# A Guide *to* Tympanometry *for* Hearing Screening

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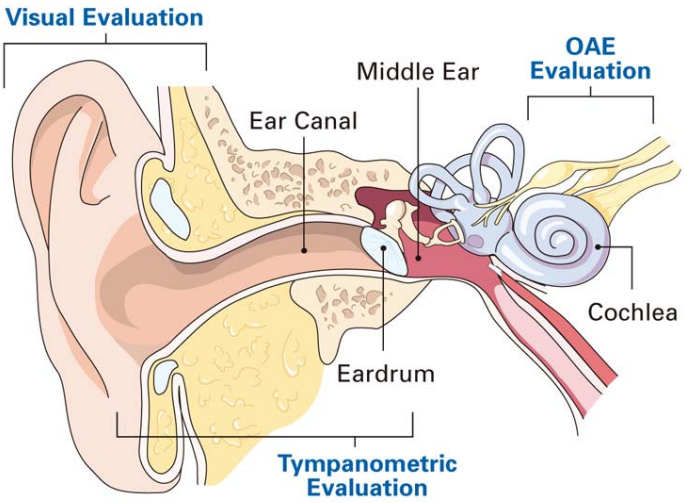
## Introduction

Tympanometry is a testing methodology that is used to evaluate the function of the middle ear. It provides a graphic representation of the relationship of air pressure in the external ear canal to impedance (resistance to movement) of the ear drum and middle ear system.

This impedance measurement examines the acoustic resistance of the middle ear. If the eardrum is hit by a sound, part of the sound is absorbed and sent via the middle ear to the inner ear while the other part of the sound is reflected.

The information derived from tympanometry provides the physician with additional information regarding the patient's middle ear function. In a pediatric population this is typically to document or rule out the presence of otitis media, tympanic membrane perforation or Eustachian tube dysfunction. The test is non-invasive and does not require any response from the patient. Typical test time for both ears is less than two minutes.



## How a tympanometer works

The tympanometer has a hand-held probe that is inserted into the ear. Inside the probe are three tubes containing a loudspeaker (figure 1: A), a microphone (figure 1: B) and a pump (figure 1: C).

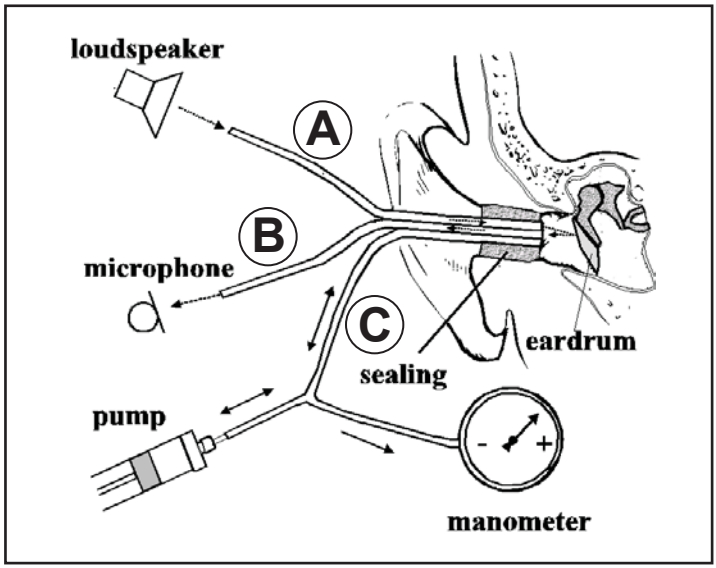



Figure 1

The probe is inserted into the ear canal and forms an airtight seal from the pressure of the eartip against the canal wall. A tone is delivered through the loudspeaker while the pressure is changed within the sealed canal. Then the microphone measures the amount of sound that is reflected back from the eardrum during the pressure sweep. This information is then displayed in graph form – the tympanogram.

## The tympanogram

A tympanogram provides several pieces of information including:

- Compliance of the middle ear system (eardrum movement)
- Ear canal volume
- Middle ear pressure
  (normally equal to atmospheric pressure in healthy ears)
- A pattern that corresponds to various disorders

*Compliance of the middle ear system*

Compliance is plotted vertically on the tympanogram (figure 2).

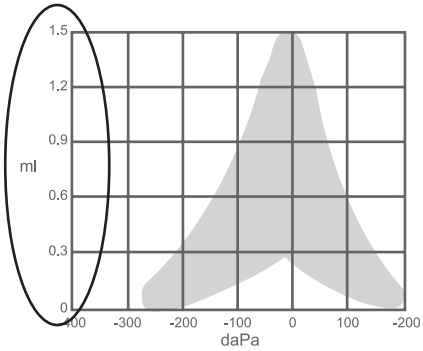



Figure 2

Maximum compliance of the middle ear system occurs when the pressure in the middle ear cavity is equal to the pressure in the external auditory canal. The maximum compliance value occurs at the highest peak of the curve on the graph (figure 3).

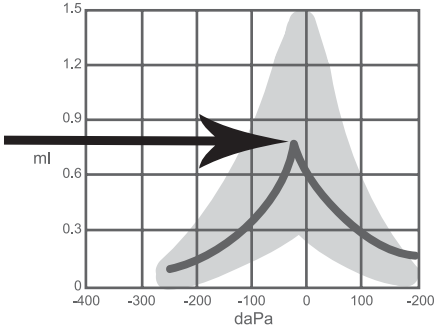



Figure 3

When you create positive and negative pressure the eardrum stiffens and the compliance decreases. You can then draw conclusions on the condition of the middle ear from the numerical value and shape of the tympanogram.

*Middle ear pressure*
Pressure is plotted horizontally on the tympanogram (circled in figure 4).

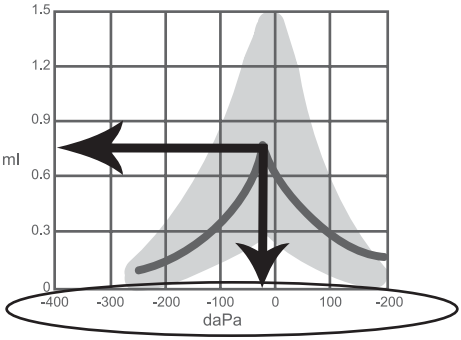



Figure 4

Pressure in the external auditory canal is varied from -200 daPa through +400 daPa while monitoring impedance. Impedance is lowest (maximal compliance) when pressure in the canal equals pressure contained within the middle ear space. Therefore you can determine the middle ear pressure by locating the value on the horizontal axis that corresponds to the peak of maximum compliance on the vertical axis (shown with arrows on figure 4).

*Ear canal volume*
As a general rule, values for ear canal volume should be between 0.2 and 2.0 ml (children and adults). A variance will be seen within this range depending on the age and ear structure of the person. For example, a 2.0 ml or larger reading in a small child could indicate a perforation in the tympanic membrane or a patent P.E. tube, while it may be a normal reading in an adult.

A compliance peak within a normative range (see appendix A on page 13) indicates normal mobility of the middle ear system. A peak found outside of these limits may indicate one of several pathologies.

*Pattern of the curve*
Figure 5 shows the "Type A" curve of a normal tympanogram. This curve is shown as a thick dark line against the shaded area (shading shows the area a "normal" tympanogram would fall into).

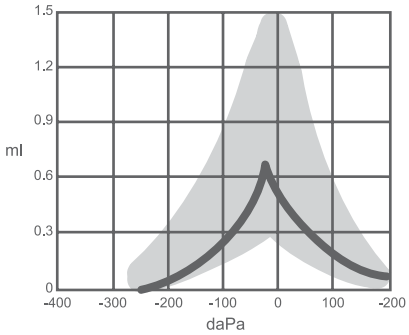



Figure 5

In a "Type A" curve, the peak compliance occurs at or near atmospheric pressure indicating normal pressure within the middle ear.

This kind of curve has three subcategories:

**A:** Normal shape reflects a normal middle ear mechanism.

**AD:** A deep curve with a tall peak indicates an abnormally compliant middle ear system, as typically seen with ossicular chain dislocation or loss of elastic fibers in the tympanic membrane.

**AS:** A shallow curve indicative of a stiff system, as seen in otosclerosis or thickened tympanic membrane.

The second pattern forms a “Type B” curve (figure 6).

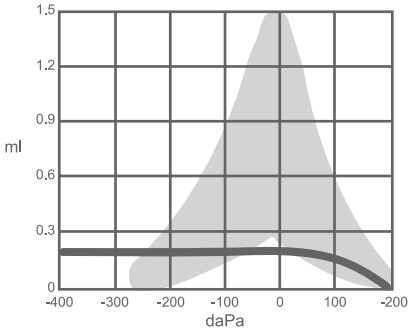



Figure 6

A “Type B” curve has no sharp peak and little or no variation in impedance over a wide sweep range. This is indicative of non-compressible fluid within the middle ear space (otitis media), tympanic membrane perforation, or debris within the external ear canal (cerumen).

With the third pattern, a “Type C” curve (figure 7), peak compliance is significantly below zero (usually less than -200), indicating negative pressure (sub-atmospheric) within the middle ear space. This finding is suggestive of Eustachian tube dysfunction or middle ear fluid.

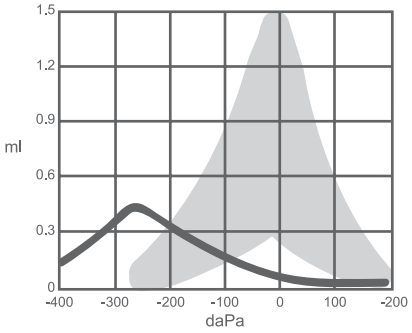



Figure 7

## Acoustic reflex measurements

An acoustic reflex, or contraction of the Stapedial muscle, occurs under normal conditions when a sufficiently intense sound is presented to the auditory pathway. This contraction of the muscle causes a stiffening of the ossicular chain which changes the compliance of the middle ear system. As in tympanometry, a probe tone is used to measure this change in compliance.

When the stimulus presentation and measurement are made in the same ear by means of the probe, this acoustical reflex is referred to as an ipsilateral acoustic reflex. When the stimulus presentation and measurement are made in opposite ears, the reflex is referred to as a contralateral acoustic reflex.

An acoustic reflex measurement is taken after the tympanogram is performed. For best results, this reflex measurement is automatically conducted at the air pressure value where the compliance peak occurred during the tympanometric test. Stimulus tones of varying intensities at 500, 1000, 2000 or 4000 Hz are presented as short bursts.

If a change in compliance greater than 0.05 ml is detected, a reflex is considered present. Because this is an extremely small compliance change, any movement of the probe during the test may produce an artifact (false response). The test result is recorded as Pass/No Response and in graphical form.

### Keys to accurate testing

- Clear the ear of debris
- Create an air-tight seal between the probe tip and the ear
- Make sure the patient is still and does not swallow

The tympanogram results can be combined with the acoustic reflex measurements to obtain an accurate picture of the middle ear function.

The following illustrate some possible scenarios.

Eustachian tube dysfunction in the absence of fluid will show a normal compliance curve, but it will be displayed to the negative side of the tympanogram. Ear canal volume will be normal and the reflex may be present, depending on the degree of involvement.

Other disorders, such as a perforation in the tympanic membrane, will cause a high ear canal volume measurement because the instrument will measure the volume of the entire middle ear space in addition to the volume of the ear canal. An extremely flaccid tympanic membrane or an ossicular chain discontinuity will yield a very high peak compliance in the presence of normal middle ear pressure. Ear canal volume will be normal and the reflex will be absent.

A fixation of the ossicular chain, as in otosclerosis, will produce a tympanogram with very low compliance in the presence of normal middle ear air pressure. Ear canal volume is normal and the reflex is absent.

Middle ear fluid such as in serious otitis media will yield a very flat tympanogram with no definite peak and negative air pressure. A resolving case or beginning case may produce a reduced peak in the presence of severe negative middle ear pressure. The ear canal volume is normal and the reflex is either absent or at an elevated level.

## How tympanometry fits into your practice

A tympanogram provides documented results of middle ear function that can assist with the visual otoscopic exam. An impedance measurement provides a method to diagnose and monitor disorders that could lead to permanent hearing loss, which is critical especially when working with children.

Uses of tympanometry in the clinic:

- Objective documentation of reduced eardrum movement (i.e., fluid or wax)
- Monitor chronic middle ear fluid
- Monitor PE tube function
- Confirm tympanic membrane perforation
- Monitor Eustachian tube function

As a non-invasive test, tympanometry can quickly and easily be performed on patients of any age, from infants to adults. Testing only takes about two minutes. The objectivity of tympanometry means the results are accurate based on the calculations - they are not dependent upon a response from the patient.

Many tympanometers have the ability to print the test results for easy filing or to transfer the data to NOAH for database storage and reporting.

### Advantages of tympanometry

- Clinical evaluations
- Objective test method
- Test patients of any age
- Documented test results
- Testing takes about 2 minutes
- Testing is CPT code reimbursable

## Working with children

It is important that patients remain still during the exam. Sometimes children are restless, react sensitively to the change of pressure or are surprised by the test sound. Take a few moments to prepare the child and child's parents about the test procedure and instruct them to stay still.

It is sometimes helpful to have the child sit on the parent's lap and help you perform a tympanogram on a stuffed animal to show how the test works. It can also be beneficial to acclimate the child to being touched on the ear. This could be done by playfully touching the ear with the probe. If you can touch the ear without problems, the child will normally accept the probe being inserted.

Once the child is still, the tympanometer will have stable pressure in the extrenal auditory canal and will activate the test.  In addition, when conducting an acoustic reflex test, it is important that the child does not speak. Speaking causes the Stapedius muscle to contract which leads to a change in the compliance of the eardrum.

## CPT reimbursement[1]

There are two tympanometry tests that are reimbursable using Current Procedural Terminology (CPT) codes.

**CPT Code 92567: Tympanometry**
**CPT Code 92568: Acoustic Reflex Testing; threshold**

In a national survey of Medicare and Medicaid reimbursement, the average reimbursement using CPT code 92567 was $22.00 per test. In a similar survey, the average reimbursement using CPT code 92568 was $12.00 per test.

In addition to the CPT code, the correct diagnosis code must be utilized. The following diagnosis codes are provided.[2]

**380.4** IMPACTED CERUMEN
**381.0** ACUTE NONSUPPURATIVE OTITIS MEDIA
**381.02** ACUTE MUCOID OTITIS MEDIA
**381.03** ACUTE SANGUINOUS OTITIS MEDIA
**381.04** ACUTE ALLERIGIC SEROUS OTITIS MEDIA
**381.05** ACUTE ALLERIGIC MUCOID OTITIS MEDIA
**381.06** ACUTE ALLERIGIC SANGUINOUS OTITIS MEDIA
**381.81** DYSFUNCTION OF EUSTACHIAM TUBE
**382.01** ACUTE SUPPURATIVE OTITIS MEDIA WITH SPONTANEOUS RUPTURE OF EARDRUM
**385.23** DISCONTINUITY OR DISLOCATION OF EAR OSSICLES
**384.20** PERFORATION OF TYMPANIC MEMBRANE UNSPECIFIED
**384.21** CENTRAL PERFORATION OF TYMPANIC MEMBRANE
**384.22** ATTIC PERFORATION OF TYMPANIC MEMBRANE
**384.23** PERFORATION, MARGINAL, OTHER
**384.24** PERFORATION, MULTIPLE

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[1] Current Procedural Terminology, CPT 2006, Standard Edition, American Medical Association, AMA Press, ISBN: 1-57947-697-X.

[2] International Classification of Diseases, 9th Revision, Clinical Modification, ICD-9-CM 2006, Volumes 1 and 2, American Medical Association, AMA Press. ISBN: 1-57947-692-9 (SPIRAL).

**384.25** PERFORATION, TOTAL
**387.0** OTOSCLEROSIS, INVOLVING OVAL WINDOW, NONOBLITERATIVE
**387.10** OTOSCLEROSIS INVOLVING OVAL WINDOW OBLITERATIVE
**387.9** OTOSCLEROSIS, UNSPECIFIED
**388.01** PRESBYACUSIS
**388.02** TRANSIENT ISCHEMIC DEAFNESS
**388.10** NOISE EFFECTS ON INNER EAR, UNSPECIFIED
**388.11** ACOUSTIC TRAUMA (EXPOSIVE) TO EAR
**388.12** NOISE-INDUCED HEARING LOSS
**388.2** SUDDEN HEARING LOSS, UNSPECIFIED
**388.30** TINNITUS, UNSPECIFIED
**388.31** SUBJECTIVE TINNITUS
**388.32** OBJECTIVE TINNITUS
**388.40** ABNORMAL AUDITORY PERCEPTION, UNSPECIFIED
**388.41** DIPLACUSIS
**388.42** HYPERACUSIS
**388.43** IMPAIRMENT OF AUDITORY DISCRIMINATION
**388.44** RECRUITMENT
**388.50** DISORDERS OF ACOUSTIC NERVE
**389.0** CONDUCTIVE HEARING LOSS, UNSPECIFIED
**389.01** CONDUCTIVE HEARING LOSS, EXTERNAL
**389.02** CONDUCTIVE HEARING LOSS, TYMPANIC
**389.03** CONDUCTIVE HEARING LOSS, MIDDLE EAR
**389.04** CONDUCTIVE HEARING LOSS, INNER EAR
**389.08** CONDUCTIVE HEARING LOSS, COMBINED
**389.10** SENSORINEURAL HEARING LOSS, UNSPECIFIED
**389.11** SENSORY HEARING LOSS
**389.12** NEURAL HEARING LOSS
**389.14** CENTRAL HEARING LOSS
**389.18** SENSORINEURAL HEAIRNG LOSS OF COMBINED TYPES
**389.2** MIXED CONDUCTIVE AND SENSORINEURAL HEARING LOSS
**389.7** DEAF MUTISM, NOT ELSEWHERE CLASSIFIABLE
**389.8** OTHER SPECIFIED FORMS OF HEARING LOSS
**389.9** UNSPECIFIED HEARING LOSS

## Maico tympanometers

Maico Diagnostics offers a variety of tympanometers that can meet the needs professionals in any testing situation.

*Testing children*

While tympanometry generally takes less than two minutes, the difficulty with children is getting them to stay still during the test.

Maico's *Race Car Tympanometer* provides a built-in visual distraction that captures and keeps your patient's attention throughout the test. Once you have a complete seal in the ear canal, a race will take place on the unit's large LCD screen for your patient to watch. You can then review the results or print them in seconds.

*Daily testing*

To perform typical daily testing, the *MI 24* automatic tympanometer provides pass/fail results and ipsilateral reflex testing. Also included is the convenience of an internal thermal printer.

*Tympanometry-audiometry testing in one unit*

The *MI 26* performs the same tympanometric testing as the MI 24 but has the added convenience of air conduction audiometry in the same unit. This is a great way to save time and office space.

The *Race Car Tympanometer* is also available as a combo unit featuring tympanometry and air conduction audiometry.

*High frequency testing*

A high frequency probe tone of 1000 Hz can be added to the *MI 24* as an option. This provides a high frequency test that is ideal for accurate results when testing neonates up to six months old.

## Conclusion

The ability to objectively measure and document middle ear function is vital for health care professionals. Most will find that incorporating tympanometry into their office protocol will not only provide a level of diagnostic objectivity that was not previously available but will also pay for itself in 3 to 6 months and generate additional revenue.

Tympanometry offers a fast, non-invasive, and cost effective method to assess the integrity of the middle ear and will ensure that the middle ear function of a particular patient has been fully evaluated.

## Appendix A - Normative Data

Normative data[3]

*Children (age 3 – 5 years)*

| | Peak Compliance (mmho or cc) | Ear Canal Volume (cc) |
|---|---|---|
| Mean | 0.5 | 0.7 |
| 90% range | 0.2 to 0.9 | 0.4 to 1.0 |

*Adults*

| | Peak Compliance (mmho or cc) | Ear Canal Volume (cc) |
|---|---|---|
| Mean | 0.8 | 1.1 |
| 90% range | 0.3 to 1.4 | 0.6 to 1.5 |

Pressure typically considered normal in the range of -150 to +25 daPa.

A compliance peak within a normative range indicates normal mobility of the middle ear system. A peak found outside of these limits may indicate one of several pathologies.

[3] Data from Margolis and Heller (1987)

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