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Short Report:

Effect of Intensity on Prevalence of N3 Potential in Ears with Severe to Profound Hearing Loss

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Abstract: Objective of the study: To look for the presence of N3 potential at two different intensities in children and in adults. **Method**: A total of 260 ears with severe to profound hearing loss were studied from the participants in the age range of 1 to 50 years, with 170 subjects in the age group below 10 years and remaining 90 subjects of more than 10 years. Auditory brainstem response (ABR) was recorded at two intensities, 90 and 99dBnHL, to look for the presence of N3 potential. **Result**: N3 potential was observed in 30% of the total ears taken in the study at 90dBnHL and 38.8% at 99dBnHL. Presence of N3 potential in children was 45%, which was higher than the age group of above 10 years. When the intensity was increased there was an increase in amplitude and a reduction in latency with better wave morphology. **Conclusion**: It is better to use higher intensity for the identification of the N3 potential while doing ABR and thus with the single recording, auditory assessment as well as saccular assessment can be done.

Key Words: N3 potential; Auditory brainstem response; Saccular origin

Introduction:

The auditory brainstem response (ABR) allows one to objectively gauge peripheral hearing acuity as well as neurological abnormalities in the auditory brainstem pathway. It serves an important role in the testing of physiological function. Neural responses to acoustic stimuli could be recorded after destruction of cochlear hair cells in guinea pigs, the response probably originating from the saccule of the vestibular system. The results of these animal experiments suggested that a vestibular evoked response to acoustic stimulation can be recorded in humans.(1-3) A large negative deflection with a latency of 3ms in the ABR wave forms of some patients with profound deafness of peripheral origin. This negative deflection has been termed as the N3 potential, and it has been assumed that the N3 potential might be a vestibular-evoked potential to acoustic stimulation, saccule being the most likely site of origin.(4)

It has been reported that as the stimulus intensity increased, the amplitude of the potential increased and the latency decreased.(4) It has also been stated that N3 potential could be recorded from all electrode placements, and the amplitudes and latencies were almost consistent, and no polarity inversion was observed over the scalp.(4) N3 potential is reported to be widely distributed over the scalp, rather than being limited to the stimulated side. This means that an N3 potential has a far-field nature similar to an ABR. Manabe et al (5) also recorded a potential similar to the N3 potential, and indicated that this potential is not an artifact which might be due to any particular recording condition or equipment, but that it arises as a physiological neural response to a loud stimulus sound and this is well supported by the important fact that the latency decreases when the stimulus becomes louder and prolonged when a higher repetition rate is used.(5)

Acoustically evoked short latency negative response (ASNR) was found only in profound hearing loss ears under intense stimuli (80 to 120dBnHL). Click-evoked ASNRs were present in 12.3% patients (11.9% ears), having neural response characteristics, that is the latency and amplitude shortened and increased respectively in response to the change in the stimulus intensity.(6) N3 potentials were recorded by Ochi K et al in 41.7% ears and VEMP was detected in 66.7% ears in subjects having hearing threshold ranging from 65 to above 110dB.(7) They suggested that although VEMP and N3 potential appear to originate from saccule, the characteristics of these two responses being not identical, the mechanisms responsible for the generation of these two responses are somewhat different, so that an additional factor might exist for the generation of the N3 potential.(7)

It is clear from the literature that N3 potential has not been studied extensively. Moreover the effect of different intensities on the occurrence of N3 potential has not been focused in any of these studies. The present study was taken up with an aim to look for the presence of N3 potential and the latency and amplitude effect at two different intensities, 90 and 99dBnHL, in ears having severe to profound hearing loss. The second aim of the present study is to see the presence of N3 potential in two age groups, children and adults at 99dBnHL.

Methods:

This is a retrospective study involving 260 subjects with severe to profound hearing loss ears (160 subjects), with age ranging from 1 year to 50 years. Auditory brainstem response (ABR) data were collected during June 2005 to May 2009 and was analyzed for N3 in all the subjects. A total of 170 ears were having age range below 10 (mean age 4.2 years) and remaining 90 ears were more than 10 years old (Mean age 21.3 years). The following subject selection criteria were adopted for the study:

1. Hearing loss of severe to profound degree and of sensory neural type.
2. The absence of ABR responses at 99dBnHL.
3. Absent distortion product otoacoustic emission (DPOAE).
4. None of the subjects had recent history or presence of any otological problem (like ear discharge, ear ache etc) or any neurological symptoms.
5. 'A' type tympanogram with absent ipsi and contra reflexes.

Procedure

All the procedures were executed in a soundproof room. Initially each subject underwent a pure tone audiometry across octave frequencies from 250 to 8000 Hz for air conduction and from 250 to 4000 Hz for bone conduction using GSI-61 audiometry and same instrument was used for Behavioral Observation Audiometer (BOA). BOA was performed using ascending method for 0.5, 1, 2, and 4 KHz frequencies. Subjects below 2 years underwent BOA and above 2 years either went for conditioning audiometry or pure tone audiometry. Subsequently tympanogram and acoustic reflexes were established using 226 Hz probe tone using GSI Tympstar. Acoustic reflex threshold were obtained for ipsilateral and contralateral for 0.5, 1, 2, and 4 KHz frequencies. GSI-Audera DPOAE was performed for all the subjects for 1, 1.5, 2, 3, and 4KHz. GSI-Audera instrument was used for recording of auditory brainstem response.

Table 1: Acquisition and stimulus parameters used to record the ABR.

Analysis time	15 msec
Filter setting	High pass: 30Hz or 100Hz Low pass: 1500Hz or 3000Hz
Gain	100000
Type of stimulus	100 µsec click as well as 0.5 KHz tone burst with 2-cycle rise/fall time.
Rate	30.1
Polarity	Rarefaction
Intensity	90 and 99dBnHL
Total number of stimulus	1500
Electrode montage	Non-inverting electrode (+): vertex(Cz) Inverting electrode (-): Test ear mastoid(M1 /M2) Ground electrode: forehead(Fz)

ABR was done at two intensity levels, 90 and 99dBnHL. The N3 potential was visually detected by two experienced clinical audiologists at both the levels. Obtained data was analyzed in terms of percentage of occurrence of N3 potential and to see the differences between two intensity levels the chi-squared test was administered.

Results:

In the present study, a total of 260 ears were studied at two different intensities, 90 and 99dBnHL. Almost 65% of the subjects were children, younger than 10 years.

Table 2: Presence of N3 potential at different intensities

Intensity (dBnHL)	Total number of ears	Total number of ears with presence of N3 potential	Presence of N3 potential in percentages	Absence of N3 potential in percentages
90	260	78	30%	70%
99	260	101	38.8%	61.2%

As it can be seen, N3 potential was observed in 30% of ears at 90dBnHL and 39% at 99dBnHL. So the trend observed was, as the intensity increased from 90 to 99dBnHL, there was an increase in the presence of N3 potential. It was also observed that all the subjects who had N3 potential at 90dBnHL also showed the presence of N3 potential at 99dBnHL.

Table 3: Prevalence of N3 potential at 99dBnHL in two different age groups.

Age group	Total number of ears	Presence of N3 potential in percentages	Absence of N3 potential in percentages
Below 10 years	170	76(44.7%)	94(55.2%)
Above10 years	90	25(27.7%)	65(72.2%)

Table 3 shows that in children the presence of N3 potential is 45% which is higher than the age group of above 10 years, among whom only 28% had N3, suggesting that children have higher incidence of N3 potential than adults at the same intensity.

Table 4: Mean and standard deviation of latency and amplitude at two different intensity 90 and 99dBnHL.

Intensity	VEMP parameters	Mean	Standard deviation
90	Latency	3.12msec	0.17
	Amplitude	172.89nV	64.37
99	Latency	3.04mesc	0.15
	Amplitude	265.08nV	75.75

As depicted in Table 4, as the intensity increased from 90 to 99dBnHL, the latency was reduced from 3.12 to 3.04 msec and there was an increase in amplitude from 172 to 265 nanovolt. The standard deviation of the N3 potential latency was less, but the standard deviation of amplitude was high. The Chi-squared test was administered to see the significance of difference between two different intensities at 90 and 99dBnHL. The chi-squared test for latency is 671.58 with an associated $p<0.005$, suggesting a significant difference in latency between 90 and 99dBnHL. The chi-squared test for amplitude is 1263.87 with an associated $p<0.005$, suggesting a statistically significant difference between the two intensity levels. Raw scores indicated a slight difference in amplitude between the two intensities.

Discussion:

In the present study, N3 potential was present in 30% of the ears taken at 90dBnHL and in 39% ears at 99dBnHL. Ochi K et al (7) reported the detection of N3 potential in 41.7% of the total ears whereas in the present study N3 potential was observed in 39% of ears. This may be due to the difference in stimulus intensity used, which was 105dBnHL in Ochi et al compared to 99dBnHL in the present study. This indicates that the stimulus intensity plays a role in the occurrence of N3 potential. The absence of N3 potential in many subjects could be attributed to the individual variation of vestibular function, particularly under unphysiologic stimulation. Nong DX (6) reported that the N3 potential were present in 11.9%. The lesser percentage of the presence of N3 potential in their study is due to the intensity used which was between 80 and 120dBnHL.(6)

It was also observed in the present study that as the intensity increased, there was an increase in amplitude and reduction in latency. Kato T et al (4) had reported two case reports in which as the intensity was increased, there was an increase in amplitude and a decrease in the latency. Nong DX (6) also reported that the N3 potential had neural response characteristics as the latency and amplitude being shortened and increased respectively in response to the change in the stimulus intensity.

In the present study, 45 % of the children below 10 years had the presence of N3 potential and 28% of the participants above 10 years of age showed the presence of N3 potential. In contrast Nong DX (6) reported significantly higher appearance rates in young subjects especially in the 20 to 30 years group. In the present study, the higher rate of occurrence of N3 potential in children might be due to the higher sound pressure level generated at tympanic membrane as the ear canal volume is less for children than adults. The sound pressure level changes might cause the presence of more N3 potential in children than in adults.

Conclusion:

In conclusion it can be put forth that as the intensity increases, there is higher rate of the presence of N3 potential with a shorter latency and higher amplitude. The presence of N3 potential is higher in children than in adults. It is better to use a higher intensity in identifying N3 potential while doing ABR so that auditory assessment as well as saccular assessment can be done at the same recording in subjects with severe to profound hearing loss.

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