Implementation of Tympanometry using Soft Core Processor

Varsha Baheti
ME student at Sinhgad Institute of Technology Campus, Lonavala, India

Flat no. 16, Building no.13 Vighnahar Society, Sec-19, Airoli

V. V. Deotare
Professor at Sinhgad Institute of Technology, Department of Electronics and Telecommunication, Lonavala, India

R. V. Babar
Professor at Sinhgad Institute of Technology, Department of Electronics and Telecommunication, Lonavala, India

ABSTRACT
Tympano metry is an electronic and acoustic measurement technique, which is used in the initial and subsequent evaluations of patients to assess tympanic membrane mobility. Objective of this technique is to identify patients hearing ability by hyperbaric treatment. Roles of this method are diagnosis, treatment and follow-up of Otitis media in general practice. It provides a graphic representation of the relationship of air pressure in the external ear canal to impedance of the ear drum. Three types of curves depicting tympanic membrane compliance and mobility can be distinguished using Tympano metry. Type-A curve indicates normal middle ear pressures and tympanic membrane mobility. Type-C curve identifies patients with negative middle ear pressures because of Eustachian tube obstruction and reduced tympanic membrane compliance. Type-B curve are flat with no change in compliance with positive or negative pressure applied to the tympanic membrane and are found when the middle ear space is filled with fluid.

Keywords
Membrane compliance, middle ear pressure, Otitis media, tympano-metry.

1. INTRODUCTION
Audition is the ability to hear. Hearing is the function of the body by which sound is perceived. The ear is the part of the body which enables this function to take place. The ear (Figure1) is contained mostly within the temporal bone, which is one of the lateral surfaces of the base of the skull. The ear is subdivided into external, middle and inner ear. Sound waves picked up and directed by the external ear travel to the eardrum (middle ear) and cause it to vibrate. These vibrations move three small bones called ossicles in the middle ear which set in motion the fluid in the internal ear. This fluid movement stimulates the nerve cells and the nerve cells in turn transmit impulses to the hearing centers of the brain and brain recognizes them as sounds.

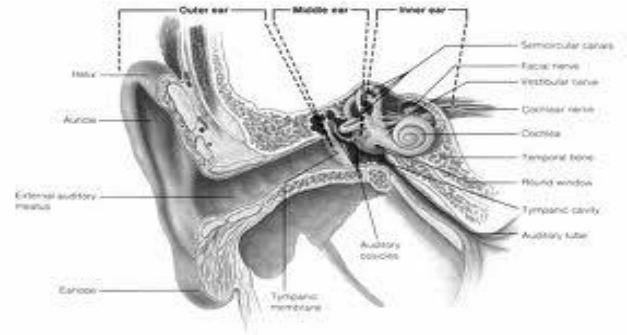

Figure.1 Structure of the ear

1.1 Utility of different instruments:
1. Audio metry

Auditory sensitivity may best be determined by the use of an audiometer, which is an electronic oscillator capable of emitting pure tones over a wide range. The patient is seated in a soundproof room and fitted with a set of earphones to measure the threshold (slightest perceptible sound) for pure tone. Various frequencies are selected and the dB's varied until the examinee reports that she/he can hear sound. The threshold for each frequency is recorded. The entire range of audible pitches is tested and plotted on an audiogram. The audiogram discloses deviations from normal values in the entire range of audible frequencies. The greater the number of decibels, the greater the hearing loss [5]

2. Tympanometry

Tympanometry is a test of the status of the middle ear measured at the level of the eardrum (tympanic membrane). It is a test of the middle ear function only and does not assess hearing ability. The test is conducted by inserting a plastic tip into the ear [1]. There are usually three connections through the plug: a pressure gauge, a pure tone source and a calibrated microphone. A pure tone is sent through the tympano meter and the depth of the tone sent back from the eardrum, recorded by means of the tube connected to the microphone. In this way, the flexibility (impedance) of the eardrum can be calculated.

There is a standard range of flexibility of the eardrum which is considered normal. Any disease process that either

increases (fluid in the middle ear) or decreases (perforated eardrum) the flexibility of the eardrum interferes with the efficiency with which sound can be transmitted through the middle ear and may be an indication of a hearing loss.

1.2 Properties of Sound:

Sound has three important characteristics: pitch, loudness and quality.

1. Pitch:
Pitch or tone is dependent upon the frequency of the sound waves (frequency: the number of vibrations or cycles of the sound waves per second).
2. Loudness:
Loudness is dependent on the intensity of the sound waves.
3. Quality:
Quality is dependent upon the higher parts of the sound or overtones. Sounds begin by vibrating as a whole and then rapidly divide into parts which vibrate on their own at their own frequency. Thus, although a sound may have the same frequency and intensity, the quality allows us to distinguish whether it is a zither or a drum.

2. HEARING LOSS AND THEIR DETECTION TECHNIQUES

There are two main types of hearing loss. One happens when your inner ear or auditory nerve is damaged. This type is permanent. The other kind happens when sound waves cannot reach your inner ear. Earwax build-up, fluid or a punctured eardrum can cause it. Tympanometry obtains information of the state of the middle ear and Audio metry measures hearing thresholds. Tympanometry is one of several tests that audiologists call "immittance" tests [3]. Immittance = impedance+admittance. The other "immittance" test is reflexes. These are typically used as a quick method of determining a perforation of the ear drum or a middle ear infection.
Audio metry will be conducted on all patients in six to nineteen years of age group. Each patient will be tested on his/her ability to hear 7 frequencies: 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz. At each frequency, the sound in each ear will be tested separately, unless while asking the audio metry questions the technician ascertains that the examinee hears better in one ear than in the other [3]. In that case, the ear in which the examinee hears better will be tested first.

Tympanometry testing will be conducted on all subjects. The Tympanometer will test the function of the middle ear by first measuring the impedance or flexibility of the eardrums and then by measuring the integrity of the bones in the middle ear. Each ear will be tested separately. Although these tests may appear simple, accurate measurement depends on many factors [5].

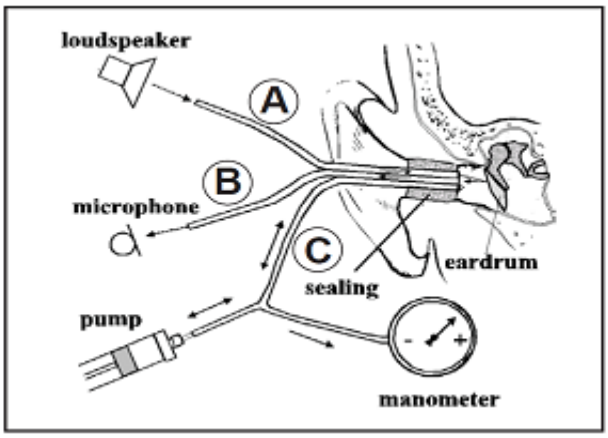

Figure.2 Functioning of tympanometer

2. TYMPANOMETRIC TERMS:

a) Ear Canal Volume(ECV):
The equivalent ear canal volume (ECV) is an estimate of the volume of air medial to the probe, which includes the volume between the probe tip and the tympanic membrane if the tympanic membrane is intact, or the volume of the ear canal and the middle ear space if the tympanic membrane is perforated [3].

b) Tympano metric Peak Pressure/Middle Ear Pressure(TTP)/ (MEP):
Tympano metric peak pressure (TTP) or middle ear pressure (MEP) is the ear canal pressure at which the peak of the tympano gram occurs [3].

Static Compliance (SC):
Static compliance (SC) "is the greatest amount of acoustic energy absorbed by the middle ear system (the vertical peak of the tympanic tracing)[3]".

Gradient:
Tympano gram gradient is an objective measure that describes the steepness of the slope of the tympano gram near the peak [3].

4. TYMPANOGRAM TYPES:

1. Type A:

As shown in Figure3

- Sharp peak.
- MEP between +50 to -99 cm3.
- SC = 0.3 to 1.6cc (adults)/0.2 to 0.9cc (children 3 – 5yrs).
- ECV within normal range.

Tympanometry showed normal middle ear pressure and static compliance.

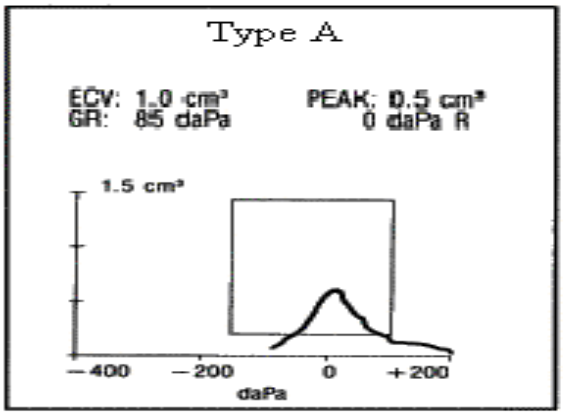

Figure.3Type A tympanogram

2. Type B:

As shown in Figure4

- Rounded line/no peak.
- Usually no measureable/reduced MEP or SC .
- ECV within normal range.

Tympanometry showed no measureable middle ear pressure or static compliance, consistent with middle ear pathology

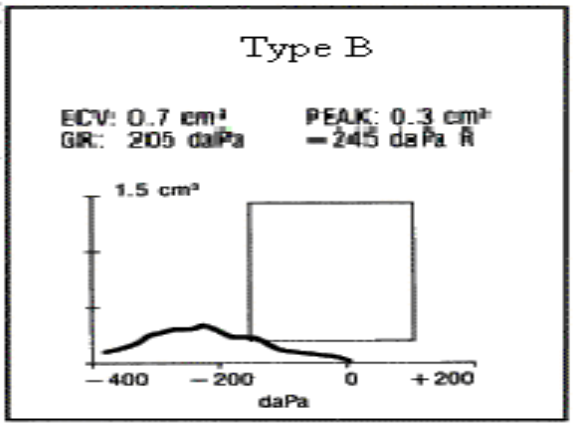

Figure.4 Type B Tympanogram

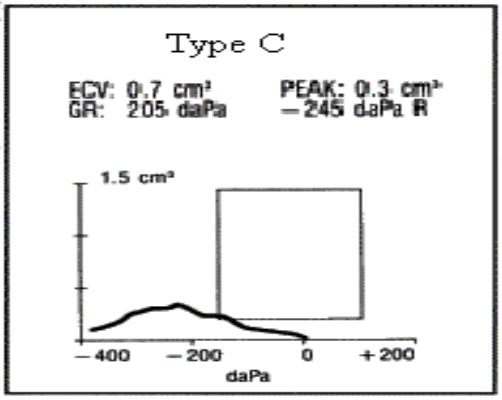

Figure.5 Type C tympanogram

3. Type C:

As shown in Figure5

- Sharp peak.
- MEP less than -99 cm3 (significant negative MEP).
- SC = 0.3 to 1.6cc (adults)/0.2 to 0.9cc (children 3 – 5yrs).
- ECV within normal range.

Tympanometry showed significant negative middle ear pressure in the presence of normal static compliance, consistent with Eustachian tube dysfunction/middle ear pathology.

4. Type As:

As shown in Figure6

- Sharp peak.
- Normal MEP.
- SC < 0.3cc (adults) (hypo mobile).
- ECV within normal range.

Tympanometry showed normal middle ear pressure with decreased static compliance, consistent with a hypo mobile tympanic membrane.

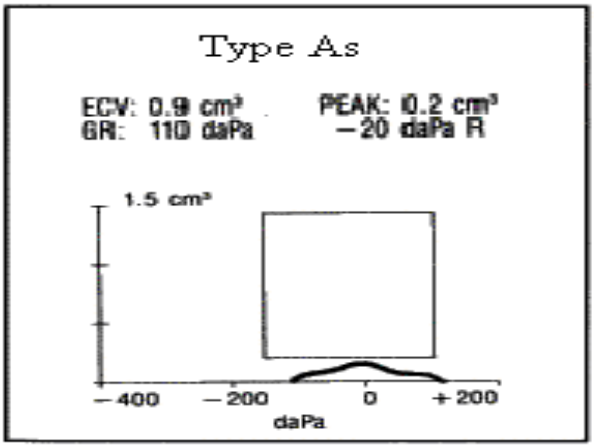

Figure6 Type As tympanogram

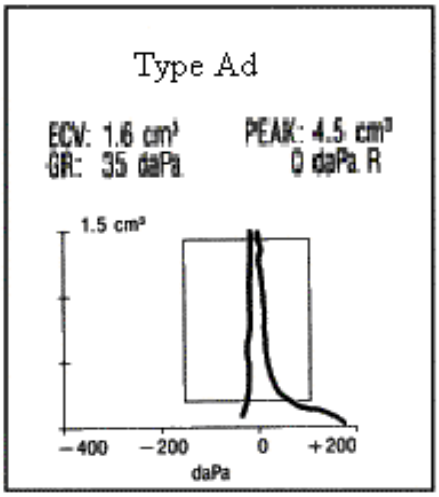

Figure.7 Type Ad Tympanogram

5. Type Ad:

As shown in Figure.7

- Sharp peak.
- Normal MEP.
- SC > 1.6cc (adults) (hyper mobile).
- ECV within normal range.
- Tympanometry showed normal middle ear pressure with increased static compliance, consistent with a hyper mobile tympanic membrane.

Tympanometry showed normal middle ear pressure with increased static compliance, consistent with a hyper mobile tympanic membrane.

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