:

There were 71 boys and 36 girls. Age groups were; 6 childrens up to 1 year, 34 were between 1-2 years and 67 were 2-5 years of age. Frequency tables showing hearing threshold of behavioural audiometry and auditory brainstem response of both ears are shown in table1. Hearing threshold of both ear were in same rank for both BOA and ABR in 64 children (59.8 %). Discrepancy between BOA and ABR threshold for either ear was found in 43 children (40.2%, Table.2). Spearman rank correlation test showed highly significant correlation between BOA and ABR thresholds in both ears (Correlation coefficient : 0.666 in right ear and 0.698 in left ear, $p< 0.001$). Considering ABR as a reference test, 2 × 2 table analysis shows that BOA has positive predictive value of 87.5 % and sensitivity of 93.4 % (table.3).

Table 1. Threshold of BOA and ABR

Hearing threshold rank	Right ear (No. of children)		Left ear (No. of children)	
	BOA	ABR	BOA	ABR
Normal	19	25	19	25
Mild hearing loss	12	12	12	11
Moderate hearing loss	21	21	21	18
Severe/profound hearing loss	55	49	55	53
Total	107	107	107	107

Table 2. Correlation between BOA and ABR

Test result children	No. of (N=107)
Good agreement between BOA and ABR	64 (59.8%)
Discrepancy between BOA and ABR	43 (40.2%)
ABR threshold came out to be better than BOA	17
ABR threshold came out to be worse than BOA	26

Table.3: 2 × 2 table BOA and ABR

	ABR abnormal (Disease present)	ABR normal (Disease absent)	Total
BOA abnormal (Test positive)	77 (true +ve)	11 (false +ve)	88
BOA normal (Test negative)	5 (false -ve)	14 (true -ve)	19
Total	82 (disease +ve)	25 (disease -ve)	107 (Grand total)

Positive predictive value = True +ve/Test +ve = 77/88 = 87.5 %
Negative predictive value = True -ve/Test -ve = 14 /19 = 73.7 %
Sensitivity = Test +ve/Disease +ve = 77/82 = 93.9%
Specificity = Test-ve/Disease -ve= 14/25 = 56 %

DISCUSSION:

In our study, behavioural observation thresholds were found to be consistent with auditory brainstem response thresholds with very good agreement between the two techniques in 59.8 % children. Rupa[5] found similar results in children with good agreement between above two methods in 57.4 % children. Lee et al,[6] in a large series of infants and young children (3month to 3 years, n=1281) showed significant correlation between sound field audiometry and tone burst ABR for hearing loss greater than 20dB ($p<0.001$). Stapells et al,[7] also found high correlation (correlation coefficient ≥0.94) between behavioural and auditory brainstem threshold. According to Lynne et al,[8] infant behavioural threshold were higher relative to adult and correlation between behavioural and ABR threshold was significant at 4 kHz for 3 month old and at 8 kHz for adults. BOA has many limitations. Children of different age respond differently to different types of stimuli. Variability of responses within individual infants, habituation and examiner bias can result in under estimating and over estimating of hearing loss.[9] Our study showed that there is more chance of over estimating the hearing loss with BOA. Due to this variability in results, behavioural threshold ≤30 dB rarely indicate hearing loss.[10] According to McCreery et al,[11] agreement between ABR and behavioural threshold varied as a function of degree of hearing loss and a correction factor based on degree of hearing loss resulted in more accurate predictions. ABR is an objective test of hearing and helps accurately to evaluate hearing threshold as well as detect auditory neuropathy.[12] However, ABR is expensive, requires expert manpower and sedation of children. It is available only in very few specialized centres in our country. So, BOA can be used as an initial screening method for hearing impairment in children in developing countries like Nepal, where ABR facilities are not readily available. In our study, positive predictive value and sensitivity of BOA was 87.5% and 93.9 % respectively. Behavioural audiometry is feasible in young children and can be used as a screening tool in community.[13] In our setting, many children with hearing loss go undiagnosed due to unavailability of otoacoustic emission and ABR facility. If we could use BOA for hearing assessment in resource poor setting we can diagnose hearing loss in many children and prevent long term disabilities. However, it is not recommended to use BOA as sole method of investigation of hearing impairment in children. High index of suspicion is necessary due to false negative results (6.1% in our study). If any hearing abnormality is suspected or detected, child should be referred to specialized centre for complete audiological evaluation by objective tests.

CONCLUSION:

Behavioural observational audiometry when done skillfully correlates well with auditory brainstem response thresholds in children. It can be used as an initial screening of hearing impairment in children where objective methods such as otoacoustic emission and auditory brainstem response audiometry are not available.

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