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OTOLOGY

Surgical intervention for acute mastoiditis: 10 years experience in a tertiary children hospital

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Abstract

Purpose To evaluate the clinical course of children with acute mastoiditis (AM) who required surgical intervention.

Material and methods Clinical and biochemical characteristics at the moment of hospital admission were reviewed for patients who required surgery for AM. Children who were successfully managed conservatively during the last 3 years of study were chosen as a comparison group.

Results During 2008–2017, 570 children were admitted with AM: 82(14%) underwent cortical mastoidectomy, including 31(38%) with decompression of epidural space and sigmoid sinus. The comparison group consisted of 167 children with AM who did not require surgery. The surgical group had a higher rate of acute otitis media before admission. At the time of hospital admission, the surgical group had a higher rate of prolonged fever, otorrhea, and sub-periosteal abscess. Their average temperature, WBC, neutrophil count, and CRP were significantly higher (39.2 vs. 37.9°. C, 20 K vs. 16.5 K, 67 vs. 55.8 percent, 17 vs. 8.8, respectively, $p=0.0001$). Fusobacterium necrophorum was the most common pathogen in the surgical group (50%), and group A streptococcus in the comparison group (22%). Sub-periosteal abscess, sinus venous thrombosis, and epidural involvement were diagnosed in 95, 35, and 38 percent of patients, respectively. Average length of IV antibiotic treatment was 20 days in operated children, compared to 5.6 days in the comparison group ($p=0.0001$). Since 2013, a significantly higher percentage of children were diagnosed with Fusobacterium mastoiditis ($p=0.0001$) who required surgery ($p=0.008$).

Conclusion In children with AM presenting with, high fever, leukocytosis, elevated CRP, and sub-periosteal abscess, early CT and surgical intervention were frequently required. The increase in Fusobacterium infection might be an explanation for the increase in complicated AM requiring surgery.

Keywords Acute mastoiditis · Mastoidectomy · Fusobacterium necrophorum

Introduction

Acute mastoiditis (AM) is a suppurative inflammation of the mastoid bone, most frequently a complication of acute otitis media (AOM), with peak prevalence at the age of 2 years [1–3]. The most common presentation is fever and postauricular swelling. However, other complications, extracranial and intracranial, such as subperiosteal abscess, sinus vein thrombosis (SVT) and epidural abscess are not rare [1–5]. The antibiotics era resulted in a tremendous decline in the incidence of acute mastoiditis, though incidence of its complications remains high [6–8]. Recent publications suggest a rise in the incidence of mastoiditis, which is attributed to restriction of antibiotics in AOM, and the emergence of resistant or pathogen changes that occurred post anti-pneumococcal vaccinations. However, population-based studies demonstrate conflicting evidence regarding the veracity of AM increase [2, 9–16].

Streptococcus pneumonia (Sp) is the most prevalent pathogen isolated in acute mastoiditis. Less common pathogens include; *Staphylococcus aureus*, *Streptococcus pyogenes* Group A strep (GAS), *Hemophilus influenza* (HI), *Pseudomonas aeruginosa*, and *Moraxella catarrhalis* [17].

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Reports of more virulent pathogens associated with complicated mastoiditis [e.g. *S. aureus*, GAS, and Fusobacterium necrophorum (Fn)] in the post Pneumococcal vaccination era are rising [12, 14, 15].

In the past, cortical mastoidectomy was common in the treatment of AM, however, in recent years, the pendulum has shifted towards a conservative treatment for uncomplicated AM, using IV antibiotics and myringotomy with or without VT insertion [2, 15, 18]. Furthermore, even for complications such as subperiosteal abscess, some publications advocate the use of needle aspiration or incision and drainage over cortical mastoidectomy [19]. Clear, unified guidelines regarding the need for surgical intervention for AM are lacking [1, 2, 6, 18].

The aim of this study was to present our 10 years experience in surgical management for acute mastoiditis, and find factors at presentation that may indicate a need for intervention.

Materials and methods

The computerized database of the Department of Otolaryngology in a university-affiliated children hospital was retrospectively reviewed for all children admitted for AM between January 2008 and December 2017. Children who were successfully managed conservatively during the last 3 years of study were chosen as a comparison group. The study protocol was approved by the Institutional Review Board (IRB–0242-17-RMC) with a waiver of Informed consent.

Children were diagnosed with AM, by a pediatric otolaryngologist, in the presence of otalgia, fever, signs of AOM and retro-auricular redness and swelling. Tympanocentesis was performed in cases without spontaneous discharge, and culture was taken for bacteriology. If retroauricular fluctuation was diagnosed, needle aspiration of the pus was performed at admission. Samples for Polymerase Chain Reaction (PCR) analysis were obtained during surgical intervention when the culture was negative or not yet specified. Intravenous Cefuroxime or Ceftriaxone was the routine antibiotic treatments for uncomplicated mastoiditis; or in addition to Metronidazole or Clindamycin when subperiosteal abscess or other complications were suspect.

Exclusion criteria were the presence of cholesteatoma, prior ear surgeries, or a diagnosis of external otitis as the cause for auricular protrusion.

According to our department imaging protocol for AM, CT scan was not routinely performed at admission. CT scan was only performed in those patients with septic appearance at presentation, subperiosteal abscess with no response to needle aspiration, or when no clinical or laboratory improvement was observed during 48 h of treatment. CT findings determined the extent of surgical intervention which included ventilation tube insertion and the following options: (1) if CT demonstrated a confined, small abscess without intracranial involvement, we performed incision and drainage of the subperiosteal abscess (2) when SVT or epidural involvement were demonstrated, the preferred surgical option was cortical mastoidectomy with unroofing of the bony plate covering the sigmoid sinus and epidural space. (3) all other cases that failed to improve underwent cortical mastoidectomy with drainage of subperiosteal abscess.

The following information was collected from patients' medical records: age, sex, physical examination findings, temperature, inflammatory markers; WBC and CRP, type and duration of treatment, culture and PCR results, and imaging and surgical findings.

Statistical analysis

All statistical analyses were carried out using SAS 9.2 software (SAS Institute Inc., Cary, NC, USA). Continuous variables are presented as mean and standard deviation. Normally distributed variables were compared using *t* tests, and categorical data ulticen using Chi-square or Fisher's exact tests, as appropriate. Statistical significance was inferred at $p < 0.05$.

Results

During the 10 year study period, 82 children underwent surgical intervention. The comparison group included 167 children. Demographic, clinical, and laboratory findings at the time of diagnosis are presented in Table 1. Forty-two (51%) patients were diagnosed with AOM prior to admission, compared with 47 (28%) of the non-operated children ($p = 0.0004$); 50 percent were treated at home with antibiotics for an average of 3.7 (range 1–21) days vs. 34 percent for an average of 3.1 (range 1–8) days in the non-operated group ($p = 0.02$). The most common treatments for both groups were amoxicillin, amoxicillin + clavulanic acid, and ceftriaxone.

Intravenous antibiotic treatment was given to all children upon hospital admission after microbiology cultures were obtained. The most common empiric regimen was a combination of ceftriaxone and clindamycin (58%) or metronidazole (28%), while for the conservatively managed patients the most common antibiotic was cefuroxime alone (75%). In the surgical group, the duration of intravenous antibiotic treatment was 7–45 days with an average of 20 ± 8.8 days, compared with 5.6 ± 1.9 days in the comparison group ($p = 0.0001$).

Table 1 Demographic, clinical and laboratory findings at the time of diagnosis of operated vs conservatively managed AM

		Operated		Conservatively managed		*p* value
		n = 82		*n* = 167		
	Normal values	Average	St. D	Average	St. D	
Age (month)		22.7	16.3	26	19.7	NS
Male gender (%)		48		53		NS
Right side (%)		46		50		NS
Fever (°C)		39.2	1.3	37.9	1.4	0.0001
White blood cells (K/micl)	5–10	20	7.8	16.5	5.3	0.0001
Neutrophil count (%)	45–70	67.3	13.6	55.8	14	0.0001
C-reactive protein (mg/dl)	0.3–1	17.2	9.9	8.8	6.7	0.0001
Hemoglobin (g/dl)	10.9–15	10	1.1	10.8	1.3	0.0001
Sub-periosteal abscess (%)		40		8		0.0001
Ear discharge (%)		35		20		0.013

Table 2 CT findings in operated children with AM

CT findings	Children, *n* = 80
Sub-periosteal abscess	77 (96%)
Sinus vein thrombosis	29 (36%)
Epidural abscess	31 (39%)
Two complications[a]	41 (51%)
All three complications	8 (10%)

[a]Subperiosteal abscess with either SVT or epidural involvement

A CT scan was performed in 80 (98%) children within an average of 3 ± 2.4 days in the surgical group, compared to only 4 (2%) children in the comparison group.

CT scan findings are presented in Table 2. Sub-periosteal abscess was the most commonly found [77 (96%) of patients], which in 46 (60%) of these children had not been clinically present at admission. SVT and epidural involvement were almost always present with subperiosteal abscess. No intracranial complications or sub-periosteal abscess were diagnosed in the four children in the non-operated group who underwent CT scan.

Surgical intervention

Surgical intervention with the insertion of ventilation tubes was performed in all 82 children. Seven (9%) patients underwent incision and drainage of a large subperiosteal abscess by insertion of a ventilation tube without performing cortical mastoidectomy. Seventy-five (91%) pediatric patients underwent cortical mastoidectomy as well. When SVT or epidural abscesses were detected, pus was drained, and granulations removed from the mastoid cavity, in addition to unroofing the bony plate covering the sigmoid sinus. The absence of distant thromboembolic events in all cases precluded the need for sigmoid sinus drainage and neck exploration for IJV ligation.

Table 3 Bacteria isolation from cultures taken from operated and conservatively managed AM

Bacteria type	Operated children *n* = 82		Conservatively managed *n* = 167	
Fusobacterium necrophorum	41	50%	1	0.6%
Group A *Streptococcus*	13	16%	37	22%
Haemophilus influenzae	9	11%	15	9%
Streptococcus pneumoniae	7	8.5%	20	12%
Pseudomonas aeruginosa	2	2.4%	22	13%
Staphylococcus aureus	3	3.6%	7	4%
Enterobacteriaceae	4	5%	5	3%
Others	15	18%	18	11%
No growth	8	10%	57	34%

Bacterial cultures

Cultures were taken from all 82 children, and when results were negative PCR samples were also taken. Bacterial isolations are shown in Table 3. The most common (50%) pathogen among operated children was Fn. In the comparison group, the most common (22%) pathogen was GAS; 57 (34%) patients had negative cultures. Pre-admission antibiotic treatment or spontaneous discharge did not alter bacterial growth.

Fn was isolated by anaerobic cultures in 21 (51%) children, and in 20 (49%) cases only by PCR. From eight children with negative cultures, only one PCR sample was taken and returned negative. In the non-operated mastoiditis, eight PCR samples were taken, all reveling the same bacteria as the culture.

Annually trends analysis

A total of 570 children were admitted with AM, during the 10 years study period.

Figure 1 presents an analysis of the surgical cases according to cohort year and common bacteria isolation.

When comparing trends between the first and the last 5 years of the cohort, the number of children admitted for AM was similar, 301 on the first half (53%) and 269 (47%) in the second. However, a statistically significant increase was seen in mastoiditis cases that had an indication for surgical intervention (11 vs. 19 percent, $p=0.008$). Analysis according to isolated pathogen showed a significant increase in the mastoiditis caused by Fn (3 vs. 12 percent, $p=0.0001$), between the first and last 5 years. Conversely, no statistically significant change over the years was found for all other bacteria ($p=0.87$).

Discussion

Since the introduction of antibiotics, the frequency of AM as a complication of AOM decreased from 20 to 0.004 percent [2]. Nonetheless, data published in recent years are signifying contradictory reports regarding a rise in the incidence of mastoiditis [2, 9–16]. An initial decrease of mastoiditis incidence, especially in younger children, was observed during the first years after routine use of Pneumococcal Conjugated Vaccine-13 [20]. This decrease could be temporary, as was observed after Pneumococcal Conjugated Vaccine-7 became a routine practice [17, 21]. Our study found no significant difference in the overall number children admitted due to AM within the last decade in our tertiary referral center. However, a significant increase in the rate of complications and a need for surgical intervention were observed. Attlmayr [9] and Benito [15], also reported an increase in surgical intervention, although the overall incidence in mastoiditis was unchanged. Both studies attributed these findings to the emerging of resistance and virulent pathogens, e.g. Fn, *P. aeruginosa*, and *S. aureus*.

To the best of our knowledge, this is the first study in the last decade that focused on differences between children who required surgical intervention compared to those who were medically managed. Our findings showed that children treated with surgery presented at time of hospital admission with higher inflammation markers such as fever, WBC levels, CRP and neutrophil count, as well as spontaneous ear discharge and subperiosteal abscess. These findings correspond to other reports in the literature that examined factors associated with complicated mastoiditis [8, 22, 23].

The need and timing for imaging in AM are controversial [3, 7, 8, 24]. CT is performed to rule out intra-cranial complications, and to determine the need and extent of surgical intervention. As most patients with AM are managed conservatively [2, 15, 18], CT scans can be avoided, as demonstrated in our case series. In contrast to our policy, others support the use of diagnostic imaging at presentation for all children, as there are not always “red

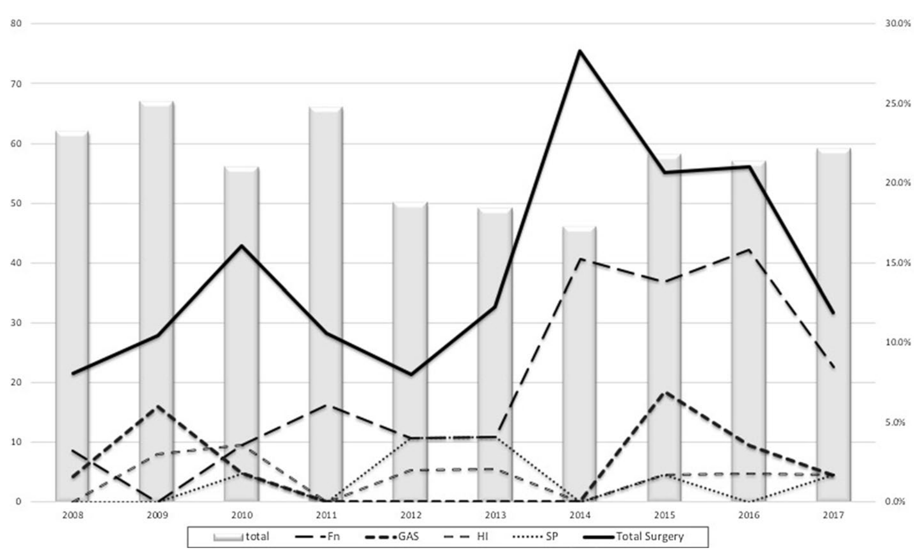

Fig. 1 Analysis of surgical cases according to years in cohort and common bacteria isolation. The columns present the annual number of all children treated for acute mastoiditis. The upper line is the percent of all children that underwent surgery, while the dashed lines indicate the percent of surgeries with isolation of *Fusobacterium necrophorum* (Fn), group A *streptococcus* (GAS), *Hemophilus influenza* (HI), and *Streptococcus pneumonia* (SP), against the number of all patients diagnosed with mastoiditis. A significant increase is seen in the percentage of all surgeries, and in Fn isolation between the first and last 5 years of the cohort, while there is no significant change in the incidence of other bacteria isolated over the years

flags" that distinguish those presenting with intracranial involvement who should be operated immediately [7, 8]. This case series and previous studies demonstrate that our conservative approach for performing CT scan can be safely adopted [11, 22].

There are still no clear guidelines for the management of acute mastoiditis. Contemporary publications trend towards a more conservative treatment, including IV antibiotics, myringotomy, and a bedside aspiration of subperiosteal abscess [6, 8, 18, 19, 24]. Studies about subperiosteal abscess as a sole complication found that the decision for surgical intervention should rely on response to conservative treatment, rather than abscess existence [19, 25]. In our study, subperiosteal abscess was the most common complication found in 94 percent of children who proceeded to surgery; in 60 percent of those children it was not present at admission, suggesting that it was minimal, initially missed, or evolved under IV antibiotics. Progression of infection leading to the development of subperiosteal abscess was previously described as an indication for a more aggressive disease [6, 8, 19, 25, 26]. Similar to the above-mentioned publications, subperiosteal abscess as an isolated complication can be managed by aspiration, as demonstrated in 8 percent of the comparison group.

A variety of bacteria were isolated from cultures taken by swabs from tympanocentesis or ear discharge (Table 3). Organisms such as *P. aeruginosa*, Enterobacteriaceae and others may result from non-pathogenic contamination of the external ear canal. For trend analysis, we chose known AOM associated pathogenic bacteria that were most commonly found in our culture results.

Pathogens isolated in the operated group demonstrated a higher rate of Fn in the second half of the cohort. This suggests that the rise in Fn mastoiditis is the culprit behind the rise in complications, and explains the need for surgical intervention during recent years. Fn is a Gram negative, obligate anaerobe bacterium that can be found in part of the oral cavity, and gastrointestinal and vaginal tract. It is mostly associated with head and neck infections and is notorious for causing Lemierre syndrome; bacteremia with thrombophlebitis of the jugular vein.

Recent studies described a rise in the incidence of Fn related AM [16, 27–31].

This trend was attributed to decreased use in antibiotics for AOM, alongside with the use of more sensitive methods to detect this pathogen [16]. Others relate Fn rise to the routine use of pneumococcal vaccines [28]. Post-vaccination changes in pneumococcal serotypes and higher rate of complicated mastoiditis were observed after the introduction of Pneumococcal Conjugated Vaccine-7 in a case series of 96 children [21]. The clear parallel rise in both operated mastoiditis and Fn mastoiditis rules out improvement in detecting methods as a sole cause for Fn increase and further epidemiological studies are warranted to determine the clinical implications of this bacterial trend.

Our study is mainly limited by its retrospective nature. Groups selection and categorization to surgically and non-surgically managed were not independent from the variables compared who lead to the decision of performing surgical intervention or not. Nevertheless, we believe that despite this inevitable retrospective bias, our large scale historical cohort emphasis the clinical characteristics to base treatment decision on, and identify important bacterial shift trends in mastoiditis causality.

Conclusions

Clinical and laboratory studies together with the response to initial antibiotic treatment are the best tools to assess the need for surgical intervention. Subperiosteal abscess, high fever, WBC count, and high CRP levels at presentation characterized children who were operated and should warrant a more aggressive treatment with broad-spectrum antibiotics that include anaerobe coverage, in addition to urgent imaging to determine prevalence of intra or extracranial complications. Fusobacterium necrophorum should be suspect as a cause for complicated mastoiditis that should verified by anaerobic cultures and PCR samples. This patients merit consideration for surgical intervention.

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to disclose.

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