OPEN ACCESS GUIDE TO AUDIOLOGY AND HEARING AIDS FOR OTOLARYNGOLOGISTS

PNEUMATIC OTOSCOPY AND OTOSCOPY

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Most ear problems can be very adequately assessed by clinical examination alone which includes otoscopy, pneumatic otoscopy, otomicroscopy and clinical hearing evaluation.

Pneumatic otoscopy delivers both positive and negative pressure through a pneumatic otoscope and allows one to gain information about the status of the middle ear space by determining tympanic membrane mobility.

Otoscopy involves systematic inspection of the external ear canal and tympanic membrane with an otoscope.

Pneumatic Otoscopy

Pneumatic otoscopy provides a dynamic assessment of the tympanic membrane and the middle ear and is a useful means to evaluate disease in the middle ear cleft. Advantages are that otoscopes are widely available and cheap compared to the cost of tympanometry. With appropriate training and experience it is simple and easy to perform.

One requires a ***pneumatic otoscope*** *(Figure 1)*, a selection of ***ear specula*** that provide a tight seal with the ear canal, and an ***insufflator bulb.***

Pneumatic Otoscope *(Fig 1)*

It must be fully charged or supplied with new batteries and the bulb (halogen / xenon) must be bright.

Figure 1: Pneumatic otoscope: Note insufflation port on side of otoscope head

Otoscope bulbs should be changed periodically (after 20h use) as adequate viewing requires >100 foot candles light. The handle contains the batteries, which may be rechargeable.

Ear Specula *(Figure 2)*

Several sizes of specula should be available. Types of specula include:

- Reusable ear specula: 2.5mm, 3mm, 4mm, and 5mm
- Single-use ear specula: 2.75mm and 4.25mm
- SofSpec™ reusable specula have a soft tip specially contoured for a pneumatic seal: 3mm, 5mm and 7mm

Figure 2a: Reusable ear specula

Figure 2b: Single-use ear specula

Figures 2c: SofSpec™ ear specula

Insufflator bulb

The insufflator bulb is attached tightly to the head of the otoscope by means a tube and a tip to avoid loss of an air seal *(Figure 3)*.

Figure 3: Insufflator bulb and tube

Mechanism of pneumatic otoscopy

A normal tympanic membrane moves 1mm medially and laterally when pressure in the external auditory canal is increased and reduced respectively.

The degree of tympanic membrane mobility depends on a number of factors including:

- Presence of a middle ear effusion
- Amount of effusion; tympanic membrane mobility is one of the most important otoscopic findings used to determine whether a middle ear effusion is present[1]
- Degree of alteration of negative or positive pressure in the middle ear space compared to an ambient state
- Condition of the tympanic membrane e.g. thickening, atrophic areas, tympanosclerosis or perforation.

It is therefore important for clinicians not only to note the presence or absence of movement, but also the degree of mobility compared to the normal tympanic membrane.

Reasons for an immobile tympanic membrane in response to pressure changes in the external canal include:

- Fluid (mucus, blood, pus, CSF) in the middle ear cavity
- Perforation of the tympanic membrane
- Adhesive otitis media

Diagnostic applications of pneumatic otoscopy

1. Otitis media with effusion (OME)

Pneumatic otoscopy is one of the principal diagnostic measures used to diagnose OME; it may indicate OME even when the appearance of the eardrum gives no other indication of middle ear pathology.

The American Academy of Family Physicians, American Academy of Otololaryngology-Head and Neck Surgery, and *American Academy of Pediatrics Subcommittee* published evidence-based clinical practice guidelines related to diagnosing and managing OME in children. The subcommittee strongly recommended that clinicians use pneumatic otoscopy as the primary diagnostic method. Tympanometry is recommended as an adjunct to confirm the diagnosis when the diagnosis is uncertain.[2] Otoscopy alone, without using of the pneumatic otoscope to test tympanic membrane mobility, is not recommended.

The Agency for Healthcare Research Quality Evidence Report systematically reviewed the sensitivity, specificity, and predictive values of eight methods to diagnose OME and used myringotomy as the gold standard.[3] Meta-analyses revealed that pneumatic otoscopy and professional

tympanometry had the highest sensitivities.[3] Although professional tympanometry had the highest sensitivity, pneumatic otoscopy optimised both sensitivity and specificity.[3] ***Pneumatic otoscopy is therefore useful in a setting where tympanometry is not readily available.*** The diagnostic accuracy of pneumatic otoscopy in OME has been shown in several studies to be dependent on clinicians' training and experience.[4,5,6] One of the limitations mentioned in this review was that most studies fail to provide enough information to assess the qualifications of testers performing pneumatic otoscopy.[3] ***Pneumatic otoscopy therefore requires appropriate training to optimise diagnostic accuracy.***

2. Acute otitis media

Diagnosing acute otitis media can be quite challenging, particularly in young children. Diagnostic criteria include a rapid onset of symptoms, symptoms and signs of middle ear inflammation as well as the presence of a purulent middle ear effusion.[7] While otoscopy detects inflammation (erythema, bulging of tympanic membrane, cloudiness, opacification and loss of landmarks), detection of reduced movement of the tympanic membrane on pneumatic otoscopy is the key to diagnosing a middle ear effusion.[8]

3. Tympanic membrane retraction

When the tympanic membrane is retracted due to negative middle ear pressure, it is often flaccid and hypermobile. Movement of the tympanic membrane is therefore exaggerated when negative pressure is applied i.e. when the bulb is released rather than when the bulb is compressed. Pneumatic otoscopy helps one to identify such a retracted tympanic membrane and also to differentiate retraction from a large central perforation.

4. Helps to assess tympanic membrane landmarks

5. Used in fistula test (Hennebert's sign)

A positive fistula test is marked by nystagmus and vertigo when pneumatic otoscopy is done. Clinical examples include the following:

- With cholesteatoma it suggests erosion of the labyrinth, most commonly of the lateral semicircular canal. Reports show that this test is positive in 40-50% of patients who have a fistula. A negative test therefore does not exclude a fistula [9, 10]
- In trauma to the middle and inner ear it alerts one to the presence of a perilymphatic fistula
- With superior semicircular canal dehiscence syndrome, pressure changes induced in the external auditory canal evoke stereotyped eye movements that align in the plane of the dehiscent semicircular canal.[11] It thereby helps to distinguish hearing loss associated with superior semicircular canal dehiscence syndrome from other conditions such as otosclerosis

6. Brown's sign

Otoscopic examination of a middle ear paraganglioma (glomus tympanicum) may reveal a reddish-blue pulsatile mass behind an intact tympanic membrane. When application of positive pressure with a pneumatic otoscope causes the mass to blanch it is referred to as "Brown's sign" It occurs in a third of glomus tympanicum cases.[12]

Technique of Pneumatic Otoscopy

There are a number of prerequisites to do the procedure correctly:

- **Test the pneumatic otoscope for air leaks**

    1. Attach an aural speculum to the otoscope and occlude the end of the speculum with the tip of an index finger
    2. Attach the insufflator bulb by its rubber/plastic tube to the otoscope head
    3. Occlude the open end of the otoscope and apply positive pressure by squeezing the bulb
    4. Listen for an air leak at the junction between the otoscope and the aural speculum or of the rubber/plastic tubing that connects the otoscope with the pneumatic bulb, or at the joint between the lens and the otoscope head

- **Snuggly fitting aural speculum**

    Another common site for a leak is at the junction between the tip of the aural speculum and the skin of the ear canal. The pressurised air then leaks out of the external auditory meatus and the tympanic membrane appears to be immobile or poorly mobile. This may cause the examiner to over-look a middle ear effusion

    1. For this reason it is important to use the ***largest aural speculum to obtain a good seal*** between the speculum and the external ear canal
    2. If a leak still persists then apply gentle tragal pressure to achieve an airtight seal around the speculum

- **Correctly hold the otoscope and bulb** *(Figure 4)*

Figure 4: Holding the otoscope and bulb

- **Slightly compress the pneumatic bulb, and then insert the aural speculum into the ear canal**

    The reason why the pneumatic bulb should be slightly compressed before insertion, and then released, is to generate negative pressure in the ear canal. Application of gentle negative pressure in pneumatic otoscopy is often neglected and is important for the following reasons:

    1. OME is often associated with a negative middle ear pressure, which can be more accurately assessed by releasing the already-compressed bulb
    2. Pneumatic otoscopy allows one to differentiate between a retracted tympanic membrane which is not adherent to any middle ear structure and therefore moves laterally with the application of negative pressure; and adhesive otitis media where the TM is adherent to a middle ear structure and therefore remains immobile

- **Reseal the system, if necessary by compressing the tragus against the ear canal opening**

- **Once an airtight seal has been secured, release the compression on**

the bulb: This causes the tympanic membrane to move laterally

- **The bulb is gently, not firmly, squeezed:** A common error is to apply excessive amounts of compression to the pneumatic bulb

- **Negative pressure is followed by positive pressure and this is repeated several times**

Otoscopy Technique

Before performing otoscopy, always do a general examination of the ear. Inspect the pinna and postauricular skin noting any scars, erythema and deformity. Both ears must be examined; if the disease affects only one ear, then the normal ear is examined first. This allows you to appreciate the normal anatomical variation for that particular patient. Inspect the entrance to the ear canal to ensure that there is no debris or wax which might interfere with the examination. The ear canal must be cleared of all debris. A common mistake is to peek through a small hole in the cerumen, thus only visualising a tiny part of the tympanic membrane.

When examining a child the head and the body need to be gently immobilised *(Figure 5)*. This is best achieved with the child seated in the parent's lap. The parent restrains the child by placing one hand firmly on the child's forehead and holding the side of the child's head against the chest, while the other arm is placed firmly around the child's body and both arms. It may help to show infants the otoscope and allow them to hold the otoscope before examining them so as to reassure them that the examination will not be painful.

When examining the patient's right ear, the otoscope is held with the physician's right hand and when examining the left ear the otoscope is held with the physician's left hand.

Figure 5: Holding a child

Find the ***largest speculum***, which comfortably fits into the ear canal in order to maximise the amount of light passing into the ear canal and to optimise the view of the tympanic membrane. Rule of thumb: adults size 4-5mm, children 3-4mm and 2,5mm for infants.

Switch on the otoscope by pressing the coloured button and turning it clockwise. Hold the otoscope close to its head between the thumb and the first two fingers, much like holding a pencil *(Figure 6).*

The little finger of the hand holding the otoscope is placed firmly against the patient's cheek and used as a fulcrum *(Figure 7).* In this way the hand moves in unison with the patient's head, avoiding injury should the patient move unexpectedly.

Figure 6: Holding the otoscope

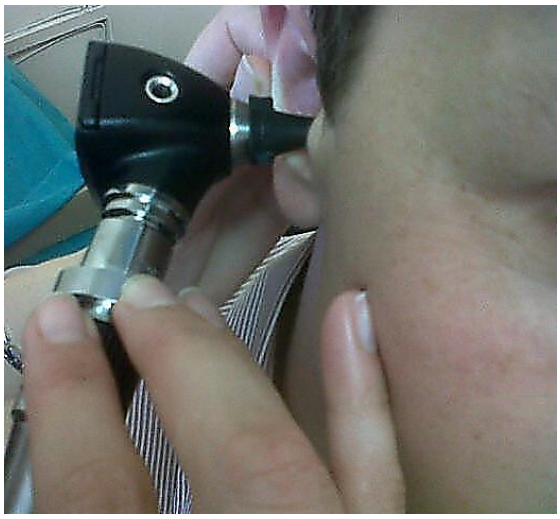

Figure 7: Little finger used as a fulcrum

Another technique of holding the otoscope is by gripping it like a pistol, with the otoscope held almost vertically in the palm of the hand *(Figure 8)*. The dorsal aspect of the patient's index finger is held against the patient's cheek.

The speculum is gently inserted into the external ear canal. The external ear canal is crooked; to straighten the canal, use the free hand to gently pull the pinna outward and downward in infants and upward and posteriorly in older children and adults. In infants or children with very stenotic ear canals (e.g. Down's syndrome) it helps to insert the speculum by gently rotating the speculum in the external auditory canal so that the speculum is inserted at the correct depth to adequately visualise the tympanic membrane.

Figure 8: Gripping otoscope like a pistol

The outer third of the external ear canal (cartilaginous portion) has hair bearing skin, whereas the inner two-thirds is hairless and very sensitive. To facilitate a non-traumatic insertion the speculum should not be inserted beyond the hair bearing skin of the external ear canal.

Now look through the magnifying lens and through the speculum. To view the entire ear canal and tympanic membrane the position of the speculum often has to be adjusted to change the line of vision.

Assessing external auditory canal

The external ear canal should be routinely examined for:

- Tenderness on pulling the auricle, which indicates otitis externa
- Infection: swollen and narrow, moisture, pus
- Bony narrowing
- Debris

Assessing tympanic membrane

- The normal tympanic membrane is pinkish-gray in colour, fairly translucent and mobile *(Figure 9)*
- Note the colour, translucency and position of the tympanic membrane and assess its mobility by pneumatic otoscopy
- Assess the landmarks of the tympanic membrane. The malleus normally lies in a slightly oblique position. Identify the *pars tensa* with its cone of light in the anteroinferior quadrant of the tympanic membrane, the handle and lateral process of malleus, the anterior and posterior folds of the *pars flaccida* and position of the malleus handle.

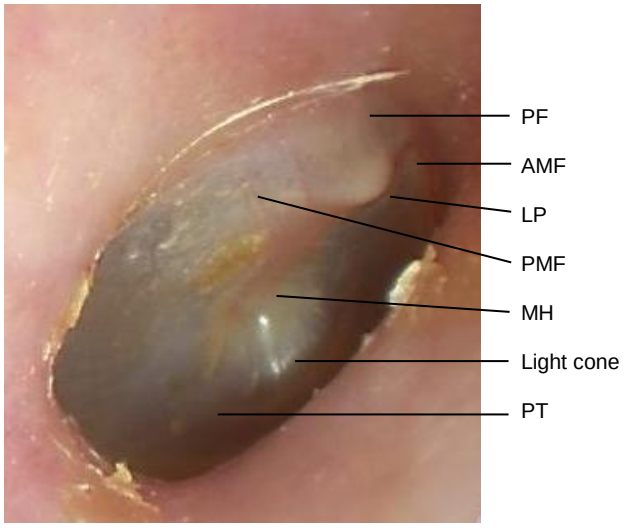

Figure 9: Otoscopic appearance of normal (right) tympanic membrane and its landmarks: Pars flaccida (PF); anterior malleolar fold (AMF); lateral process of malleus (LP); posterior malleolar fold (PMF); malleus handle (MH); pars tensa (PT)

- Colour and appearance
  1. Yellow (amber): serous fluid behind TM suggestive of otitis media with effusion (OME) *(Figure 10)*

Figure 10: Otitis media with effusion (OME)

2. Red (erythema): suggests acute otitis media; however crying in infants and young children can also cause reddening
3. Dull/loss of light reflex: otitis media with effusion or acute otitis media
4. White plaques: tympanosclerosis
5. Translucency: A normal tympanic membrane is translucent. A transparent tympanic membrane is typically seen in a very atrophic tympanic membrane due to loss of the fibrous layer

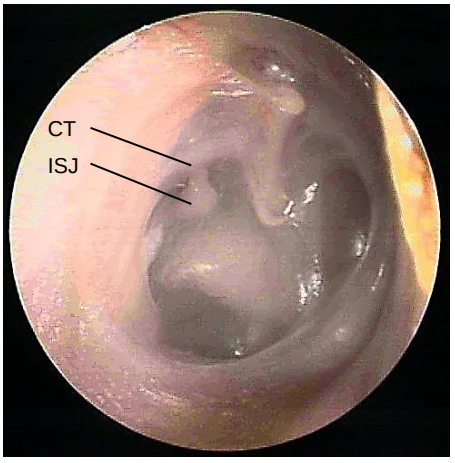

Figure 11: Chorda tympani (CT) and incudostapedial joint ISJ) visible through a very atrophic TM

6. Landmarks: Absent landmarks occur in acute otitis media
7. Perforation:
   - Size and location; anterior/posterior quadrant *(Figure 12)*
   - Condition of middle ear mucosa (granular, polypoid)

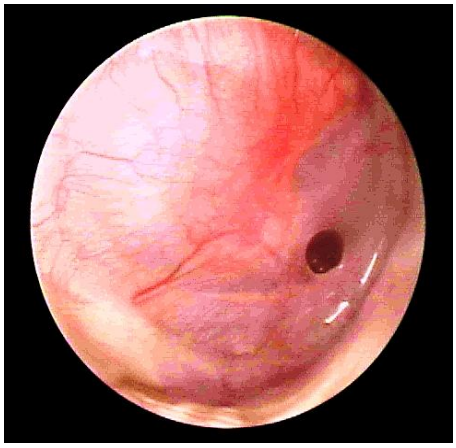

Figure 12: Small anterior inferior quadrant perforation

8. Note the position of the handle of malleus (neutral/medialised)
9. Squamous debris: A cholesteatoma is a collection of keratinising squamous epithelium in the middle ear cleft associated with bone resorption. It may be congenital or acquired. Acquired cholesteatomas most commonly originate from a large posterosuperior perforation or attic perforation. There is usually a history of chronic infection with discharge
10. Position of tympanic membrane
    - Bulging suggests acute otitis media
    - Retraction suggests eustachian tube or middle ear mucosal dysfunction
11. If retracted: Is *pars flaccida* or the *pars tensa* retracted? *(Figure 13)*

Figure 13: Pars tensa and pars flaccida retractions with bony erosion – cholesteatoma case

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