A MULTIDISCIPLINARY REVIEW ON OTITIS MEDIA: FROM MICROBES TO MEDICINES

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ABSTRACT

Worldwide, otitis media (OM) is a major contributor to childhood morbidity and health care use. The goal of this review is to present a thorough update on the pathophysiology, epidemiology, clinical characteristics, microbiology, diagnosis, management approaches, new developments, and lingering issues related to OM. The results from peer-reviewed research, clinical guidelines, and systematic reviews that have been published in the last 20 years are combined in this narrative review. With a focus on the variations between paediatric and adult cases, evidence-based treatment modalities, and new developments in diagnosis and treatment, it discusses acute otitis media (AOM), otitis both chronic suppurative otitis media (CSOM) and with effusion (OME). Every year, more than 700 million individuals are impacted by OM, mostly children under five. Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis are the most common infections; biofilm formation and antibiotic resistance are growing concerns. Despite the widespread use of antibiotics, current guidelines encourage watchful waiting in some situations. The standard treatment for recurrent or chronic OME with hearing loss is still tympanostomy tubes. Vaccines like the influenza and PCV13 vaccines have demonstrated some effectiveness in lowering the occurrence of OM. AI-assisted otoscopy, microbiome studies, and innovative medicine delivery methods are examples of recent developments. Overuse of antibiotics, the efficacy of vaccines, surgical indications, and the treatment of asymptomatic OME continue to present difficulties. OM necessitates a sophisticated, evidence-based strategy that strikes a balance between long-term results and treatment effectiveness. Improving patient outcomes requires early diagnosis, individualized treatment, and the combination of microbiological and technological advancements. Addressing the shifting landscape of OM management demands constant research and public health interventions.

Keywords: Otitis Media, Antibiotic Resistance, Paediatric Infections, Biofilm Formation, Microbiome, Tympanostomy Tubes, Vaccination, Hearing Loss, Otoscopy.

1.INTRODUCTION

A common middle ear condition that has serious economic ramifications, otitis media (OM) can affect up to 11% of people worldwide, particularly in developing countries like Africa [1 - 4].

Clinical manifestations vary according to the length, intensity, and course of the illness. Severe intracranial and extra cranial problems may arise from untreated or inadequately treated OM due to the intricate continuous link between the middle ear and critical brain structures. To effectively treat this condition, one must have a solid understanding of the anatomy and physiology of the ear. As a result, before delving deeper into this illness entity (including readings from mainstream sources like the Scott Brown series), a brief explanation of these characteristics must be provided [5].

1.1 CLASSIFICATION OF OTITIS MEDIA

The broad topic of OM can be divided into four categories: (1) duration (acute and chronic OM); (2) fluid/discharge nature (suppurative and non-suppurative OM); (3) OM with effusion and aero-OM; and (4) causative organism (bacterial OM, which is common) and specific OM, such as tubercular and syphilitic OM, which are less common. Since otology is a development of the same pathologic process, Browning et al.'s current categorization of choice, which de-emphasizes the terms "suppurative" and "non-suppurative" OM, was brought about by the field's dynamism [6]. Moreover, depending on the circumstances at hand, one may lead to the other.

Acute OM, chronic OM, OM with diffusion, and particular OM are still the conventional classifications, while OM could also be characterized as "active," "inactive," and "healed"[6] A quick overview of the rarer forms of OM will be provided, while the three most prevalent forms—acute otitis media (AOM), chronic otitis media (COM), and otitis media with effusion (OME)—will be the subject of the in-depth conversation. The account omits the specifics of the surgical techniques, which are covered in major ENT and otology textbooks. Aero-OM is brought on by an imbalance in the pressure equalization between the middle ear cavity and the environment through the Eustachian tube. Common sources include rapid ascents and descents from heights and deep-sea diving. The resulting inflammation, as demonstrated by experimental models, can spread to the nasopharynx, the middle ear cavity, the Eustachian tube, and occasionally nasal cavities and paranasal sinuses [7].

1.1.1 ACUTE OTITIS MEDIA

The symptoms of acute otitis media (AOM) and infectious and inflammatory middle ear condition, typically include middle ear effusion (fluid) and acute inflammation signs (such as fever, ear pain, and a bulging tympanic membrane). It is a bacterial or viral infection that usually follows an upper respiratory tract infection (URI) and is the most prevalent in early childhood. [8].

ETIOLOGY

Bacteria, viruses, or both may be the cause of AOM. Due to fluid accumulation and Eustachian tube dysfunction, it frequently occurs after a viral upper respiratory illness [9], which makes a secondary bacterial infection more likely.

Common Causative Pathogens:

- **Bacteria**:
  - *Streptococcus pneumoniae*
  - *Haemophilus influenzae* (non-typeable)
  - *Moraxella catarrhalis*
- **Viruses**:
  - Respiratory Syncytial Virus (RSV)
  - Rhinovirus
  - Adenovirus
  - Influenza viruses

1.1.2 OTITIS MEDIA WITH EFFUSION

The presence of non-purulent fluid in the middle ear without any acute infection-related symptoms, such as fever or otalgia (ear pain), is known as otitis media with effusion (OME). With the exception of hearing loss or a feeling of fullness in the ears, the effusion is usually asymptomatic. It can be serous (thin and fluid), mucoid (thick and sticky), or glue-like [10-11].
OME is also commonly known as:

- Serous Otitis Media
- Secretory Otitis Media
- "Glue Ear" (especially in the UK)

ETIOPATHOGENESIS

When the middle ear fluid doesn't go away after an episode of Acute Otitis Media (AOM), OME typically follows. Due to Eustachian tube dysfunction, it can also arise in the absence of an illness, particularly when upper respiratory infections or allergic rhinitis are present.

Mechanisms involved [12]:

1. Dysfunctional Eustachian tube - results in negative middle ear pressure.
2. Fluid transudation - into the space between the ears.
3. Mucosal inflammation - Increased fluid production, reduced clearance

Over time, the fluid can become thicker (mucoid or "glue-like"), leading to the term “glue ear.”

1.1.3 CHRONIC OTITIS MEDIA

The term Chronic Otitis Media (COM) describes a chronic or recurring inflammatory disease of the middle ear and/or mastoid cavity that is typified by a persistent perforation of the

tympanic membrane, intermittent or continuous ear discharge (otorrhea), and hearing loss of various intensities. [13]

SUB-TYPES OF CHRONIC OTITIS MEDIA [14]

Chronic Suppurative Otitis Media (CSOM): a persistent, frequently infected ear discharge through a perforated tympanic membrane.

Chronic Choleastoma and Otitis Media an aggressive variant that invades the middle ear and causes bone erosion and major problems is caused by keratinizing squamous epithelium.

Dry or inactive COM: A perforated tympanic membrane that is susceptible to hearing loss or repeated infections but does not currently have an active infection.

ETIOPATHOGENESIS

COM is usually the end result of untreated or recurrent AOM, Eustachian tube dysfunction, or repeated infections. It may also follow trauma or iatrogenic causes (e.g., ear surgery) [15].

Contributing Factors:

- Repeated middle ear infections (especially in childhood)
- Poor socioeconomic conditions
- Inadequate medical treatment or follow-up
- Eustachian tube dysfunction
- Upper respiratory tract infections
- Craniofacial anomalies (e.g., cleft palate)

1.1.4 SPECIFIC OTITIS MEDIA

Specific otitis media is a form of middle ear infection caused by specific pathogenic organisms or is part of a systemic disease process. These types of otitis media often have distinct histopathological features, require special diagnostic methods, and may be resistant to standard treatment for otitis media. They are less common than nonspecific forms (like acute otitis media or chronic suppurative otitis media), but clinically significant due to their potential for complications, chronicity, and diagnostic difficulty [15].

1.2 EPIDEMIOLOGY OF OTITIS MEDIA

GLOBAL BURDEN OF OTITIS MEDIA [8]

The Global Burden of Disease (GBD) Study and the World Health Organization (WHO) both state:

- Otitis Media Acute (AOM):
  - 709 million cases worldwide each year
  - 51% of cases involve youngsters younger than five.
- Effusion-associated Otitis Media (OME):

- Up to 80% of kids are impacted at least once before they turn ten.
- CSOM, or chronic suppurative otitis media:
- impacts 65–330 million individuals worldwide.
- Every year, about 31 million cases in children occur.
- Extremely common in LMICs (low- and middle-income countries)

I. AGE DISTRIBUTION [16]

Age Group	**Epidemiological Description**
Infants (6–24 months)	Eustachian tube disease and underdeveloped immunity cause the highest incidence of AOM.
Preschool (1–5 years)	High prevalence of OME, resulting to probable speech delay.
School-age (6–12 years)	OME and COM may continue, but incidence is declining.
Adults	Fewer; primarily chronic illness or consequences.

Table 1: Epidemiological Variation of Otitis Media by Age

II. GEOGRAPHIC AND SOCIOECONOMIC VARIATION [17]

Region	**Epidemiological Trends**
High-income countries	Reduced prevalence as a result of improved access to healthcare, vaccinations, and personal hygiene.
Low- and middle-income countries	Increased CSOM and complications rates; limited access to medical care.
Indigenous populations	High COM/CSOM burden (e.g., Native Americans, Inuit, and Australian Aboriginals)

Table 2: Epidemiological Variation of Otitis Media by Age, Region, and Socioeconomic Status

III. TRENDS OVER TIME (1990–2021) [18]

- Globally, there were 391.3 million cases in 2021 compared to 322.1 million in 1992.
- Better healthcare and vaccination programs led to a decline in the age-standardized prevalence rate**.**

2. PATHOPHYSIOLOGY

Despite the high prevalence of the condition, most OM instances in developed nations are straightforward and self-limiting, with little chance of developmental delay or long-term hearing loss [24]. However, because they are exposed to a variety of genetic, environmental,

and societal risk factors, high-risk people living in both developing and developed regions frequently suffer from severe hearing loss that lasts a lifetime.

Premature onset acute otitis media (AOM) is the initial phase in the complex course of OM disease, which starts with early bacterial colonization of the nasopharynx. A viral infection eventually causes severe chronic disorders affecting the ears, whereas continuous exposure to infectious agents, such as bacterial persistence through biofilm formation, causes acute inflammatory cycles in the middle ear over time (Figure 1). [19]

EUSTACHIAN TUBE ANATOMY

An intact Eustachian tube is necessary to shield the middle ear from respiratory viruses and bacterial otopathogens. It also facilitates the drainage of secretions from this region and maintains pressure equalization. Infants are particularly vulnerable to middle ear infections due to their undeveloped Eustachian tube architecture. Mostly made up of ciliated respiratory epithelial cells that produce antimicrobial proteins (such lysozyme), the epithelium lining this structure serves as the primary barrier against otopathogen invasion and colonization. Goblet cells, which are dispersed amid them, also produce serous and mucoid mucus. While antimicrobial protein secretion guards against inflammatory responses brought on by bacteria that live there, the activity regulates the appropriate direction of mucociliary flow, which moves from the nasopharynx toward the middle ear. [20]

The Eustachian tube is distinguished in neonates and young children under a year of age by its shorter length, bigger diameter, and higher horizontal inclination. This shape makes it simpler for viruses to enter the middle ear, increasing the risk of developing otitis media. Additionally, putting new-borns in a supine position increases their susceptibility to illnesses. As children become older, their skull base elevation shifts downhill, gradually rising in angle from 10° at birth to around 45° in adulthood. At the same time, their length increases from about 13 mm at birth to about 35 mm when they are completely grown.

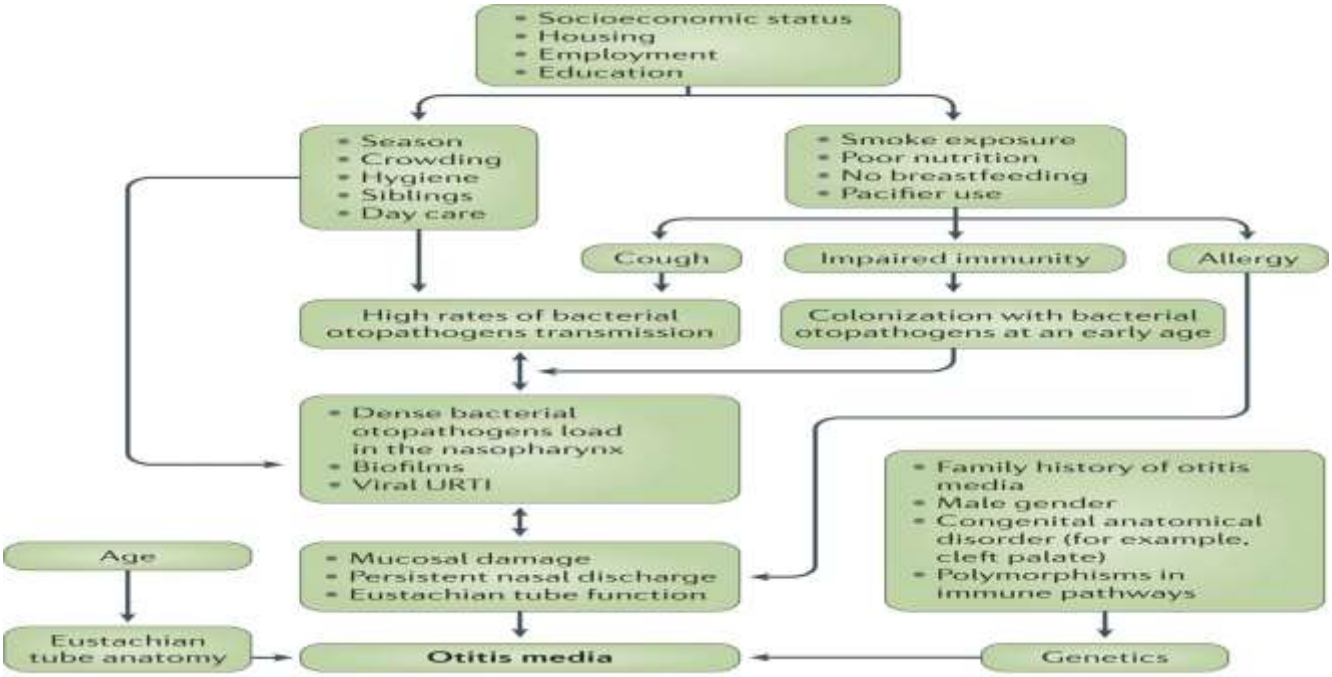

Figure1: Pathways and factors affecting otitis media [20]

MECHANISM OF BIOFILM FORMATION IN OTITIS MEDIA [21-23]

There are several steps in the pathogenesis process:

- First Adhesion

After the Eustachian tube becomes inflamed and malfunctions, nasopharyngeal germs adhere to the middle ear mucosa.

- Formation of Micro colonies

Bacteria start to split apart and group together.

- The process of maturation

EPS is secreted by micro colonies, which develop into a mature, well-organized biofilm.

- Spreading

A persistent or recurring illness can result from certain germs that separate and colonize new locations.

2.1 MICROBIOLOGY OF OTITIS MEDIA

Most often, a mix of bacterial and viral infections causes otitis media (OM), making it polymicrobial based on if it is chronic suppurative otitis media (CSOM), otitis media with effusion (OME), or acute otitis media (AOM).

i. BACTERIAL PATHOGENS [24-26]

- **Acute Otitis Media (AOM)** – most common pathogens:

Pathogen	Description
Streptococcus pneumoniae	Most frequent cause; linked to more intense symptoms. Penicillin resistance exists in certain strains.
Haemophilus influenzae (nontypeable)	Second most prevalent; frequently observed in children often linked to recurring infections.
Moraxella catarrhalis	Frequently observed in moderate instances; typically produces beta-lactamases (resistant to amoxicillin).

Table 3: Common Bacterial Pathogens Causing Acute Otitis Media (AOM)

❖ **Otitis Media with Effusion (OME) [25]:**

- May contain lingering germs and frequently follows AOM.
- Low bacterial load and the presence of biofilms (a state that cannot be grown) are two reasons why culture investigations are frequently negative.
- Common organisms:
  - *H. influenza.*
  - *S. pneumonia.*
  - *M. catarrhalis*.

❖ **Chronic Suppurative Otitis Media (CSOM) [26]:**

Pathogen	Description
Pseudomonas aeruginosa	Most prevalent in CSOM; violent and damaging.
Staphylococcus aureus	Frequently results in subsequent infections.
Proteus species, Klebsiella	Observed in nosocomial or advanced patients.
Anaerobes	Less frequent; present in ears with inadequate aeration or chronic conditions.

Table 4: Common Bacterial Pathogens Causing Chronic Suppurative Otitis Media (CSOM)

ii. VIRAL PATHOGENS [27]

Viruses are important in the pathophysiology of AOM, frequently as co-infections that hinder the function of the Eustachian tube and encourage bacterial colonization.

Virus	Association
Respiratory syncytial virus (RSV)	Typical cause of AOM in new-borns.
Rhinovirus	Frequently linked to upper respiratory infections that occur prior to AOM.
Influenza virus	Can result in or exacerbate AOM.
Adenovirus, Enterovirus, Coronavirus	Contributory yet less frequent.

Table 5: Common Viral Pathogens Causing Acute Otitis Media (AOM)

iii. BIOFILMS IN OTITIS MEDIA [28]

- Biofilms, which are bacterial colonies encased in a protective matrix, are commonly observed in CSOM and OME and are linked to antibiotic resistance and chronicity.
- Biofilm-forming pathogens include:
  - *Nontypeable H. influenza.*
  - *S. pneumoniae.*
  - *M. catarrhalis.*
  - *P. aeruginosa* (especially in CSOM).

2.2 CLINICAL MANIFESTATIONS OF OTITIS MEDIA

1. ACUTE OTITIS MEDIA: AOM is an acute middle ear infection that usually occurs after upper respiratory illnesses, particularly in youngsters [8, 29-35].

Symptoms	Description
Ear pain (otalgia)	Most typical presenting symptom.
Fever	The range is modest to high, particularly in young children.
Irritability, fussiness	Especially in infants who cannot verbalize pain.
Hearing loss	Temporary conductive hearing loss due to middle ear fluid.

Otorrhea	Indicates tympanic membrane rupture.

Table 6: Typical Clinical Findings in Acute Otitis Media.

❖ Otoscopic Findings
- Tympanic membrane bulging (a crucial diagnostic characteristic)
- Limited movement during pneumatic otoscopy;
- Loss of landmarks.

2. OTITIS MEDIA WITH EFFUSION (OME): OME, which frequently accompanies AOM or happens on its own, involves non-infected fluid in the middle ear [35].

Symptoms	**Description**
Hearing loss	Most frequent symptom; usually mild to moderate.
Ear fullness or popping	Due to fluid accumulation.
Speech or language delay	Particularly in chronic/recurrent cases.
Rare but serious compilations.	Differentiates it from AOM.

Table 7: Symptomatology and Otoscopic Findings in OME

❖ Otoscopic Findings
- Tiny movement during pneumatic otoscopy;
- Air-fluid level or visible bubbles;
- Retracted tympanic membrane;
- Amber or blue tympanic membrane.

Symptoms	**Description**
Chronic or recurrent otorrhea	Often foul-smelling.
Conductive hearing loss	Can be significant, sometimes permanent.
Tinnitus and dizziness	In advanced or complicated cases.
Facial nerve palsy, mastoiditis, intracranial abscess	Rare but serious compilations.

3.CHRONIC OTITIS MEDIA (COM): COM is a chronic middle ear irritation that frequently results in ongoing leakage and perforation [36-37].

Table 8: Clinical Features and Complications of COM

❖ Otoscopic/Imaging Findings
- Choleastoma (white mass);
- Granulation tissue;
- Perforated tympanic membrane; and
- Alterations in the mastoid bone on CT

3.DIFFERENCE BETWEEN PEDIATRIC AND ADULT CASES

Due to differences in anatomy, immunological response, etiology, and clinical course, otitis media (OM) manifests differently in children and adults. These distinctions are summed up in the table below [8,38-41]:

TABLE 9: COMPARISON TABLE

Aspect	Paediatric Otitis Media	Adult Otitis Media
Incidence	Extremely high, peaking between six months and two years.	Less frequent; frequently a result of other illnesses.
Eustachian Tube Anatomy	More collapsible, shorter, and horizontal; hinders drainage.	Stiff, upright, longer, and better ventilated.
Immune System	Immature; less effective at eliminating pathogens.	Mature; improved control of the immunological system.
Common Pathogens	*S. pneumoniae*, *H. influenzae*, *M. catarrhalis*.	Can include *P. aeruginosa*, *S. aureus*, esp. in chronic cases.
Symptoms	Fever, ear pulling, irritability, feeding issues.	Otalgia, fullness, hearing loss; rarely systemic symptoms.
Communication of Symptoms	Relies on behavioural signs; children cannot verbalize pain.	Adults describe symptoms clearly and specifically.
Complications	Risk of speech/language delays, hearing loss.	Chronic OM, cholesteatoma, mastoiditis more likely.
Diagnosis	Based on otoscopy, clinical signs, behavioural cues.	Based on otoscopy and patient-reported symptoms.

Vaccination Impact	PCV and Hib vaccines reduce AOM incidence.	Indirect benefit via herd immunity.
Recurrence	High due to anatomy and immature immunity.	Less frequent unless structural or chronic issues exist.

4.DIAGNOSIS OF OTITIS MEDIA

Every kind of otitis media has its own diagnostic standards, although they all entail evaluating middle ear fluid, inflammation, and hearing. [8, 42-43]

i. Clinical History

Symptoms	**AOM**	**OME**	**COM/CSOM**
Otalgia (ear pain)	Present, acute	Usually, absent	Variable
Fever	Common	Uncommon	Uncommon
Hearing loss	Mild to moderate	Common	Common
Otorrhea (discharge)	May be present (if perforated)	Rare	Persistent or intermittent
Irritability	Often in children	Possible	Rare

Table 10: Clinical History and Symptom Profile in Otitis Media Diagnosis

ii. Otoscopic Examination

Pneumatic Otoscopy

- AOM: Reduced movement, purulent fluid, redness, and bulging TM
- OME: Air-fluid level, amber discolouration, no bulging, retracted or neutral TM
- COM/CSOM: Choleastoma, granulation tissue, perforated TM, and visible discharge

iii. Tympanometry

Used to measure middle ear pressure and TM mobility objectively. It results in a tympanogram.

Type	**Curve Shape**	**Interpretation**
A	Normal peak at 0 daPa	Normal middle ear function
B	Flat curve	Effusion or perforated TM

C	Peak at negative pressure	Eustachian tube dysfunction

Table 11: Tympanometric Patterns in Otitis Media Diagnosis

- Usually, OME displays Type B.
- AOM may exhibit Type B as well, but with acute inflammatory symptoms.

iv. Audiometry

It is used to evaluate hearing loss.

- ➢ OME and COM patients frequently have conductive hearing loss.
- ➢ The standard for older children and adults is pure tone audiometry.
- ➢ For infants, behavioural audiometry or Auditory Brainstem Response (ABR) is employed.

v. Imaging Studies: It is used mainly in chronic or complicated OM.

- ❖ Temporal Bone CT Scanning:
- ▪ Recommended when cholesteatoma, mastoiditis, or intracranial problems are suspected.
- ▪ Evaluates mastoid air cells, ossicular chain, and bony erosion.
- ❖ MRI:
- ➢ Saved for suspected tumours, facial nerve involvement, or intracranial extension.

vi. Additional Diagnostic Modalities (Advanced)

Test	**Utility**
Otoacoustic emissions (OAE)	Evaluates cochlear (outer hair cell) function, especially in children.
Endoscopic examination	Visualizes Eustachian tube orifices, adenoid hypertrophy.
Nasopharyngeal swab	Detects colonization with potential OM pathogens in research settings.

Table 12: Specialized Diagnostic Approaches for Otitis Media

4.1 DIAGNOSTIC CRITERIA (BASED ON CLINICAL GUIDELINES) [42-43]

- ❖ AOM (per AAP/AAFP 2013 Guidelines)

Diagnosis requires:

1. Rapid onset of signs and symptoms
2. Presence of middle ear effusion (confirmed via otoscopy or tympanometry)
3. Signs of middle ear inflammation (e.g., TM erythema, otalgia, bulging)

- ❖ OME

Diagnosis requires:

- Presence of fluid in the middle ear for >3 weeks
- Without signs of acute infection

❖ CSOM
- Chronic otorrhea through a perforated TM lasting >6 weeks
- Often with hearing loss

4.1.1DIAGNOSTIC TOOLS

Modality	Use	Best for
Otoscopy	Visual Inspection	All types
Pneumatic Otoscopy	TM mobility	AOM, OME
Tympanometry	Middle ear pressure	OME, AOM, ETD
Audiometry	Hearing assessment	OME, COM, Post treatment
Culture & sensitivity	Identifying bacteria	CSOM, recurrent OM
Imaging (CT/MRI)	Complications, cholesteatoma	CSOM, suspected complications

Table 13: Overview of Diagnostic Instruments for Otitis Media

5.MANAGEMENT AND TREATMENTS OF OTITIS MEDIA (OM) [44-45]

Treatment options for otitis media (OM) vary according to the patient's age, symptom intensity, and risk of consequences. The primary kinds consist of:
- Acute Otitis Media (AOM)
- Otitis Media with Effusion (OME)
- Chronic Suppurative Otitis Media (CSOM)

❖ **Acute Otitis Media (AOM)**

➢ First-Line Management
- Observation ("Watchful Waiting") for 48–72 hours if:
  - Age >6 months
  - Non-severe symptoms (mild otalgia <48 hrs, fever <39°C)
  - Unilateral infection

➢ Antibiotic Therapy
- Indications:
  - Severe symptoms, bilateral AOM in <2 years, or lack of improvement with observation
- First-line:
  - Amoxicillin: 80–90 mg/kg/day in divided doses
- If risk of β-lactamase-producing organisms:
  - Amoxicillin-clavulanate (Augmentin)
- Penicillin allergy:
  - Cefdinir, Cefuroxime, or Azithromycin (if non-type I allergy)

➢ Treatment Duration:

- 10 days (children <2 years or severe symptoms)

1. 7 days (ages 2–5 with mild symptoms)

- 5–7 days (ages ≥6 years)

❖ **Otitis Media with Effusion (OME)**

➢ Management

- Watchful waiting: Most cases resolve spontaneously within 3 months
- Audiologic evaluation if:
  - Persistent OME >3 months
  - Hearing loss, speech delay, or learning concerns

➢ Not Recommended with:

- Routine antibiotics, decongestants, antihistamines, or corticosteroids

➢ Surgical Intervention:

- Tympanostomy tube insertion for:
  - Bilateral OME with hearing loss >3 months
  - Recurrent OME affecting quality of life

❖ **Chronic Suppurative Otitis Media (CSOM)**.

➢ Medical Management

- Aural toilet (ear cleaning and suctioning)
- Topical antibiotic drops:
  - Ciprofloxacin or ofloxacin drops preferred over systemic antibiotics
- Avoid ototoxic drops like neomycin in case of TM perforation

➢ Systemic antibiotics:

- Only for severe infections, suspected complications, or failure of topical therapy

➢ Surgical Options:

- Tympanoplasty (TM repair)
- Mastoidectomy if cholesteatoma or extensive infection

5.1 VACCINES FOR OTITIS MEDIA [46-50]

Vaccination is essential for preventing otitis media, especially Acute Otitis Media (AOM), which is brought on by bacterial infections like Haemophilus influenzae and Streptococcus pneumoniae.

❖ **Pneumococcal Conjugate Vaccines (PCVs)**

- Target Pathogen: *Streptococcus pneumoniae* - the primary bacterial cause of AOMPCV13 (Prevnar 13)
- PCV15 (Vaxneuvance) — introduced in 2021
- PCV20 (Prevnar 20**)** — includes more serotypes, licensed for broader age use.
- Mechanism: Produce**s** protection against pneumococcal serotypes linked to pneumonia, bacteraemia, and OM.
- Effect on OM:
- Overall, it lowers the incidence of AOM by 6–8%.
- Lowers the incidence of antibiotic-resistant patients and recurrent OM.
- A previous version of PCV7 decreased the installation of tympanostomy tubes by 20%

❖ **Haemophilus influenzae type b (Hib) Vaccine**

- Target Pathogen: *Haemophilus influenzae* type b - formerly a prevalent pathogen for meningitis and OM.
- Mechanism: inhibits nasopharyngeal colonization, which indirectly lowers OM and prevents invasive illness brought on by Hib.
- Effect on OM: Hib generates a markedly lower frequency of severe or recurrent OM, which helps to lower the number of complex OM cases.

❖ **Influenza Vaccine**

- Target Pathogen: Influenza A and B viruses
- Mechanism: inhibits the development of primary influenza, which frequently occurs before secondary bacterial AOM.
- Effect on OM:
- Particularly beneficial for children under two years old;
- reduces AOM incidence by up to 30% during influenza season

❖ **RSV Vaccine / Monoclonal Antibodies**

- Target Pathogen: Respiratory Syncytial Virus (RSV)
- Mechanism: keeps OM from developing by preventing upper respiratory infections and RSV bronchiolitis.
- Options include: **Nirsevimab (Beyfortus)** — long-acting monoclonal antibody

Maternal RSV vaccines — passive immunity to infants

➢ Effect on OM:

- RSV prophylaxis has been demonstrated to lower AOM linked to RSV.
- Studies showed that Nirsevimab decreased medically attended RSV-related AOM by more than 70%.

6. RECENT ADVANCE TRENDS AND RESEARCH IN OTITIS MEDIA [51-53]

❖ **Novel Antibiotics and Drug Delivery Systems** [53-54]

- Innovation: The goal of new topical antibiotics and sustained-release administration methods is to increase compliance and combat resistance.
- Examples:

a) Hydrogel-based ear drops: antibiotics that are released gradually and directly into the middle ear.

b) Nanoparticle formulations: enhanced biofilm and tympanic membrane penetration. Clinical results from localized ciprofloxacin/dexamethasone administration systems (like OTO-201) were encouraging.

❖ **Role of Microbiome and Genetics** [55-57]

- Microbiome:
- Current studies investigate the role of middle ear and nasopharyngeal bacteria in OM susceptibility. Imbalance (dysbiosis) may promote pathogenic colonization (*S. pneumoniae*, *H. influenzae*).
- Genetics:
- Children may be more susceptible to recurrent AOM if they have polymorphisms in immune function-related genes (such as IL-6, TNF-α, and TLR4).
- Emerging Concepts:

• Taking probiotics to help the nasopharyngeal flora return to a healthy state.
• Microbiome sequencing (16S rRNA) to personalize prognosis and treatment.

❖ **Biofilm-Targeted Therapies** [58-60]

▪ Problem:
• Biofilm-forming organisms, which are resistant to antibiotics, are frequently linked to chronic and recurring OM.
▪ Strategies:
• Enzymatic biofilm disruption (e.g., dispersin B, DNase);
• Anti-quorum sensing compounds;
• Bacteriophage therapy; and
• Nanoparticles that can enter the biofilm matrix and release medications locally are some examples.

❖ **Hearing Preservation Strategies** [61-63]

▪ Focus:
• Using both preventive and restorative measures, OM-related hearing loss is addressed.
▪ Advances:
• Early installation of hearing aids (tympanostomy tubes, bone conduction aids);
• Regenerative therapies (e.g., neurotrophins, stem cells) being researched to repair damaged inner ear structures;
• Tunable tympanostomy tubes are one example of a minimally invasive breathing tube system.

7.CONTROVERSIES AND CHALLENGES IN OTITIS MEDIA

Otitis media (OM), proper therapy, preventative measures, and surgical intervention are still up for debate despite clinical advancements. [64-66]

❖ **Antibiotic Overuse and Resistance**

▪ Problem:
• Antibiotics are often overprescribed for acute otitis media (AOM), especially in viral or self-limiting cases.
• Overuse contributes to antimicrobial resistance (AMR), especially in pathogens like *Streptococcus pneumoniae* and *Haemophilus influenzae*
▪ Evidence:
• Most AOM cases resolve spontaneously within 7–10 days.
• Cochrane reviews suggest minimal benefit from immediate antibiotics in non-severe cases, particularly in children over 2 years old.

❖ **Indications for Surgery (e.g., Tympanostomy Tubes)**

▪ Problem:
• There is disagreement about how to balance the advantages of improved hearing with the dangers of anaesthesia, chronic otorrhea, or scarring;
• Clinical practice varies on when to implant tympanostomy tubes for chronic or recurrent OM.
▪ Evidence:

- In general, surgery is advised for: o ≥3 AOM episodes in 6 months, or ≥4 in 12 months.
- Prolonged OME for longer than three months with a record of hearing loss
- According to certain research, watchful waiting has comparable long-term results.

❖ **Vaccine Effectiveness in Prevention**

▪ Problem:

- Some studies indicate a minimal impact on the prevalence of OM, despite the widespread use of influenza and PCV vaccines. Concerns over serotype replacement with non-vaccine strains in pneumococcal OM.

▪ Evidence:

- PCV7 and PCV13 decreased vaccine-type OM, but their total AOM incidence reduction was only about 6–8%.
- Vaccination against influenza lowers OM mostly during the busiest flu seasons, not all year long.

❖ **Management of Asymptomatic Otitis Media with Effusion (OME)**

▪ Problem:

- OME is frequently asymptomatic but can result in mild hearing loss;
- Watchful waiting versus early intervention is debatable, particularly for youngsters who are still establishing their language skills.

▪ Evidence:

- AAP/AAO guidelines recommend watchful waiting for 3 months in most cases, unless hearing or speech is affected.
- Surgical intervention (e.g., tympanostomy tubes) may be warranted in cases of:
  - Bilateral OME >3 months with documented hearing loss
  - At-risk children (e.g., with speech delay, Down syndrome)

CONCLUSION

Acute otitis media (AOM), otitis media with effusion (OME), and chronic suppurative otitis media (CSOM) are among the illnesses that fall under the umbrella of OM; each has unique clinical characteristics and treatment requirements. The anatomy, immunological response, microbiology, and prognosis of paediatric OM are very different from those of adult instances. Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis are common infections; biofilms and microbiome dysbiosis are becoming more and more implicated. Though they need more clinical validation, recent developments like biofilm-targeted medicines, AI-assisted diagnostics, and innovative drug delivery systems are encouraging.

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