OPEN ACCESS GUIDE TO AUDIOLOGY AND HEARING AIDS FOR OTOLARYNGOLOGISTS

TYMPANOMETRY

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Tympanometry is not a test of a patient's hearing. It objectively provides an indication of the ***status of the middle ear*** and the ***mobility of the ear drum.*** It does this by measuring the degree to which sound transmission through the eardrum and middle ear is modified when there is a change in air pressure applied to the eardrum. Tympanometry provides useful information about:

- Pressure in the middle ear space
- Presence of fluid in the middle ear space
- Mobility of the middle ear system
- Volume of the ear canal

Indications for tympanometry

Not all patients with ear pathology require tympanometry.

1. ***Suspected middle ear effusion (OME)***

Tympanometry is recommended main-ly to ***evaluate suspected*** OME/secre-tory otitis media (SOM). It is done in conjunction with information obtained from the history, appearance and mobility of the eardrum. Otoscopic and otomicroscopic evidence of OME may include yellowness, redness, hypervascularity, bulging or retraction of the ear-drum, visible air-fluid levels, and diminished mobility on pneumatic otoscopy. Otomicroscopic and pneu-matic otoscopy have been reported to have a high accuracy for diagnosing OME in children[1]. Yet it is uncertain what degree of training and expertise is required to obtain high accuracy [1]. Tympanometry however requi-res minimal training, is quick and simple to perform, and provides objective information.

2. ***Patency of tympanostomy/ventilation tubes/grommets***
3. ***Whether there is a perforation in the eardrum***
4. ***Mobility of the eardrum***
5. ***Mobility of the ossicular chain***

Principles of tympanometry

Tympanometry provides a ***measurement of impedance of the middle ear system including the eardrum***. It allows one to determine ***how much resistance the middle ear system renders to passage of sound to the inner ear.***

Impedance of the middle ear is increased if:

- The middle ear is filled with ***fluid***, especially with thick secretion
- There is ***increased stiffness of the ossicular chain***, for example when there is a fixation of the malleus or stapes (hammer or stirrup). In oto-sclerosis the stapes becomes progress-sively fixed in the oval window; due to this the impedance increases in later stages of the disease.

Impedance of the middle ear is reduced if:

- The eardrum is overly mobile or flac-cid
- There is a disruption of the ossicular chain

How does tympanometry work?

A constant low-pitch sound (~220Hz) is introduced into the ear through an opening in the head (tip) of the tympanometer that is tightly introduced into the external ear canal using a plastic or foam rubber collar *(Figure 1)*. In the same tip there is another opening that leads to a ***microphone that continuously registers the sound reflected***

from the ear drum; a third opening in the tip is connected to an ***air pump that can change the air pressure*** applied to the eardrum from positive to low pressures.

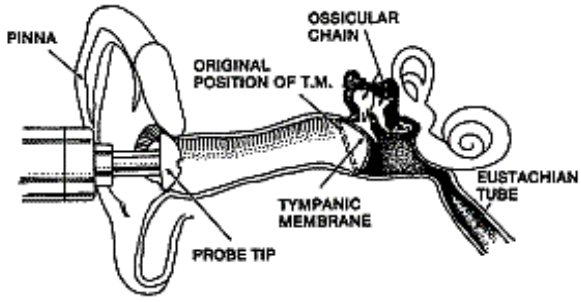


Figure 1: Tympanometer probe tip in the ear canal

Between the tip of the tympanometer and the eardrum a small "chamber" is thus created in the deep ear canal in which the sound level is constantly measured while the pump alters the air pressure in this "chamber". The least amount of sound is reflected when the eardrum is in a normal and relaxed position since most of the sound passes through the eardrum and middle ear. When the eardrum is however pressed outwards or retracted inwards it becomes stiffer and more sound is reflected back from its surface into the "chamber".

Tympanogram

The tympanometer displays the reflected sound in the ear canal "chamber" relative to changes in stiffness of the eardrum (achieved by changes in ear canal pressure produced by the tympanometer) as a ***tympanogram***. The tympanogram curve is plotted upside-down - the ***inverted reflected sound level is called "compliance"***. The pressure is expressed along the X-axis in deca-Pascal (daPa) and the compliance along the Y-axis in "volume of air in cm^3" required putting the system "under pressure". The resulting curve is called a tympanogram *(Figure 2).* Tympanometry is thus an acoustic method that indirectly measures the compliance of the tympanic membrane and middle ear.

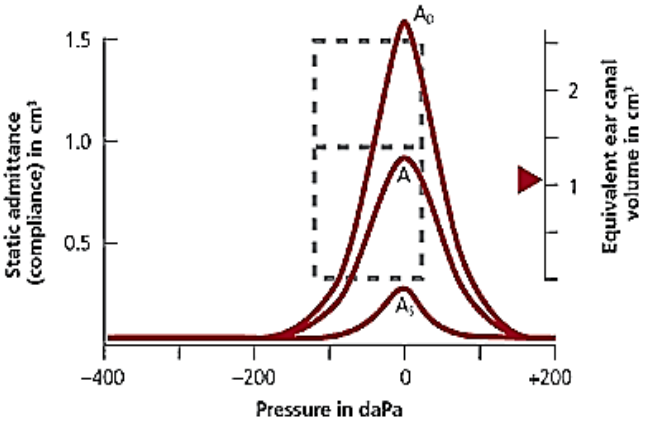


Figure 2: A: Normal type-A tympanograms; A_D: hypermobile; A_S: restricted

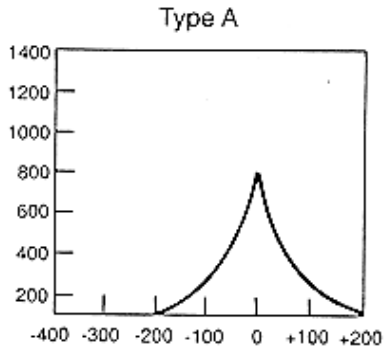
Types of tympanogram readings

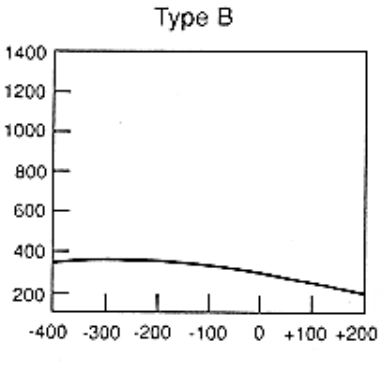
The reflected sound has its lowest value when the eardrum is in its most relaxed and normal position. Tympanogram tracings are classified as type A (normal), type B (flat, clearly abnormal indicating fluid in the middle ear or a perforation), or type C (indicating a significantly negative pressure in the middle ear (< -200 daPa). *(Figure 3)*

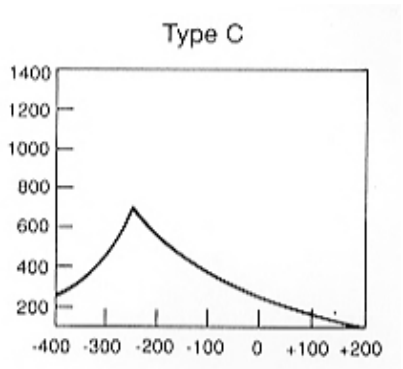
What can "tympanometry" tell us?

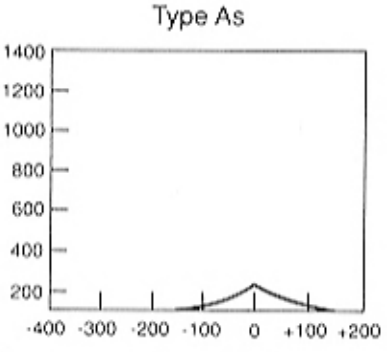
1. ***Pressure in the middle ear:*** A negative pressure of < -200 daPa (Type C curve) is considered pathologic *(Figure 3).* To have an idea what this means, you may think of it as the pressure of a 20cm column of water.

2. ***Is the middle ear fluid-filled?*** One then sees a flat tympanogram (Type Bcurve) with a normal ear canal volume *(Figure 3)*









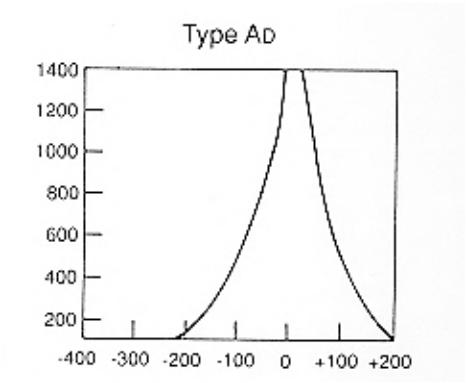


Figure 3: Typical tympanogram tracings

3. If the eardrum has a ***perforation*** or an ***open tympanostomy/ventilation tube /grommet*** one also sees a flat tympanogram (Type B curve), but with a big ear canal volume (>3cm^3)

4. If the ***eardrum or middle ear system*** is ***overly mobile***, one then obtains a high tympanogram curve (Type-A_D) with high compliance of >1.5cm^3 *(Figures 2 and 3)*

5. If the ***eardrum or middle ear system*** has ***restricted mobility***, one sees a very low tympanogram curve (Type-A_S) with a small volume, (low compliance <0.3cm^3) *(Figures 2 and 3)*

6. The ***stapedial reflex*** measurement allows one to assess facial nerve function in the examined ear and mobility of the ossicular chain (including the stapes) in the same ear. Note that in otosclerosis the stapedial reflexes are already changed or absent at an early stage of the disease even when the shape of the tympanogram is still fairly normal

How does one perform tympanometry?

It only takes a few seconds to record a tympanogram. *Figures 4 & 5* show typical

examples of tympanometers. Tympanometers found in developing countries are usually ***automatic screening tympanometers*** that automatically start to record when the tip is tightly introduced into the ear canal to create an airtight seal; the pump that alters the pressure in the ear canal is automatically activated when the tip of the instrument is tightly fitted into the ear. It is important that it is kept tightly fitted during the whole recording process to ensure the airtight seal is not interrupted during testing. The tympanometer produces a tympanometric curve that represents the compliance of the middle ear system, including the ear drum, as a function of the pressure applied to the eardrum *(Figure 2)*. From the shape of the curve or the figures, one can also read the volume between the tip of the tympanometer and the eardrum and determine the compliance of the middle ear system. Many screening tympanometers also have a function to automatically measure the ipsilateral (same side) stapedial reflex at 1-3 supraliminal sound stimuli (90-100 dB).

Advantages of tympanometry

It is an ***objective audiometric method*** because it does not depend on information that the patient gives us but rather measures something without subjective feedback from the patient. The patient then becomes the object and does not have to say whether he or she has heard or experienced anything.

It also ***does not require clinical expertise to diagnose middle ear effusions***.

Pitfalls of tympanometry

- An undiagnosed, perforated eardrum or an inadequate seal between the tip of the tympanometer and the ear canal will produce a Type B tympanogram which may be misconstrued as a middle ear effusion
- Diagnosis of a middle ear effusion *per se* is not an indication for insertion of ventilation tubes; it must be accompanied by clinically significant and persistent conductive hearing loss
- Although a conventional probe tone of 220 Hz is sufficient for tympanometry in almost all populations it is not effective for evaluating infants younger than 7 months. For these young infants a higher frequency probe tone of 1000 Hz is recommended.

Figure 4: Microtympanometer with printout of tympanogram on right side

Figure 5: Tympanometer

References

1. Takata GS *et al*. Evidence assessment of the accuracy of methods of diagnosing middle ear effusion in children with otitis media with effusion. *Pediatrics*. 2003;112(6 Pt 1):1379-87

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