

Clinical Application of Brainstem Evoked Response Audiometry in Non-Organic Hearing Loss

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Abbreviations:

Auditory brainstem response: **ABR**, Non-organic hearing loss: **NOHL**, Pure tone average: **PTA**, Acoustic reflex threshold: **ART**, Acoustic reflex: **AR**, Electric response audiometry: **ERA**, Hearing threshold level: **HTL**, Electrocochleography: **ECochG**, Slow vertex response: **SVR**, Otoacoustic emissions: **OAEs**

Abstract

Objectives: The application of auditory brainstem response in the hearing evaluation of patients with suspected non-organic hearing loss.

Patients & Methods: At Al-Rasheed military hospital (from May 1985 to Oct 1986), 137 patients with suspected non-organic hearing loss (NOHL) were referred for auditory brainstem response test, only 32 patients (aged 18-35 years) were selected on criteria that indicated the absence of middle ear problem and they have marked exaggeration by pure tone audiogram with pure tone average (PTA) of 70 db or more in 500-2000 Hz.

Results: The results revealed that only 25 % of the suspected cases have a genuine organic hearing losses, while the rest of the cases (75 %) either have a pure NOHL (about 16 %) or overlapping an organic hearing loss (about 59 %).

Conclusion: For diagnosis of non-organic hearing loss, dependence on pure tone audiometry and acoustic reflex threshold (ART) are unreliable procedures and they should be supplemented by neurophysiological tests of which ABR is one of the powerful tests in this respect.

Key words: Non-organic hearing loss, Auditory Brainstem evoked response, Electric response audiometry

INTRODUCTION

The expression non-organic hearing loss (NOHL) is used to describe condition in which pure tone audiometric responses do not reflect the real hearing status. It is currently a common finding, mainly because of wars and the vast increase in compensational industrial hearing loss as well as in medico-legal cases. It occurs in both sexes and in all age groups and occupations. Frequently, NOHL occurs as an overlay on an organic hearing loss; it is due to many causes, which range from a pure NOHL, through deliberate exaggeration of a hearing loss to a pure psychiatric disease or a pure organic hearing loss⁽¹⁻⁷⁾. The role of

audiological investigation in such patients will be to confirm the suspicion and to give an indication as to the patient's real hearing threshold⁽⁵⁾. Hanley and Tiffany⁽¹⁾ were able to describe over 40 tests for auditory malingering and they described three basic limitations of these tests: (1) Lack of reliability; (2) dependence upon patient naivete; and (3) necessity for expert interpretation. More recently, impedance audiometric measurements, based on acoustic reflex threshold (ART), have received some popularity in the detection of NOHL. The ARTs to various stimuli occur within 70 to 90 dB above normal hearing threshold⁽⁸⁻¹²⁾. The initial approach was based on the simple concept that

any patient in whom the ART is equal to or apparently more sensitive than pure tone threshold is certainly giving inaccurate responses^(1,3). Sophisticated methods to predict hearing loss by acoustic reflex (AR) were described by many authors⁽¹³⁻¹⁷⁾. Miller et al⁽¹⁴⁾ have suggested a formula based on the comparison between ART for pure tones and those for wide band noise. The various types of these methods have been analyzed in detail by Hyde et al., and Hall and Bleakney⁽¹⁶⁻¹⁷⁾ and they have concluded that none of the methods predict hearing loss without error and none are adequate in medico-legal assessment or for clinical use in adults. All these methods and the various types of formulae were based on data from subjects who have normal hearing or pure sensorineural hearing loss with a detectable AR.

With the advent of the averaging computer, the various forms of electric response audiometry (ERA) have been widely applied in the detection of NOHL cases and the determination of the real hearing threshold level (HTL). As such cases do not depend upon a conscious response by the subject they are regarded as being objective, where the responses of auditory nerve, brainstem auditory nuclei, and cerebral cortex to acoustic stimuli are recorded by means of electrodes. These tests from periphery to cortex are electrocochleography (ECochG), auditory brainstem response (ABR) or Brainstem Evoked Response Audiometry (BERA), and cortical evoked responses or slow vertex responses (SVRs) respectively^(7, 18-21). These tests were used successfully in the investigation of NOHL^(3, 5, 22).

At Al-Rasheed military hospital (from May 1985 to Oct 1986), as well as in most audiology departments in this country, the HTLs of NOHL cases were usually estimated from pure tone audiometric tests and clinical judgment and aided for confirmation by the presence or absence of the AR. In these cases, the HTL is usually calculated from hearing levels at the frequencies 500, 1000, and 2000 Hz based on the concept that the average of hearing levels at these three frequencies correlate fairly well with the loss of sensitivity for speech or the degree of hearing disability of the patient^(3, 23).

The purpose of this study is to apply the recording of ABR in the assessment of the audiolgically suspected NOHL cases.

PATIENTS AND METHODS

The retrospective study was done on data collected during the interval from May 1985 to October 1986 in the otolaryngology department of Al-Rasheed Military Hospital:

(1)Subjects: out of 137 subjects with suspected NOHL, who were referred for ABR test, only 32 subjects,

ranging in age from 18 to 35 years, have been selected in this study on the bases of the following criteria: (a) they have marked exaggeration of the pure tone average (PTA), in the speech frequencies 500-2000 Hz, with hearing loss of 70 dB or more in one or both ears, (b) they have a normal tympanic membranes by otoscopic examination, and (c) they have a normal tympanometric curves by impedance audiometric measurements. So that cases with conductive hearing loss were excluded in this study to rule out the possibility of an absent AR due to middle ear problem. The reason for choosing the criterion 70 dB hearing level is because at this level of hearing there is a possibility of discharge from military service or employment.

(2)Apparatus: pure tone audiometry was carried out in a sound proof room with Peters AP6 clinical audiometer equipped with TDH-39 earphones. Impedance audiometric measurements were obtained with Peters AP65 automatic acoustic impedance meter, provided with probe tone of 220 Hz. The ABR tests were recorded with Neuromatic 2000C in electrically shielded sound treated room. For all tests, physiologic calibration was carried out with 5 young (20 to 30 years) normal hearing subjects (i.e. 10 ears).

(3)Procedure: The pure tone thresholds were measured for audiometric frequencies 250, 500, 1000, 2000, 4000, and 8000 Hz. The tympanometric curves and the ARTs were measured; only contralateral ARTs data for 500, 1000, and 2000 Hz were analyzed in this study, because there has been some uncertainty concerning the interpretation of ipsilateral AR responses⁽¹²⁾.

The ABRs were recorded with three electrodes, the first is placed on the vertex (cz) as an active electrode, and the second is placed on the mastoid process (reference) and the third one is on the forehead (ground). The patient was usually tested relaxed in the recumbent position on a couch and tested by monaural rarefaction click stimuli at a rate of 10 per second and contralateral white noise masking delivered by a TDH-39 headphones; 1000 click stimuli were used with analysis time of 10 milli-seconds for ipsilateral recording only. In this study wave V has been used for threshold estimation since it has been established that this wave is most stable, robust one of the seven waves recorded by ABR test^(5, 24-28). The wave V latency was recorded at maximum equipment output level and at 10 dB decrements until no longer observed and

The lowest intensity level at which responses could be elicited was defined as the ABR HTL.

RESULT

Table 1 classify the selected patients into 3 groups according to the PTA which shows that 62.5 % of the cases have bilateral sensorineural hearing losses of 70 dB or more, 25 % of the cases have pure unilateral hearing loss of 70 dB or more, and the rest of the cases (12.5 %) have bilateral hearing losses, with one ear of 70 dB or more and the other ear is less than 70 dB.

Table 2 shows the means and standard deviations of the ARTs for five normal hearing subjects (i.e. 10 ears).

Table 3 shows the norm values for the subjective click hearing threshold and wave V latency for five young (20 to 30 years) normal hearing subjects, and figure 1 shows the type of ABR responses in a normal subject. It is seen clearly that as intensity of sound stimulus decreases, there is increase in the latency of wave V ⁽¹⁸⁾.

Table 4 classify patients in each group of table 1 according to the hearing level estimated by ABR test (i.e. the real hearing threshold), which shows that only 25 % (8 patients: 4 in group I and 4 in group II) of the selected NOHL cases have a genuine hearing loss and the rest of patients (24 patients) have NOHL ranging from a pure NOHL representing about 16 % of patients (5 patients: group I) to NOHL overlaying an organic hearing loss constituting about 59 % (19 patients).

Also, it appears from table 1 that there are 52 ears with a hearing loss of 70 dB or more, who were subjected for investigation by ABR and impedance tests according to criterion (1) as mentioned previously and as shown in table 5, there are only 14 ears which have a genuine hearing loss (26.9 %) and the rest of the ears (38) which represents 73.1 % are NOHL ranging from a normal hearing to overlay of organic hearing loss.

On the other hand, the results of ARTs in comparison with ABR HTLs are shown in table 6, which shows that 14 ears with a hearing loss of 70 dB or more as estimated by ABR test, either have an absent ART at 500 – 2000 Hz , with the exception of one ear with elicited ART only at 500 Hz, while the rest of ears showed ABR HTLs less than 70 dB and their ARTs results as follows: one ear with ABR HTL of 60 dB showed absent ART at 500-2000 Hz; 7 ears with ABR HTLs of 50-60 dB revealed absent ART at 2000 Hz, but raised in the other frequencies, 16 ears with ABR HTLs of 30 -50 dB associated with raised ART in all frequencies, and the rest of 14 ears which have a normal ABR HTLs of 20 dB demonstrated a normal ARTs in all test frequencies.

Table 1. The patients with suspected NOHL classified according to the PTA in the speech frequencies 500-2000 Hz.

Group	No of patients	Unilateral- or bilateral hearing loss
I	20 (62.5%)	PTA = > 70 dB in both ears
II	8 (25%)	PTA = > 70 dB in one ear, and the other ear is normal
III	4 (12.5%)	PTA = > 70 dB in one ear, and the other ear with PTA of 60, 50, 40, and 30 dB.
Total:	32 patients (64 ears)	

Table 2. The ARTs for the speech frequencies 500, 1000, and 2000 Hz for 10 normal ears.

Frequency Hz	Mean ART dB	SD
500	87.5	3.54
1000	88.5	4.74
2000	86.5	3.69

Table 3. The norm values of ABR wave V latencies at different intensity levels and the subjective click threshold for 5 normal hearing subjects (i.e. 10 ears).

Intensity of click dB	Mean of latency ms	SD
70	5.56	0.18
60	5.63	0.20
50	5.89	0.21
40	6.24	0.23
30	6.45	0.27
20	6.82	0.30
Normal click threshold = 40 dB SPL		4.80

Table 4. The ABR HTLs for the groups of table 1

Group I	Group II	Group III
5 patients with normal hearing in both ears	4 patients with normal HTL = > 70 dB	2 patients with normal HTL in one ear and the other ear is = > 70 dB
4 patients with normal hearing in one ear and the other ear is = > 70 dB	4 patients with HTL < 70 dB	2 patients with HTL < 70 in both ears
7 patients with HTL < 70 dB in both ears		
4 patients with HTL = > 70 dB in both ears		
Total = 32 patients (64 ears)		

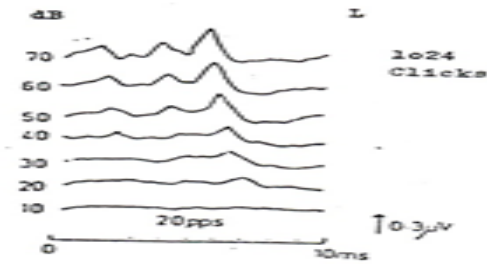


Figure 1. ABR traces from a normal hearing subject.

Table 5. The hearing threshold as estimated by ABR test in 52 ears of NOHL.

Number of ears	ABR hearing threshold dB
14 (26.9%)	>70 =
5 (9.6%)	60
6 (11.5%)	50
VCXZQ10 (19.2%)	40
3 (5.8%)	30
14 (26.9%)	20
Total= 52 ears	

Table 6. the ARTs at 500, 1000, and 2000 Hz compared to ABR HTLs.

No. of ears	ABR HTL dB	ART dB		
		500	1000	2000 Hz
9	= > 70	A	A	A
5	= > 70	116	A	A
1	60	A	A	A
4	60	102.5	111.5	A
3	50	105	110	A
3	50	100	108.3	116.7
10	40	98	104	106
3	30	91.7	93.3	103.3
14	20	86.4	91.1	90
Total = 52 ears,		A: Absent		

DISCUSSION

It appears from this study, that the ABR test is effective in the estimation of the real hearing threshold in suspected cases of NOHLs, and it is found that 75 % of the suspected cases were of the NOHLs, who either have a pure NOHL or exaggerated an organic deafness. It seems clear that deafness is very easily feigned in pure tone audiometry specially when there is a motive to simulate deafness such as discharge from military service or employment and medico-legal cases. On the other hand prediction of hearing threshold from the ART, although an objective procedure, is also unreliable as it influenced by a variety of factors, one of them is the possibility of absence of ART in minor middle ear disorders [8-17, 29-34]; the other factor is the degree of hearing loss as noted in the result of table 6, which showed that about 42 % (22 ears) of the tested ears have absent AR in at least one of the frequencies 500 -2000

Hz; this factor was also described by many authors [29-33]. Also there are other factors that influence the AR arc such as disorders of the integrity of the 8th and 7th nerves as well as brainstem function which mediates the central part of the AR arc [31, 35]. Also the ART is a supra-threshold test and this will raise the possibility of recruitment at such levels, which add further difficulty in prediction of hearing threshold from ART [36], while in ABR test the responses are detected or approached near threshold [28].

The ABR, in addition to its increase use in threshold measurement, has much value in neuro-otology than the other forms of ERAs [37], and it is unlike the SVR is little effected by the state of patient` arousal, drug intake below toxic limits and anesthesia [38], but in SVR, in contrast to ABR (with click stimulus) and ECochG, is a frequency specific, and therefore mirroring the pure tone audiometric configuration, and in SVR the whole auditory system is assessed, from its peripheral part to the cerebral cortex. The ABR test is proven, by Hall [39], to be more reliable than SVR in the detection of NOHL, and is preferred on ECochG because it is a non-invasive procedure [5]. The transient evoked otoacoustic emissions (TEOAEs) is an important test in the diagnosis of the site of auditory lesion and estimation of hearing sensitivity of NOHL or non-cooperative patients [40], but of no value for those with real HTLs greater than about 40 dB [41].

Having once decided that there may be NOHL, it is useful to supplement routine pure tone audiometric tests and impedance audiometry with electro-physiological tests including ABR by means of which the auditory threshold can be estimated with reasonable certainty.

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