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REVIEW ARTICLE

Management of paediatric acute mastoiditis: systematic review

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Abstract

Background: Acute mastoiditis remains the commonest intratemporal complication of otitis media in the paediatric population. There has been a lack of consensus regarding the diagnosis and management of acute mastoiditis, resulting in considerable disparity in conservative and surgical management.

Objectives: To review the current literature, proposing recommendations for the management of paediatric acute mastoiditis and appraising the treatment outcomes.

Method: A systematic review was conducted using PubMed, Web of Science and Cochrane Library databases.

Results: Twenty-one studies were included, with a total of 564 patients. Cure rates of medical treatment, conservative surgery and mastoidectomy were 95.9 per cent, 96.3 per cent and 89.1 per cent, respectively.

Conclusion: Mastoidectomy may be the most definitive treatment available; however, reviewed data suggest that conservative treatment alone has high efficacy as first-line treatment in uncomplicated cases of acute mastoiditis, and conservative therapy may be an appropriate first-line management when treating acute mastoiditis.

Key words: Pediatrics; Otitis Media; Mastoiditis; Abscess; Otologic Surgical Procedures; Conservative Treatment

Introduction

Since the advent of antibiotic treatment, there has been a drastic decline in the incidence of acute otitis media episodes progressing to acute mastoiditis, decreasing from 0.4 per cent in 1954 to 0.004 per cent in the 1980s. Previously, the frequency was reported to be up to 20 per cent in acute otitis media cases.[1–3]

Acute mastoiditis remains the most common intratemporal complication of otitis media in the paediatric population.[4] Peak incidence occurs at age two to three years, with twice as many children below the age of two years developing acute mastoiditis.[5] Younger children are vulnerable to infections because of immature immunological defences, predisposing them to otitis media risk factors, with an increased risk of progression to acute mastoiditis.[5,6]

There have been recent reports of increasing susceptibility of younger children to acute mastoiditis and a rise in hospital admission for paediatric acute mastoiditis cases.[6,7] The emergence of antimicrobial resistance and the masking of clinical signs by prior antibiotic therapy are possible hypotheses raised by some authors on contributors to the rising incidence of acute mastoiditis.[2,6,8] A Dutch paper published in 2001 suggested an association between restricted antibiotic prescribing in paediatric acute otitis media cases and a higher incidence of paediatric acute mastoiditis.[9] A later study analysing the rates of antibiotic prescription in paediatric acute otitis media between 2002 and 2003 in the Netherlands reiterated similar concerns, noting that under-prescription of antibiotics occurred in up to 11 per cent of acute otitis media consultations.[10] However, there has been conflicting evidence on the incidence of acute mastoiditis in recent years, and a clear trend presented as population-based information has not been demonstrated.[8]

In a systematic review published by van den Aardweg *et al*., only 26 studies included the diagnostic criteria of acute mastoiditis, and the criteria were divergent.[2] The most frequently reported diagnostic criteria were post-auricular swelling, erythema, tenderness and auricle protrusion.[2]

There has been a lack of consensus regarding the diagnosis and management of acute mastoiditis. Treatment of paediatric acute mastoiditis differs between hospitals depending on presentation, severity, the presence of complications and surgeons' expertise.[2] There is considerable disparity in the rates of conservative and surgical management of acute mastoiditis between different reports.[3] Most notably, rates of mastoidectomy for the treatment of paediatric acute mastoiditis vary significantly, ranging from 9 to 88 per cent between different studies.[2] Historically, simple

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mastoidectomy was the mainstay of surgical treatment. However, there has been a recent shift towards a conservative approach for acute mastoiditis and its complications.[2,3,11] Conservative treatment consists of antibiotics alone, antibiotics plus myringotomy with a ventilation tube (grommet), or grommet insertion and abscess drainage.

It is imperative to treat acute mastoiditis promptly and effectively in order to prevent potentially fatal intracranial complications that can arise from progression of the condition.[11] Possible intracranial and extracranial complications include subperiosteal abscess, suppurative labyrinthitis, facial paralysis, lateral sinus thrombophlebitis, meningitis, epidural or subdural abscesses, brain abscess, Bezold's abscess, and Gradenigo's syndrome.[3,12] The incidence of acute mastoiditis related intracranial complications remains high, at between 5 and 29 per cent, as seen in different studies.[13] Ginsburg *et al.*[14] and Luntz *et al.*[7] concluded that despite the reduction in occurrence of acute mastoiditis, the rates of severe complications remain significant.

There is controversy regarding the best management of acute mastoiditis in children, and no study has reviewed the efficacy of individual treatment modalities. This systematic review aimed to investigate the most efficacious treatment modalities and their outcomes in paediatric acute mastoiditis by comparing and analysing current evidence in the literature.

Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses ('PRISMA') statement was followed in this review.

PubMed, Web of Science and Cochrane Library databases were searched from the date of each database inception to 14 December 2016. The search was performed using the following combinations of keywords: 'mastoiditis' and 'management'; 'mastoiditis' and 'surgery'; 'mastoiditis' and 'conservative'; 'mastoiditis' and 'medical'; 'mastoiditis' and 'antibiotic'; 'mastoiditis' and 'myringotomy'; 'mastoiditis' and 'tympanostomy'; 'mastoiditis' and 'grommet'; 'mastoiditis' and 'drainage'; and 'mastoiditis' and 'mastoidectomy'. These were used in conjunction with the Medical Subject Headings 'mastoiditis' and 'child'. No language restrictions were applied to the database searches. A search of references was performed to identify additional relevant articles.

The inclusion criteria were: abstracts, case reports, case series, literature reviews, retrospective analyses, clinical trials, randomised controlled trials, and systematic reviews that discussed treatment and the treatment outcomes of paediatric acute mastoiditis. Data were from children aged less than 18 years, obtained from articles available in full-text form.

We categorised treatment as: (1) medical therapy only (oral and parenteral antibiotic therapy); (2) medical therapy and myringotomy, with or without grommet insertion; (3) medical therapy and myringotomy plus subperiosteal abscess drainage; and (4) medical therapy and formal mastoidectomy, with or without myringotomy. Studies that did not report the outcomes based on the categories mentioned, those that failed to specify what 'conservative' or 'surgical' management encompassed, and studies involving patients with co-existing cholesteatoma, intracranial complications, immunological deficiency, chronic mastoiditis or cochlear implants, were excluded from the review.

Two reviewers screened titles and abstracts independently according to the predefined inclusion and exclusion criteria. The full texts of potentially relevant studies were subsequently examined. Disagreements between reviewers were resolved by discussion and examination of the full text. The following information was independently extracted by the reviewers: number of patients, study design, patient age, use of antibiotic therapy prior to hospital admission, treatment modality, complications and sequelae.

Results

A total of 520 studies were identified following a combined search of electronic databases, with an additional 2 studies identified from the retrieved articles. After removal of duplicates, 443 studies remained. Sixty-eight articles were selected for full-text assessment after abstract screening. Twenty-one articles were eventually selected for final inclusion and data extraction.[15–35] The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for article inclusion is shown in Figure 1.

Table I summarises the characteristics of the included studies.[15–35] Of the 21 studies included, 12 were cohort (retrospective) studies, 5 were case series and 4 were case reports. The studies comprised a total of 564 patients, whose ages ranged from 1 month to 16 years. Of this group, 253 cases were complicated with subperiosteal abscesses. (An indeterminate number of complicated acute mastoiditis cases reported in the study by Harley *et al.*[27] (1997) were not included in this figure.)

Medical management

All patients were started on parenteral antibiotics upon admission. The initial antibiotics prescribed in the reviewed studies were based on epidemiological knowledge along with treatment site guidelines (if any). Subsequent changes were made to the antibiotics prescribed based on culture and sensitivity results obtained.

A total of 122 patients (21.6 per cent) were managed medically with antibiotics alone (Table II). Of these, 117 (95.9 per cent) were treated successfully; no further otological problems were noted during follow up. Two patients required further treatment with myringotomy because of persistent middle-ear effusion, and another three patients required subsequent mastoidectomy because of insufficient improvement following

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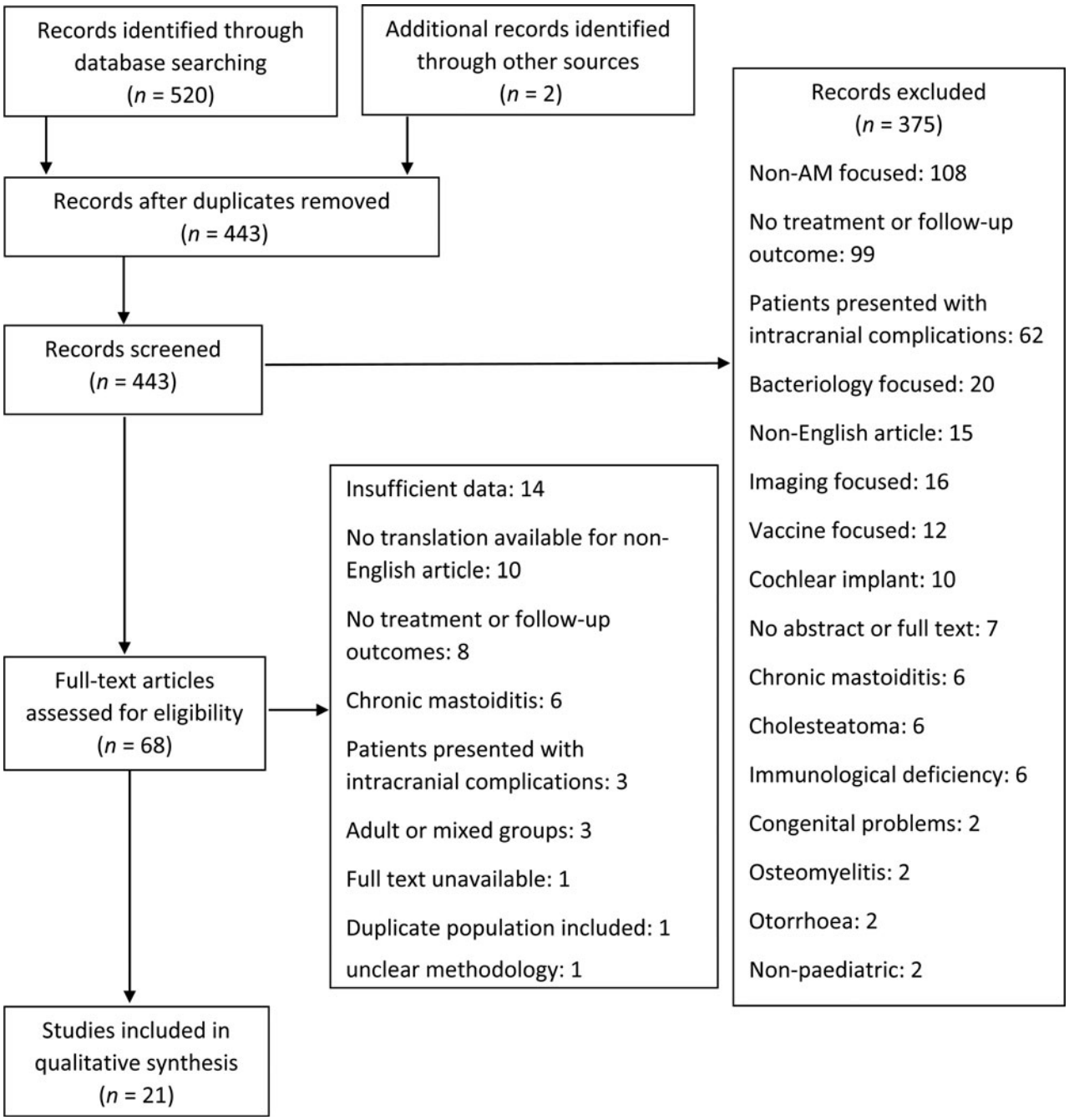

FIG. 1
Flow diagram for article inclusion. AM = acute mastoiditis

medical management or the development of subperiosteal abscess during hospitalisation.

Surgical management

Surgical procedures were performed in 442 patients. Surgical procedures were categorised as either 'conservative' or 'extensive'. 'Conservative' surgery refers to myringotomy, with or without grommet insertion, and/or subperiosteal abscess drainage (either via needle aspiration, or incision and drainage), while 'extensive' refers to mastoidectomy (simple/cortical or radical).

Conservative surgery was carried out in 268 patients (Table II). Of these, 160 underwent myringotomy, with or without grommet incision, and 108 underwent subperiosteal abscess drainage. Of the 160 patients who underwent myringotomy, 3 were complicated cases with a co-existing subperiosteal abscess, 1 was complicated with hearing impairment, 1 with mastoid abscess and 155 were uncomplicated cases. Of the patients who underwent conservative surgery, 258 were reported to be cured on follow up (96.3 per cent).

Of 174 patients who underwent extensive surgery (mastoidectomy), 155 were noted to have successful treatment (89.1 per cent cure rate).

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TABLE I
SUMMARY OF INCLUDED STUDIES

Study (year; country)	Cases (*n*)	Age range	Presenting condition (*n*)	Treatment modality (*n*)	Treatment complication (*n*)	Follow-up duration	Follow-up outcomes (*n*)
Enoksson *et al.*[15] (2015; Sweden)	100	2mo–16y	SPA (100)	Abscess drainage (33)	None reported	Unknown	AM recurrence (1)
				Mastoidectomy (67)			AM recurrence (9), persistent TM perforation (2)
Kim *et al.*[16] (2013; Korea)	1	2y	SPA (1)	Abscess drainage (1)	No clinical improvement, requiring mastoidectomy (1)	5mo	No recurrence
Psarommatis *et al.*[17] (2012; Greece)	33	2mo–8y	SPA (33)	Abscess drainage (21)	Lack of improvement, requiring mastoidectomy (9)	>6mo	No long-term sequelae
				Mastoidectomy (12)	None		
Bakhos *et al.*[18] (2011; France)	27	5mo–13.5y	SPA (26); SPA + facial palsy (1)	Abscess drainage (14)	None reported	Unknown	Facial palsy improved (1), all cured
				Mastoidectomy (13)			Cured
Abdel-Aziz & El-Hoshy[19] (2010; Cairo)	18	9mo–11y	AM (12); SPA (6)	Med only (5)	All improved	>1y	No recurrence
				Myringotomy (7)	No improvement, requiring mastoidectomy (2)		AM + SPA recurrence (1)
				Mastoidectomy (6)	All improved		No recurrence
Molloy *et al.*[20] (2008; Ireland)	1	9y	AM (1)	Myringotomy (1)	None reported	Unknown	Complete resolution on CT scan (1)
Glynn *et al.*[21] (2008; Ireland)	28	4mo–11y	AM (18); SPA (10)	Med only (11) Myringotomy (2) Abscess drainage (10) Mastoidectomy (5)	None reported	1–14y	AM recurrence (2), recurrent AOM (1) Well & asymptomatic Recurrent AOM (1) Cholesteatoma 14y later (1), recurrent AOM (1)
Zanetti & Nassif[22] (2006; Italy)	32	2mo–15y	AM (32)	Med only (20)	None reported	1–3.1y	Fully recovered
				Myringotomy (8) Mastoidectomy (4)			
Lahav *et al.*[23] (2005; Israel)	77	4mo–10y	AM (55); SPA (22)	Myringotomy (55)	None	1–7y	No recurrences
				Abscess drainage (16)	4 persistent disease (1 underwent mastoidectomy & 3 repeated abscess drainage)		AM recurrence (4)
				Mastoidectomy (6)	None		AM recurrence (3)
Taylor & Berkowitz[24] (2004; Australia)	36	2mo–12.8y	AM (25); SPA (11)	Med only (14)	None	11.8mo (mean)	No recurrences of AM
				Myringotomy (11)	Persistent fever & SPA development, requiring abscess drainage		
				Abscess drainage (10)	None		
				Mastoidectomy (1)	None		
Bauer *et al.*[25] (2002; USA)	3	1–3y	SPA (3)	Abscess drainage (3)	None	2.5–3.5y	No further otological problems

Continued

Table I *Continued*

Study (year; country)	Cases (*n*)	Age range	Presenting condition (*n*)	Treatment modality (*n*)	Treatment complication (*n*)	Follow-up duration	Follow-up outcomes (*n*)
Niv *et al.*[26] (1998; Israel)	32	1mo–12y	AM (32)	Myringotomy (32)	Progression of infection & development of SPA, requiring mastoidectomy	≥3mo	No recurrences
Harley *et al.*[27] (1997; Australia)	56	3mo–15y	AM ± SPA (56)	Med only (17)	None	3–12mo	Cure rate 100%
				Myringotomy (27)	Treatment failure, requiring mastoidectomy (3)		AM recurrence (1), cure rate 85%
				Mastoidectomy (12)	None		AM recurrence (1), cure rate 92%
Kaplan *et al.*[28] (1995; Ireland)	1	18mo	AM (1)	Med only (1)	SPA development, requiring mastoidectomy (1)	Unknown	Well
Nadal *et al.*[29] (1990; Switzerland)	68	4mo–14y	AM (35); SPA (33)	Med only (25)	Persistent MEE, requiring myringotomy (2); insufficient improvement, requiring mastoidectomy (2)	Unknown	All healed without sequelae
				Myringotomy (8)	Insufficient improvement, requiring mastoidectomy (2)		
				Mastoidectomy (35)	None		
Scott & Jackler[30] (1989; USA)	3	3–11mo	AM (1); SPA (2)	Myringotomy (3)	No clinical improvement, requiring mastoidectomy (2 SPA)	Unknown	Recurrent AOM (1)
Leiberman & Fliss[31] (1987; Israel)	3	7mo–2y	AM (3)	Mastoidectomy (3)	None	1–3y	AM recurrence (2), well (1)
Ogle & Lauer[32] (1986; USA)	25	3mo–14y	AM (19); AM + facial palsy (1); SPA (5)	Med only (16)	Relapse due to oral antibiotics non-compliance (1)	Unknown	No sequelae reported
				Myringotomy (2)	None		No sequelae reported
				Mastoidectomy (7)	None		Resolved facial palsy (1)
Harlowe[33] (1972; USA)	1	5y	AM (1)	Mastoidectomy (1)	None	Unknown	No sequelae reported
Zoller[34] (1965; USA)	2	2–3y	AM + facial palsy (1); AM + zygomatic abscess (1)	Mastoidectomy (2)	None	6–12mo	Complete resolution of facial palsy (1), no recurrence (1)
Moffett & Dalton[35] (1949; UK)	17	2mo–12y	AM (15); AM + partial hearing loss (2)	Med only (13)	None	1–11mo	Recurrent AOM (1), persistent hearing impairment (1), no further ear trouble (11)
				Myringotomy (4)	Development of zygoma swelling, requiring mastoidectomy (1)		Development of mastoid abscess & recurrent OM (1), recovery of hearing impairment (1), no further ear trouble (2)

Mo = months; y = years; SPA = subperiosteal abscess; AM = acute mastoiditis; TM = tympanic membrane; med = medical treatment; CT = computed tomography; AOM = acute otitis media; MEE = middle-ear effusion; OM = otitis media

Clinical outcome on follow up

In the studies reviewed, follow-up periods ranged from 1 month to 14 years (follow-up duration was not specified in 9 studies). All of the studies had a follow-up period of at least three months, except the study by Moffett and Dalton[35] (1949) with no reason specified.

Of the patients, 530 (94.0 per cent) were considered to have been successfully treated, with no long-term sequelae noted. They were reported to have 'no treatment failures', to have 'recovered', to have been 'cured', to have 'no recurrences', to have 'no further hearing trouble' or to be 'well and asymptomatic'.

The most frequently observed adverse outcome was recurrent acute mastoiditis (23 cases). Other adverse outcomes included: recurrent acute mastoiditis, recurrent acute otitis media, recurrent subperiosteal abscess, persistent hearing impairment, cholesteatoma, persistent tympanic membrane perforation and mastoid abscess development.

In summary, the cure rates of those who received medical therapy only, abscess drainage, myringotomy and mastoidectomy were 95.9 per cent, 94.4 per cent, 97.5 per cent and 89.1 per cent, respectively. This includes both uncomplicated and complicated acute mastoiditis cases. Twenty-four cases required mastoidectomy after the failure of improvement following initial therapy with either medical or conservative surgical treatment.

Secondary management

In the studies reviewed, 31 cases in total required subsequent management (Table II). The indications for additional management were: treatment failure within a threshold period of 48–72 hours, or the development of a new complication (i.e. subperiosteal abscess). Amongst these 31 cases, 25 required mastoidectomy as the definite treatment; in 15 cases this was because of initial treatment failure within 48–72 hours, and in 2 cases it was because of subperiosteal abscess development. Of the remaining cases that required subsequent mastoidectomy, one patient had a zygomatic abscess and seven had unspecified reasons for the progression to mastoidectomy.

Uncomplicated acute mastoiditis treatment

A total of 250 acute mastoiditis cases were uncomplicated (excluding cases from Harley *et al.*[27]); that is, they were simple acute mastoiditis cases, without associated complications (Table III). Medical therapy only was received by 104 patients; conservative therapy with myringotomy, with or without grommet insertion, was undertaken in 129 patients; and mastoidectomy was performed as the primary treatment in only 17 patients. Of the 104 patients in the medical therapy only group, 5 required subsequent therapy with either conservative surgery (myringotomy) or extensive surgery (mastoidectomy) because of persistent middle-ear effusion, subperiosteal abscess development or lack of clinical improvement within 48–72 hours.

Six patients who received myringotomy, with or without grommet insertion, required further treatment with mastoidectomy. The reasons were: subperiosteal abscess development, zygoma swelling and poor clinical improvement.

No sequelae were reported during follow up in: 96.2 per cent of those who received medical therapy only (100 of 104 cases), 97.7 per cent of those who received conservative surgery (myringotomy) (126 of 129 cases) and 76.5 per cent of patients who received extensive surgery (mastoidectomy) (13 of 17 cases). The adverse follow-up outcomes experienced by patients

TABLE II
SUMMARY OF TREATMENT AND FOLLOW-UP OUTCOMES

Intervention	Cases (*n*)	Treatment outcomes (*n*)	Follow-up outcomes (*n*)
Medical – antibiotics	122	Persistent middle-ear effusion, requiring myringotomy (2); insufficient improvement, requiring mastoidectomy (2); SPA development, requiring mastoidectomy (1)	Recurrent AM (2), recurrent AOM (2), persistent hearing impairment (1), no sequelae reported (117)
Conservative surgery			
– Myringotomy ± VT insertion	160	No clinical improvement, requiring mastoidectomy (9); SPA development, requiring abscess drainage (1); SPA development, requiring mastoidectomy (1); zygoma swelling development, requiring mastoidectomy (1)	Recurrent AM (1), recurrent AOM (1), AM + SPA recurrence (1), mastoid abscess & recurrent OM (1 – same patient who had zygoma swelling), no sequelae reported (156)
– Drainage of SPA (needle aspiration/ I&D)	108	No clinical improvement, requiring mastoidectomy (11); persistent disease, requiring repeated abscess drainage (3)	Recurrent AM (5), recurrent AOM (1), no sequelae reported (102)
Extensive surgery – mastoidectomy	174	–	Recurrent AM (15), recurrent AOM (1), persistent tympanic membrane perforation (2), cholesteatoma (1), no sequelae reported (155)

SPA = subperiosteal abscess; AM = acute mastoiditis; AOM = acute otitis media; VT = ventilation tube; OM = otitis media; I&D = incision and drainage

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TABLE III
TREATMENT AND FOLLOW-UP OUTCOMES IN UNCOMPLICATED ACUTE MASTOIDITIS CASES

Intervention	Cases (*n*)*	Treatment complications (*n*)	Follow-up outcomes (*n*)
Medical treatment only	104	Insufficient local improvement, requiring mastoidectomy (2); persistent middle-ear effusion, requiring myringotomy (2); SPA development, requiring mastoidectomy (1); relapse due to antibiotic therapy non-compliance (1)	Recurrent AOM (2), recurrent AM (2), no sequelae reported (100)
Myringotomy ± VT	129	No improvement, requiring mastoidectomy (4); progression of infection & SPA development, requiring mastoidectomy (1); zygoma swelling, requiring mastoidectomy (1)	Recurrent AOM (1), recurrent AM + SPA (1), mastoid abscess & recurrent OM (1 – same patient who had zygoma swelling), no sequelae reported (126)
Mastoidectomy	17	None	Recurrent AM (2), recurrent AOM (1), cholesteatoma (1), no sequelae reported (13)

*Total *n* = 250. SPA = subperiosteal abscess; AOM = acute otitis media; AM = acute mastoiditis; VT = ventilation tube; OM = otitis media

with uncomplicated acute mastoiditis included: recurrent acute mastoiditis, recurrent acute otitis media, cholesteatoma, subperiosteal abscess and mastoid abscess development.

Subperiosteal abscess treatment

As mentioned previously, 253 of the reported acute mastoiditis cases were complicated with subperiosteal abscess (excluding cases from Harley *et al*.[27]). All of these patients underwent surgical management. A total of 111 patients received 'conservative' surgery for treatment of subperiosteal abscess. Of those 111 patients, 12 (1 who initially underwent myringotomy and 11 who initially underwent abscess drainage) received subsequent mastoidectomy because of the lack of clinical improvement within 48–72 hours; 4 patients (1 who initially underwent myringotomy and 3 who initially underwent abscess drainage) required subsequent or repeated abscess drainage because of persistent disease or newly developed subperiosteal abscess during their clinical course. The remaining 142 patients underwent primary treatment with mastoidectomy, with no reported treatment complications. During follow up, acute mastoiditis recurrence was the most frequent outcome noted (17 cases). Table IV summarises the treatment and follow-up outcomes of subperiosteal abscess cases.

The cure rates for conservative and extensive surgery in cases complicated with subperiosteal abscess were 94.6 per cent and 90.1 per cent respectively. Adverse follow-up outcomes experienced by subperiosteal abscess patients included recurrent acute mastoiditis, recurrent acute otitis media and persistent tympanic membrane perforation.

Discussion

In uncomplicated acute mastoiditis cases, a conservative approach was much more frequently undertaken than extensive surgery (93.2 per cent *vs* 6.8 per cent). A conservative approach constituted either medical therapy only, or medical therapy plus conservative surgery with myringotomy (with or without ventilation tube insertion). Contrarily, in cases complicated with subperiosteal abscess, extensive surgery was more commonly performed than conservative surgery (56.1 per cent *vs* 43.9 per cent).

The majority of the reviewed patients (94.0 per cent) had a favourable clinical outcome, with no long-term sequelae on follow up. Of these 526 patients, 22.2 per cent ($n = 117$) received medical therapy only, 48.7 per cent ($n = 256$) received conservative surgery and 29.1 per cent ($n = 153$) underwent extensive surgery.

Correspondingly, conservative surgery was the most commonly selected treatment modality (47.3 per cent, 267 of 564). The extensive surgery treatment group had the lowest percentage of patients with a good clinical outcome (95.9 per cent medical only *vs* 96.3 per cent conservative surgery *vs* 89.1 per cent extensive surgery).

Of subperiosteal abscess patients, 14.4 per cent (16 of 111) who received conservative surgery required subsequent therapy, with either abscess drainage or mastoidectomy, because of persistent disease. All subperiosteal abscess patients who received mastoidectomy as the definitive treatment required no further therapy. Interestingly, this extensive surgery group also had a higher number of adverse follow-up outcomes (9.9 per cent) (Table IV). Similarly, all uncomplicated acute mastoiditis patients who received mastoidectomy as definitive treatment also had the highest number of adverse follow-up outcomes (23.5 per cent). Subsequent therapy with either myringotomy or mastoidectomy was required in 4.81 per cent (5 of 104) and 4.65 per cent (6 of 129) of uncomplicated acute mastoiditis patients who received medical treatment only and conservative surgery (myringotomy with or without grommet insertion) respectively.

There is a predilection for conservative therapy (medical therapy alone and conservative surgery) in the studies reviewed, and conservative therapy has been shown to be as effective as mastoidectomy in producing favourable long-term outcomes. However, we do not know what influenced the physicians' decisions

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TABLE IV
TREATMENT AND FOLLOW-UP OUTCOMES IN SUBPERIOSTEAL ABSCESS CASES

Intervention	Cases (*n*)*	Treatment complications (*n*)	Follow-up outcomes (*n*)
Conservative surgery			
– Myringotomy + VT	3	Persistent fever, requiring abscess drainage (1); no clinical improvement, requiring mastoidectomy (1)	No sequelae reported (3)
– Abscess drainage	3	No clinical improvement, requiring mastoidectomy (11); persistent disease, requiring repeated abscess drainage (3)	Recurrent AM (5), recurrent AOM (1), no sequelae reported (102)
– Abscess drainage + myringotomy	69		
– Abscess drainage + VT	36		
Extensive surgery – mastoidectomy	142	None	Recurrent AM (12), persistent tympanic membrane perforation (2), no sequelae reported (128)

*Total *n* = 253. VT = ventilation tube; AM = acute mastoiditis; AOM = acute otitis media

regarding treatment, as the majority of studies involved retrospective analyses. Furthermore, the lack of consensus regarding the diagnosis and management of acute mastoiditis could have contributed to the difference in surgical rates between the reviewed studies.[2,11] The cases that received extensive surgery may have been more severe on presentation, therefore possibly having more adverse follow-up outcomes.

In this review, studies were of a low evidence level (i.e. case reports, case series and retrospective studies). Although these articles contain valuable data, selection bias may be present.[36,37] Hence, this review may not provide the most accurate assessment of evidence-based medicine with regard to managing paediatric acute mastoiditis.

Moreover, some studies did not clearly report their methodology; some studies did not elaborate on what was considered to be 'conservative' management (i.e. antibiotics only *vs* conservative surgery). Such articles were excluded because of difficulties in extrapolating and comparing data. However, this also correlates to a reduction in potentially valuable data for our review. Additionally, taking into consideration our exclusion criteria (e.g. non-English articles, articles without full text, and cases of intracranial complication on presentation), other sources of valuable data would inevitably have been omitted as well.

To our knowledge, this is the first ever systematic review to concentrate on the management of paediatric acute mastoiditis. It focused particularly on subperiosteal abscess, the most prevalent complication of acute mastoiditis, and aimed to provide optimal comprehensive coverage of data from relevant studies.[7,15,38]

A notable shortcoming in this review would be the exclusion of cases with other equally important complications (i.e. intracranial complications). This exclusion allowed the streamlining of data for comparison, but also resulted in a narrower scope of review. Other improvements to establish a more well-rounded review include an analysis of the relationship between microbiology, antibiotic regimens and treatment outcomes. Additionally, there were insufficient data to compare admission time and acute mastoiditis recurrence between the treatment modalities, which would have provided valuable information for analysis.

Generally, the treatment outcomes of paediatric acute mastoiditis were favourable. The data extracted suggest that conservative treatment (medical therapy only, and myringotomy with or without grommet insertion) has high efficacy as a first-line treatment in uncomplicated acute mastoiditis cases. In contrast, in cases of acute mastoiditis complicated with subperiosteal abscess, conservative surgery provided similar cure rates when compared to those of extensive surgery. Hence, we conclude that although mastoidectomy may be the most definitive treatment available, medical therapy with or without conservative surgery is an appropriate and safe first-line management when treating acute mastoiditis.

Several studies specified a general timeframe of 48–72 hours for gauging treatment response. A failure to show improvements within this period, or the development of new complications, were the main reasons that warranted stepping up management in these studies. Given that the data did not seem to suggest any negative outcomes associated with receiving delayed surgery, 48–72 hours seems to be a reasonable threshold for gauging the initial treatment response.

Unfortunately, no statistical data could be provided in this paper to suggest the superiority of a single treatment modality over another. Furthermore, it is not possible to foresee which cases will result in a poor response and necessitate further treatment. Future meta-analyses could be conducted to address this issue, in view of the heterogeneity of treatment outcomes and methodologies across studies.

As mentioned, proper diagnostic and therapeutic criteria of acute mastoiditis are still unavailable. This remains an area for further research considering the potential benefits it could yield, such as providing a framework for conducting a well-designed prospective study. Future studies could include more detailed reporting of outcomes, and an in-depth analysis into

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the relationship of other variables (i.e. antibiotic regimens, other complications on presentation) and treatment outcomes.

Conclusion

Generally, the treatment outcome of paediatric acute mastoiditis was favourable. Mastoidectomy may be the most definitive treatment available; however, the reviewed data suggest that conservative treatment alone has high efficacy as first-line treatment in uncomplicated cases of acute mastoiditis, and conservative therapy may be an appropriate first-line management when treating acute mastoiditis.

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