

Eustachian tube dysfunction in allergic rhinitis

JUAN GERARDO LAZO-SÁENZ, MSc, ARMANDO ALEJANDO GALVÁN-AGUILERA, MD,
VERÓNICA ARACELI MARTÍNEZ-ORDAZ, MSc, VÍCTOR MANUEL VELASCO-RODRÍGUEZ, MSc,
ARMANDO NIEVES-RENTERÍA, MSc, and CUAUHTÉMOC RINCÓN-CASTAÑEDA, MD, Torreón, Coahuila, México

OBJECTIVE: To assess eustachian tube function in patients with allergic rhinitis and compare them with a control group.

STUDY DESIGN AND SETTING: Tympanometry was performed in 130 patients (260 ears), divided into 2 groups: 80 cases with allergic rhinitis and 50 healthy controls. Cases underwent skin hypersensitivity tests.

RESULTS: Cases, age 21.1 ± 14.9 ; Controls, age 23.9 ± 15.6 . Most frequent skin hypersensitivity: *Dermatophagoides pt* (62%), *Zea Maiz* (44%), and Cockroach (37%). Tympanometry of cases showed negative values of peak tympanometric pressure in both children and adults ($P \leq 0.05$). Among children under 11 years of age, 15.5% tympanograms showed abnormal curves (13% C curves and 3% B curves); among the control group only normal curves were found (type A).

CONCLUSION: Allergic rhinitis patients have a higher risk of eustachian tube dysfunction, particularly during childhood. Tympanometry is a noninvasive, readily available procedure that may be useful in these patients to prevent chronic middle-ear disease. (Otolaryngol Head Neck Surg 2005;132:626-631.)

Allergic rhinitis affects a large portion of the population, and otitis media with effusion (OME) continues to be the leading cause of hearing loss and impaired speech in children today. Controversy remains with respect to its pathogenesis, prevention, and treatment.^{1,2}

Epidemiologic studies in several countries show over 50% rate of allergic rhinitis among patients with otitis media, whereas 21% of allergic rhinitis patients

have otitis media. Among allergic children, reported incidence of otitis media is twice that of nonallergic children.³⁻⁵ The eustachian tube plays a key role in middle ear function by regulating air pressure inside the ear vis-à-vis atmospheric pressure. Disruption of this mechanism is associated with pathophysiologic changes that cause eustachian tube obstruction, mainly due to infection-related inflammation or allergic processes.⁶⁻⁸

The role of allergic rhinitis in middle-ear disease is not fully understood. Rhinitis may be related to otitis media etiology through either of 2 ways: eustachian tube dysfunction caused by allergic reaction of nasal mucosa or an impaired mucociliary function.⁹ Bernstein¹⁰ proposed 3 mechanisms that explain eustachian tube obstruction due to an inflammatory process: (1) dysfunction may represent a retrograde spread of edema and congestion of nasal mucosa; (2) mucociliary activity may cause the secretion to cover the ostium and lead to intraluminal inflammation; and (3) obstructed lumen of the eustachian tube could be the result of hypersecretion by seromucous glands. On the other hand, it has been proven that an antigen placed in the nasal mucosa of allergic rhinitis patients can induce the release of inflammation mediators, which favors obstruction of the Eustachian tube. Some nasal challenge tests with histamine and an allergen have shown that eustachian tube dysfunction may occur right after exposure, or within few hours, during late-phase.^{11,12}

Tympanometry is an objective test that assesses transmission and pressure system integrity at middle ear, it also measures auditory canal volume and eustachian tube function by introducing air under pressure.

Considering the impact of chronic middle ear disease regardless of age, we conducted this study to assess eustachian tube function using tympanometry in allergic rhinitis subjects and to compare them with healthy subjects with the aim to explore the magnitude of this problem in the population at risk seeking a rationale for preventive action.

MATERIAL AND METHOD

This is a prospective and comparative study conducted at Specialty Hospital No 71, Torreón Medical Center, Social Security Mexican Institute, from April to July 2002. A total of 130 subjects were enrolled and divided into 2 groups. Group 1 (cases) were consecutive patients with allergic rhinitis and asymptomatic of

From the Otorhinolaryngology Department (Mr Lazo-Sáenz and Dr Galván-Aguilera), the Medical Research Unit in Clinical Epidemiology (Ms Martínez-Ordaz, Mr Velasco-Rodríguez, and Mr Nieves-Rentería), and the Clinical Immunology and Allergy Department (Dr Rincón-Castañeda), Specialty Hospital No 71, Social Security Mexican Institute, Torreón, Coahuila, México.

Reprint requests: Verónica Araceli Martínez-Ordaz, Calle Dalias No. 356 colonia Torreón Jardín, Torreón, Coahuila, México, CP 27200; e-mail: veromart@internetul.com.mx.

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ear complaints, referred to the department of allergy and immunology, free of drug therapy during 2 weeks prior to study (antihistamines, steroids, decongestants, and antibiotics), and no history of immunotherapy. Work-up was carried out through a questionnaire, physical examination, and hypersensitivity skin tests that included a panel of 54 inhaled allergens (pollen, fungi, dust mites, animal dander, and hair). A neck x-ray was performed in children using soft-tissue technique to assess adenoid nasopharyngeal radius. Group 2 (controls) were healthy subjects, selected among relatives of outpatients of the same institution who agreed to participate in the study.

Exclusion criteria for both groups were: history of ear, nose, or throat surgery, congenital ear or palate malformations, trisomy 21, chronic obstructive rhinopathy, nasal polyps, metabolic diseases, family history of otic abnormalities or hearing loss, and history of chronic ear infection. Once patients and healthy controls gave their written consent to participate in the study, tympanometry was performed using a Grason-Stadler Inc GSI 38 Autotymp device, with a test tone of 226 Hz, calibrated according to the values of the American National Standards Institute (ANSI 987-1996). Tympanometric parameters assessed were compensated static acoustic admittance (Peak Ytm) that measures admittance of the external auditory canal, eardrum, and middle ear and normal values range from 0.22 to 0.8 millimhos. The equivalent volume for the auditory canal (Veq) is the estimate of the air volume between the tip of the probe and the auditory canal (range, 0.9 to 1.6 cm³), tympanometric width (TW) that measures the peak shape with values 50 to 110 daPa in adults and 60 to 150 daPa in children, and tympanometric peak pressure (TPP) that is the peak admittance in the tympanogram and constitutes an indirect measurement of the middle ear pressure through the intact eardrum. Figures under -100 daPa are considered as negative curves that reflect an impaired eustachian tube function.

The tympanographic trace was classified according to basic curve types described by Liden¹³ and Jerger¹⁴: *Type A*, normal eustachian tube function; *Type B*, flat tympanogram characteristic of the presence of fluid in the middle ear, eardrum perforations, or impacted cerumen; *Type C*, characterized by peaks at very negative pressures, typically -150 daPa, and may be indicative of eardrum retraction. Parameters obtained with pediatric table based on Palmú's¹⁵ criteria were adjusted in children under 11 years old. The cases and controls were stratified by age groups.

Analysis was performed using SPSS 10.0 version for windows software with descriptive statistics and tests for hypotheses to compare 2 independent samples.

Table 1. Groups distribution by gender and age strata

Group	Allergic	Control	Total
Children (n)	40	17	57
Age ($\bar{x} \pm SD$)	8.8 $\pm$ 4.2	7.11 $\pm$ 4.0	
Gender (m/f)	25/15	8/9	
Adults (n)	40	33	73
Age ($\bar{x} \pm SD$)	33.4 $\pm$ 11	33.9 $\pm$ 12.5	
Gender (m/f)	11/29	8/25	
Total (N)	80	50	130
Age ($\bar{x} \pm SD$)	21.1 $\pm$ 14.9	24.8 $\pm$ 16.5	
Sex (m/f)	36/44	15/35	

N, total of patients; m, male; f, female.

Table 2. Skin hypersensitivity tests

Allergens	Frequency	Percentage
<i>Dermatophagoides pt</i>	50	62%
<i>Zea Maiz</i>	35	44%
Cockroach	30	37%
<i>Franseria</i>	24	30%
<i>Fraxiuns</i>	23	29%
<i>Plantagom</i>	22	27%
<i>Aspergillus</i>	20	25%
<i>Alternaria</i>	18	23%
<i>Ambrosia</i>	16	20%

N, 80 allergic rhinitis patients.

RESULTS

A total of 130 subjects were studied: 80 in the group 1 and 50 in group 2. Study subjects distribution by age and groups is shown in Table 1. The duration of allergic rhinitis was less than 2 years in 37 (46.3%) cases, 3 to 5 years in 23 (28%) cases, and more than 5 years in 20 (25%) cases. Allergic rhinitis was considered to be perennial in 80% of cases and seasonal in the remaining. Fourteen (17.5%) patients with allergic rhinitis had bronchial asthma as well. Table 2 shows the most frequent allergens reported in skin hypersensitivity tests, headed by *Dermatophagoides pt* (62%), *Zea Maiz* (44%), and Cockroach (37%).

Mean tympanometric measurements for both ears (n = 260 ears) is shown in Table 3 indicating that both children and adults with allergic rhinitis had more negative values of tympanometric peak pressure (TPP) than controls ($P \leq 0.05$). Rate of altered Peak Y, Veq, and TW values were similar in both groups, but the TPP abnormalities were seen only in allergic rhinitis patients (Table 4). When adjustment of tympanometric parameters using Palmú's criteria was applied, of the 42 children under age 11 (29 cases of allergic rhinitis and 13 healthy controls), abnormal curves were observed in 15.5% (9 ears) among allergic rhinitis patients

Table 3. Tympanometric measurements (n = 260 ears)

	Children					Adults				
	Allergic $\bar{x} \pm SD$	Range	Control $\bar{x} \pm SD$	Range	P	Allergic $\bar{x} \pm SD$	Range	Control $\bar{x} \pm SD$	Range	P
Peak Y (millimhos)	0.57 $\pm$ 0.37	0.1-1.9	0.47 $\pm$ 0.34	0.2-1.6	NS	0.63 $\pm$ 0.45	0.1-3.3	0.61 $\pm$ 0.36	0.2-2.6	NS
Vec (cm ³)	0.80 $\pm$ 0.28	0.4-1.7	0.67 $\pm$ 0.16	0.5-1	NS	1.17 $\pm$ 0.28	0.6-2.2	1.14 $\pm$ 0.24	0.5-1.6	NS
TW (daPa)	82.87 $\pm$ 33.2	35-200	81.47 $\pm$ 22.0	120-30	NS	66.5 $\pm$ 24.2	0-130	65.75 $\pm$ 22.3	15-115	NS
TPP (daPa)	-54 $\pm$ 66.2	-250-0	-6.17 $\pm$ 9.44	-25-10	S*	-27.7 $\pm$ 45	-280-15	-15.07 $\pm$ 16.6	-70-25	S*

Peak Y, Static acoustic admittance; Vec, equivalent volume for auditory canal; TW, tympanometric width; TPP, peak admittance; NS, not significant; S*, significant at $P < 0.05$.

Table 4. Proportion of tympanometric abnormalities (N = 260 ears)

Parameter	Allergic (n = 160 ears)	Control (n = 100 ears)	P
Peak Y (millimhos)	20 (12.5%)	5 (6.0%)	0.089 NS
Vec (cm ³)	15 (9.4%)	4 (6.0%)	0.105 NS
TW (daPa)	45 (28.1%)	19 (19.0%)	0.097 NS
TPP (daPa)	18 (11.3%)	0	0.000 S*

Peak Y, Static acoustic admittance; Vec, equivalent volume for auditory canal; TW, tympanometric width; TPP, peak admittance; NS, not significant; S*, significant at $P < 0.05$.

(13% C curves, 3% B curves), and only A curves were found in the control group ($P = 0.03$).

Duration of allergic rhinitis and type of presentation (seasonal or perennial) were not associated with the tympanographic abnormalities found among cases.

ANALYSIS AND DISCUSSION

Our results show that eustachian tube function abnormalities among a group of allergic rhinitis patients were greater than that of healthy subjects. The main finding of tympanometry in these patients was the presence of negative values of tympanometric peak pressure (TPP) and abnormal curves, types C and B, in 15.5% of children with allergic rhinitis.

The role of allergy in the pathogenesis of otitis media with effusion is still controversial. The need to find new diagnostic and therapeutic strategies for this disease led to further efforts to study this association. Recent studies consider that the inflammatory mechanisms in the middle ear and nasopharynx are the major triggering factors of a series of events leading to chronic middle-ear disease. Bluestone⁶ suggests that the target mechanism of allergy-induced inflammation is eustachian tube dysfunction. This hypothesis was confirmed experimentally by Downs et al¹⁶ who stimulated allergy by transtympanic exposure to histamine that impair mucociliary transport causing eustachian tube dysfunction in rats and more recently by Hardy et

al,¹⁷ whose findings show that allergy-induced late stage of middle-ear inflammation in sensitized rats triggers a significant dysfunction of the eustachian tube and the resulting effusion. A year later, Pollock et al¹⁸ were able to prevent middle-ear effusion and eustachian tube dysfunction in sensitized rats by pretreating them with sIL-4R (soluble interleukin-4 receptor) and, to a lesser extent, with IL-5Ab (interleukin-5 antibody). Confirmation of these findings in a clinical research setting are scarce. Most studies in human beings try to set a retrospective causal linkage of this by studying patients with chronic otitis media to determine the history of an allergic background. For example, a study¹⁹ was conducted among 100 children ages 5 to 19 years with eustachian tube dysfunction, with the use of tympanometry (86.5% of B curves and 13.5% of C curves) showed a family history of allergy in 26% of study subjects and allergic rhinitis with hypersensitivity to inhaled agents in 21%. A different study²⁰ was conducted in Japan and enrolled 346 patients with otitis media with effusion; it reported allergic rhinitis in 12% of adults and 14% of children. Kayhan et al²¹ included a control group to study the same association. Although the sample was small (22 cases and 22 controls), they found that 23% of children with otitis media with effusion had signs of allergic rhinitis (symptoms, serum IgE, skin tests, and nasal challenge tests), as compared with 4.8% of children in the control group.

Comparison between our results and the former reports becomes difficult because we used the history of allergy as a starting point to determine its effects in the middle ear. Unlike other studies, we included patients who, from the otologic standpoint, were asymptomatic, without a history of chronic ear infection, chronic obstructive rhinopathy, nasal polyps, family history of ear abnormalities or hearing loss, ear and palate congenital malformation, history of ear, nose, and throat surgery, adenoid hypertrophy, trisomy 21, and metabolic disease. This represented an attempt to avoid, as far as possible, other factors interference with the effect we were trying to measure, ie, eustachian tube dysfunction.

Moreover, all rhinitis allergic patients that we included had positive skin hypersensitivity tests for inhaled allergens and clinical confirmation of allergic rhinitis. As a result of this, our results confirm the role of allergy in the middle ear from the strongest causality approach instead of retrospective studies that consider effect as a starting point. However, we are aware of the need for longitudinal studies that more clearly show a time relationship and that will resolve some unanswered questions such as: What proportion of patients with eustachian tube dysfunction will progress to chronic otitis media? To what extent could the progression of allergic patients to chronic middle-ear disease be prevented with antiallergic treatments? Are patients with longer-standing allergic rhinitis at a higher risk of progressing to chronic otitis media?

With respect to the last question, our study did not find any association between rhinitis duration and eustachian tube dysfunction. However, this is not a conclusive finding because of the possible influence of recall biases and the broad age range of enrolled patients; children had higher rates of ear abnormalities, possibly due to anatomic and physiologic features.

CONCLUSIONS

Allergic rhinitis patients have a higher risk of eustachian tube dysfunction, particularly during childhood. Tympanometry is an accessible and noninvasive procedure that may be useful in rhinitis allergic patients to prevent chronic middle ear disease. Longitudinal studies and clinical trials are needed to further support a cause-effect relationship between allergic rhinitis and otitis media.

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