An Introduction to Tympanometry

Raymond C. Bredfeldt

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The tympanogram is an objective measure of middle ear effusion or eustachian tube dysfunction. It provides information about the compliance or mobility of the tympanic membrane, the pressure within the middle ear and the volume of the external ear canal. Tympanograms are classified as type A (normal), type B (indicating fluid behind the tympanic membrane) or type C (indicating eustachian tube dysfunction). The objective data obtained by tympanometry are a useful adjunct in the diagnosis and follow-up of middle ear disease.

Otitis media is one of the most frequent acute illnesses in children. Approximately 80 percent of all preschool-age children have at least one episode of otitis media. In one study, otitis media was responsible for 6.5 percent of all visits to a midwest family practice center.

Although most acute ear infections resolve without sequelae, residual fluid (effusion) develops in many cases and may take weeks or months to subside. Persistent effusion, also known as serous otitis, is a common cause of low-grade conductive hearing loss in school-age children and has been implicated as a contributing factor in language, learning and behavior disorders. In addition to the possible sequela of hearing loss, persistent middle ear effusion is a potential source of recurrent episodes of acute otitis media.

Given the importance of accurate diagnosis of residual middle ear effusion, it is imperative that follow-up of an acute episode of otitis media be carried out until the middle ear has returned to normal. However, examination with the pneumatic otoscope depends on subjective interpretation, with different clinicians making different assessments concerning middle ear disease. One response to this dilemma was the development of tympanometry in the mid-1970s. Tympanometry equipment has become relatively inexpensive and is now widely used by primary care physicians. The tympanogram has been found to be an accurate measure of middle ear effusion, especially in children over four months of age.

How Tympanometry Works

Tympanometry measures the relative compliance of the middle ear as air pressure is altered in the external auditory canal. Compliance reflects the degree of mobility of the tympanic membrane. It represents the volume of air displaced by movement of

the tympanic membrane. Unlike otoscopic examination, tympanometry is interpreted on the basis of established, measurable criteria. Tympanometry provides an indirect measurement of the air pressure in the middle ear, as well as the degree of compliance of the tympanic membrane.

The examination is performed with a probe inserted into the external ear canal. A 226-Hz tone is transmitted through the probe, and the compliance of the tympanic membrane is measured while the external canal pressure is varied. The pressure at which peak compliance occurs is recorded. Most tympanometry equipment also provides an estimate of the external ear canal volume.

Interpretation

Tympanograms are most commonly classified according to a system introduced by Jerger in 1970. The classification system is based on the presence and shape of a compliance peak and the pressure at which this peak occurs. Normally, the middle ear has a pressure gradient of +100 mm H_2O to -150 mm H_2O. Type A tympanograms show a compliance peak within this pressure range, indicating a normal middle ear. Type B tympanogram have no compliance peak, indicating fluid behind the tympanic membrane. In type C curves, the peak occurs at a pressure below the normal limit of -150 mm H_2O. (Some authors consider -100 mm H_2O as the lower limit of normal pressure.) Type C tympanograms indicate that some degree of eustachian tube dysfunction is present and are considered to be intermediate between type A and type B tympanograms. During the course of an acute episode of otitis media, the tympanogram may progress from type B to type C to type A.

The interpreter must examine both the graph of the compliance curve and the display of the numeric data accompanying the graph. Three aspects of the tympanogram should be analyzed: the shape and height of the compliance peak, the pressure at which peak compliance occurs and the volume of the external ear canal.

Compliance Peak

In general, the shape of the compliance peak is more significant than the height of the peak. The peak usually shows a displacement of 0.2 to 2.0 mL of air as measured on the vertical axis. A blunted or absent curve indicates decreased compliance, which is generally due to middle ear effusion. An unusually high and sharp curve indicates a hyperflaccid tympanic membrane, which may be due to thinning of the membrane. A curve that is displaced more than 3.0 mL may indicate ossicular disarticulation, and referral to an otolaryngologist should be considered.

Middle Ear Pressure

The horizontal axis of the tympanogram indicates the amount of pressure in the middle ear. As mentioned earlier, the normal range of pressure is approximately +100 mm H_2O to -150 mm H_2O. (Some tympanometry equipment provides measurements in deca Pascals (daPa) rather than mm H_2O; these units are essentially equivalent.) A pressure gradient that is more negative than -150 mm H_2O generally indicates a poorly functioning eustachian tube. Serous otitis media may develop as a result of an excessive negative pressure. The compliance peak often occurs at negative pressures during recovery from an episode of otitis media with effusion.

External Ear Canal Volume

Most tympanometry devices provide the volume of the external ear canal. This value varies widely according to the patient's age and bone structure but usually falls within the range of 0.2 to 2.0 mL. An unusually small volume for age indicates the presence of cerumen or other debris in the external ear canal. An excessively large volume, especially in conjunction with a flat compliance graph, indicates that the tympanic membrane is perforated or that a pressure-equalizing tube is in place. In the case of perforation, the volume of the middle ear has also been measured to some degree.

In addition to providing information about compliance, pressure and volume, some tympanometry devices provide information about the auditory reflex. This parameter is useful for screening in mass populations but has limited value in the assessment of individual patients. The auditory reflex is absent in 5 percent of children with normal hearing; the presence or absence of the reflex should not affect the interpretation of tympanometric findings.

Illustrative Tympanograms

Accurate interpretation of a tympanogram is possible by determining the characteristics of the compliance curve (normal volume: 0.2 to 2.0 mL), the middle ear pressure (normal; +100 mm H_2O to -150 mm H_2O) and the volume of the external ear canal (normal: 0.2 to 2.0 mL). Obviously, not all tympanograms fall into the classic A, B and C categories.

The typical pattern seen when the tympanic membrane is perforated. Note that while the curve is flat, the volume of the ear canal is excessive. This increased ear canal volume indicates that the middle ear volume is also being measured to some degree. In the case of a hyperflaccid tympanic membrane, the tympanogram will show a peak above 2.0 mL. This is often the result of a scarred tympanic membrane.

Extremely increased volume of the compliance curve is seen in cases of ossicular disarticulation. Note that the peak is "off the graph".

Fairly typical tympanogram in the setting of otitis media with effusion, serous otitis and other eustachian tube disorders. The compliance peak is flatter than normal while the pressure within the middle ear is negative.

Clinical Application

As mentioned previously, several studies have shown a limited correlation between tympanometric and pneumato-otoscopic findings. These studies also indicate that the utilization of tympanometry results in more accurate diagnosis of middle ear effusion. The tympanogram can also be used to verify pneumato-otoscopic findings. For example, the tympanogram could be used to confirm that an episode of otitis media has completely resolved. This approach minimizes the failure to detect serous otitis, since the ear may appear to be normal on the basis of the pneumato-otoscopic examination alone. Although routine use of the tympanogram in the follow-up of otitis media may result in increased expense, it would be reasonable to expect the charge for each tympanogram to decrease with increased utilization of the equipment.

Several studies have shown that the natural course of otitis media often includes persistence of middle ear effusion for 12 weeks or more, even with proper treatment. The physician should not prematurely refer patients with a history of otitis media to an otolaryngologist on the basis of pneumato-otoscopic and tympanometric evidence of persistent effusion. Although referral should be considered after 12 weeks of persistent type B tympanograms, delay of referral should be considered if improvement is noted on successive tympanograms.