

Complications of otitis media in Indigenous and non-Indigenous children

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Complications from otitis media may occur because of acute otitis media (AOM), otitis media with effusion, or chronic suppurative otitis media (CSOM) with or without cholesteatoma. Complications may be broadly classified into three groups:

- extracranial complications, such as mastoiditis, cholesteatoma and tympanic membrane perforation (Box 1);
- intracranial complications, such as meningitis, brain abscess and sigmoid sinus thrombosis (Box 1); and
- significant morbidity due to the impact of otitis media on childhood hearing, speech and language development, and education.

Before the antibiotic era, widespread morbidity and mortality from complications of paediatric otitis media were commonplace.² Today, with the wide availability of antibiotic therapy, complication rates from otitis media have reduced, but remain a significant problem in developing countries.³ Globally reported complication rates (intracranial and extracranial) from childhood otitis media in developed countries range from 0.04% to 0.69%, with developing countries reporting complication rates as high as 3.2%.^{1,4,5} Low socioeconomic status, increased bacterial virulence and genetic predisposition are important reasons for why such unacceptable levels persist in developing countries.

Globally, complications of otitis media are mainly experienced by children; overseas studies estimate that 80% of extracranial and 70% of intracranial complications occur among children.⁶ In Australia, three to five children die each year because of complications of otitis media, and 15 children suffer permanent hearing loss each year as a result of otitis media. Each year in Australia, 300 000 children experience mild-to-moderate temporary hearing impairment as a result of otitis media, 90 000 children develop a tympanic membrane perforation, and over 60 000 children suffer from CSOM.⁷

We aimed to broadly examine and review the complications of otitis media among children in Australia, both Indigenous and non-Indigenous. Here, we assess key areas, such as mastoiditis, cholesteatoma and tympanic membrane perforations, and discuss some less common, but potentially life-threatening, intracranial complications of otitis media. We also compare the impact of otitis-media-related hearing loss on speech and language development and education between both groups.

Pathophysiology and microbiology

Complications of otitis media occur because of the spread of infection from the middle ear and mastoid, by direct extension, haematogenous spread or thrombophlebitis. The direction and extent of the spread of infection dictates the type of complication that occurs and the method of presentation. When infection is confined within the temporal bone, complications are termed extracranial. Extracranial complications include injury to any of the structures within the temporal bone, and can manifest as acute mastoiditis, facial nerve paralysis, semicircular canal or cochlear fistula, or erosion of the middle ear ossicles. Intracranial complica-

ABSTRACT

- In Australia, three to five children die each year because of otitis media complications, and 15 children will suffer permanent hearing loss each year as a result of otitis media.
- Extracranial complications occur most commonly, and include mastoiditis, cholesteatoma and otitis media with perforation. Intracranial complications are less common, and include meningitis, brain abscess and lateral sinus thrombosis. In Australia, approximately 60% of extracranial and intracranial complications of otitis media occur in children.
- The contrasting rates of childhood otitis media among Indigenous and non-Indigenous children have implications for the frequency and types of complications occurring in both groups. Otitis media with effusion and acute otitis media predominate among non-Indigenous children, whereas chronic suppurative otitis media (CSOM) occurs most commonly among Indigenous children.
- The incidence of mastoiditis in Australia is low by international standards (2/100 000 children), but cholesteatoma rates among Indigenous children in Australia are higher than previously estimated (up to 10% in CSOM). A high rate of chronic tympanic membrane perforation occurs among Indigenous children, estimated to be as high as 80%.
- Intracranial complications of otitis media are uncommon, but are potentially life-threatening and are more likely to occur among Indigenous than non-Indigenous children.
- Reduced access to medical care, lower socioeconomic status and remote living conditions mean that levels of early childhood hearing loss among Indigenous children are likely to be underestimated. This has implications for early childhood speech and language development and education.

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tions occur because of progression beyond the temporal bone to the intracranial cavity, resulting in meningitis, cerebral abscess, sigmoid sinus thrombosis, or hydrocephalus.

Complications of acute otitis media are typically caused by *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Haemophilus influenzae* and *Moraxella catarrhalis*. Recently, there has been increasing evidence for the emergence of penicillin-resistant *S. pneumoniae* as an important pathogen in complications of otitis media. Complications from CSOM (with or without cholesteatoma) occur because of both aerobic and anaerobic bacteria; most commonly *Pseudomonas aeruginosa*, *Escherichia coli*, *S. aureus*, and *Proteus*, *Klebsiella* and *Bacteroides* species.^{8,9}

Clinical presentation

A high index of clinical suspicion may be required for diagnosing complications of otitis media. In many cases, the clinical signs are

1 Complications of otitis media¹

Extracranial complications

- Mastoiditis (70% of cases of extracranial complications)
- Bezold abscess* (10%)
- Facial nerve paralysis (12%)
- Labyrinthine fistula (1%–2%)
- Labyrinthitis (1%–2%)
- Sensorineural deafness (1%–2%)
- Petrous apicitis[†] (1%)
- Encephalocele and cerebrospinal fluid otorrhoea (1%)
- Cholesteatoma[‡]
- Tympanic membrane perforation[‡]

Intracranial complications

- Meningitis (71% of cases of intracranial complications)
- Cerebral abscess (17%)
- Epidural abscess (7%)
- Sigmoid (lateral) sinus thrombosis (1%–2%)
- Subdural abscess (1%–2%)
- Otitic hydrocephalus (1%)

*Suppuration from mastoiditis spreads to the deep muscle spaces of the neck adjacent to the mastoid tip, presenting as mastoiditis with an ipsilateral neck abscess. † Infection progresses to the petrous apex (medial aspect) of the temporal bone. Associated with a classic triad of retro-orbital pain, lateral rectus palsy (cranial nerve VI) and otorrhoea. ‡ The study from which the figures in this Box are obtained regard these as sequelae of otitis media rather than true complications, so their rates of occurrence are not included. ◆

2 Signs of extracranial and intracranial complications

Extracranial complications

- Fever
- Post-auricular swelling and erythema
- Sudden hearing loss
- Vertigo
- Facial nerve paralysis
- Severe otalgia

Intracranial complications

- Fever
- Headache
- Nausea and vomiting
- Lethargy
- Reduced level of consciousness
- Focal neurological signs
- Seizures
- Coma ◆

where associated raised intracranial pressure has been excluded by fundoscopy and/or radiological imaging.

Complications — general considerations

Prevalence rates of otitis media among Aboriginal children in Australia are well recognised as among the highest in the world.¹¹ Middle ear disease is reportedly present in as many as 91% of Indigenous children in rural communities; 50% have signs of CSOM and 25% have signs of a tympanic membrane perforation.¹² With such high rates of otitis media among Indigenous children in Australia, one would assume that these children also experience unacceptably high levels of complications. In contrast, otitis media rates among non-Indigenous children parallel those of other developed countries. Rates of otitis media among urban and rural Indigenous children also differ. A Perth-based study found that 0.7% of urban Indigenous children had a 30 dB hearing loss, compared with 20% of children in a Western Australian rural Indigenous community the same year.¹³

The underlying primary disease experienced by Indigenous and non-Indigenous children also differs, with most Indigenous children with otitis media suffering from CSOM, whereas non-Indigenous children tend to suffer from AOM and otitis media with effusion. The type of underlying primary disease present dictates the frequency and nature of complications that occur in each group.

Extracranial complications

Many complications occur because of the progression of otitis media within the temporal bone, with most complications being accounted for by mastoiditis, cholesteatoma and otitis media with perforation. We will therefore focus on these key areas.

Mastoiditis

Nearly 250 children in Australia develop mastoiditis each year, with the remaining minority of cases occurring in adults.⁷ Overseas, mastoiditis occurs most commonly in children, with a peak incidence occurring between 6 and 13 months of age, and almost 70% of cases occur as a complication of AOM.^{14,15} The overall

subtle because of the masking effects of prior antibiotic therapy.¹⁰ Often, significant disease progression has occurred before clinical signs of complications develop. Equally, a reduction in the frequency of complication rates, and resulting infrequent exposure of health care professionals to these complications, may lead to potential delays in diagnosis. In general terms, if further clinical signs develop in the setting of otitis media, urgent specialist consultation is advised (Box 2).

Investigations

Among patients with otitis media, baseline investigations are useful and include assessing blood profiles for leukocytosis and elevated C-reactive protein levels to ensure a normal immune response. Ear swabs sent for culture in the presence of otorrhoea allow directed therapy for topical and/or systemic antibiotic therapy. Audiometry allows distinction between conductive, sensorineural (cochlear), or mixed hearing loss, which may occur as a complication of otitis media.

Radiological imaging is indicated in the presence of suspected extracranial or intracranial complications. Contrast-enhanced computed tomography, the standard investigation, allows assessment of the bony architecture of the middle ear and mastoid, the status of the middle ear ossicles, and the integrity of the cochlea and semicircular canals. Computed tomography is also used to identify intracranial complications. Magnetic resonance imaging in otitis-media-related complications is used principally for the assessment of intracranial complications, such as a cerebral abscess or hydrocephalus.

Lumbar puncture is also clinically useful when meningitis secondary to otitis media is suspected, but should be performed

incidence of mastoiditis in Australia (adults and children) is low (2/100 000) when compared with other countries (the Netherlands, 3.5/100 000; Denmark, 4.2/100 000).¹⁶ Countries with low prescribing rates for AOM have higher incidences of mastoiditis.¹⁶

Mastoiditis remains the second most common complication of otitis media (after tympanic membrane perforation). Mastoiditis may be acute (typically from AOM), or subacute or chronic (from CSOM). Pathologically, any inflammatory process of the middle ear is rarely confined to the middle ear alone; in most cases, a degree of inflammation or infection occurs in the mastoid. In more severe cases, infection is aggressive and progresses throughout the cellular system of the mastoid, leading to erosion of the bony architecture of the mastoid and injury to structures within and adjacent to the mastoid bone.

Management involves medical and surgical techniques, with more cases now effectively managed with intravenous antibiotic therapy. Mastoidectomy rates worldwide have reduced substantially since the introduction of antibiotics; previously, mastoidectomy was performed for 20% of cases of mastoiditis.¹⁶ Surgery is indicated for subperiosteal abscess collection, coalescent mastoiditis, intracranial complications of mastoiditis, and mastoiditis that fails to respond to 48 hours of antibiotic therapy.¹⁶ Surgery aims to decompress the mastoid system by deroofting the mastoid cortex by cortical mastoidectomy. This provides ventilation between the middle ear and mastoid system and allows removal of granulation tissue and cholesteatoma, if present.

To our knowledge, no studies exist that compare the rates of mastoiditis among Indigenous and non-Indigenous children in Australia. Anecdotally, however, we have observed that Indigenous children are more likely to develop acute mastoiditis than non-Indigenous children, and that Indigenous children are likely to experience greater levels of morbidity and complications as a consequence of mastoiditis.

Cholesteatoma

Cholesteatoma can be congenital or acquired. Acquired cholesteatoma typically occurs because of medial retraction of the pars flaccida of the tympanic membrane, and gradual failure of the normal lateral migratory process of keratinising squamous epithelium of the tympanic membrane. This leads to accumulation of squamous epithelium in the middle ear, with progressive enlargement into the mastoid system over time. Chronic local infection results, manifested as foul-smelling otorrhoea and progressive destruction of middle ear and mastoid structures due to a combination of erosive effects of osteoclastic enzymes produced because of cholesteatoma and direct expansive pressure of the cholesteatoma sac.

Overseas studies estimate a prevalence of cholesteatoma (congenital and acquired) of 6/100 000, with a peak incidence occurring in the 10–19-years age group.¹⁷ Although otitis media and cholesteatoma development share a common aetiological factor in eustachian tube dysfunction, cases of childhood otitis media are not necessarily a predictor of future cholesteatoma development. With many cases of otitis media among Indigenous children being accounted for by CSOM, a long-held assumption has been that there is a low incidence of cholesteatoma in this group. However, recent studies have assessed the incidence of cholesteatoma in Indigenous patients with otitis media. In 2002, researchers at the Royal Darwin Hospital identified a cholesteatoma rate of

5/100 000 among Indigenous patients and 6/100 000 among non-Indigenous patients. They also observed that Indigenous patients were more likely to present with the complications of cholesteatoma.¹⁸ WA researchers identified an overall 10% rate of cholesteatoma in a series of 423 major ear surgeries over 10 years.¹⁹ The previously held view that cholesteatoma was rare among Indigenous children should certainly be reconsidered. Although most ear disease among Indigenous children is accounted for by CSOM, the possibility of an associated cholesteatoma should certainly be considered.

Tympanic membrane perforation

Perforation of the tympanic membrane is a common complication. In the presence of acute inflammation, middle ear pressure increases, and a rupture of the tympanic membrane occurs, with drainage of the middle ear fluid into the external auditory canal. The reported rate of rupture of the tympanic membrane in AOM is between 5% and 30%,²⁰ with over 90% of these perforations subsequently closing spontaneously within 1 month.²¹ Where the perforation persists for 3 or more months, it is termed chronic.²² This predisposes children to CSOM, manifested by recurrent episodes of middle ear infection and discharge, with recurrent middle ear and mastoid inflammation and granulation tissue formation.

High rates of tympanic membrane perforations among Indigenous Australians are well documented. Studies report that 40% of Indigenous children will have a perforated tympanic membrane by the age of 18 months, with tympanic membrane perforations being documented as early as in the first 6 weeks of life.^{12,23} Rates of perforation peak at 3 years of age and remain above 10% until over 16 years of age.²⁴ In contrast, the rate of perforation among non-Indigenous children is estimated to be under 2%.²⁵ Among Indigenous children, the positive benefits of the surgical repair of tympanic membrane perforations (myringoplasty) are well documented and include benefits for children's hearing, socialisation and education.²⁶

Intracranial complications

Intracranial complications may occur because of AOM or CSOM, with reports suggesting that intracranial complications of otitis media occur more commonly with AOM than CSOM.²⁷ Reported intracranial complication rates range from 0.3% to 2%.² Mortality related to intracranial complications remains a persistent problem in developing countries where mortality may be as high as 26%.¹ Among intracranial complications, meningitis occurs most commonly (51%), followed by brain abscess (42%) and sigmoid sinus thrombosis (19%). Studies from developing countries report that in 25% of cases, more than one intracranial complication may be present simultaneously.⁵ In Australia, intracranial complications of otitis media occur most commonly in children (56%), with an estimated 217 cases each year.⁷ To our knowledge, no Australian data exist that delineate whether Indigenous or non-Indigenous children are more likely to develop intracranial complications of otitis media; however, our experiences suggest that intracranial complications of otitis media are experienced more frequently by Indigenous children.

Complications of hearing loss — speech, language and education

Hearing loss

Hearing loss in otitis media may occur due to AOM, otitis media with effusion or CSOM. AOM typically results in transient hearing loss of 15–40 dB, and otitis media with effusion results in a mean hearing loss of 28 dB.^{22,28} CSOM, which predominates among Indigenous children, is typically associated with a 30 dB hearing loss.⁷ Several studies have compared hearing loss levels among Indigenous and non-Indigenous children in Australia. A 1982 study showed that 53% of Indigenous children in central Australia had a significant hearing loss compared with only 11% of non-Indigenous children.²⁹ In WA, 41% of Indigenous children had a hearing loss of 25 dB or greater in at least one ear, compared with 4%–5% of non-Indigenous children.³⁰ Furthermore, there is evidence to suggest that these studies may underestimate the degree of hearing loss among Indigenous children — 61% of Indigenous children have signs of otitis media,³¹ and up to 80% of Indigenous children suffer hearing loss as a consequence of otitis media.³²

Speech development

A crucial phase of language development occurs between birth and the age of 3 years, and any hearing loss during this phase potentially leads to delays in language development. Although a widely quoted study suggests no long-term effects of hearing loss on speech development in this age group, these findings are contrary to those of many other studies and fly in the face of the known impact on language development, when cochlear implantation is delayed, even by 1 year.^{33,34} For a detailed review of the management of childhood otitis media in primary care, see Gunasekera and colleagues (page S55) in this supplement.³⁵

Education

Several studies have identified a link between hearing impairment and poor progress in education. Hearing impairment has been implicated in poor literacy levels among Aboriginal children.³⁶ Some studies show that when hearing levels are restored to within normal limits, most children will return to normal levels of literacy, but others will continue to have long-term educational difficulties.^{36,37}

Conclusion

Although global complication rates from otitis media have reduced substantially since the advent of the antibiotic era, morbidity and mortality remains a problem, particularly in developing countries. With the wide availability of antibiotic therapy, the clinical presentation of complications of otitis media may require a high index of suspicion, with signs often masked by prior antibiotic therapy. In Australia, rates of mastoiditis are low compared with overseas figures, and the previously held view that the rate of cholesteatoma among Indigenous children is low should certainly be reconsidered. High rates of tympanic membrane perforation and CSOM are prevalent among Indigenous children. Intracranial complications of otitis media are uncommon but are more likely to occur in Indigenous than non-Indigenous children. Finally, Indigenous children are far more likely than non-Indigenous children to experience complications of otitis media, particularly in the areas

of hearing loss and its subsequent implications for early childhood speech and language development and education.

Competing interests

None identified.

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