



ORIGINAL ARTICLE

# Mastoiditis diagnosed by clinical symptoms and imaging studies in children: Disease spectrum and evolving diagnostic challenges

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## KEYWORDS

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Surgery

**Background/Purpose:** Acute mastoiditis has been increasingly reported. We reviewed our experience of mastoiditis in children in the era of expanding application of imaging tools and endless emerging antimicrobial resistance.

**Methods:** We reviewed all medical records of children (< 18 years of age) hospitalized with mastoiditis between January 2001 and December 2010. Diagnosis of mastoiditis was based on clinical features and confirmed by imaging studies. Patients were classified as having acute or nonacute mastoiditis according to the duration of the disease. Acute mastoiditis was defined as illness of less than 3 weeks prior to hospitalization. Cases of longer than 3 weeks' duration were defined as nonacute mastoiditis. We compared the clinical, laboratory and microbiological features of acute and nonacute mastoiditis.

**Results:** A total of 104 children were enrolled in this study, comprising 56 acute cases and 48 nonacute cases. Fever and coryza were significantly more common in acute cases. C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) were both initially higher in acute mastoiditis. CRP, rather than ESR, declined faster in acute than in nonacute mastoiditis. Computerized tomography (CT) scans, but not plain films, were highly sensitive. *Streptococcus pneumoniae* and *Haemophilus influenzae* accounted for 52% of all isolates. Staphylococci, *Pseudomonas* spp. and polymicrobials were predominantly seen in non-acute mastoiditis.

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**Conclusion:** With the application of imaging studies, many cases of mastoiditis were identified. The classical postauricular signs were present in only 10% of patients. The presenting symptoms, inflammatory markers, pathogens, management and outcome were greatly influenced by the duration of the illness prior to admission.

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## Introduction

In the pre-antimicrobial era, mastoiditis was the most common and feared complication of acute otitis media, and caused significant and even life-threatening complications beyond the tympanomastoid system, including subperiosteal abscess, Bezold's abscess, facial paralysis, suppurative labyrinthitis, meningitis, epidural and subdural abscess, brain abscess, and lateral sinus thrombophlebitis.<sup>1</sup>

Since the introduction of antimicrobial therapy, incidence of mastoiditis and its complications have markedly reduced. However, an increase in incidence of acute mastoiditis has been noted in recent reports.<sup>2,3</sup> Mastoiditis is more common in the pediatric age group, and most patients are younger than 4 years of age.<sup>4–8</sup> The typical local signs of acute mastoiditis are postauricular pain, swelling, erythema and tenderness<sup>9</sup>; however, these classical signs are less common in the antimicrobial era, even in acute disease, which leads to difficulty in and delay of the diagnosis.<sup>7</sup>

In a recent systemic review of diagnostic criteria for acute mastoiditis in children, it was suggested that this disease is poorly evaluated and understood and there is lack of consensus regarding the criteria and strategies for diagnosing acute mastoiditis in the pediatric population.<sup>10</sup> To date only scanty clinical and microbiological data on mastoiditis in children are available in Taiwan. Two reports on mastoiditis in Taiwanese children have been published over the past decade. Jiang et al reported 19 cases based on physical, imaging (eight patients) and surgical (six patients) findings and suggested that acute mastoiditis was uncommon, but its complications were high.<sup>8</sup> In their series, 90.5% of cases had postauricular pain and over one-third of cases had underlying diseases. In contrast, Cheng et al reported that among 19 cases (15 patients underwent imaging studies), only six patients (32%) had postauricular swelling and tenderness.<sup>7</sup> The article demonstrated a lack of typical physical findings in most cases of mastoiditis, and thus the authors suggested that mastoiditis was often overlooked by physicians.

The clinical spectrum and case definition of mastoiditis in children has evolved overtime. The availability of antibiotic therapy, imaging studies and preventive vaccines has had a great impact on the outcome and complications of this disease. Clearly, mastoiditis in children is not well understood and its clinical spectrum needs further delineation. This report describes our clinical experiences on 104 children with mastoiditis confirmed by clinical and computed tomography (CT) scans (97 patients) or plain films of mastoid region (seven patients). It discusses diagnostic challenges and provides comparative data on clinical, laboratory and microbiological features at acute and nonacute stages of the illness, and shares our approach to management of mastoiditis in children.

## Methods

This retrospective study reviewed medical records on all patients less than 18 years of age who presented with the clinical diagnosis of mastoiditis to the Kaohsiung Veterans General Hospital (KVGH) from January 1, 2001 to December 31, 2010. The hospital is a tertiary referral medical center with 1200 beds, including 130 beds in the Department of Pediatrics, serving the population of Kaohsiung and surrounding communities of southern Taiwan.

Diagnosis of mastoiditis was established by both clinical features and imaging studies. Clinical features of mastoiditis included: fever, otalgia, otorrhea, postauricular inflammation (swelling, redness, tenderness) and anterior-inferior displacement of auricle, eardrum abnormalities, and other nonspecific signs such as coryza, vomiting and poor appetite (Table 1). An increased soft tissue density in the mastoid air sinus by plain films or CT image was considered a positive finding. Patients with any one of the above clinical features plus positive findings on CT scan or plain films of mastoid region were enrolled in our study. Indications for obtaining imaging studies were based primarily on the judgment of the attending physicians. Patients with incomplete data or in whom the diagnosis was not conclusive were excluded. A total of 104 children meeting the diagnostic criteria were enrolled in this study.

The clinical course and spectrum of mastoiditis are poorly understood. Most papers refer to this clinical entity as "acute" mastoiditis. Clinical data on "subacute" or "chronic" mastoiditis are very limited. In contrast, otitis media is traditionally classified as acute (<3 weeks), subacute (3 weeks to 3 months) and chronic (>3 months) according to the clinical course of the disease.<sup>11</sup> In this study, we modeled otitis media and classified mastoiditis into acute (<3 weeks) or nonacute (>3 weeks) cases based on the duration of the disease (from onset of the illness to the time of diagnosis). We examined and compared the differences in clinical features, inflammatory markers, bacterial pathogens, and outcome between acute and nonacute mastoiditis. Recurrence within 3 months after completion of antibiotic therapy was defined as relapse; recurrence after 3 months was defined as reinfection. Relapse was considered to be the same episode as the previously recognized disease, and was regarded as treatment failure, while reinfection suggested a distinct episode. Images, microbiological and laboratory data, antimicrobial selection, medical or surgical intervention, and outcomes were also reviewed and recorded in a standard form.

The magnitudes of change in inflammatory markers, i.e., erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), leukocyte and neutrophil counts) during therapy were analyzed. The mean daily decrement of CRP or ESR,

**Table 1** Inflammatory markers and clinical features at presentation in 104 children with acute or nonacute mastoiditis

Inflammatory markers	Acute cases	Nonacute cases	<i>p</i>
	Median (25–75% quartile range)	Median (25–75% quartile range)	
CRP (mg/dL)	3.35 (1.17–10.43)	1.00 (0.32–4.10)	0.015
ESR (mm/h)	62.00 (27.00–88.50)	25.00 (6.00–42.50)	0.040
Mean neutrophils (%)	60%	56%	0.295
Mean daily CRP decrement	25.6%	20.8%	0.034
Mean daily ESR decrement	4.5%	6.5%	0.903
Clinical features	No. of patients (%)	No. of patients (%)	
Fever	53 (95%)	39 (81%)	0.033
Coryza	35 (63%)	19 (40%)	0.024
Otalgia	25 (45%)	16 (33%)	0.239
Vomiting	8 (14%)	2 (4%)	0.103
Otorrhea	19 (34%)	16 (33%)	0.147
Congested eardrum	56 (100%)	48 (100%)	1.000
Poor appetite	10 (18%)	9 (19%)	0.906
Postauricular pain	7 (13%)	4 (8%)	0.491

CRP = C-reactive protein; ESR = erythrocyte sedimentation rate.

namely the declining rate of CRP or ESR, during treatment was calculated (i.e., first CRP or ESR values minus second CRP or ESR values divided by the number of days in the interval).

### Statistical analysis

All categorical variables were analyzed using  $\chi^2$  test or Fisher's exact test as appropriate, and continuous variables by the Student *t* test. The result was considered to be significant if a two-tailed *p* value was less than 0.05. The tool for data analysis was SPSS 17.0 for Windows (SPSS Inc. Chicago, USA).

### Results

Of the 104 children with mastoiditis enrolled in this study, there were 46 females and 58 males. The mean age was 3.58 years (range: 7 months to 12 years of age). Seventy-three patients (70%) were younger than 4 years of age. Fifty-six cases (54%) were assessed as acute mastoiditis, and 48 cases (46%) were assessed as nonacute mastoiditis. Thirty-four cases (33%) were unilateral, and 70 cases (67%) had bilateral involvement. All patients with mastoiditis had middle ear infection, regardless of whether disease was acute or nonacute.

### Laboratory and clinical features

Inflammatory markers and clinical presentations are summarized in Table 1. The initial median CRP values at the time of hospitalization were significantly higher in acute mastoiditis as compared to nonacute mastoiditis (3.35 mg/L vs. 1.00 mg/L, *p* = 0.015). Similarly, ESR values were higher in acute cases than in nonacute cases (62 mm/hour vs. 25 mm/hour, *p* = 0.040). During therapy, mean daily CRP declined significantly faster in acute cases than in nonacute cases (25.6 % vs. 20.8%, *p* = 0.034). ESR also declined in

both acute and nonacute mastoiditis, but in much slower rates (mean daily decrement: 4.5% vs. 6.5%). Neutrophil percentage and total leukocyte count did not show differences between these two groups, regardless of the initial measurement or the rate of decline.

As showed in Table 1, there were some differences in clinical features between acute and nonacute cases. For example, fever and coryza were more common in acute cases than in nonacute cases: fever (95% vs. 81%, *p* = 0.033) and coryza (63% vs. 40%, *p* = 0.024). In contrast, otalgia and otorrhea occurred in less than 50% of the patients in both groups and without significant difference. Postauricular pain, swelling, erythema or tenderness was less common in both groups (13% vs. 8%). All patients had signs of otitis media, including bulging drums, erythematous changes ruptured membranes or otorrhea. Nineteen patients (18%) had history of allergies, including rhinitis (11), asthma (five) and three with both conditions. Eleven of these 19 patients were nonacute cases and eight were acute cases.

### Imaging and radiographic features

Ninety-seven of 104 patients (93%) underwent examinations by CT scans of the inner petrous pyramids region. All had soft tissue density instead of air, in the mastoid air cells, suggestive of mastoiditis. The other seven patients were diagnosed with mastoiditis by plain films only. Of the 31 patients who received both CT scans and plain film examinations, all showed positive findings by CT scans, but only 20 (65%) by plain films.

### Microbiological studies

Blood cultures were performed in 88 patients. Only three patients (3%) revealed bacteremia, uniformly caused by *Streptococcus pneumoniae*. Other cultures were obtained from 49 patients: ear drainages (29 patients) and surgical specimens (20 patients, including 19 myringotomy, and one

cortical mastoidectomy). Table 2 summarizes the pathogens isolated from patients with acute and nonacute mastoiditis.

Of the 49 patients, 35 gave positive microbiologic results (71%). *S. pneumoniae* was isolated in 15 and *Haemophilus influenzae* in seven patients (including in the polymicrobial group). *S. pneumoniae* and *H. influenzae* accounted for 52% of all isolates. All *S. pneumoniae* strains were susceptible to clindamycin, cefotaxime and vancomycin. Twelve (79%) *S. pneumoniae* strains were sensitive to penicillin with minimum inhibitory concentration (MIC  $\leq$  2  $\mu$ g/mL. None of the strains had MIC  $\geq$  8  $\mu$ g/mL. Five *H. influenzae* isolates were  $\beta$ -lactamase producers (71%). Isolates from surgical specimens included four strains of *S. pneumoniae*, four strains of methicillin-resistant *Staphylococcus aureus* (MRSA) and seven strains of *Pseudomonas aeruginosa*. *Staphylococcus* spp. were isolated in 10 cases: with six MRSA strains (two in acute disease, and four in non-acute disease), two methicillin-sensitive strains and two coagulase-negative *Staphylococcus* strains. Ten patients had *P. aeruginosa*, of whom nine had nonacute mastoiditis. As expected, MRSA, *P. aeruginosa* and polymicrobial isolates were significantly more common in nonacute mastoiditis. All of the *P. aeruginosa* strains were susceptible to amikacin, ceftazidime, cefepime, ciprofloxacin, levofloxacin, imipenem and piperacillin.

### Management and outcome

Our initial antibiotic approach to mastoiditis included intravenous amoxicillin/clavulanate or ampicillin/sulbactam. Anti-*Pseudomonas* agents or glycopeptides were added, as needed, when culture information become available. In this study, 20 patients (19%) underwent surgical intervention, including 19 myringotomy with ventilation tube placement, and one cortical mastoidectomy.

One of 56 patients (2%) had a relapse of infection in the acute mastoiditis group, whereas eight of 48 patients (17%) had a relapse in the nonacute mastoiditis group ( $p < 0.001$ ).

**Table 2** Bacterial pathogens isolated by cultures of ear discharge and surgical specimen from 49 children with acute or nonacute mastoiditis

Pathogens	Acute cases	Nonacute cases	<i>p</i>
<i>Streptococcus pneumoniae</i>	8	7	0.966
<i>Haemophilus influenzae</i>	3	4	0.701
Methicillin-susceptible <i>Staphylococcus aureus</i> (MSSA)	0	2	0.211
Methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)	2	4	0.411
Coagulase-negative <i>Staphylococcus</i>	0	2	0.211
<i>Pseudomonas aeruginosa</i>	1	9	0.005
Polymicrobial <sup>a</sup>	2	9	0.012

<sup>a</sup> The number of isolates including those of polymicrobial infection. Components of polymicrobial infection in acute mastoiditis included *H. influenzae* with positive  $\beta$ -lactamase and MRSA. Nine polymicrobial infections in nonacute mastoiditis included: *S. pneumoniae* ( $n = 6$ ), *H. influenzae* ( $n = 3$ ), MRSA ( $n = 3$ ), *P. aeruginosa* ( $n = 4$ ) and *Achromobacter* spp. ( $n = 2$ ).

All relapses occurred within 3 months of completion of therapy. Among 48 nonacute cases, the relapse rate was 11% in the surgical intervention group and 21% in the nonsurgical intervention group ( $p = 0.451$ ).

Twenty-nine (28%) of our patients had hearing impairment at the time of admission, and five of them had residual hearing impairment at follow-up evaluations.

### Discussion

The mastoid is contiguous to the middle ear cleft. Infection of the middle ear has the potential to spread to the mastoid air cells and beyond. The term "mastoiditis" elicits alarm among those who care for the patient. Furthermore, the terminology applied to mastoiditis is vague; for example: incipient mastoiditis, coalescent mastoiditis, surgical mastoiditis, acute, subacute or chronic mastoiditis. The clinical spectrum of mastoiditis and natural history of the disease are not well understood. There is lack of consensus on current diagnostic criteria.<sup>10,12</sup>

Published data from Taiwan on mastoiditis in children have been limited to two retrospective reports involving a total of 38 patients over the past decade.<sup>7,8</sup> Our retrospective study on 104 children with mastoiditis offers a unique opportunity to re-examine the clinical spectrum and diagnostic challenges. We found that the disease is not uncommon and that duration of the illness (i.e., under or over 3 weeks) prior to hospitalization had a significant influence on clinical presentation, level of inflammatory markers, type of bacterial pathogens, antibiotic choice, and disease relapse. Our observations, although not novel or unexpected, represent a rare attempt to compare the differences between patients with acute and nonacute disease, and provide further information relevant to diagnosis and management of mastoiditis in children.

For many decades, postauricular symptoms and signs (i.e., pain, swelling, redness, tenderness and anteroinferior displacement of the auricle) have been used as major clues for clinical diagnosis of mastoiditis in children.<sup>3,6,9,13</sup> Our experience differs somewhat from these published reports. The present report confirms our previous observations that most children with mastoiditis, confirmed by CT scans, did not demonstrate the typical postauricular signs.<sup>7</sup>

CT scanning of the temporal bone has been generally recommended for the evaluation of mastoiditis. A recent review of published data on mastoiditis indicated that CT scanning was performed in 68% of patients with mastoiditis.<sup>10</sup> CT findings of mastoiditis vary with the stage of the infection, and usually include opacification of the mastoid cells, loss of sharpness or visibility of the mastoid cell walls, haziness or distortion of the mastoid outline, enhancement of areas of abscess formation, elevation of periosteum of mastoid process or posterior cranial fossa, and osteoblastic activity in chronic mastoiditis. CT scanning is very sensitive in detecting changes of mastoiditis, but its specificity is not well evaluated. Based on histopathological findings, Staheli-Massik et al reported that CT scanning had a sensitivity of 100% and specificity of 38%.<sup>14</sup> In studying the correlation between CT scan and surgical findings, Migirv reported that CT scanning had a sensitivity of 97% and a predictive value of 94%. Others have reported sensitivity of 80–100%.<sup>15</sup>

One of the biases in our series is that not all patients received a CT scan. Among those who received only the less sensitive plain x-ray studies, some patients might not have been identified and enrolled in the study (underdiagnosis). On the other hand, among those who received the highly sensitive and less specific CT scans, some patients might have been falsely identified and enrolled (overdiagnosis). Since mastoid air cells are in continuity with the middle ear cavity, children with acute otitis media may be associated with mucosal inflammation in the mastoid air cells (asymptomatic or incipient "mastoiditis"). The number of under- or overdiagnosed mastoiditis in our series is unknown.

Our microbiological findings were not unexpected. *S. pneumoniae* and *H. influenzae* accounted for over half of all bacterial isolates and were evenly distributed among the acute and nonacute cases. In contrast, *Staphylococcus*, *Pseudomonas* and polymicrobials were predominantly seen in the nonacute cases. Others have found *Streptococcus pyogenes* as an important pathogen in mastoiditis in children, but none of our patients had *S. pyogenes*.

There are two major deficiencies in our microbiological studies: not all patients had adequate specimens for cultures and insufficient information from mastoid aspiration or tympanocentesis (except the 19 patients who underwent myringotomy). MRSA and *Pseudomonas* spp. were more often isolated from surgical than nonsurgical specimens: surgical (four MRSA, seven *Pseudomonas*) versus nonsurgical (two MRSA, three *Pseudomonas*). Overall *P. aeruginosa* and polymicrobials were significantly more common in nonacute mastoiditis. MRSA was also more common in nonacute cases, but this difference was not statistically significant. The precise role of *Staphylococcus*, *Pseudomonas* and polymicrobial agents in our nonacute patients remains to be determined. Some are from surgical specimens, but some are likely colonization or contamination. Their pathogenic role in nonacute cases of mastoiditis cannot be excluded with certainty. Mastoiditis with meningitis caused by *P. aeruginosa* has been reported in Taiwan.<sup>8</sup>

Undoubtedly antibiotic therapy prior to admission had a major effect on the clinical course of mastoiditis. Others have reported as high as 80–100% of patients were under antibiotic treatment prior to admission.<sup>3,6</sup> In our series, history indicated that most patients were on medications of unspecified nature prior to hospitalization. From the records we were able to identify only a relatively small number of patients on specific antibiotics: ampicillin/amoxicillin (nine), ampicillin–sulbactam/amoxicillin–clavulanate (nine), macrolide (two) and cephalixin (two). The number is too small to determine the correlation between antibiotic consumption and bacterial isolation from patients.

Our knowledge about mastoiditis in children has been acquired over many decades covering the pre- and postantibiotic era, mostly by retrospective studies. With the introduction of imaging modality, our view about the disease and approach to this infection are changing. The emergence of antibiotic-resistant bacteria and increasing application of conjugated vaccines for *S. pneumoniae* and *H influenzae* type b will undoubtedly alter the patterns of the disease and our approach to this infection. Our retrospective review, as in most published papers on mastoiditis in children, has many inherent limitations and deficiencies as discussed. Mastoiditis will continue to evolve as we enter the era of increasing

pressure from antibiotic-resistant microbes. It will require well-designed prospective studies to evaluate its clinical spectrum, microbiological features, approach to diagnosis and management, and long-term follow-up of this poorly understood and underevaluated disease that continues to alarm parents and physicians.

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