"AUDITORY BRAINSTEM EVOKED RESPONSE AUDIOMETRY"
A REVIEW 1991-1995

REG NO. M 9628

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT OF FIRST YEAR M.Sc., (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE,

ALL INDIA INSTITUTE OF SPEECH AND HEARING

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MAY 1997

**DEDICATED TO
MAMMI AND PAPA**

CERTIFICATE

This is to certify that the Independent Project entitled **"AUDITORY BRAINSTEM EVOKED RESPONSE AUDIOMETRY A REVIEW 1991 - 1995"** is a bonafide work in part fulfillment for the First Year M.Sc., in Speech and Hearing of the student with Reg.No.M-9620.

Mysore
May 1997

Director
All India Institute of
Speech and Hearing
Mysore - 6

CERTIFICATE

This is to certify that the Independent Project entitled "AUDITORY BRAINSTEM EVOKED RESPONSE AUDIOMETRY A REVIEW 1991 - 1995" has been prepared under my supervision and guidance.

Mysore
May 1997

Guide

Dr. (Miss) S. Nikam

DECLARATION

I hereby declare that this Independent project entitled "AUDITORY BRAINSTEM EVOKED RESPONSE AUDIOMETRY A REVIEW 1991 - 1995" is the result of my *own.* study under the guidance of **Dr. (Miss) S. Nikam**, Director, All India Institute of Speech and Hearing, Mysore, has not been submitted earlier to any University for any other Diploma or Degree.

Mysore
May 1997

Rag.No.M-9620

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To my Parents:

My feelings can't be expressed in words. I am feeling at the top of the world by having such parents. What I am today is just because of them. I never found myself alone in any trouble. Mummy and Papa I really love you, even more than my life.

To my Brother, Bhabi:

Sometimes I really do wonder if you know how special persons you are to me and how many times a day I think of you.

To my Seema Didi and Jijaji:

Sometimes I really do wonder if you can read my mind or look into my heart and see how much it means to have you in my life.

To my Rajni Didi and Ashok Jijaji:

Some times I really do wonder how to let you know, how important place you have in my life.

To my Cute and Lovely Sister Poonam,

That in all the world there is not a Sister as nice as you. Thanks for being there for me, when I needed you.

To my Chintoo, Mintoo, Palki, Anusha and Aseem,

I Love You................

I Hiss You................

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INTRODUCTION

INTRODUCTION

The term ABR was formally introduced by Davis (1979) in a report of a United States Japan Seminar on "Auditory Response From The Brain Stem". But other terms are also in vogue. The most common two alternative terms for the ABR are Brain Stem Auditory Evoked Response (BAER) which is used consistently in neurology, and Brain Stem Auditory Evoked Potential (BAEP). The term Brain Stem Evoked Response (BSER) popular in the late 1970s, is inappropriate because it does not specify the auditory system.

Since 1970, the brainstem auditory evoked response audiometry has emerged as a vital adjunct to the clinical armamentarium of the audiologist, otologist, neurologist and pediatrician who jointly determine hearing sensitivity, lesion site, and central nervous system disorders (CNS).

ABR applications in audiologic - otologic disorders and site of lesion testing have shown that the responses are well suited for the detection of hearing abnormalities (Shea and Albright, 1980). They became popular in clinical audiology and otology because of reproducibility, ease of administration, low inter and intra subject variability, and accuracy in estimating hearing sensitivity (Shu1man and Galambos, 1977; Sohmer and Feinmesser, 1970, 1973, 1974).

An interest in the hearing of children led investigators to discover that norms applied to adults were not appropriate for various developmental stages in children. This led to a series of systematic studies in premature infants, full term infants and preadolescent children (Galambos and Hecox, 1974; Jewett and Romano, 1972).

Another application is an attempt to discover electrophysiologic correlates underlying demyelinating diseases such as multiple sclerosis (Brookes, et al., 1980). The majority of these investigators subscribe to the well known relationship that, as the peripheral and central nervous systems mature (Eg. as additional myelinization takes place, and perhaps as axon diameter increases) latency of BAERs tend to decrease until an adult norm is achieved. In addition, the magnitude of the potentials is observed to increase with age.

A series of articles are published in the otolaryngologic and audiologic literature by Setters and by Brackmann, Clemis and Thonson, that confirmed remarkable power of ABR in diagnosis of acoustic tumors in particular, and posterior fossa lesions in general. Other applications of ABR reported but not enjoying much clinical acceptance, included estimation of outcome in severe traumatic head injury and confirmation of brain death (Starr, 1976).

Since 1980, the effect of virtually every possible measurement parameter on ABR has been evaluated and described in the literature. Early studies on pediatric auditory assessment with ABR provided the foundation for the current emphasis on new born auditory screening and other studies are still on.

Need of the Study:

ABR is now widely applied and research is still going on to find different applications and aspects of ABR audiometry. These are scattered throughout the literature, literally thousands of articles describing some aspects of one or more of ABR.

So the aim of the study is to collect within a single volume, the more important findings emonating from these diverse sources to enable the reader to get a comprehensive and varied knowledge about ABR.

The information provided in the project will be of great help to researchers, teachers and future students in the field of Audiology.

METHODOLOGY

METHODOLOGY

The journal articles dealing with auditory brainstem responses in human beings and other lower animals were selected for the study. The articles were collected from various journals. The journals in which the articles were found are:

1. Journal of Acoustical Society of America
2. Scandavian Audiology
3. Ear and Hearing
4. Acta Otolaryngologica
5. Annals of Otology, Rhinology and Laryngology
6. Journal of Speech and Hearing Research
7. British Journal of Audiology
8. Audiology
9. Archieves of Otolaryngology
10. Laryngoscope
11. Hearing Journal
12. Indian Journal of Otolaryngology and Head and Neck.

All the journals related to ENT and Audiology including the above mentioned journals were scanned and articles related to ABR were included in the review.

The information from these articles were classified under various columns and were tabulated chronologically under different chapters, viz.,

Chapter I - Factors Affecting ABR

Chapter II - ABR in Pediatric Group

Chapter III - Clinical Applications of ABR

After compiling the data in tabular form, it was analyzed to determine the trend in various aspects.

The various columns under which the articles are tabulated are:

Column 1 : Sl.No.

Column 2 : Author/Year

Column 3 : Purpose of the Study

Column 4 : Subject variables: no/age/normal/abnormal

Column 5 : Stimulus variables: Type/Number (No.)/Intensity (Int.)/Polarity (Pol.)/Filter setting (F.S)/Masking

Column 6 : Electrode montage: Type/inverting/non-inverting/ground

Column 7 : Results

Column 8 : Remarks

CHAPTER - I

Factors Affecting ABR

CHAPTER - I

FACTORS AFFECTING ABR

Sl. No.	Author/ Year	Purpose of the stud;	Subject No	Age	Variable N/abn	Stimulus Variables	Electrode lontage Type/Inverting/ Ion-inverting/ Ground	Results	Reiarks
1.	2.	3.		4.		5.	6.	7.	8.
1.	Aoyagi, M. et. al., (1997)	The Cross correlation function was applied to the analysis of ABB in patients with Spinocerebellar degeneration and its clinical usefulness in detecting abnormalities contributes to of All. procedure.	30M 30F 33	Adults	I SCD	Type Clicks No.1024 Int.90dBnHL Pol.alternating F.s. S0-3000Hz Masking. No.	Double channel needle electrode/ vertex/earlobes/ Forehead	The results suggest the evaluation of ABS wavefort characteristics by leans of cross correlation function using normative ABR for the sale gender contributes to the precise detection of functional changes in the brainsten auditory pathway in patients with SCD.	Neither the site of the lesion nor the origin o the lateney deviation ca be evaluated by this procedure. Age range ha not been lentioned. Various pathological groups (with hearing loss should be studied.
2.	Anantha Narayan, A.K. et.al. (1991)	ABR data «as evaluated in terns of wave II alterations across recording configurations, stimulus intensities, and stimulus rep. rate.	(11) 3M 8F	20-30 Trs.	I	Type Clicks Rate 19.9-S9.9/sec Int.40-80dB nHL/ Pol./Alternating, So Masking	Vertical and Horizontal electrode configuration Vertical Configuration a) Hairline to Ipsilateral Mastoid b) Hairline to Contralateral Mastoid Horizontal Configuration Mastoid to Mastoid	Save IIsatin horizontal derivative consistantly occurs earlier than wave IIb (vertical derivative). The slopes of the latency-intensity functions for wave;s IIa and IIb are different, The effects of stiiulus rep. rate are different for IIa and IIb. These findings suggest that different derivative merely provide	The finding reported here bear further coroberatic by other types of studies and the results don't permi identificat ion of actual generator sites.

1.	2.	3.	4.			5.	6.	7.	8.
								different views of the sale generator in the wave II time frame.	
3.	David, R.S et. al., (1991)	The study describes the comparative saturation of the ipsilaterally and contralaterlly recorded ABRs recorded from a cross sectional group of infants.	37 6	2Mon-20 Weeks --	N N	Monaural click 2000 19.1/sec 29-89dB nHL Rerefaction 39-3990Hz No. Masking.	Two channel gold cup electrodes/at each mastoid/vertex/ forehead	Kith increasing age contralateral waves and ipsila-teral, decreased in latency, with the contralateral morphology closely resembling the ipsilateral Morphology as age increase especial1yf after the age of 9 Months. The smaller contra-lateral responses make their use for threshold estimat-ion problematic especially before the age of 9 Months	Further study is needed of the maturation of the scalp distribution of infant's Alls, as well as iavestigation of those factors, such as neurological disease, which light affect the relationship between the ipsilaterally and contralatera-11y, recorded ABE peaks and their maturation.
4.	Eggermont, JJ. et al., (1991)	this study focuses on the frequency speci-fic, development that closely follows the development of the cochlear Morphology	11 24 40 15 79 22 17 12	34Weeks 35-37Wk 38-42Wk 3Wk-3Mon. 3-6Mon. 6Mon.-lyear 1-2 years. adults	Pretern Late Preterm Terms	Clicks 1000 Rate 1.9/sec Int. 60dB nHL, Pol. condensation No Masking	Single channel/ vertex/ipsilateral mastoid/forehead	Study shows that the frequency dependent electro-physiological maturatiom of brain stem parallels the anatomical development of cochlear.	The observed effects in ABR mlost likely. Only relate to neurological maturation and not to perceptual maturation.

1.	2.	3.	4.			5.	6.	7.	8.
5.	Gereling, I.J (1991)	As investigation of the effects of repetatien rate on audioietric brain stea response (unaided, aided conditions).	1(F)	Adult	N	Click late 11/sec. 33/sec. 4 71/iec. Pol. single Pol. Int. 20dB nHL to 604B nHL No tasking	Single channel/upper forehead/ipsilateral earlobe/contralatera earlobe.	As repetition rate was increased beyond 11/sec. in the aided condition, prolonged or reversal of wave latency, became more pronounced. Degree of reversal was 0.22 msec at 33/sec and 6.41 tsec at 71/sec.	Only adult is taken, so good generalization is not possible. Large sample size other pathological groups shold be included.
6.	Gerul1, & et. al., (1991).	The phase and intensity dependence of sasking a click by a loud low freque-nce tone was exanined white brain sten potentials.	6 2	25-45Yrs --	N SNhg loss	Click alternating polarity 10-60dB nHL Masking Los frequency ipsilaterally.	Single channel/neck/ vertex/forehead	Wave V latency is practically uneffectel1 - its amplitude is maximally suppressed at a phase of 270degree In the phase of maximal suppression, wave V can be cancelled by 36Hz tone of 115dB SPL up to click intensities of 40dB nHL. Vith cochlear damage, total suppression can be achieved at even higher click int.	More subjects should be taken. In the study age range of subjects has not been mentioned. It should be done in every age range.
7.	Hamil, T.A et. al., (1991).	The purpose of this study was to examined threshold testing using spoor's techni-que for rapid ECoch G applied to the measurment of ABRS	(13) 5M 8F	24-38 Tears	II	Clicks 10.1624 Rate 70.1/sec Int. 10-70dB nHL Pol. rarefac-tion. For chained Clicks with 10 msec interval. No tasking.	Single channel gold disk electrodes/ ipsilateral earlobe/ vertex/controlateral earlobe	Chained-stimuli AIR threshold estimation for norsal hearers were essentially equivalent to those obtained using as automated conven-tional, ABR mathod. The data for a seven point latency intensity function using the chained stimuli technique were obtained in a meantime of only 8min per year.	The chained-stiiuli technique has a no. of applications in electro physiologic testing. Routine clinical application of this technique is not yet recommanded because the technique has not been thoroughly investigated

1.	2.	3.	4.	5.	6.	7.	8.
							in hearing impaired populations.
8.	Jiang, Z.0 et. al., (1991)	Change in the amplitude in ABRs with change in click rate	80 lmon-Syr. N 21 22-36 Years. N	Click 1024 Kate:10, 30, SO, 70 & 90/sec Int:70, 40, 20dB nHL F.S:100-2000/Hz No tasking	Single channel silver disk electrodes/ Ipsilateral earlobe/ Middle of forehead/ contralateral earlobe.	As repetition rate increased from 10-90Bz at 70dB nBL, the aiplitude in different age groups decreased by 33–45% for wave I. The amplitude of wave I is affected tore than that of wave V. At low intensities changes in wave amplitude is similar. The greatest reduction in wave amp. occurred when the rep. rate was increased from 10-30Hz. In a few cases, wave V aiplitude decreased little or even increased slightly at high repetition rates (70 i 90Hz).	Adult sample is stall and is not latched with children group with respect to no. of subjects. Such factors can affect ABE results so it should be taken care of.
9.	Liu, X.Y et. al., (1991)	Intensity effect on wave latency and interval (IPI) in brainstem auditor; responses birth to adult hood was investigated.	178 Chi 1-dern lmon to 6yrs N 18 adults 22-32 yrs. N	Clicks Ho:1024 Sate:10/sec Int.varled between 0-99dB nHL Pol: rarefaction Masking: While noise contralateral ear	Single channel Silver-silver-chloride electrode/ Ipsilateral earlobe/ Forehead/Contralateral earlobe.	The L-I functions were slightly steeper in younger groups thas in older groups, which was associated with age related difference in the absolute latencies. As click intensity decreased, the I-III IPI tended to decrease slightly while the III-V IPI tended to increase slightly in most age groups.	Adult sample is stall and homogenous with other evoked group with from respect to No. of subjects.
10.	Roger, R.M et al., (1991).	Notch filters are underivably effective in eliminating the artifacts	6 Adult -	Click No:2000 Rate:23.3/sec and 20.3/sec	lot mentioned.	Latency was virtually uneffected with any filter or stimulus rate and distortion	The disadvantages of sharp filter is that it is difficult to

1.	2.	3.	4.	5.	6.	7.	8.
		due to line frequency interference. In this study concerns have been expressed as to their effect on ABRs		Int.20, 40, 60 4 80dB nHL Polarity alternating No. masking		was minisal when a sharply tuned filter was used in conjunction with a stimulus rate of 23.3Hz whose nearest hormonic to 68 is 69.9Hz	obtained as deep notch and that very slight changes in cotponents will badly degrade performance. Satple size is very stall.
11.	Sohmer, N et. al., (1991).	ID this study ABE threshold and latencies were recorded in 4 groups of normal controlled animals and then in the same aninal after induction of conductive hg. loss. and SN hg loss.	4group of animals - N	Click Eate:20/sec Int.80dB nHL Pol.alternating tasking used to situlate hg. loss (ipsi)	Single channel subdermal electrodes/Pinna/ vertex/at hindlimb	In each group, there were stall decreases in the interpeak latency. Prolongation of latency of wave I to a greater extent than wave I? (In SI group).	In attempting to apply these conditions to the human clinical situation, these stall decrease in interpeak latency would not be considered abnormal. Simulated conditions do not give the true picture of results.
12.	Conijn E.A.J.G. et al., (1992)	The frequency specificity of the Ail threshold to stimulation with a click tasked with 1590Hz high pass noise was detemined.	(S3) 11-88 Tears 38M 15F Hg. Imp. with 4 N	Click 8.R:20/sec Int.34dB peSPL Pol altern-ating F.S:High pass 135dB/ octave Shite noise (Ipsi) as tasking.	Single channel silve r chloride cup electrodes/tastoid of stim-ulated ear/vertex/ forehead.	The results show that the ABE threshold elicited by this stimulus is low frequency specific. Click tasked with l590Hz high pass noise can be regarded as an accurate tool to predict the hg. loss at lOOOHz	This tethod is less suitable for routine clinical testing because of the tasking noise needed.
13.	Conijn E.A.J.G et al., (1992).	Freq. specificity of the ABR threshold to a click masked with 1S90Hz high pass tasking noise is compared with the freq. specificity	26 - High freq. loss 8 - Low freq. loss	Click Masking White noise (Ipsi).	Rot mentioned	The ABE thershold to the high pass noise tasked click is low freq. specific vith 1OOOHz pure tone threshold. The ABB threshold to the	High frequency part of the click although not able to elicit a response in case of severe hg. loss in a high frequency area, can

1.	2.	3.			4.	5.	6.	7.	8.
		of the unmasked click evoked ABE threshold	4	-	N			unmasked click corresponds with the 3000Hz puretone threshold, the freq. specificities seems much less pronounced than that of lot freq. speech stimulus	still hamper the low freq. part of the cochlear meabrace.
14.	Fausti, S.A. et. al., (1992).	The purpose of this study was to evaluate ABRs obtained with a portable high frequency tone burst system as compared to the laboratory system.	5 4F 1M	19-27 yers.	N	Type:High freq. tone burst of 8 10 12 14kHz	for laboratory system Single channel/Mastoid prominence of testear/ vertex/forehead	ABRs to high frequency tone bursts revealed no significant lean latency differences between systems.	Study should include pathological subjects for good generalization.
			30 13M 17F	16-32 yers.	N	Portable 8&14kHz tone burst Int. 60dB SL Rise fall time 0.2 msec Bate: 11.1/sec No:1000 Masking band pass. Contra, at 30dB less than tone burst signal	For portable Two channel/right t left mastoic/vertez/ forehead.	These results confira that the portable systet is comparable to the obtaining reliable high Freq. tone burst responses.	
15	Fower, G.C et al (1992)	The purpose of this investigator was to determine the effects of stimulus phase on the latencies and morphology of ABRs of normal hearing subjects	10 (F)	24-32 yrs	N	R&C Cliks Rate:25/3 Int:100dB	Single channel gold cup electrodes/ nape of the neck/ vertex/fore head	Latency of click-evoked ABR is dominated by high frequency responses with equivalent latencies regardless of stimulus phase, low frequency components contribute overall lorphology of ABR that yields the phasic difference potential - Tone pip stimuli produced polarity differences that were inversely related stimulus frequency	Ions based upon responses from normal hearing subjects may be inappropriate through the ABR of clients with high frequency hearing losses because they can not account for latency differences attributable to stimulus phase. Sample size is small
			5 (F)	25-37 yrs	N	Tone pips (500, 1khz 2 khz, 4 khz) with linear rise fall time of lmsec (same for all frequencies) at 65 dB SPL Masking Broad Band Noise			

1.	2.	3.		4.	5.	6.	7.	8.
16	Kanner, S.J. et al (1992)	The feasibility of recording bone conducted ABRs investigated in normal hearing adults	15F 21-35 yrs	N	Tone burst of 590 and 2000hz Click with repetition rate of 10/s Tone burst cycle 580hz 4-1-4 for 2khz 1-1-1 Intensity 40,30,20,10dB nHL Masking white noise (cont.)	Single channel silver disc electrodes/ vertex/ipsilateral mastoid/forehead	Results support the use of bone conducted tone burst ABRs for demonstrating frequency specific normal cochlear sensitivity	Sample size should be large. Distortions of bone conducted stimuli at high frequencies would affect the results. Study should test subjects with different hearing loss.
17	Light Foot, G.Rt et al (1992)	The utility of ABR rate induced latency shift measurements was investigated	(189) 95M 94F 48yrs (31) 15M 16F 52yrs (16) 9M 7F 51yrs	RCP M.A A.I Sus. RCP	R&C click lo.lOOO Rate: 11.1, 44.4, 88.8/ sec Int: SOdB nHL No tasking	Single channel Ag/AgCl electrodes/ipsilateral mastoid/forehead/ contra lateral mastoid	Results suggests that ABR rate induced latency intensity shift measurements when applied with a criteria, which includes the loss of wave V at the higher rate, are capable of identifying patients with acoustic neuroma which requires no correction for age, sex, hearing loss or stimulus intensity.	more studies on repetition rate and nerve VIII lesions are required for more definitive evidence for its use. In all group, No. of subjects taken is tot same which can affect results.

1.	2.	3.			4.	5.	6.	7.	8.
18	Morre,E J et al (1992)	Recording of a positive ware which preceeds wave I, and is called I' is described. Qualitative and quantitative aspects of the I' potential has been described	38 19M 191	18.4-29.3 yrs	I	Clicks Eate:ll.l/sec Ist: 59-80 dB nHL Polarity rarefaction and condensation No tasking	Single channel/vertex ipsilateral ear lobe/ forehead	It is postulated that V represents initial neural activity of the auditory nerve which presusably has its origin from auditory nerve dendrites. Thus I' may represent a summed farfield dendritic potential from currents of excitatory post-synaptic potential	Identification of I' ny be lore difficult in pathologic ears and thus limits its clinical usefulness.
19	Shoon-hoven,R et al (1992)	Effect of click polarity on the ABRs in cases of simulated high frequency hearing loss	8M 4F	20-25 yrs	N	R&C clicks No.2000 Bate: 13/sec 1nt: 70dB SL Filter setting 48 dB/octave (Two high pass) Basking High pass filtered noise (Ipsi)	Single channel/fore head/ipsilateral mastoid/contra lateral mastoid	There does not exist a general systematic trend within a population of subjects concerning All clicks polarity dependence inspite of sometimes drastic R-C differences observed within individual subjects	Simulated condition cannot give real picture of cochlear high frequency hearing loss No of subjects are very less.
20.	Soucek.S et al (1992)	To study effects of adaptation on electro cochleography and auditory brainstem responses in the elderly(By increased stimulus rates	12 (7M 5F 8 (4M 4F)	65-88 yrs 15-27 yrs	Mod. and sev. Eg. Loss N	Click No:2048 Rate:randoi Int. 80, 90, lOOdB nHL No tasking	Rot mentioned	Amplitude of the AP and wave III component were reduced with increased stiiulus rate. It was similar in both elderly and young adults. So results suggested that synaptic connections to nerve fibres from surviving hair cells in elderly are functioning so that disturbance of this part of the acoustic nerve is not a feature of presbyacusis CM and SP were not affected by adaptation at any age.	Procedure is not specified in the study. No. of patients should be more.

1.	2.	3.	4.	5.	6.	7.	8.
21.	Suzuki,T et al (1992)	Binaural interaction in Auditory brain stes response (ABRs) and MLR was measured in awake and asleep states.	14F 26-44 yrs N	Clicks No.1024 Int: 45 dB nHL Polarity alternative filter setting 30-1200 bx No Masking	Single channel Ag cup electrodes/7th cervical vertebra/aid point of frontal hair line/ nasion	The magnitude of binoral interaction was smallest in ABR (waves I-V) and largest in later components of MLR in both waking and sleeping states. BI values for the peak to peak amplitudes in the ABR and HLR were significantly lower in the sleeping state than in the waking state.	Sample size is mil. Other pathological group should be studied for good generalization.

1.	2.	3.			4.	5.	6.	7.	8.
22	Thomas,E et al (1992)	In the present study ABRs were measured in a group of normal hearing subjects with systemic lupus erythematosus as well as in a group of subject controls.	10 5F 2M 10 5F 2M	28-52 yrs 33-80 yrs	N hg with SLE N	Clicks Rate:9.3/sec and 55.3/sec Int:75 dB nHL No tasking	Single channel/vertex	Results of present study did not reveal significant mean differences at any IPL between group of patients with and without (systamic lupus erythematosis)	Lack of agreement between results of this study and earlier studies. Lack of agreement lay be because of measurement procedures, the experimental design or individual subject differences. So diagnostic conclusion from this study are still controversial.
23.	Barth, C.D et al (1993)	The purpose of this article is to examine the effects of noise burst rise tine and level on the human BAER.	10	adults	1	Noise burst list time 0,0.5,1.25, 2.25ms Int: 15,30, 45 and (0 dB nHL Masking white noise Ips)	Single channel/masteid ipsilateral to acoustic stimulation/vertex/ forehead	With increase in noise burst level there is a decrease in wave T latency. The slope of latency intensity function increases with increase in rise time. The slope of the latency rise time function increases with decreasing noise burst level. The change in wave V latency associated with change in rise time is less than the change in rise time in all experimental conditions.	Sample size is small Age range is not lentioned in the study Study should include pathological cases
24	Boettcher F.A. et al (1993)	The aim of this stud; is to find out mechanism of resistance to noise induced hearing loss. Subjects were tested for a preexposure base	6 anim- als	6-12 mths	N	Tone pips No.2000 Rate: 10/sec Rise fall time 0.5ms Int: variable Masking at SO dB SPL Centered at	Single channel needle electrodes/vertex/ behind the pinna.	ABR latencies of waves II and IV were prolonged at low stimulus levels on days one and sixth of exposure, but recovered to base line levels by 12th day of exposure.	Different age groups should also be studied. The neurophysiology of gerbil should also be examined

1.	2.	3.	4.		5.	6.	7.	8.
		line, then on days 1,6 and 12th of noise exposure.			4 khz. (Ipsi)		Because resistance to noise exposure vas observed in all subjects and resitance was United in specterm. The results suggest that the gerbil is an excellent model for examining mechanism of resistance to noise induced hearing loss.	carefully before generalizing these results to humans.
25.	Burkard, 8., et al (1993)	The present study seeks to provide empherical support for the assumption that wave I of the gerbil BAER corresponds to the NI of the whole nerve action potential by comparing the latency and amplitude of the BAER wave I and VAMP.	14 8M 6F	3 mths. N	Clicks and tone bursts Rise fall time las Fq: 1,2,4,8 and 16 khz. Int: 30,50, 70 and 90 dB SPL No tasking	For BAEs grass needle electrodes placed subdermally. For MAP silver lire placed in the round window niche.	Latency/intensity slope functions for N1 and wave I were very similar with both dependent variables shoving an increase in LI functions slope with decrease tone burst frequency. The amplitude ratio of N1/wave I appears to increase with increase in stimulus level. The similarity of N1 and wave I peak latencies supports the assumption that wave I of the BAES is a far field reflection of It of the HAP.	Sample size is small, various groups with othre age ranges and pathologies should be included.
26	Cashman M.Z., et al (1993)	The aim of this study is to focus on the effect of a correction factor on the latency of wave V. To look at the frequency of occurance of absent wave V in tutor and non-tumor patients.	1500 97 1403	- SN Ng loss with tum-or with out tum-or	Click So. 1000 and 2000 late: 10.3 and 21.3/sec int: 83 dB nHL Polarity alternating Masking Contro lateral masking at 45 and 50 dB nHL	Single channel/vertex or high forehead/ ipsilateral mastoid process/contra lateral mastoid	The false +ve and false -ve rates are ABR are presented as a function of hearing less at 4000 hz, both before and after using Setters and Brackmann's correction factor for hearing loss. A correction factor is helpful with reservations of hearing and that ABR is not a useful test when 4000 hz hearing	The age and gender differneces were accounted for in present study, their interactions with hearing toss was not studied.

1.	2.	3.	4.	5.	6.	7.	8.
						loss is greater than 90 dB nHL and 2000 hz is greater than 75 dB nHL. Delay in latency V is greater for males than females.	
27	Don,M. et al (1993)	This study reports on amplitude and latency measurements of derived narrow bands ABR is tales and females	17F 24.8 yrs N 14M 26.2 yrs N	Click Polarity Rarefaction Int: 93,83,73, 63,53,43,and 38 dB SPL Masking Pink noise (contra)	Single channel/vertex/ ipsilateral nstoid/ contra lateral lastoid	Derived narrow bands ABRs in nortal hearing subjects reveal a significant difference between genders in the response tite between various frequency regions of the cochlear. Females showed shorter delays than tales between derived bands. The faster response tite is a consequence of a steeper stiffness gradient in the female cochlear.	Whether these differences in ABS latencies and apmlitudes have important clinical application requiring separate normal values based on gender retains to be seen. An understanding of these cochlear techanism tay improve the diagnostic capabilities of ABRs in patients with peripheral hearing loss.
28	Fausti, S.A., et al (1993)	High frequency tone burst stimuli have been developed and demonstrated to provide reliable and valid ABRs in normal subjects	14 16-32 yrs N 9M 5F	High frequency tone burst at 8,10,12 and 14 khz. Eise fall time 0.2ms Plateau 1.6ms Int: variable Masking Contra laterally at 20 dB less than the click	Double channel/ mastoids/vertex/ forehead	Significant shifts in response latency occured as a function of stimulus intensity for all tone burst frequencies. For each 10 dB shift in intensity, latency shifts for waves I and V. LIFs for high frequency tone burst evoked ABRs suggest the degree of response latency change that light be expected frot the hearing loss	more research is needed in this area to understand the effects of these NF stiiuli on cotpromised auditory system. They have been taken only adult group. lore age range should be included for study.

1.	2.	3.	4.	5.	6.	7.	8.
						due to ototoxic insult.	
28	Foxe, J.J., et al (1993)	The purpose of the present study WAS to investigate the normal effects on the ABE to BC tones of subjects.	14 19-33 yrs N 21 2weeks to 13 mths N	Tone bursts of 500 and 2000 hz Rate:39.1/sec Rise fall time (500 hz) 4-2-4 msec 2000 hz 1-0.5-1 Int: 45 dB nHL (500hz) 60 dB nHL (2000 hz) No masking	Single channel/ ipsilateral mastoid/ vertex/forehead	Infant ABR thresholds for 500 hz BC tones are significantly lower than their threshold to 2000hz BC tones. Infant wave V latencis to 500 hz BC tones are significantly shorter than those of adults, whereas infant and adult responses to 2000 hz BC tones are similar in latency, suggesting that the effective intensity of the BC tones tay be 9 to 17 dB greater for infants than for adults.	Such studies should include investigations of the effects of bone oscillator placement and stimulus frequency on the amplitude and temporal characteristics of BC stimuli in infants and adults heads, and their effects on ABR threshold and the ipsilateral and contralateral asymetries.
29	Hall, I.J., et al (1993)	The study investigated the tasking level difference (MLB) and ABEs in a group of children with a history of otitis media with effusion	13 8M 5F 5.7-8.3 yrs N 14 9m 5F 5.2-9.2 yrs OHL	R click lo.2000 Rate: 21/sec Int: 80 dB HL Masking 3000 hz white band noise at 60 dB (contra)	Single channel/ ipsilateral ear lobe lidline forehead/ contralateral lobe	Results indicated that the group of children having a history of OKI had significantly reduced HLDs and had significantly prolonged waves III and V, III and I-V interwave latency. The reduction in MLS found in children having a history of ONE may be related to abnormal brain stet processing.	Other age groups should be included for good generalization.
30	Katbamna B., et al (1993)	The study documented the effects of hyper thermia on the A1B evoked in response to past and slow stimulation rates in lice, to evaluate its effectiveness in	6 (nice) 11 week old N	Click No.l024 for slow rate and 2041 for fast rate Rate: 21.1 and 61.1/sec No Masking	Not mentioned	The latencies and amplitudes of waves I - 7 were measured temperature elevation between and 37 and 41^{0}C shortened the latencies of all the ABRs the effects	Sample size is small This study is done on lice so generalization of these results to human

1.	2.	3.			4.	5.	6.	7.	8.
		Monitoring, brain stem and CIS status.						being linear and accumulative across the time window. At 41 and 42°C latencies of ail the waves stabilised or showed minimal prolongation	population will not be very good.
31	Kidd,G et al (l993)	The purpose of this study us to determine whether the BAER could be detected auditorily rather than through ususal or automatic techniques, and it so, to enhance the auditory detection performance.	10	Adults 19-26 yrs	N	Clicks		BAER when extended in duration and used to frequency modulate a 1000 hz pure tone, was highly detecable in a yes-no paradigm for BAERs elicted with high level acoustic clicks. Performance declined to near chance as the level of the BAER eliciting stimulus was lowered to 10 dB. Detection performance for stimuli presented visually was slightly, but consistently superior to that which occurred for stimuli presented auditorily comments.	Number of subjects taken are very less. Other ages ranges should also be studied.
32	Light Foot,G.S: (1993)	To investigate the effect of age, sex hearing loss and stimulus intensity on ABR V latency	189 95M 94F	13-81 yrs	Co* Ph*	R&C clicks No.2000 Rate: 11.1 /sec Int: 80 and 105 dB nHL Masking White noise (contra)	Single channel mastoid/vertex/ forehead	All four factors exert a significant influence on latency and hearing loss and intensity were most effectively represented when combined to form a sensation level valuable together with a audiogram slope.	Diagnosis should be made carefully taking all these aspects into consideration to make ABR as a reliable diagnostic tool. It requires a control group also.

Co* = Cochlear Ph* = Pathology

1.	2.	3.			4.	5.	6.	7.	8.
33	Lauter, J.L, et al (1993)	The study examines the stability of auditory brain stem responses peak amplitude of children with adults	7 4M 4F 7 M	5-7 yrs 10-12 yrs	N N	Clicks No. 2000 Bate:11.4-23/ sec Int: SOdB nHL Filter settingr 150-3000 hz No tasking	Two channel/A_1A_2/ vertex/forehead	Data from both groups reveal differences in both amplitude and latency stability for diffrent peaks and for ear conditions that provide additional evidence for developmental changes in brainstem.	This study does not tell upto which age these changes eas be observed. Should examine the degree to which ABE peak aiplitude stability can reveal additional evidence of iuaturity in ABR.
34	Ponton, C.W., et al (1993)	To determine if head size light contribute to increased interpeak latency variability among infants, ABR data were normalized based on head circumference.	95 (inf) 10	29-42 yrs Adults	F.T and Pre N	Clicks No.1000 .Rate:11.9/se Int: SOdB nHL Polarity condensation No masking	Single channel/ vertex/mastoid/ forehead	Data from this study indicate that clinical accuracy of ABR data will not be improved by "correcting" infant latencies for differences in bead size. Inaccurate estimation of gestational age at the time of birth may contribute significantly more than head size to interpeak latency, variability, particularly in preterit populations. However the change in the relationship between head circuaference and ABE interpeak measurements eay be explained by differential patterns of myelination and synaptic development in the auditory nerve and brainstea auditory pathway.	Number taken in two groups should be saae as far good generalization is repired. Adult sample is very stall. Pathological sample should also be included.

F.T. = Full Term Pre. = Premature

1.	2.	3.			4.	S.	6.	7.	8.
35	Pratt,H et al (1993)	Two computational procedures that don't rely on Manual evaluation are discussed i) for peak identification on and measurement ii) for clustering evoked potentials according to thier wave form	120 M	21-68 yrs	N	Clicks No.2000 Rate:10/sec Int:75dB nHL Polarity alternating No tasking	Single channel/ vertex/ipsilateral mastoid/contra- lateral nstoid	The results of computerized peak identification and measurement without uses intervention, were correlated with manual measurements of the sue peaks in a large number of wave forms. The wave form analysis and classification procedure differentiated wave foris to Monaural left, monoaural right and binaural stimulation as well as according to recording montage. The automated alogrithm for evaluation of ABEP by wave form hold the promise of a more comprehensive consistent evaluation and hence improved sensitivity.	Pathological group should also be studied for better generalization.
33	Rupa,V et al (1993)	Study the combined effects of age, sex and cochlear heairng loss on ABRs	69 45K 19F 37M 21F	20-78 yrs -	Coh. N	Click No:1024 or 2048 Rate:11.1/sec Int: 90dB nHl Polarity ratefaction No masking	Single channel/ ear lobe/vertex/ high forehead	Among normals, wave V latency increases with age. Latencies in females shorter than males. In patients with hearing loss, wave V latency increases was determined largely by the degree of heairng loss and the effect of age was moderate. Influence of sex was minimal.	In cochlear hearing group female sample is small, so for good comparisons, sample size should be balanced.

Cob. = Cochlear Hearing Loss

34	Thodic,O et al (1993)	Binaural interaction (BI) wave forms were derived from tultichannel	7M 7F	22-33 yrs	N	Clicks No.2500 Rate:ll.l/sec Int: 65 and 85	Three channels/ (Fz-Nl-II-I) (Ipsilateral) Contralateral	The component latencies of all the BI responses derived from contra lateral channel were	Sample size is small. Various path groups should

1.	2.	3.	4.			5.	6.	7.	8.
		recordings of ABRs obtained at moperate and high intensity levels.				dB nHL No tasking	(Fz-Mc) (I) and (Fz as ground)	significantly prolonged as compared with ipsilateral aad non-cephalic channels. Differences identified only at moderate intensity levels. Amplitudes are sot significantly different for different recordings. The findings indicate that ipsilateral, contralateral or non-cephalic recoridngs can be used to study BI. But channel differences on simultaneous multichannel recordings lay facilitate seggregation of true neural inter- action from stimalus interaction.	also be studied for good validation of results.
35	Thorton, A.R., at al (1993)	The effects on ABRs amplitude and latency of using MLSs and conventional ABR	10	-	I	Clicks Sate:9.1/sec and MLS 67-1000/sec Int: 80dB nHL and 40dB SL Polarity rarefaction Masking White noise at 40dB SL (contra)	Single channel/ vertex/tastoid/ forehead	Results show that the optimum stimulation rate appears to be order of 200 clicks and thus can give a speed improvement by a factor of approx. 2.8 over conventional recording at 9 or 10 clicks/sec. Adaption is less.	Sample size is small. Pathological group should also be studied.

MLSs = Maximum Length Sequences

1.	2.	3.	4.			5.	6.	7.	8.
36	Beattie, R.C., et al (1994)	This study investigated the effects of signal to noise ratio (S/N) on the latency and amplitude of the auditory brain stem	F15	18-25 yrs	I	Tone bursts of 0.5 and 2 khz No:3000 -band 7000 preferred Eate:25.6/sec Int: 80dB nHL	Single channel/ neck/vertex/neck	At moderate and high intensities high pass/ notch noise or broad band noise is preferred to the quite condition because of the	Validation of these recommendations is required by testiig hearing impaired subjects having

1.	2.	3.	4.	5.	6.	7.	8.
		response (wave f) using 0.5 and 2 khz tone bursts in high pass/notch noise broad band noise. Normal listeners weret presented with 40 & SO dB nHL tone burst is quite and in noise at SN/s of 10,15,20 and 25 dB.		Polarity frequency rarefaction and condensation Masking Broad band noise at l06 dB SPL for 0.5khz (Ipsilateral) 100 dB nSPL for 2khz (ipsi) Rise fall time 1-1-1		improved frequency specificity provided by the tasking, And because the,former provided larger wave V amplitude to 0.5 and 2 khz tone burst at 80 dB nHL. Wave V amplitudes to the 40 dB nHL tone bursts suggest that testing in quite may be preferred to testing in noise when 0.5 and 2 khz tone bursts are presented at low levels.	various degrees of hearing loss and audiometric configurations. Sample size is very smal
37	Brown, C.J., et al (1994)	EABEs were measured in patients with the nucleus cochlear plant. Difference between intra and postoperative EABR threshold was examined.	*26* 12A 14 Chi. 22mths. to 13 yrs P.L deaf Pr.L deaf	RF bursts late: 20hz biphasic current pulses at 250/sec duration 500as Int:varying No Basking	Single channel/ vertex/contra-lateral mastoid/ forehead	EABR thresholds were strongly correlated with both T and C levels. In subjects where both intra-operative and post-implant EABE measures were obtained, intra-operative EABR were higher than post implant thresholds (consistent). So it is useful in very young, developmentally delayed and disabled. T - Threshold level C - Comfortable level	Sample size should be large for good generalization. Various age groups should be included.
38	Burkard,R et al (1994)	This study evaluated the feasibility of obtaining constant quality BAERs in less time than is possible with conventional averaging technique with MLS technique	10F gerb-ils 3 mths. -	Pulse trains with HPIs 1, 2, 4 4 6 msec Int. 50, 60, 70, 80 & 90dB SPL No tasking.	Single channel grass needle elect-rodes/left ear/lid line of the skull/ midline of the back	With increasing click level there were decrease in peak latencies and increases in peak amplitudes. Kith increasing rate, there were increases in peak latencies, increases in the I-IV internal, aad decreases in peak amplitudes.	More research is required for good generalization. Studies on human subjects are required. Saiple size of animals taken in this study is very stall.

1.	2.	3.	4.	5,	6.	7.	«.
						It has been demonstrated that BAERs can be obtained to MLS MPIs as short as las which represents an average rate of stitulation roughly 500/sec. This is appreciably faster rate than is possible with conventional averaging. Thus this technique nay prove useful in characterizing adaptation in the auditory systems approaching the absolute refractory period of auditory neurons. This lay prove useful in improving the sensitivity of the BAER in identification of denyelination in the auditory brain stem.	

1.	2.	3.	4,			5.	6.	7.	8.
39	Lina Granade,8 et al (1994)	ABfis were recorded using pseudo-random pulse trains called Max. length sequences and were compared to ABES obtained by conventional averaging	29 10N 10F 3 17 13M 4F	20-33 33,35 and 22 yrs 22-67 yrs	N Uni. Deaf S.8	Psaedo random Pulsetrains 32 pulses per train 5120 clicks Rate:20/sec for conventional ABR Binaural HLS-ABS at 98 clicks/sec Int80-lOOdB nHL no tasking	Single channel cup electrodes/ipsilateral earlobe/forehead/contralateral lobe For MLS - ABRs fourth electrode was placed on the nape as ground	In normals, ABRs by NLS produce the sate waves as conventiional ABRs although wave latencies increased and amplitude decreased. In SH ears, MLS-ABRs threshold were similar to common ABRs and correlated with high frequency audiometric thresholds. Binaural MLS-ABE recoridng represent the individual response at each ear as in monaural deaf.	More time saving, but wave characteristics across stimulus levels and threshold evaluation would have to be studied as these rates, if it is to be used in clinical practise.
				M.A.					
40	Sand,T et al (1994)	ABR amplitude behaviour to condensation (c) and rerefaction (r) clicks was investigated in normal ears, ears with meinere's disease and ears with HF hearing loss	9 8 8	45yrs 55yrs 57yrs	1 M*	C&R clicks No:1500, Rate:10/sec Int.67dB DHL (C) & 75dB nHL (R) No masking	Single channel NI: vertex	lean ABE amplitude were highest in the normally hearing group. The wave IV-V amplitude intensity function was steeper in ABRs evoked by E than by C clicks. So two different cochlear generator components, one intensity dependent and other polarity dependent, contribute to click evoked ARBs. Rave IV-V amplitude was significantly hiher in Meniere's ears compared to the HF ears. Hence, audio metric steepness seems to predict the wave IV-V amplitude decline more precisely. Wave IV-V dispersion variables was close to normal in	The correlation between CR amplitude difference and audioietric steepness is only moderate. So it would not be possible to predict an individual audioietric pattern from ABE C-R amplitude differneces. More research is needed. lumber of subjects should be more for good generalization.

1.	2.	3.	4.	S.	6.	7.	i.
			M* Meniere's disease			Heniere ears, while wave IV-7 was in dispersed is EF ears. C-click ABRs were less affected than R click ABIt by 'peripheral' factors.	
41	Bankactis, A.E., et al (1995)	Study investigated effects of click rate on the latencies of the ABRs is subjects with varying degrees of HIV infection	13 13-45 yrs Aids 9 HIV with aids 9 HIV -ve	Broad Band clicks No:1000 & 2000 Rate:21.1/sec and 61.1/sec Int. 85dB nHL No Basking	Single channel/Al, A2/ FZ/right shoulder	Statistically significant delays in wave V latency utilizing both click rates occured for the aids groups only. A comparison of wave V latency group leans as a function of click rate showed an apparent trend for faster click rate to induce a more exaggerated prolongation in the laency of wave V for HIV infected group that may be indicative of easy neurological involvement in asymptomatic patients.	For better generalization, the study should include more subjects.
42	Deltenre, P., et al (1995)	The rare faction condensation differential potential obtained by subtracting brain stet auditory evoked potentials to clicks (C) from those of t clicks is studied	32 12M 20F 10-37 yrs N 31 UN 20F 2-(8 yrs Coch*	R&C clicks Rate:21.7/sec Int.0-lOOdB nHl in 5dB steps. masking white noise at 40dB (Contra).	Single channel/ipsi-lateral earlobe/vertex /forehead	In normals no RCDP was recorded along the lower 30-55 d8 of the latency-intensity function, thus defining pre RCDP range. The pre RCDP range was always abolished in losses masking BAEPs from lower (< 1khz) tono-topic regions. When the BAEP origniated from higher (> 1khs) tonotopic regions, the pre RCDP range was either reduced or abolished. These results led to a	Lengthy procedure, promising diagnostic information. Small sample size.

1.	2.	3.			4.	5.	6.	7.	8.
					Coch* Cochlear hearing loss			working hypothesis based on single unit. (RCDP rarefaction - condensation differential potential).	
43	Fausti, S.A., et al (1995)	The latency intensity functions of ABRs elicited by high frequency (8,16,12,14 khz) TB* stimuli were evaluated in cases with SI hearing loss TB* Tone Burst	20 1F 19M	24-15 yrs	SN Hg. loss	Tone burst 8, 10, 12, 14kHz Rise fall time 25-58msec Int:70dB nHL - 120dB nHL no tasking	Not mentioned	This study demonstrates that tone bursts at 8,10,12 khz evoked ABEs which decreases in latency as a function of increasing intensity and that the LIFs were consistent and orderly. These results will contribute infrotation to facilitate the establishment of change criteria used to predict change in hearing during treatment with ototoxic drugs.	The study did not talk about age and sex differences. Sample taken in stall and male and female number is not balanced.
44	Lasky,R,E et al (1995)	The traditional binaural interaction (BI) paradigm and a maximum length sequence (MLS). BI paradigi were evaluated to investigate BI effects M.A* Mean Age	11 3M 8F	M.A* 21.9 yrs.	N	100 usec pulses, Rate:99/sec and 10/sec Int. 90dB SPL no tasking	Double channel/tastoids/vertex/forehead	MLS BI kernels ean be recorded in normal hearing subjecta. The MLS BI paradigi offers 3 potential advantages in recording binaural effects: avoidance of some of the methodological problems associated with tradition BI paradigi. Faster stimulus rates permitting a lore complete characterization of binural rate effects. More rapid data collection.	More studies are needed in this area for good generalization.

1.	2.	3.			4.	5.	6.	7.	8.
45	Mark,S et al (1995)	This study was conducted to investigate morphologic changes in the ABR as a result of reversing the stimulus polarity of frequency limited single cycle stimuli in normal hearing subjects	16 3M 13F	19-29 yrs	N 3,	digitally synthesized single cycle sinusoids with peak energy at 300, kHz and 3kHz Sate:33/sec rise times l.OOOmsee, 0.605msec, and 0.158msec No.1024 Int.60&40dB nHL no tasking	Single channel/ipsi-lateral mastoid/mid-line of forehead/ contralateral mastoid.	The results clearly demonstrate that large latency differences occur between condensation and rarefaction stimuli for low frequency stiiuli. It is believed that polairty specific latencies are the result of the highly phase sensitive neural elements tuned to low frequency stimuli. C-R latency difference were found lore at 80 dB as compared to 100 dB. Intersubject variability for R-C at 80 dB produce tore differences. Considering the large C-R differences expected in high frequency SI hearing loss or under any circuastances When using low frequency stiiuli, summation of alternating polarity stiiuli in clinical application is not recommended. Accumulation of alternating stiiuli under these circuistances loved degrade the response as latency shifted responses are averaged together. The use of single polarity stiiuli or separate averages for each polarity condition is warranted.	Sample size should be large for good generalization. Cases with various tyupes of hearing losses should be included.

1.	2.	3.			4.	5.	6.	7.	8.
46	Muchnik,C et al (1995)	The present study was designed: (1) to describe clinical observation regarding the characteristics of BC-ABR in normals (2) to study how conductive HL due to ME* affects AC and BC ABB in children. NRE* Middle Ear Effusion	75 10 11 11	20-37 yrs 5.S-8 yrs 5-18	I MEE 1 Sus pec ted NEE	Click Ho.1024 Rate:31/sec Int.70dB SPL Pol:alternat-ing, no MASking	Single channerl/vert-ex/ipsilateral ear-lobe/contralateral ear lobe	In AC-ABR, the lean latency of wave ¥ was significantly prolonged, as compaed to that of BC-ABR in children with confirmed NEE and infants with suspected NEE. By combining AC and BCABB lore information concerning cochlear reserve status can be confined in infants and young children.	Synamic range of stimuli intensity in BC-ABR is narrow due to the low intensity that can be aehieved by way of the bone oscillator. BC-ABI in different is clinical practise because of the need of centralateral masking and presence of a stimulus artifact as a result of electromagnetic energy from the bone vibrator. In this study the comparison group taken is not homogeneous (with respect to age and number) it can affect results. Numbeer of sample (pathological group) is small.
47	Prasher,D et al (1995)	The study examined the influence of increasing stimulus repetition rate on the ipsi/contra latency difference	20 10F 10M	23-61 yrs	N	Click Rate:10/sec 40/sec Int.9OdB nHL Pol.alternat-ing, masking white noise at 60dB nHl (Contra)	Two channel/vertex & contralateral mastoid /ipsilateral mastoid/ forehead	There is a progressive increase in latency from wave I to wave V ipsilateraly with an increase in stimulus rate. However contralaterally there is no further increase in latency after wave III. With a 90 hz stimulus	Saiple size is small which haapers in the process of good. generalization. Validation of these results required other pathological group with various types of hearing

1.	2.	3.	4.	5.	6.	7.	3.
						rate, the ipsi/contra difference in the latency of wave V disappears, suggesting that there is a differential effect of peripheral and adaptation on the central ipsi and contralateral auditor; pathways.	losses.
48	Sullivan, M., et al (1995)	Estimation of the residual noise in the auditory brain stem waveform is studied	14 33-52 mis N	Click No.4000 iate:24.4/sec Pol.Rarifac- tion Int.65dB SPL no masking	Double channel/mast- oids/vertex/back of the neck.	LOW frequency noise components which contribute to the observed auto correlation could be reduced by using a high pass filter to the data before averaging. Correlated lean sum of spares estimate SRC and the block average estimate RNBM both have significantly less bias than the usual estimate RHnss. Since termination of the test is dependent on the signal detection alogrithm, increased time is a consequence.	Sample size is small. Only infants are studied which hampers generalization to other age groups. Various pathological groups with various hearing losses should be included for good generalization.

CHAPTER - II

ABR in Pediatric Group

CHAPTER - II

All II PEDIATRIC GROUP

Sl. No.	Author/ year	Purpose of the stud;	Subject No	Age	Variable N/abn	Stimulus Variables	Electrode montage Type/Inverting/ Ion-inverting/ Ground	Results	Reiarks
1.	2.	3.			4.	5.	6.	7.	8.
1	Durieux, S.P., et al (1991)	Comparison of ABR in infants to those obtained on the same children with pure tone and comentery at 3 years of age (Longitudinal study)	333	-	-	Click Rate:61/sec and 11/sec Int. 30-95 dB nHL Pol.Barefa-ction, F.S* 25-300082 masking white noise	Single channel/fore-head/ipsilateral mastoid/contralateral mastoid.	BERA is a powerful tool in the evaluation of auditory function in high risk membranes elemated BERA thresholds in infancy need to be interpreted with respect totype of hearing loss. Frequency specific BERA lay become important In 89% BERA results accurately predicted the heairng status at the age of 3. BERA results in infancy predict normal heairng in the 2000-1000 frequency area. Since adventitious conductine or SN hearing losses lay occur after BERA testing, normal BERA testing results in infantry don't guarantee normal heairng later in life.	Conductive hearing losses are a particular problem for taking comparisens across different ages, since they fluctuate a great deal. So predictive value of ABE can decrease.
2	Edward, Y.Y., et al (i»91)	The effect of vibrator of head coupling force on the auditory brain sem response (ABB) to bone conducted clicks in new born infants were tested	20	38-42 yrs	N	Click 56.7/sec alternating Pol. Filter Setting 30-3000Hz Int.15&30dB nHL no tasking	Single channel/left post auricular area/ high forehead/post auricular area	ABRs to bone conducted clicks were obtained with vibrator to head coupling forces at 225,325,425 and 525g. The results of this study indicated that ABR wave V latencies to bone conducted clicks in new born	Clinical implication of bone conducted clicks in new born infants is very The vibrator is often displaced from underneath the flauid

1.	2.	3.	4.	5.	8.	7.	8.
						infants were affected significantly when the vibrator to head coupling force shift exceeded 280g, It is recommended that the coupling force controlled and retain consistent when implementing ABR to bone conducted stimuli in new born infants.	elastic band when the baby move his/her and the practise of holding the vibrator by hand, as a means of vibrator to head coupling is not encouraged, because of dampened stimulus output from the bone vibrator.
3	Hyde,N.L et al (1991)	Click ABE wave V threshold in the first year sere compared with follow up behavioural pure tone audiometry under earphones at age 3 to 6 years in 713 infants (Longitudinal study)	713 Infants and follow up at 3-Syrs At risk for HG Loss	Clicks 21/sec Int.75-95dB nHL	Electrode darivation forehead to ipsila-teral mastoid	The click ABE provides an accurate test, with both false posture and false negatives rates of less than 10% using an ABB threshold criteria of 3D dB nBL. The false posttime error rate can be at-least halved by using a simple rule for wave V latency that descriminates conductive and sensorineural ABE threshold abnormalities. False negative errors nay be explicable in terns of the frequency specificity of the click stiiulus.	Still there is no clear consensus regarding exactly what should be the target disorder for clinical programs for early identifi-cation of hearing loss.

1.	2.	3.			4.	5.	6.	7.	8.
4	Johnson, E.S., et al (1991)	This study investigated spectral differences for auditor; brain stem response. Click measured ABRs in infants and adult ear canals. (differences is ABB for adults and infants)	11 15	3no-6m 20-40 yrs	N N	Click 21.3/sec alternating polarity Int.30&60dB nHL	Not mentioned	Results indicate that click stimuli such as those used for ABR testing resonate in infants and adult ar differently, and that the resonance in infants is much tore valuable than the resonance of adults. So there is no ned to use infant norms when screening infant hearing using ABR.	Additional study into the causes of the difference and its implications is warranted. Knowledge of these differences is essential for appropriate ABB interpretation.
S	Bowe,S.J et al (1991)	Effectiveness of ABR as a tool to detect hearing loss in infants	243	48weeks	-	Click No.2048 Rate:20/sec alternating Pol. filtersetting 3-3000HZ Int.50, 60, 70dB nHL	Single channel/cont-lateral mastoid/ips-ilateral aastoid/ forehead.	Delaying screening until the post neonatal stage is only alternative to screening neonates prior to discharge from the SIBU because of increased chance of detecting progressive heairng impairement. False positive rate can be reduced by delaying screening.	For more accuracy, in infants ABR testing should be repeated after 3 or 4 months.
6	Bansal,R et al (1992)	Too high risk neonates and infants were subjected to BOA and BE8A. Importance of BERA in screening is highlighted	25 300	1-12 mths. 0-12 mths.	N high risk	Click 28/sec Int.30dB nHL and 42dB nHL	Two channel/mastoids /vertex/forehead	BERA shoved 20% mild, 4% Moderate and 2% severe hearing loss on screening and 13.9% mild, 2.7% moderate, 1,34* severe hearing loss on follow up, results on screening and follow up respectively. False negative results of BOA - It was 26% in screening and 16% on follow up. ABR hearing threshold - determined using T wave criteria and was decreasing with increasing age.	...

1.	2.	3.			4.	5.	6.	7.	8.
7	Bergman, B.M., et al (1992)	An examination of factors affecting the use of ABR in identifying and quantifying hearing loss and in selecting hearing aid characteristics	1	Child	High Freq. hg loss	Clicks and tone burst 250 and SOS Hz. Int.70dB for Clicks and 75dB nHL for tone burst	Not mentioned	ABR can be used to provide frequency specific estimates of hearing loss. ABE threshold estitates can be entered into a hearing and selection program such as the DSL to obtain target values. An infant's auditory status should be monitored with repeated ABR or behavioural tests, depending on age and developmental level. This is necessity until the degree and configuration of the child's hearing loss is clearly established. The perfortance of aaplification assessed using aided ABRs is not recommended, because confounding technical factors. Because the relation ship between wave V amplitude of latency and loudness apparently is sufficiently resolved, so it is not recommended for selecting output limiting characteristics.	Only one subject has been studied in this study. For good generalization number of subjects should be more.
8	Lauter, J.L., et al (1992)	To study latency stability of ABRs	9 M	10-12 yrs	H	Clicks So:2000 Rate: l1/s & 23/s Int: 80dB ṁL Pol:Conden-sation No tasking	Two channel/ mastoids/vertex/ forehead	Children show the expected similarities with adults in terms of ABR peak latencies Individual differences Within subject distinction according to ear of stimulation Instances of good	Subject number taken is very less. No male, female distinction is taken.

1.	2.	3.		4.		5.	6.	7.	8.
								replicability of latency profiles.	
9	Spivak, L.G., et al (1993)	Primary objective of this study is (1) to exmine the spectral composition of Alls recorded from normal full term neonates (2) compare the new born ABR spectrum with the adult ABR spectrum	20 10	1-5 days Adults	N N	Clicks Rate:22.1/s Int: 70 S 35dBnHL F.S: 30 - 3000 Hz no Nasking	Single channel/ ipsilateral mastoid/ high forehead/ cheek or contralateral mastoid	Results indicated that significant amounts of low frequency information are concentrated below 150 hz in both the neonate and the adult ABRs although the neonate ABR has a slightly greater percentage of low frequency information than that of adults. This has implications for filtering duirng ABR recordings. Use of a 30-3000 hz band pass is feasible in the neonatal intensive care unit which allow enhanced detectibility of wave V in infant ABRs recorded at low stimulus intensity.	The results of this study have important implications for filtering during recording of AB1 peaks, filter new boras as well as adults. In order to optimize detectibility of ABR peaks, filter setting must be carefully chosen to ensure preservation of the main spectral energy contributing to response.
10	Katbamna, B., et al (1995)	This stud; compares ipsi, contra, horizontal and non-cephalic ABRs obtained from normal infants to assess their utility in neurodiagnosis. Wave latencies aaplitudes and waveform Morphology were evaluated at slow and fast repetition rates	16 8M 8F	39-42 weeks (post concep-tional age)	N	Click No: 2000 - 4000 Rate: 11.1/3 & 61.6/s Int:70dBnHL Pol: Rare-faction No masking	Single channel/ Ipsilateral (z-Az) NI-I Contralateral (Fz-Ac) Norimontal (Ac-A1) Noncephalic Fz, nape of the neck F_{1z}: serving as ground electrode	Ipsilateral and horizontal recordings obtained with a fast repetition rate provide best waveform characteristics for neuro diagnostic interpretation. Enhancement of wave V amplitude and separation of IV-V wave complex may be achieved by using the non-cephalic recording montage. Compromised or low amplitude components on contralateral measurement may confound neurological interpretation.	Sample size is small because for proper generalization sample size should be large. Infants with othre types of hearing loss should also be included in the study for good generalization.

1.	2.	3.			4.	5.	6.	7.	8.
11	Sininger, T.S., et al (1995)	Filtering at electrode recorded activity before averaging is used in evoked potential measurements to reduce back ground noise	24 10M 14F	35-42 weeks	N	Broad band clicks Pol: Rare-faction Int: 15 & 30dBnHL Tone bursts at 500 Hz Int: 40 & 60dBnHL Masking 707 Hz High pass filtered noise	Two channel/ vertex/mastoids/ forehead	Results indicate that 1) energy in the infant ABB is concentrated below 100hz and 2) a high pass recording filter of 30hz reveals a large amplitude ABE and enhances the overall signal to noise ratio as measured by FSP as compared to a 100hz high pass.	The infants in this study were sleeping. Changes in sleep state or arousal level would produce changes in the spectrum of background noise. So the results of this study lay not generalize to infants evaluated in states of higher arousal.
12	Stapells, R.D., et al (1995)	To assess the accuracy of threshold estimation, determined using the ABrs to brief tones presented in notched noise in a group of infants and young children with normal hearing and SNHL	34 54	lwk-8 yrs	N SNHL	Tone bursts 500, 2000, 4000 Hz Rate:39.1/s No: 2046 Tone cycle (2-1-2) F.S: 30 - 3000 Hz Int: 26 & 29dBnHL Masking Notched noise (contra).	Single channel/ ipsilateral mastoid/ vertex/forehead	ABSs can be a good diagnostic tool if diagnosis is made carefully keeping in mind all other variables which can affect ABR results.	92-100%, infants with normal hearing showed ABRs to 30dBnHL tones. High correlation between ABRs and Behavioural responses for both groups.

CHAPTER - III

Clinical Application of ABR

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Sl. No.	Author/ Year	Purpose of the study	Subject lo	Age	Variable l/abn	Stimulus Variables	Electrode aontage Type/Inverting/ Ion-inverting/ Ground	Results	Reaarks
1.	2.	3.			4.	5.	6.	7.	8.
1	Fuse,T., (1991)	ABR changes in two cases with braiastem ischemia are reported. In order to clarify the correlation between ABE changes and cochlear blood flow, experimental studies on guinea pigs with brain ischemia were performed	14F 14M 14	56yrs 62yrs	f* Int* Imd*	Click No:1924 Rate: 30/s Int: 90dBnHL Pol: Alternating F.S: 320 - 1500 Hz No masking	Single channel/ Left pinna/vertex/ roof of tail.	Changes of ABB in human brain stem ischeaic condition consisted of a decrease of the aaplitudes of all waves and a delay in wave latencies. Even if ABR showed no response, it turned to normal when the blood flow was recovered. In experimental condition sue pattern was observed which suggest that ABR change reflect the degree of schemia in the auditory pathway, and that non-response ABE does not imply irreversible ischemic condition.	More cases should be studied for good generalization.

V* = Vertigo and right vertebral artry injury Int* = Intra classial verteberal artry stenosis, Imd* = Induced condition

Sl. No.	Author/ Year	Purpose of the study	Subject lo	Age	Variable l/abn	Stimulus Variables	Electrode aontage Type/Inverting/ Ion-inverting/ Ground	Results	Reaarks
2	Nunnerley G.N., et al (1991)	Frequency specific auditory brainstem relationship to behavioural threshold in cochlear impared adults were studied.	50 16F 14M	25-64 Yrs.	Hg. Imp air ed	Tone pip of 500, t,2i4kHz Cycle 4-2-4 2-1-2 1-1-1 1-1-lasec Int.40dB SL Masking. white noise (contra).	Single channel/vertex /ipsilateral ear lobe /contralateral ear lobe.	A strong positive relationships was found between ABE and behavioural threshold elevation. Absolute ABE thresholds at 500hz were significantly higher than those at other frequencies.	As reported in this study, even with aany repeats at a given intensity, ABE thresholds are difficult to judge due to low response amplitude and poor response clarity. This

1.	2.	3.	4.			5.	6.	7.	8.
									could be a drawback of this study. In addition, it retains to be sen whether modifications of stimulus parameters, recording technique threshold determination procedures affect the result or not.
3	Prosser,S et al (1993)	The aim of this study was to investigate whether or not the Alls of acoustic neuron (AH) cases could reflect the cotbinated effects of cochlear and neural impairement	20 280 153M 127F 85 IS 8F 3M	11-74 yrs 21-72 yrs 22-26 yrs	I Coc* AN* CP*	Click No:2000 Int:90-100dB nHL (N) 90dB nHL (AN, Ch) Pol.alternat-ing masking white noise at SOdB SPL (Contra).	Single channel/Mastoid /vertex/forehead	Cochlear and letro-cochlear lesions lay be differentiated by a diagnotic index (D5) which is derived froa the patients auditory brainstem wave ? latency and pure tune hearing loss at 2-4 khz. Results indicating a lesser prolongation of wave V latency in cases with pronounced hearing loss. Assuaing this finding is indicative of some degree of cochlear impaireient conconitant to the neural dysfunction.	As mentioned, cases could reflect the combined effects of cochlear aad neuro impairment, so while interpreting ABr results, proper care should be taken.
4	Wilson,D et al (1992)	To see the accuracy and role of ABR in the diaposis of acoustic neuromas	51		AN*	Clicks Sate:13.3/sec 53.3/sec Int.8OdB nHL	Single channel/vertex/ ipsilateral earlobe/ contralateral earlobe.	85% had abnorul ABRs. Tuaor size and nerve of origin were important factors affecting the ABR sensitivity. The ABR was less sensitive in detecting intracanalicular tumors than in detecting extracanalicular tuiors.	For more reliability ABR testisg should be repeated after a few months interval.

Coc* Cochlear hearing loss

AN* Acoustic neuroia
CP* CP angle tumour other than AN

1.	2.	3.			4.	5.	6.	7.	8.
5	Janssen, E.A. et. al., (1993)	The purpose of the study was to assess the conductive loss component (CLC) by braiastem electric response to a conventional air conducted click stimulus	21	Adults	N	Click Rate:20/sec Int.34dB pe SPL. Pol.alternat-ing. masking white noise al 23dB SPL (contra).	Two channel/vertex/ mastoid (ipsi)/fore-head.	The difference between the level of the click and the noise is defined as the masked threshold (1TII) to noise ratio. This was MTNR=-13+5 The increase in NTNR compared to normmative value is a measure of the CLC Increase in MTER is in good agreement with results of conventional pure tone and brainstet electric response audiotetry.	Sample size is small. Should include pathological group. This procedure is limited to detect CLCs in ears with cochlear loss components upto 50-55 dB because above that dispersion problets of bone conductor take results wrong.
6	likitori-dis.G.C, et al (1993)	This study compares the ABRs of 30 patients with active vitiligo (systematic disease) and SO healthy human subjects in order to detect possible subclinical abnormalities of the auditory system in this disorder	30 19F 11M 50 30F 20M	23-37 yrs 20-42 yrs	Vit-ligo N	Clicks No:2000 Rate:ll.l/sec Int.70dB SL Pol.rarefac-tion. no masking.	Two channel/both mast-oids/vertex/frontal location midway betw-een the nasion and the vetex.	Significant decrease if the interpeak latency and significant increase of the I-III inter-peak latency in the patients as compared to control group. The decrease tay be due to a numerical decrease of active telanocytes in the inner ear which results in an impairment of the ion exchange between the endo lymph and perilytph. The increase in latency (I-III) may be due to an abnormal synaptic activity and transtission of the action potential frot and nerve to superior olive.	For proper validation of results, tore studies are required, Degree of hearing loss has not been mentioned (presence).
7	Aubert, L.R., et al (1994)	The study investigated EAB8 test reliability in relation to pulse	8	10-50 yrs	Fit-ted with Coch.	Tone pulse at 10-500 Hz No.1200 F.S:10-2000Hz	Single channel/contra-lateral mastoid/vertex /low forehead	Very high correlation between EABR threshold and psychophysical threshold for the same	If EABE is to be used as a tool for setting the

1.	2.	3.	4.	5.	6.	7.	8.
		rate and evaluated the relationship between the low public rate EABR threshold and the high pulse rate thresholds used in mapping of Multi-channel cochlear implants	imp-lant			pulse rate. Poorer correlation between the low pulse rate EABR. Threshold and the high pulse rate psychophysice threshold.	electrodes of an implant patient. caution, should be excused and the appropriate correlation formula appropriately.
8	Yamada,K et al (1994)	ABRs recorded in low rates with total spinal anesthesia induced by injection into the subarachnoid space through skull.	10 Anest-hesia induc-ed	Click No:1024 Rate:10/sec Pol:alterna-ing Int.110dB SPL masking white noise at 70dB SPL (contra)	Single channel/vertex/ right mastoid/neck	The disappearance started with the later waves of ABR with injection. After cessation of the injection the ABR reappeared and recovered progressively from wave I to IV. The effect of lidocains on ABR was reversible and extended in the acoustic nerve to aid brain.	Number of rats should be lore to make a good sample.
9	Kaga,K et al (199$)	The pathological changes in red blood cells in and around the blood vessels, basic structure of the cochlear, and brainstem in patients with brain stem death determined by ABR	6 32, 56, 3i, 17, 59, 70 years, Bra-ins-tea death	Click Int.85dB nHL	Not mentioned.	Results showed that the cochlear, the visceral organs and the spinal cord below a certain level of the cervical segments continued to line after brain stem death. RBCs in the vessels of brainstem and cerebellum exhibited severe autolysis, where as most RBCs in the cochlea were preversed. Findings of autolytis changes in RBCs in the brain stea, and the presentation of RBCs in the cochlea, imply initial loss of brian stem function and delayed loss of	Good generalization needs more cases to be studied.

1.	2.	3.		4.	5.	6.	7.	8.
							cochlear function after prolonged absence of Alls.	
10	Lemaire, N.C., et al (1995)	BSERs of patient with unilateral or bilateral tinnitus were recorded in order to evaluate the effect of tinnitus on the central auditory system	129 331 96F 355 133 87 135	20 to 56yrs 18-55 yrs. 13-85 yrs	N Tinni tus L ear i ear Both ear	Clicks No.2000 Rate:ll.l/sec Pol.alternat-ing Int.90dB nHL masking White noise at 50dB nHL (contra)	Doable channel/masto-ids/vertex/forehead	The results have revealed significant medifications of latencies and amplitudes of BSARs related to side of subjective tinnitus. The disturbances recorded, localized principally in waves I and III, suggest involvement of the efferent systems (lengethned latencies)	In this study cases with tinnitus suffered from hearing loss also. So this factor is able to lengthen the latency of the first wave. So each factor which is responsible for lengethening of latencies should be taken care of.
11	Musiek,E et al (1995)	Purpose of this study was to determine the value, based on true positive and false positive rates of various ABRs indices in discriminating patients with brain stea lesions from patients with cochlear lesions.	65 31 21F 11M 33 17F 16M	Mean Avg. 52yrs 54yrs	B.S Le. Coh. Pt.	Clicks Eate:15/sec Int:80 dB nHL F.S:150-3000hz No Masking	Single channel/ ear lobe of the stimulated ear/ high forehead/ contralateral ear lobe or aid forehead	ROC curves were constructed to analyse the absolute latency of wave ¥ the I-III, III-V, and I-V inter wave internals. The interaural latency difference and the V/I amplitudes ratio. Based on ROC curves, the clinically aost valuable index was the I-V internal but over all the individual indices showed only moderate sensitivity to brain stea pathology. By coabining all indices, brainstem involvement improved but false positive rate also increased.	

B.S = Brain Stem Le. = Lesion Coh. = Cochlear Pt. = Pathology

1.	2.	3.	4.	5.	6.	7.	8.
12	Rosen-hall,U et a1 (1995)	Two groups of patients with anaoying tinnitus were studied with brainstea response audiometry.	56 M.A N 38F 43.8yrs with 26M 4.Syrs Tn. 57 20F 59.5yrs mod. 37M 54.9yrs SN H.L 220 Ctrl. 54 Grp. with out Tn. 166 with SN H.L	Click no.1000 Rate:20/sec Int:80dB nHL Polarity rarefaction	Not mentioned	Prolongation of wave ! accompanied by a prolongation of waves III and V, findings which are consistent with a lesion in the peripheral auditory system. Lengthening of III-V IPL indicating a dysfunction in the brainstem. Both patterns occurred most often in tinnitus patients with normal hearing or slight hearing loss.	The results of this study can be used as a useful diagnostic tool. Position of electrodes has not been mentioned.

Tn. = Tinnitus H.L = Hearing Loss Mod. = Moderate

SUMMARY

SUMMARY

In this project an attempt has been made to provide a concise report about the literature available on ABR in the recent journal articles (1991-1995). All the information available has been divided into three chapters i.e.,

a) Factors affecting ABR
b) ABR in pediatric group
c) Clinical applications of ABR.

The review of above articles revealed the following trends.

The subjects used in the studies belonged to following categories.

a) Normal Adults
b) Normal Infants
c) Pathological Adults
d) Pathological Infants
e) Normal Animals
f) Pathological Animals.

It is apparent from the articles that ABR is affected by many variables such as age, sex, hearing, stimulus intensity, stimulus rate, temperature, electrode placement, head size and brain maturation.

Stimulus polarity and type of stimulus (click, tone burst) also has considerable effects on ABR results. So

while interpreting the results these all factors should be taken into consideration.

Studies have shown that bone conducted tone bursts are useful in defining frequency specific cochlear sensitivity and also good in defining conductive loss component. Studies have revealed that thresholds for 500 hz BC tones are better as compared to 2000 hz (Fox and Stapells, 1993).

High frequency latency-intensity functions have been studied, (Paust et al., 1993), which revealed that as a function of increase in intensity, there is a considerable decrease in latency (Liu and Ziang, 1991).

Studies have revealed better results with computerized analysis over user intervention (Pratt, et al., 1993).

Absolute and interpeak latency maturation with age has been studied and the studies have clearly reported that there is a considerable decrease in latency, with increasing age. Contralateral morphology is also closely resembling the ipsilateral morphology, especially after the age of 9 months (David and Mosseri, 1991; Eggermont, et al., 1991).

Fast methods using maximum length sequence has been suggested in the studies to calculate ABR. This method has a high reliability. Studies have revealed that, using this method adaption is quite less and can be a good screening tool (Burkard, 1994; Thorton, et al., 1993; Lina Granade, et al., 1994; Hamil et al., 1991).

On the whole studies show that ABR can be effectively used for screening procedure and high reliability of ABR results have been found in studies.

In children, studies have revealed that ABR can be used along with high risk register in a pediatric set-up. However, its usefulness or specificity depends on repeated testing and follow-up.

ABR findings in children until normal hearing starting from pre-term babies (age at which different waves make their first appearance) till the age level when different waves are stabilized have been reviewed. Different response parameters like latency, amplitude and thresholds have been considered and the ages at which these different parameters attain adult values are given.

Apart from response parameters, signal parameters have also been studied. ABR findings in children with bone conducted click stimulation and real ear measures with click stimulation i children have been studied. It has been suggested that, there is a need to use infant norms when screening infant hearing using ABR because of variation of infant and adult canal resonances (Johnson, et al, 1991; Foxe, 1993).

Electrode settings, best for neurodiagnostic interpretation have been given. Filtering settings and spectral characteristics have been given for good interpretation of results in children (Spinak, 1993; Katbamna et al., 1995; Sininger, et al., 1995).

Studies under the heading "Clinical Applications of ABR" have shown the importance of ABR in brain death cases and found ABR as a very useful tool in telling the extent of brain stem death (Kaga, et al, 1975).

Importance of wave V latency, in differentiating Cochlear Pathology and Retero Cochlear Pathology cases has been reported (Prosser et al., 1992). It was suggested that ABR is less sensitive in detecting intracanalicular tumors than in detecting extra canalicular tumors.

A few studies (Janssen, Brocaar and Van Zanten, 1993) have tried to assess conductive component of hearing loss by auditory brain stem electric response audiometry. A bone conducted noise was used to mask out the response to a conventional air conducted click. The results of the study reported that conventional pure tone and ABR to find out conductive hearing loss are in good agreement to each other. So ABR can be used successfully to find out conductive hearing loss on difficult to test cases.

Changes of ABR in vertebrobasilar ischaemia cases and cases with vitiligo has also been studied (Fuse, 1991; Nikiforidis, et al., 1993). A significant difference has been found in the wave latencies and amplitude of waves as compared to normal group.

Patterns of waveform in tinnitus patients in terms of latency changes and morphology of wave form have been studied. Several studies (Lemoire and Beutter, 1995; Rosenhall and Axelsson, 1991) have suggested that a great deal of knowledge about the site of lesion can be inferred from the results.

Overall findings suggest that ABR has gripped the area of audiology, maximally, starting from the studies on generation of nerve potentials to the clinical application such as threshold estimation and hearing aid evaluation etc. ABR results go deep into the neurologic implications.

REFERENCES

REFERENCES

Albright, P.W., (1983). An evaluation of BERA for hearing screening in high-risk neonates. Laryngoscope, 93, 1115-1121.

Ananthanarayan, A.K., Durrant, J.D., (1991). On the origin of wave II of the auditory brainstem evoked response. Ear and Hearing, 12(3), 174-179.

Aoyagi, M., Suzuki, T. , Yokoyama, J., Sakai, M., Kiren, T., Koike, Y., (1991). Cross correlation function in the analysis of auditory brainstem responses in spinocerebellar degeneration. Audiology, 30(5), 266-274.

Aubert, L.R., Clark, G.P., (1994). Reliability and predictive value of the electrically evoked auditory brainstem response. BJA, 28(3), 121-124.

Bankaitis, A.E., (1995). The effects of click rate on the auditory brainstem response (ABR) in patients with varying degrees of HIV-Infection : A pilot study. Ear and Hearing, 16(3), 321-324.

Bansal, R., Agarwal, A.K., Kakar, P.K., (1992). BERA in high risk neonates and infants : Hearing Assessment. Indian ^ Journal of Otolaryngology and Head and Neck, 1(4), 169-172.

Barth, CD., Burkard, R., (1993). Effects of noise burst rise time and level on the human brainstem auditory evoked response. Audiology, 32(3), 225-233.

Beattie, R.L., Alehs, L.A., Abbott, C.L., (1994). Effects of signal to noise ratio on the auditory brainstem response to 0.5 and 2 khz tone bursts in broad band noise and high pass noise or notch noise. Scandavian Audiology, 23(4), 211-224.

Bergman, B.M., Beauchaine, K.L., (1992). Application of the auditory brainstem response in pediatric audiology. Hearing Journal, 45(9), 19-25.

Boettcher, F.A., (1993). Auditory brainstem response correlates of resistance to noise induced hearing loss in Mongolian gerbils. JASA, 94(6), 3207-3214.

Brackman, D.E., (1980). Rare tumors of the cerebello pentine angle. Oto1aryngo1ogy, Head and Neck Surgery, 88, 555-559.

Brown, C.J., Abbas, P.J., Bertschy, H.F., Kelsay, D., Oantz, J.B., (1994). Intraoperative and postoperative electrically auditory brainstem responses in nucleus cochlear implant users : Implications for the fitting process. Ear and Hearing, 15(2), 168-176.

Burkard, R., Veigt, H.F., Smith, L.R., (1993). A comparison of N1 of the whole nerve action potential and wave I of the brainstem auditory evoked responses in Mongolian gerbil. JASA, 93(4), 2069-2076.

Burkard, R., (1994). Gerbil brainstem auditory evoked responses to maximum length sequences. JASA, 95(4), 2126-2135.

Caahman, M.Z., Stanton, S.O., Sagle, C, Barber, H.O., (1993). The effect of hearing loss on ABR interpretation : Use of a correction factor. Scandavian Audiology, 22(3), 153-158.

Clemis, J.D., (1984). Hearing conservation in acoustic tumor surgery : Pros and Cons. Otolaryngo1ogy Head and Heck Surgery, 92, 152-161.

Conijn, E.A.J.G., Brocal, M.P., Van Zanten, O.A., (1992). Low frequency specificity of the auditory brainstem response threshold elicited by clicks masked with 1590 hz high pass noise in subjects with sloping cochlear hearing losses. Audiology, 30, 272-283.

Conijn, E.A.J.G., Brocaar, M.P., Van Zanten, O.A., (1992). Comparison between the frequency specifities of auditory brainstem response thresholds to clicks with and without high pass masking noise. Audiology, 31, 284-292.

David, R.S., Mosseri, M., (1991). Maturation of the contralaterally recorded auditory brainstem response. Ear and Hearing, 12(3), 167-173.

Deltenre, P., Mansbach, A.L., (1995). Effects of click polarity on brainstem auditory evoked potentials in cochlear hearing loss : A working hypothesis. Audiology, 34(1), 17-35.

Don, M., Ponton, C.N., (1993). Gender differences in cochlear response time : An explanation for gender amplitude differences in the unmasked auditory brainstem response. JASA, 94(4), 2135-2148.

Dusieux-Smith, A., Picton, T.W., Bernard, P., MacMurray, B., Goodman, J.T., (1991). Prognostic validity of brainstem electric response audiometry in infants of a neonatal intensive care unit. Audiology, 30, 249-265.

Edward, Y.T., Staurt, A., Stenstorm, R., Hollett, S., (1991). Effect of vibrator to head coupling force on the auditory brainstem to bone conducted clicks in new born infants. Ear and Hearing, 12(1), 55-60.

Eggermont, J.J., Ponton, C.W., Coupland, S.G., (1991). Frequency dependent maturation of the cochlear and brainstem evoked potentials. Acta otolaryngologica, 111(2), 220-224.

Fausti, S.A., Olson, D.J., Frey, R.H., Henry, J.A., Shaffer, H.I., (1995). High frequency tone burst - evoked ABR latency - intensity functions in sensorineural hearing - impaired humans. Scandavian Audiology, 24(1), 19-25.

Fausti, S.A., Olson, D.J., Frey, R.H., Schaffer, H.I., (1993). High-frequency tone burst - evoked ABR latency - intensity functions. Scandavian Audiology, 22(1), 25-33.

Fausti, S.A., Frey, R.H., Henry, J.A., Olson, D.J., (1992). Comparing laboratory and portable tone burst auditory brain stem response systems for monitoring high frequency (> 8 khz) auditory dysfunction. Scandanian Audiology, 21(4), 211-218.

Fower, G.C., (1991). Effects of stimulus phase on the normal auditory brainstem response. JSHR, 35(1), 167-174.

Foxe, J.J., Stapells, D.R., (1993). Normal infant and adult auditory brainstem responss to bone conducted tones. Audiology, 32(2), 95-109.

Fuse, T., (1991). ABR findings in vertebrobasilar ischemia. Acta otolaryngologica, 111(3), 485-490.

Gerull, G., Mrowinaki, D., Nubel, K., (1991). Low frequency masking of brainstem potentials. Scandavian Audiology, 20(4), 227-234.

Gerling, I.J., (1991). In search of a stringent methodology for using ABR audiometric results. Hearing Journal, 44(11), 26-30.

Hall, W.J., Orose, H.J., (1993). The effects of Otitis media with effusionk on the masking level difference and the auditory brainstem response. JSHR, 36(1), 210-217.

Hamil, T.A., Hussuing, R.A., Sammeth, A.C., (1991). Rapid threshold estimation using the "chanied stimuli" technique for auditory brainstem response measurement. Ear and Hearing, 12(4), 229-234.

Hecox, K., Galambos, R. , (1974). Brainstem auditory evoked response in human infants and adults. Archives of otolaryngology, 99, 30-33.

Hyde, H.L., Malizia, K., Riko, K., (1991). Audiometric estimation error with the ABR in high risk infants. Acta otolaryngo1ogica, 111(2), 212-219.

Janssen, E.A., Brocaar, M.P., Vanzausten, Z.A., (1993). The masked threshold to noise ratio in brainstem electric response audiometry : Assessment of conductive loss component by bone conducted masking. Audiology, 32(3), 153-163.

Jewelt, D.L., Romano, M.H., (1972). Human auditory evoked potentials : Possible brainstem components detected on the scalp. Science, 167, 1517-1518.

Jiang, Z.D., Wu, Y.Y., Zhang, L., (1991). Amplitude change with click rate in human brainstem auditory evoked responses. Audiology, 30(3), 173-182.

Johnson, E.S., Nelson, P.B., (1991). Real ear measures of auditory brain stem response click spectra in infants and adults. Ear and Hearing, 12(3), 180-183.

Katbamna, B. , Bankartis, A.E., Metz, D.A., (1993). Effects of hyperthesmia on the auditory evoked brainstem in mice. Audiology, 32(6), 344-355.

Katbamna, B., Benett, S.L, Dokler, P.A., Metz, D.A., (1995). Effects of electrode montage on infant auditory brainstem response. Scandavian Audiology, 24(2), 133-136.

Kaga, K., Vebo, K., Satrata, H., (1995). Auditory brainstem response and temporal bone and brainstem pathology in brainstem death, with special reference to autolysis of red blood cells. Acta Otolaryngologica, 115(2), 183-186.

Kidd. 0., Burkard, F.R., Hanson, R.C., (1993). Auditory detection of the human brainstem evoked response. JSHR, 36(2), 442-447.

Kramer, S.J., (1992). Frequency specific auditory brainstem responss to bone conducted stimuli. Audiology, 31, 61-71.

Lasky, R.E., Maier, M.M., Mexox, K., (1993). A comparison of binaural interactions using traditional and maximum length sequence evoked response paradigms. Ear and Hearing, 16(4), 354-360.

Lauter, J.L., Oyler, R.F., (1992). Latency stability of auditory brainstem responses in children aged 10-12 yrs compared with younger children and adults. British Journal of Audiology, 26(4), 245-253.

Lauter, J.L., Oyler,R.F., Iord Mars, J. , (1993). Amplitude stability of auditory brainstem responses in two groups of children compared with adults. British Journal of Audiology, 27(4), 263-271.

Lemaire, M.C., Beutter, P., (1995). Responses in patients with tinnitus. Audiology, 34(6), 287-300.

Lightfoot, G.R., (1993). Correcting for factors affecting ABR wave V latency. British Journal of Audiology, 27(3), 211-200.

Lightfoot, G.R., (1992). ABR screening for acoustic neuromata : The role of rate induced latency shift measurements. British Journal of Audiology, 26(3), 317-227.

Lina-Oranade, G., Collet, L. , Morgon, A., (1994). Auditory evoked brainstem responses elicited by maximum length sequences in normal and sensorineural ears. Audiology, 33(4), 218-236.

Liu, X.Y., Jiang, Z.D., (1991). Intensity effect on latency and internal of human BAER. Acta Otolaryngologica, 111(3), 477-484.

Mark, S., Richard, C., (1995). The effects of reversing the polarity of frequency limited single cycle stimuli on the human auditory brainstem response. Ear and Hearing, 16(3), 311-320.

Moore, E.J., Semela, J.J.M., Rakerd, B., Robb, R.C., Ananthanarayan, A.K., (1992). The I potential of the brainstem auditory evoked potential. Scandavian Audiology, 21(3), 153-156.

Muchnik, C., Neeman, R.K., Hildesheimer, M., (1995). Auditory brainstem response to bone conducted clicks in adults and infants with normal with normal hearing and conductive hearing loss. Scandavian Audiology, 24(3), 185-91.

Munnesley, O.M., Orewlle, K.A., Purdy, 8.C., Kerth, W.J., (1991). Frequency specific auditory brainsem responses relationship to behavioural thresholds in cochlear impaired adults. Audiology, 30(1), 25-32.

Musiek, E.F., Lee, W.W., (1995). The auditory brainstem response in patients with brainstem or cochlear pathology. Ear and Hearing, 16(6), 631-636.

Nikiforidis, G.C., Tsamboas, I.G., Karamitsos, D.S., (1993). Abnormalities of the auditory brainstem response in vitiligo. Scandavian Audioloty, 22(2), 97-100.

Panton, C.W., Eggerment, J.J., Compland, S.G., (1993). The relation between head size and auditory brainstem response interpeak latency maturation. JASA, 94(4), 2149-2158.

Pratt, H., Geva, A.B., Mittelman, N., (1993). Computational waveform analysis and classification of auditory brainstem evoked potential. Acta Otolaryngologica, 113(3), 279-284.

Prasher, D., (1995). Differential effects of adaptation on the ipsi and contralateral auditory brainstem pathway. Scandavian Audiology, 24(2), 101-106.

Prosses, S., Arslan, E., Turrini, M., (1992). Cochlear and neural dysfunction in acoustic neuroma, can they be separately revealed by auditory brainstern wave V latency. Scandavian Audiology, 23(3), 195-200.

Roger, R.M., (1991). The auditory brainstem response recorded with 60 hz notch filters. Ear and Hearing, 16(4), 155-158.

Rosenhall, U., Axelsson, A., (1995). Auditory brainstem response latencies in patients with tinnitus. Scandavian Audiology, 24(2), 97-100.

Rowe, S.J., (1991). An evaluation of ABR audiometry for the screening and detection of hearing loss in ex-SCBV infants. British Journal of Audiology, 25(5), 259-274.

Rupa, V., Dayal, A.K., (1993). Wave V latency shifts with age and sex in normals and patients with cochlear hearing loss : Development of a predictive model. British Journal of Audiology, 27(4), 273-279.

Sand, T., Saunte, C., (1994). ABR amplitude and dispersion variables. Relation to audiogram shape and click polarity. Ear and Hearing, 16(4), British Journal of Audiology, 26(3), Scandavian Audiology, 23(1), 7-2.

Schoonhoven, R. , (1992). Dependence of auditory brainstem response on click polarity and high frequency sensorineural hearing loss. Audiology, 31, 72-86.

Setters, W.A., Brackmann, D.E., (1977). Acoustic tumour detection with brainstem electric response audiometry. Archieves of Otolaryngology, 301, 181-187.

Schulman, A.H., (1981). Central tinnitus diagnosis and treatment : Observations of simultaneous binaural auditory brain responses with monaural stimulation in the tinnitus patient. Laryngoscope, 92, 2025-2036.

Sininger, Y.S., (1995). Filtering and spectral characteristics of averaged auditory brainstem response and background noise in infants. JASA, 98(4), 2048-2055.

Schmer, H., Freemans, Friedman, I., (1991). Auditory Brainstem Response (ABR) latency shifts in animal models of various types of conductive and sensori-neural hearing losses. Acta Otolaryngologiea, 111(2), 206-211.

Sohmer, H.,Feinmesser, M., (1967). Cochlear action potentials recorded from the external ear in man. Annals of Otology, Rhinology and Laryngology, 76, 427-435.

Soucek, S., Mason, S.M., (1992). Effects of adaptation on electro cochleography and auditory brainstem responses in the elderly. Scandavian Audiology, 21(3), 149-152.

Spivak, L.G., (1993). Spectral composition of infant auditory brainstem responses : Implication for filtering. Audiology, 32(3), 185-193.

Starr, A., (1976). Auditory brainstem response in brain death. Brain, 99, 543-554.

Stapells, R.D., Gravel, J.S., Martin, A.B., (1995). Thresholds for auditory brain stem responses to tones in notched noise from infants and young children with normal hearing or sensorineural hearing loss. Ear and Hearing, 16(4), 361-371.

Sullivan, M., Neely, S.T., (1995). Estimating residual noise in the auditory brainstem response. JASA, 98(4), 2056-2061.

Suzuki, T., Kobayashi, K., Aoki, K. , Umegabi, Y. , (1992). Effect of sleep on binaural interaction in auditory brainstem response and middle latency response. Audiology, 31, 25-30.

Thodic, C, Katbamna, B., (1993). Binaural interaction in the auditory brainstem response multichannel recordings. Scandavian Audiology, 22(3), 205-208.

Thomas, E., Thomas, L., Eugene, V., (1992). Stimulus repetition rate effect on the auditory brainstem response in systemic lupus erythematosus. Laryngoscope, 102(3), 335-339.

Thorton, A.R.D., Slaven, A., (1993). Auditory brainstem responses recorded at fast stimulation rates using maximum length sequences. British Journal of Audiology, 27(3), 205-210.

Wilson, D., Hodgson, R., Gustafson, M.F., (1992). The sensitivity of auditory brainstem response testing in small acoustic neuromas. Laryngoscope, 102(9), 961-964.

Yamada, K., Kaga, K. , (1994). Analysis of auditory brainstem response with lidocaine injection into the cerebrospinal fluids in rats. Annals of Otology, Rhinology and Laryngology, 103(10), 796-800.