



Otitis media with effusion with or without atopy: audiological findings on primary schoolchildren

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Abstract

Objective: The objective of the study was to evaluate the role of atopy in otitis media with effusion (OME) in children attending primary school, focusing on the audiometric and tympanometric measurements among atopic and nonatopic subjects suffering from OME.

Materials and methods: Three hundred ten children (5–6 years old) were screened in Western Sicily by skin tests and divided into atopics (G1) and nonatopics (G2). The samples were evaluated for OME by pneumatic otoscopy, tympanogram, and acoustic reflex tests. The parameters considered were as follows: documented persistent middle ear effusion by otoscopic examination for a minimum of 3 months, presence of B or C tympanogram, absence of ipsilateral acoustic reflex, and a conductive hearing loss greater than 25 dB at any one of the frequencies from 250 Hz through 4 kHz.

Results: The overall prevalence rate of OME was 12.9% (42.85% for G1 and 6.30% for G2, odds ratio = 11.16); OME was bilateral in 28 children (70%). B tympanogram was evidenced in 48 ears (70.59%), with a significative difference between G1 and G2 ($P < .001$). The analysis of mean air conduction pure tone (31.97 dB for G1 and 29.8 dB for G2) and of tympanometric measurements such as ear canal volume, tympanometric peak pressure, and static compliance by analysis of variance test showed a significative difference between G1 and G2 ($P < .05$).

Conclusions: The higher prevalence of OME in atopic children and the statistically significant differences in audiometric and tympanometric measurements among atopic and nonatopic subjects suffering from OME suggest the important role of allergy in the genesis and recurrence of OME.

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1. Introduction

Otitis media with effusion (OME) describes an inflammatory process within the middle ear space that is generally associated with accumulation of fluid and that may lead to hearing loss, learning difficulties, and delay of language development [1–6]. It is a common disease in children, with an incidence range from 6% to 64%. [7]. Among the major

causes of OME is the dysfunction of the eustachian tube that is generally related, in younger children, to upper respiratory tracts infections, adenoid hypertrophy, and craniofacial malformations, such as cleft palate deformities and Down syndrome [8].

The involvement of immunoglobulin E–mediated allergic reactions in the pathogenesis of OME has been suggested by clinical observations of a high prevalence of OME among patients with allergies [9–11]. In fact, several studies evidenced that 40% to 50% of children with OME, older than 3 years, had nasal allergy, whereas 21% of allergic children have OME. It is known that middle ear mucosa

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itself is rarely a target organ for allergy, and the release of biologic mediators of inflammation from basophils and mast cells occurs in the nasal and nasopharyngeal mucosa. These mediators most likely produce eustachian tube edema and inflammation. Over a long period, this chronic inflammatory response, along with viral or bacterial infection, produces middle ear effusion [12,13]. Even if, in the last years, there was a great consensus among the studies with respect to the role of atopy on OME, the knowledge on the audiological characteristics of OME among atopic and nonatopic subjects is still incomplete.

The aim of this study, carried out on primary school-children aged 5 to 6 years who had undergone skin prick tests, is to evaluate the prevalence of OME among the screened population to determine any difference either in OME incidence or in audiometric and tympanometric measurements between atopic and nonatopic subjects suffering from OME.

2. Materials and methods

This study was carried out by the Department of Audiology, University of Palermo, together with the District of Sciacca, examining a group of children attending primary schools in Sciacca from September 2006 to June 2007. The subject group consisted of 313 patients, 155 boys and 158 girls, ranging from 5 to 6 years of age. The study protocol was fully explained to patients or their guardians, and written informed consent was obtained from each patient. Children with skull-facial malformations, Down syndrome, perforated drums, and ventilation tubes were excluded from the study. At the time of the first screen, all the children underwent skin prick tests and otoscopic examination. Skin tests were performed using 12 common perennial and seasonal allergens: *Alternaria*, *Aspergillus*, *Cladosporium*, *Penicillium*, ragweed, grass mix, trees mix, cockroach, dust mites, *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*, and cat and dog epithelium. Solutions of histamine and saline were used as positive and negative controls, respectively. The results were evaluated after 10 minutes. Wheals at least 3 mm in diameter greater than wheals at the site of the negative control were considered positive. The children with at least 1 positive skin prick test result to any antigen were classified as atopic and included in group 1 (G1), whereas the children with negative skin prick test results served as nonatopic controls and were included in group 2 (G2). Patients in both groups were evaluated for OME and underwent pneumatic otoscopy. When abnormalities suggestive of OME, which included presence of retracted tympanic membranes, presence of fluid level, bubbles, and hypervascularity, were noted, tympanogram and ipsilateral acoustic reflex were performed. The instrument used was a tympanometry machine, model Amplaidd 766 (Biomedica Amplifon, Milano, Italy), with a probe frequency of 220 Hz and an air pressure range of –400 to 100

mm H₂O with automatic recording. Tympanograms were divided into the following types: type A (+99 to –99 mm H₂O), type C (>–100 mm H₂O), and type B (flat curve without peak identification). For ipsilateral acoustic reflex, the same machine was used: an Amplaidd 766 with a signal of 105 dB hearing threshold level and pure tone stimulus at 1000 and 2000 Hz. Children with otoscopic appearance of OME and abnormal tympanogram result (type B or C with no stapedial reflex) were regarded as positive screens and given a follow-up appointment within 3 months after the initial screening. The criteria for diagnosis of OME in the study were as follows: documented persistent middle ear effusion by otoscopic examination for a minimum of 3 months, presence of B or C tympanograms, absence of ipsilateral acoustic reflex, and a conductive hearing loss greater than 25 dB at any one of the frequencies from 250 Hz through 4 kHz. Audiogram was performed if the child had a type B or C tympanogram. Audiometric tests were performed using a duly calibrated pure tone audiometer and were applied to each ear at frequencies of 0.5, 1.0, 2.0, and 4.0 kHz. The tympanometry measurements considered for OME population were as follows: ear canal volume (ECV), which is an estimate of the volume of air medial to the probe, which includes the volume between the probe tip and the tympanic membrane; the tympanometric peak pressure (TTP), corresponding to ear canal pressure at which the peak of the C tympanograms occur; and the static compliance (SC), which describes the greatest amount of acoustic energy absorbed by the middle ear system.

For the statistical analysis, the χ^2 test, the odds ratio (OR), the regression analysis, the *t* test, and the analysis of variance (ANOVA, MathWorks Italia, Torino, Italy) test were calculated using the Matlab computer program.

3. Results

The total number of children examined was 313, but 3 children were excluded from the study because of skull-facial malformations and perforated drums. A total of 310 children were analyzed. The age of children ranged from 5 to 6 years, with a mean age of 5.56 years (5.59 ± 0.49 for male and 5.53 ± 0.50 for female). Of the children, 155 (50%) were boys and 155 were girls.

At the time of the first examination, based on skin tests, children were classified in 2 groups: G1 (atopics), which included 56 children (18.06%) with positive skin test results, and G2 (nonatopics), which included 254 controls (81.94%) with negative skin test results.

Of the 56 children in G1, 29 patients (51.78%) had positive skin test results for both inhalant and food allergens, 17 patients (30.36%) had a positive test result only for food allergy, and 10 (17.86%) patients had an allergy only against inhalant allergens.

During pneumatic otoscopy, a total of 44 children were found to be suspicious of OME. Of these, 4 had no evidence

of OME in the follow-up appointment after 3 months and were excluded from the study. A total number of 40 children (overall prevalence rate of 12.9%) were studied with persistent OME (≥ 3 months). Of children with OME, 12 were boys and 28 were girls.

Of the 40 children with OME, 24 (60%) were atopic (G1), whereas 16 (40%) were nonatopic (G2) (Fig. 1).

Of the 56 children in G1, 24 (42.85%) were found to suffer from OME, whereas 32 (57.15%) were healthy. Of the 254 nonatopic children in G2, 16 (6.29%) were diagnosed with OME, whereas the others (93.71%) were healthy (Fig. 2).

Of those with OME, 12 were boys (7 G1 and 5 G2) and 28 were girls (17 G1 and 11 G2). The rate of OME was 30% for boys (29.16% for G1 and 31.25% for G2) and 70% for girls (70.83% for G1 and 68.75% for G2), with a statistically significant difference ($\chi^2 = 7.384$, $P = .0067$) (Table 1).

Twenty-eight subjects had bilateral OME (70%) and 12 had unilateral OME (7 right ear and 5 left ear), for a total of 68 ears. In G1, OME was found as bilateral in 19 cases (79.17%) and unilateral in 5 cases (20.83%), for a total of 43 ears, whereas in G2, OME was found as bilateral in 9 cases (56.25%) and unilateral in 7 cases (43.75%), for a total of 25 ears.

Of the total of 68 ears, 48 ears (70.59%) had B tympanogram with negative reflex test result and 20 had C tympanogram with negative reflex test result (29.41%). As for atopic children with OME (G1), 34 ears (79.07%) had B tympanogram and 9 had C tympanogram (20.93%), whereas in G2, 14 ears (56%) had B tympanogram and 11 had C tympanogram (44%) ($\chi^2 = 4.053$, $P < .05$).

The ECV average for the total of 68 ears with OME was 0.65 ± 0.38 cc (0.59 ± 0.37 cc for the 48 ears with B tympanogram and 0.79 ± 0.36 cc for the 20 ears with C tympanogram), whereas for G1, ECV was 0.64 ± 0.38 cc (0.6 ± 0.38 cc for B tympanogram and 0.78 ± 0.37 cc for C tympanogram) and for G2, ECV was 0.66 ± 0.37 cc (0.56 ± 0.35 and 0.80 ± 0.37 cc, respectively, for B and C tympanogram).

The study of the TTP and SC among OME patients in the presence of C tympanogram showed mean values, respec-

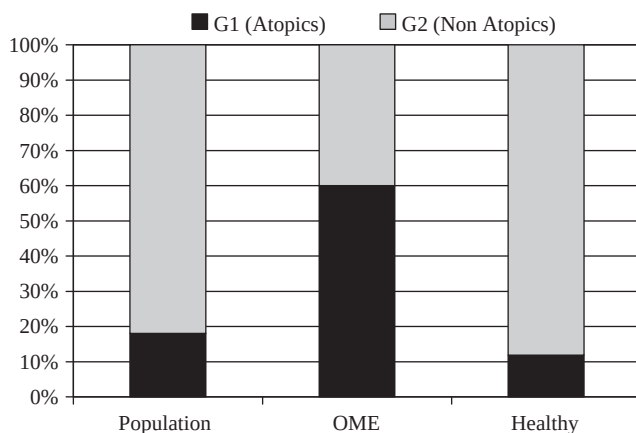


Fig. 1. Distribution of pediatric population according to OME and atopy.

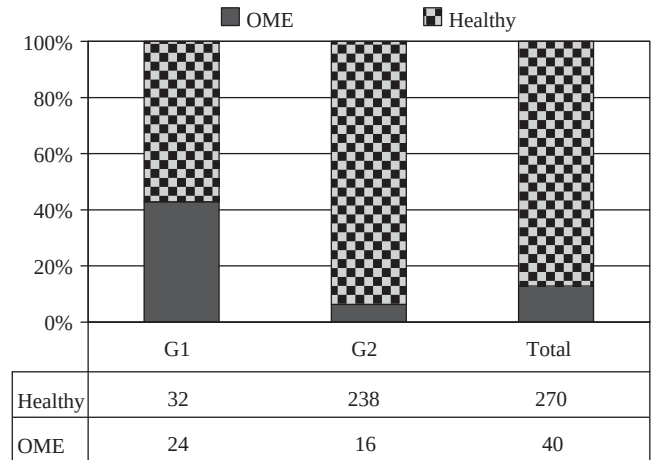


Fig. 2. Distribution of 310 children according to atopy and OME. $\chi^2 = 54.56$, degree of freedom = 1, $P = 1.50 \times 10^{-13}$.

tively, of -251.75 ± 112.24 daPa and 0.59 ± 0.23 cc. In particular, among the atopic population, the TTP average was -312.11 ± 85.49 daPa and the SC mean value was

Table 1
Audiological characteristics of OME population

Factors	OME populations			χ^2 (P value) odds ratio (95% confidence intervals)
	Atopics + nonatopics G1 + G2	Atopics G1	Nonatopics G2	
	n (%)	n (%)	n (%)	Regression coefficient b ($P < .001$)
Children				$\chi^2 = 7.384$, $P = .0067$
Boys	12 (30)	7 (29.16)	5 (31.25)	OR = 1.10 (0.28–4.37)
Girls	28 (70)	17 (70.83)	11 (68.75)	$b = 0.05$
OME				$\chi^2 = 2.401$, $P = .121$
Unilateral	12 (30)	5 (20.83)	7 (43.75)	OR = 2.96 (0.73–11.93)
Bilateral	28 (70)	19 (79.17)	9 (56.25)	$b = 0.04$
Ears				$\chi^2 = 0.004$, $P = .947$
Right	35 (51.47)	22 (51.16)	13 (52)	OR = 0.97 (0.36–2.59)
Left	33 (48.53)	21 (48.84)	12 (48)	$b = 0.06$
Tympanogram				$\chi^2 = 4.053$, $P = .044$
Tymp C	20 (35)	9 (20.93)	11 (44)	OR = 2.97 (1.01–8.73)
Tymp B	48 (65)	34 (79.07)	14 (56)	$b = 0.03$
Hearing threshold				$\chi^2 = 1.005$, $P = .985$
25–30 dB	42 (61.76)	26 (60.46)	16 (64)	OR = 0.98 (0.45–2.47)
35–40 dB	22 (32.35)	14 (32.56)	8 (32)	$b = 0.0002$
45–50 dB	3 (4.41)	2 (4.65)	1 (4)	
55–60 dB	1 (1.47)	1 (2.33)		

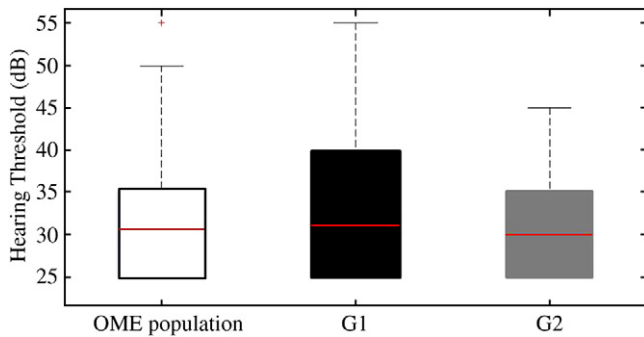


Fig. 3. Hearing threshold and ANOVA test. Average value of 31.17 dB for OME population, 31.97 dB for G1, and 29.8 dB for G2.

0.51 ± 0.12 cc, whereas for G2 OME patients, the TTP average was -202.36 ± 110.12 and the SC mean value was 0.65 ± 0.28 cc ($P < .05$).

As for audiometric threshold observed in OME population, 42 ears (61.76%) had a hearing loss between 25 and 30 dB, 22 (32.35%) between 35 and 40 dB, 3 (4.41%) between 45 and 50 dB, and 1 (1.47%) between 55 and 60 dB. The mean air conduction pure tone, according to diagnosis at frequencies 500 Hz to 4 kHz, was 31.17 dB for OME population, 31.97 dB for G1, and 29.8 dB for G2.

4. Discussion

Otitis media with effusion is defined as the presence of fluid in the middle ear without signs or symptoms of acute

ear infection. It is a common disease in children that may lead to hearing loss or surgical intervention. In most children, OME improves spontaneously and has a good prognosis; but approximately 10% of pediatric patients experience repeated or chronic OME. In addition to hearing loss, chronic OME may be associated with learning difficulties and delay of language development. The reported prevalence rates of OME among primary schoolchildren in literature were as follows: 10.4% in a study from Turkey including 912 children between 6 and 8 years of age [14], 6.8% in Italy (2132 children, 5–14 years old) [15], 9.5% in Netherlands (1004 children, 5–8 years old) [16], 13.8% in Saudi Arabia (4124 children, 1–8 years old) [17], and 6.5% in Greece (5121 children, 6–12 years old) [18].

The prevalence rate of OME in our study including 310 children between 5 and 6 years of age is 12.9%. Our results are higher than most other reports. It could be linked, according to Zielhuis et al [19], to the highest percentage value of upper respiratory tracts infections among children in the first years of school activity. As for sex, in our study, the number of girls with OME significantly exceeds the number of boys with OME ($\chi^2 = 7.384$, $P = .0067$).

The different prevalence rates may also depend on the high percentage of atopy among the population screened. In fact, the middle ear may be considered a component of the united airway in atopic individuals; and the allergic inflammation occurs uniformly in the nasopharynx, middle ear, and eustachian tube, leading to the development of OME [20].

Our epidemiologic data support the existence of a relationship between OME and atopic disease. In fact,

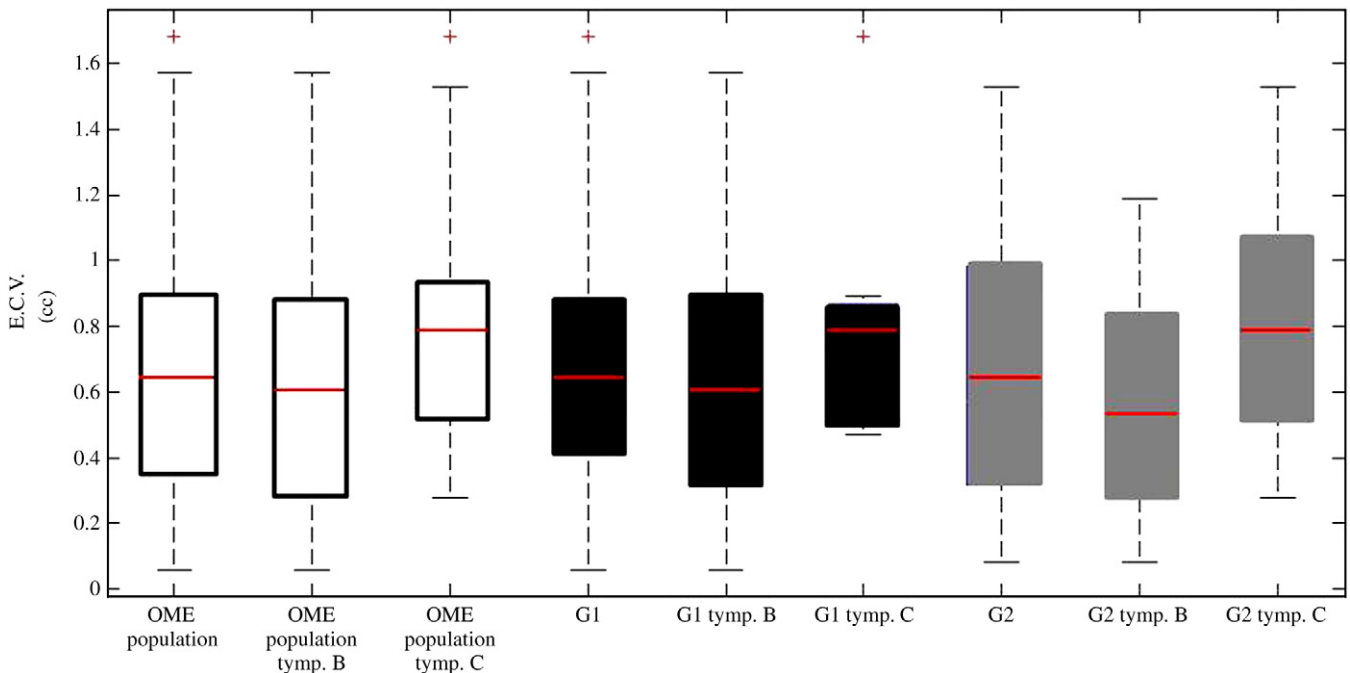


Fig. 4. Ear canal volume and ANOVA test. Mean OME population: total, 0.65 ± 0.38 cc (0.59 ± 0.37 cc for B tympanogram, 0.79 ± 0.36 cc for C tympanogram); G1, 0.64 ± 0.38 cc (0.6 ± 0.38 cc for B tympanogram and 0.78 ± 0.37 cc for C tympanogram); G2, 0.66 ± 0.37 cc (0.56 ± 0.35 and 0.80 ± 0.37 cc, respectively, for B and C tympanogram).

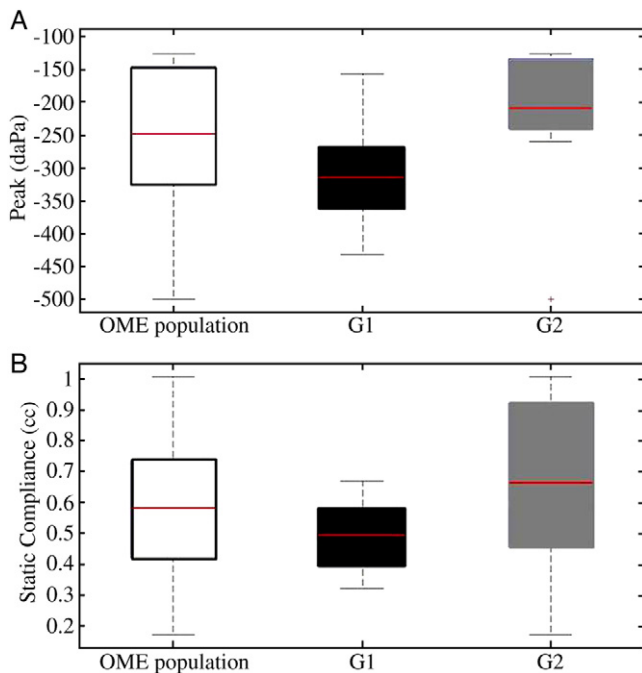


Fig. 5. Analysis of variance test for (A) TTP (mean, -251.75 ± 112.24 daPa for the OME population, -312.11 ± 85.49 daPa for G1, and -202.36 ± 110.12 for G2) and (B) SC (mean, 0.59 ± 0.23 cc for the OME population, 0.51 ± 0.12 cc for G1, and 0.65 ± 0.28 cc for G2).

statistical analysis evidenced a significant correlation between atopy and OME with a correlation index $r = 0.998$ ($\chi^2 = 54.56$, $P = 1.50 \cdot 10^{-13}$, OR = 11.16), with a higher incidence of OME among atopic population. In particular, of a total of 56 atopic children, 24 (42.85%) were found to suffer from OME, whereas 16 (6.29%) of 254 nonatopic children were diagnosed with OME (Figs. 1 and 2).

The role of atopy in the development and persistency of OME may be supported by the different audiological characteristics between atopic and nonatopic subjects. In fact, in our study, we found a predominance of bilateral OME in atopic subjects with respect to either nonatopics or total OME population; of a total of 24 atopic children suffering from OME, 19 subjects, corresponding to 79.17%, had bilateral OME, whereas only 56.25% (9/16) of the children in G2 and 70% of the OME population were found to be affected by bilateral OME. From the regression analysis, it resulted that the relative risk for bilateral OME increases significantly in the presence of atopy ($r = 0.99$, $P = .005$).

These data are also supported by the different audiological and tympanometric measurements. In fact, in both groups, hearing sensitivity ranges from slight hearing loss (20–40 dB hearing level) to moderate hearing loss (40–70 dB hearing level); but the mean air conduction pure tone was, respectively, 31.97 dB for atopics and 29.8 dB for nonatopics (index correlation $r = 0.99$, $P < .0001$). Moreover, the moderate hearing loss was evidenced in a total of 4 ears, 3 (75%) of which

belong to G1 (3/43, corresponding to a percentage rate of 6.98%), whereas only one belongs to G2 (1/25, corresponding to 4%) (Fig. 3).

In our study, there was a statistically significant predominance of B tympanograms in atopic children (79.07%) with respect to nonatopics (56%) and to the OME population (70.59%) ($\chi^2 = 4.053$, $P = .044$, OR = 2.97).

The tympanometric measurements have evidenced significant differences among the considered groups. Ear canal volume was, in all cases, within reference range (0.4–1.0 cc); but the lower values were evidenced in atopic children (mean value of 0.64 ± 0.38 cc) with respect to either nonatopics or the total OME population (0.66 ± 0.37 cc for G2 and 0.65 ± 0.38 cc for the OME population), as shown in Fig. 4 where ECV values were assessed for each group by the ANOVA test.

The study of TTP and SC among the OME population with C tympanogram also evidenced lower average values of TTP and SC in G1, with a statistically difference between G1 and G2 ($P < .05$) (Fig. 5A, B).

In sum, we concluded that the point prevalence rate of OME among primary schoolchildren aged 5 to 6 years in our series was 12.9%. The incidence of OME was higher in atopics with respect to either the total screened population or the nonatopic subjects (42.85%, 12.9%, 6.29%, respectively, for G1, overall subjects, and G2). Moreover, our results, also supported by statistical analysis, show a clear difference in audiological and tympanometric measurements between atopic and nonatopic populations. It confirms the hypothesis that allergic inflammation may have a role in the genesis and recurrence of OME indirectly by causing a persistent blockage of the eustachian tube or directly by means of middle ear mucosa inflammation.

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