Original article

Diagnosing acute mastoiditis in a pediatric emergency department: a retrospective review

Chiara Bertolaso[1], Ignazio Cammisa[1], Nicola Orsini[2], Michela Sollazzo[3], Valeria Sardaro[4], Antonio Gatto[1], Antonio Chiaretti[1], Bruno Sergi[3]

[1]Department of Pediatrics, Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Università Cattolica del Sacro Cuore, Rome, Italy; [2]Department of Global Public Health, Karolinska Institutet, Associate Professor of Medical Statistics, Head of the Biostatistics Team, Stockholm, Sweden; [3]Department of Otolaryngology, Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Università Cattolica del Sacro Cuore, Rome, Italy; [4]Università Cattolica del Sacro Cuore, Rome, Italy

Abstract. *Background and aim:* Acute mastoiditis (AM) is a common complication of acute otitis media in children. There is currently no consensus on criteria for diagnosis. Head CT is the most frequent diagnostic tool used in the ED although the increasing awareness on the use of ionized radiations in children has questioned the use of CT imaging versus solely using clinical criteria. Our research aimed to understand if CT imaging was essential in making a diagnosis of AM. *Methods:* We retrospectively analyzed medical records from pediatric patients who accessed our Pediatric Emergency Department (ED) between January 2014 and December 2020, with a clinical suspicion of AM. We reviewed clinical symptoms upon presentation, head CT and lab values (white blood cell count or WBC, C-Reactive Protein or CRP) when done, presence of complications and discharge diagnosis. A multilogistic regression model was specified to establish the role of clinical features and of CT in the diagnosis of AM based on 77 patients. *Results:* Otalgia (OR= 5.01; 95% CI= 1.52-16.51), protrusion of the auricle (OR= 8.42; 95% CI= 1.37-51.64) and hyperemia (OR= 4.07; 95% CI= 1.09-15.23) of the mastoid were the symptoms strongly associated with a higher probability of AM. In addition to clinical features, the adjusted OR conferred by head CT was 3.09 (95% CI = 0.92-10.34). *Conclusions:* Clinical signs were most likely predictive of AM in our sample when compared to Head CT. Most common symptoms were protrusion of the auricle, hyperemia or swelling behind the ear and otalgia. (www.actabiomedica.it)

Key words: acute mastoiditis, children, emergency department, clinical signs, imaging

Introduction

Acute mastoiditis (AM) is a common complication of acute otitis media in children, complicating about 0.004% of cases (1). In recent years, since the introduction of modern antibiotic therapies, we have observed a decrease in cases of AM although some authors are describing a new surge likely due to the development of antibiotic resistance (2). Its incidence is currently estimated to be between 1.2 and 6.1 cases per 100.000 per year in the pediatric population between 0 and 14 years of age (3). Identifying specific criteria for diagnosing AM remains a matter of debate, mostly due to the fact that there is no definitive consensus regarding the role of imaging in the diagnosis of AM and of its complications (4). Gold standard in the diagnosis of AM is Magnetic Resonance Imaging (MRI) enhanced with gadolinium, which is not an exam you would perform in an Emergency Department (ED) due to its length and to the fact it usually requires pediatric patients to be sedated (5). Head Computed tomography (CT) on the other hand is a quick exam, and is considered very sensitive, although its specificity is not well assessed. Studies looking at histopathological and surgical findings found CT to be 100% sensitive but only 38% specific (6,7). Given the increasing awareness in the medical field on the use of ionized radiations in children there has been discussions regarding the necessity of CT imaging in diagnosing AM versus solely using clinical criteria. In this regard we retrospectively analyzed cases of suspected AM which accessed the ED of a major tertiary hospital in Rome to further understand if CT imaging, when done, was essential in making a diagnosis.

Patients and methods

We retrospectively analyzed medical records from the pediatric patient population which accessed the Pediatric ED of Policlinico Agostino Gemelli Hospital between January 2014 and December 2020. All medical records of patients with a suspected diagnosis of mastoiditis were reviewed. The inclusion criteria were based on the presence of clinical features indicative of AM such as otalgia, fever, protrusion of the auricle, hyperemia or swelling behind the ear, perforation on otoscopy or otorrhea. Presence of vomiting, facial nerve palsy, lymphadenopathy, headache, lethargy, upper respiratory infection (URI) or torticollis were also reviewed. Given the fact that there is no predefined algorithm in our hospital for diagnosing AM, the decision of performing a CT was based exclusively on physician preference and comfort. Therefore, some patients had CT performed and others didn't. Laboratory values were also reviewed (white blood cell count or WBC, C-Reactive Protein or CRP) as well as the presence of complications and the discharge diagnosis. Based on discharge diagnosis 36 patients out of 77 were found to have simple acute otitis media, URI or other infections involving the upper airways, but not AM. All information was obtained from the clinical and electronic archive of the hospital. The study was reviewed and approved by the Institutional Review Board, Protocol number 3738. The Kolmogorov-Smirnov test was used to determine if the continuous variables were normally distributed. The Mann-Whitney test was performed to assess if differences between two groups were statistically significant. Univariate logistic regression analysis was performed for every single clinical feature considered as well as CT scan relative to our primary outcome (diagnosis of AM), odds ratio was calculated as well as *P* value and CI. We further performed multivariate logistic regression analysis considering more than one independent variable relative to our primary outcome (dependent variable). Statistical analysis was conducted using STATA and SPSS.

Results

Our sample included 77 patients who accessed the Pediatric ED with a clinical suspicion for mastoiditis, 41 of which were confirmed to have AM. In the AM group there were 25 males (61%) and 16 females (39%), ages were between 2 months and 17 years of age (mean age of 8). 39 patients had a CT performed, 25 of which were confirmed with a diagnosis of AM, while another 16 patients from our total sample were diagnosed with AM exclusively based on clinical criteria for a total of 41 cases. CRP and WBC values were obtained for 35 patients in the AM group. Mean value for CRP was 76.49 mg/L in the AM group and 54.76 mg/L in the negative group; median value for CRP was 37.3 mg/L in the AM group and 13.6 mg/L in the negative group. Mean value for WBC was 14.56 x 10^9L in the AM group, and 13.24 x 10^9L in the negative group; median value for WBC was 13.3 x 10^9L in the AM group, and 11 x 10^9L in the negative group. Descriptive statistics are presented in Table 1.

7 patients in the AM group presented with intra cranial complications, mainly erosion of the posterior mastoid bone, intracranial abscess and in one case thrombophlebitis. In the group diagnosed with AM, 24 patients had already started oral antibiotics. Frequency of clinical features was as follows in the AM group: 28 out of 41 patients (68%) presented with otalgia, 28 patients presented with hyperemia or swelling behind the ear, 21 patients (51%) presented with protrusion of the auricle, and 21 patients presented with fever. 21 patients had an upper respiratory infection, 19 patient (46%) had otorrhea. Less frequently patients in the AM group presented with VII nerve palsy (5%), torticollis (5%), tympanic membrane

Table 1. Demographics, laboratory values and computed tomography performed in the acute mastoiditis (AM) group versus the non acute mastoiditis group.

	Acute Mastoiditis (total 41)	Non Acute Mastoiditis (total 36)	P value
Male	25 (61%)	19 (53%)	
Female	16 (39%)	17 (47%)	
Age, mean value	8 y	5 y	
Computed Tomography	25	14	
White blood count, median value	13,3 × 10^9L	11 × 10^9L	0.03
C-Reactive Protein, median value	37,3 mg/L	13,6 mg/L	0.09

perforation (5%) and lethargy (5%). On the other hand, the negative group presented most frequently with otalgia, hyperemia, and otorrhea although with less frequency when compared to the AM group. In univariable analysis (Table 2), the clinical variables of otalgia, protrusion of the auricle and hyperemia of the mastoid were found to be strongly associated with the probability of AM diagnosis when compared to obliteration of the mastoid on CT scan. In a multivariable model, considering the most frequent clinical features, protrusion (OR= 8.42; 95% CI= 1.37-51.64), otalgia (OR= 5.01; 95% CI= 1.52-16.51) and hyperemia (OR= 4.07; 95% CI= 1.09-15.23) were strongly and independently associated with AM diagnosis probability. The odds ratio conferred by a CT scan, along with the 3 major clinical features, was estimated to be 3.09 (95% CI = 0.92-10.34), lower than the clinical symptoms previously reported. When considering the 3 main clinical features, CT scan, WBC and PCR, we found the laboratory values to have the lowest OR (0.93 and 1.01 respectively) and were not statistically significant. While CT scan still had an OR lower than the clinical features reported. This is most likely due to the fact that we did not have laboratory data for all patients, specifically we had 35 measurements in the AM group and 20 in the non AM group.

Conclusions

Increasing awareness has been developing in the scientific community towards the use of ionizing radiations for diagnostic imagining in Pediatrics. Factors to consider are that a growing child has less mature and rapidly dividing tissues as well as a smaller weight and a longer life expectancy than an adult and is therefore more susceptible to the effects of ionizing radiation (8). The increased risk of cancer induced by radiation must be carefully considered and CT scans should be ordered judiciously (9). Some studies have estimated the lifetime mortality cancer risk from exposure due to a head CT in a one-year-old child to be 0.07% and 0.18% for an abdominal CT (10). According to Brenner et al. in the USA about 600.000 CT scans are performed on children every year, of these about 140.000 will eventually die of cancer and about 0.35% of them will have had a risk increase which can be attributed to radiation (10). Although in most cases the benefits of CT use outweigh the risk of radiation, there is no clear indication of its use in the diagnosis of AM (9). In our study we analyzed the contribution of CT in making a diagnosis of AM versus just using clinical criteria. An increasing body of evidence has been published to better understand the role of CT in making a diagnosis of AM. Luntz et al in 2012 in a prospective case series observed the clinical course of 71 patients diagnosed with AM and found contrast-enhanced CT to be indispensable for the diagnosis of intra cranial complications (ICCs) and therefore concluded that imaging was necessary to screen for ICCs in every case of AM (11). Other retrospective reviews based their diagnosis on both clinical and imaging studies. Chien et al. found fever and coryza to be the most frequent clinical features in cases of acute AM and in their study CT was performed on 93% of their sample and was found to be highly sensitive (12). In a review of 11 years of experience in treating AM in the pediatric population, Pang LHY at al. described the

Table 2. Univariable odds ratio (95% confidence intervals) conferred by clinical signs, symptoms, and CT scan in predicting a diagnosis of AM in a sample of 77 patients with suspected AM.

	N. of AM patients (% total)	Total number of patients (% total)	OR	95% confidence intervals		P value
CT head scan	25 (60%)	39 (51%)	2.445	0.980	6.149	0.053
Fever	21 (51%)	30 (39%)	3.150	1.192	8.323	0.019
Otalgia	28 (68%)	38 (49%)	5.600	2.097	14.953	0.000
Protrusion or swelling of the auricle	21 (51%)	23 (30%)	17.850	3.781	84.267	0.000
Hyperemia of the mastoid bone	28 (68%)	37 (48%)	6.462	2.375	17.580	0.000
Perforation	2 (5%)	4 (5%)	0.872	0.116	6.527	0.894
Otorrhea	19 (46%)	30 (39%)	1.963	0.768	5.014	0.156
7th nerve palsy	2 (5%)	3 (4%)	1.795	0.156	20.664	0.635

most common clinical features indicative of AM to be otalgia, mastoid tenderness, pain, erythema, auricular swelling and fever. In this review CT was performed in 59% of the sample and mostly in those who had failed medical management or in whom there was a suspicion of a complication (13). More recently other authors have been arguing that CT should be only used in cases of suspected ICCs. In Israel, Mansour et al. reviewed a sample of 166 patients which all underwent CT scanning as part of a standardized protocol of management for diagnosing AM. Based on the CT results and laboratory values, the authors were able to identify factors that increase the risk of ICC and that pose an indication for CT scanning on admission. These are patients with a history of prior antibiotic use and CRP >93.5 mg/L (14). This is probably due to the fact that a prior antibiotic therapy could favor the growth of antibiotic resistant bacteria predisposing patients to development of ICCs. Also in Israel, Tamir et al. reported that in a population of 46 patients who were diagnosed with AM, 92% did not require imaging and were treated conservatively based only on clinical criteria, specifically most frequent symtpoms were bulging tympanic membrane in 100% of the sample, postauricular edema and hyperemia (94% and 90% respectively). In this series indications for imaging were mainly 3, presence of neurological involvement (stupor), history of cholesteatoma and cranial nerve involvement (4). Lastly Marom et al., retrospectively reviewed 88 episodes of AM and their management. In their sample 23% of the patient population had a CT performed, mainly because ICCs were suspected, all the remaining patients were diagnosed clinically and did well with IV treatment without any further complications on a follow up period of 3 months. The clinical signs of AM most commonly seen were bulging and redness of the tympanic membrane (97%), tenderness and erythema of the postauricular region (83%) and protrusion of the auricle (89%) (15). Overall, in a systematic review looking at all literature on the subject over 27 years, the most common clinical criteria used to diagnose AM were signs of postauricular swelling, erythema, tenderness and protrusion of the auricle. In this literature review CT imaging was performed on 68% of patients when reported. The article concluded that there was no consensus regarding clinical criteria for the diagnosis of AM or the use of head CT (2). A case note review by Attlmayr et al. in the UK, compared demographic data, clinical management and complications in a cohort of children with AM between 2003-2012 and 1995-2000. Even if the use of CT and MRI was equally distributed between the two time frames, more ICCs were found in the 2003-2012 cohort, which is explained by the improved resolution and quality of the CT and MRI images in identifying ICCs (16). The increase in the number of ICCs diagnosed, despite the reduction of AM cases, could be explained by the improvements in radiological techniques and the amount of CT and MRI scans performed, detecting subtle and missed abnormalities (16). MRI enhanced with gadolinium is able to evidence subtle intracranial abnormalities that might not be visible on CT: if a suspicion of ICCs persists despite a negative CT, a MRI should be done (5). Based on recent literature it appears that the main role of radiology is to recognize the complications of AM (4,5,14). In our sample, we were able to identify the clinical signs and symptoms that most powerfully predicted diagnosis of AM which were protrusion of the auricle, hyperemia or swelling behind the ear and otalgia. CT was not as powerful in predicting the outcome, although this is also due to the fact that CT was not done for the whole sample with AM. Regardless, our analysis shows that clinical signs and symptoms could be enough to diagnose AM, start IV treatment and monitor for signs of ICC, which would warrant further imaging. Limits of the study are that it is retrospective, therefore data is not complete for the whole sample considered, also CT scanning was only performed in selected cases based on physician comfort and not a specific diagnostic algorithm. But overall, our results confirm most recent literature, where increasing evidence shows that clinical signs and symptoms should suffice for the diagnosis of AM and the use of CT scanning, given the exposure to ionized radiations, should be reserved to selected cases.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Contributors: All authors contributed to the study conception and design. Material preparation and data collection were performed by Chiara Bertolaso, Bruno Sergi, Ignazio Cammisa, Michela Sollazzo and Valeria Sardaro. The first draft of the manuscript was written by Chiara Bertolaso and all authors commented on previous versions of the manuscript. Analysis and interpretation of data were performed by Nicola Orsini. Antonio Chiaretti and Antonio Gatto made critical revisions related to relevant intellectual content of the manuscript, validation and final approval of the version of the article to be published. All authors read and approved the final manuscript.

Funding: The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Ethics approval: Ethics committee approval was obtained by the Ethics Committee of the Universita' Cattolica del Sacro Cuore, Rome Italy, with Protocol N. 0051838/20 on 22/12/2020. Protocol ID 3738.

References

1. Palva T, Virtanen H, Mäkinen J. Acute and latent mastoiditis in children. J Laryngol Otol. 1985 Feb;99 (2):127-136. doi: 10.1017/s0022215100096407.
2. van den Aardweg MT, Rovers MM, de Ru JA, Albers FWJ, Schilder AGM. A systematic review of diagnostic criteria for acute mastoiditis in children. Otol Neurotol 2008 Sep;29 (6):751–757. doi: 10.1097/MAO.0b013e31817f736b.
3. Cassano P, Ciprandi G, Passali D. Acute mastoiditis in children. Acta Biomed 2020 Feb 17;91 (1-S):54-59. doi: 10.23750/abm.v91i1-S.9259.
4. Tamir S, Schwartz Y, Peleg U, Perez R, Sichel JY. Acute mastoiditis in children: is computed tomography always necessary? Ann Otol Rhinol Laryngol 2009 Aug;118 (8): 565-569. doi: 10.1177/000348940911800806.
5. Minks DP, Porte M, Jenkins N. Acute mastoiditis-the role of radiology. Clin Radiol 2013 Apr;68 (4):397-405. doi: 10.1016/j.crad.2012.07.019
6. Stähelin-Massik J, Podvinec M, Jakscha J, Rüst ON, Greisser J, Moschopulos M, et al. Mastoiditis in children: a prospective, observational study comparing clinical presentation, microbiology, computed tomography, surgical findings and histology. Eur J Pediatr 2008 May;167 (5):541–548. doi: 10.1007/s00431-007-0549-1.
7. Migirov L. Computed tomographic versus surgical findings in complicated acute otomastoiditis. Ann Otol Rhinol Laryngol 2003 Aug;112 (8):675-677. doi: 10.1177 /000348940311200804.
8. Rao P, Bekhit E, Ramanauskas F, Kumbla S. CT head in children. Eur J Radiol 2013 Jul;82 (7):1050-1058. doi: 10.1016/j.ejrad.2011.11.038.
9. Brody AS, Frush DP, Huda W, Brent RL, American Academy of Pediatrics Section on Radiology. Radiation risk to children from computed tomography. Pediatrics 2007 Sep;120 (3):677-682. doi: 10.1542/peds.2007-1910.
10. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR Am J Roentgenol 2001 Feb;176 (2):289-296. doi: 10.2214 /ajr.176.2.1760289.
11. Luntz M, Bartal K, Brodsky A, Shihada R. Acute mastoiditis: the role of imaging for identifying intracranial complications. Laryngoscope 2012 Dec;122 (12):2813-2817. doi: 10.1002/lary.22193.
12. Chien JH, Chen YS, Hung IF, Hsieh KS, Wu KS, Cheng MF. Mastoiditis diagnosed by clinical symptoms and imaging studies in children: disease spectrum and evolving diagnostic challenges. J Microbiol Immunol Infect 2012 Oct;45 (5):377-381. doi: 10.1016/j.jmii.2011.12.008.

13. Pang LH, Barakate MS, Havas TE. Mastoiditis in a paediatric population: a review of 11 years experience in management. Int J Pediatr Otorhinolaryngol 2009 Nov;73 (11):1520-1524. doi: 10.1016/j.ijporl.2009.07.003.
14. Mansour T, Yehudai N, Tobia A, et al. Acute mastoiditis: 20 years of experience with a uniform management protocol. Int J Pediatr Otorhinolaryngol 2019 Oct; 125:187-191. doi: 10.1016/j.ijporl.2019.07.014.
15. Marom T, Roth Y, Boaz M, et al. Acute Mastoiditis in Children: Necessity and Timing of Imaging. Pediatr Infect Dis J 2016 Jan;35 (1):30-34. doi: 10.1097/INF.0000000000000920.
16. Attlmayr B, Zaman S, Scott J, Derbyshire SG, Clarke RW, De S. Paediatric acute mastoiditis, then and now: is it more of a problem now? J Laryngol Otol 2015 Oct;129(10):955-9. doi: 10.1017/S0022215115002078. PMID: 26446760.

Correspondence:
Received: 20 October 2022
Accepted: 30 November 2022

Ignazio Cammisa, MD
Department of Pediatrics, Fondazione Policlinico Universitario “A. Gemelli” IRCCS, Università Cattolica del Sacro Cuore, Rome, Italy
Via: Largo Agostino Gemelli, 8. 00168 Roma.
Phone: 0630154475
Email: cammisaignazio93@gmail.com
ORCID 0000-0002-8591-0964