# A Comparison of Auditory Brainstem Responses to Air and Bone Conducted Clicks in Normal Adults.

**Register No. M 9701**

**An independent Project submitted as part fulfilment for the First Year M.Sc. (Speech & Hearing) to University of Mysore.**

**All India Institute of Speech 8s Hearing**
**MYSORE - 570 006**
**May 1998**

**DEDICATED**

**TO MY**

**COUNTRY**

# CERTIFICATE

*This is to certify that the independent project entitled.* **"A comparison of Auditory brainstem responses to air and bone conducted clicks in normal adults"** *is a bonafied work done in part fulfilment for the first year degree of Master of Science (Speech & Hearing ), of student with Register -No. M9701.*

Director

All India Institute of Speech & Hearing
Mysore - 570 006

Mysore

May 1998

# CERTIFICATE

*This is to certify that the independent project entitled.* **"A comparison of Auditory Brainstem Responses to Air and Bone Conducted Clicks in Normal Adults"** has been prepared *under my supervision and guidance.*

Mysore

May 1998

Animesh Barman
Guide

# DECLARATION

*I hereby declare that this indepedent project entitled* **"A Comparison of Auditory Brainstem Responses to Air and Bone Conducted Clicks in Normal Adults"** *is the result of my own study under guidance of Mr.Animesh Barman, Lecture in Department of Audiology, All India Institute of Speech & Hearing, Mysore, and has not been submitted earlier at my any other University for any other Diploma or Degree.*

Mysore

May 1998 - Register No. M 9701 .

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Reg. No.M 9701

# CONTENTS

# INTRODUCTION

Since Caton (1875) described the electrical activity of the brain, Neurophysiologist have slowly accumulated a significant amount of information regarding the neurophysiology, anatomy and bioacoustics of hearing.

Auditory brainstem response (ABR) audiometry is of great interest to-day in the field of Audiology, Otology, Neurology and Neuro-otology and is probably one of the most exciting advances in evoked response audiometry (ERA). It is used to estimate the hearing threshold of infants, young children and other unco-operative subjects [Jerger 8B Hayes, 1976; Pratt 8s Sohmer, 1978; Davis & Hirsh, 1979].

The ABR responses' are obtained from surface electrode by a completely safe and non-traumatic technique which may be performed without the necessity for medical training. A normal ABR waveform is characterized by 5 to 7 peaks that occur within 2 to 10 milliseconds (Davis, 1976). Jewett & Williston (1971) gave Roman numericals to be used for the ABR peaks.

Information on the anatomic origins of ABR is less precise and more conflicting for later components (waves HI, IV, V, VI) than for the earlier components (waves I 8s II). The quality and reproducibility of ABR is quite independent of the state of subject and can be obtained in subjects under general anaesthesia or comatose. Because of its replicability consistency among subjects and sensitivity to disorders in the auditory pathway ABR has become an important tool in both clinical evaluation and intraoperative monitoring.

A number of factors unrelated to pathology affect the normal parameters. These factors can be generally considered under:

(a) Stimulus effects:

1. Intensity
2. Repetition rate
3. Polarity
4. Envelope
5. Prolonged or repeated stimulation

(b) Procedure effects :

1. Electrode location
2. Filter characteristics
3. Time domain averaging
4. Monoaural Vs Binaural
5. Effects of contralateral masking
6. Transducer type
7. Bilateral recording of ABR.

c) Subject effects :

1. Age
2. Gender
3. Pharmacologic agents
4. Body temperature.

The auditory system as well as the nerve function is checked and hence ABR provides information on both impairments of hearing (audiologic) as well as neurological disorders.

**1) Audiological application** - The pure tone hearing thresholds can be determined at about 10-20 dBSL lower than the intensity level at which wave V can be identified. ABR threshold elicited by click stimuli correlates best with the audiometric thresholds between 1 KHz and 4 KHz (Hall, 1992)..

**2) Neurological application** -

a) To assess the maturation of the auditory pathway in premature infants and neonates.
b) To check the neurological integrity in some paediatric population.
c) Detecting VIII nerve and low brainstem lesions

d) Detection of multiple sclerosis and other demyelinating diseases.

e) Intra operative monitoring.

f) Monitoring neurological status of comatose patient.

g) Determining brain death.

To differentiate between cochlear and retrocochlear lesions in sensorineural hearing loss is one of the most important task of ABR. The importance of utilizing ABR in the evaluation of retrocochlear lesions have been emphasized by Selters & Brackman (1977).

ABR measurements in many patients is carried out for neurodiagnosis but it is important to keep in mind that external and middle ear is always the first link in the auditory system for air conduction stimulation. ABR measurements used for identification of sensoryneural impairments can be strongly influenced by peripheral auditory deficts.

The three general principles that should be remembered during ABR assessment of patients dysfunction resulting in conductive hearing loss are :

1) Conductive hearing loss essentially attenuates the level of sound reaching the cochlea.

2) Many middle ear pathologies produce relatively greater low frequency than high frequency hearing loss.

3) Air versus bone conduction measures are required for complete description of conductive hearing loss. The air bone gap helps in rating the degree of hearing loss caused by the conductive component.

Probably, bone and air conduction brainstem responses are better means than impedance audiometry to evaluate the hearing loss and the conductive component. It will help to estimate the amount of conductive component in infants and children and also to evaluate the post treatment changes in the hearing sensitivity of the difficult to test population.

**Need for the present study -**

A complete description of conductive hearing loss by ABR requires a comparison of findings for air versus bone conduction stimulation. Bone conduction ABR measurement is clinically feasible (Hooks & Weber 1984; Yang, Rupert & Moushegian, 1987; Stuart, Yang & Stentrom 1990; Stapells & Ruben, 1989) but it requires an appreciation of the substantial differences in bone-versus air conduction transducer and stimulus characteristics.

**Purpose of the study** :

The study was taken up with the aim of achieving the following purposes.

1. To obtain normative data for BC stimulation elicited ABR measurements in normal hearing adults.
2. To investigate if any latency differences exist between AC Vs BC - ABR.
3. To determine if the amplitude of wave V differed significantly for AC & BC - ABR.
4. To highlight the use of AC 8B BC - ABR in clinical practice.

## REVIEW OF LITERATURE

Since first described by Sohmer & Feinmesser (1967) in Israel and Jewett, Romano & Williston (1970) in the United States, the measurement of the scalp recorded auditory brain stem response (ABR) to air conducted stimuli has become an integral part of Audiological practice to assess or screen for hearing loss and to assist in otoneurological diagnosis. Estimates of hearing sensitivity from the ABR are typically derived from the latency-intensity function for the Jewett peak V as recorded to a click or tone pip, transduced by a matched pair of electrodynamic earphones.

Despite the value for estimating degree and type of hearing loss from the air conducted latency - intensity series, it is at times advantageous also to record ABR to bone conducted stimuli. The discrepancy between air and bone conduction estimates of hearing loss represents the electrophysiological analog of an airbone gap. In addition to its use in quantifying the magnitude of air bone gap, the bone conducted ABR is often recorded to assess sensorineural reserve in patients with congenital atresia or microtia of the external ear, or when there is no observable ABR to air conducted stimuli.

One problem common to all auditory electro-physiological measurement is limited data describing the changes in responses due to the use of different transducers to deliver the signal. Particularly salient to ABR is the difference in the responses obtained with an earphone versus a bone conduction (BC) vibrator (Mauldin & Jerger, 1979; Stapells & Ruben, 1989).

Mauldin & Jerger (1979) recordedABR with a 3000 Hz half sine wave transduced through earphone (TDH-39) with CZW-6 circumaural cushions and by a forehead placed Radioear B-70A bone conduction vibrator. The results were a 0.5 msecs. longer latency for bone conducted signal as compared to air conducted signal .For conductive hearing loss the seperation of latency -intensity functions for AC versus BC responses provided a valid estimate of the behavioural air bone gap in the l000Hz to 4000Hz region.

Weber (1984) reported the responses obtained through Radioear B-70A bone vibrator and earphone using a rectangular pulse. He reasoned that the low frequency energy stimulating a more apical region along the basilar membrane results in transmission delay of about 0.5 msec.

Similarly Schwartz, Larson & De Chicchis (1985) determined differences in the acoustic spectra of bone vibrators (Radioear B-70A, B-71, B-72), a earphone (TDH-49) and an insert receiver. A delay of 0.5 msec for wave V latency with B-70A transducer as compared to TDH-49 earphone was noticed. But greater prolongations in latency were seen for the B-71 (Latency=. 6) and B-72 (latency =0.6) oscillators were observed.

The effect of the vibrator placement and masking in newborns, 1 year old children and adults were studied by Yang, Rupert & Moushegian (1987). ABR were obtained for bone conduction vibrator (B-70A) on frontal, occipital and temporal bones placement. Results showed that temporal placements in neonates and 1 year old children produced significantly shorter wave V latency of ABR than frontal or occipital placements. In adults differences of wave V latencies from various vibrator placements were comparatively small.

Cornacchia, Martini & Morra (1983) described the real time spectrum of 0.1 msec bone conducted click in 20 adults" and 20 infants with a shielded TDH-39 headphone and a standard B-70A vibrator. Adult and infants showed a bone conduction threshold < 15 dBHL and air conduction threshold < 20 dBHL. The amplitude of wave V is greater for BC stimuli as a function not complete of intensity as compared to AC stimuli in both the groups. The BC stimulation ABRs gave longer latencies for adult group (on average 0.56 ms) and for infant group (0.88 msec) the air conduction ABR.

Yang, Stuart, Stenstrom & Hollett (1991) obtained ABRs to bone conducted clicks with four different coupling forces (225, 325, 425, 525 gms) using a Radioear B-70B bone vibrator for the new born infants. The intensity levels for bone conducted stimulation were 15 and 30 dBnHL and 30 dBnHL for the air conducted stimulation. At 30 dBnHL a coupling force of 525 gms yielded the shortest ABR wave V latency while a coupling force of 225 gms yielded the longest for bone conducted ABR. At 30 dBnHL ABR wave V latencies from air conducted click stimulation appeared to be longer than those from BC clicks with a static force of 525 gms and shorter than those from coupling forces of 425, 325 and 225 gms.

Stuart, Yang 8B Stenstrom (1990) studied effect of different temporal placements using Radioear B-70B bone Oscillator. ABR wave V latencies were obtained from three different temporal area (superior, postero superior and superior) at 15 and 30 dBnHL. Results showed significant ABR wave-V latency shifts with changes in the three different placements.

Foxe & Stapells (1993) recorded ABR to 500 Hz and 2000 Hz bone conducted tones for normal infants and adults. The tones were presented through Radioear B-70A bone oscillator. Wave V latencies were easier to determine in the responses to 2000Hz tones than those to 500 Hz. Infants ABR thresholds for the 500Hz BC tones were significantly lower than their thresholds at 2000Hz BC tones. The wave V latencies to 500 Hz BC tones were significantly shorter than those of adults, whereas infants and adults ABR to 2000 Hz BC tones were similar in latency, suggesting that the effective intensity of the BC tones may be 9-17 dB greater for infants than for adults.

Yang, Stuart, Stenstrom 8s Green (1993) studied the variability of the ABRs on 20 normal full term infants for bone and air conducted clicks using a test retest paradigm. The stimulus intensities were 15 and 30 dBnHL for bone conduction ABR and 30 dBnHl for air conduction ABR. Results indicated no significant difference among the test-retest variability of wave V latencies and amplitudes between bone and air conducted clicks.

Muchnik, Neeman & Hildesheimer (1995) obtained ABR to bone conducted clicks in adults and infants with normal hearing and conductive hearing loss with the Radioear B -71 BC vibrator. The wave V latencies were significantly longer than those obtained from AC-ABR for normals. The air conduction ABR latency for wave V was prolonged than the bone conduction ABR in conductive hearing loss subjects. In air conduction ABR the mean latency of wave V was significantly prolonged as compared to that of bone conduction ABR in children with confirmed middle ear effusion and infants with suspected middle ear pathology.

Kramer (1992) investigated the feasibility of recording bone conducted ABRs to 500 Hz and 2000 Hz tone burts and clicks in normal hearing adults using a Radioear B-70A vibrator. The responses for all the stimulus were detectable at 30 dBnHL. At 20 dBnHL the tone burst responses were detectable in 80-87% of the subjects, demostrating that even the responses to 500 Hz tone bursts were relatively robust. The responses for the 500Hz tone burst were broader than those obtained for the 2000 Hz tone burst or clicks. The longest latencies occured for the 500 Hz ;tbne bursts and were typically greater than 10 ms at 40 dBnHL to as long as 19 ms at 10 dBnHL.

While the clinical literature continues to support the use of bone - conducted ABR testing information relative to the characteristics of the waveform obtained viz BC mode in adults are at best, limited. Along these same lines, there are very less data to our knowledge concerning the waveform characteristics obtained by the click stimulation through transducers often used in intra operative recordings of the ABR.

## METHODOLOGY

This study was taken up with an aim of establishing a normative baseline for air and bone conducted click ABR in adults and to compare these two to establish the difference in them, if any.

**Subjects** : comprised of 30 adult volunteers aged 17 to 28 years, both male and female (mean age - 20.5 years).

All subjects had pure tone hearing thresholds in the frequency range 250 Hz to 8000 Hz, less than 20 dBHL. This was ascertained using a two-channel clinical audiometer (OB - 822).

All subjects also had normal middle ear function. This was ascertained by using an Immitance audiometer. All subjects had "A type" tympanograms and had normal reflexes, on screening.

None of the volunteers reported of any audiological symptoms hearing loss, tinnitus, giddiness, no exposure to noise, ototoxicity etc.

**Equipment** :

The following equipments were used in the study :

**a. Pure tone audiometer** :

A two channel clinical audiometer (OB - 822) was used to assess the behavioural thresholds of all the subjects. The audiometer was calibrated prior to the study as per the recommendations of the manufactures (Appendix I).

**b. Immittance audiometer** : .

An immittance audiometer (GSI - 33, version-2) was used to assess the middle ear function of the subjects. The audiometer was calibrated as per recommendations of the manufactures (Appendix II).

**c. ABR measuring system** :

The ABR measuring system is a computer-based system. This computer being a dedicated system is used only for measurement of ABRs. The software being used for the purpose is the "Biologic

Navigator version 5.44" with a Radioear B - 71 bone oscillator and TDH - 39 P headphone. The AC & BC - ABR was calibrated as per the recommendations of the manufacturer (Appendix - III).

Using a computer-based instrument gives the ABR measurement immense flexibility. The system allows for the user specifications to be used in testing for a number of parameters. With reference to the study the values that were set up for air and bone conduction ABR testing are illustrated in table 1 8B 2.

**Test environment** :

The tests were carried out in a room where the ambient noise level measured was within the permissible level as recommended by ANSI (1977). The test room had adequate lighting and was at a comfortable temperature.

The subjects were provided with a comfortable chair to sit on during the test since this is an objective test, the subjects were not required to perform any task.

**Test procedure** :

All volunteers were first screened for their pure tone thresholds in both ears using a audiometer (OB - 822). The frequencies tested were 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz. Any volunteer with thresholds greater than 20 dBHL at any frequency were rejected.

Subjects who had thresholds within 20 dBHL were then tested for tympanograms and reflexes in both ears using an immittance audiometer (GSI-33). Only subjects who had A-type tympanograms and normal acoustic reflexes were tested for ABR's.

To determine ABR, rarefraction polarity clicks were presented at a rate of 11.1/sec through a Radio ear B-71 bone oscillator and TDH-39 P head phones using the above mentioned parameters.

| General set up | Amp set up | Channel (1) | Channel (2) |
| --- | --- | --- | --- |
| Test: AEP | Gain (1) | 150000 | 150000 |
| Channels :2 | Hi filt (1) | 3000.00 | 3000.00 |
| Window : 10.240 | Lo filt (1) | 100.00 | 100.00 |
| Pre/post: 0 | Notch (1) | Out | Out |
| Points : 256 | Artifact (1) | Enabled | Enabled |
| | Montage (1) | Cz/A1 | Cz/A2 |

**Stimulus set up** :

Stimulator: bone oscillator  Type : Rarefraction click

Max # Stimiulus : 1500  Rate( /S) : 11.1

Ear : Right  Mask : None

A2. =Test EAR-

**Table 1 (a)** :- Parameters for BC - ABR measurements

| General set up | Amp set up | Channel (1) | Channel (2) |
| --- | --- | --- | --- |
| Test: AEP | Gain (1) | 100000 | 100000 |
| Channels :2 | Hi filt (1) | 3000.00 | 3000.00 |
| Window : 10.240 | Lo filt(l) | 100.00 | 100.00 |
| Pre/post: 0 | Notch (1) | Out | Out |
| Points : 256 | Artifact (1) | Enabled | Enabled |
| | Montage (1) | Cz/A1 | Cz/A2 |

**Stimulus set up** :

Stimulator: Headphone  Type : Rarefraction click

Max # Stimiulus : 1500  Rate ( /S) : 11.1

Ear : Right Mask : None

A1 = Non Test Ear A2 = Test Ear

**Table l(b)** : - Parameters for AC - ABR measurements.

**BC - ABR -**

For all subjects the bone vibrator was placed on the temporal bone in the superoposterior auricular position, within 2.5 cm. of but not touching the pinna, and held in place with 550 gms of force by a steel headband as recommended (ANSI - 1996).

**AC ABR -**

For all the subjects the headphones were placed on the pinna and held in place with 500 gms. of force by a standard head band as recommended (ANSI - 1996).

Two channel simultaneous recordings of ABR were obtained from each subject using vertex (non-inverting), ipsilateral mastoid (inverting), contralateral mastoid (inverting) electrode montages. An electrode on the forehead served as ground. Interelectrode impedances were less than 5000 Ώ. The initial intensity level was 50 dBnHL and was reduced in 10 dB steps until a ABR threshold was obtained.

**Physiological ABR threshold** :

The thresholds of AC and BC - ABR were defined as the minimal intensity level to which a visible repeated response could be observed in two sequential trials.

## RESULTS & DISCUSSIONS

A typical recording of AC & BC - ABR to clicks at stimulus output of 50 dBnHL is illustrated in Fig. 1. It should be noted that in the BC - ABR recording, only waves III and V were identified where as in AC - ABR waves I, III and V could be clearly identified.

**AC & BC - ABR threshold**

The AC - ABR threshold were obtained at 10 - 20 dBnHL. On the other hand the BC - ABR threshold were obtained at 20 - 30 dBnHL for all the subjects under study (Fig. 2a & b). This difference may be attributed to the determination of ABR threshold in 10 dB steps.

**Relationship of ABR threshold to AC & BC clicks** :

For normal hearing young adults the BC - ABR threshold were obtained at a high intensity level than the AC - ABR threshold. In the statistical analysis a t-test for independant samples was used when a comparison regarding AC & BC - ABR thresholds was performed (Table 2).. The difference was statistically significant ( $P < 0.0001$ ) at 0.01 level.

| | Mean | SD | |
|---|---|---|---|
| AC | 17.33 (10 - 20) | 4.42 | T=8.91 |
| BC | 27.66 (20 - 30) | 4.22 | $P < 0.0001$ |

**Table - 2:** - Mean, Standard deviation (SD), T & P value for AC & BC-ABR thresholds.

Several investigators have reported a similar relationship of AC 8B BC - ABR threshold ( Cornacchia et al., 1983, Stuart et al, 1993). However, Gorga et al. (1993), who tested 10 young normal hearing adults, found no significant differences between AC & BC - ABR threshold for clicks. The differences in AC &BC - ABR threshold for

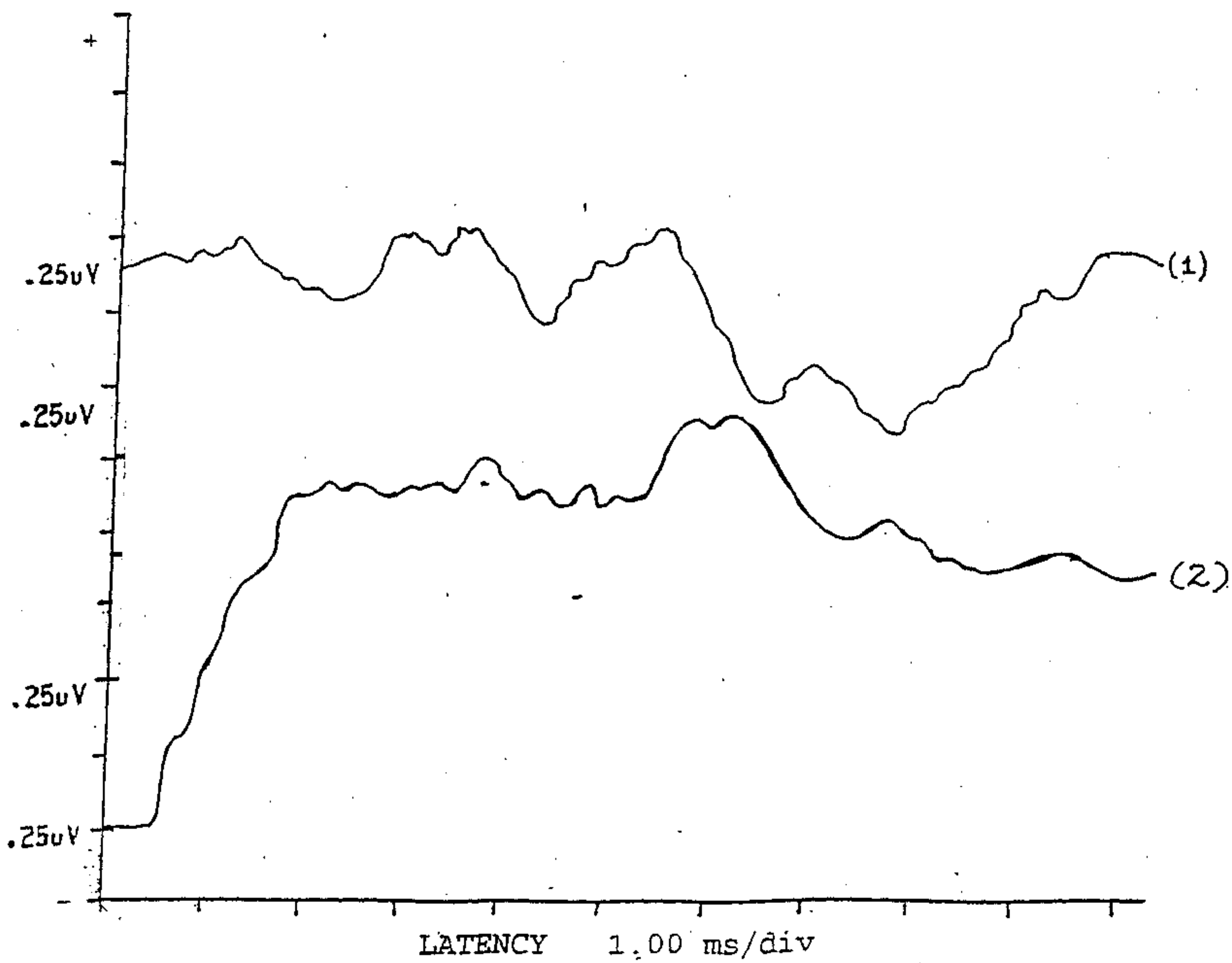



Fig 1: Illustrates the (1) AC - ABR, (2) BC - ABR wave form at 50dBnHL

| | BC- ABR | | | | | AC - ABR | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | **V** | I | II | HI | IV | V |
| 50 dB | | | 4.40 (4.19-4.58) | 5.79 | 6.39 (6.18-6.59) | 1.34 (1.12-1.49) | 2.48 (2.25 - 2.64) | 3.19 (3.01 -3.59) | 4.40 (4.16-4.61) | 5.70 (5.56 - 5.93) |
| 40 dB | | | 4.96 (4.81 -5.06) | | 7.00 (6.72-7.16) | 1.71 (1.62- 1.188) | 2.72 (2.61 -2.87) | 3.92 (3.68 - 4.06) | 4.81 (4.71 -5.18) | 6.24 (5.98-6.46) |
| 30 dB | | | 5.12 (5.10-5.23) | | 7.47 (7.29-7.71) | 2.18 (1.98-2.21) | | 4.31 (4.19-4.51) | | 6.77 (6.51 -6.98) |
| 20 dB | | | | | 7.81 (7.69 - 7.99) | | | 5.04 (4.91 -5.12) | | . 7.14 (.6.86 - 7.37) |
| 10 dB | | | | | | | | | | 7.61 (7.39-7.78) |

Table 3 : - Depicts the mean latency values and range for the different peaks for AC & BC - ABR measurement.

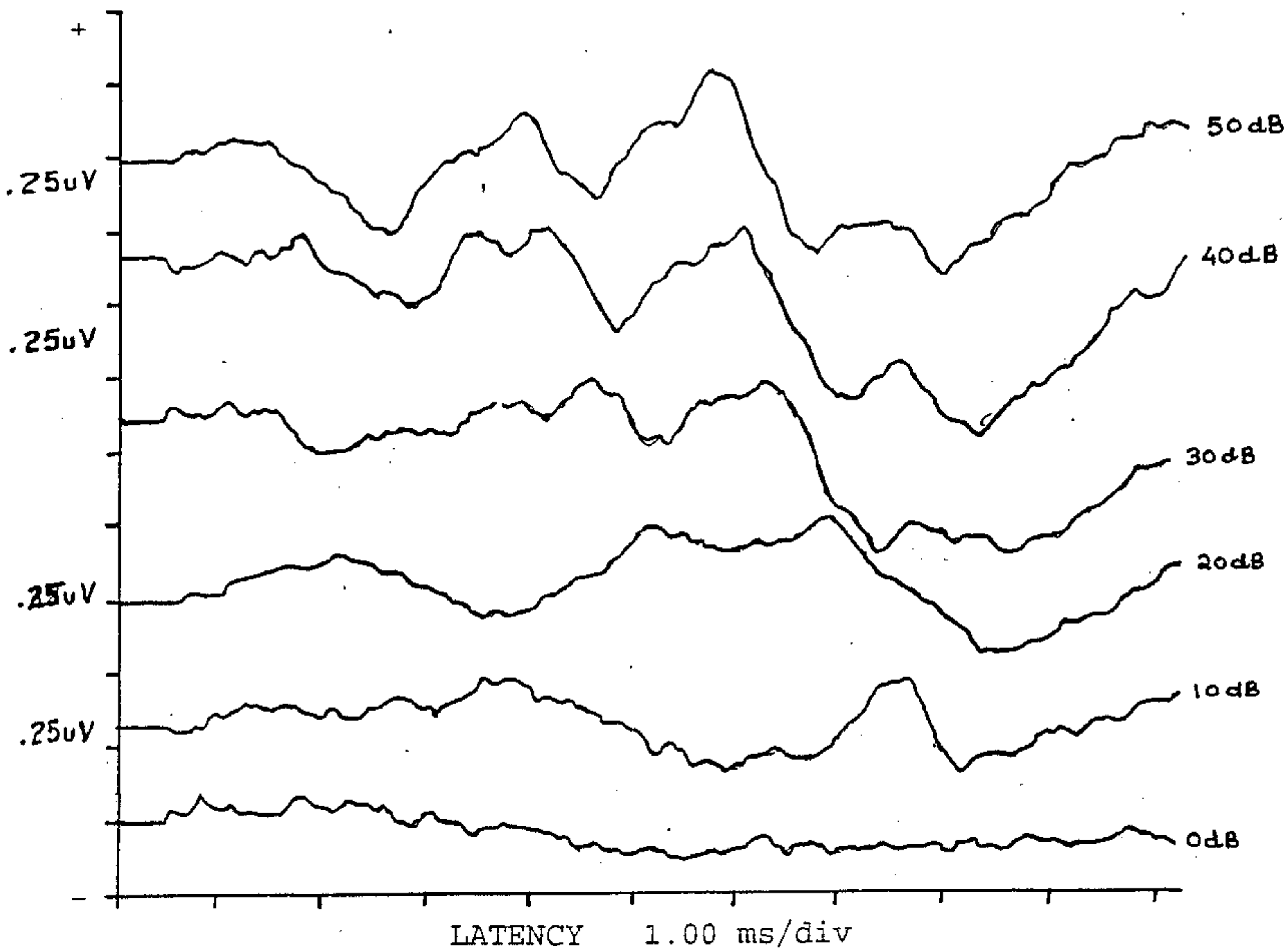



Fig 2a : Illustrates the wave form obtained for AC - ABR at different intensity levels.

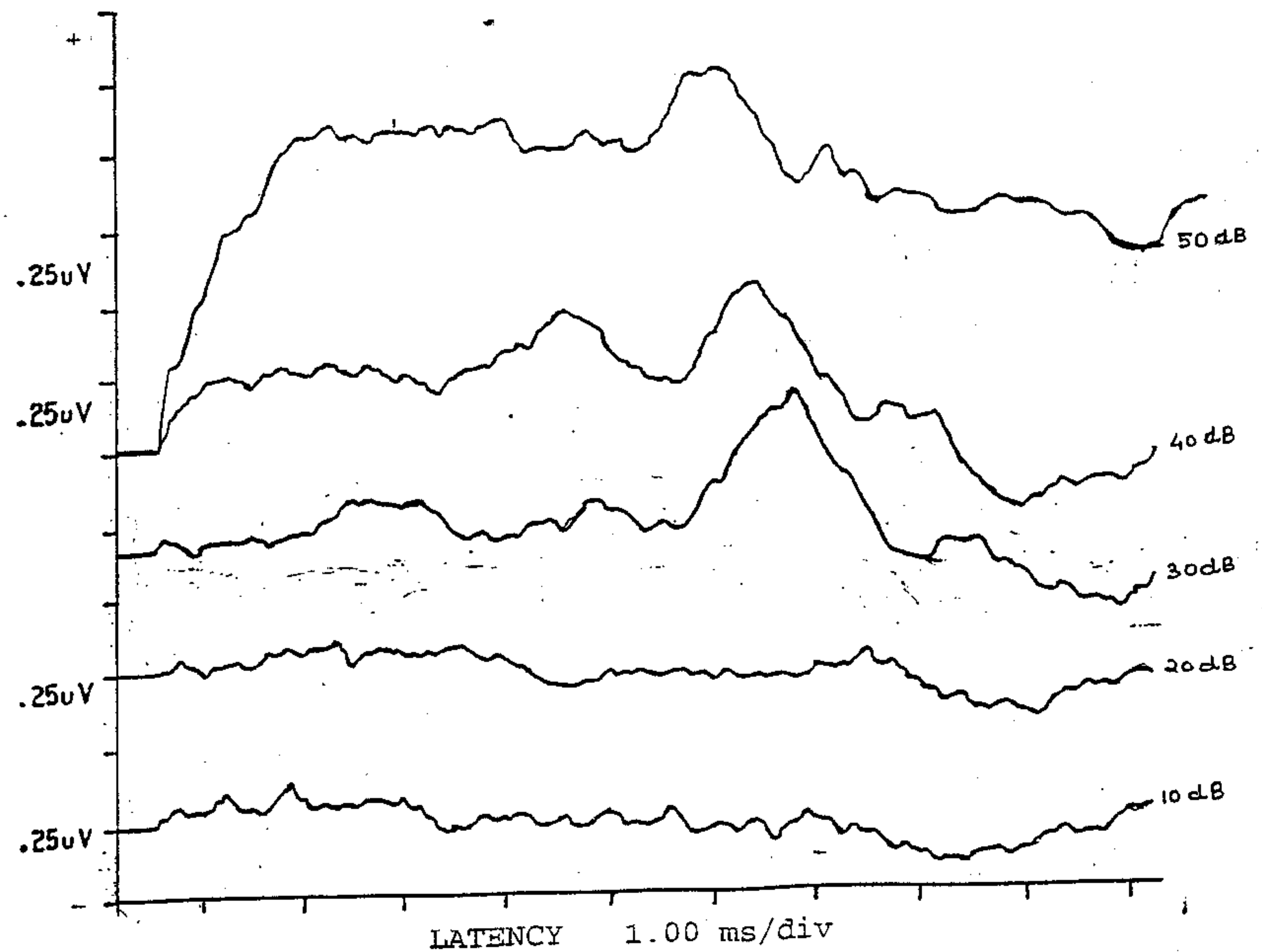



Fig 2b : Illustrates the wave form obtained for BC - ABR at different intensity levels.

the adults may be due to the difference in efficiency of signal delivering to the cochlea through the two different modes of stimulation. (Hooks & Weber, 1984, Yang et al, 1987, 1991).

**Latency of different peaks in BC 8B AC-ABR measurements** :

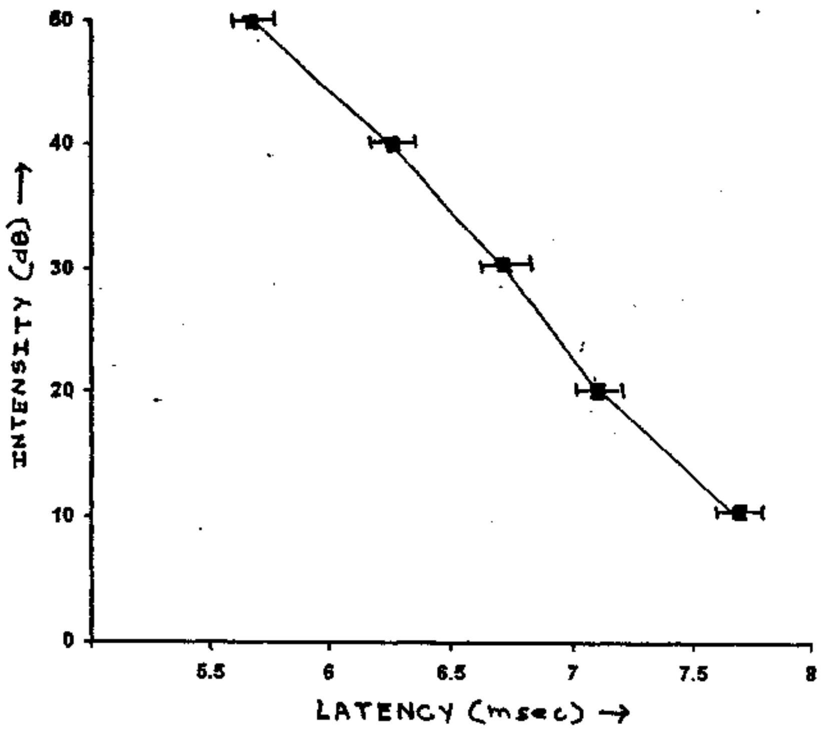
The latency of different peaks at the various intensity levels for BC 8B AC-ABR measurement is depicted in Table 3. As the intensity level was decreased there was a corresponding increase in latency for all the peaks for both AC & BC - ABR measurement. As the intensity was decreased wave I was first to mdisappear in AC - ABR measurements and then was wave III in both AC & BC - ABR measurements. The wave V was last to disappear for both AC & BC - ABR measurement.

**Wave V latencies for AC & BC - ABR** :

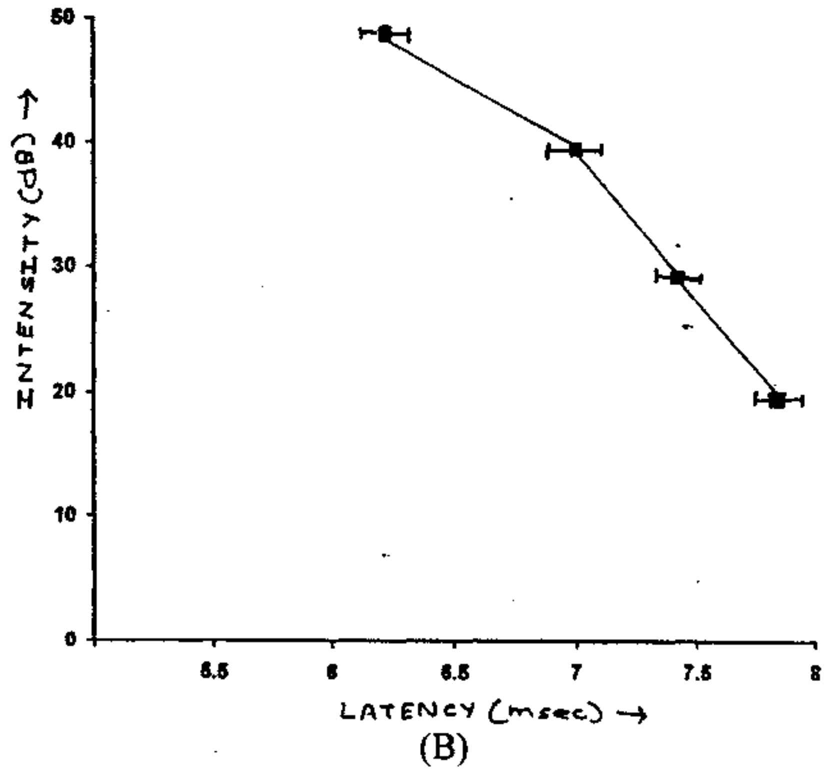
In both AC & BC stimulation mode an inversely proportional relationship was obtained between the peak V latency and the intensity level (Fig 2a and b). For the purpose of statistical analysis a t-test for independent samples at 0.05 level was used. The results of data analysis for the peak V latency values at various intensity levels for AC 8B BC - ABR are depicted in Table -4. The results indicated a statistically significant difference for the latency of wave V between AC 8B BC - ABR measurement at all the intensity levels.

| | AC-ABR<br>M SD | BC-ABR<br>M SD | T&P<br>Value | **D** |
|---|---|---|---|---|
| 50 dB | 5.70 ± 0.23<br>(5.08 - 6.00) | 6.39 ± 0.27<br>(6.04 - 6.92) | T= 12.45<br>P< 0.0001 | 0.69 |
| 40 dB | 6.24 ±0.21<br>(5.68 - 6.60) | 7.00 ± 0.41<br>(6.88-7.18) | T=9.86<br>P< 0.0001 | 0.76 |
| 30 dB | 6.77 ± 0.22<br>(6.44 - 7.06) | 7.47 ± 0.43<br>(7.23 - 7.69) | T= 10.96<br>P< 0.0001 | 0.70 |
| 20 dB | 7.14 ±0.17<br>(6.90 - 7.38) | 7.81 ±0.29<br>(7.75 - 7.92) | T= 11.61<br>P< 0.0001 | 0.67 |
| 10 dB | 7.72 ± 0.26<br>(7.65 - 7.82) | - | - | |

**Table 4:** - Mean latency, standard deviation, range T 8B P value and the differences between the latency of wave V for AC & BC - ABR measurement.




(A)




(B)

Fig 3: (A) Intensity latency function of wave V for AC - ABR.
(B) Intensity latency function of wave V for BC - ABR.

The latency intensity function of wave V for AC & BC - ABR are shown in Fig. 3.

Similar findings have been reported by Cornacchia et al, (1983); Mauldin & Jerger, (1979), Yang et al, (1987), Stuart et al (1993). Several authors (Hooks & Weber, 1984, Mauldin 8B Jerger 1979, Schwartz et al, 1985) attributed this prolongation in BC stimulation to the different spectrum of the transducers to clicks, namely the lower frequency emphasis in the spectrum of bone vibrator compared to an earphone.

The travelling wave that begins at the basal end is propagated at a much slower velocity than the compressional wave, and it slows as it proceeds towards the apex because membrane stiffness decreases. Since the travelling wave serves to define the place for a given frequency it is clear that the latency for the filtering action by the basilar membrane should be longer for the low frequencies than for the high ones, in as much as their places lie farther away from the stapes and thus require longer time to travel (Gullick, Gescheider 8B Frisina, 1989).

The observed latency difference may also be attributed to the conduction properties of the two modes of transmission. More massive or dense media tend to propagate sound more slowly. More stiff media propagate sound at greater speeds. Between different modes of transmission there will be a trade off between these two characteristics of each mode (Durrant 8B Lovrinic, 1977). Therefore, the sound may travel with a greater speed through the air conduction mode as compared to the bone conduction mode.

Further no significant differences in the peak V latency were obtained for BC - ABR when a comparison was made between the male and the female subjects using the wilcoxon test for matched pairs at 0.05 level (Table -5).

| | | Males<br>M SD | Females<br>M SD | Z | P |
|---|---|---|---|---|---|
| 50 dB | BC | 6.45 ±0.31 | 6.47 ± 0.32 | - 0.3975 | 0.6909 |
| | AC | 5.81 ±0.30 | 5.79 ±0.19 | 0.1255 | 0.9001 |
| 40 dB | BC | 7.04 ± 0.49 | 6.97 ± 0.32 | - 0.4436 | 0.6496 |
| | AC | 6.27 ± 0.27 | 6.21 ±0.12 | - 0.8474 | 0.3967 |
| 30 dB | BC | 7.49 ± 0.40 | 7.44 ± 0.26 | 0.3138 | 0.7536 |
| | AC | 6.79 ±0.27 | 6.81 ±0.31 | 0.1255 | 0.9001 |
| 20 dB | BC | 7.96 ± 0.29 | 7.94 ±0.31 | 0.1312 | 0.3481 |
| | AC | 7.04 ±0.16 | 7.11 ±0.23 | -0.1624 | 0.4024 |
| 10 dB | BC | | - | - | - |
| | AC | 7.64 ± 0.26 | 7.68 ±0.18 | 0.2142 | 0.5864 |

**Table 5** :- Depicts the mean and standard deviation of the latency of wave V for males and females for AC & BC - ABR measurement.

**Amplitude of Wave V for AC & BC - ABR** :

In both AC & BC mode of stimulation a directly proportional relationship was obtained between the peak V amplitude and intensity level. In general the amplitude of wave V was lesser for BC - ABR as compared to AC -ABR measurement at the same intensity level. For the purpose of statistical analysis a t-test for independent samples at 0.05 level was used. The results indicate a statistically significant difference with a lower amplitude of wave V for BC - ABR than for AC - ABR across all the intensity levels tested. The mean, standard deviation and range for wave V amplitude are depicted in Table - 6.

The observed differences between the amplitudes (wave V) between AC & BC - ABR may be attributed to :

a) The efficiency of signal delivering to the cochlea through the two modes of stimulation. The AC - ABR thresholds were obtained at (10 dBnHL) lower level as compared to BC - ABR. Therefore the amplitude of wave V for BC - ABR may be lesser as caompared to AC - ABR.

b) The signal delivered through the bone osillator has a greater low frequency emphasis as compared to the click presented through the headphones (Hooks 85 Weber, 1984). As the synchronization of the nerve fibres is greater for higher frequencies (Gorga, Kaminski 85 Beauchaine, 1987) the amplitude of wave V was greater for AC - ABR as compared to the BC - ABR.

| | BC - ABR<br>M SD | AC-ABR<br>M SD | T&P | D |
|---|---|---|---|---|
| 50 dB | 0.48 ± 0.2<br>(0.15-0.88) | 0.61 ±0.25<br>(0.30 - 1.44) | T = - 2.275<br>P = 0.03 | 0.13 |
| 40 dB | 0.37 ±0.16<br>(0.12-0.71) | 0.49 ± 0.29<br>(0.21 - 1.28) | T = - 2.274<br>P = 0.03 | 0.12 |
| 30 dB | 0.20 + 0.14<br>(0.14-0.5) | 0.32 ± 0.20<br>(0.13-0.91) | T = - 4.608<br>P = 0.0001 | 0.12 |
| 20 dB | 0.16±0.11<br>(0.10-0.34) | 0.26 ±0.13<br>(0.16-0.61) | T=-3.416<br>P = 0.0001 | 0.1 |
| 10 dB | | 0.81 ±0.81<br>(0.15-0.48) | | |

Table 6: - Depicts the mean, stand deviation (SD), Range T & P values and difference between the amplitude of wave - V for AC 8B BC -ABR.

Clinical applications of BC - ABR :

Several investigators have introduced BC - ABR as an additional tool for the differential diagnosis between conductive and sensorineural hearing loss. With this mode of stimulation information is available regarding the cochlear reserve status.

In the past, BC - ABR was recorded essentially to assess cochlear reserve in subjects with congenital atresia or microtia of the external ear. Later investigators suggested that the BC - ABR measurement be included in the early identification of hearing loss in high risk infants who failed the AC - ABR procedure (Stuart et al, 1990).

In the present study the nature of AC/BC-ABR relationship in normal hearing adults was examined. The results suggest that the relationship of wave V latency for AC & BC stimulation may serve as an additional evidence for the type of hearing loss.

The fact that BC - ABR is still not included in the -routine procedure of auditory assessment with ABR is probably due to a number of technical problems.

1) The maximum effective intensity level of approximately 40 dBnHL for BC stimulation which causes a narrow dynamic range of the stimuli itensity (Muchnik et.al, 1995).
2) The need for contralateral masking.
3) The presence of stimulus artifact as a result of electromagnetic energy radiating from the bone vibrator.

The problem can be minimized by

a) ear lobe electrode placement instead of mastoid.
b) Alternating polarity clicks as recommended by Hall (1992).

Although there are still limitations to the use of BC - ABR, it can still be used as a clinically feasible tool and often extremely valuable electro physiology auditory assessment for difficult to test population. From the observations in this study it can be concluded that at this point it would be preferable to compare the BC - ABR to AC - ABR recordings as quality estimates for the differential diagnosis between conductive and sensorineural hearing loss rather than to use the BC - ABR as a quantitative measure for cochlear reserve status.

## SUMMARY AND CONCLUSIONS

The study was taken up with an aim of

1) To obtain normative data for BC stimulation elicited ABR measurements in normal hearing adults.
2) To investigate if any latency differences exist between AC & BC - ABR.
3) To determine if the amplitude of wave V differed significantly for AC & BC - ABR.
4) To highlight the use of AC & BC - ABR in clinical practise.

For this purpose, 30 young adults (15 males, 15 females, mean age = 20.5 years) were studied for their AC & BC - ABR measurements. The obtained results were then used to generate the normative values for BC - ABR. These were also used for the comparision between BC & AC - ABR across above mentioned parameters using appropriate statistical techniques. The results of the study indicated that the BC - ABR thresholds were obtained at 10 dBnHL higher than that for AC - ABR. Thus it may be expected that the BC - ABR threshold may be obtained at least within 10 dBnHL higher than that for AC - ABR in normal hearing adults. For BC - ABR only waves III and V could be identified clearly whereas for AC-ABR waves I, III and V were identified. The results also indicated a statistically significant longer latencies (for all the peaks ) for BC-ABR as compared to AC-ABR. Thus while using BC-ABR a separate normative data should be used. This is because of the difference in efficiency of the signal delivering to the cochlea through the two modes of stimulation. No significant differences were obtained when a comparision of wave V (latency) was made between males and females. Also the amplitude of wave V for BC-ABR measurements was lesser as compared to AC-ABR. Furthermore the clinical apllications of BC-ABR and its use in estimating the hearing status are highlighted.

The study also makes possible further research on BC-ABR since the expected normal values have now been determined. A few topics for research on BC-ABR are as follows :

1) To obtain a correlation between BC-ABR and the behavioral thresholds in normals.
2) To study the different parameters using BC-ABR in paediatric population

Thus this study on AC and BC-ABR opens the doors to futhur research on the topic and enhances the use of ABR in the routine clinical practise of Audiology.

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# APPENDIX -1

## STANDARDS FOR CALIBRATION OF PURE TONE AUDIOMETER

The following standards were used for the calibration of the audiometer.

Air conduction (ear phones) - ANSI S3 - 6 1989

Bone conduction (BC Vibrator) - ANSI S3 - 26 1981

The procedure used was as prescribed by the instruction manual of the audiometer, using a Sound Level Meter with Octave filter set, 1 inch condenser microphone, artificial ear (for headphone calibration) and artificial mastoid (for bone conduction vibrator calibration).

## APPENDIX II

### STADARDS FOR CALIBRATION OF IMMITANCE AUDIOMETER

The imittance audiometer used for the study was calibrated using the following standards

| | | |
|---|---|---|
| ANSI | S 3 - 7 | 1973 |
| ANSI | S 3 - 39 | 1987 |
| ANSI | S3 - 6 | 1969 |
| IEC | 645 | 1979 |
| IEC | 126 | 1973 |

## APPENDIX - III

### Calibration of AC & BC - ABR

For this purpose the threshold in dB SPL was determined for 20 normal hearing adults. -The stimulus was presented through the Radioear B - 71 bone vibrator and the TDH - 39 P headphone. The threshold for clicks presented through bone oscillator was obtained at 75 dB SPL and for air conduction mode the threshold was obtained at 35 dB SPL. These values were then used to calibrate the bone oscillator and headphones by converting the above mentioned values into OdBnHL for the two transducers.