

Acute mastoiditis in children

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Abstract. Acute mastoiditis is the most common complication of acute otitis media. Although rare, the disease is carefully studied by otolaryngologists because it usually affects very young children with severe clinical course and sometimes causes serious complications. Most important risk factors are the young age (often >2 years), high fever, alteration of the laboratory findings (very high values of WBC count, absolute neutrophil count and C-reactive protein), while less important are previous antibiotic therapy or previous middle ear infections. The main pathogen of the acute mastoiditis is *Streptococcus pneumoniae*, followed by *Streptococcus piogenes*, *Haemophilus influenzae*, and *Staphylococcus aureus*. The finding of *Pseudomonas aeruginosa* is not uncommon, but often its presence is often considered a contamination or simultaneous infection. The complications can be extracranial (subperiosteal abscess, Bezold's abscess); intratemporal (facial nerve palsy, labyrinthitis) and intracranial (subdural abscess). The complications have often a very serious clinical course and potentially life-threatening. Antibiotic therapy is the main treatment in not complicated forms. Considering the prevalence of *Streptococcus pneumoniae*, cephalosporins are the antibiotic of choice, but they have to be administered intravenously in hospitalized patients. Combinations with other antibiotic are suggested when multibacterial flora is present. In complicated forms of acute mastoiditis, the antibiotic treatment can be particularly important, in combination with other specific drugs (i.e. anticoagulants and/or corticosteroids). Surgical treatments, such as incision of abscesses, mastoidectomy, and neurosurgical procedures, are sometimes performed in combination with medical therapy in very severe complications. Data from our experience are briefly reported. (www.actabiomedica.it)

Key words: acute mastoiditis, pathogens, antibiotics, surgery

Introduction

Acute mastoiditis (AM) is a serious bacterial infection of the mastoid bone that occurs as a consequence of acute otitis media (AOM). The illness needs to be correctly defined. Given that the middle ear (ME) communicates with the mastoid area through *aditus ad antrum*, a mastoid involvement in infectious acute or chronic diseases of ME is very common; therefore, "otomastoiditis" is the correct definition of all otitis. Instead, AM represents a severe complication of an acute (sometimes chronic) otitis media, favoured by

several factors (anatomic condition of the temporal bone, age, bacterial flora, immunological defects, etc).

The main etiopathogenetic factor is represented by the closure of the *aditus ad antrum* due to oedema or granulation tissue which prevents the drainage of the purulent exudate from the mastoid air cells (1). Very common in the pre-antibiotic era (at least 20% of OMA resulted in AM, often complicated by devastating extratemporal and intracranial sequelae), the disease is currently rare but it is often dangerous because it mostly affects very young children, with important clinical course and complications.

OMA is a suppurative infection of mastoid air cells with bone destruction (osteomyelitis); sometimes the process spreads through the periosteum and induces periostitis and subsequent involvement of surrounding structures, in particular, neurological and vascular. So, complications of acute AM are sometimes dramatic and difficult to treat. It is very important to perform a precocious diagnosis and a well-planned and prolonged antimicrobial or surgical treatment to avoid severe complications, sometimes with lethal risks.

In this review, we aim to illustrate a synthetic overview of AM, with some reference to personal experience of the last 15 years.

Incidence

Acute mastoiditis represents the most common complication of an AOM, affecting 1 in 400 cases (0.24%) (2). Its incidence is variously reported in different countries, varying in pediatric age from 1.2 to 6.1 per 100,000 children aged 0-14 years, per year (3,4). Dramatically decreased in the antibiotic era, the incidence of AM in pediatric age has consistently increased in the last two decades even in developed countries (5). This event can be attributed to a selection

of resistant bacterial strains, more frequently detected over time, due to inadequate antibiotic treatments (abuse or non-specific use) (6,7,8).

Pediatric age is undoubtedly the most prone to mastoid involvement in middle ear infections, due to particular anatomical, immunological and infectious conditions, above all in the first years of life:

In children, the mastoid bone is more pneumatized with thin bone trabeculae and the aditus ad antrum is smaller than in adult's: so, there is a greater predisposition to the accumulation of secretion and osteitic infection. Pediatric age is often characterized by physiological immaturity of the immune system with a peak incidence between the second and third year of life. Particularly in children, non-selected antibiotic therapies can induce a selection of resistant bacterial strains. In a wide casuistry, Groth et al. evidenced differences in the evolution of the AM in different ages: youngest children have more rapid evolution and more serious symptoms of the disease than adults (4).

Our experience confirms the previous studies on the incidence of AM. In our study, most children (27 observed from 2003 to 2017) were < 3 years old; just one case was > 10 years old (Figure 1).

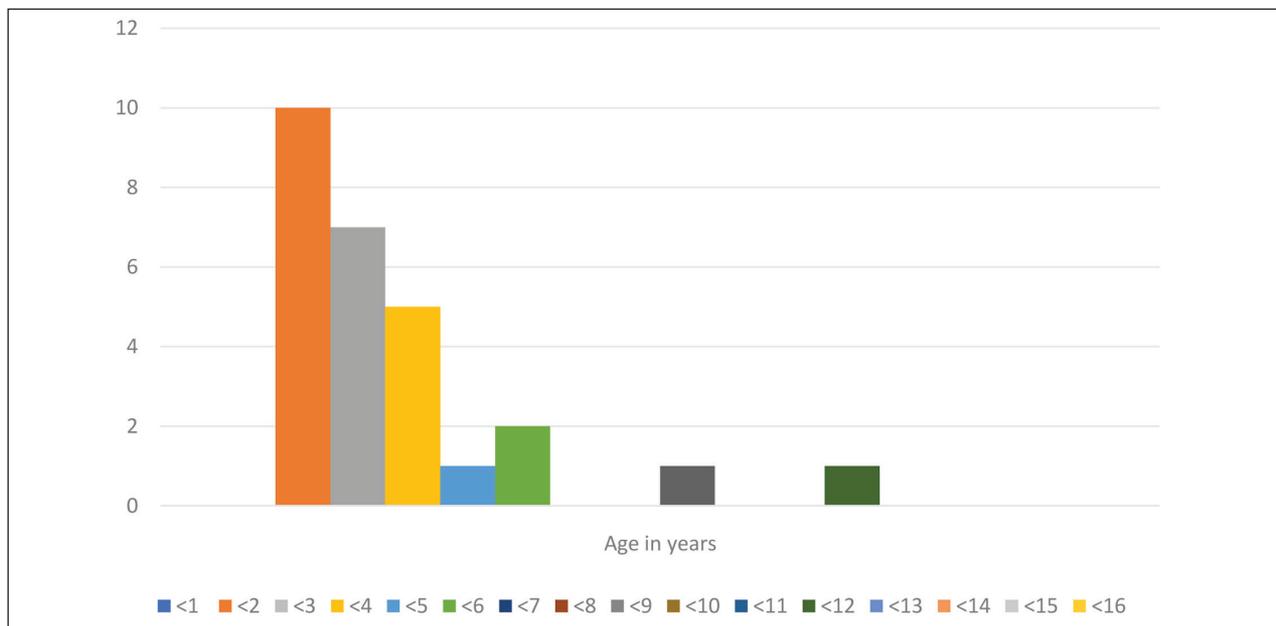


Figure 1. The distribution of ages of the 27 children with acute mastoiditis during the period 2003-2017

Complications

If not properly treated, AM can lead to extracranial and intracranial complications, which are sometimes very serious and even life-threatening. Complications are particularly frequent in children younger than 2 years, in which the disease progresses faster and more seriously (9,10). The incidence of complications in AM is variously estimated, depending on interpretation and classification of the complications; intracranial complications range from 4 to 16% (11,12).

The main pathogenetic factor of the AM, and in particular of the complications, is the obstruction of the aditus ad antrum, by edematous mucosa or granulation tissue with inhibition of purulence's drainage from the mastoid. High bacterial virulence and decreased immune defences are also important.

The most frequent complication is the subperiosteal abscess, following the progression of the inflammatory process; periostitis, the release of cytokine with osteoclasts activation and consequent decalcification and bone resorption (coalescent mastoiditis) (1). The clinical picture may include ear pain, persistent high fever, post-auricular tenderness or purulent collection with the displacement of the pinna. Other extracranial complications (facial nerve pulse, labyrinthitis, internal jugular vein thrombosis, periphlebitis of the sigmoid or lateral sinus) are consequent to the involvement of the neurological or vascular structures of the mastoid. Bezold's abscess originates from erosion of the mastoid bone cortex medially to the attachment of sternocleidomastoid muscle (13). The pus extends into the infratemporal fossa and then proceeds along the deep cervical fascia. The main symptoms are fever, severe pain in the perimastoid area, dysphagia, sore throat, and nuchal rigidity. Intracranial complications are not common, but undoubtedly represent very dangerous diseases that can sometimes have a lethal outcome. Symptomatology is mainly neurological and/or septic in case of meningitis, epidural abscesses, encephalitis or thrombosis of the sigmoid or cavernous sinus. The main pathogenetic factors in the complications are the same as those of AM, in particular, the obstruction of the aditus ad antrum, but often associated to high bacterial virulence and decreased immune-defences in very young children (14). In our case history, we had a

Complications	Number of cases
SUBPERIOSTEAL ABCESS	11
PERIPHEBITIS OF LATERAL SINUS	3
FACIAL NERVE PALSY	2
LABYRINTHITIS	1
BEZOLD'S ABCESS	1
SEPTIC THROMBOSIS OF THE LATERAL SINUS	1
EPIDURAL ABCESS	1
Total:	20

Figure 1. Complications of AM

high number of complications, probably due to a delayed diagnosis of AM (Figure 2).

Bacteriology

In the current opinion, *Streptococcus pneumoniae* is considered the predominant pathogen in children affected by AM. It is undoubtedly the most common and likely cause of the most acute forms of disease and most complications. It has been observed both in the middle ear effusion (spontaneous discharge) and in the purulent collections (15,16,17,18). In lower percentages, *Streptococcus pyogenes*, *Staphylococcus aureus* and *Hemophilus influenzae* were identified. The role of *Pseudomonas aeruginosa* is still controversial. Some authors consider it a predominant pathogen in AM (19,20). In particular, in the opinion of Butbul et al., it is a leading agent in children > 4 years old, while *S. pneumoniae* is prevalent in patients < 2 years old; moreover, this study evidenced that *P. aeruginosa* is present in mastoiditis resulting from recurrent or chronic otitis media, whereas *S. pneumoniae* is more easily found in isolated episodes of AM (19). Laulajainen et al. found a clear correlation between previous tympanostomy tubes and AM caused by *P. aeruginosa*. Moreover, the study underlined a different course of the disease due to this pathogen, compared to *S. pneumoniae*: the patients had mild signs and symptoms, but all with otorrhea (15). However, most Authors do not consider it a main causative agent of AM. *P. aeruginosa* (as well as *Staphylococcus aureus*, often associated), is present in the external ear canal as

a component of saprophytic flora; so, its presence in the culture obtained from ear canal swab is considered contamination or simultaneous infection (21). Actually, in the cultures coming from the middle ear (via tympanic paracentesis) or from abscesses collections the leading pathogen turns out to be *S. pneumoniae* (22).

Finally, some Authors evidenced no growth flora, probably due to previously administered antibiotic therapy; in these cases, a statistically significant higher complication rate was verified (18,23).

In our experience, *S. pneumoniae* was the predominant bacterium (21-77%), followed by *Streptococcus pyogenes* (9-33%), *Hemophilus influenzae* (6-22%) and *Pseudomonas aeruginosa* (2-7%). Association of two or more pathogens was found in 9 (40%) cases; no growth flora in 5 (18%) cases. In the study, the bacteriological examination was performed almost always on the purulent exudate taken from the middle ear, by aspiration or from the retro-auricular purulent collection, never from the external ear canal. The low presence of the *P. aeruginosa* confirms the hypothesis that this pathogen is often a contaminant element of the external ear canal, sometimes simultaneously infected.

Diagnosis

In non-complicated AM the diagnosis is mainly clinical, considering in particular two factors: clinical picture and risk factors for the involvement of the mastoid bone in an acute or chronic middle ear infection.

Signs and symptoms of a non-complicated AM generally do not differ from those of AOM (fever, ear-ache, otorrhea, etc.) but are often more serious, with spontaneous or pressure pain in the mastoid area, sometime with tense, red and swollen retro-auricular skin, even in the cases where there is still not complete erosion of the cortical bone or purulent collection.

Risk factors for AM are frequently highlighted in the literature. Particularly interesting is the analysis performed by Garcia et al (Figure 3) which evidenced that the main suspected factors for an acute mastoid involvement during AOM, are the age (< 24 months), high values of C-reactive protein and previous surgical treatment for otitis. High values of Leucocyte count are also important but less so. Furthermore, the same predisposing factors to AM seem also to be implicated in

its complications (16,22). Instead, significantly less important predisposing factors to AM and its complications are the previous otolaryngology diseases (in particular, chronic otitis media or recurrent AOM and adenoids) and previous antibiotic treatments (22). So, most authors agree that the uncomplicated forms of AM can be diagnosed only based on a clinical observation: when in very young children affected by AOM, high fever, compromised general condition and particularly altered laboratory findings are present. In these cases, more detailed and specific examinations (CT scan, MRI, angiography, angio-MR) can be avoided, while they are essential in the intratemporal, vascular and intracranial complications (23-26). However, different opinions have been expressed by some Authors who consider it essential to perform at least a CT SCAN in any case of suspected AM for early recognition of complications not yet clinically evident and for a treatment adequate to the severity of the illness (22, 27).

Treatment

In the uncomplicated forms of AM, antibiotic therapy is the main treatment. Most studies underline the necessity of carrying out in every case a middle ear culture for a more specific choice of antibiotic. Considering the high incidence of *S. pneumoniae* and its specific sensitivity to cephalosporins (less frequently to penicillins), this antibiotic, in particular, Ceftriaxone sodium, is widely used in the treatment of AM, always administered intravenously in hospitalized patients. The treatment with different antibiotics (amoxicillin, amoxicillin-clavulanate, erythromycin, etc), orally administrated, often proves to be ineffective and may even predispose to complications (4,18,28). The use of antibiotics other than cephalosporins can be justified only by a specific response of the bacteriological examination and antibiogram (i.e. antipseudomonal agent if *P. aeruginosa* infection is established). The association of 2 or 3 specific antibiotics is often opportune in polymicrobial infections (18,22). Also, antibiotic therapy with amoxicillin-clavulanate (less frequently other antibiotics) should continue for at least 10 days after recovery to avoid recurrences or long-term sequelae of AM, which are sometimes observed (recurrent otorrhea, recurrent AOM, persistent OM with effusion,

tympanic membrane perforation, etc) (18,28,29).

The introduction of the pneumococcal conjugate vaccine (PCV7) in 2000, subsequently replaced by a polyvalent version (PCV13), has certainly reduced the incidence of pneumococcal infections and consequently of AOM (15,23). Surprisingly, no decrease has been reported in the incidence of AM after vaccination, probably due to a possible pneumococcal serotype replacement. However, pneumococcal vaccination is always recommended in young children to avoid at least recurrent AOM, of which AM is the main consequence (30).

Many studies agree on the need for a myringotomy \pm tympanostomy tube placement, above all in the cases of AM without spontaneous TM perforation (most often verified in children < 24 months) or AM of children with recurrent AOM or EOM (6,10,28,29,31).

The importance of this simple surgical procedure is enhanced by two studies, which demonstrate its validity even in some complications of AM, i.e. subperiosteal abscess. The Authors evidenced that myringotomy \pm tympanostomy tube placement, combined with a simple retro-auricular puncture of the abscess and antibiotics (29) or retro-auricular incision and antibiotics (23) (conservative treatment), obtained the same results observed in patients treated with mastoidectomy and antibiotics (operative treatment). Conservative treatment was adopted even in some cases of more serious neurological or vascular complications (intracranial abscesses or lateral sinus thrombosis), in which the medical treatment with broad-spectrum intravenous antibiotic agents, anticoagulants and/or corticosteroids are often effective. However current opinion suggests that more aggressive surgical procedures, such as mastoidectomy, neurosurgical procedures, etc, are undoubtedly indicated in more important complications, in particular when intratemporal, endocranial or vascular structures are seriously involved (32, 33).

In our patients, antibiotic treatment was carried out in the cases of uncomplicated AM and in some cases of complications in which CT scan did not highlight serious mastoid osteomyelitis (2 cases of periphlebitis and 1 of thrombophlebitis of the lateral sinus); in these two cases antibiotics associated with anticoagulants and/or corticosteroids were effective. In all cases of the unperforated tympanic membrane (TM) was im-

mediately performed with the suction of the secretion to allow better drainage and a bacterial examination without contamination of the bacterial flora in the ear canal. For this reason, an accurate toilet of the middle ear by suction was performed also in spontaneous perforation of MT cases. More important surgical procedures ("operative treatment": mastoidectomy with toilet and/or an enlargement of *aditus ad antrum*, tympanoplasty, abscess incisions, etc) were adopted in most complications and in all cases in which CT scan showed a serious impairment of the mastoid bone. In just 2 cases of subperiosteal abscess, we performed a "conservative treatment" (tympanic paracentesis and abscess incision) associated with medical therapy.

Our therapeutic strategy allowed in all cases healing of the AM and its complications. No cases required further surgical treatment.

Conclusions

Despite the increasingly effective antibiotic and vaccine treatments, the AM is still a worrying disease that even seems to be growing in pediatric age due to ever-increasing antibiotic resistances. The severity of the complications of AM suggests careful clinical observation in all cases of OMA in which the symptoms are particularly severe, especially when they occur in very young children. In these cases, specific laboratory findings are certainly useful in diagnostic assessment. An early, specific and well-planned antibiotic therapy is fundamental for the resolution of the disease and the prevention of complications, that often require conservative or demolitive surgical treatments, sometimes dangerous in very young children.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

References

1. Harrison HW, Shargorodsky J, Gopen Q. Clinical strategies for the management of acute mastoiditis in the pediatric population. *Clin. Pediatr.* 2010; 49(2): 110-115
2. Rosenfeld RM, Kay D. Natural history of untraded otitis media. *Laryngoscope.* 2003; 113: 1645-1657
3. Quesnel M, Nguyen S, Contencin P, Manach V, Coloigner V

- Acute mastoiditis in children: a retrospective study of 188 patients. *Int. J. Pediatr. Otolaryngol.* 2010; 74: 1388-1392
4. Groth A, Enoksson F, Hultcrantz M, Stalfors J, Stenfeldt K, Hermansson A. Acute mastoiditis in children aged 0-16 years. A national study of 678 cases in Sweden comparing different age groups. *Int. J. Pediatr. Otolaryngol.* 2012; 76:1494-500
 5. Ruiz Diaz AI, Del Castillo Martin F, Bilbao Garitagoitia A, Diaz Roman MJ, Garcia Miguel C, Barque Andres C. Acute mastoiditis: an increasing entity. *An. Esp. Pediatric.* 2002; 57: 427-432
 6. Nussivotich M, Yoely R, Elishkevitz K, Varsano I. Acute mastoiditis in children: epidemiologic, clinical, microbiologic, and therapeutic aspects over past years. *Clin. Pediatr.* 2004; 43: 261-267
 7. Van Zuijlen DA, Schindler AG, Van Balen FA, Hoes AW. National differences in the incidence of acute mastoiditis: relationship to prescribing patterns of antibiotics for acute otitis. *Pediatr. Infect. Dis. J.* 2001; 20: 1012-1013
 8. Luntz M, Brodski A, Nussem S, Kronenberg J, Caren G, Migirovet al. Acute mastoiditis in the antibiotic era: a multicenter study. *Int. Pediatr. Otolaryngol.* 2001; 57: 1-9
 9. Dhooge JM, Albers FWJ, Van Cawenberg, PB. Intratemporal and intracranial complication of acute suppurative otitis media in children: renewed interests. *Int. J. Pediatr. Otorhinolaryngol.* 1999; 49(Suppl): 109-114
 10. Oestreicher- Kedem Y, Raveh E, Kornreich L et al. Complication of mastoiditis in children at the onset of new millennium. *Ann. Otol. Rhinol. Laryngol.* 2005; 114: 147-152
 11. Spiegel JH, Lusting LR, Lee KC, Murr AH, Schindler RA. Contemporary presentation and management of a spectrum of mastoid abscesses. *Laryngoscope.* 1998; 108: 822-8
 12. Go C, Bernstein JM, De Jong AL, Sulek m, Friedman EM. Intracranial complication of acute mastoiditis. *Int. J. Pediatric. Otorhinolaryngol.* 2000; 52: 143-148
 13. Marioni G, De Filippis C, Tregnaghi A, Marchese Ragona R, Staffieri A. Bezold abscesses in children: case report and review of the literature. *Int. J. Pediatric. Otorhinolaryngol.* 2001; 61: 173-177
 14. Lin HW, Shargorodsky J, Gopen Q. Clinical strategies for the management of acute mastoiditis in the pediatric population. *Clinical. Paediatrics.* 2010; 49(2): 110-115
 15. Laulajainen- Hongisto A, Saat R, Lempienen L, et al. Bacteriology in relation to clinical findings and treatment of acute mastoiditis in children. *Int. J. Pediatric. Otorhinolaryngol.* 2014; 72(12): 1-7
 16. Bilavsky E, Yarden- Bilavsky H, Samra Z et al. Clinical, laboratory, and clinical differences between children with simple or complicated mastoiditis. *Int. J. Pediatr. Otorhinolaryngol.* 2009; 73: 1270-1273
 17. Rodriguez RH, Schwartz RH. Streptococcus pneumoniae causes otitis media with higher fever and more redness of tympanic membranes than Haemophilus influenzae or Moraxella catarrhalis. *Pediatr. Infect. Dis.* 1999; 18(10): 942-944
 18. Carmel E, Curotta JH, Cheng AT. Prognostic effect of pre- and post-admission antibiotic treatment in pediatric acute mastoiditis. *The Journal of Laryngology & Otolaryngology.* 2016; 131: 1-6
 19. Batbul-Avief Y, Miron D, Halevy R, Koren A, Sakran W. Acute mastoiditis in children: Pseudomonas aeruginosa as leading pathogen. *Int. J. Pediatr. Otolaryngol.* 2003; 67: 277-281
 20. Cohen- Kerem N, Uri N, Rennert H, Efrat M. Acute mastoiditis in children: is surgical treatment necessary? *J. Laryngol. Otol.* 1999; 113: 1081-1085
 21. Anthsen K, Hostmark k, Hansen s. Acute mastoiditis in children: A 10 years retrospective and validated multicenter study. *Pediatr. Infect. Dis. J.* 2013; 32(5): 436-440
 22. Garcia C, Salgueiro AB, Luis C, Correia P, Brito M J. Acute mastoiditis in children: middle ear culture help in reducing the use of broad-spectrum antibiotics. *Int. J. Pediatric. Otolaryngol.* 2017; 92: 32-37
 23. Ghadersohi S, Young NM, Smith-Bronstein V, Hoff S, Billings KR. Management of acute complicated mastoiditis at an urban, tertiary care pediatric hospital. *The Laryngoscope.* 2017; 127: 2321-2327
 24. Bluestone CD, Klein JO. Intratemporal complications and sequelae of otitis media. In: Blueston CD, Casselbrant ML, Stool SE et al. *Pediatric. Otolaryngology.* forth Ed 2003: 687-764
 25. Luntz, Bartal K, Brodski A, Shihada R. Acute mastoiditis: the role of imaging for identifying intracranial complications. *Laryngoscope.* 2012; 122: 2813-7
 26. Chesney J, Black H, Choo D. What is the best practice for acute mastoiditis in children? *Laryngoscope.* 2014; 124: 1057-8
 27. Vassbotn FS, Klausen OG, Lind O, Moller P. Acute mastoiditis in a Norwegian population. *Int. J. Pediatr. Otolaryngol.* 2002; 62(3): 237-242
 28. Psarommatis IM, Voudouris C, Douros K, Giannakopoulos P, Bairamis T, Carabino C. Algorithmic management of pediatric acute mastoiditis. *Int. J. Pediatr. Otolaryngol.* 2012; 76: 791-6
 29. Bakhos D, Trijolet JP, Morinière S, Pondaven S, al Zahran M, Lescanne E. Conservative management of acute mastoiditis in children. *Arch. Otolaryngol. Head. Neck. Surg.* 2011; 37(4): 346-50
 30. Choi SS, Lander L. Pediatric acute mastoiditis in the post-pneumococcal conjugate vaccine era. *Laryngoscope.* 2011; 121(5): 1072-1080
 31. Geva A, Oestreicher- Kedem Y, Fishman G, Landsberg R, Derowe A et al. Conservative management of acute mastoiditis in children. *Int. J. Pediatr. Otolaryngol.* 2008-634
 32. Zanetti D, Nassif N. Indication for surgery in acute mastoiditis and their complication in children. *Int. J. Pediatr. Otolaryngol.* 2006; 70: 1175-1182
 33. Loh R, Phua M, Shaw CI. Management of paediatric mastoiditis: systematic review. *J. Laryngol. Otol.* 2018; 132(2): 96-10
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