DIAGNOSTIC EVALUATION OF TYMPANIC MEMBRANES

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The most common middle ear diseases are otitis media with effusion (OME), acute otitis media (AOM) and chronic suppurative otitis media (CSOM)). Diagnosing middle ear disease is based mainly on inspection of the tympanic membrane (TM) and indirect measurements of the status of the middle ear. *(Tables 1, 2; Figure 1)* To improve diagnostic accuracy in general practice the important factors are assessment of the position and transparency of the TM, and use of pneumatic otoscopy and/or tympanometry [1].

Diagnosis	*Pneumatic otoscopy*	*Tympanogram*	*OM grade**	*Description*
Normal	Normal	Type A	Grade 0-1R	A transparent TM in a fairly normal position without signs of middle ear fluid together with a type A tympanogram or normal pneumatic otoscopy
OME	Impaired mobility	Type B or C	Grade 1F-3	A transparent TM with visible middle ear fluid or an opaque TM in a fairly normal position with a type B or C tympanogram
AOM**	Impaired mobility	Type B	Grade 3-5C	An opaque and bulging TM together with a type B tympanogram
CSOM	Impaired or no mobility	Type C (retraction) or B (perforation)	6	TM with chronic perforation and recurrent secretion/pus

* OM grade – image-based grading scale for otitis media diagnosis (see Table 2 and Figure 3)
** Diagnosis of AOM is based on a combination of symptoms and signs. In some cases with OM grade scale-step 3 and tympanogram B an AOM diagnosis can be made in combination with symptoms e.g. otalgia and fever

Table 1: Diagnosis of otitis media

Step 1: Tympanic membrane
1) Transparency
2) Position
3) Mobility
4) Colour
5) Reflex
6) Surface structure
7) Patency

Step 2: Middle ear
1) Fluid levels
2) Mobility
3) Pneumatic otoscopy
4) Tympanometry

Table 2: Evaluation of middle ear

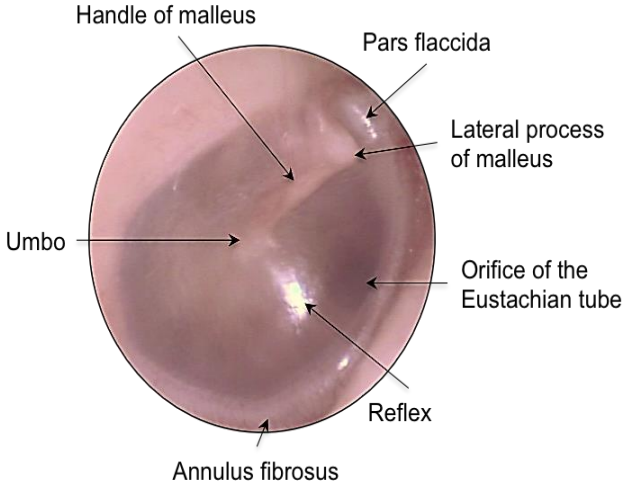

Figure 1: Surface anatomy of the normal tympanic membrane

Evaluation of tympanic membrane

Step 1

The 1st step to diagnose otitis media is to ***recognise a number of different characteristics in the appearance of the TM*** *e.g.* transparency, position, mobility, colour, reflex characteristics, surface structure and patency *(Figure 2)*. A cloudy and bulging TM are strong indications of AOM. A chronic perforation may also be seen with secretions or severe retraction of the TM (CSOM).

The most common characteristic of AOM is an opaque TM (100% of ears) and almost as common is a bulging TM (93% of ears) [2]. The 3rd most common characteristic of the TM in AOM is a white or yellow colour (64% of ears) with redness coming only 4th (58% of AOM) [2]. The positive likelihood ratio for redness has been found to be only 8 compared to 51 for bulging TM and 34 for opaque TM [3]. However, clinicians often use redness as one of the most important diagnostic features to diagnose AOM; this has been found to lead to overdiagnosis of AOM [1].

The surface structure may also add information about inflammatory processes in the TM. The light reflex is normally of a triangular shape but may appear as a dot on a bulging or retracted TM or shattered in swollen TMs.

Step 2

The second step in assessing otitis media is to ***determine if there is a middle ear effusion, or a TM perforation*** (high volume on tympanometry, >3cm^3). An effusion can be seen through a transparent TM as fluid levels and/or air bubbles, whereas a bulging TM can be attributed to pronounced middle ear purulent secretion. However, a TM in a normal position may be opaque and then it can be difficult to see the secretion. Here both pneumatic otoscopy and tympanometry can be of help *(Table 1)*. One requires an otoscope, plus a selection of ear specula that provide a tight seal with the ear canal, and an insufflator bulb (see chapter: *Pneumatic otoscopy and otoscopy*). With this equipment the air pressure in the external ear canal can be increased repeatedly to assess the mobility of the TM. An indirect sign of fluid behind the TM is a restriction of its mobility.

Normal: Transparent TM in a normal position with no visible fluid levels. The reflex has a triangular shape and surface structure appears smooth

Otitis media with effusion: Transparent TM in normal position or slightly retracted with fluid levels visible. The reflex is dot-shaped, surface structure appears smooth

Acute otitis media: Opaque, bulging TM. The reflex is shattered, surface structure appears irregular. The normal anatomy cannot be assessed and the malleus handle is hidden by the bulging TM

Chronic suppurative otitis media: Perforated TM with or without secretion. Severe retraction of the TM and cholesteatoma may occur

Figure 2: Tympanic membrane appearances

In a review of the literature, sensitivity and specificity were found to be 94% and 80% respectively for pneumatic otoscopy to detect middle ear effusion [4]. Similarly, in another study, pneumatic otoscopy was shown to improve sensitivity and specificity by 24% and 42% respectively compared to otoscopy [5].

A tympanometer can also be used to provide information on the mobility of the TM (*Table 1*; and chapter *Tympanometry*). Evaluation of middle ear fluid using tympanometry or pneumatic otoscopy has been found to be most important in improving diagnostic accuracy for otitis media in general practice [1, 4, 5]

Grading OM observations

Visual assessment of the TM has its obstacles ranging from obscuring wax to an uncooperative child and faulty equipment. This is apart from the difficulty to interpret the findings once the TM is visualised. In order to guide the clinician, a scoring system has been developed together with one image-based grading scale. This image-based grading scale, the *OM grade scale (Table 3, Figure 3)*, has been developed, validated and tested as a diagnostic guide for otitis media. The scale is based on the transparency and the position of the TM [6, 7].

Other diagnostic tools for OM

Advancements in digital technology have offered new ways of diagnosing OM. Digital imaging with video-otoscopes that can be attached to a computer or smartphone provides a detailed view, aiding in accurate diagnosis. Images or videos can be recorded for future assessment or for remote consultation. The latter could be suitable for rural areas lacking immediate access to healthcare.

Additionally, artificial intelligence (AI) has emerged as a reliable tool in various medical applications, particularly in image-based diagnostics like OM. Experimental studies have demonstrated the high accuracy of AI-supported diagnostics when applied to carefully selected, high-quality images [8, 9].

Grade	Subgrade	Description
0	*0*	Transparent TM in normal position
1	*1*	Transparent TM in normal position or slightly retracted with fluid level or fluid filled ME
2	*2*	Transparent TM in normal position or slightly retracted with turbid/opaque fluid level
3	*3*	Opaque appearance of TM in fairly normal position
4	*4*	Opaque appearance of TM and bulging
5	*5B*	Opaque appearance of TM with bulla formations
	5C	Contourless TM with wet appearance and swollen keratin patches, +/- pulsating pus from small perforation
6	*6*	TM perforation, retraction pocket or cholesteatoma +/- purulent discharge

Table 3: Grading according to a modified OM grade scale including CSOM

Diagnosis of OM

A differential diagnosis of OM may be made when combining otoscopic observations, with the results from pneumatic otoscopy and/or tympanometry *(Table 1)*.

Otitis media with effusion

Diagnostic criteria: Requires visible fluid levels or, in a case of an opaque TM, evaluation with pneumatic otoscopy or tympanometry (impaired mobility or type C or B tympanograms) *(Table 1)*. There may be a

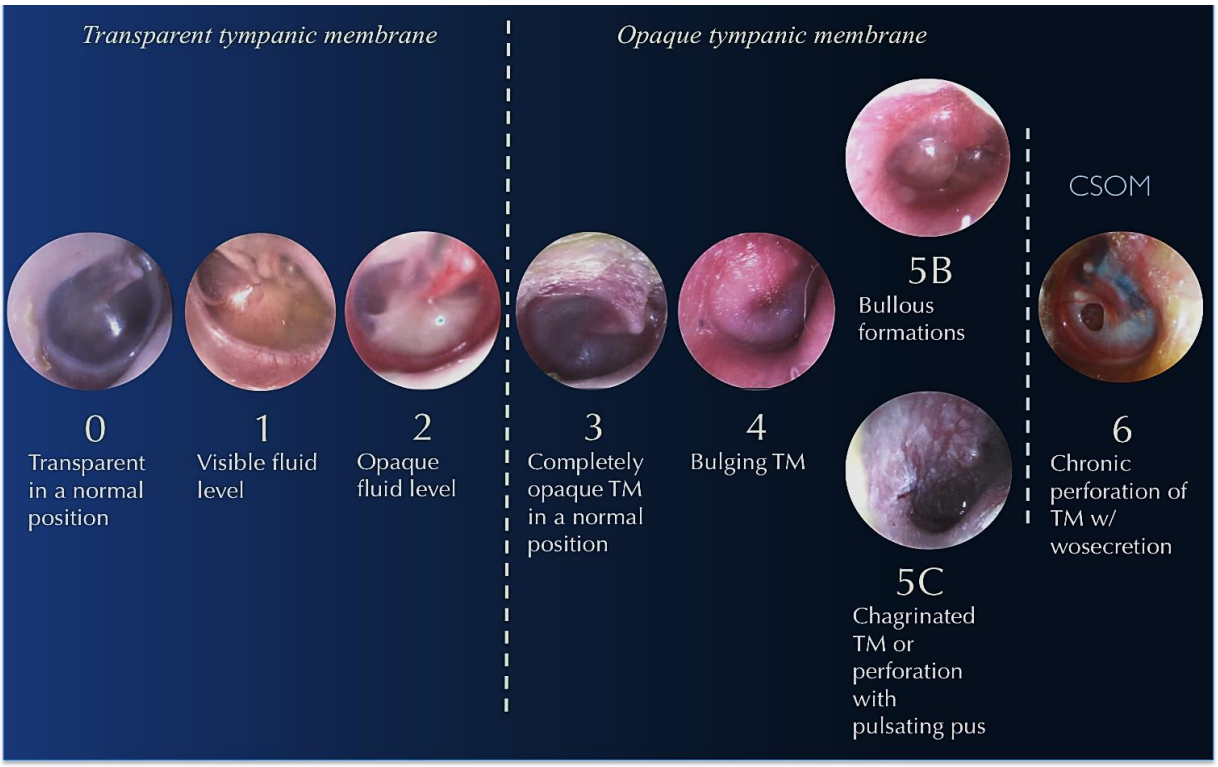

Figure 3: The modified OM grade scale including CSOM

temporary slight hearing impairment. OME is a dynamic process and may precede or follow AOM. Therefore, a distinct separation between OME and AOM is in some cases difficult to make.

Acute otitis media

Diagnostic criteria: A combination of acute onset of symptoms and characteristic TM changes. Symptoms include otalgia, fever, and symptoms attributable to an upper respiratory tract infection (URI). Signs required for the diagnosis are an opaque and bulging TM, often together with discolouration and sometimes increased vascularisation. A bulging TM has high diagnostic value. The *American Academy of Paediatrics (AAP)* states that the diagnosis of AOM can be made in the presence of a bulging TM or with acute onset of otorrhoea [10]. The diagnosis may also be established if there is a mild bulging of the TM together with recent onset of ear pain.

The appearance of the TM is usually described as thickened and opaque with an irregular surface structure and with a varying discolouration.

The TM can perforate and pus may pulsate out through the perforation; this is known as a perforated AOM. Furthermore, bullous formations can be found on the TM (bullous myringitis). This is mainly associated with AOM and rarely occurs without purulent middle ear fluid. If it does, it is as a local inflammatory process in the TM.

In one study 76 - 89% of spontaneously draining ears were reported to have swollen keratin patches on the TM, sometimes called chagrinated [11]. The TM in those cases is reddish with white and elevated keratin patches together with a wet appearance. Common symptoms associated with AOM are otalgia, ear tugging, irritability, decreased play activity, decreased appetite, disturbed sleep and fever [12].

Chronic suppurative otitis media

CSOM is defined as a chronic inflammatory process in the middle ear and mastoid cavity with current secretion through a perforation of the TM (open for >3 months) [13]. In CSOM one may also observe severe retractions of the TM as well as cholesteatoma formation *(Figure 4)* originating from a TM retraction or perforation of a retraction pocket [14].

Figure 4. Left tympanic membrane (CSOM) with deep attic retraction and cholesteatoma (white keratin).

Conclusions

OM is common. Primary care providers can play an important role in diagnosing and managing the disease. Using otoscopy and this guide, the practitioner can recognise classic signs to determine the type and grade of OM by observing the tympanic membrane.

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