USEFULNESS OF IMMITANCE AUDIOMETRY TO IDENTIFY RETROCOCHLEAR PATHOLOGY- A TUTORIAL

Suchi Soni

Register No. 10DNA007

Independent Project as a fulfillment of the Post Graduation Diploma in Neuro Audiology,

submitted to University of Mysore,

Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTHRI

MYSORE 570 006

JUNE 2011

CERTIFICATE

This is to certify that this independent project entitled **"Usefulness of Immittance Audiometry to identify Retrocochlear Pathology - A Tutorial"** is a bonafide work in part fulfillment of degree of Post Graduate Diploma in Neuroaudiology of the student registration no: 10DNA007. This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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Mysore

June, 2011

CERTIFICATE

This is to certify that this independent project entitled **"Usefulness of Immittance Audiometry to identify Retrocochlear Pathology- A Tutorial"** has been prepared under my supervision and guidance. It is also certified that this independent project has not been submitted earlier to any other university for the award of any diploma or degree.

Mysore

June 2011

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DECLARATION

This independent project entitled '**Usefulness of Immitance Audiometry to identify Retrocochlear Pathology- A Tutorial'** is the result of my own study and has not been submitted earlier at any university for any other diploma or degree.

Mysore **Register No. 10DNA007**

June, 2011

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Here I would like to remember Late Dr. Vijaylakshmi Basavaraj under whose tenure we began this course. Ma'am, I remember your words and good deeds and pray that you may rest in peace.

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My final thanks are to my parents for their support and their confidence in me. I hope I have lived up to the faith they have in me. I love you mom and pa.

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INTRODUCTION

The word ‘tutorial ‘as defined by scientific and English dictionaries refer to an ‘instruction book’ or ‘intensive instruction in some area’. It aims at providing supplementary instructions in order to present better opportunities to student and concerned professionals to actively participate in the learning process and receive immediate feedback. The information is carefully selected and delivered in an organized and structured manner. It also evaluates the user’s knowledge through different kinds of questions which gives him/her an immediate feedback of the performance. It thus, acts as an efficient guide for students and experts linked with the particular field. The present tutorial aims at providing intensive instruction in the area of ‘usefulness of immittance to identify retro cochlear pathology’.

Though the concept of immittance is very old and a routine component of the audiological evaluation, immittance audiometry is one of the most powerful tools available for the evaluation of auditory disorders. It serves three functions in the audiological assessment:

- It is sensitive in detecting middle ear disorders
- It can be useful in differentiating cochlear from retro cochlear disorders, and
- Helpful in estimating degree of peripheral hearing sensitivity and is often used to cross check pure tone behavioral thresholds.

Acoustic immittance measurement includes two major procedures: ‘TYMPANOMETRY’ and ‘REFLEXOMETRY’. Tympanometry is used to study the compliance change of the tympanogram with respect to pressure variation in the external ear canal. The measurement is represented in a graphical form called ‘tympanogram’. Depending on the type of tympanogram obtained, one can predict the possible middle ear pathology.

Acoustic reflex measures the impedance change occurring in the middle ear on presentation of loud stimulus. This procedure also gives us an insight into the middle ear functioning and also provides information about the hearing sensitivity of the individual.

This procedure is now common, not only in audiology clinics, but also in ENT centers and other diagnostic units. In the present century when great importance is being given to early identification and intervention, it is obvious, how great an importance this technique has in identifying otological abnormalities at an early stage.

From the above discussion, it is now clear, how important it is for students and professionals in the field of audiology to know about these measurement procedures in depth. The present tutorial has been developed keeping this aim in mind. It deals with applications of immittance measurement in separate sections under which a great amount of information has been presented on each sub topic in a comprised form. The informations have been collected from books, journals and other sources. This is followed by a set of questions. These questions are of the following types:

- Fill in the blanks
- Multiple choices
- True/false
- Short answer
- Complete the diagrams.
- Match the following, etc.

The questions are neither too complex nor too simple. In order to cross check the results, answers are being provided to all the questions at the end of each section. This would give an immediate feedback to one's performance.

Thus, this particular project is aimed to serve the following purposes:

- Gives intensive information on immittance audiometry and its application in detecting retrocochlear pathology.
- To test one's knowledge of the topic.
- To serve as a guide for students and other concerned professionals.
- To train and evaluate trainees during a training program

HISTORICAL ASPECTS OF IMMITTANCE TEST

The history of clinical acoustic immittance is well over 100 years old. Wollaston, 1820 reported that the negative pressure in the middle ear altered the tension on the tympanic membrane and resulted in decreased hearing sensitivity. According to Feldman (1970) the first attempt at objective assessment of middle ear function using acoustic immittance measures were performed in 1867 by Lucae.

The term impedance was first introduced as an electrical term by Heaviside (1892). Heaviside adapted the term impedance from the verb impede and used this term to represent the ratio of an impressed force to the current in a circuit line. In 1919, Webster extended the principle of electrical impedance to the analysis of acoustical system. The first acoustic impedance measure with an actual probe tube inserted into the human ear canal, were reported by Troger in 1930. Application of acoustic impedance in clinical audiology was evident from the work of Metz. He published his classic monograph on impedance in 1946.

Developments in instrumentation permitted easy measurement, but it was largely ignored in clinical practice for decades as emphasis was placed on the objective measurement of middle ear disorders. Until the late 1960s, diagnostic use of impedance measures emphasized the identification of middle ear disorder. Terkildsen and Thompson (1959) explored the utility of tympanometry as a differential diagnostic technique for middle ear abnormalities. However the term ‘tympanometry’ was first used by Anderson and colleagues in 1956 to describe a clinical test.

The acoustic reflex in diagnostic audiology has a long history. It was first reported to be reliably measured in clinical patients in 1946 by Metz. He described the first practical impedance bridge for measurement of the acoustic reflex that would eventually permit inexpensive noninvasive recording of the effect of the acoustic reflex on the input immittance of the middle ear.

Over the next four decades, diagnostic use of the acoustic reflex progressed in parallel with instrumentation refinements. Luscher made the first direct observation of the acoustic reflex in humans in 1929. He viewed the movement of stapedius tendon through a perforation in the tympanic membrane of the patient who had an otherwise normal middle ear. Jepson (1955) reported the use of intra aural muscle reflex in the location of facial nerve lesion.

Anderson, Barr & Wedenberg (1969) showed acoustic reflex to be a sensitive measure of VIII nerve disorder and a useful tool in differential diagnosis between cochlear and retro cochlear disorders. After that the acoustic reflex was studied clinically in conjunction with other impedance measures and shown to be a valuable diagnostic tool.

Anderson et. al. (1969) proposed the use of reflex measures, specifically reflex decay, as an indicator of retro cochlear pathology. The addition of routine measurement of uncrossed reflexes allowed for successful differentiation of middle ear from cochlear, cochlear from VIII nerve, and VIII nerve from brain stem disorders. Finally, advances were made in the measurement of supra threshold reflex properties and thus increased the diagnostic sensitivity of the acoustic reflex measurement (Kristensen & Jepsen, 1952; Jepsen, 1963).

However it is largely based on the contributions of Jerger during the early 1970s that immittance audiometry earned its way into routine clinical use. In the middle 1970s, Jerger extended the concepts to the identification of VIII nerve and brainstem disorder. At the same time, other laboratories were beginning to report similar effectiveness of the acoustic reflex in identification of neuropathology.

QUESTIONS

Answer in one word:

1. Who described the first practical impedance bridge for measurement of the acoustic reflex?
2. Who first reliably measured Acoustic reflex in clinical population?
3. Who proposed reflex decay, as an indicator of retro cochlear Pathology?
4. Who first introduced the term impedance?

Fill in the blanks:

1. ------------made the first direct observation of the acoustic reflex in humans in---------
2. -------- in -------- showed acoustic reflex to be a sensitive measure of VIII nerve disorder.
3. The term ‘tympanometry’ was first used by ---------

Multiple choices:

1. Who explained the utility of tympanometry as a differential diagnostic technique for middle ear abnormalities.
   a) Luscher (1929)
   b) Jerger (1970)
   c) Terkildsen and Thompson (1959)
   d) Jerger (1969)

2. Immittance audiometry earned its way into routine clinical use because of the major contribution of-------
   a) Jerger
   b) Kristensen
   c) Jepsen
   d) Borg
3. Who reported that the negative pressure in the middle ear altered the tension on the tympanic membrane and resulted in decreased hearing sensitivity?
   a) Luscher (1929)
   b) Wollaston, 1820.
   c) Jepsen (1984).
   d) Wedenberg (1969).
4. Metz published his classic monograph on impedance in the year ------
   a) 1946
   b) 1820.
   c) 1984.
   d) 1969.
5. Who reported the use of intra aural muscle reflex in the location of facial nerve lesion?
   a) Jepson (1955)
   b) Wedenberg (1969).
   c) Anderson (1969).
   d) Starr, 1996

True/false:

1. The acoustic reflex is studied clinically in conjunction with other impedance measures and shown to be a valuable diagnostic tool.
2. The first attempt at objective assessment of middle ear function using acoustic immittance measures were performed by Lucae (1867).
3. Reflex measures does not allow differentiation between cochlear and retrocochlear pathologies.

Answers:

One word answers:

1. Metz
2. Metz (1946).
3. Anderson, Barr and Wedenberg (1969).
4. Heaviside (1886).

Fill in the blanks:

1. Luscher, 1929.
2. Anderson (1969)
3. Anderson (1956)

Multiple choices:

1. Terkildsen and Thompson (1959)
2. James jerger.
3. Wollaston, 1820.
4. 1946.
5. Jepson (1955)

True/false:

1. True.
2. True.
3. False.

TYMPANOMETRY

Tympanometry is defined as the dynamic measure of acoustic immittance in the external ear canal as a function of changes in air pressure in the ear canal (ANSI, S3.39, 1987). Acoustic immittance is a general term that refers to either acoustic admittance or impedance. Acoustic admittance is the ease with which the energy of a pure tone flows into the middle ear system. The inverse of admittance is acoustic impedance, which is the opposition to the flow of energy (ANSI, S3.39, 1987; Wiley & Fowler, 1997). Pathological conditions of middle ear alter the mechano acoustic characteristics of the system, which thus alter the acoustic admittance of middle ear system. Tympanometry basically measures the physical changes associated with middle ear pathology (Lilly, 1972).

To measure these variations in admittance, a pure tone of known frequency and constant intensity is introduced in the ear canal. Usually frequencies of 226 HZ, 660 HZ or 1000 HZ probe tones are used to obtain tympanogram and are called as probe tones. The intensity of the probe tone at 226 Hz is 85 dB SPL and 75 dB SPL at 1000 Hz. (Jerger, 1970). Usually 660 and 1000 HZ frequency probe tones are used with infants. The pressure in the ear canal is varied from +200 mmH20 to -400 mmH20. The variations in the impedance are noted on a graph, called as tympanogram. Thus, the tympanogram is a graphical representation of pressure compliance function (Jerger, 1970; Liden, Harford & Hallen, 1974).

Classification of tympanogram

Tympanograms are useful in clinical diagnosis of middle ear pathologies. There are 3 parameters which are considered for the classification of the tympanograms (Feldman & Wilber, 1976). These are:

- The maximum compliance of the eardrum (amplitude).
- The peak pressure i.e. the air pressure at which maximum compliance of the ear drum is noteds.
- Shape of the tympanogram.

Table 1: Amplitude, tympanometric peak pressure and shape of different types of tympanogram.

Type	Amplitude (mmho)	Pressure peak(dapa)	Shape
A	Normal (0.5 -.75)	Normal(+60 to-100dapa)	Smooth
As	Reduced(<0.5)	Normal	Smooth
Ad	Increased (1.75)	Normal	Smooth
B	Reduced	No peak	Flat
C	Normal	Negative (<-100)	Smooth
D	Normal	Normal	Double Peak
E	Normal	Normal	Double Peak

Table 1 is depicting normal values of compliance, peak pressure and also different shapes of the tympanogram. Based on these parameters the tympanograms are expressed as type ‘A’, ‘B’, ‘C’, ‘D’, ‘E’, ‘As’, and ‘Ad’ (Jerger et al, 1972; Liden et al, 1974). The different types of tympanograms can be seen in figure 1, 2 and 3.

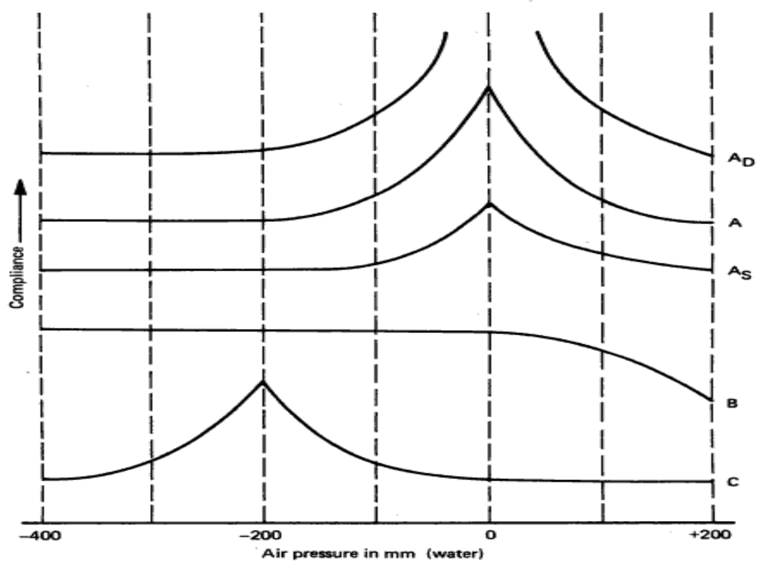


Figure 1: Group of tympanograms of type A, As, Ad, B, and C.

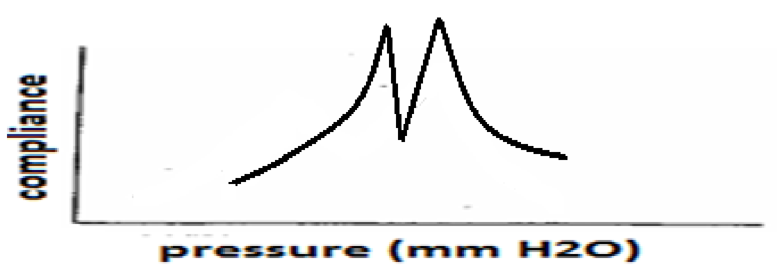


Figure 2: 'D' type tympanogram.

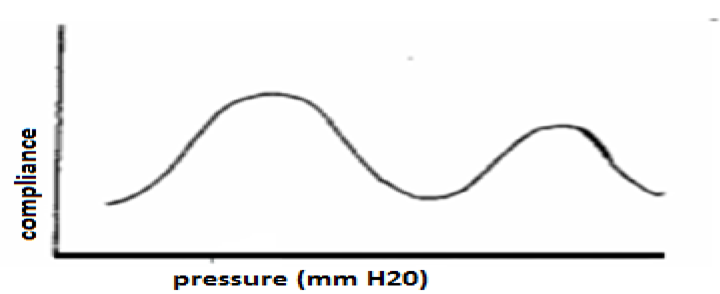


Figure 3: 'E' type tympanogram.

Tympanometric findings in retrocochlear pathology

Space occupying lesion

Retrocochlear pathology refers to site of lesion at the cranial nerve VIII, cerebellopontine angle, or root entry zone of the VIII nerve into the brain stem without any middle ear and cochlear involvement.

In the patient with Space occupying lesion (with intact and healthy middle ear), the tympanometry results will show 'A' type tympanogram with normal Peak Amplitude, peak pressure at or near 0 dapa i.e. characteristics of normal middle ear function (Feldman & Wilber, 1976).

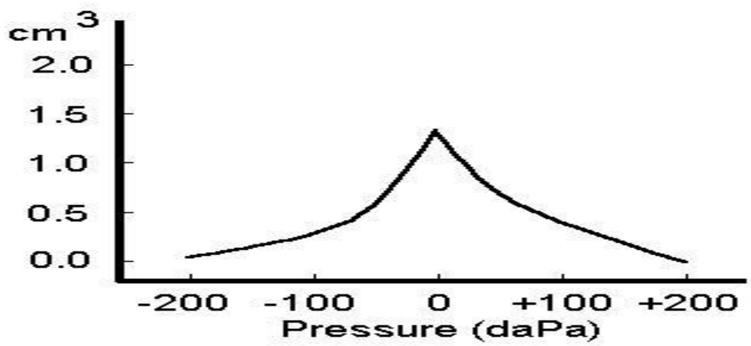


Figure 4: 'A' type tympanogram in retrocochlear pathology.

Neuromuscular disorders (myasthenia gravis)

Myasthenia gravis is a disease affecting the nerve muscle transmissions which causes a poor Eustachian tube function. This subsequently results in muscular weakness. Morioka et al (1976) reported that on tympanometry, a negative middle ear pressure was observed. This may be because of the weakness of the tensor veli palatine muscle. In such a condition the tympanometry result will show 'C' type tympanogram with normal peak amplitude and negative peak pressure i.e. beyond -100 dapa.

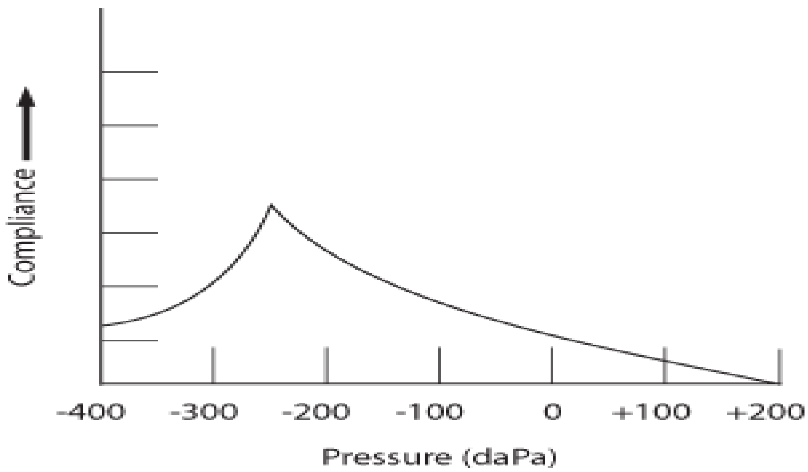


Figure 5: 'C' type tympanogram in myasthenia gravis.

Demyelinating disease (multiple sclerosis)

Multiple sclerosis is an autoimmune disease that affects the brain and spinal cord (central nervous system) in which the fatty myelin sheaths around the axons of the brain and spinal cord are damaged, leading to demyelination and scarring of nerve fibers. The site of pathology in this condition is beyond the cochlea that indicates the normal middle ear function.

In such a condition, the tympanometry result will show 'A' type tympanogram with normal peak amplitude and peak pressure at or near 0 dapa i.e. characteristics of normal middle ear function (Feldman & Wilber, 1976).

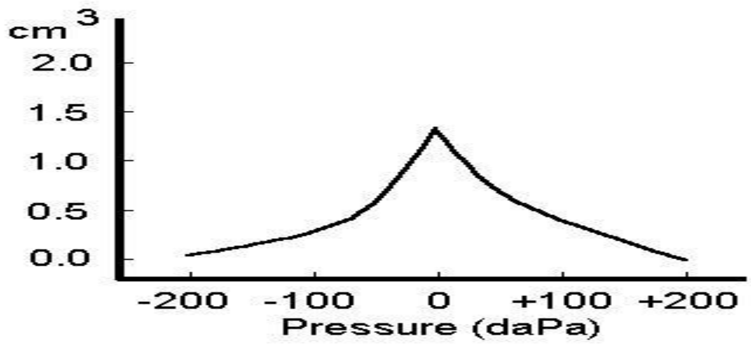


Figure 6: 'A' type tympanogram in multiple sclerosis.

QUESTIONS

One word questions

1. What is the peak amplitude in ‘A’ type tympanogram?
2. What is the type of tympanogram seen in eight nerve tumor?

Fill in the blanks

1. Tympanometry is defined as the dynamic measure of -------- in the external ear canal as a function of changes in air pressure in the ear canal.
2. Tympanometry measures the physical changes associated with --------ear pathology.
3. Pathologic conditions of middle ear alter the ---------- of the middle ear system.

Multiple choice questions

1. How many major parameters are there which are considered for the classification of the tympanograms?
   a) 3
   b) 4
   c) 2
   d) 1
2. What are the characteristics of normal middle ear function?
   a) Peak pressure at or near 0 dapa.
   b) Compliance between0.5to1.75 mmho
   c) None of the above.
   d) Both a & b
3. Myasthenia gravis is usually associated with --------- type tympanogram.
   a) ‘C’
   b) ‘A’
   c)‘E’
   d ‘As’

True/False

1. Acoustic admittance is the ease with which the energy of a pure tone flows into the middle ear system.
2. 660 and 1000 HZ frequency probe tones are used with infants.

Answers

One word questions:

1. 0.5 -1.75.
2. 'A' type.

Fill in the blanks:

1. Acoustic immittance.
2. Middle.
3. Mechano acoustic characteristics.

Multiple choice questions:

1. 3
2. Both.
3. 'C' type.

True/False:

1. True.
2. True.

NEURONAL ORGANIZATION OF ACOUSTIC REFLEX

The muscles of the middle ear (stapedius and tensor tympanic) are important regulators of the auditory input to the cochlea. The stapidial reflex is bilateral reflex that includes neuronal structures on both sides of the head. A complete evaluation of the neuronal structure involves in a stapedius reflex arc, requires both ipsi lateral and contra lateral reflex measures.

The both ipsilateral and contralateral reflex arcs are well described by Borg (1973). Although the neural pathway for ipsi and contra lateral reflexes shares common structures, there are differences in two pathways that may produce different measurement outcomes in specific pathologies involving the neuronal system.

Knowledge about the pathways is critical for stapedius reflex measures to put to use in diagnostic applications. Below is the ipsi lateral acoustic reflex pathway described by Borg (1973).

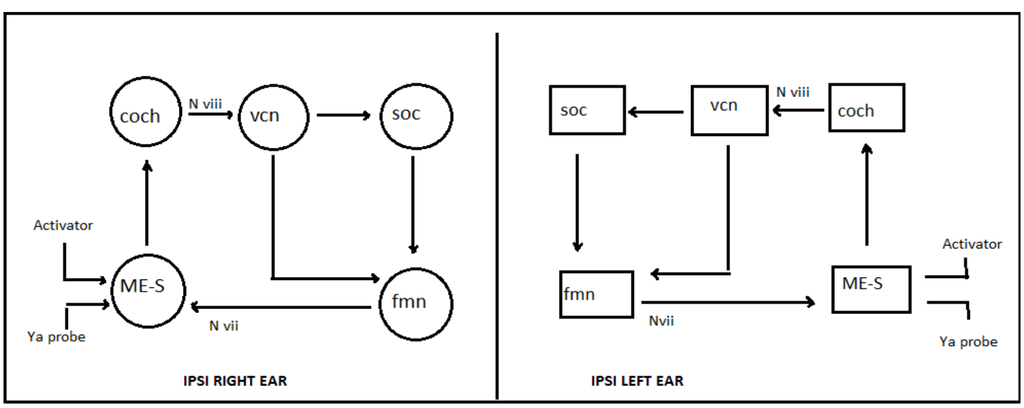


Figure7: ipsilateral reflex arc.(COC-cochlea, ME-middle ear, SOC-superior olivary complex, VCN-ventral cochlear nucleus, FMN-facial motor nucleus, N VIII-cranial nerve 8th, VII- cranial nerve 7th, S- stapedial muscle).

The **ipsi lateral reflex pathway** is a three or four neuron pathway as illustrated in figure 4. Ipsi lateral reflex measure requires presentation of acoustic stimulus in the same ear in which the acoustic immittance changes indicative of stapedius contractions are measured. That is, the activator (stimulus) ear and the probe ear are the same.

Neuronally the primary ipsi lateral acoustic reflex pathway involves the cochlea, eight cranial nerve, ventral cochlear nucleus, superior olivary complex, facial motor nucleus, and motor branch of facial nerve, which innervates the stapedius muscle.

In the diagram, the second line leaving the ventral cochlear nucleus indicates a secondary ipsi lateral pathway that involves only three neurons. Although smaller in fiber density, the direct fiber tract from the ventral cochlear nucleus to the region of the facial motor nucleus has been well documented (Borg, 1973).

A comparable block diagram for the **contra lateral reflex pathway** given by Borg (1973) is shown as figure 8. In the case of contra lateral acoustic reflexes, we deal with crossover of neuronal activity from one side of the head to the other.

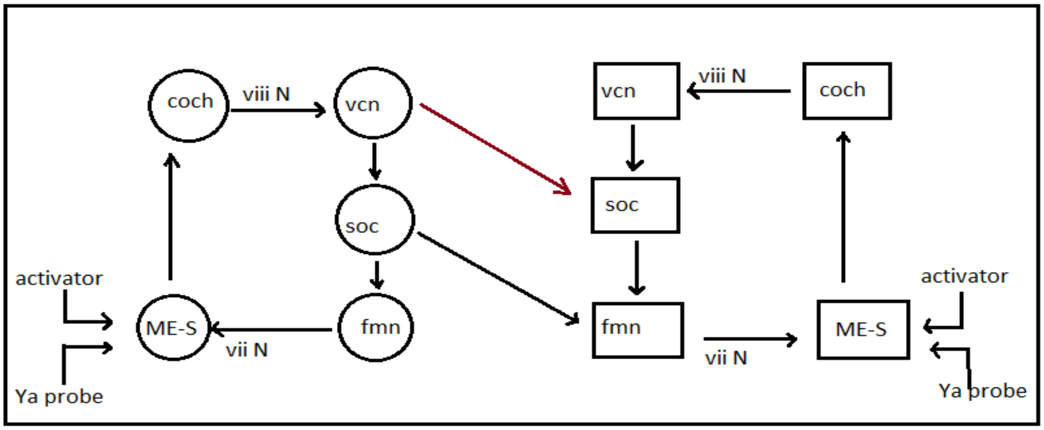


Figure 8: contrlateral reflex arc.(COC-cochlea, ME-middle ear, SOC-superior olivary complex, VCN-ventral cochlear nucleus, FMN-facial motor nucleus, N VIII-cranial nerve 8^{th}, VII- cranial nerve 7^{th}, S- stapedial muscle).

An acoustic activating signal is presented to one ear (stimulus ear) and acoustic immitance changes reflective of stapedius contraction are measured in the opposite ear (probe ear). The neuronal pathway for contra lateral acoustic reflex is a mandatory four-neuron system, after its exit from the cochlea, includes eight cranial nerve, ventral cochlear nucleus, contra lateral superior olivary complex, contra lateral facial motor nucleus, and motor branch of facial nerve which innervates the stapedius muscle on the contra lateral side.

Another contra lateral pathway goes from the ipsi lateral VCN to the ipsi lateral SOC, from which third order neurons cross to the contra lateral facial nerve nucleus. The motor leg of the reflex arc goes from the contra lateral facial nucleus via facial nerve (VII cranial nerve) to the stapedius muscle in the ear opposite to the stimulated cochlea.

QUESTIONS

Fill in the blanks

1. The reflex arc is well described by ………. in (1973) and Lyons in ……..
2. The stapidial reflex is bilateral reflex that includes …….. structures on both sides of the head.

Multiple choice questions

1. Ipsi lateral acoustic reflex pathway involves…..

   a) Cochlea and VIII CN

   b) SOC and FMN

   c) Ventral cochlear nucleus.

   d) All of the above.

2. The neuronal pathway for contra lateral acoustic reflex is a ……… neuron system.

   a) 3

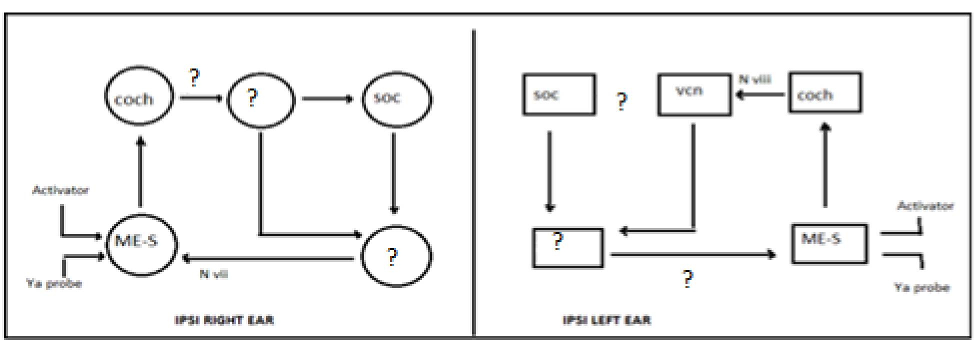
   b) 4

   c) 2

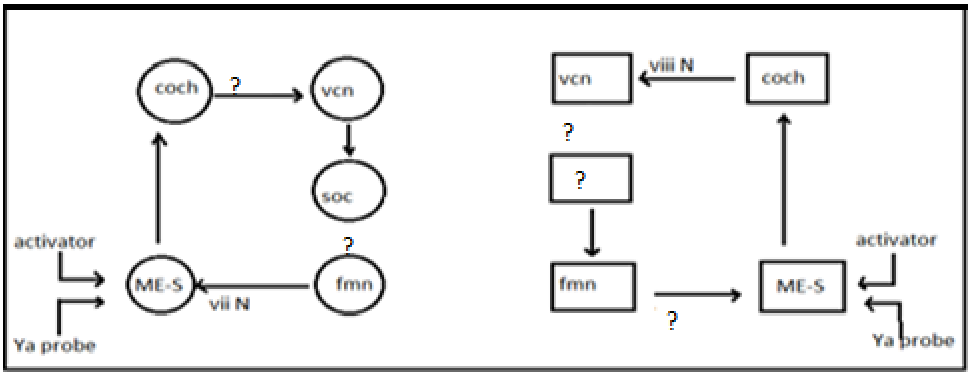
   d) 5

Complete the diagram:

1. Ipsi lateral acoustic reflex pathway.



2. Contra lateral acoustic reflex pathway.



ANSWER:

Fill in the blanks

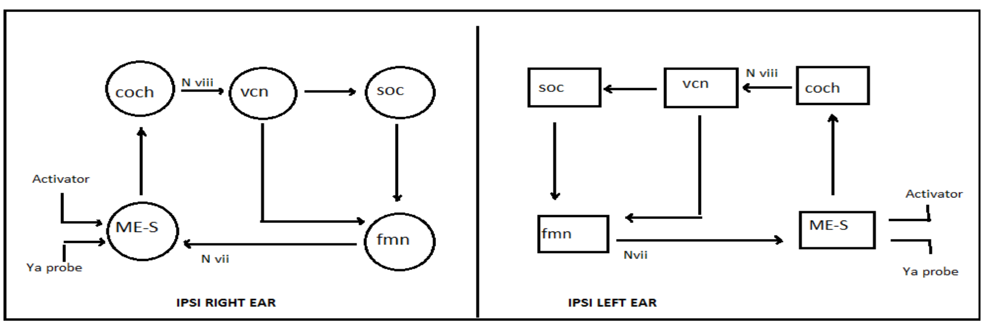
1. Borg, 1978.
2. Neuronal.

Multiple choice questions

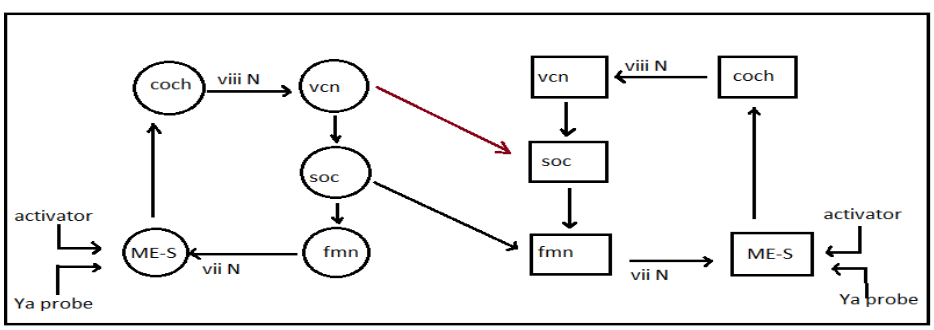
1. All of the above.
2. 4

Complete the diagrams:

1. Ipsi lateral acoustic reflex pathway.



2. Contra lateral acoustic reflex pathway.



ACOUSTIC REFLEX TEST TO IDENTIFY RETRO COCHLEAR PATHOLOGY

Reflex is defined as the simplest form of involuntary response to stimulus. It has been found that, on presentation of loud sound, the stapedius muscle contracts thereby stiffing the ossicular chain. This contraction of the stapedius muscle to loud sound or high intensity sound stimuli is termed as acoustic reflex. It is also known as stapedius reflex, attenuation reflex, or auditory reflex (Wiley & Fowler, 1997). The softest sound or minimum intensity that elicits a reflex contraction of stapedius muscle is called as 'acoustic reflex threshold' (Gelfand, 1997).

In humans, acoustic reflex can be helpful in checking for non organic hearing loss (Alberti, 1970; Feldman, 1963; Lamb & Peterson. 1967; Silman, 1988; Gelfand, 1994). They also point to central nervous system pathology (Greisen & Rasmussen, 1970; Jerger & Jerger, 1981; Gelfand, 1984).

Acoustic reflex thresholds generally are determined in response to acoustic stimuli of 500, 1000, 2000, and 4000 Hz (Gelfand, 1984). For screening purposes or for a general check of pathway integrity usually acoustic reflex is checked at 1000Hz.

Acoustic reflex measurement

Acoustic reflex assessment involves the presentation of tonal and/or noise stimulus to elicit reflex response. Stimulus levels used for reflex testing may be expressed in terms of sound pressure level (SPL), hearing level (HL), or sensation level (SL) (Gelfand, 1984).

The ipsi lateral and contra lateral reflexes can be measured using either ‘probe ear method’ or ‘stimulus ear method’. The ear in which the immittance change is measured due to stapedius muscle contraction, is called ‘probe ear’, while the ear receiving the stimulus used to activate the reflex is called the ‘stimulus ear’ (Gelfand, 2007). The ipsi lateral or uncrossed acoustic reflex is being measured when the stimulus is presented to the probe ear (stimulus and measurement occur in the same ear). The contra lateral crossed acoustic reflex is being measured when the probe tip is in one ear and the stimulus is presented to the opposite ear (stimulus presented to one ear, while measurement occurs in the opposite ear) (Gelfand, 2007). However stated the correct way to refer to the measurement is based on which ear is being stimulated by the loud sound.

According to stimulus ear principle, if the right ear is stimulated by the loud sound and measurement also occurs in the same ear, it would be a right ipsi lateral acoustic reflex measurement. If the stimulus was presented to the right ear, but the reflex was recorded in the left, it would be called a left contra lateral reflex measurement (Gelfand, 2007). It can be understood better by looking at the table 2.

Table 2: Stimulus ear principle

Test condition	**Right ear**	**Left ear**
Right contra	Stimulus	Probe
Left contra	Probe	Stimulus
Right ipsi	Stimulus+probe	-
Left ipsi	-	Stimulus+probe

Similarly, in probe ear principle, the right ear is stimulated by the loud sound and measurement also occurs in the same ear, it would be a right ipsi lateral acoustic reflex measurement and if the stimulus was presented to the left ear, but the reflex was recorded in the left, it would be called a left contra lateral reflex measurement (Gelfand, 2007), as given in the table3.

Table 3: Probe ear principle.

Test condition	**Right ear**	**Left ear**
Right contra	Probe	Stimulus
Left contra	Stimulus	Probe
Right ipsi	Stimulus+probe	-
Left ipsi	-	Stimulus+probe

The diagnostic application of acoustic reflex is maximized with the combined use of both ipsi lateral and contra lateral reflexes. Ipsi lateral testing offers major benefits particularly in middle ear pathology, whereas contra lateral testing is sensitive to disorders involving the crossed reflex pathways (brainstem pathology) which is not possible through ipsi lateral testing alone. Retrocochlear pathology often give rise to abnormalities in acoustic reflex, even at early stage (Anderson, Barr & Wedenberg, 1970). The following are the important measures of acoustic reflex that help in assessment and diagnosis of neural disorders:

- Acoustic reflex threshold.
- Acoustic reflex decay.

- Acoustic reflex magnitude and growth function.
- Acoustic reflex latency.

Acoustic reflex threshold

ART is the lowest intensity of an acoustic stimulus at which a minimal change in the middle ear compliance can be measured. The normal ARTs ranges from about 85 to 100 dB SPL for pure tone and lower for broad band noise (Gelfand, 1984). A group of individuals with normal hearing thresholds and normal middle ear function will exhibit a range of acoustic reflex threshold value between 70 to 100 dB HL, with the average level occurring at about 85 dB HL (Gelfand, 2002) and at sensation levels of 70 to 95 dB.

Table 4: Acoustic reflex thresholds in dB HL for normal hearing subjects reported by Wiley, Oviatt, and Block (1987).

	Pure-Tones (Hz)				Broadband Noise
	500	1000	2000	4000	
Contralateral ART					
Mean	84.6	85.9	84.4	89.8	66.3
Standard deviation	6.3	5.2	5.7	8.9	8.8
Ipsilateral ART					
Mean	79.9	82.0	86.2	87.5	64.6
Standard deviation	5.0	5.2	5.9	3.5	6.9

When the findings of audiometric tests suggest the presence of auditory disorder, the ARTs findings can potentially confirm the abnormal results. The following are the several examples of acoustic reflex results and their potential findings.

- **Acoustic reflexes within normal limits (70-100 dB HL):** This suggests normal hearing sensitivity with no apparent pathology. This may be seen in individuals with mild to moderate cochlear HL. The reason for normal ARTs in SNHL is related to the principle of loudness recruitment (Gelfand, 2002). Once the hearing threshold is reached, it takes less intensity to elicit a reflex in individual with cochlear hearing loss.
- **Elevated ARTs (100 + dB HL):** Jerger, Oliver, and Jenkins (1987) considered reflex thresholds to be abnormal/elevated if the thresholds are more than 100 dB HL. The finding of elevated ARTs occurs in several pathologies, specifically, in mild low frequency conductive hearing loss (Jerger et al, 1974a) and also in cases with acoustic neuroma. It can also be seen in client with moderate to moderately severe cochlear hearing loss.
- **Absence of ARTs**: if a reflex was not elicited at any intensity up to the maximum equipment limits (greater than 110/120 dB HL), the reflex is said to be absent. Ears with significant hearing loss (≥70 dB HL) will likely to have absent reflexes additionally. Acoustic reflexes may be absent in cases in whom auditory nerve function is compromised (Anderson et al, 1970; Sanders, Josey, Glasscock, & Jackson, 1974; Silman & Silverman, 1991; Ferguson et al, 1996).

An abnormality at any location in the acoustic reflex arc can alter the characteristics of the acoustic reflex. With a 60 dB HL cochlear hearing loss, 15 % of the patients do not have measurable acoustic reflex. If the hearing loss increases beyond 60 dB, acoustic reflex thresholds increase linearly. As the degree of hearing loss increases above 70 dB, the % of absent reflexes also increases rapidly. In most cases with auditory nerve lesion, the acoustic reflex are absent even if the hearing loss is mild (40 dB)

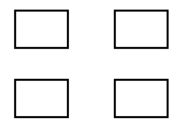
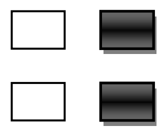
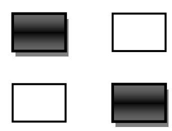
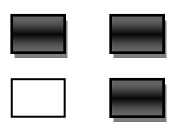
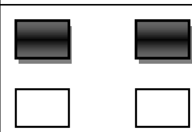
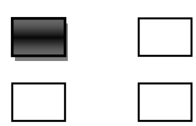
(Jerger, Clemis, Harford, & Alford, 1974). As the hearing loss increases above 40 dB HL, there is a corresponding increase in the percentage of absent reflexes.

It has been suggested that inter ear comparison of ARTs can assist in the identification of RCP (Chiveralls, 1977; Mangham & Lindaman, 1980; Prasher & Cohen, 1993). Chiveralls (1977) suggested that retro cochlear involvement should be suspected when inter ear reflex threshold differences exceed 15 dB at more than one frequency. However, Prasher and Cohen (1993) recommended that the criterion should be an inter-ear difference greater than 10 dB at two adjacent octave frequencies (500 & 1000 Hz, 1000 & 2000 Hz, 2000 & 4000 Hz).

Jerger box pattern

The combination of crossed and uncrossed reflexes yield four reflex thresholds, two uncrossed (ipsi lateral) and two crossed (contra lateral). Presentation of reflex data in this pattern is called as jerger box pattern. Jerger and Jerger (1977) developed a classification system that categorizes findings into six distinct patterns as shown in the table 5.

Table 5: Jerger box pattern interpretation with left side involvement.

Reflex pattern name		**Probe ear**		**Interpritation**
Normal	Crossed Uncrossed		Normal for both ears	Normal
Vertical	Crossed Uncrossed		Abnormal whenever probe is in affected ear	Mild middle ear disorder. CN VII lesin.
Diagonal	Crossed Uncrossed		Abnormal when sound is in affected ear	VIII CN lesion. Severe Cochlear disorder.
Inverted L	Crossed Uncrossed		Abnormal on both ears to cross stimulation,abnormal on affected ear to uncrossedstimulation.	Unilateral middle ear disorder. Intra axial brain stem lesion eccentric to one side.Combined CN VII and CN VIII lesion.
Horizontal	Crossed Uncrossed		Abnormal to crossed stimulation on both ears.	Extra axial and/or intra axial brain stem lesion.
Unibox	Crossed Uncrossed		Abnormal with sound to affected ear on crossed stimulation only.	Extra axial/intra axial lesion.

Acoustic reflex decay

Acoustic reflex decay, or adaptation, is the reduction in the magnitude of the acoustic reflex response during the presentation of a sustained stimulus or it is perstimulatory decline in stapedial contraction for sustained acoustic activating signal. It records the acoustic reflex response during the presentation of a pure tone stimulus for 10 seconds at a level 10 dB above the (acoustic reflex threshold).

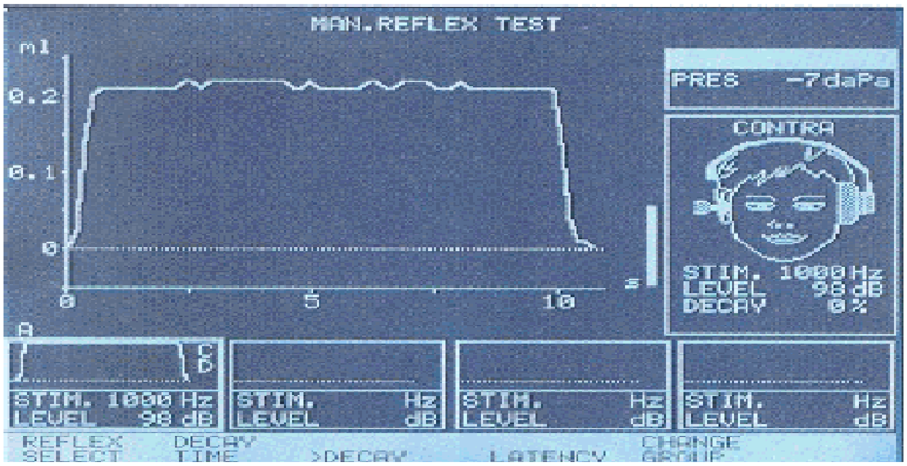


Figure 9: Negative reflex decay test result in normal hearing subject.

Clinical testing is limited to 500 Hz and 1000 Hz because rapid adaptation of the reflex response is quite common at higher frequencies (Goney, Dutillieux, Matz, 1974; Gelfand, 1984; Silman & Silverman, 1991). Reflex decay is determined according to whether the response falls to ≤ 50% of its initial magnitude during the 10 second stimulus. Acoustic reflex decay is usually tested contra laterally (Alberti, Fria & Cummings, 1977; Oviatt & Kileny, 1984).

Abnormally rapid reflex decay is associated with retro cochlear disorders (Anderson, Barr, & Wedenberg, 1970; Jerger, Harford, Clemis, & Alford, 1974; Wilson, Shanks, & Lilly, 1984). The combined use of ARTs and reflex decay results in 85 to 95% sensitivity of the test (Anderson et al, 1970; Jerger et al, 1974c; Sanders et al, 1974; Sheehy & Inzer, 1976; Johnson, 1977; Hayes & Jerger, 1980; Gelfand, 1984; Silmen & Silverman, 1991; Prasher & Cohen, 1993; Ferguson et al, 1996).

There is some controversy about the exact criteria for abnormal reflex decay in terms of whether the decay occurs within the first 5 seconds or any time during the 10 second stimulus presentation and whether decay occurs at just 500 Hz versus 500 and/or 1000 Hz (Anderson et al, 1970; Segal, 1978; Silman & Gelfand, 1982a). The index of suspicion for retro cochlear pathology is stronger when reflex decay occurs at 500 Hz than at 1000 Hz and within the first 5 seconds than during the second 5 seconds of the 10-second test (Olsen, Noffsinger, & Kurdziel, 1975).

Ferguson et al (1996) considered ≥ 50 % reflex decay within 5 second as positive and ≤ 50 % decay in 6 to 10 seconds as negative decay. The following is a useful set of rules that can be applied to the interpretation of reflex adaptation data (Hirsch & Anderson, 1980a, 1980b):

- RD+++, if the reflex amplitude declines ≥ 50 % within 5 second at 500 and 1000 Hz.
- RD++, if the reflex amplitude declines ≥ 50 % within 5 second at 1000 Hz but not at 500 Hz.
- RD+, if the reflex amplitude declines ≤ 50 % within 5 second at 500 Hz and at 1000 Hz.

- RD +++ is a positive sign of CN VIII disease, RD++ is a questionable sign of CN VIII disease, and RD+ is not a significant sign of CN VIII disease.

Reflex half life is time required for the acoustic reflex response to decline in magnitude by one half. (Decline of 50% of the peak value). Reflex half life of 10 seconds or less is a positive sign for 8th nerve involvement (Jerger, 1974; Sheehy et al, 1976).

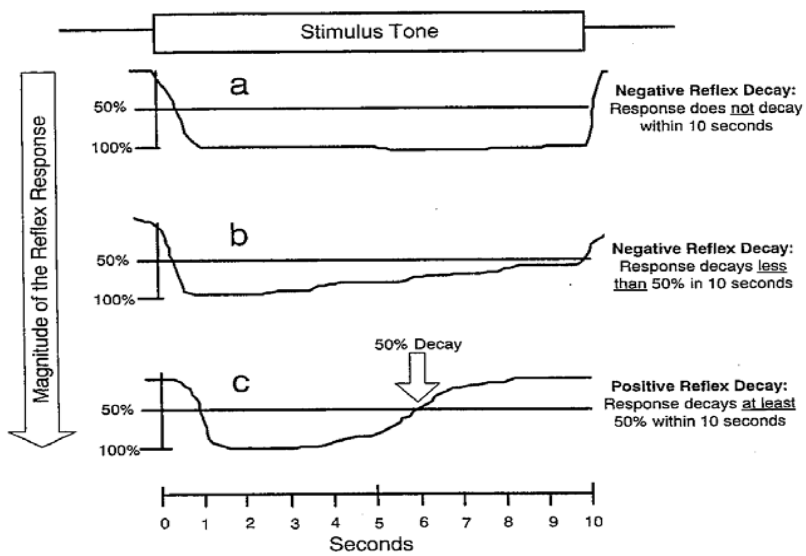


Figure 10: Measurement of the acoustic reflex decay or adaptation.

Anderson, Barr and Wedenberg (1970) reported that most normals were found to exhibit reflex decay at 2000 Hz and 4000Hz. The median half life was 14 and 7 sec for 2000 and 4000 Hz respectively. In cases of RCP, the decay was observed at those frequencies where no decay was observed in normal's, i.e.; at 500 and 1000HZ. Reflex decay at 2000 and 4000 Hz did not yield diagnostically important information.

However it is difficult to resolve the issues for several reasons. Reflex decay testing is limited because absent and elevated reflexes are common in cases of retro cochlear pathology. Roughly 57% of retro cochlear pathology cases have absent reflexes, in addition to which reflex decay is positive in about 25%, using the 5second method, and 29% with the 10 second method (Wilson, Shanks, & Lilly, 1984).

Acustic reflex magnitude and growth function

Acoustic reflex magnitude is simply the size of the response, i.e., the amount of immitance change caused by the reflex (Silman & Gelfand, 1982b; Silman, 1984; Gelfand, 1998). Acoustic reflex magnitude increases as the stimulus level increases above the reflex threshold. It was described as the acoustic reflex growth function (Moller, 1962; Wilson, 1981). The acoustic reflex growth functions illustrate the fundamental relationship between reflex magnitude and stimulus level.

The normal acoustic reflex growth for pure tone stimuli shows that reflex magnitude increases linearly with stimulus level. The normal acoustic reflex growth function for BBN stimuli has two segments. Beginning from the reflex threshold, reflex magnitude increases very little with increasing noise level over a range of roughly 10 dB, above which the BBN growth function rises linearly with further increases in noise level. In other words, the normal BBN growth function has a curvilinear “tail” with little or no reflex growth on its low end, followed by linear growth (Silman, Popelka, & Gelfand, 1978).

The acoustic reflex growth function for ears with cochlear impairments is quite similar to the normal function, except that it is shifted to the right, reflecting their higher reflex thresholds (i.e., it rises linearly with stimulus level) (Silman, Popelka, & Gelfand, 1978).

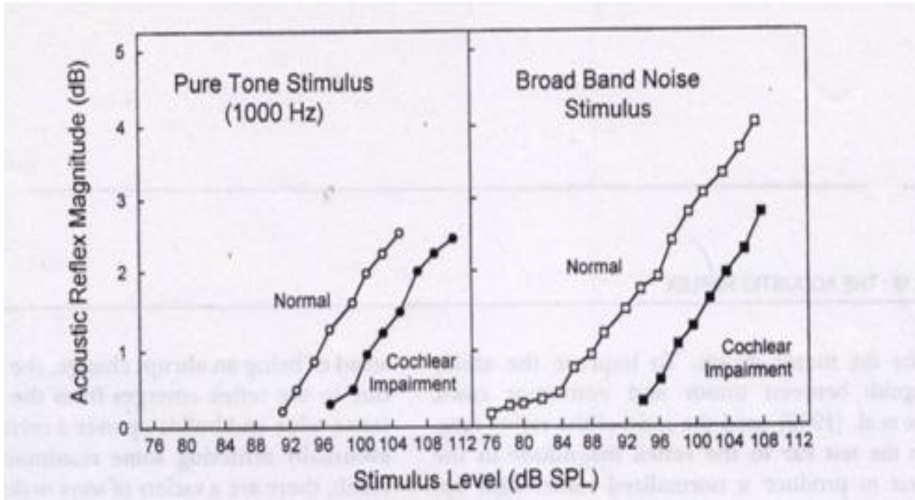


Figure 11: Acoustic reflex magnitude as a function of stimulus level for pure tone and broad band noise (BBN), in normals and cochlear hearing loss.

In contrast to cochlear disorders, reflex magnitude and growth is reduced by eighth nerve and brainstem pathologies affecting the acoustic reflex pathways (Borg, 1977; Bosatra, 1977; Silman, Popelka, & Gelfand, 1978; Lew & Jerger, 1991). Significantly reduced acoustic reflex growth functions have also been reported in a case of a cerebellar tumor causing indirect pressure on the reflex pathways, which returned to normal after the tumor was removed (Harrison, Silman & Silverman, 1989).

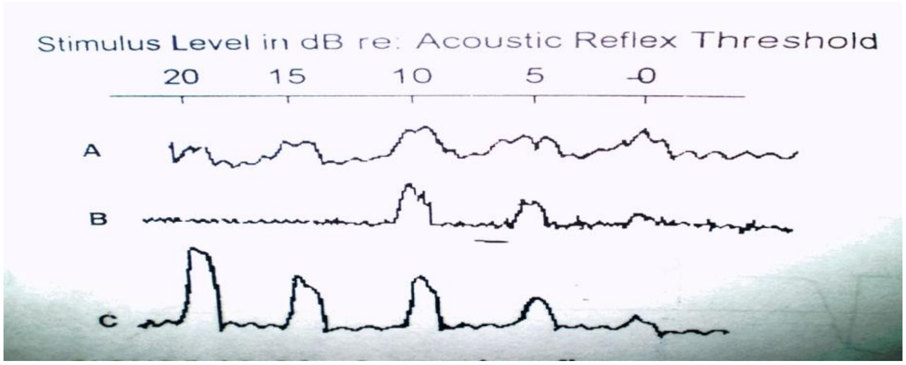


Figure 12: Acoustic reflex magnitude as a function of increased stimulus level for A: in patient with eight nerve tumor. B: in cochlear pathology, and C: in individual with normal hearing.

The figure shows the acoustic reflex magnitude as a function of increasing stimulus levels for unilateral VIII nerve tumor patient. The bottom tracing (c) is from an individual having normal ear and shows the normal pattern of increasing reflex magnitude as the stimulus is raised above the reflex threshold. (a) Shows no growth of reflex magnitude at 500 Hz in retrocochlear pathologic ear. (b) Shows the normal pattern of reflex growth in a ear with cochlear pathology (Silman, Gelfand, & Chun, 1978).

Acoustic reflex magnitude is also reduced in the affected ears of patients with unilateral facial nerve paralysis when the facial nerve lesion is proximal to the portion of the facial nerve innervating the stapedius muscle (Ruth, Nilo & Marvec, 1978).

To improve the ability to distinguish between tumor and non tumor cases, Mangham & Lindaman (1980) used the ratio of the reflex magnitude in the test ear to the reflex magnitude in the non test ear to produce a normalized value. This approach is a form of inter ear comparison, in which 1.0 means the two ears have equal reflex magnitudes. All of the normalized values for the tumor patients were less than 0.75, and this approach distinguished between the tumor and non tumor groups without overlap when the stimuli were presented at 10 dB SL with respect to ART.

Acoustic reflex latency

Acoustic reflex latency refers to how long it takes for the acoustic reflex to occur after the stimulus is presented. The delay is measured from the onset of the stimulus until the beginning of the reflex response (J. Katz, 2009). Some researchers (Borg, 1972; Liden, Harford, & Hallen 1974) described latency as the time, in second, from stimulus onset to the time when the acoustic reflex has attained 10 % of maximum amplitude. Colletti (1975) defined latency as the period from signal onset to 5 v of maximum impedance change; While Strasser (1975) suggested measuring latency from signal onset to the beginning of impedance change.

Latency parameters contain important biologic information and can be used as sensitive indicators of disease status (Colletti, 1974; Colletti, 1975; Norris, Stelmachowicz, Bowling, & Taylor, 1974; strasser, 1975).

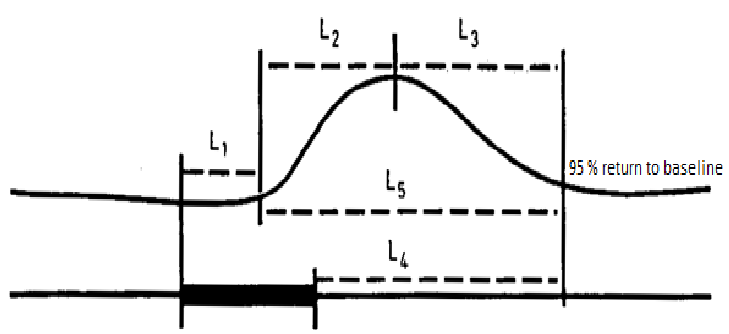


Figure 13: Definition of the acoustic reflex latency parameters (Norris et al, 1974).

L1= latency from onset of stimulus to initial reflex response.

L2=latency from initial response to peak of the response.

L3= latency from response peak to point where reflex reaches 95% return to baseline.

L4= latency from cessation of stimulus to 95% return to baseline.

L5=latency total response time, L2 + L3.

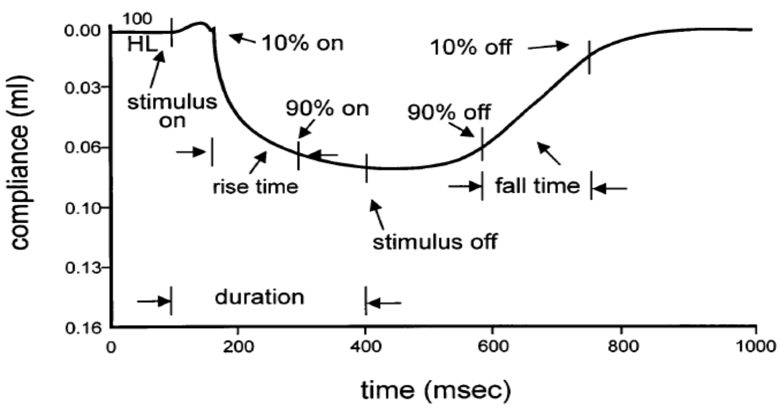


Figure 14: Various parameters of acoustic reflex latency according to Colletti (1974).

Colletti (1974) studied latency parameters with varying intensities. He defined these parameters as:

Onset latency: the time interval between onset of stimulus and 5 % of the maximum amplitude of the response.

Rise time: the time required for the response to rise from 10 % to 90 % of its final value or rise time may be defined as the time from the onset of response to the time period at which maximum amplitude is reached.

Amplitude: it is expressed in arbitrary units as width of its response at steady state.

Offset latency: time interval for the response to fall to 95 % of its value after cessation of the stimulus.

Decay time: the time interval between 90 % and 10 % of the amplitude of the response after the cessation of the stimulus.

There are a variety of ways to define the start of the reflex response. Latency values might be affected by the definition as well as by the sensitivity and temporal characteristics of the immittance device being used (Bosatra, Russolo & Silverman, 1984; Lilly, 1984; Jerger, Oliver & Stach, 1986).

Stimulus:	500 Hz	1,000 Hz	2,000 Hz	4,000 Hz
Contralateral				
Mean	102.8	101.9	127.7	147.3
95% range	56.0–149.6	51.7–152.1	66.5–188.9	77.9–216.7
Ipsilateral				
Mean	104.4	102.0	115.2	144.2
95% range	59.2–149.6	51.4–152.0	70.6–159.8	74.8–213.6

Figure 15: Means of acoustic reflex latencies (in msec) of a normal hearing subjects, obtained using the GSI-33 middle ear analyser.

The latency of acoustic reflex is inversely related to the level of the reflex activator signal (Dallos, 1964; Hung & Dallos, 1972; Lilly, 1964; Ruth & Niswander, 1976) i.e. latency increases as the stimulus intensity is decreased. Latency values are affected by the electro acoustic characteristics of the instrument also. Acoustic reflex latencies appear to be similar for normal individuals through the fifties but become lengthened with increasing age beginning in the sixties (Bosatra, Russolo, & Silverman, 1984). Typical reflex latencies in normal subjects are 107 msec, ranging from 40-180 (Bosatra, Russolo, & Poli, 1976).

Acoustic Reflex Latency (ARL) in normals:

- 150 msec at 80 dB sensation level to 40 msec at 100 dB SL (Metz, 1951).
- As short as 12 ms by electromyography (Zakrisson, Borg & Bloom, 1974).
- ARL shorter as the stimulus level increases (20-<300 ms) (Bosatra et al, 1984)
- Reflex latency within 95% normal ranges: 56 ms at 500 Hz (Qiu, & Stucker 1997).
- Reflex latency of 25 ms for 500Hz, and 130 ms for 1500 Hz (Moller, 1958).

Clinical acoustic reflex latencies are much longer than this because we are monitoring the immittance changes caused by the mechanical effects of the muscle contraction. Acoustic reflex latencies tend to be within the normal range for ears with cochlear disorders but are substantially longer (often exceeding 200 ms) for ears with retro cochlear pathology (Strasser, 1975; Clemis & Sarno, 1980; Mangham & Lindeman, 1980; Bosatra Russolo, & Silvermanl, 1984).

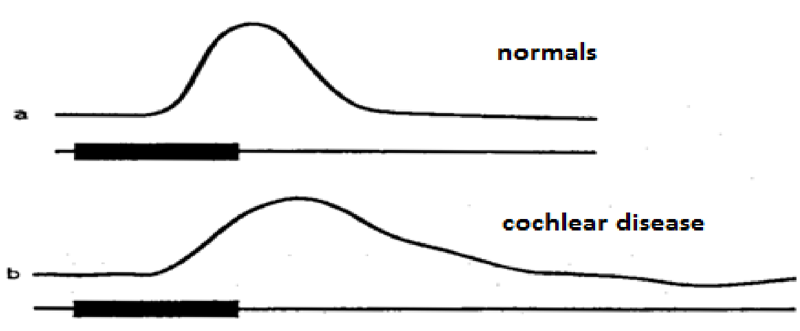


Figure 16: Latency measure of the acoustic reflex.

Sarno and Clemis (1980) used acoustic reflex latency to test the hypothesis that a retro cochlear lesion involving the afferent portion of the reflex arc will result in a slowed neural conduction time. Both contra lateral and ipsi lateral values were obtained for absolute reflex latency and inter aural latency differences on clinical populations

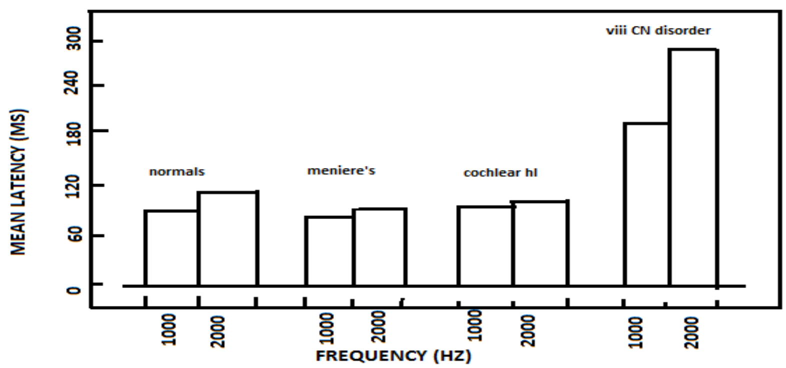


Figure 17: Histogram showing the mean reflex latencies obtained at 1000 and 2000HZ activator signals for subjects with normal hearing, patients with meniere's disease, cochlear HL and retro cochlear pathology.

Clinically, Clemis and Sarno (1980) found that the retro cochlear group had latencies of 181.5 ms and 274.0 ms at 1000 and 2000Hz, respectively, with no cases within normal range. Thus it suggested that the latency of the acoustic reflex was useful in differentiating cochlear from retro cochlear disease.

Acoustic reflex latency appears to be normal in patients with cortical lesions and inconsistent among patients with brainstem disorders, so it does not provide diagnostically useful information when dealing with central auditory pathology (Bosatra et al., 1984).

QUESTIONS

Fill in the blanks:

1. Clinical testing of acoustic reflex decay limited to ……. and …….
2. Most normals were found to exhibit reflex decay at ………and ………
3. The median half life was ……..and……… for 2000 and 4000 Hz respectively.
4. Acoustic reflex magnitude is simply the amount of …………… caused by the reflex.
5. Acoustic reflex magnitude is …….. related to stimulus level.
6. The normal acoustic growth for pure tone stimuli shows that reflex magnitude increases …….. with stimulus level.
7. Reflex magnitude and growth is ………. by eighth nerve and brainstem pathologies.
8. Acoustic Reflex Latency …………… as the stimulus levels increases.
9. What is the normal range of acoustic reflex threshold value in a group of individuals with normal hearing thresholds and normal middle ear function?

Multiple choices:

1. Acoustic reflex decay records the acoustic reflex response during the presentation of a pure tone stimulus for:

a. 10 sec at 10 dB above the ART
b. 10 sec at 10 dB SL of threshold
c. 10 sec at 10 dB SPL of ART
d. 10 sec at the ART threshold

2. Reflex decay is determined according to whether the response falls to……………..during the 10 sec stimuli:
   a) ≤100% of its initial magnitude
   b) ≤50% of its initial magnitude
   c) ≥100% of its initial magnitude
   d) ≥50% of its initial magnitude

3. The decay occurs within:
   a) First 5 sec of stimulus presentation
   b) Last 5 sec of stimulus presentation
   c) Any time during the 10 sec of stimulus presentation
   d) Occurs in every presentation of the stimulus

4. The index of suspicion for retro cochlear pathology is stronger when reflex decay occurs at ……………………….and within the first 5 seconds?
   a) 1000Hz then at 500 Hz
   b) 500Hz then at 1000Hz
   c) Both at 1000 and 2000Hz
   d) Occurs at higher frequencies

5. Most normals were found to exhibit reflex decay at…………..?
   a) 1000 Hz and 2000 Hz
   b) 500 Hz and 1000 Hz
   c) 2000 Hz and 4000 Hz
   d) Only 4000 Hz

6. The acoustic reflex growth functions illustrate the fundamental relationship between
   a) Reflex magnitude and stimulus level.
   b) Reflex magnitude and frequency.
   c) Reflex magnitude and stimulus type.
   d) Reflex magnitude and latency.

7. The normal acoustic reflex growth function for BBN stimuli has

a) 2 segments
b) 3 segments
c) 1 segment
d) 4 segments

8. The acoustic reflex growth function for ears with cochlear impairments shifts towards

a) Right
b) Left
c) Remain same
d) None of the above.

9. ……….used the ratio of the reflex magnitude to distinguish between tumor and non tumor cases.

a) Ruth, 1978.
b) Harrison, 1989.
c) Mangham, 1980.
d) Silman, 1978.

10. Acoustic reflex latencies tend to be substantially longer for :

a) Retro cochlear pathology
b) Cochlear pathology
c) Brainstem lesion
d) Middle ear disorders

11. Normal ARTs in cochlear HL is related to

a) Loudness recruitment
b) Adaptation
c) Fatigue
d) None of the above.

12. If a reflex was not elicited at any intensity up to the maximum equipment limits (greater than 110/120 dB HL), then the reflex is said to be

    a) Absent
    b) Normal
    c) Elevated
    d) Reduced

True/false:

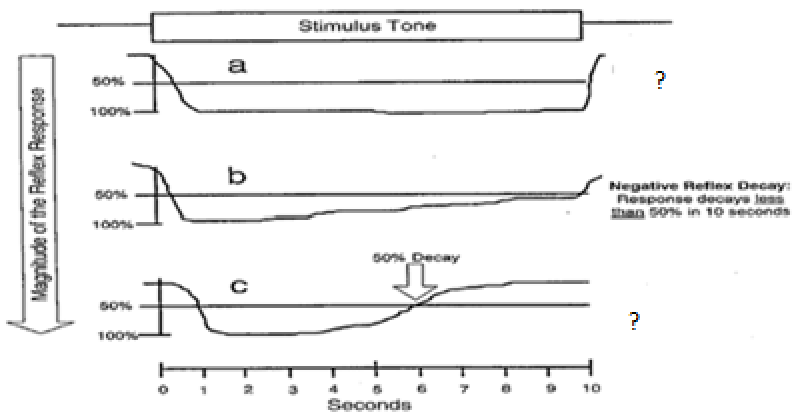
1. An abnormality at any location in the acoustic reflex arc can alter the characteristics of the acoustic reflex.
2. The acoustic reflex growth function for ears with cochlear impairments is quite similar to the normal function.
3. For inter ear comparison, the value of 1.0 means the two ears have different reflex magnitudes.
4. Acoustic reflex magnitude is simply the size of the response.
5. Acoustic reflex magnitude is also known as acoustic reflex growth function.
6. Abnormally rapid reflex decay is associated with cochlear disorders.
7. Reflex decay at 2000 and 4000 Hz yield diagnostically important information.

Complete the diagrams:

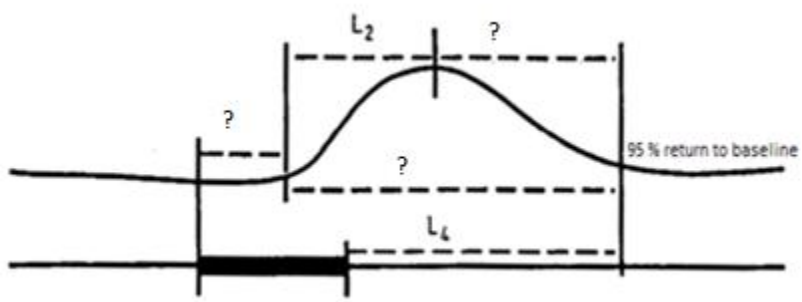
1. Horizontal jerger box pattern.

	RIGHT	LEFT
Contralateral		Absent
Ipsi lateral		Normal

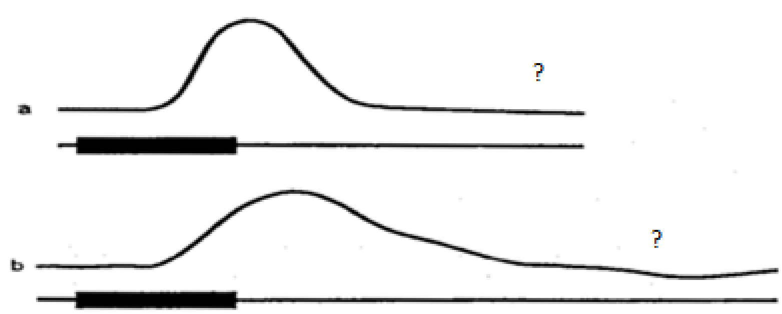
2. Measurement of acoustic reflex decay.



3. Acoustic reflex latency parameters.



4. Latency measure in different pathologies**.**



ANSWERS

Fill in the blanks:

1. 500 and 1000 HZ
2. 2000Hz and 4000Hz
3. 14 sec and 7 sec
4. Immittance change.
5. Directly.
6. Linearly.
7. Reduced.
8. Decrease.
9. Acoustic reflex threshold.

Multiple choices:

1. ≤100% of its initial magnitude
2. ≤50% of its initial magnitude
3. First 5 sec of stimulus presentation
4. 500Hz then at 1000Hz
5. 2000 Hz and 4000 Hz
6. Reflex magnitude and stimulus level.
7. 2 segments.
8. Right.
9. Mangham, 1980.
10. Retro cochlear pathology.
11. Loudness recruitment.
12. Absent.

True/false:

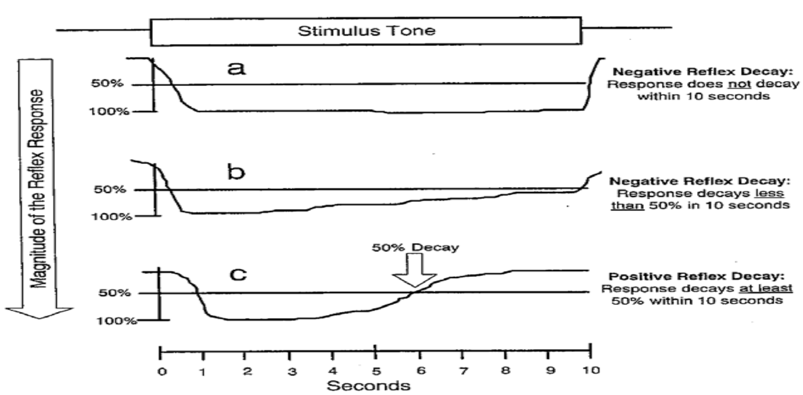
1. True.
2. True
3. False
4. True
5. True
6. False.
7. False.

Complete the diagrams:

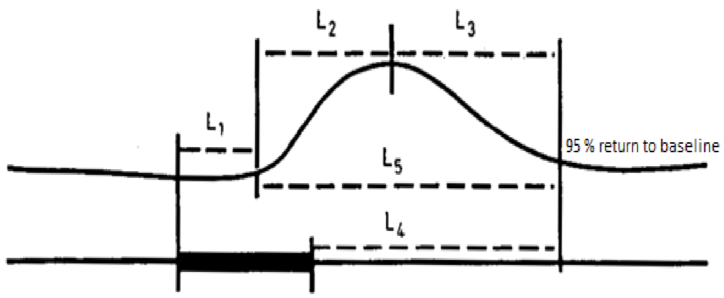
1. Horizontal jerger box pattern.

	RIGHT	LEFT
Contralateral	Absent	Absent
Ipsi lateral	Normal	Normal

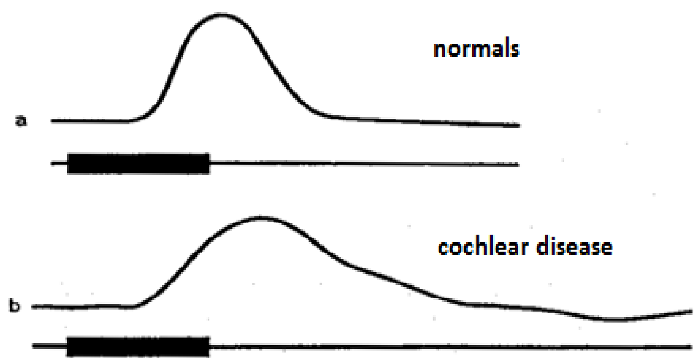
2. Measurement of acoustic reflex decay.



3. Acoustic reflex latency parameters.



4. Latency measure in different pathologies.



ACOUSTIC REFLEX FINDINGS IN DIFFERENT RETRO COCHLEAR PATHOLOGIES

Vestibule cochlear nerve lesion

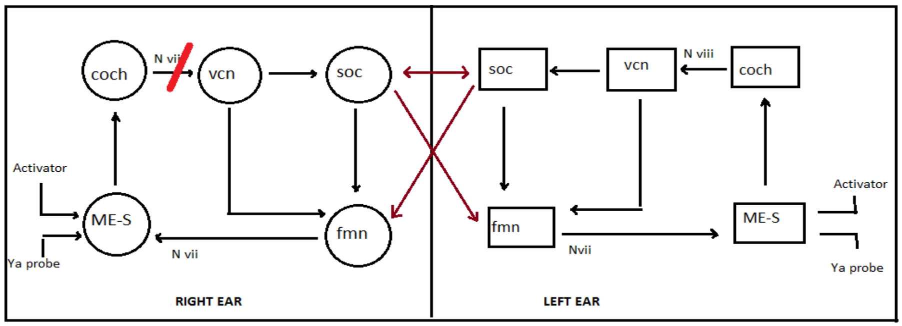


Figure 18: Lesion in auditory nerve.

The eight nerve pathology is associated with reflex abnormalities affecting the stimulating ear. The eight nerve is the sensory leg of the acoustic reflex arc. Lesion occurring in the auditory nerve affects the reflex pathways going from one side to the other (Jerger & Jerger, 1977). The Jerger box pattern shows 'diagonal' configuration

Table 6: Diagonal Jerger box pattern.

	RIGHT	LEFT
Contralateral	Normal	Absent
Ipsi lateral	Absent	Normal

Right ear's ipsi lateral and left ear's contra lateral reflexes are absent because they both stimulate the pathological auditory nerve, whereas left ipsi lateral and right contra lateral reflexes are present as they stimulate the normal auditory nerve (table 6).

The reflexes can be elevated. The VIII nerve lesion patients exhibit more than 50% adaptation in acoustic reflex decay test at 500 and/or 1000 Hz over 10 seconds.

Anderson, Barr & Wedenberg (1970) reported a marked reflex decay at 500 Hz and 1000 Hz in acoustic tumor patient.

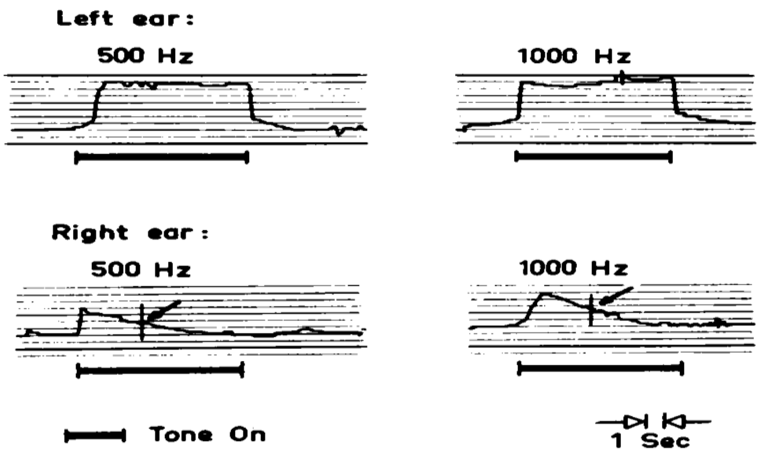


Figure 19: Acoustic reflex decay in auditory nerve tumor (right ear). No reflex decay in normal (left ear).

The latency of the acoustic reflex was useful in differentiating cochlear from retro cochlear disease (Clemis & Sarno, 1980). Jerger & Hayes (1983) found large latency difference between the normal and abnormal ears of four patients with unilateral eight nerve tumors.

Facial nerve disorder

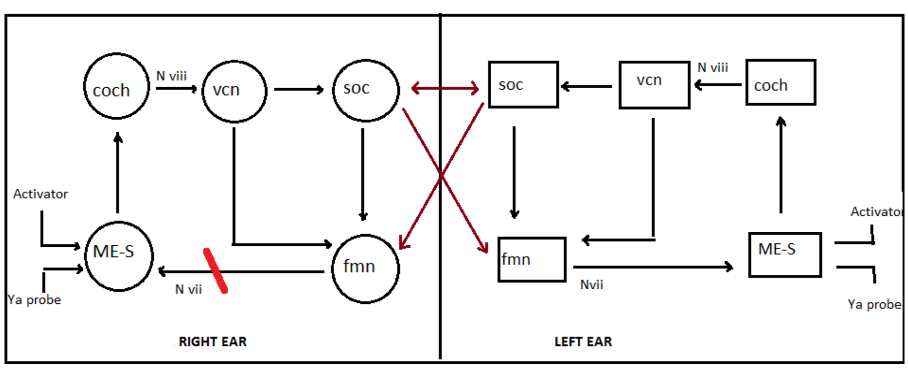


Figure 20: Lesion in facial nerve.

Facial nerve disorder is associated with abnormal reflexes when the probe tip is on the pathological side (Alford, Jerger, Coat, Peterson & Weber, 1973; Citron & Adour, 1978; Wiley & Block, 1984). The Jerger box pattern shows ‘vertical’ configuration. The facial nerve is the motor leg of the acoustic reflex arc that innervates the stapedius muscle. Hence, the abnormality is seen in the probe ear because this is where the effects of the muscle contraction are being monitored.

Table 7: Vertical jerger box pattern.

	RIGHT	LEFT
Contra lateral	Absent	Normal
Ipsi lateral	Absent	Normal

In general, three reflex patterns may emerge depending on whether the lesion is proximal or distal to the facial nerve nucleus in the brainstem (Jerger & Jerger, 1981).

First pattern is absence of acoustic reflex whenever the probe is in the ear on the affected side. No contraction of the stapedius muscle is observed when the reflex-eliciting signal is delivered to either the ipsi lateral or the contra lateral ear. This pattern may be seen when seventh cranial nerve disorder is proximal to the branching to the stapedius muscle.

In second pattern elevated acoustic reflex can be seen. In this case, sound elicits the reflex contraction, but only to abnormally intense signal levels (greater than 100dB). It observed in patients with recovering seventh cranial nerve function.

A third reflex pattern associated with seventh cranial nerve disorder is normal acoustic reflexes. All four reflexes are present at normal reflex threshold level. This pattern is seen in patient with seventh cranial nerve disorder distal to the branching of the nerve to the stapedius muscle.

Intra axial brain stem lesion

Brain stem lesions affecting the acoustic reflex pathways can interrupt neural impulses that are elicited from ipsi lateral or contra lateral stimulation. Brain stem tumors often cause many varied symptoms, due to involvement of cranial nerve nuclei, and the ascending and descending pathways. The symptoms may be very complex, and in all cases every symptom helps in diagnosing the exact site of lesion. A lesion in the brain stem may cut the reflex arch which is localized in brain stem.

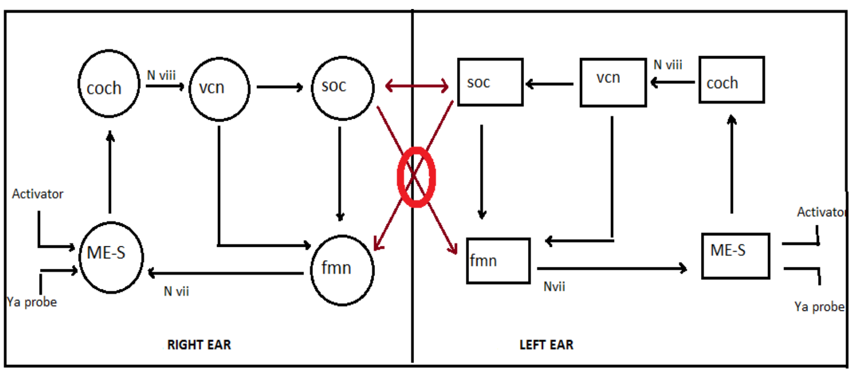


Figure 21: Small intra axial lesion.

Abnormal acoustic reflexes are associated with intra axial lesion, i.e.; lesion occurring within the brainstem proper that involve the reflex pathways (Greisen & Resmussen, 1970; J. Jerger & S .Jerger, 1974; Stephens & Thornton, 1976; Bosatra, Russolo, & Silverman, 1984; Gelfand, 1984). Because intra axial lesion often damage one or both of the crossed reflex pathways, they are often associated with abnormal contra lateral reflexes without affecting the ipsi lateral reflexes (Jerger & Jerger, 1977). They usually exhibit horizontal Jerger box pattern.

Table 8: Horizontal Jerger box pattern seen in small intra axial lesion.

	RIGHT	LEFT
Contra lateral	Absent	Absent
Ipsi lateral	Normal	Normal

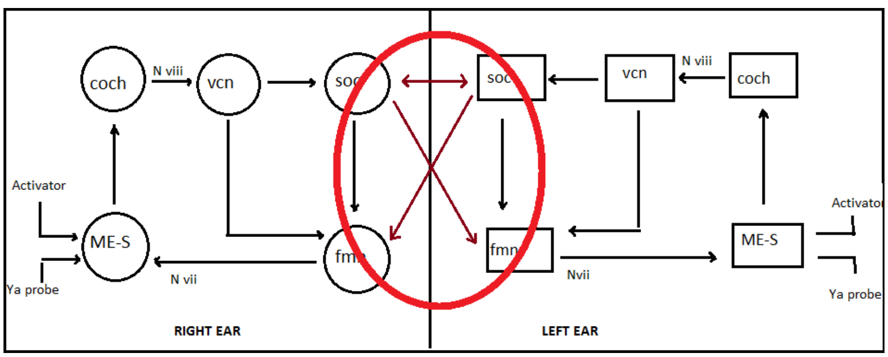


Figure 22: Large intra axial lesion.

Table 8 is showing absent contra lateral reflexes in case of small intra axial tumor but in case of large intra axial tumor all the four reflexes must be absent if it involves both the ipsi and contra pathways of acoustic reflex arc.

Table 9: acoustic reflexes cannot be obtained from large intra-axial brain stem pathology.

	Right	Left
Contra lateral	Absent	Absent
Ipsi lateral	Absent	Absent

Both latency and the reflex threshold are increased in brain stem lesion (Bosatra, Russolo & Poli, 1976). Some cases of intra axial lesions represent reflex decay if acoustic reflexes are obtained (Jerger & Jerger, 1977).

Extra axial brainstem lesion

Extra-axial brainstem pathology can result in a variety of ART patterns depending on the size and location of the lesion. The lesion may mimic a vestibule cochlear (VIII nerve) pathology or an intra-axial pathology, or it could mimic facial nerve pathology.

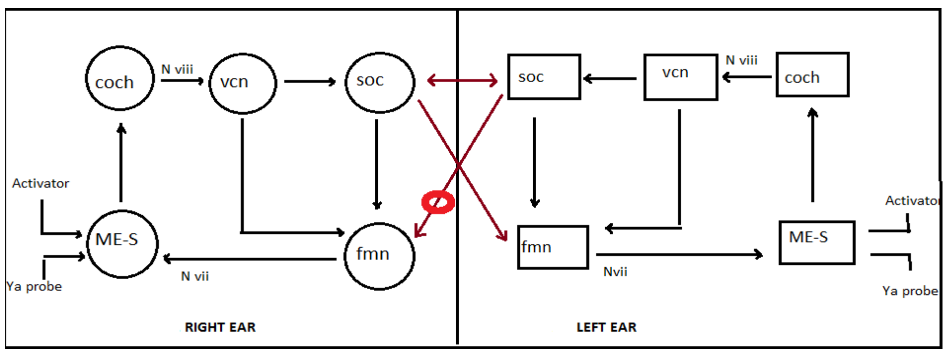


Figure 23: Extra axial lesion.

Acoustic reflexes are abnormal with sound to the affected ear on contralateral stimulation only. Both of the ipsilateral reflexes and the other contralateral reflex are normal. It observed in a patient with an extra-axial acoustic schwannoma. Table 9 shows Jerger box pattern of right side extra axial lesion (right contra lateral ARTs are absent, left contra is present, and all ipsi lateral ARTs are present).

Table 10: Uni Jerger box pattern.

	RIGHT	LEFT
Contra lateral	Absent	Present
Ipsi lateral	Normal	Normal

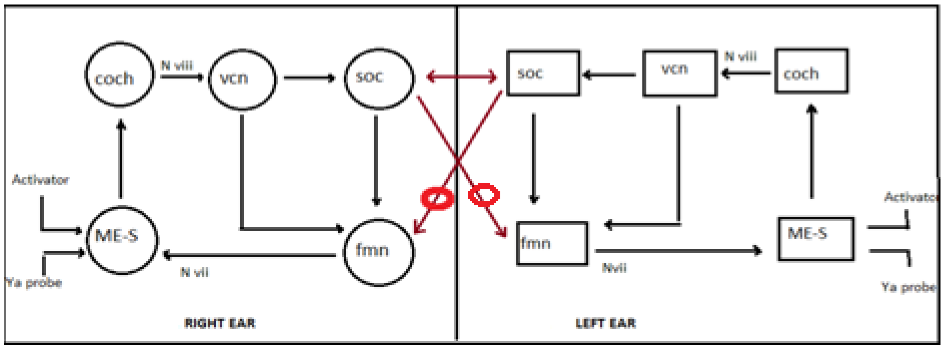


Figure 24: Bilateral extra axial lesion.

Table 10 is showing absent contra lateral reflexes in case of bilateral extra axial tumor. Because the damage occur in both the crossed reflex pathways, they are often associated with abnormal contra lateral reflexes without affecting the ipsi lateral responses (Jerger & Jerger, 1977). They usually exhibit horizontal Jerger box pattern which is similar to Jerger box pattern seen in small intra axial tumors.

Table 11: acoustic reflex in bilateral extra axial brain stem pathology.

	Right	Left
Contralateral	Absent	Absent
Ipsi lateral	Normal	Normal

Lesion in cochlear nucleus

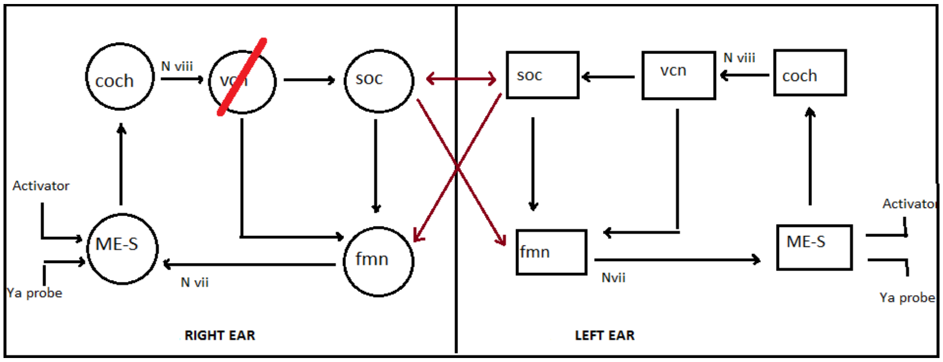


Figure 25: Destructed ventral cochlear nucleus.

Borg (1977) observed that destruction of dorsal cochlear nucleus in rabbit did not influence the acoustic reflex. Lesions produced in ventral CN brought about an elevation in the reflex thresholds. The lesion In VCN may mimic a vestibule cochlear (VIII nerve) pathology as it interrupt the reflex pathways going from one side to the other and also to the same side. It would exhibit a diagonal Jerger box pattern as it is seen in case with acoustic nerve pathology.

Table12: Diagonal Jerger box pattern. Lesion at right VCN.

	RIGHT	LEFT
Contra lateral	Normal	Absent
Ipsi lateral	Absent	Normal

Lesions produced in ventral CN brought about an elevation in the reflex thresholds and decay of reflex response. It was observed that recording the time course of response was useful. A reduction in amplitude was accompanied by increase in rise time. Borg (1977) suggested that a long rise time indicates that rapidly conducting pathways of the brain stem are affected.

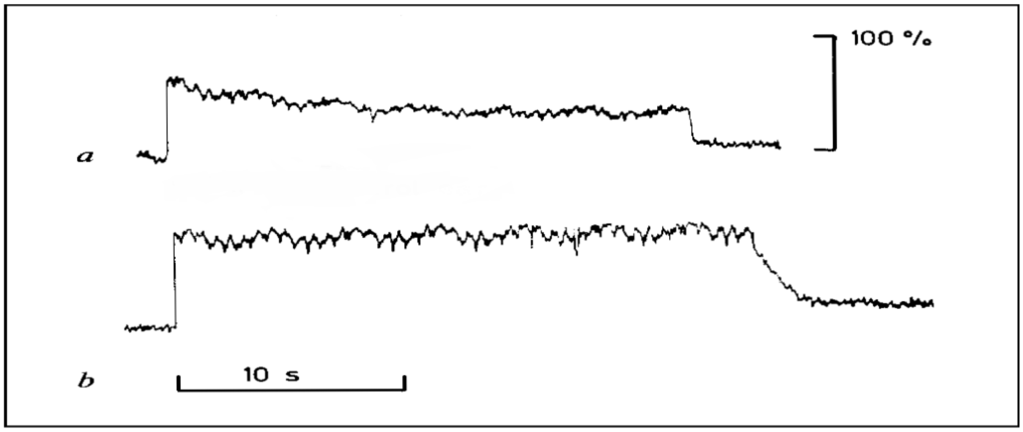


Figure 26: Impedance change in a rabbit with a unilateral electrolytic lesion in the ventral cochlear nucleus. a- reflex decay in the ear with lesion. b- normal reflex response in intact ear.

Auditory neuropathy

Auditory neuropathy is associated with reflex abnormalities affecting the stimulating ear (Sininger et al, 1995; Starr, Picton, Sininger, Hood, & Berlin, 1996; Shivashanker, Satishchandra, Shashikala, & Gore, 2003). Auditory neuropathy can interrupt neural impulses that are elicited from stimulating ear as it involves a disruption of auditory function due to demyelinating conditions at the inner hair cells of the cochlea, auditory neurons in the spinal ganglia, auditory nerve fibers or any combination of these (Starr et al, 1996).

The demyelinated neurons function abnormally in ways other than their slowed velocity (Waxman, 1996). They do not conduct rapid trains of action potentials very well.

The acoustic reflexes are typically absent in auditory neuropathy (Starr et al, 1996) as the auditory nerve may not achieve a sufficiently high rate of discharge to activate acoustic reflex contraction of middle ear muscles. The Jerger box pattern shows 'Diagonal' configuration which is similar to the configuration in auditory nerve tumor/lesion.

Table 13: Diagonal Jerger box pattern in client with right auditory neuropathy.

	RIGHT	LEFT
Contralateral	Normal	Absent
Ipsi lateral	Absent	Normal

QUESTIONS

Fill in the blanks

1. The Jerger box pattern shows ………. configuration in eight nerve lesion.
2. The eight nerve is the …….. leg of the acoustic reflex arc.
3. The facial nerve is the ……… leg of the acoustic reflex arc that innervates the stapedius muscle.

Multiple choice questions

1. What type of Jerger box pattern is seen in facial nerve damage?
   a) Vertical.
   b) Diagonal.
   c) Horizontal.
   d) Unibox.

2. In which condition all the reflexes are absent?
   a) Large intra axial tumor involvine both ipsi and contra pathways.
   b) Bilateral auditory nerve tumor.
   c) Both a and b
   d) None of the above.

3. What type of Jerger box pattern is seen in extra axial lesion?
   a) Unibox.
   b) Horizontal.
   c) Vertical.
   d) Diagonal.

4. Destruction of …….. part of cochlear nucleus does not influence the acoustic reflex?
   a) Ventral.
   b) Dorsal.
   c) Posterior.
   d) Superior.

Match the followings:

1. Horizontal Jerger box configuration.	All the reflexes absent.
2. Lesion in cochlear nucleus.	Bilateral extra axial lesion.
3. Bilateral facial nerve paralysis.	Auditory neuropathy.
4. Demyelination of neurons.	Diagonal Jeger box configuration.

True/false:

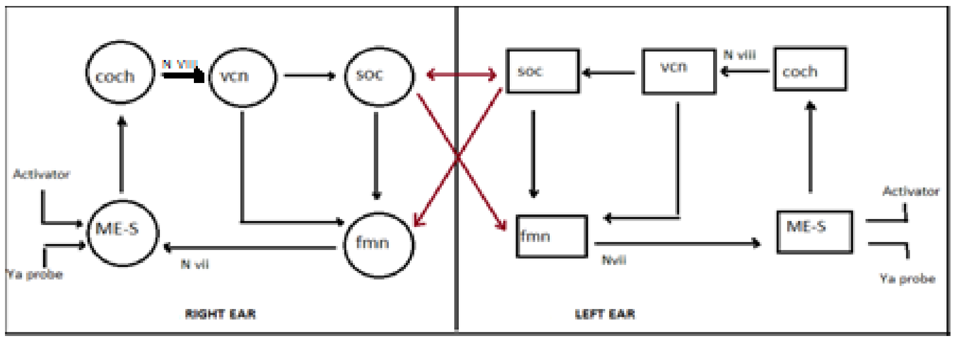
1. Eight nerve tumors are associated with uniform audiometric patterns, particularly at the early stages.
2. Unilateral auditory neuropathy shows diagonal type configuration of jerger box pattern.
3. The latency of the acoustic reflex is useful in differentiating cochlear from retro cochlear disease.

Complete the diagram:

1. Unibox Jerger box pattern.

	RIGHT	LEFT
Contra lateral		
Ipsi lateral		

2. Intra axial lesion.



3. Jerger box pattern in facial nerve lesion.

	Right	Left
Contra lateral		
Ipsi lateral	Absent	

4. Jerger box pattern in auditory neuropathy.

	RIGHT	LEFT
Contralateral		Absent
Ipsi lateral		

ANSWER:

Fill in the blanks

1. Diagonal.
2. Sensory.
3. Motor.

Multiple choice questions

1. Vertical.
2. Both.
3. Unibox.
4. Dorsal.

Match the followings:

1. Horizontal Jerger box configuration.	All the reflexes absent.
2. Lesion in cochlear nucleus.	Bilateral extra axial lesion.
3. Bilateral facial nerve paralysis.	Auditory neuropathy.
4. Demyelination of neurons.	Diagonal Jeger box configuration.

True/false

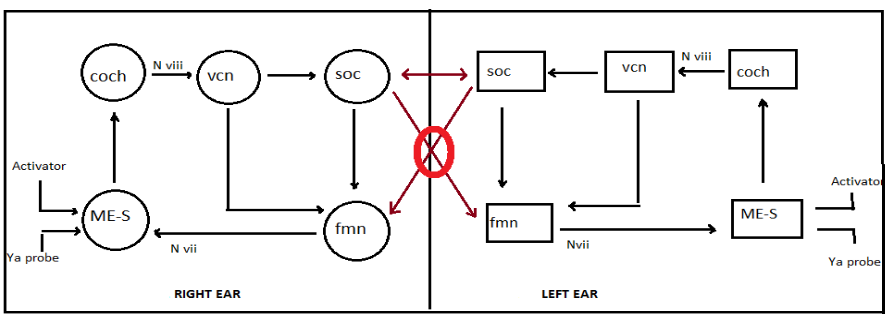
1. False.
2. True.
3. True.

Complete the diagrams:

1. Unibox Jerger box pattern.

	RIGHT	LEFT
Contra lateral	Absent	Present
Ipsi lateral	Present	Present

2. Intra axial lesion.



3. Jerger box pattern in facial nerve lesion.

	Right	Left
Contra lateral	Absent	Normal
Ipsi lateral	Absent	Normal

4. Jerger box pattern in auditory neuropathy.

	RIGHT	LEFT
Contralateral	Normal	Absent
Ipsi lateral	Absent	Normal

ACOUSTIC REFLEX FINDINGS IN OTHER NEUROLOGICAL DISORDERS

Cortical and/or upper brain stem lesion

Central disorders above the brain stem have no effect on acoustic stapedius function. Patients with cortical lesions exhibit normal acoustic reflex measure (Wiley & Fowler, 1997). Although lowered ART's have been reported in a few patients with cortical disorders because of the loss of central inhibitory influences on the reflex are (Downs & Crum, 1980). On the other hand, Jerger and Jerger (1981); Gelfand and Silman (1982) reported that the ARTs are unaffected by cortical pathology. Cortical involved patients have the same ARTs as normal and cochlear impaired patients with similar hearing sensitivity (Gelfand & Silman, 1982).

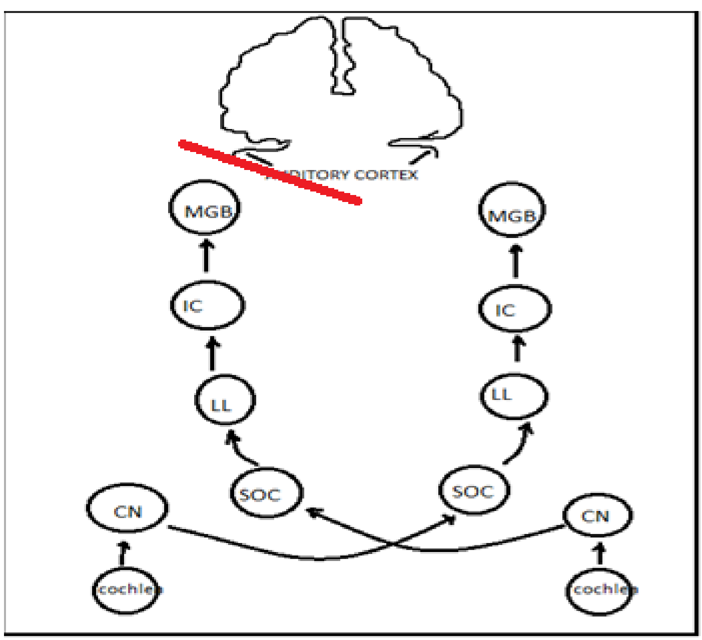


Figure 27 : Lesion in the auditory cortex.

Table 14: Contra lateral and ipsi lateral AR are present in client with central lesion.

	RIGHT	LEFT
Contra lateral	Normal	Normal
Ipsi lateral	Normal	Normal

Totally normal acoustic reflexes in the presence of a brainstem auditory disorder suggest that the lesion is above the level of the central reflex arc in the pons. However, central auditory pathologies that are proximal to the lower brain stem may manifest themselves in abnormal acoustic reflex patterns (Wiley & Fowler, 1997).

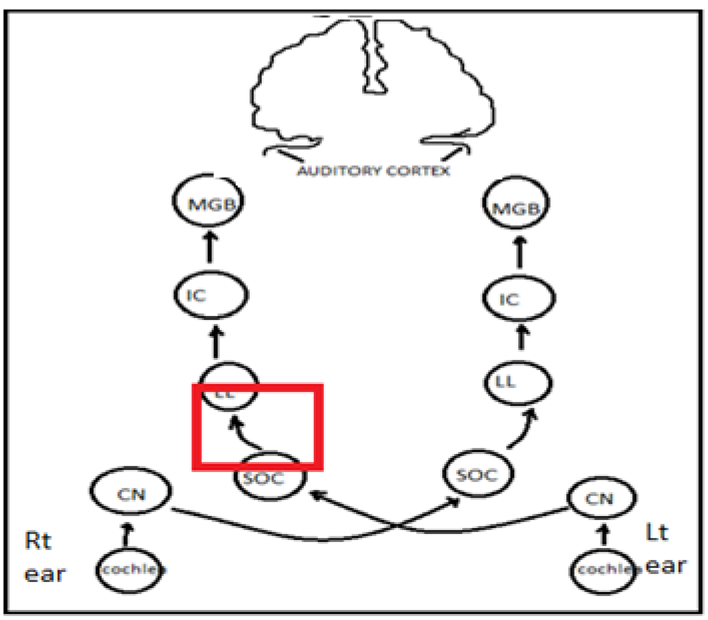


*Figure 28: C*entral lesion spreading to superior olivary complex.

The given diagram exhibits lesion in brain stem superior to SOC (including some portion of SOC). In such condition both the ipsi as well as contra acoustic reflexes of affected side will be absent as the tumor is compromising both the ipsi and contra lateral pathways of the affected side. The Jerger box pattern will show vertical configuration in a given situation which is similar to the configuration seen in facial nerve lesion.

*Table 15: V*ertical Jerger box pattern seen in client with SOC lesion.

	RIGHT	LEFT
Contra lateral	Absent	Normal
Ipsi lateral	Absent	Normal

Acoustic reflex latency appear to be normal in patients with cortical lesions and inconsistent among patients with brain stem disorder, so it does not appear to provide diagnostically useful information in central auditory pathologies (Bosatra, Russolo, & Silverman, 1984).

Demyelinating disease (Multiple sclerosis)

Multiple sclerosis is a degenerative disease affecting the central nervous system through the demyelination (destruction of the myelin sheath of the nerves) while sparing the nerve axons. Plaque like scars forms at the sites of myelination (Cohn, 1981). Although the plaques may form anywhere in the brain stem, spinal cord, visual system, cerebellum, and/or pyramidal motor system are the sites most commonly affected (Cohn, 1981).

When the cortical or brainstem auditory pathways are involved, a central auditory disorder may be present. Clinically, multiple sclerosis is characterized by episodes of localized central nervous system disorders (Jerger & Jerger, 1981).

Multiple sclerosis is found to bring about certain changes in reflex even before affecting the results of pure tone or speech audiometry. Abnormalities of reflex thresholds, magnitude, and latencies have been reported to occur in multiple sclerosis (Colletti, 1975; Bosatra, Russolo, & Poli, 1976; Stephen & Thornton, 1976; Hess, 1979; Wilson et al, 1984; Mangham, 1984; Jerger, 1986; Keith, Garza, Smolak & Pensak, 1987).

Colletti (1975) observed that cases with multiple sclerosis had elevated reflex thresholds. The rise time of reflex was very long (at 1000 and 2000 Hz, but no difference was seen at 500 Hz for white noise) and the amplitude had reduced. According to Bosatra et al (1984) the rise time of the AR appears to be of greater diagnostic value than threshold or latency measure.

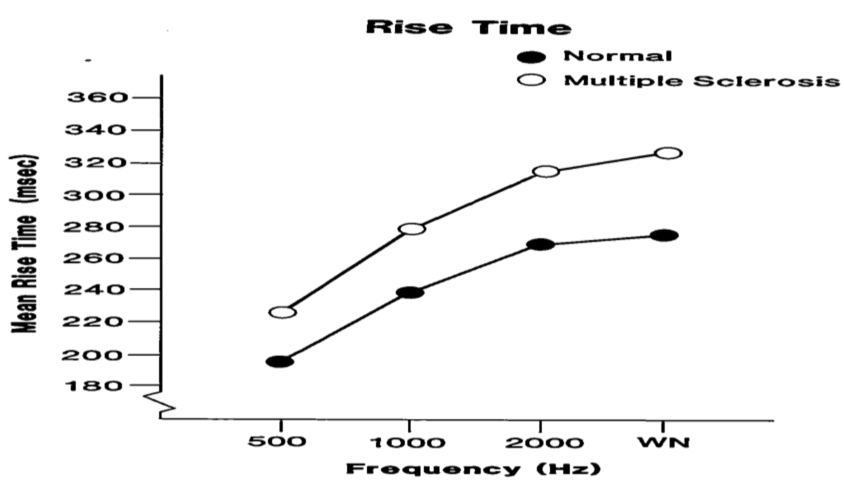


Figure 29: Mean rise time in response to 500, 1000, 2000 Hz, and white noise stimulus.

Table 16: Diagonal Jerger box pattern in eight nerve involvement.

	RIGHT	LEFT
Contralateral	Normal	Absent
Ipsi lateral	Absent	Normal

Reflex threshold abnormality may be cherecterised by a diagonal or horizontal Jerger box pattern depend upon the site of disorder. In diagonal configuration, crossed and uncrossed acoustic reflexes are abnormal with sound to the affected ear.

Table 17: Horizontal Jerger box pattern in intra axial brainstem involvement.

	RIGHT	LEFT
Contra lateral	Absent	Absent
Ipsi lateral	Normal	Normal

In horizontal configuration reflexes on both ears are abnormal in the crossed condition and normal in the uncrossed condition. The diagonal pattern is consistent with eight nerve involvement whereas horizontal pattern is consistent with intra axial involvement.

Neuro muscular disorder (Myasthenia gravis).

Myasthenia gravis is a neuromuscular disorder which also can evidence abnormal reflex adaptation. Repeated stimulation results in abnormal fatigue of the muscle, which is manifested as abnormal adaptation (Blom & Zakrisson, 1974; Wilson et al, 1984; Smith & Brezinova, 1991; Toth, Lampe, Dioszeghy & Repassy, 2000). With the administration of anticholinesterase agent, the adaptation is slow, with reflex declining to 25 to 60 % of its original magnitude in 60 seconds for 500 and 1000 Hz (the RCP, on the other hand, displayed adaptation in less than 10 seconds). The onset magnitude of the reflex also is decreased by 50 to 75 % as compared to normal, and reflex thresholds may be elevated.

Blom and Zakrisson (1974) studied the contralateral stapedius reflex in patients with myasthenia gravis. The reflex was assessed by recording the change which occurred in the acoustic impedance of the middle ear. In all patients decay of the reflex was found, and interpreted as a sign of increased fatigability at the neuromuscular junction of the stapedius muscle.

Cerebrovacular diseases

Cerebrovascular disease is a group of brain dysfunctions related to disease of the blood vessels supplying the brain. Cerebrovascular disease (CVD) includes all disorders in which an area of the brain is transiently or permanently affected by ischemia or bleeding and one or more of the cerebral blood vessels are involved in the pathological process. Blood vessel abnormalities may include weakening or rupture of vessel walls, failure of systematic circulation, vasospasm, and occlusion by thrombus or embolus. Consequences of blood vessel disease may include intra cranial blood ischemia (Jerger & Jerger, 1981). As the age increases the brain tends to fall caudally, that leads to arteriosclerosis and deterioration of vascular collagen, result in distended arteries (Moller

& Moller, 1985). This vascular collagen in the brainstem exerts stress on the nerves of the cerebellopontine angle (Moller & Moller, 1985).

Abnormality in the acoustic reflexes will be seen when the vascular compression at the brainstem affects the cochleovestibular nerve or the facial nerve. Vascular compression on the VIII CN may result from elongation of one of the loop of anterior inferior cerebellar artery between/under/above VII and/or VIII CN (Moller & Moller, 1985). Vascular compression of the VIII CN may result from elongation of one of the loop of superior cerebellar artery, in the posterior fossa (Moller & Moller, 1985).

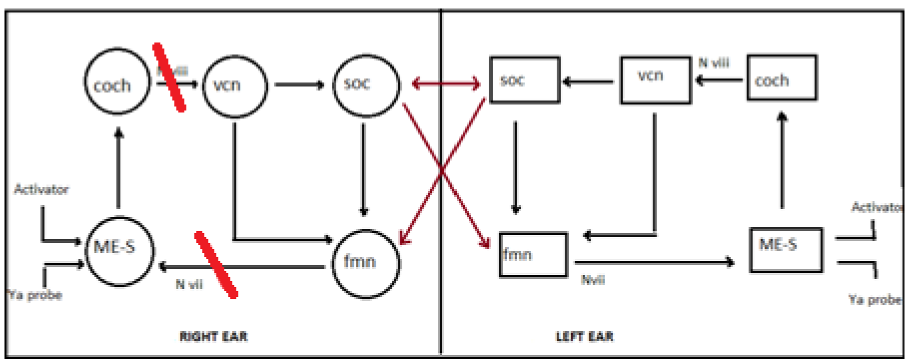


Figure30: Effect of vascular brainstem compression on both the cochleovestibular nerve and the facial nerve.

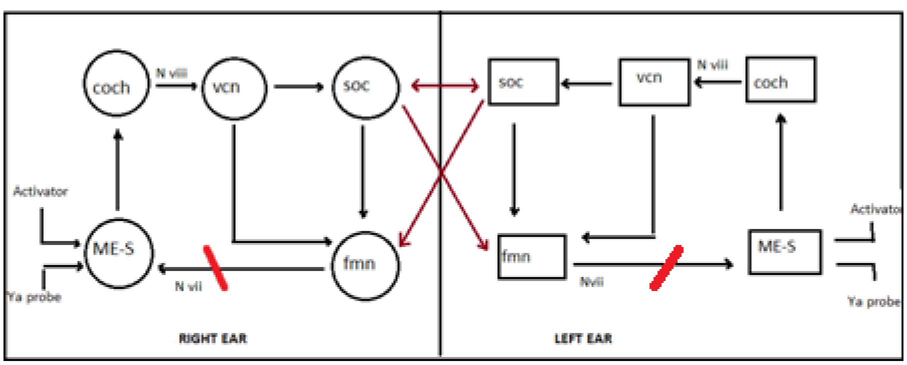
As discussed earlier that the acoustic reflex pattern depends upon the site of lesion in the brain stem (Jerger & Jerger, 1977). When the vascular brainstem compression affects the cochleovestibular nerve, the uncrossed reflexes will be absent in the affected side. Whereas in a condition where vascular brainstem compression affects both the vestibulocochlear nerve and the facial nerve, both the crossed and uncrossed reflexes will be absent as ipsi as well as contra pathways will be compromised on the affected side.

Table 18: Inverted L shaped Jerger box pattern in cases with both vestibulocochlear and facial nerve atrophy.

	RIGHT	LEFT
Contra lateral	Absent	Absent
Ipsi lateral	Absent	Normal

Moebius syndrome

The Moebius syndrome is a rare congenital development disorder of facial diplegia associated with bilateral VI CN paralysis. Moebius syndrome is caused by several factors that act between the fourth and seventh weeks of gestation life resulting in hypoplasia of sixth and seventh nerve nuclei.



Figures 31: Bilateral facial nerve hypoplegia affecting both ipsi lateral and contra lateral pathways.

The acoustic reflex in Moebius syndrome represents an involuntary muscle contraction (stapedius and tensor tympani muscles) in the middle ear, since the motor function of the stapedius muscle, innervated by the facial nerve, may be compromised in cases of Moebiüs Sequence (Bezerra, Griz, Azevedo, Ventura & Revoredo, 2006). In such condition all the uncrossed as well as crossed acoustic reflexes will be absent as both side ipsi and contra pathways will be compromised.

Table 19: All the reflexes are absent in client with Moebius syndrome.

	Right	Left
Contra lateral	Absent	Absent
Ipsi lateral	Absent	Absent

QUESTIONS

Match the following:

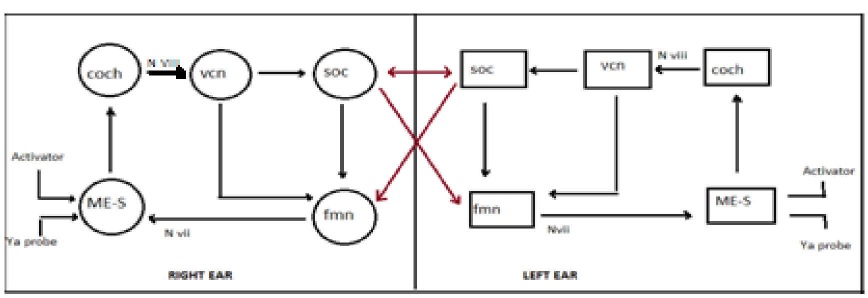
1. Hypoplasia of facial nerve. — Multiple sclerosis.
2. Upper brainstem lesion. — Cerebrovascular disorder.
3. Degeneration of CNS. — Moebius syndrome.
4. Inverted L Jerger box pattern. — Normal acoustic reflexes.

Complete the diagram:

1. Vertical Jerger box pattern.

	RIGHT	LEFT
Contralateral		
Ipsi lateral		

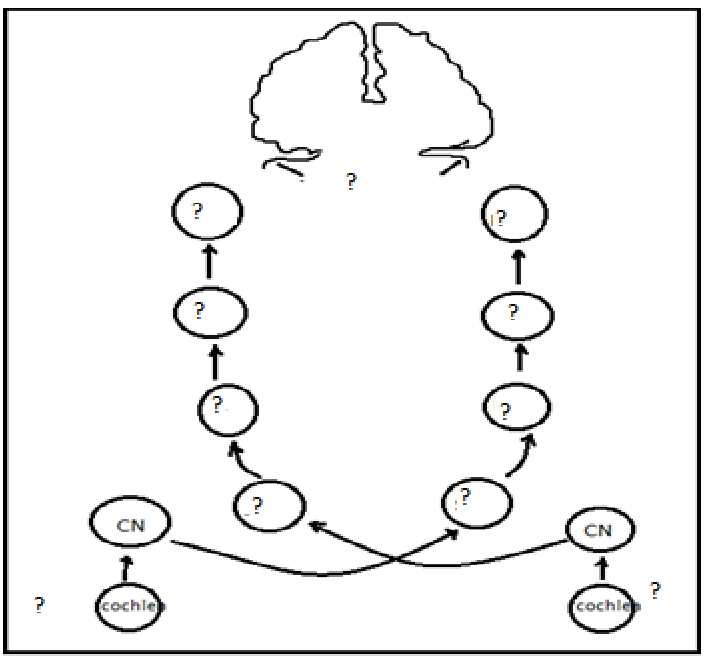
2. Interruption in pathway due to cerebro vascular disorder.



3. Jerger box pattern in Moebius syndrome.

	RIGHT	LEFT
Contralateral		
Ipsi lateral	Absent	

4. Nuclei of the brain stem.



5. Jerger box pattern in cortical lesions.

	RIGHT	LEFT
Contra lateral		
Ipsi lateral		

ANSWERS

Match the following:

1. Hypoplasia of facial nerve.
2. Upper brainstem lesion.
3. Degeneration of CNS.
4. Inverted L Jerger box pattern.

Multiple sclerosis.

Cerebrovascular disorder.

Moebius syndrome.

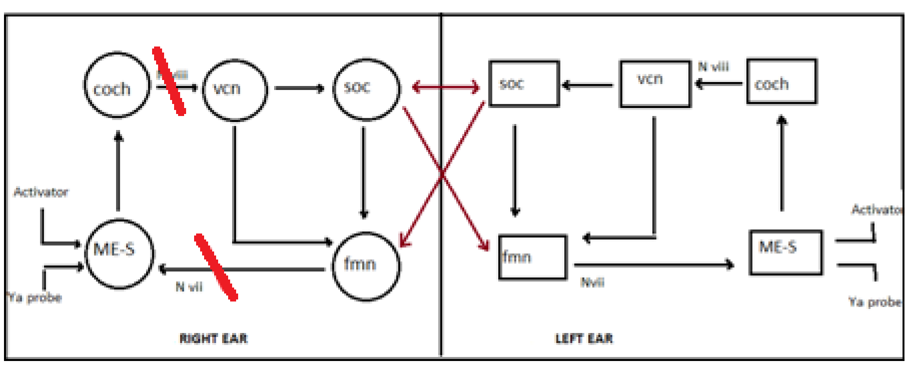
Normal acoustic reflexes.

Complete the diagram:

1. Vertical Jerger box pattern.

	RIGHT	LEFT
Contralateral	Absent	Normal
Ipsi lateral	Absent	Normal

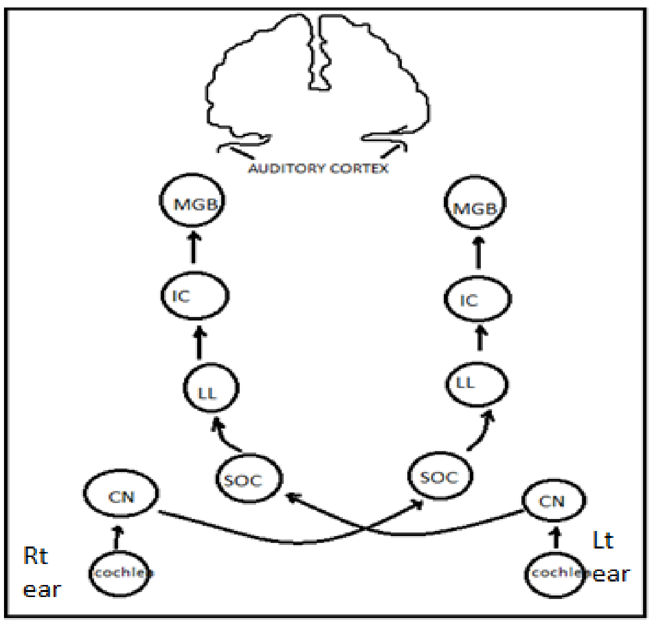
2. Interruption in pathway due to cerebrovascular disorder.



3. Jerger box pattern in Moebius syndrome.

	RIGHT	LEFT
Contralateral	Absent	Absent
Ipsi lateral	Absent	Absent

4. Nuclei of the brain stem.



5. Jerger box pattern in cortical lesions.

	RIGHT	LEFT
Contralateral	Normal	Normal
Ipsi lateral	Normal	Normal

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