GSC Advanced Research and Reviews
eISSN: 2582-4597 CODEN (USA): GARRC2
Cross Ref DOI: 10.30574/gscarr
Journal homepage: https://gsconlinepress.com/journals/gscarr/

(REVIEW ARTICLE)

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Risk factors and management for acute otitis media in Referral Hospitals

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GSC Advanced Research and Reviews, 2025, 23(03), 048-055

Publication history: Received on 27 April 2025; revised on 05 June 2025; accepted on 07 June 2025

Article DOI: https://doi.org/10.30574/gscarr.2025.23.3.0158

Abstract

Acute Otitis media (AOM) is a common inflammatory condition of the middle ear, particularly affecting children. About 85% of children experience at least one episode of acute otitis media within the first three years of life, with a significant risk for developing recurrent or chronic forms of the disease. The primary etiological agents are viral and bacterial infections, primarily from upper respiratory tract infections. Main risk factors include upper respiratory infections, exposure to smoke, and the anatomical design of the Eustachian tube, increase its susceptibility in children. Proper management is crucial to avoid complications such as chronic otitis media with effusion (OME) and potential intracranial infections. Treatment may include observation for mild cases, analgesics, and antibiotics for confirmed bacterial infections. For children at high risk or with severe symptoms, immediate antibiotic therapy is recommended. Surgery, such as tympanostomy tube placement, is considered for recurrent AOM in children, particularly those experiencing multiple episodes within a year. Non-pharmacological interventions should focus on addressing anatomical abnormalities and enhancing Eustachian tube function. The implementation of pneumococcal vaccination is vital in reducing AOM incidence. Overall, addressing both environmental and biological risk factors alongside appropriate therapeutic measures is fundamental to managing otitis media effectively and preventing recurrences in the pediatric population.

Keywords: Acute Otitis Media; Middle Ear Infection; Risk Factors; Management

1. Introduction

Almost 85% of children have at least one episode of acute otitis media in the first 3 years of life and 50% of children have 2 or more episodes. Children who suffer from otitis media in the first year of life have an increased risk of chronic otitis media or recurrent otitis media. The incidence tends to decrease after 6 years old. In the United States, almost all children by 2 years of age will have experienced otitis media, and approximately 17% of children aged 6 months have experienced 3 or more episodes. Frequent recurrent episodes result in increased parental worry and anxiety, as well as medical costs. In developing countries, the most common complication is hearing loss, emphasized the importance of pneumococcal vaccination to prevent otitis media and its complications [1].

Ear canal infections, include infections of the external ear canal (otitis externa), middle ear canal (otitis media), mastoid (mastoiditis) and inner ear (labyrinthitis). Otitis media, an inflammation of the middle ear is associated with middle ear effusion, which is an accumulation of fluid in the middle ear. Otorrhea is ear discharge that can originate from the tympanic membrane. Otitis media is classified based on clinical manifestation, otoscopy, duration of illness, and complications. Otitis media occurs due to disruption of middle ear aeration, usually caused by blockage of the eustachian tube. Accurate diagnosis and proper treatment are critical, as otitis media is a common disease that may lead to intracranial complications [2].

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2. The Anatomy of Ear

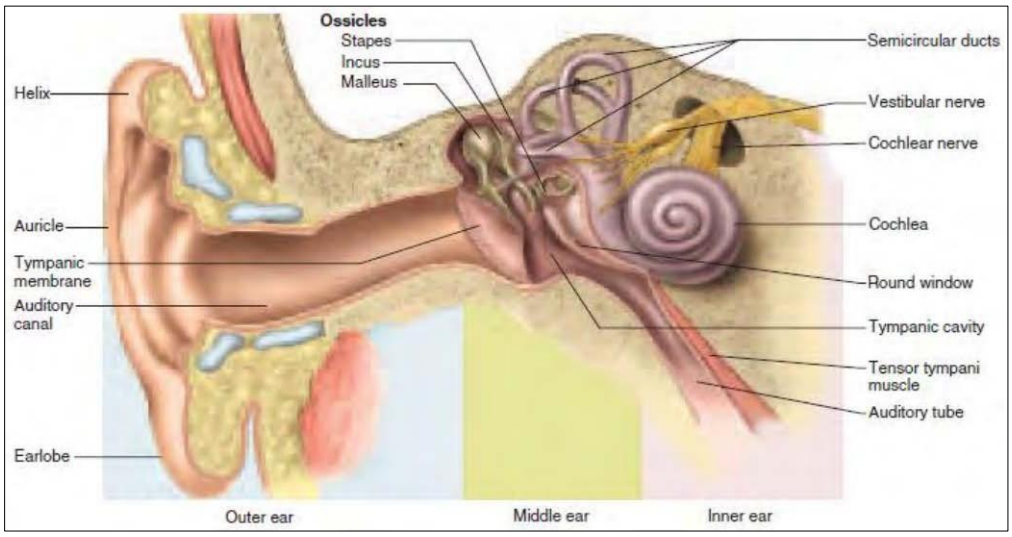

Figure 1 The Anatomy of Ear [3]

The external ear consists of the auricle, ear canal (meatus acusticus externa) to the lateral tympanic membrane. The auricle is formed by cartilage and muscle, covered by skin. Towards the ear canal a funnel-shaped layer of cartilage covers almost the lateral third, the other two-thirds of the ear canal is formed by bone covered by skin that is tightly attached and associated with the tympanic membrane. The shape of auricle with various protrusions and depressions, along with the straight shape of the ear canal that length about 2.5 cm, will produce resonance about 3500 Hz. The outer third consists of cartilage, containing many cerumen glands and hairs, while the inner two-thirds consists of bone with little cerumen [1].

The middle ear is a cube consisting of the tympanic membrane, cavum timpani, eustachian tube and auditory bones.The upper part of the tympanic membrane is called pars flaxida (Shrapnell's membrane) which consists of two layers, namely the outer layer is a continuation of the skin epithelium of the ear canal and the inner layer is lined by ciliated cube cells.The lower part of the tympanic membrane is called pars tensa (membrane propria) which has one layer in the middle, which is a layer consisting of collagen fibers and a few elastomeric fibers. The auditory bones consist of the malleus, incus and stapes which are arranged from the outside in like a chain that connects from the tympanic membrane to the inner ear cavity. The processus longus of the malleus is attached to the tympanic membrane, the malleus is attached to the incus, and the incus is attached to the stapes. The eustachian tube connects the nasopharyngeal region with the middle ear. The prosessus mastoideus is the part of the temporalis bone that lies behind the ear. Antrum mastoideus, the air space at the top, is connected to the middle ear cavity. Infection can travel from the middle ear cavity to the antrum mastoideus which can cause mastoiditis [3].

The inner ear is composed of two main structures: the bony and membranous labyrinth. The bony labyrinth includes the cochlea, vestibule and semicircular canal, while the membranous labyrinth consists of the utriculus, sacculus, cochlear duct and semicircular duct. The bony labyrinth cavity is lined by a thin layer of internal periosteum (endosteum), and is largely filled with trabeculae, giving it a sponge-like appearance. The cochlea shaped like two semicircles, which its apex is called the helicotrema, connecting the perilymph of the vestibuli scale (upper chamber) and the tympanic scale (lower chamber). Between the vestibuli scale and the tympanic scale is the media scale (cochlear duct). The vestibuli scale and tympanic scale contain perilymph with 139 mEq/l of sodium ions, while the media scale contains endolymph with 144 mEq/l of potassium ions. This difference in ionic concentration is essential for auditory transduction [1].

The vestibular membrane (Reissner's membrane) separates the vestibuli scale from the media scale. The basilar membrane forms the base of the media scale and supports the organ of Corti, the primary sensory structure for hearing. The organ of Corti contains a single row of approximately 3.000 inner hair cells and three rows of 12,000 outer hair cells. Afferent and efferent nerve endings are attached to the lower end of the hair cells. On the apical surface of the hair cells are stereocilia, which are tectorial membrane—a gelatinous structure supported and secreted by the limbus, located medially [1].

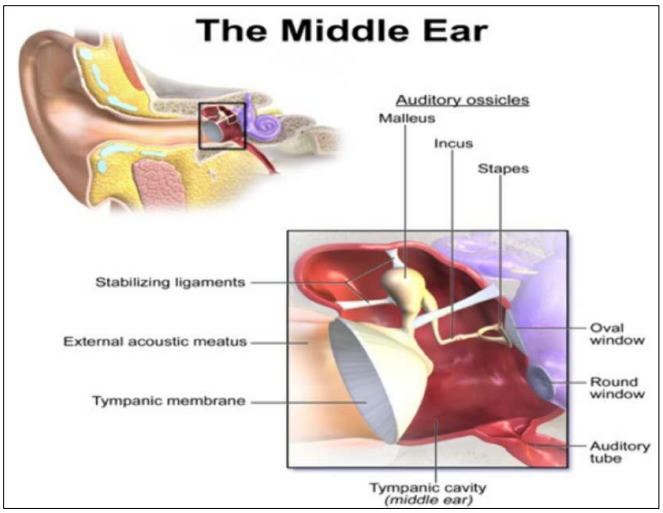

Figure 2 The Structure of Middle Ear [4]

The auditory nerve is composed of two parts: the vestibular nerve (responsible for balance) and the cochlear nerve (responsible for hearing). Fibers of the vestibular nerve project to the vestibular nucleus, located at the junction of the pons and medulla oblongata, and then continue to the cerebellum. Meanwhile, fibers of the cochlear nerve first transmit signals to a specialized nucleus located just posterior to the thalamus, before relaying them to the primary auditory cortex in the lower part of the temporal lobe [1].

The inner ear receives its blood supply from the labyrinthine artery, which typically branches from the anterior inferior cerebellar artery (AICA), or less commonly from the basilar or vertebral artery. This artery enters the internal acoustic meatus and divides into: the anterior vestibular artery and the common cochlear artery (which further branches into cochlear artery and vestibulocochlear artery). The anterior vestibular artery supplies the vestibular nerve, the utricle, and part of the semicircular canals. The vestibulocochlear artery travels to the modiolus of the cochlea's basal turn and splits into: the terminal vestibular branch, which supplies the saccule, most of the semicircular canals, and the basal end of the cochlea the cochlear branch, which supplies the spiral ganglion, bony spiral lamina, limbus, and spiral ligament The cochlear artery courses around the acoustic nerve in the internal acoustic canal and loops around the modiolus within the cochlea [1].

Venous blood from the inner ear drains into the labyrinthine vein, which empties into either the inferior petrosal sinus or the sigmoid sinus. Smaller veins also pass through the vestibular and cochlear aqueducts, draining into the superior and inferior petrosal sinuses Innervation of the inner ear is provided by the vestibulocochlear nerve (cranial nerve VIII), also known as N. acousticus, which consists of both cochlear and vestibular components. These two parts merges in the internal acoustic meatus, lateral to the root of the facial nerve (N. facialis), and enter the brainstem at the junction of the pons and medulla. Vestibular sensory cells are innervated by fibers from the vestibular ganglion (Scarpa's ganglion), located at the base of the internal acoustic meatus. Auditory sensory cells are innervated by fibers from the spiral ganglion of Corti, located within the modiolus of the cochlea [1].

3. The Physiology of Auditory System

When the external ear (auricle) captures sound waves from the surrounding environment. These waves travel through the air or, in certain cases, through bone conduction, eventually reaching the cochlea. The vibrations vibrate the tympanic membrane and are transmitted to the middle ear through a series of auditory ossicles. This system amplifies the vibrations through the leverage of the auditory ossicles and the multiplication of the area ratio difference between the tympanic membrane and the oval window. This amplified vibration energy will be transmitted to the stapes, which then transmits the vibration to the oval window of cochlea, sets the perilymph in the vestibule scale into motion [5].

This fluid movement creates pressure waves that deform the Reissner's membrane, which in turn displaces the endolymph in the media scale. The resulting fluid motion causes relative movement between the basilar membrane and the tectorial membrane, generating a mechanical stimulus that bends the stereocilia on the hair cells of the organ of Corti. Deflection of the stereocilia opens ion channels, allowing charged ions to enter the hair cells. This leads to depolarization, prompting the release of neurotransmitters at the synapse with the auditory nerve fibers. These

chemical signals generate action potentials that travel along the cochlear nerve, a branch of the vestibulocochlear nerve (cranial nerve VIII). The nerve impulses are then transmitted to the auditory nuclei in the brainstem, relayed through the thalamus, and finally reach the auditory cortex (Brodmann areas 41 and 42) in the temporal lobe of the brain, where sound is consciously perceived and interpreted [5].

4. Risk factors

Otitis media is a multifactorial disease, some of the factors that most often influence the occurrence of acute otitis media (AOM) are infection, allergies, and the environment [6]. Upper respiratory tract infection is the most frequent risk factor for AOM in children, which may cause by viruses or bacteria. Pathogenic bacteria, such as *Streptococcus pneumoniae, Haemophilus influenza*, and *Moraxella catarrhalis* are responsible for more than 95% of cases. While viral pathogens such as *Respiratory Syncytial Virus, Influenza virus, Parainfluenza virus, Rhinovirus,* and *Adenovirus* can also commonly develop AOM [2].

Otitis media begins as an inflammatory process after an upper respiratory tract viral infection, involving the nasal mucosa, nasopharynx, middle ear mucosa, and Eustachian tube. Because the anatomical space of the middle ear is narrowed, edema caused by the inflammatory process blocks the narrowest part of the Eustachian tube, which then causes decreased of ventilation. This causes a series of events that result in increased negative pressure in the middle ear, increased exudate from the inflamed mucosa, and accumulation of mucosal secretions, which allows colonization of bacterial and viral organisms in the middle ear. The growth of these microbes then results pus in the middle ear space [7]. This is manifested as a prominent or erythematous tympanic membrane with purulent fluid. This must be differentiated from chronic suppurative otitis media (CSOM), which presents with thick yellow fluid in the middle ear space and retraction of the tympanic membrane (TM) on otoscopic examination. Both will decrease tympanic membrane mobility on tympanometry or pneumatic otoscopy [8].

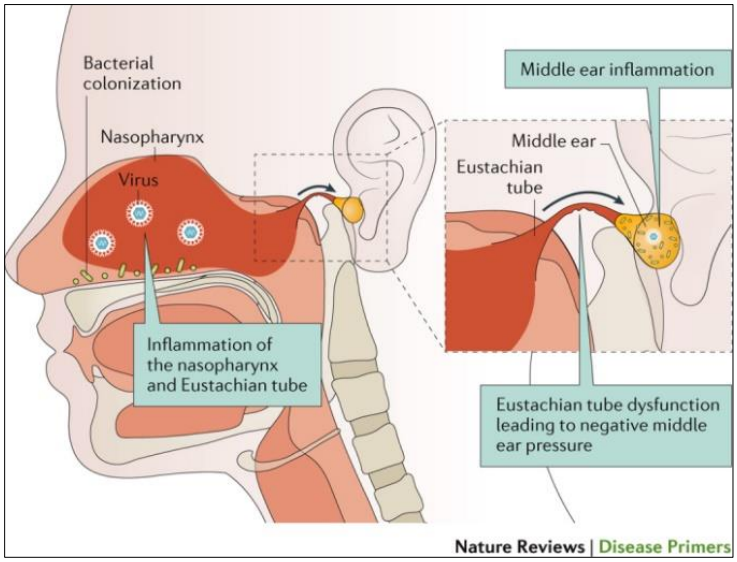

Figure 3 Pathogenesis of Acute Otitis Media [8]

While other risk factors such as male gender, adenoid hypertrophy (obstruction), allergies, vitamin A deficiency, anatomical abnormalities of the palate and tensor veli palatini, ciliary dysfunction, and cochlear implants also affect the occurrence of AOM. Daycare visits, low socioeconomic status, exposure to smoke in the environment, lack of breastfeeding, use of pacifiers, immunodeficiencies (human immunodeficiency virus/HIV, diabetes, and others), gastroesophageal reflux, family history of recurrent AOM in parents or siblings, and other genetic predispositions are other risk factors for AOM. Mucins that include abnormalities in gene expression, especially upregulation of MUC5B are also known to be associated with AOM [6].

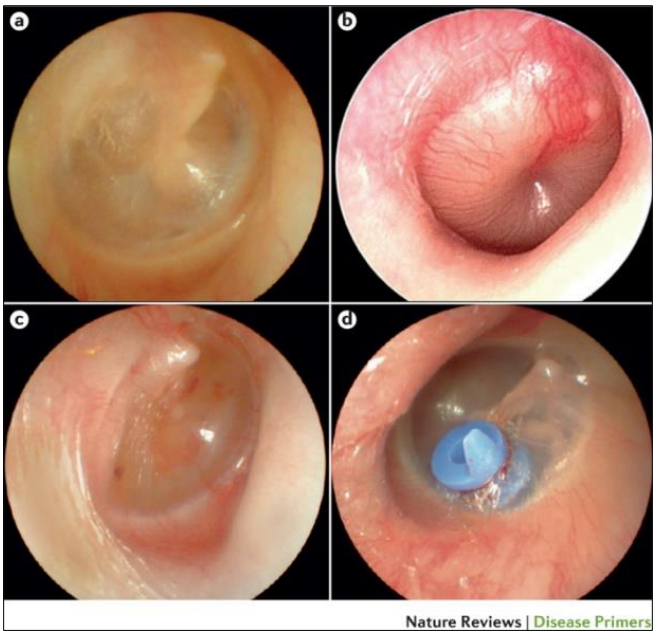

Figure 4 Tympanic Membrane (a) Normal MT; (b) Hyperemic and prominent MT in AOM; (c) Otitis media with effusion; (d) MT with tympanostomy tube installed [8]

5. Management

The clinical course of acute otitis media (AOM) in healthy children is often self-limiting, with symptoms typically resolving within a few days. Most cases heal without complications, even in the absence of antibiotic therapy. In addition, the routine usage of antibiotics for common infections such as AOM contributes to the development of antimicrobial resistance at both individual and community levels. Therefore, the decision to use antibiotics should carefully balance the potential risks and benefits, taking into account the patient's clinical presentation [4]. For healthy children aged 6 months or older who present with mild symptoms and appropriate to AOM diagnostic criteria, or children with uncertain diagnosis, an observation for 48 hours with analgesics is recommended. Management options during observation include:

- Reassess the child within 24 - 48 hours to document the clinical course;
- Advise caregiver or parents to return if the child fails to improve or worsens at any time within 48 hours; or
- Provide a "delayed antibiotic prescription", to be used only if the child does not show signs of improvement [4].

Antibiotics are most effective in children aged <2 years with bilateral AOM and in all ages who experience acute ear discharge due to AOM. For these cases, immediate antibiotic treatment is recommended according to the latest guidelines [4]. Immediate antibiotic treatment is also recommended for AOM in patients who are less than 6 months of age, immunocompromised, craniofacial malformations, as well as those with severe symptoms of AOM. In contrast, for children with uncomplicated and non-severe AOM who are not at high risk for complications, observation still considered appropriately. Antibiotic prescription may be delayed, unless AOM symptoms persist for 48-72 hours [5].

5.1. Pharmacological treatment

Once acute otitis media (AOM) is diagnosed, the primary goals of management are symptom control particularly relief of pain and fever and eradication of the underlying infection through appropriate antibiotic therapy. Pharmacological therapy in the form of nonsteroidal anti-inflammatory drugs (NSAIDs, such as ibuprofen) or acetaminophen (paracetamol) can be used to control pain. Paracetamol can be given 10 to 15 mg/kgBW every 4 to 6 hours in children, and 500 mg every 4 to 6 hours in adults [9]. There is controversy about prescribing antibiotics in early otitis media as previously described. Antibiotics are indicated in certain conditions, such as children with MT protrusion accompanied by fever (≥39°C) and moderate to severe systemic complaints, or who have experienced severe otalgia, or who have been seriously ill for 48 hours. In addition, when bacterial infection is suspected such as in suppurative stage AOM, oral antibiotics can be recommended. First-line therapy in patients who are not allergic to penicillin is high-dose amoxicillin in both children and adults:

- Amoxicillin 75 mg/kg/day to 90 mg/kg/day divided twice daily per oral, or
- Amoxicillin 45 mg/kg/day to 60 mg/kg/day divided three times daily per oral [10].

A five-day course of appropriately dosed antibiotics is recommended for most children aged ≥2 years with uncomplicated AOM. For younger children (aged 6–23 months), or in cases of tympanic membrane (TM) perforation or recurrent AOM, a ten-day course is advised [10]. In cases of penicillin allergy, the American Academy of Pediatrics (AAP) recommends

- A single dose of azithromycin 10 mg/kg/day
- Clarithromycin (15 mg/kg/day in two divided doses)
- Cefdinir 14 mg/kg/day in 1 or 2 doses
- Cefpodoxime 10 mg/kg/day once daily
- Cefuroxime 30 mg/kg/day in 2 divided doses [8]

Oral antibiotics reduce the duration of AOM symptoms and middle ear effusions, respectively. However, it should be considered for potential side effects, such as gastrointestinal symptoms and skin rashes. If TM perforation is present, treatment should be continued with ototopical antibiotics that are safe for use in the middle ear (e.g., ofloxacin). These provide higher local concentrations without systemic side effects and are preferred over systemic antibiotics [10].

In recurrent AOM, management aims to prevent further episodes. Immunization with pneumococcal conjugate vaccine (PCV) during early infancy has proven effective in reducing the risk of recurrent AOM, though it is less effective in older children. Antibiotic prophylaxis can reduce recurrence rates from 3 to 1.5 episodes per year but is generally not recommended due to concerns about side effects and antibiotic resistance [11]. If symptoms persist after treatment with high-dose amoxicillin, switching to high-dose amoxicillin-clavulanate is recommended (amoxicillin 90 mg/kg/day and clavulanate 6.4 mg/kg/day in two divided doses). In cases where oral antibiotics are not feasible (e.g., vomiting), ceftriaxone 50 mg/kg/day for three consecutive days via IV or IM administration is an alternative option [12].

Topical and oral decongestants, antihistamines, and corticosteroids have not shown consistent benefit in managing AOM symptoms and are not recommended. Tympanocentesis or myringotomy, a small incision in the tympanic membrane that allows fluid to drain from the middle ear, may assist in identifying the causative pathogen, but are not effective as stand-alone treatment options for AOM [5].

5.2. Surgical management

Tympanocentesis is a procedure used to relieve pressure within the middle ear cavity in cases of acute otitis media (AOM). It involves the insertion of a fine needle through the tympanic membrane into the middle ear to aspirate accumulated fluid. In addition to its diagnostic value—particularly in identifying the causative pathogen—tympanocentesis also offers therapeutic benefits by reducing middle ear pressure and alleviating pain. Furthermore, the procedure facilitates more effective delivery of topical antibiotic agents directly to the site of infection [4,13,14]. According to the American Academy of Pediatrics (AAP), patients who have experienced four or more episodes of acute otitis media (AOM) within the past 12 months should be evaluated for myringotomy with ventilation tube (grommet) insertion [8]. Similarly, the American Academy of Otolaryngology–Head and Neck Surgery recommends tympanostomy tube placement in children with recurrent AOM and middle ear effusion at the time of evaluation [5].

A ventilation tube also known as a tympanostomy or myringotomy tube is a small plastic device surgically inserted into the tympanic membrane under local or general anesthesia. These tubes typically remain in place for 6 to 12 months and are self-extruding or self-dissolving. The primary indications for this procedure are the restoration of hearing in children with chronic otitis media with effusion (glue ear) and the prevention of recurrent AOM by improving middle ear ventilation and drainage. Ventilation tubes also facilitate direct access to the middle ear, allowing for the administration of topical antibiotics when needed. The benefits of ventilation tube placement are most evident within the first six months after insertion, during which approximately one episode of AOM may be prevented. However, current evidence suggests that tympanostomy tubes are not effective for recurrent AOM in the absence of persistent middle ear effusion. They are, however, appropriate for managing recurrent AOM associated with effusion in one or both ears [7,8].

Tympanostomy tube placement has been shown to improve disease-specific quality of life. Improvements have been observed in psychosocial aspects such as physical discomfort, hearing loss, speech impairment, emotional distress, and activity limitations. Although the procedure does not significantly reduce the long-term recurrence rate of AOM, it is not associated with major complications such as sensorineural hearing loss, vascular injury, or ossicular chain damage.

Common, generally mild complications include otorrhea, tube extrusion or retention, granulation tissue formation, and residual tympanic membrane perforation. Myringoplasty may be necessary if the perforation is persistent, particularly when accompanied by secondary infection and hearing loss. Rarely, tympanostomy tubes may migrate into the middle ear behind an intact tympanic membrane without causing symptoms [5].

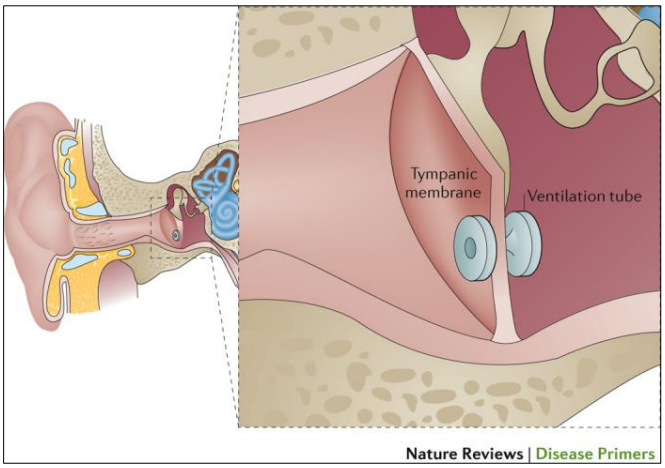

Figure 5 Tympanostomy tube installation [14]

Other structures such as adenoids that serve as a nasopharyngeal reservoir for respiratory pathogens, when enlarged can cause nasal airway obstruction and interfere with Eustachian tube function. Adenoidectomy is a surgical removal of adenoids performed in children with recurrent AOM to improve middle ear function and thereby prevent further AOM episodes [8]. However, adenoidectomy alone is not recommended for the prevention of AOM, tympanostomy tube placement should still be considered as it has more benefits.

Chemoprophylaxis with low-dose amoxicillin showed a significant reduction in the frequency of AOM compared with placebo in two studies with a one-year follow-up period. Surgical intervention should be considered in cases of recurrent AOM, either due to Eustachian tube dysfunction or bacterial resistance, Down syndrome, and craniofacial abnormalities such as cleft palate [5,15].

6. Conclusion

Otitis media is a middle ear inflammation typically triggered by an acute respiratory infection. Viral entry initiates inflammation and compromises the ear's defenses, allowing secondary bacterial infection. This leads to fluid accumulation, causing ear pain and a bulging tympanic membrane, with possible discharge if perforation occurs. In children, the condition often follows an upper respiratory tract infection, with Eustachian tube dysfunction playing a key role. Due to their immature immune systems and anatomical differences, children are more susceptible. Diagnosis is based on the presence of middle ear effusion with symptoms such as fever, otalgia, irritability, and respiratory signs, with the WHO identifying upper respiratory infections as the leading cause.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This study did not require ethical approval or informed consent, as it is based solely on a review of existing literature.

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