COMPUTER BASED INTERACTIVE LEARNING PROGRAM ON ABR

Reg. No. M0102

An Independent project submitted in part fulfillment for the first year M.Sc (Speech and Hearing) to University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE-570006

MAY- 2OO2

DEDICATED TO

MUMMYJI AND PAPAJI

FOR YOU BOTH HAVE MOULDED ME INTO WHAT I AM TODAY

CERTIFICATE

This is to certify that this independent project entitled "COMPUTER BASED INTERACTIVE LEARNING PROGRAM ON ABR" is a bonafide work in part of fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No.MO 102)

DIRECTOR

All India Institute of
Speech and Hearing.
Mysore-570006

Mysore,
May, 2002

CERTIFICATE

This is to certify that this independent project entitled **"COMPUTER BASED INTERACTIVE LEARNING PROGRAM ON ABR"** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any degree or diploma.

GUIDE

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MYSORE-570006

Mysore,

May,2002

DECLARATION

This Independent project entitled "COMPUTER BASED INTERACTIVE LEARNING PROGRAM ON ABR" is the result of my own study under the guidance of **Dr.C.S Vanaja,** Lecturer in Audiology, Department of Audio logy, All India Institute of Speech and Hearing, Mysore and not been submitted in any other University for the award of any degree or diploma.

Mysore,

May, 2002 **Reg. No. M0102**

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To my MUMMYJI AND PAPAJ1,

IN THE DARKNESS AND IN UGHT,
IN THE RAIN AND IN STORM,
THROUGH THE DARK DAYS OF MY UFE,
TO THE BRIGHT ONES,
IT'S YOUR STRENGTH, GUIDANCE AND HOPE IN ME
THAT HAS DRIVEN ME THROUGH,
I AM STUCK WITH NO WORDS TO EXPRESS....
LOVE YOU LOTS, IS ALL WHAT I CAN SAY!

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INTRODUCTION

The auditory evoked potentials are the electrical responses of the nervous system to auditory stimuli. Auditory evoked potentials provide powerful, objective method of assessing the neural integrity of the auditory pathways from the VIII cranial nerve to the cortex. One of the reasons for the Auditory Brainstem Response (ABR) gaining such rapid acceptance, is its ability for objective threshold estimation without the active participation of subjects in difficult-to-test population. Other applications include objective detection, localization and monitoring of auditory and neurological deficits. In evaluations using ABR, the electrical potentials generated at various levels of the nervous system, in response to acoustic stimulation, are recorded non-invasively with no discomfort to the patient and often without anesthesia, which further enhances their clinical applicability.

The ABR is recorded by attaching electrodes to the surface of the scalp and amplifying the electrical activity obtained immediately following an auditory stimulus. The ABR latency epoch consists of five to seven peaks within the first 10 msec. (Jacobson, 1985). The response is low in amplitude and is buried in other ongoing activity in the nervous system. Therefore, special common mode rejection amplification response filtering and computer averaging are needed to differentiate the response to the stimulus from the other activity.

A number of factors affect the latency and amplitude of ABR. These include subject related factors such as age, gender and body temperature (Hall, 1992). The latency and amplitude values in newborns and infants differ from adult values (Jacobson, Morehouse, and Johnson, 1982). Technical aspects such as electrode placement, stimulus polarity, filtering characteristics, rate of presentation and type of stimulus may influence the latency, amplitude and morphology of the auditory brainstem response (Jacobson, 1985). Stimulus properties such as frequency, duration, intensity, rate and polarity exert profound and often inter-related effects on ABR measurements (Hall, 1992).

The clinical application of ABR has provided a unique diagnostic dimension that has transcended inter-disciplinary boundaries. The proliferation of ABR technique has provided a mutual appreciation of the expertise and responsibilities of hearing specialists concerned with the needs of auditorally and neurologically affected community, making it necessary for today's audiologists to be well acquainted with this diagnostic tool.

The information on ABR is available in the form of various textbooks, journals, independent projects, tutorials etc. Tutorials can be in two forms: Printed form and Computer based. Computer based tutorial programs facilitate the learning of new information through a step-by-step presentation. Usually, basic information and instructions are displayed on the computer monitor and opportunities for 'branching' are offered. This means that what happens next on the screen depends on user's input. Tutorial programs are usually recognition based i.e. the user is provided with choices and needs only to recognize information to find the answer. (Schery and O'Connor, 1995).

AIM OF THE STUDY:

The aim of the present study was to develop a Computer based Interactive Learning Program, which can be used by trainees, practicing clinicians or allied professionals to get acclimatize with ABR. The program comprises of a question bank, which evaluates the user's knowledge of ABR and helps in improving his /her knowledge.

NEED OF THE STUDY:

From the time ABR was recorded by Jewett and Williston (1971) using far field technique, there has been growing research on the subject. Though there are a few comprehensive textbooks on ABR, a lot of information on ABR is available in various other sources. This program makes an attempt to compile information available in the literature on various aspects of ABR. The following aspects indicate the need for the study:

* There is a lot of vagueness, confusion and numerous queries regarding various aspects of ABR, which need to be compiled and collectively presented to enrich a reader's knowledge.

* There is a stringent need for an ABR desk reference for trainees and practitioners. In this day and age of modern technology, a computer based information bank will be user friendly, easy- to-access package.

* Educators who are given the challenging task of setting, asking and answering questions often have quite a task on their hands. This package would alleviate their quandary to some extent.

* Trainees who are being introduced to the topic of ABR need to have firm grounding with concepts and there is an ongoing requirement for assessment of their learning. This package is a handy tutorial-cum-test schedule, which serves this purpose.

The advantages of this program include:

- Making learning of ABR exciting and innovative.
- To keep up with the advancing use of computers in education.

METHODOLOGY

SOURCE OF MATERIAL:

Information was collected from various references like textbooks, journals, independent projects and internet.

TYPES OF QUESTIONS:

The questions are presented in various forms such as:

- Multiple choice questions
- Yes - No questions
- Fill in the blanks
- Filling in missing alphabets
- Expand the abbreviations
- Anagrams

In order to ascertain that questions are not confusing and ambiguous, a pilot study was conducted. The questionnaire was administered on 5 under-graduate and 5 post-graduate trainees. They were requested to mark the questions and/or answers, which were not clear. The questions and/or answers, which were not clear, were then modified.

PROGRAMMING OF SOFTWARE:

Visual Basic 6.0 programming language used was to program the package. The reason for using Visual Basic for programming was that Visual Basic is not just a programming language but it's an integrated development environment in which one can develop, run, test and debug the application program. Apart from this Visual Basic is user friendly and employs Graphical User Interface (GUI).

The database, which was used for the program, was Access Database. The reason for using Access Database was that it is accessible on all the computers supporting windows environment and also it can handle small amount of data very well.

SOFTWARE OPERATIONS:

When the user logs on to the program, he has to enter his /her name. Once user enters his name, a choice to choose any one of the topics is given. Some of the topics that are included are as follows:

- History
- ABR in infants
- Acquisition of ABR
- Factors affecting ABR
- Clinical Applications of ABR

After each question is answered, the program will show whether the answer is correct or incorrect. If the answer is incorrect, the user will be given two options i.e. whether he wants to go for "50-50" or he wants to know the correct answer. If user selects "50 —50" option then appropriate action will be taken by the program and if user selects the option to know the correct answer, then correct answer along with a little explanation will be displayed. Even if the answer is correct, a little explanation will be given. For each correct answer, 1000 points will be given, no points will be rewarded for the incorrect answer. Apart from this, references will also be provided to help the reader to know more about the subject. Also appropriate reinforcers and messages will be displayed in between the program.

Once user finishes one topic, the program will display a performance certificate mentioning the total points scored by the user. Similar procedure will be used for rest of the topics.

QUESTIONS AND SOLUTIONS

HISTORY

1. Who coined the term ABR?

(a) Jewett and Williston

(b) Hallowell Davis

(c) Starr

(d) Jerger and Hall

2. Who was first to report the existence of ABR?

(a) Jewett and Williston

(b) Sohmer and Feinmesser

(c) Jerger and Hall

(d) Hecox and Galambos.

3. Who was the first to record ABR using far field technique?

(a) Jerger and Hall

(b) Sohmer and Feinmesser

(c) Jewett and Williston

(d) Galambos

4. Schulman and Galambos first reported use of ABR in infants in 1974.

True or False

5. **G_____d** _ was the first to report applications of ABR in intra-operative monitoring?

6. Who was the first to record ABR for bone conduction stimulation?

(a) Jerger and Hall

(b) Jerger and Mauldin

(c) Starr

(d) Arlinger

7. When was MLS and Fsp features incorporated into commercially available evoked response system?

(a) 1995

(b) 1994

(c) 1993

(d) 1997

8. Electrical potentials emanating from surface of scalp in response to an auditory signal was first recorded by D_____I___.

9. Jewett and Williston in 1971, reported 7 peaks while recording ABR.

True or false

10. Beginning of evoked response audiometry can be traced back to the year

(a) 1850

(b) 1961

(c) 1875

(d) 1961

11. Recording of spontaneous bioelectric activity generated from human scalp was first described by_____in 1929.

12. He described systematic application of ABR in intensive care unit monitoring. You may get the name if you unscramble this jumble.

ALHL

13. He first described ABR in patients with CNS pathology. Who is he?

RTASR

14. Match the following:

1.	Davis	a)	Father of Diagnostic Audiology
2.	Don Williston	b)	Among the first to apply ABR in new born screening
3.	Robert Galambos	c)	One of the first to describe ABR
4.	Raymond Carhart	d)	Developed a device for summating evoked response data in 1947.

15. Expand fhe following:

1.	ABR	6.	BSER
2.	SSEP	7.	AEP
3.	AER	8.	BAEP
4.	BAER	9.	SNio
5.	ECOG		

16. Who was the first to report on recordings of auditory evoked potentials from human ear and auditory nerve.
    (a) Ruben et. al.,
    (b) Sohemer and Feinmesser
    (c) Jewett and Williston
    (d) Berger

17. Fsp was developed by
    (a) Jacobson
    (b) Hecox and Galambos
    (c) Elberling and Don
    (d) Davis

SOLUTIONS

1. (b) Hallo well Davis

Hallo well Davis, in 1979, also known as father of Auditory evoked responses, coined the term ABR. (Hall, 1992)

2. (b) **Sohmer and Feinmesser**

Sohmer and Feinmesser first reported existence of ABR in 1967. In a paper "Cochlear Action potentials recorded from external ear in man", they reported waveforms that appear to include what is now known as ABR. (Hall, 1992)

3. (c) **Jewett and Willis ton**

Jewett and Williston (1971) reported the first ABR recording using far field technique, which marks the "true" discovery of ABR for clinical purposes.

4. **False:**

By Hecox and Galambos (1974).

5. **Grundv** in 1981 first reported applications of ABR in intra-operative monitoring (Hall, 1992)

6. (b) **Jerger and Mauldin**

Jerger and Mauldin (1979) first reported clinical study of ABR with Bone Conduction stimulation.

(Hall, 1992)

7. (b) **1994**

1994 by M/S Nicolet Biomedical (Hall and Muller, 1997)

8. **Davis**

It was Davis in 1939 who recorded these potentials, commonly known as late auditory potentials. (Hood, 1998)

9. **True:**

ABR consists of a series of seven positive to negative going waves, occurring with in 10 msec, for clicks presented through supra-aural earphone. (Hall, 1992)

10. (c) 1875

In 1875 Caton first noticed the presence of electrical potentials in brain. (Cited in Hall, 1992)

11. **Berger** recorded 1st human EEG from electrodes placed on scalp in 1928. (Hall, 1992)

12. **Hall**

Hall (1982) first reported application of ABR in intensive care unit monitoring. (Hall, 1992)

13. **Starr**

Starr (1976) first described ABR in patients with CNS pathology. (Hall, 1992)

14.

1. Davis	d) Developed a device for summating evoked response data in 1947.
2. Don Williston	c) One of the first to describe ABR
3. Robert Galambos	b) Among the first to apply ABR in newborn Screening
4. Raymond Carhart	a) Father of Diagnostic Audiology

(Hall and Muller, 1997)

15. ABR — Auditory Brainstem Response

SSEP- Steady State Evoked Potentials

AER - Auditory Evoked Response

BAER - Brainstem Auditory Evoked Response

ECOG - Electrocochleargraphy

BSER - Brainstem Evoked Responses

AEP - Auditory Evoked Potentials

BAEP - Brainstem Auditory Evoked Potentials

SNio - Slow Negative at 10 msec

(Hall, 1992)

16. (a) Ruben et. al

Ruben et. al., (1961) first recorded evoked potentials, now popularly known as ECOG potentials, from human ear.(Moller,1998).

17. (c) Elberling and Don

Elberling and Don developed a method of signal and noise estimation referred to as Fsp, in 1964. (Hood, 1998)

ABR IN INFANTS

1. ABR recorded from infants and old children manifests differences in the following parameters.
   (a) Latency
   (b) Amplitude
   (c) Morphological differences
   (d) All of the above

2. In infants, absolute latency of earlier peaks is more prolonged than later peaks.

True or False

3. Wave V is the most prominent wave in infants.

True or False

4. ABR can be used to test infant hearing soon after birth.

True or False

5. Absence of ABR in infants always indicates that the infant is having hearing loss.

True or False

6. ASHA (1994) recommends the following combination of clinical tools for hearing screening in infants.
   (a) OAE and Behavioral Observation Audiometry
   (b) ABR and Pure Tone Audiometry
   (c) OAE and ABR
   (d) Behavioral Observation Audiometry and Pure Tone Audiometry

7. The optimal placement of electrodes for ABR recording in infants is:

(a) Higher forehead and ear lobe or mastoid
(b) Vertex and Ears
(c) Vertex ,forehead and Ears
(d) Lower forehead and Ears

8. What is the reason for not recommending two- channel montage for infants and newborn?

(a) Ipsilateral ABR is difficult to record

(b) Time-consuming

(c) Does not give reliable threshold

(d) Contralateral ABR is difficult to record.

9. What is the recommended filter setting for recording ABR for clicks while testing infants.

(a) 100-3000 Hz

(b) 30-3000 Hz

(c) 10-3000 Hz

(d) 150-3000 Hz

10. What is the disadvantage of using lower filter settings of 30 Hz while testing infants and newborns?

(a) Greater interference from 60 Hz electrical noise.

(b) Increase in latency

(c) Decrease in latency

(d) All of the above.

11. Tone - bursts are preferred over clicks while recording ABR in infants because tone-bursts evoked ABR has the following advantage:

(a) Has good reliability

(b) Gives more frequency specific information

(c) Has good waveform resolution

(d) Is less time consuming.

12. ABR in infants attain the adult morphology by_____months.
    (a) 12 months
    (b) 36 months
    (c) 20 months
    (d) 48 months

13. Wave I reaches adult values by_____months in infants.

14. Which of the following conditions will lead to an abnormal ABR in infants?
    (a) Autism
    (b) Toxic metabolic disorders
    (c) Learning disability
    (d) All of the above

15. What are the intensity levels that are routinely used for infant hearing screening?
    (a) 30 dBnHL and 80 dBnHL
    (b) 40 dBnHL and 75 dBnHL
    (c) 35 dBnHL and 75 dBnHL
    (d) 35 dBnHLand 70 dBnHL

16. ABR can be recorded as early as____weeks of gestational age.

17. In order to minimize interaction between stimuli and 60 Hz electrical noise, usually an odd stimulus rate is used.

True or False

18. A lower repetition rate of 10/sec must be used in infants to obtain an ABR.

True or False

19. Match the following (typical ABR parameters for estimating the hearing status of infants).

1. Stimulus	(a) 2000
2. Stimulus rate	(b) 30-3000 Hz
3. Number of stimulus averaged	(c) 100,000 %
4. Filter settings	(d) Rarefaction polarity clicks
5. Amplification	(e)33.3/s
6. Analysis-time	(f) 10-15 msec.

20. What is the advantage of insert earphone over supra-aural earphone while testing infants.

(a) Prevents ear canal collapse since newborn pinna and external ear canal are prone to collapse from pressure of earphone.
(b) More comfortable
(c) Both a and b
(d) None of the above

21. A reliable ABR can be recorded from infants with inverting electrode located on the nape region.

True or False

22. What is the analysis window required for recording click evoked ABR in an infant hearing-screening program

(a) 10 msec
(b) 15 msec
(c) 25 msec
(d) 12 msec

SOLUTIONS

1. (d) AH of the above

Differences are observed in latency, amplitude and morphology due to developing peripheral and central auditory system.(Jacobson and Hall, 1994)

2. False:

In infants, the absolute latency of later peaks is more prolonged than earlier waves, resulting in longer interwave latency.(Gorga, Kaminski, Beauchaine, Jesteadt and Neely, 1989)

3. False:

In infants, Wave I and III are more prominent than wave V as wave I and III mature early where as wave V matures or reach adult like stage only by 12-18 months.(Jacobson, Morehouse and Johnson, 1982)

4. True:

ABR can be used to test infant hearing soon after birth but neural maturity of responses should be kept in mind. (Salamy, Eggermont, Eldredge, 1994)

5. False:

ABR can be absent in infants with normal hearing if there is nervous system immaturity or poor neural synchrony. (Weber and Jacobson, 1994)

6. (c) OAE **and ABR**

ASH A (1994) recommends the combination of OAE and ABR clinical tools for hearing screening in infants. (Hall and Muller, 1997)

7. (a) **Higher forehead and ears**

Usually higher forehead and ears are the preferred sites for electrode montage in infants. The difference in electrode placement between infants and adults may be related to differences in the orientation of scalp electrodes in relation to position of

brainstem. In infants skull is not fully developed and moreover placement of electrodes on infant earlobe is often difficult due to small size of earlobe. (Jacobson and Hall, 1994)

8. (d) **Contralateral ABR is difficult to record**

Standard two-channel montage is not recommended in newborns and young as contralaterally recorded ABR is poorly developed in newborns and infants and that highest amplitude ABR in infants result from vertex or higher forehead to ipsilateral ear(Edwards, Durieux-Smith and Picton, 1985)

9. (b) **30-3000 Hz**

While recording ABR from infants, low-frequency cut off is lowered fromlOO Hz to 3QHz as it enhances amplitude of wave V because there is greater energy in the jpwer frequencies in infant than adult ABR. (Stuart and Yang, 1994)

10. (a) **Greater interference from 60 Hz electrical noise**

Decreasing the low-frequency setting to 30 Hz may allow greater interference from 60 Hz electrical noise. Good electrode impedance and careful placement of electrodes should reduce this problem. (Hood, 1998)

11. (b) **Gives more frequency specific information.**

Tone - bursts are preferred over clicks while recording ABR in infants because tone-bursts evoked ABR gives more frequency specific information. (Hall, 1992)

12. (a) **12-18 months.**

ABR in infants begin to appear similar to that of adults around 12-18 months. (Gorga, Kaminski, Beauchaine, Jesteadt and Neely, 1989)

13. **2-3 months**

Wave I reaches adult values by 2-3 months in infants. (Jacobson, Morehouse and Johnson, 1982)

14. (d) All of the above (Hall,1992)

15. (c) 35 dBnHL and 75 dBnHL

Routinely low intensity level of 35 dBnHL is used when conducting any infant hearing screenings. Additional neurological screening may be done with high-stimulus intensity level i.e., 75 dBnHL in infants who are at risk for CNS dysfunction with asphyxia or hydrocephalus. (Hall, 1992)

16. <u>27-28 weeks</u>

ABR can be recorded as early as 27-28 weeks of Gestational age i.e., ABR can be easily recorded in pre-mature infants. (Stockard, Stockard and Coen, 1983)

17. True:

An odd stimulus of 37.1 or 30.1/sec is usually used to minimize interaction betwe'en stimuli and 60 Hz electrical n6ise. (Hall, 1992)

18.True:

Effect of repetition rate is more in infants, so if higher repetition rate is used, morphology becomes poor and latency increases. So, lower the repetition rate, better the ABR in infants. (Stockard et.al, 1989,cited in Jacobson, 1994)

19.

1. Stimulus	(d) Rare faction polarity clicks
2. Stimulus rate	(e) 33.3/s
3. Number of stimulus averaged	(a) 2000
4. Filter settings	(b) 30-3000 Hz
5. Amplification	(c) 100,000
6. Analysis time	(f) 10-15 msec.

(Hall, 1992)

20. (c) Both a and b (Gorga, Jyaminski and Beauchaine,1988)

21. True:

A reliable ABR can be recorded with electrode in noncephalic region such as nape of neck as this region is not active with respect to intracranial electrical activity (unlike customary ear electrode sites) and provides a true reference for ABR recording. (Hall, 1992)

22. (b) **15 msec**

Usually a longer analysis period i.e., 15 msec, is required in infants than in adults (10 msec). Even at high intensity levels (80 dB), the latency of wave V is more than 8.5 msec for normal hearing newborns. Therefore at screening intensity levels, for the hearing-impaired infants, wave V latency may exceed 10msec. (Ruth, Dey-Sigman, and Mills, 1985)

ACQUISITION OF ABR

1. The principle which enabled to bring up the area of evoked potentials to its present level is_____.
   (a) Magnetism
   (b) Averaging
   (c) Localization
   (d) Summation

2. What is a transient stimuli?
   (a) A click
   (b) Narrow band noise
   (c) Pure tone
   (d) All of the above

3. These are mainly used during ABR recording to reduce the background electrical activity. What is this?
   LITTER

4. Forehead is the area located at the point equidistant between the right / left ear canals on the coronal plane.
   True or False

5._____,_____or_____transducers are generally used for presenting stimulus for recording ABR.

6. In India, which of these filters can be used to reduce electrical artifact while recording ABR.
   (a) Low-pass filters
   (b) High-pass filters
   (c) 50 Hz notch filters
   (d) 60 Hz notch filters

7. Which of the following conditions is ideal for recording ABR.

(a) Impedance less than 10K ohms.

(b) Impedance less than 5 k ohms

(c) Impedance between 25-15 k ohms

(d) Any of the above

8. Near field recording is an invasive technique.

True or False

9. What is the meaning of neural Synchrony?

(a) Averaging discharge of a large number of neurons.

(b) Simultaneous discharge of a large number of neurons.

(c) Both a and b

(d) None of the above.

10. Signal averaging while recording ABR requires that:

(a) Onset of the stimulus is time locked with the signal averager.

(b) No acoustic signal is used

(c) The acoustic signal is only in one ear.

(d) Acoustic signal intervals are random once averaging has begun.

11. If the ABR system is working properly which of the following might occur if two successive runs are obtained at the same repetition rate and intensity level?

(a) Response should be nearly identical.

(b) Response will look different due to noise.

(c) Second response will be smaller due to adaptation.

(d) One cannot predict similarities between two traces

12. ABR is an attempt to measure the integrity of the auditory nervous system upto the level of_____.
    (a) Lateral Lemniscus
    (b) MGB
    (c) VIII nerve
    (d) Dorsal and ventral cochlear nucleus

13. Which of the following labels for electrode sites are correct as per international 10-20 system (Jasper).
    (a) Vertex-Fz, Left ear-Al, Right ear-A2, Forehead-Cz.
    (b) Vertex-Cz, Left ear-A2, Right ear-Al, Forehead-Fz.
    (c) Vertex-Cz, Left ear-Al, Right ear-A2, Forehead-Fz.
    (d) Vertex-Al, Left ear-Cz, Right ear-Fz, Forehead-A2.

14. Why are insert earphones preferred over supra-aural earphones for acquisition of ABR?
    (a) Wave I is more visible
    (b) Better view of cochlear response
    (c) a and b
    (d) none of the above

15. Why do we use clicks and not pure-tone to elicit an ABR?
    (a) Because pure-tone has long onset time.
    (b) Time consuming
    (c) None of the above
    (d) Both a and b

16. The non- inverting electrode is usually placed on .

(a) Mastoid process on the side of test-ear.

(b) Vertex -

(c) Ear-lobe of non-test ear

(d) Promontory

17. Which of the following methods are used to improve signal-to-noise ratio while recording ABR.

(a) Use of a differential amplifier and a D.C power amplifier.

(b) Use of a differential amplifier and a signal averager

(c) Use of a D.C. power and A.C power amplifier.

(d) Changing the polarity.

18._____are the potentials obtained using frequency-modulated and amplitude-modulated tones.

SOLUTIONS

1. (b) **Averaging**

While recording the early potentials, it is necessary to distinguish a low amplitude response from higher background noise which is accomplished by averaging large number of responses together and time-locking the onset of stimulus. (Hood,1998)

2. (a) **Click**

A click is defined as a transient stimuli having instantaneous onset and a brief duration (0.1msec). Though it has energy at all the frequencies it provides maximum stimulation in 2000 to 4000 Hz range and thus mainly reflects activity of basal portions of the cochlea.(Hood, 1998)

3. **Filters**

Filters are mainly used to reduce the background electrical activity. While recording ABR for clicks, generally a bandpass filter of 100 Hz to 3000 Hz is used (Hall, 1992)

4. **False:**

Vertex is the area located at the point,equidistant between the right / left ear canals on the coronal plane. (Hall, 1992)

5.**Supra-aural earphone. Bone-vibrator or Insert-earphone** transducers are generally used for presenting stimulus for recording ABR. (Hall, 1992)

6. (c) **50 Hz Notch filters**

One of the problems **in** the recording of ABR is the pick up. of **extraneous** electrical noise via the electrodes (Ferraro and Durrant, 1994). A majority of the evoked potential systems have an option of choosing notch filters of 60 Hz or 50 Hz. Depending on the frequency of the power line, a filter is chosen .In India, 50 Hz notch filter should be used.

7. (b) Impedance less than 5 k ohms

Electrode impedance should be less than 5 k ohms while recording ABR. (Hood, 1998)

8. True:

If two electrodes are placed on an axon and other electrode on a ground, this is near field recording and is invasive. However recording can also be done even when electrodes are placed at a distance from the source such as on surface of the skull and recording takes place via volume conduction. This is called far-field technique. (Hall, 1992)

9. (b) Simultaneous discharge of a large number of neurons

Neural synchrony is a phenomenon in which most of the neurons in a nerve fire at the same time for a given stimuli.

10. (a) Onset of the signal is time locked with the signal averager.

Signal averaging requires that the signal is time-locked to the stimulus onset so that noise will be cancelled and the signal is enhanced. (Hall, 1992)

11. (a) The response should be nearly identical.

Under normal ABR conditions, the response should be nearly identical. (Hall, 1992)

12. (b) MGB

ABR is an attempt to measure electrical activity upto MGB. (Moller and Jannetta ,1983)

13. (c) Vertex-Cz ,Left ear-Al, Right ear-A2, Forehead-Fz..

According to the International 10-20 system (Jasper), each abbreviated name for placement site is a code. Odd numbers are on the left side of the head, even numbers on the right side of the head and 'z' refers to the midline of the head. The letter 'F' stands for frontal, 'C refers to the coronal and 'A' represents auris. (Jasper, 1958 cited in Hall, 1992)

14. (c) Both a and b

Separation of the stimulus artifact from the onset of the response through 0.9 msec delay line in insert earphone makes wave I of ABR more visible. Moreover the use of insert earphones, by virtue of isolation of stimulus artifact may allow a better view of the cochlear response. (Hood, 1998)

15. (a) Because pure-tone has long onset time

Usually clicks are used to elicit an ABR and not the pure-tones because pure-tone (a frequency specific stimulus) has a long rise time which leads to poor neural synchronization and hence not efficient in eliciting an ABR. On the other hand, a click which is abrupt in onset and brief in duration, is able to elicit a synchronous neural response. (Hood, 1998)

16. (b) Vertex

The non-inverting electrode is usually placed on vertex. (Hood, 1998)

17. (b) A differential amplifier and a signal averager

Usually a differential amplifier and a signal averager are used to improve the waveform morphology by eliminating signal noise i.e. By using a different amplifier, voltages at each of two electrodes in a pair are subtracted from each other and electrical activity common to both electrodes is cancelled (called common mode reflection), On the other hand a signal averager eliminates random noise by averaging many signal samples, thereby improving waveform morphologies. (Hood, 1998)

18. <u>Steady State Evoked Potentials.</u> (SSEP's)

Steady State Evoked Potentials are the potentials obtained using frequency-modulated and amplitude-modulated tones. Unlike ABR obtained with click stimuli, SSEP's use stimuli that are continuous tones and provide good frequency specificity because spectral energy is contained only at the frequency of the carrier tone and at the frequency of the modulation. (Hood, 1998)

FACTORS AFFECTING ABR

1. Females present_____latencies and_____amplitudes than males.
2. As stimulus intensity decreases, wave V latency_____proportionally.
3. Neural firing becomes less rapid as stimulus intensity_____in magnitude.
4. The latency of ABR waves decrease from birth to one year of age.

True or false.

5. The 'morphology' refers to the visual appearance or actual shape of the averaged responses.

True or False.

6. Compared to ipsilateral response, contralateral ABR shows:
   (a) Diminished or absent wave I
   (b) No change in wave I
   (c) Prolonged wave I
   (d) Overlapping of wave IV and V

7. Can you unscramble the following to find out the criteria used for interpretation of ABR?
   1. Ynltace teulbaos
   2. Keprtniae latency
   3. Kpeadutilepma
   4. edutpmali oiatr
   5. Gophloormy

8. Wave IV and V are better separated in ipsilateral recordings and wave III is more prominent in contralateral recordings

True or False.

9. ABR recording using 250 or 500Hz tonebursts requires a time window of at least

(a) 10 msec
(b) 12 msec
(c) 20 msec
(d) 15 msec

10. Why is a two-channel recording preferred while obtaining ABR's
(a) One can obtain better definition of waves IV and V.
(b) It is possible to collect ipsilateral and contralateral ABR's simultaneously.
(c) Both a and b
(d) None of the above.

11. Which method is helpful in determining the number of sweep, required to obtain the best possible response.
(a) MLS
(b) Fsp
(c) FFT
(d) None of the above.

12. Females may show_____interwave latency than males.

13. Recording of ABR can be influenced by
(a) Relaxants
(b) Barbiturates
(c) Sedatives
(d) None of the above

14. ABR recordings differ significantly as a function of attention.

True or False.

15. What happens if the rise time of the stimulus is increased while recording ABR?
    (a) Latency increases, amplitude increases and morphology deteriorates.
    (b) Latency decreases, amplitude increases and morphology improves,
    (p) Latency increases, amplitude decreases and morphology deteriorates,
    (d) Both latency and amplitude decreases and morphology improves.

16. It is generally recommended that the patient should be quiet and relaxed while doing ABR, as_____activity may affect the ABR.

17. When intensity of the stimulus is decreased while recording ABR, the first peak to disappear is_____and the last peak to disappear is_____.

18. How many channel recordings is generally recommended for neurological applications?
    (a) One -channel recording
    (b) Two- channel recording
    (c) More than two-channel recording
    (d) Any of the above.

19. Following is a method, which uses statistical properties of the response to determine when an acceptable signal-to-noise relationship in the averaged response is reached. You may get the name if you unscramble this jumble.
    SPF

20. While recording an ABR using 500 Hz tone-burst stimuli, which of the following parameters must be adjusted, in contrast to recording the response with the conventional click stimuli:
    (a) Analysis time window must be increased.
    (b) High-pass filter must be extended down to 30Hz.

(c) Blackmann windowing should be used for stimulus generation to reduce spectral splatter.

(d) All of the above.

21. What is the upper limit of the accepted inter electrode impedance while recording ABR.

(a) Less than 5000 ohms

(b) Within 2000 ohms

(c) Within 3000 ohms

(d) Within 4000 ohms

22. In comparison to condensation stimulus, latency is slightly longer and amplitude is higher for the early components of the ABR for rarefaction stimulus.

True or False.

23. Increasing the stimulus repetition rate, enhances the morphology and amplitude of the ABR.

True or False.

24. For the ABR, which is in the range of 0.1 to 1.0 uv, a typical artifact rejection while recording ABR will be

(a) lOuµ

(b) 7uµ

(c) 3 uµ

(d) 2 uµ

25. What is the recommended filter settings while recording the ABR for low-frequency tone bursts.

(a) 100-3000 Hz

(b) 150-3000 Hz

(c) 30 - 3000 Hz

(d) 80 - 200 Hz

26. With the use of alternating clicks, we can elicit sharply defined peaks.

True or False.

27. Under ideal measurement conditions (quiet baby, minimal electrical artifact), fewer averages are probably adequate to record an ABR in infants and adults

True or False.

28. The typical five- to- seven-wave complex seen with clicks generally is not seen in responses obtained with 500 Hz tone bursts

True or False

29. What happens to absolute latency and waveform morphology when repetition rate is increased while recording ABR?

(a) Absolute latency of all waveforms decreases and waveform clarity increases.

(b) Absolute latency of all waveforms increases and waveform clarity decreases.

(c) No change in absolute latency and waveform clarity.

(d) Absolute latency of all waveforms increases and waveform clarity improves.

SOLUTIONS

1. **Shorter latencies and larger amplitudes**

Females present shorter latencies and larger amplitudes than males. Wave V latency is about 0.2 msec shorter in females and amplitude is higher in females, particularly for wave IV, V and is due to a sex difference in cochlear response time leading to better synchronization of the cochlear output across the frequency regions. (Don, Ponton, Eggermont and Masuda, 1993)

2. **Increases**

As stimulus intensity decreases, wave V latency increases proportionally.
(Hood, 1998)

3. **Decreases**

Neural firing becomes less rapid as stimulus intensity decreases in magnitude.
(Hood, 1998)

4. **True:**

With increase in age in infancy, latency of wave components of ABR decreases. (Jerger and Hall, 1980)

5. **True:**

Morphology refers to the visual appearance of the averaged responses. (Hood, 1998)

6. (a) **Diminished or absent Wave I**

Usually diminished or absent Wave I is observed in contralateral ABR (Hall, 1992)

7.

1. Absolute Latency
2. Interpeak latency
3. Peak amplitude

4. Amplitude ratio
5. Morphology.

8. **False:**

Wave IV and V are better separated in contralateral recordings and wave III is more prominent in ipsilateral recordings. (Mizrahi, Maulsby and Frost, 1983,cited in Hood)

9. (c) **20msec**

ABR testing with tone-bursts requires a time window of at least 20 msec. Low frequency tone-bursts activate more apical portions of the cochlear portion resulting in longer latency of ABR waves. (Hood, 1998)

10. (c) **Both a and b**

The two-channel recording method is preferred for obtaining ABR's as one can obtain better definition of waves IV and V and also it is possible to collect ipsilateral and contralateral ABR's in sequential runs. (Hood, 1998)

ll.(b)Fsp

Fsp, an objective estimate of signal-to-noise ratio can be helpful in determining the number of sweeps required to obtain the best possible response. (Hood, 1998)

12. **shorter interwave latency**

Females may show shorter interwave latency which may be related to shorter cochlear response times in females than males. (Don, Ponton, Eggermont and Masuda, 1994)

13. (d) **None of the above**

Various studies suggest that the recording of ABR is not influenced by sedatives, relaxants and barbiturates . (Hood, 1998)

14. False:

ABR recordings are not affected by sleep or altered by metabolic or toxic coma and hence do not differ significantly as a function of attention. (Hood, 1998)

15. (c) Latency increases, amplitude decreases and morphology deteriorates.

With increase in rise time, latency increases, amplitude decreases and morphology deteriorates. (Hood, 1998)

16. Muscle activity

Muscle activity may effect the ABR, as muscle potentials generated due to movement increases noise / artifact. So it is generally recommended that patient should be quiet and relaxed while doing ABR. (Hall, 1992)

17. Wave I and WaveV

The first peak to disappear is wave I, which disappears at approximately 50 dBSL and the last to disappear, is wave V which disappears at approximately lOdBSL. (Hall, 1992)

18. (b) Two channel recording

Usually two-channel recording, using a four-electrode montage is recommended for neurological applications in order to obtain both ipsilateral and contralateral responses. (Hood, 1998)

19. Fsp

Fsp, F denotes an F ratio and SP a single point in the time window of the response. The Fsp method calculates an F ratio that compares variance of the averaged response (an estimate of the averaged signal and the noise) to the variance of the amplitude of single point at a given time in each sweep (which is an estimate of background noise). (Don and Elberling, 1996)

20. (d) All of the above

For 500 Hz tone-burst stimuli, a longer analysis time (20 msec), extending high pass filter to 30Hz and Blackmann windowing is selected for generation of tone-burst as it is characterized by relatively little spectral splatter and is therefore reasonably frequency specific. (Bachmann and Hall, 1998)

21. (b) With in 2000 ohms

Fairly equal impedance i.e with in 2000 ohms of each other facilitates the efficiency of the common mode rejection system, which serves to minimize background interference. (Hood, 1998)

22. False:

A rarefaction stimulus produces an initial outward movement of the earphone diaphragm that generally leads to an outward movement of the footplate of the stapes and an upward motion of the basal most structures of organ of corti. Since the upward motion of basilar membrane is the depolarizing motion for hair cells, latency is slightly shorter and amplitude is higher for the early components of ABR. (Borg and Lofqvist, 1982).

23. False:

As the repetition rate is increased, morphology of ABR wave components becomes poorer and poorer. Although ABR wave components I and V usually donot become indistinct with increased rate in normal subjects, wave II,III and IV may become less identifiable or may even disappear at higher stimulus rates such as 80-100/msec.
(Fowler and Noffsinger, 1983)

24. (a) **10nv**

Practically more than lOuv and less than $50\mu v$ is used as it serves to exclude large electrical responses such as those related to muscle activity or the environmental noise while including response of interest. (Hood, 1998)

25. (c) 30 to 3000 Hz

While recording the ABR using low-frequency tone-bursts such as 500 Hz, filter settings of 30 to 3000 Hz are recommended to emphasize wave V primary component in low frequency tone-bursts ABR. (Hood, 1998)

26. False:

Use of alternating clicks may produce waves which are less sharply defined because the initial displacement of the cochlear partition in response to a condensation wave (initial stapes move inward) is toward the scala tympani, whereas the direction of initial displacement to a rarefaction wave (initial stapes move outward) is towards scala vestibuli, So there will be slight temporal disparity and resultant latency difference between the auditory nerve and brainstem components evoked by condensation versus rarefaction stimuli, thus alternating clicks may 'smear' or broaden the waveform of the averaged response.(Weber, 1994)

27. True:

Under ideal conditions, 1000 averages are probably adequate and averaging can be halted with fewer stimulus repetitions if a clear and reliable response is recorded. (Hall, 1992)

28.True:

The typical five- to- seven wave complex seen with clicks generally is not seen in responses obtained with 500 Hz tone bursts. When interpreting the responses obtained to 500 Hz tonebursts, we look for a single replicable peak that represents wave V of the ABR. (Hood, 1998)

29. (b) Absolute latency of all waveforms increases and waveform clarity decreases.

An increase in the absolute latency of all waveforms and a decrease in waveform clarity occurs when repetition rate is increased while recording ABR (Musiek, Borenstein, Hall and Schwaber,1994)

CUNICAL APPLICATIONS OF ABR

1. Inter-peak latency difference between I and III peak is approximately 4 msec in normal hearing adults.

True or False

2. Latency of wave_____is used, most often, in differential diagnosis of auditory disorders.

3. Conductive hearing loss results in prolongation of all the waves but the inter peak intervals remains within normal limits.

True or False.

4. The presence of wave III is used to estimate the threshold

True or False.

5. Air conduction (AC) auditory brain stem responses and bone conduction (BC) auditory brain stem responses have same waveform morphology.

True or False.

6. In comparison to persons with normal hearing, the slope of latency-intensity function observed in cochlear hearing loss is often_____.
   (a) Parallel
   (b) Steeper
   (c) Overlapping
   (d) Same

7. In which of the following conditions there is an increase in the absolute latency and the inter-aural latency difference:
   (a) Cochlear pathology
   (b) Retrocochlear pathology
   (c) Parkinsonism
   (d) All of the above

8. The latency of bone conduction stimulus is approximately 0.5 msec_____ latencies than air conduction in adults and older children.

9. ABR is a subcortical response

True or False

10. One can ensure the presence or absence of hearing loss based on the presence or. absence of ABR

True or false

11. It is possible to detect ABR, from a quiet sleeping , normal hearing child at intensity as low as:
   (a) 30 dBnHL
   (b) 35 dBnHL
   (c) 20 dBnHL
   (d) 40 dBnHL

12. ABR can be effectively used in hearing aid selection

True or False

13. Identification of Wave I helps in differential diagnosis of cochlear vs retrocochlear pathology

True or False

14. Wave V/I amplitude ratio indicates retrocochlear pathology when its value is less than
    (a) 1.0 sec
    (b) 2.0 sec
    (c) 0.5 sec
    (d) 1.5 sec

15. Match the neural generator responsible for generation of different waves.

1. Wave I	a) Cochlear Nucleus
2. Wave II	b) Lateral Lemniscus and also some fibres ending in Inferior Colliculus
3. Wave III	c) Distal part of auditory nerve
4. Wave IV	d) Proximal part of auditory nerve
5. Wave V	e) Superior Olivary Complex and some fibres from Lateral Lemniscus

16. A majority of the studies reports that ABR threshold using clicks correlates best with behavioral threshold at_____frequencies.
    (a) 2000-4000 hz
    (b) 250-4000 hz
    (c) 2000-6000 hz
    (d) 500-4000 hz

17. Interpeak latency difference between Wave I and Wave V is called_____.

18. Absolute amplitude is not considered for diagnosis in ABR because of _____and_____variability.

19. Presence of cochlear microphonic in an ABR waveform can be detected by

(a) Increasing the intensity

(b) Reversing the polarity.

(c) Decreasing the intensity

(d) None of the above.

20. Which of the following measures has excellent sensitivity and specificity for VIII nerve tumor detection:

(a) Interpeak latency difference

(b) Absolute latency of wave V

(c) Interaural latency

(d) Absolute latency of wave I

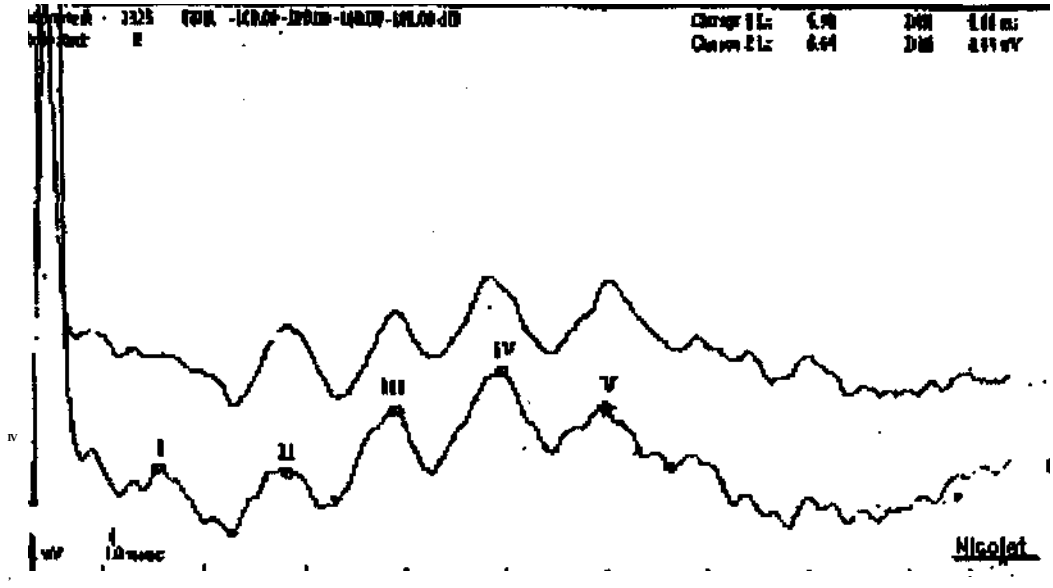
21. Auditory neuropathy patients usually demonstrate abnormal OAE's and normal ABR.

True or False

22. Identification of peaks is necessary while recording steady state evoked potentials

True or False

23. A 35 year old female patient complaining of tinnitus intermittantly in the right ear and constantly in the left ear consulted an audiologist. Pure-Tone audiometry results showed mild flat hearing loss in the right ear and mild low frequency loss in the left ear. Tone decay was negative in both the ears .The ABR waveform configuration is given below.



The pathology could be:

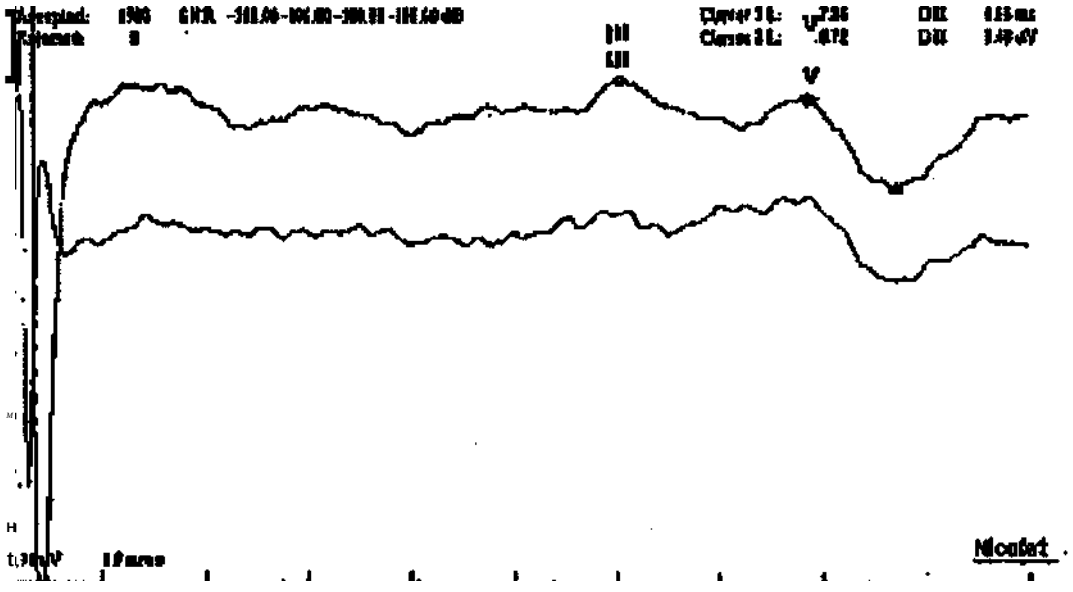
(a) Multiple Sclerosis

(b) Acoustic Neuroma

(c) Menieres Disease

(d) Otitis Media

24. A 7 year old female complained of unilateral tinnitus and difficulty in understanding speech in the left ear. Audiogram indicated a high frequency loss in the left ear. ABR waveform is given below.



The pathology could be:

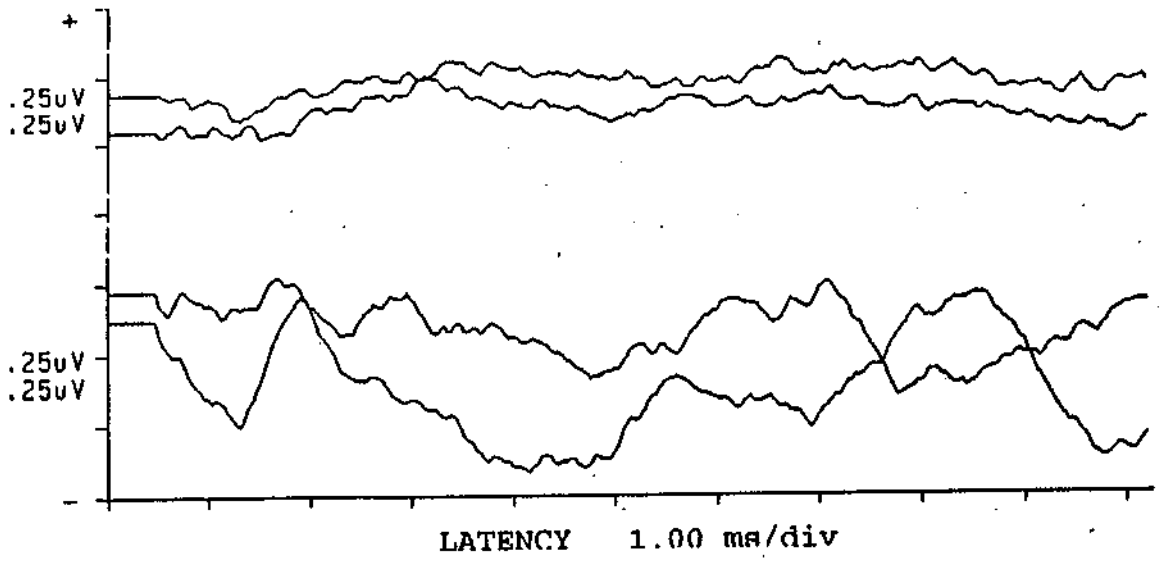
(a) Multiple sclerosis

(b) Acoustic Neuroma

(c) Menieres Disease

(d) Otitis Media

25.A 14 year old boy was referred from school with a complaint of inattentiveness in the class. Pure tone audiometry showed moderate SN hearing loss with inconsistent responses. DPgram indicated normal cochlear functioning. ABR waveform is given below:



The diagnosis could be:

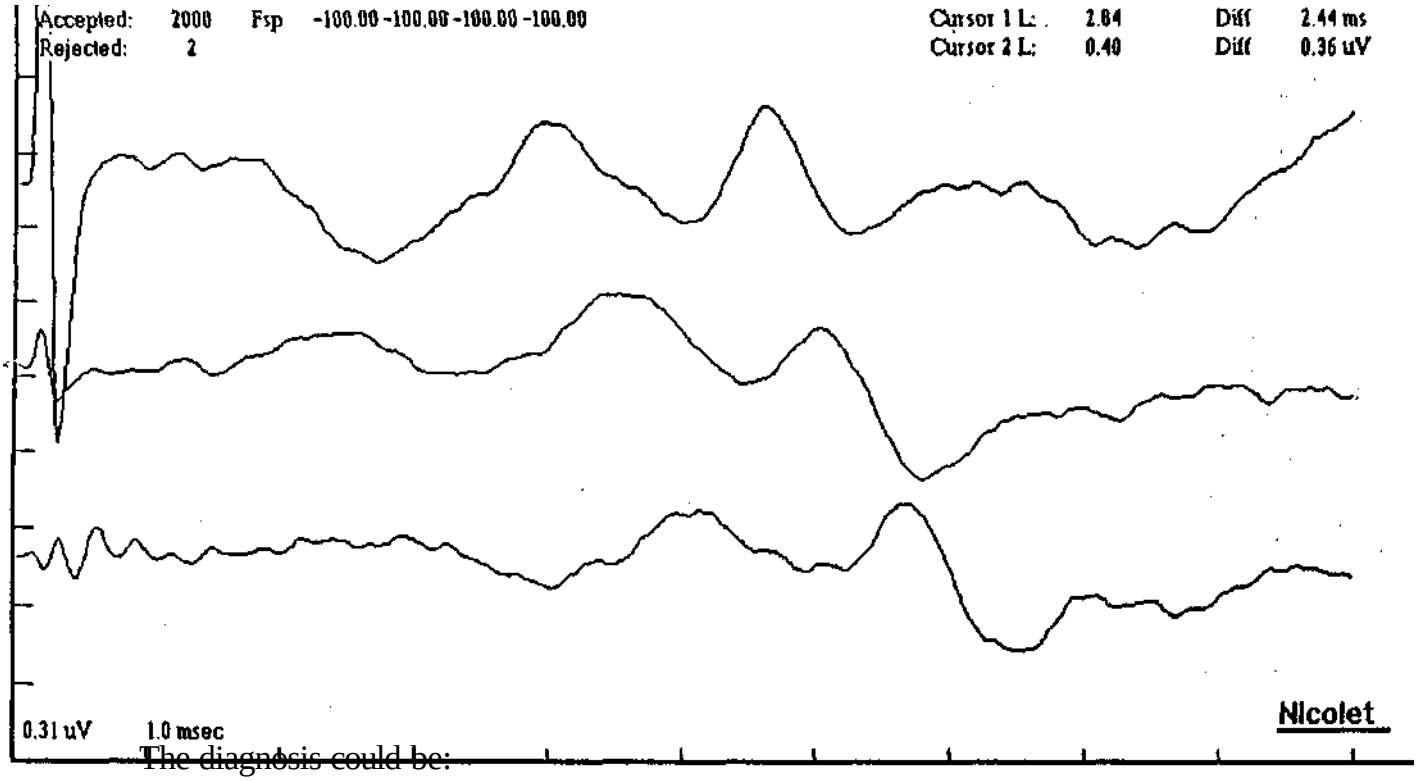
(a) Cochlear Pathology

(b) Auditory Neuropathy

(c) Pseudohypocusis

(d) None of the above

26.A man brought his child with a complaint of hearing loss in the right ear after being slapped by the teacher. Pure tone audiometry indicated moderate hearing loss in the right ear. Stapedial reflexes were present in both the ears. The ABR recording at 70dBnHL, 50dBnHL and 30 dBnHL is shown below:



The diagnosis could be:

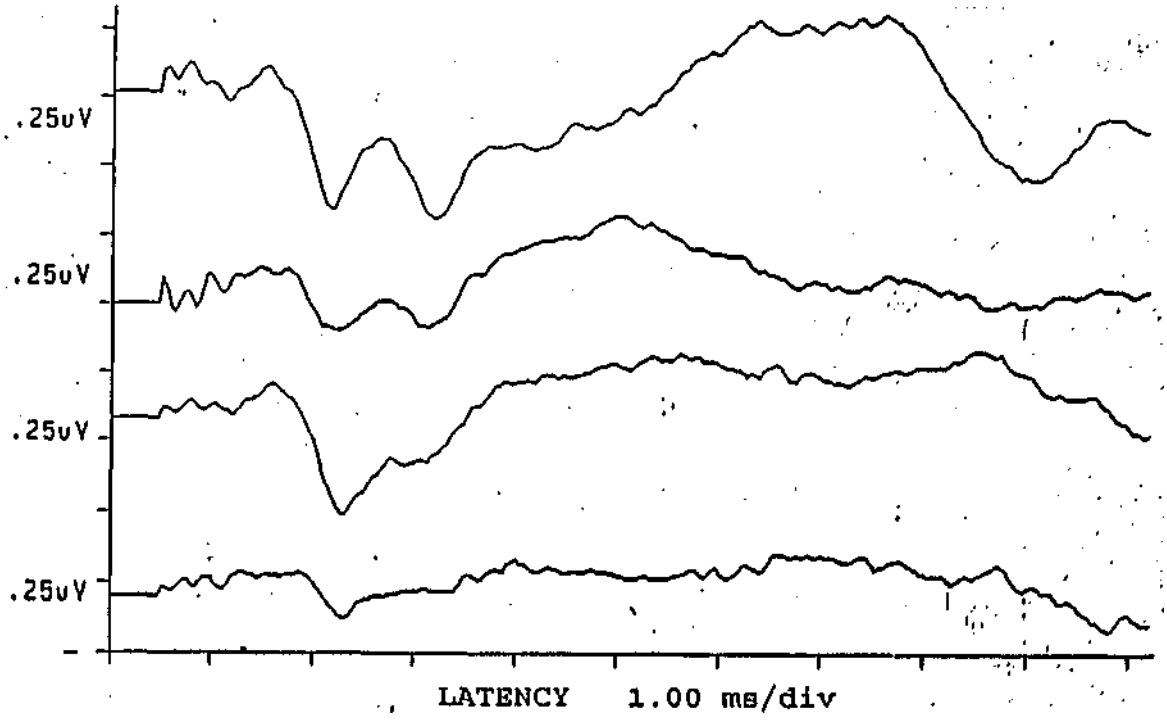
(a) Acoustic Trauma

(b) Pseudohypocusis

(c) Autoimmune Disorder

(d) None of the above

27. A girl of 16 reported of poor scholastic performance and difficulty in hearing in noise. Audiogram revealed mild hearing loss. Speech Identification Scores were near normal. ABR result was normal in the right ear. The responses recorded from the left ear are shown below.



The possible site of lesion could be:

(a) Temporal Lobe lesion

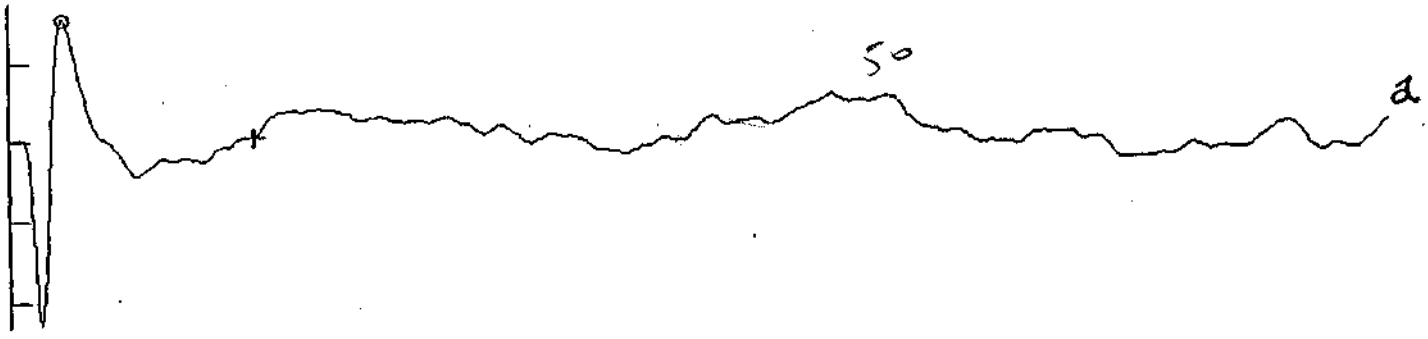
(b) Retrocochlear pathology

(c) Upper Brainstem Lesion

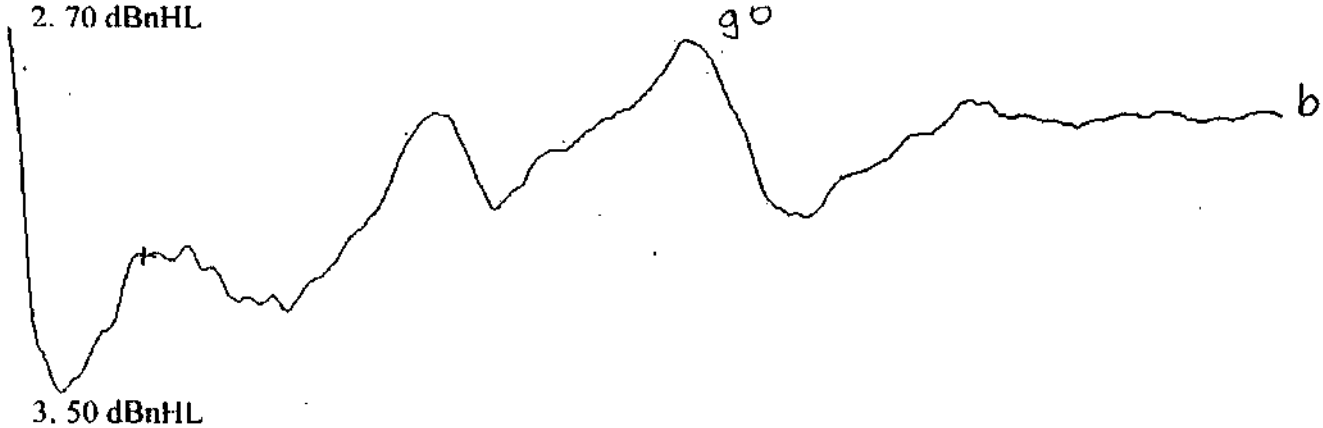
(d) Lower Brainstem Lesion

28. Match the following ABR waveforms with possible respective intensity levels of click stimuli.

1. 90 dBnHL

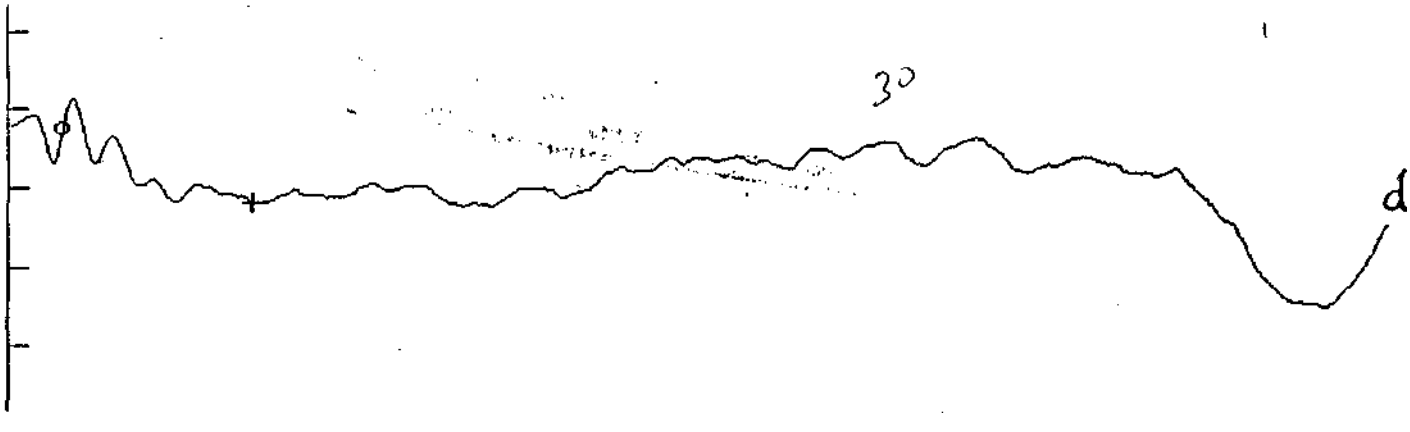


2. 70 dBnHL

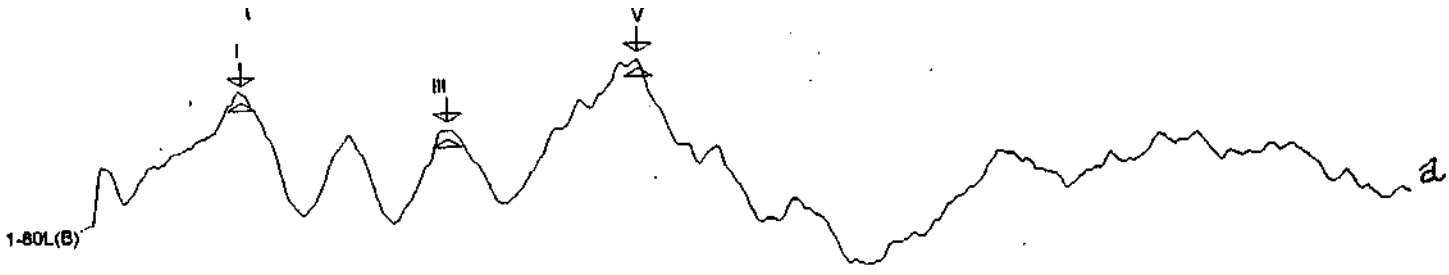


3. 50 dBnHL

4. 30 dBnHL



29. Match the following ABR waveforms with possible electrode montage:



30. A 30 year old patient reported with the complaint of hearing loss and giddiness since 3 years. Pure tone audiometry indicated high frequency hearing loss in both ears. Poor performance was observed on speech identification task. Refiexometry showed absent reflexes in both ears. TEOAE's were present in both ears. The ABR results are shown below:

The pathology could be:

(a) Cochlear pathology

(b) Retrocochlear pathology

(c) Pseudohypocusis

(d) None of the above

SOLUTIONS

1. False:

Inter-peak latency between I and III peak is approximately 2 msec where as IPL between I and V peak is approximately 4 msec in normal hearing adults. (Musiek, Borenstein, Hall and Schwaber, 1994)

2. **Wave** V

Latency of wave V helps in differential diagnosis of auditory disorders.
(Musiek, Borenstein, Hall and Schwaber, 1994)

3. **True:**

When there is conductive hearing loss, there is prolongation of all the waves with normal inter peak intervals. (Hood, 1998)

4. **False:**

Presence of Wave V is used to estimate threshold, as it is the most robust and stable component of ABR. (Weber, 1994)

5. **True:**

Compared with ABR's elicited by AC clicks, at the same intensity levels BC ABR's have essentially the same waveform morphology, but have approximately 0.5 msec longer latency in adults and older children. (Weber, 1994)

6. (b) **Steeper**

Latency-intensity function observed in cochlear hearing loss is often steeper than that seen in normal or retrocochlearpathology as wave V latency increases at faster than normal rates at moderate intensities. (Hood, 1998)

7. (b) Retrocochlear pathology

Usually in RCP, the absolute latency and inter-aural latency difference increases. (Musiek, Borenstein, Hall and Schwaber, 1994)

8. **Longer**

In adults and older children, the latency of ABR for bone conduction stimuli is approximately 0.5msec longer than that air conduction ABR which is likely due to increased travel time along the cochlear partition for the BC stimulus which has more energy at lower frequencies. (Weber, 1994)

9. **True:**

ABR is a subcortical response and is highly sensitive to disorders impacting the brainstem, hence cannot be viewed as a measure of hearing in the same manner as a conscious behavioral response. (Weber, 1994)

10. **False:**

ABR testing examines only a limited portion of the auditory system i.e. presence of ABR indicates that the test stimulus has elicited synchronous neural firings within the auditory system upto level of midbrain but doesn't ensure normal processing of auditory stimuli at the cortical level. Similarly absence of ABR doesn't always indicate that a peripheral hearing loss exists. Disorders such as hydrocephalus and auditory neuropathy, which reduces the synchrony of neural firings with in the brainstem, may obliterate the ABR even when the peripheral auditory system is normal. (Kraus, Ozdamar, Stein and Reed, 1984)

11 (c)20dBnHL

It is possible to detect ABR, from a quietly sleeping, normal hearing child at intensity as low as 20 dBnHL.(Weber, 1994)

12. False:

The clinical application of ABR in hearing aid selection has been limited because of many reasons:

1. First the abrupt click stimulus, which is so important in eliciting a clear ABR, can produce ringing in the hearing aid, thus results in artifacts which may persist sufficiently long so that it obliterates much or all of the ABR.
2. A second procedural problem relates to the compression circuits as they respond too slowly to be reflected in the ABR to click stimuli. (Weber, 1994)

13. **True:**

Identification of Wave I latency allows calculation of the wave I-V interval and resolve whether the reason for wave V delay is related to peripheral hearing loss or retrocochlear lesion. (Hood, 1998)

14. (c) **0.5 msec.**

It has been reported that in patients with eighth nerve tumors and auditory brainstem disorders, wave V/I amplitude ratio is less than 0.5 msec. (Hood, 1998)

15.

1. Wave I	c)	Distal part of auditory nerve
2. Wave II	d)	Proximal part of auditory nerve
3. Wave III	a)	Cochlear Nucleus
4. Wave IV	e)	Superior Olivary Complex and some fibres from Lateral Lemniscus
5. Wave V	b)	Lateral Lemniscus and also some fibres ending in Inferior Colliculus

(Hall,1992)

16. (a) 2000-4000 Hz

The frequency emphasis of click is determined by resonant frequency of the transducer. Thus when we use standard TDH-39 or TDH-49 or ER-3 Insert earphones, the energy peaks are in frequency region between 2-4 kHz. Therefore ABR threshold correlates best with behavioral threshold between 2-4 kHz.
(Bauch and Olsen, 1986)

17. **Brainstem conduction time/ Central conduction time.**

Interpeak latency difference between Wave I and Wave V is called as brainstem conduction time / central conduction time as it tells about time taken for impulse to reach auditory nerve from brainstem i.e. it tells whether the condition of signal in brainstem is normal or not. (Hood, 1998)

18. **Intersubiect and intrasubject variability.**

Absolute amplitude is not considered for diagnosis in ABR because of high intersubject and intrasubject variability. (Silman and Silverman, 1991)

19. (b) **Reversing the polarity.**

When the polarity of the stimulus (i.e. changing from condensation to rarefaction clicks) is reversed, the recorded responses also reverse, which is characteristic of cochlear microphonics. (Hood, 1998)

20. (a) **Interpeak latency difference**

Interpeak latency difference measure has excellent sensitivity and specificity for VIII nerve tumor detection as it is least affected by conductive or cochlear pathology. (Hood, 1998)

21. **False:**

Subject with auditory neuropathy usually demonstrate normal otoacoustic emissions suggesting normal outer hair cells and absent or grossly abnormal ABR consistent with a neural disorder. (Starr, Picton, Sininger, Hood, and Berlin, 1996)

22. False:

Identification of peaks is not necessary while recording steady state evoked potentials as a composite of responses to stimuli at various frequencies and intensities can be constructed in order to view the lowest levels where responses are obtained.
(Hood, 1998)

23. (c) **Menieres Disease.**

ABR results show that inter-peak and inter-aural latency is with in normal limits indicating the presence of cochlear lesion. Low frequency hearing loss and intermittant tinnitus shows that the pathology could be Meniere's Disease.

24. (b) **Acoustic Neuroma.**

Prolonged absolute latency of Peak V and III, normal III-V inter-peak latency, absence of Wave I, all these along with the audiometry findings of unilateral hearing loss indicates a pathology in auditory nerve.

25. (b) **Auditory Neuropathy**

A typical indicator of auditory neuropathy is an abnormal ABR with normal OAE's

26. (b) **Pseudohypocusis.**

ABR results shows that ABR was present till 30 dBnHL, also stapedial reflexes were present in both the ears. All these indicate that this might be a case of Pseudohypocusis.

27. (c) **Upper Brainstem Lesion.**

ABR results show that earlier peaks are present while later peaks are absent indicating a possible pathology in the upper brainstem.

28.

1. b)
2. c)

3. a)
4. d)

29. 1 - a)

2- b)

Here b) is the contralateral ear as Wave IV and V are better separated in contralateral recordings as seen in the waveform,while a) is the Ipsilateral as Wave I is more prominent in ipsilateral recording ,also wave IV is overlapped with wave V in ipsilateral recordings.

30. (b) **Retrocochlear pathology**

Prolonged absolute latency of Peak V and absence of earlier waves, all these indicate that the pathology could be a retrocochlear one.

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