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Review

Epidemiology, Diagnosis, and Treatment of Mastoiditis in Children: A Review of the Current State of Knowledge

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Mastoiditis is an infection of mastoid process, the portion of the temporal bone of the skull which is behind the ear and contains open air-containing spaces. With possible extra cranial and intracranial complications, acute mastoiditis is the leading complication of acute otitis media (AOM). The goal of this review was to assess the clinical features, pathogens, complications and management of acute and chronic mastoiditis. Retrospective systematic review of studies and articles on acute and chronic mastoiditis between 1983 and 2010 in pubmed, include clinical, epidemiological, microbiological, treatment and outcome data. In 10 studies, the average age was 16, ranging from 6 months to 70 years, with 55% from 0 to 5 years. Most common symptom was otalgia (84 %), 58% of patients had history of past AOM and 61% were under antibiotic therapy during admission. 74% presented with retroauricular swelling and erythema, 58% had a displaced pinna. In general, the prevalence of organisms causing mastoiditis varies greatly between studies, among countries and according to the age of the patient. Reported pathogens were as follows: *Streptococcus pneumoniae*, most frequently isolated pathogen in acute mastoiditis, prevalence of approximately 25% Group A beta-hemolytic streptococci, *Staphylococcus aureus*, *Moraxella catarrhalis*, *Haemophilus influenzae*, *Pseudomonas aeruginosa*, *Mycobacterium* species, *Aspergillus fumigatus* and other fungi, *Nocardia asteroides*. Extension of the infectious process beyond the mastoid system can lead to a variety of intracranial and extracranial complications, including meningitis, cerebral abscess, epidural, subdural and intraparenchymal abscesses, vascular thrombosis, osteomyelitis, and abscesses deep within the neck. Permanent damage of the ear leads to hearing loss, vertigo and sometimes facial weakness. The Cochrane review found that antibiotic treatment of otitis media may play an important role in reducing the risk of mastoiditis in populations where it is more common. Despite the use of antibiotics, acute mastoiditis still remains a threat to patients with AOM, especially children under 5 years of age. On the basis of the clinical features and imaging findings, the disease is managed conservatively with intravenously administered antibiotics or treated with mastoidectomy and drainage plus antibiotic therapy. Great care is required by clinicians to make an early diagnosis in order to promote adequate management and prevent complications.

Key words: Mastoiditis, otitis media, childhood.

INTRODUCTION

Acute mastoiditis is a rare and serious complication of acute otitis media (AOM) in children. Mastoiditis is an infection of mastoid process, the portion of the temporal bone of the skull that is behind the ear which contains open, air-containing spaces. The tympanic cavity of the middle ear is in communication with the mastoid antrum. Suppuration in the mastoid may, rarely, spread to cause meningitis or a cerebral abscess. Other surrounding structures include the facial nerve canal, the sigmoid sinus and the lateral sinus (Lin et al., 2010). Children with acute mastoiditis should be managed in centres where

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timely and complete medical and surgical treatment is available.

When the mastoid cells become infected or inflamed, often as a result of an unresolved middle ear infection, mastoiditis can develop. Acute mastoiditis affects mostly young children and peaks in those aged 6 to 13 months. Some people have chronic mastoiditis, an ongoing infection of the middle ear and mastoid, causing persistent drainage from the ear. In addition, a skin cyst (cholesteatoma) in the middle ear may block drainage of the ear, leading to mastoiditis (Rana and Moonis, 2011). Suppurative disease in the mastoid region occasionally spreads to the adjacent dura mater of the posterior and middle cranial fossae and the sigmoid sinus by means of thrombophlebitis, osseous erosion or anatomic pathways, producing intracranial complications (Nussinovitch et al., 2004).

The clinical picture of mastoiditis and its complications have changed during the past decades. With the development of antibiotics, mastoiditis has become quite rare in developed countries. Although intratemporal and intracranial complications of AOM are rare today, they still cause morbidity, and need prompt treatment (Leskinen, 2005). The microbiology of acute otitis media has changed in the heptavalent pneumococcal conjugate vaccine (PCV) era. Authors hypothesize similar changes with pediatric mastoiditis (Roddy et al., 2007).

Although it now occurs much less frequently than it did in the preantibiotic era, mastoiditis is still the most common complication of otitis media in the temporal bone (Kaplan et al., 2000; Fliss et al., 1997; Palva et al., 1985). Patients with immunocompromise may be more prone to mastoiditis (Lin et al., 2010).

Incidence

In the pre-antibiotic era, up to 20% of cases of acute otitis media (AOM) evolved into acute mastoiditis and were frequently associated with more severe intracranial complications (Spratley et al., 2000). The reported incidence decreased from 0.4% in 1959 (Palva and Pulkkinen, 1959) to 0.004% in the 1980s. Since 1989, however, several investigators have documented an increased frequency of acute mastoiditis in children (Spratley et al., 2000; Dhooge et al., 1999). Van Zuijlen et al. (2001) in a comparative study demonstrated that the incidence of acute mastoiditis in children in the Netherlands, Norway and Denmark, where antibiotics are restricted, was higher than that in the United Kingdom and United States where almost all children with AOM receive antibiotics (Nussinovitch et al., 2004).

Before the advent of antibiotics, mastoiditis was relatively common with a mortality rate of 2 per 100,000 children. The mortality rate is now less than 0.01 per 100,000 children (Rana and Moonis, 2011). Untreated otitis media increases the risk of acute mastoiditis and is the cause of higher incidences in developing countries. Rates of antibiotic treatment of otitis in the Netherlands, Norway and Denmark were 31, 67 and 76%, respectively and the incidence of mastoiditis was approximately 4.3 to 16.8 cases per 100,000 children per year. In the Western world including Canada and the United States, where prescription of antibiotics for otitis media is greater than 96%, the incidence was 1.2 to 2 of mastoiditis per 100,000 children per year (Nussinovitch et al., 2004; Rana and Moonis, 2011). Further work in Norway showed the incidence of acute mastoiditis in children below 2 years of age as 13.5 to 16.8 per 100,000 and for those aged 2 to 16 years as 4.3 to 7.1 per 100,000 (Kvaerner et al., 2007; Pang et al., 2009).

Etiologic agents

In a study where the result of culturing of the mastoid was reported, *Streptococcus pneumoniae* was the most frequently isolated bacterium. Streptococcus (particularly *S. pneumoniae* and group A hemolytic Streptococcus) and *Haemophilus influenzae* account for 65 to 80% of bacterial cases (Hawkins et al., 1983).

In another study (Mustafa et al., 2004), *S. pneumoniae* was cultured in 12 cases (38.7%), *Pseudomonas aeruginosa* in 2 cases (6.4%), Streptococcus beta-haemolyticuis in 1 case (3 %), Staphylococcus coagulase-positive in 1 case (3 %) and *Mycobacterium tuberculosis* hominis 1 in case (3%).

In 1980, Ostfeld and Rubinstein (1980) reported 33 patients with AOM and mastoiditis caused by gram-negative bacilli, mostly *P. aeruginosa*. Khafif et al. (1998) in 1998 and Luntz et al. (2001) found *P. aeruginosa* to be the most common pathogen in children with acute mastoiditis with isolation rates of 38 and 39.5%, respectively.

In another study (Migirov and Kronenberg, 2005) the most common pathogens isolated from subperiosteal abscesses, the mastoid cavity and intracranial collections were *Streptococcus* spp. and *Staphylococcus aureus*. Baljosevic et al. (2006) reported that the most frequently isolated causative microorganism was *S. pneumoniae* which was found in 32.5% patients, *S. aureus* in 21.5% patients and *Hemophilus influenzae* in 5.5% patients.

Roddy et al. (2007) reported that the most common bacterial isolates were *S. pneumoniae, P. aeruginosa, S. aureus, Streptococcus pyogenes*, and *H. influenzae*. *S. pneumoniae* was more likely to be implicated in acute versus chronic mastoiditis.

Streptococcus pneumoniae is the most common cause of acute mastoiditis in children in most of the studies (Hoppe et al., 1994; Gliklich et al., 1996; Kaplan et al., 2000; Bahadori et al., 2000; Katz et al., 2003; Jiang et al., 2000). *P. aeruginosa* was more frequently implicated in

chronic versus acute mastoiditis (Roddy et al., 2007). Despite the extensive use of PCV in recent years, there was no reduction in the proportion of mastoiditis cases caused by *S. pneumoniae* in the post-PCV era. *S. pyogenes* was inexplicably seen more often in post-PCV patients (Roddy et al., 2007). Zevallos et al. (2009) reported S*treptococcus pneumoniae* as the most commonly cultured organism in patients with and without intracranial complications. There was an increased incidence of anaerobic organisms in patients with intracranial complications as compared to those without it, indicating the importance of culture and antibiotic coverage which is appropriate for anaerobes. Previous studies have demonstrated *P. aeruginosa* as the significant mastoiditis pathogen in children with history of recurrent otitis media (Roddy et al., 2007; Butbul-Aviel et al., 2003).

In general, the prevalence of organisms causing mastoiditis varies greatly between studies, among countries and according to the age of the patient. Reported pathogens are as follows: *S. pneumoniae*: most frequently isolated pathogen in acute mastoiditis, with prevalence of approximately 25%, Group
A beta-hemolytic streptococci, *S. aureus*, *Moraxella catarrhalis*, *H. influenzae*, *P. aeruginosa, Mycobacterium* species, *Aspergillus fumigatus* and other fungi, *Nocardia asteroides*.

Pang et al. (2009) reported that the most common bacterial isolates are in order: *S. pneumoniae, P. aeruginosa, S. aureus, S. pyogenes* and *H. influenzae*. Spratley et al. (2000) reported that the most common organisms recovered from cultures were *S. pneumoniae* and *S. pyogenes*.

Clinical findings

Clinical findings of acute mastoiditis are: Recent or recurrent acute otitis media, otalgia, fever, post-auricular swelling, erythema, postauricular or supraauricular tenderness, and protrusion of the auricle, hearing loss, pain in the mastoid area, swelling, redness or a boggy, tender mass behind the ear, any nonspecific history consistent with infection such as poor feeding, loss of body weight, irritability, vomiting, diarrhea or severe anemia that requires red blood cell transfusion (Nussinovitch et al., 2004; Mustafa et al., 2004; Baljosevic et al., 2006). The external ear may protrude forwards; fluctuance can sometimes be demonstrated behind the ear, ear discharge may be present and the eardrum may be perforated, tympanic membrane might bulge and be erythematous, and patient will be sick (Rana and Moonis, 2011).

Clinical findings of chronic mastoiditis are: they are presents in a subtle or subclinical fashion after an episode of acute otitis media or with history of chronic suppurative otitis media, recurrent bouts of otalgia and retro-aural pain, recurrent headache, episodes of fever, infants may present with irritability, intractable crying and feeding problems (Palva et al., 1985).

Some common symptoms and signs of mastoiditis include pain, tenderness and swelling in the mastoid region. There may be ear pain, and the ear or mastoid region may be red. Drainage from the ear occurs in more serious cases. The diagnosis of mastoiditis is clinically based on the medical history and physical examination (Figure 1).

Differential diagnosis

Differential diagnosis includes basilar skull fracture, bell palsy, cellulitis, cysts, deep neck infections, lympadenopathy, parotitis, stroke, trauma, tumors.

Laboratory investigations

The investigations that should be done are: Full blood count which may show leucocytosis, ESR which may be elevated, blood cultures should be taken, fluid can be extracted from the middle ear through perforated drums or by intervention (tympanocentesis) and should be sent for gram staining, culture and acid-fast stain, skull X-ray of the mastoid area is not usually helpful. CT and/or MRI scanning can be used to aid diagnosis. CT had a sensitivity of 97% and a positive predictive value of 94% in the diagnosis of complicated acute mastoiditis (Migirov, 2003).

Treatment

Without timely and optimal management, mastoiditis may progress rapidly and have serious consequences. If untreated, the infection can spread to surrounding structures, including the brain, causing serious compli-cations. Surgical treatment is indicated by the failure of medical management or the presence of complications. On the basis of the clinical features and imaging findings, the disease is managed conservatively with intravenously administered antibiotics or treated with mastoidectomy and drainage plus antibiotic therapy (Mustafa et al., 2004).

Some conservative treatment failed to cure acute mastoiditis, such cases should raise a suspicion of a subperiosteal abscess, an underlying cholesteatoma, or an infection caused by gram-negative bacteria. Upon hospital admission, patients should receive antibiotics that are effective against both gram-positive and negative organisms. Patients with intracranial complications or facial nerve paralysis may require a combination of two or

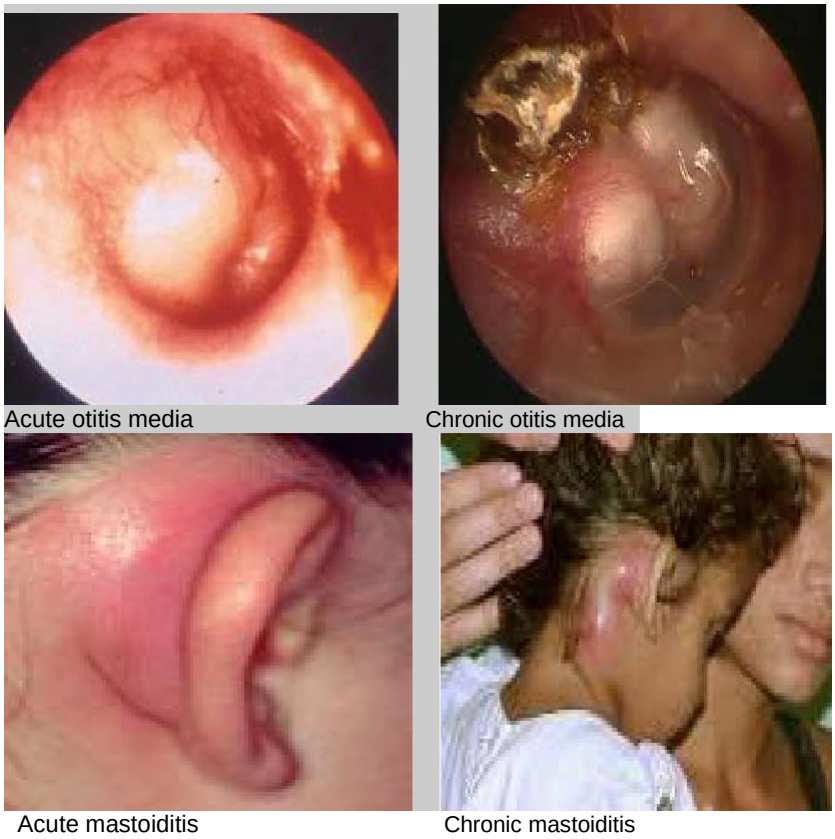

Figure 1. Some common symptoms and signs of mastoiditis and otitis media.

more antibiotics. Long-term follow-up is highly recommended (Migirov and Kronenberg, 2005). Mastoidectomy is needed when abscess-forming mastoiditis or intracranial complications develop (Leskinen, 2005).

According to the results of one study, the combination of antibiotic and surgical treatment is optimal in treating acute mastoiditis (Baljosevic et al., 2006).

Ceftriaxone is the most common antibiotic empirically chosen by emergency physicians. The observed rising resistance of tympanomastoid *S. pneumoniae* isolates to ceftriaxone should be considered by emergency physicians when deciding on empiric antimicrobial therapy for pediatric mastoiditis cases. Combination therapy with clindamycin is supported by some authors in acute mastoiditis. Acute mastoiditis and chronic mastoiditis are distinct entities. The microbiological results presented here can be used by physicians to guide empiric antimicrobial therapy when confronted with a child with mastoiditis in the emergency department. Empiric therapy for acute mastoiditis that covers ceftriaxone-resistant *S. pneumoniae* is recommended. In addition, emergency physicians should consider the possibility of *P. aeruginosa* as an etiological agent especially in chronic mastoiditis cases and, thus, empirically start broad-spectrum antimicrobial therapy with pseudomonal coverage (Roddy et al., 2007). Patients with suspected mastoiditis should be managed in a hospital setting. Usually, initial therapy is high-dose broad spectrum intravenous antibiotics, given for at least 1 to 2 days (e.g. with a third generation cephalosporin or the combination of a penicillinase-resistant penicillin and an aminoglycoside). If a patient is allergic to penicillin, clindamycin can be considered instead of penicillins. If *Pseudomonas* species is suspected, antipseudomonal penicillin should be used. After identification of the organism, antibiotic coverage can be narrowed. Oral antibiotics are usually used after this, starting after 48 h without fever on IV treatment, and continuing for at least 1 to 2 weeks. Paracetamol, ibuprofen and other agents may be given as antipyretics and/or painkillers. Myringotomy and/or tympanostomy tube insertion may be performed in some cases as a therapeutic procedure, or to collect middle ear fluid for culture. Surgical intervention, usually in the form of mastoidectomy and/or tympanoplasty is suggested if there is mastoid osteitis, intracranial extension, abscess formation, co-existing cholesteatoma and limited improvement after IV antibiotics(Rana and Moonis, 2011; Lin et al., 2010).

Table 1. Results of the 10 studies conducted.

Study	Patients	Patients managed surgically	Microorganisms recovered from cultures
Bahadori et al. (2000).	22	8	*Streptococcus pneumoniae, Streptococcus pyogenes*
Baljosevic et al. (2006)	37	37	*Streptococcus pneumoniae, Staphylococcus aureus, Hemophilus influenzae*
Butbul-Aviel et al. (2003)	57	5	*Pseudomonas aeruginosa*, *Streptococcus pneumoniae* , Group A Streptococcus
Gliklich et al. (1996).	124	76	*Streptococcus pneumoniae*
Hawkins et al. (1983)	54	23	*S. pyogenes, S. Pneumoniae, H. İnfluenzae, enterococci, anaerobes, M. tuberculosis.*
Hoppe et al. (1994).	58	-	*S. Pneumoniae*
Jiang et al. (2000).	19	6	*Pseudomonas aeruginosa, Streptococcus pneumoniae*
Katz et al. (2003)	101	32	*S. pneumoniae, Streptococcus pyogenes,* nontypable *Haemophilus influenzae, Pseudomonas aeruginosa* and *Escherichia coli.*
Khafif et al. (1998)	134	15	*S. pneumoniae*
Luntz et al. (2001)	223	16	*Streptococcus pneumoniae, S. pyogenes*, *Staphylococcus aureus, Pseudomonas aeruginosa, Haemophilus influenzae, Proteus mirabilis, Escherichia coli, Klebsiella pneumoniae, Enterobacter, Acinetobacter,* anaerobic gram-negative bacilli, fungi.

Gliklich et al. (1995) investigated the indications for surgical treatment and found an elevated white blood cell count, proptosis of the auricle, and fever on admission. In the preantibiotic era, the incidence of mastoiditis requiring surgical treatment was 25 to 50%. In the 1980s, the incidence decreased to approximately 0.02%.

Chronic mastoiditis is treated with oral antibiotics, eardrops and regular ear cleanings. If these treatments do not work, mastoid surgery may be necessary to prevent further complications. Antibiotics will be given through an IV route to treat the infection. Surgery (myringotomy) may also be needed to drain the fluid from the middle ear. A small tube may be inserted into the middle ear to ventilate and prevent fluid from getting into the middle ear. If the infection is severe, a mastoidectomy surgical procedure may be needed to remove the infected bone behind the ear. If left untreated, mastoiditis can cause serious, even life-threatening health complications, including hearing loss, blood clot, meningitis or brain abscess. But with early and appropriate antibiotic treatment, these complications can be avoided and the patient can recover completely. All bacterial ear infections should receive timely treatment with an appropriate antibiotic to prevent mastoiditis, and other serious health complications.

In the developed countries, the primary treatment for mastoiditis is administration of intravenous antibiotics. Initially, broad-spectrum antibiotics are given, such as ceftriaxone. As culture results become available, treatment can be switched to more specific antibiotics directed at the eradiaction of the recovered aerobic and anaerobic bacteria. Long-term antibiotics may be necessary to completely eradicate the infection. If the condition does not quickly improve with antibiotics, surgical procedures may be performed. Table 1 shows results of the 10 studies conducted.

Complications

A small proportion of untreated or inadequately treated patients may experience complications. Antibiotics have produced an overall decline in the frequency of complications of otitis media relativ e to the preantibiotic

era (Lin et al., 2010).

Common complications include hearing loss and extension of the infectious process beyond the mastoid system. If the spread of infection is to the intracranial region, deadly and devastating consequences develop. Intratemporal complications include tympanic membrane perforation, conductive hearing loss, ossicular lesions, facial palsy and petrositis (Pang et al., 2009). Extension of the infectious process beyond the mastoid system can lead to a variety of intracranial and extracranial complications, including meningitis, cerebral abscess, epidural, subdural and intraparenchymal abscesses, vascular thrombosis, osteomyelitis, and abscesses deep within the neck. Permanent damage of the ear leads to hearing loss, vertigo and sometimes facial weakness (Leskinen, 2005).

CONCLUSION

The Cochrane review found that antibiotic treatment of otitis media may play an important role in reducing the risk of mastoiditis in populations where it is more common (Pang et al., 2009; Glasziou et al., 2004).

Despite the use of antibiotics, acute mastoiditis still remains a threat to patients with AOM, especially children under 5 years of age. Great care is required by clinicians to make an early diagnosis in order to promote adequate management and prevent complications (Mustafa et al., 2004). Antibiotic treatment has decreased the mortality associated with the complications of AOM, but it is still high in countries with developing health care systems. Early diagnosis and effective treatment of the complications are the basis for a good prognosis.

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