Decisions regarding intracranial complications from acute mastoiditis in children

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Purpose of review

To review the clinical findings and treatment algorithms for intracranial complications of acute mastoiditis, such as sigmoid sinus thrombosis, otitic hydrocephalus, intracranial abscess, and otitic meningitis. We also briefly discuss the clinical sequelae of these complications.

Recent findings

Recent changes in the microbiology and treatment paradigms of otitis media have the potential to influence the rates of intracranial complications of mastoiditis; however, evidence supporting a resultant increase in the rates of these complications is lacking.

Summary

Antibiotic therapy and myringotomy with ventilation tube placement, with or without mastoidectomy, are the mainstays of treatment for intracranial complications of acute mastoiditis. Adjunct treatment, such as anticoagulation for sigmoid sinus thrombosis, is often used; however, the rarity of these complications makes establishing appropriate levels of evidence to support their use difficult.

Keywords

lateral sinus thrombosis, mastoidectomy, PCV7, *Streptococcus*

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Introduction

Acute otitis media is the most common bacterial infection of childhood. In the preantibiotic era, the incidence of resultant mastoiditis and subsequent intracranial complications was high. In addition to being common, intracranial complications of mastoiditis carried mortality rates ranging from 50 to 100% [1]. Subsequent introduction of antibacterial agents has greatly decreased the incidence of complicated mastoiditis and has improved the overall outcomes. In the setting of adequate access to healthcare, current estimates of the incidence of mastoiditis are 1.2–3.8 per 100 000 children and rates of intracranial complication are generally 5–15% of cases of acute mastoiditis [2–5]. Despite the low incidence of these complications, their attendant, potentially devastating outcomes necessitate our awareness of their presentation and management.

Presentation is often not classically 'otologic'

Intracranial complications of mastoiditis (ICoM) are sigmoid sinus thrombosis (SST), otitic hydrocephalus, intracranial abscess, and meningitis. Although these complications often present with fever, otalgia, and otorrhea (classic otologic signs and symptoms), antibiotic use can diminish or even eliminate these symptoms. As shown in Table 1, patients with ICoM therefore may present after a prolonged course (1–2 weeks) with slowly developing neurologic symptoms (nonclassic otologic signs and symptoms) such as headache, nausea, vomiting, obtunded consciousness, diplopia, photophobia, and nuchal rigidity [6]. A large number of patients with ICoM will present with a recent history of otitis media that resolved with an adequate course of antibiotics.

The utility of imaging in diagnosis

The diagnosis of ICoM is often made based on otologic or neurologic physical findings and radiographic imaging. Although the routine use of computed tomography (CT) imaging in mastoiditis has been questioned [7], the determination of coalescence by CT scan of the temporal bones is considered by many to be an important decision point in the treatment of mastoiditis [8] (Fig. 1). The addition of intravenous contrast material and the extension of the scanned fields to include the brain generally allows the detection of ICoM. Even in the case of SST, the sensitivity of contrast-enhanced CT is 84% [9]. Accordingly, we feel an appropriate protocol is initially

Table 1 Presentation of intracranial complications of mastoiditis in the presence and absence of prior antibiotic therapy

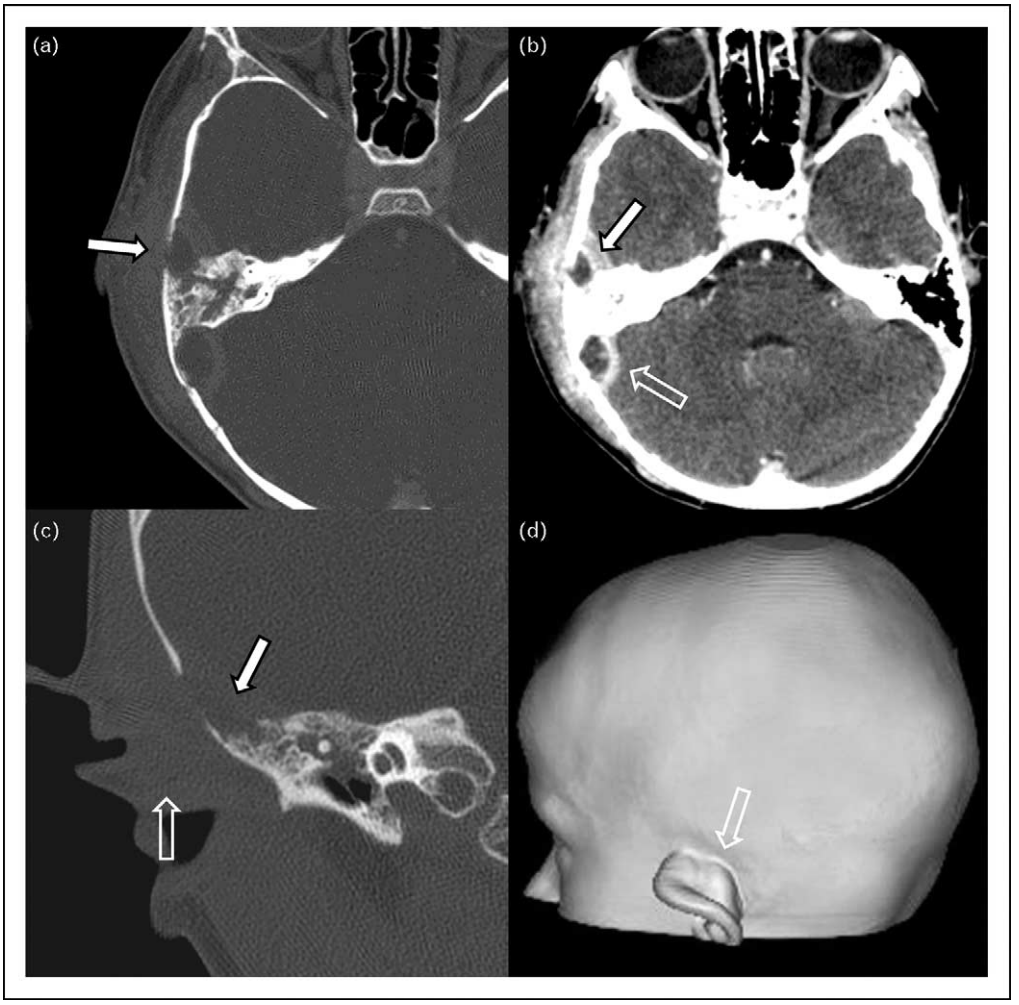
Without antibiotics	With antibiotics
Typical otologic signs and symptoms	Neurologic signs and symptoms
Otorrhea	Nausea and vomiting
Otalgia	Altered mental status
Fever	Photophobia
Headache	Nuchal rigidity
	Seizures
	Papilledema
	Diplopia
	Headache

to perform an enhanced CT scan and reserve magnetic resonance imaging or magnetic resonance venography for instances where either the CT scan is inconclusive or an ICoM is suspected in the setting of a negative CT scan.

Evolving microbiology of mastoiditis

It is worthwhile to briefly consider the microbiology of acute otitis media and mastoiditis. Three evolving issues potentially play a role in the development of mastoiditis as a complication of otitis media. The first is the development of antibiotic resistance among *Streptococcus pneumoniae* isolates. It is incumbent upon the attending pediatric otologist to be familiar with the rates of resistance in the area in which they practice because this varies considerably among geographic areas. Rates of antibiotic resistance tend to be as high as 50–60% in the setting of complicated acute otitis media [10,11] as well as in complicated and advanced mastoiditis [12•]. Furthermore, a correlation has been noted between the rise of antibiotic resistance and the increasing rate of complicated otitis media, leading some to conjecture that initial

Figure 1 Coalescent mastoiditis



Axial (a) and direct coronal (c) bone computed tomography (CT) reveal mastoid opacification with destruction of air cells and erosion of lateral tegmen tympani and the temporal squamosal bone (arrows). Contrast-enhanced axial (b) CT demonstrates epidural abscess (filled arrow) in middle cranial fossa. Filling defects within the sigmoid sinus (open arrow) are present because of thrombosis. Periauricular soft tissue swelling (open arrows) deforms the ear on coronal bone CT (c) and three-dimensional CT surface reconstruction (d).

treatment failures with routine first-line antibiotic therapy may play a role in the increasing development of mastoiditis from otitis media [11,13,14]. However, at least one large, population-based study has found that the incidence of mastoiditis is not increasing in the United States. Changing referral patterns as more patients with ICoM are referred to academic centers, which contribute more manuscripts to the literature, might explain the perceived increases in multiple single hospital studies (M. Thorne, personal communication).

The second recently introduced variable that has altered the landscape of acute otitis media and mastoiditis is the widespread adoption of the pneumococcal-7-valent conjugate vaccine (PCV7). Prior to the introduction of PCV7 in 2000, *S. pneumoniae* serotype 19F was among the most common strains to cause mastoiditis [15]. The widespread application of the PCV7 has largely eliminated this strain, along with serotypes 4, 6B, 9V, 14, 18C, and 23F. Furthermore, the rates of otitis media in both vaccinated and unvaccinated children decreased [16]. The infective niche left behind has been filled, however, by a previously minor *S. pneumoniae* serotype, 19A [17•]. Other studies have documented the prominence of this serotype since the introduction of the vaccine and found it to possess a high rate of multidrug resistance [18•]. This serotype shift has had noticeable effects on the development of mastoiditis. A recent study found that the 19A serotype has gradually grown from being causative in no cases of mastoiditis before the advent of PCV7 to accounting for 100% of the cases in the 2 years prior to publication of the study [19••]. This same study confirmed the increased rate of multidrug resistance in the 19A serotype, as well as an increased rate of coalescence requiring surgery. Although the contribution that this new strain might add to the rate of intracranial complications is unknown at present, an effect may be revealed through larger, multicenter, epidemiologic studies.

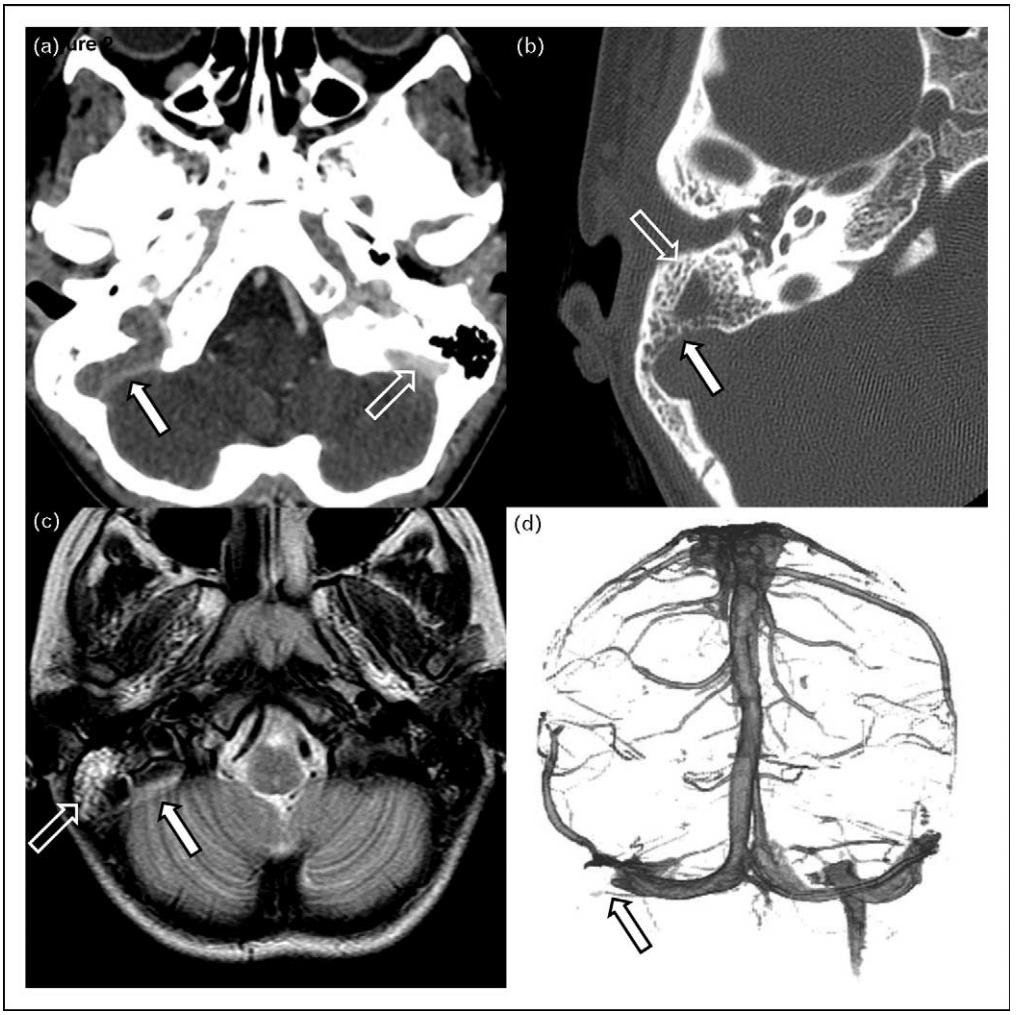
The third issue potentially playing a role in the changing incidence of ICoM is changing treatment algorithms in otitis media. In 2004, the American Academy of Pediatrics Subcommittee on Management of Acute Otitis Media published guidelines for the treatment of acute otitis media. Although antibiotic therapy was recommended for most children, the option of observation was endorsed in select cases where illness was mild, the child was older, and adequate monitoring was possible [20]. It is tempting to conjecture that reduced antibiotic use might lead to an increase in complication rates of otitis media, including mastoiditis; however, one might conversely argue that the resultant decrease in antibiotic resistance might ultimately lead to a lower rate of complications. North American studies have not been completed to determine how these guidelines might impact the rates of mastoiditis. Similar guidelines have been adopted in much of Europe, however, and Scandinavian studies have shown no difference in the rates of mastoiditis before and after the recommendation of observation as a treatment option for otitis media [21,22]. Part of the reason for this might be a lack of adherence to the guidelines, leading to little change in practice patterns [23]. Similarly, it appears that the rates of antibiotic use in the United States for otitis media have not decreased since the publication of the AAP guidelines [24,25]. Accordingly, current evidence does not suggest that these guidelines will influence the rates of mastoiditis in North America.

Sigmoid sinus thrombosis

SST is frequently cited as the most common ICoM and can be present in 5–15% of cases of advanced mastoiditis [10,12•] (Fig. 2). Despite this, cases of SST are rare in developed countries, and series from such areas are generally small [10,11,12•,26–29]. In contrast, series from countries where large portions of the population do not have ready access to the healthcare system have been larger, with higher rates of morbidity and mortality [30,31]. The distinction between SST in the two healthcare environments is not trivial, as the presentation of the disease in each can be different. In instances where thrombosis results from untreated otitis media, otorrhea, otalgia, fevers, and headache are the most common symptoms and signs [31]. With the exception of headache, antibiotic administration can mask or eliminate all of these presenting symptoms and signs. Therefore, although most patients report a history of otitis media in the 4 weeks prior to presentation, neurologic signs such as headache, nuchal rigidity, photophobia, papilledema, and VI (abducens) palsy predominate as the presenting symptoms of SST in areas where antibiotic therapy is widely available and readily administered [26,28].

Mastoidectomy, typically with the insertion of ventilation tubes, and 4–6 weeks of intravenous antibiotics are the mainstays of treatment for SST. The mastoidectomy can be somewhat limited and may simply involve open drainage of the mastoid, as the mastoidectomy is often effectively done by the disease process. Exenteration of every single air cell is not generally recommended in the acute phase, as landmarks are often very hard to identify and extensive surgery is not associated with any modicum of improved outcome. The use of a facial nerve monitor is strongly recommended in cases of mastoidectomy for acute mastoiditis. Incision of the sinus and evacuation of the thrombus is suggested inconsistently among published series and does not appear to be necessary for positive outcomes. Nonpneumococcal *Streptococcus*, anaerobic, and *Staphylococcus* species are commonly associated with cases of SST [10,12•,26,29], and thus

Figure 2 Sigmoid sinus thrombosis



Enhanced computed tomography (CT) (a) demonstrates a 'delta' sign (arrow) of the right sigmoid sinus due to unopacified clot surrounded by enhancing dural reflections. Contralateral sigmoid sinus (open arrow) is opacified by contrast material. Bone CT (b) reveals opacified middle-ear and mastoid air cells (open arrow) and dehiscent sigmoid plate (arrow). T2-weighted axial image (c) also demonstrates opacification of the mastoid air cells (open arrow), although magnetic resonance imaging lacks the resolution required to show the bony dehiscence. High signal (arrow) confirms clot in the sigmoid sinus. Magnetic resonance venography (d) demonstrates the occlusion of the right sigmoid sinus (arrow).

antibiotic choices should reflect this. Ceftriaxone and metronidazole or clindamycin are commonly used.

Anticoagulation with unfractionated heparin or subcutaneous low-molecular-weight heparin is also recommended inconsistently in the setting of otogenic SST. Adult and pediatric studies have demonstrated a benefit in using unfractionated heparin for sinovenous thrombosis outside the setting of an infectious cause, such as in posttraumatic or prothrombotic cases (i.e. protein S and C deficiencies, factor V Leiden deficiency, homocysteinemia, etc.) [32]. The frequency of otogenic SST is too low to make randomized trials feasible; however, a survey of the literature does not seem to favor one approach over the other. Overall patient outcomes tend to be good and rates of recanalization appear similar whether anticoagulants are used or not [26–28,33]. At least one series has found an unusually high rate of prothrombotic factors in children with otogenic SST [29]. Thus, a reasonable approach may be to test children with SST for prothrombotic factors and selectively use anticoagulants in situations where these tests are positive. Other indications for anticoagulation include aggressive extension of the thrombus (i.e. Lemierre's syndrome), hydrocephalus, or increased intracranial pressure. Avoiding anticoagulation mandates the use of follow-up imaging in order to monitor for thrombus propagation. Ligation of the internal jugular vein is rarely necessary in the setting of adequate antibiotic coverage and the decision of whether or not to do so does not seem to be influenced by the use of anticoagulation [26,28].

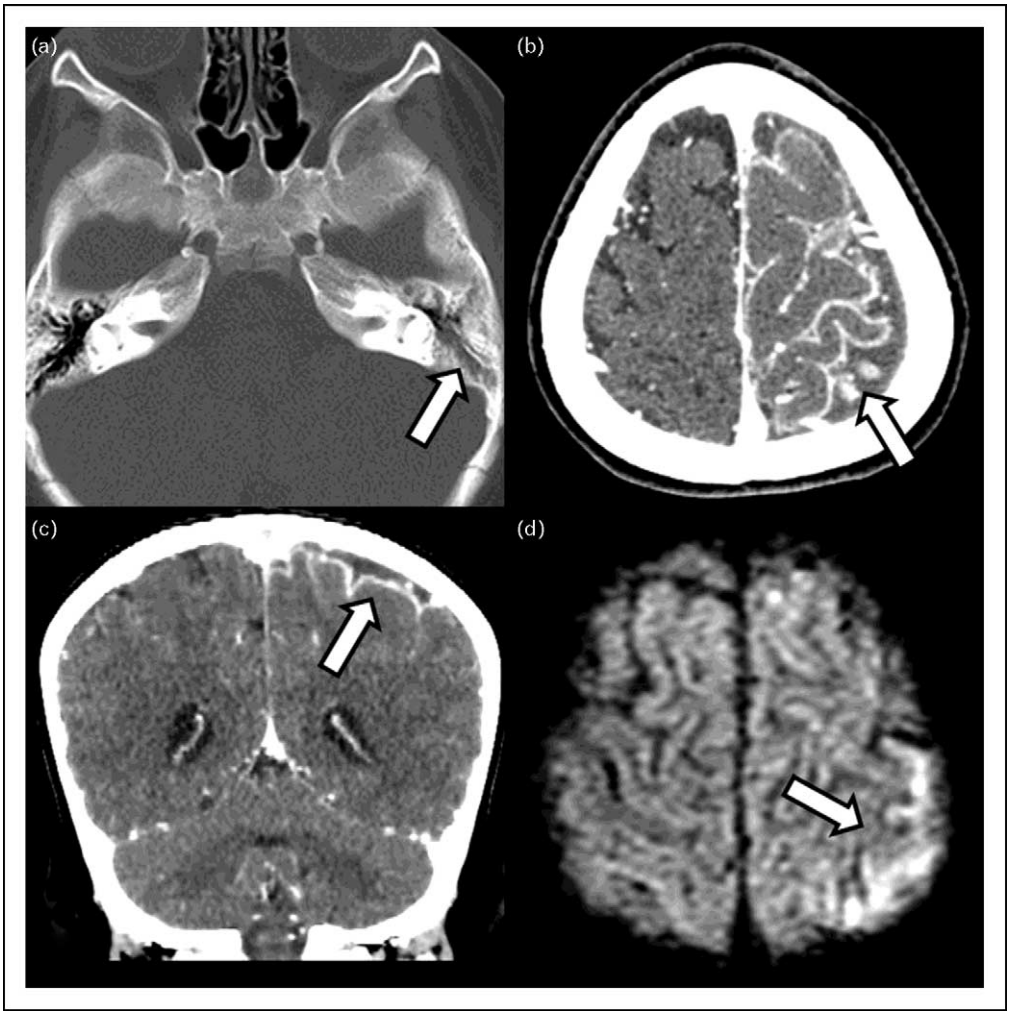
Otitic hydrocephalus

The presence of otitic hydrocephalus is heralded by typical symptoms of increased intracranial pressure such as headache, nausea and vomiting, papilledema, and possibly VI nerve palsy. Otitic hydrocephalus is uniformly seen in the presence of dural sinus thrombosis; however, the sagittal sinus need not be involved [34,35]. The presence of even a nonocclusive thrombus in the dominant transverse or sigmoid sinus is thought to result in sufficient venous congestion to raise intracranial pressure. This pathophysiologic theory of otitic hydrocephalus is supported by findings of occlusive or partially occlusive thrombus of the transverse sinus that does not extend to the sagittal sinus in some patients with otitic hydrocephalus [34,36]. The fact that otitic hydrocephalus may be caused by venous congestion also explains the imaging findings of an essentially normal brain without enlarged ventricles. This pathophysiologic process also accounts for the opening pressure of over 200 mmH_2O and normal cell count and biochemical parameters, which are required to distinguish otitic hydrocephalus from meningitis. In addition to intravenous antibiotics and mastoidectomy, treatment of otitic hydrocephalus consists of corticosteroids, acetazolimide, and anticoagulants.

Intracranial abscess

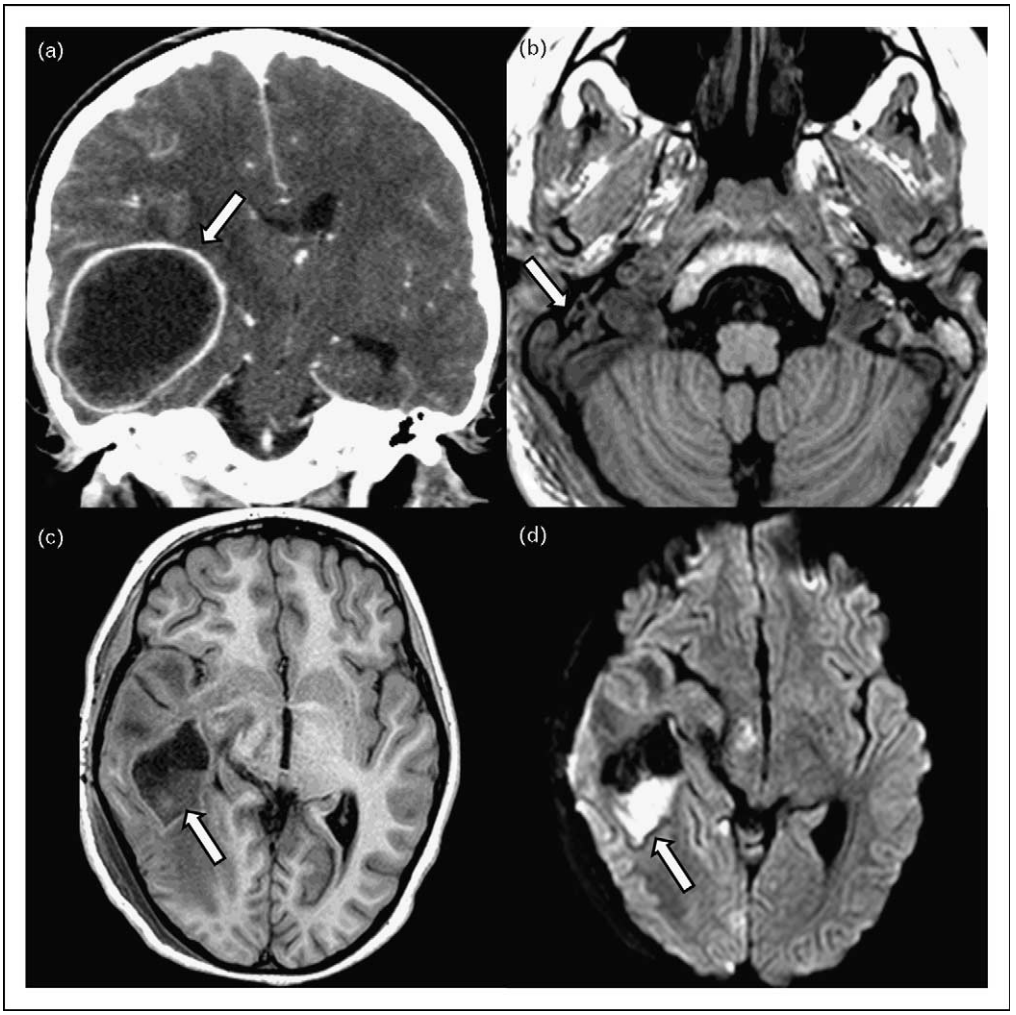
Intracranial abscess is common among complications of mastoiditis [3,12•,37] and can be seen in the epidural, subdural (Fig. 3), or intraparenchymal (Fig. 4) areas. Again headache, fever, otalgia, and otorrhea are prominent presenting signs and symptoms; however, subdural empyema and intraparenchymal abscess often lead to mental status changes, seizures, and nausea and vomiting. In contrast to intracranial abscesses in patients with

Figure 3 Subdural empyema



Bone computed tomography (CT) (a) confirms partial opacification of mastoid air cells and middle ear (arrow). Axial and coronal enhanced CT (b and c) reveal left subdural fluid collection with leptomeningeal enhancement of the brain surface. Diffusion-weighted imaging (d) demonstrates the diffusion restriction of the empyema.

Figure 4 Intraparenchymal brain abscess



Enhanced computed tomography (CT) (a) reveals a large rim enhancing abscess (arrow) with mass effect, perilesional brain edema, and shift of midline structures. T1-weighted axial image (b) reveals opacification (arrow) of the mastoid air cells. T1-weighted axial image (c) through the abscess demonstrates the layering of purulent debris (arrows) which restricts on diffusion-weighted imaging (d).

chronic suppurative otitis media or cholesteatoma, those in the setting of acute mastoiditis tend to be a result of *S. pneumoniae* or other nonpneumococcal *Streptococcus* species [37,38]. *Staphylococcus* and anaerobic species are less commonly seen; nonetheless, broad-spectrum antibiotics are warranted, given the serious nature of the infection.

In addition to antibiotics, surgical treatment should consist of mastoidectomy to remove the source of infection. In this setting, our experience differs from for SST in that the mastoidectomy is not as usually 'done' by the disease, because the confinement of the disease (lack of connection to the mastoid air cell system) is by definition what predisposes it to extend intracranially. The localized process in this case, either infection or cholesteatoma, complicates initially by extending beyond the bone of the mastoid instead of the preferential route through the aerated mastoid and through the less resistant tympanic membrane. Therefore, a more complete surgical mastoidectomy is often required in these patients, and intracranial drainage is often possible via exposure of the presigmoid or temporal lobe dura [12•,39]. Alternatively, a formal craniotomy can be performed if the purulent material cannot be drained through the mastoid route. Intraparenchymal abscesses are drained through either stereotactic aspiration, neuroendoscopy, or craniotomy [40]. Lesions that are small, multifocal, or inaccessible can be treated with antibiotics alone [37,40]. Intracranial abscess is the most dangerous sequela of acute mastoiditis and mortality can be as high as 10% [39,41], whereas rates of morbidity such as vestibular dysfunction, sensorineural hearing loss, cranial nerve dysfunction, encephalopathy, and paralysis can be much higher [6].

Otogenic meningitis

Otogenic meningitis is currently less common as an ICoM than intracranial abscess or SST. This stands in distinction to complications of chronic suppurative otitis media and older studies of complicated acute otitis media and mastoiditis [3,30,31,42]. Most cases of *Haemophilus influenza*-related otogenic meningitis in developed countries occur in individuals who have not been vaccinated [43]. Perhaps, then, the decreased incidence of meningitis as a complication of acute mastoiditis and otitis media is because of the implementation of the *Hib* and PVC7 vaccines.

The diagnosis of meningitis is made through a combination of a lumbar puncture and classic meningitic physical findings such as fever, altered mental status, photophobia, and nuchal rigidity. The presence of white blood cells and low glucose in the cerebrospinal fluid confirms the diagnosis of meningitis and helps to differentiate this entity from otitic hydrocephalus. *S. pneumoniae* remains the most common infectious cause of otitic meningitis [44,45], and early treatment with intravenous antibiotics, and possibly corticosteroids, is important for optimal outcomes. Though mastoidectomy is reported to be highly beneficial, the actual number of cases of otogenic meningitis where a mastoidectomy is performed is very small (except if you include those being performed during cochlear implantation). Even with adequate treatment, mortality in one large study of pneumococcal otogenic meningitis was 7% for children [44]. This same study documented a 17% rate of neurologic sequelae, largely consisting of sensorineural hearing loss, but also with a 5% rate of severe neurologic deficit consisting of aphasia, ataxia, or paresis.

Conclusion

Intracranial complications of mastoiditis are rare in the modern era; however, prompt recognition and treatment are paramount as the morbidity associated with such complications can be severe. Diagnosis is typically made based on history of otitis media, clinical presentation, and imaging, for which a CT scan is usually sufficient. It is important to remember that neurologic, rather than otologic, signs and symptoms are the typical heralds of ICoM in the setting of good access to healthcare. Treatment consists of antibiotics and surgically addressing the mastoiditis. The use of adjuvant treatments is debated, but the rarity of ICoM makes evidence-based evaluation of such treatments difficult.

(1) Though rare, ICoM occur and need rapid diagnosis and treatment to limit morbidity and mortality which are associated with these entities.
(2) Most children will have been treated with antibiotics for otitis media, masking the otologic signs of ICoM, and they will often present with neurologic signs and symptoms.
(3) Antibiotic treatment for ICoM should cover not only *S. pneumoniae*, but also nonpneumococcal strep, anaerobes, and *Staphylococcus* species.
(4) Surgical treatment, typically consisting of a simple mastoidectomy and ventilation tube placement, is generally recommended in the case of ICoM.

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Conflicts of interest

There are no conflicts of interest.

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Papers of particular interest, published within the annual period of review, have been highlighted as:
- • of special interest
- •• of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 488).

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