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RESEARCH ARTICLE

Eustachian tube dysfunction in patients with severe sleep disordered breathing: evidence from inflation-deflation test

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Abstract

Background and Aim: Some risk factors for obstructive sleep apnea (OSA) such as upper respiratory airways abnormalities and obesity overlap with the risk factors for Eustachian tube dysfunction (ETD). In this study, we investigated the prevalence of ETD in a population of patients with OSA.

Methods: Tubal dysfunction was determined by tympanometry and inflation-deflation test in 36 patients diagnosed with severe OSA and 20 normal participants.

Results: More than 80% of patients with OSA had concomitant ETD at least in one ear. Obese participants had a smaller tympanometric peak pressure (TPP) shift after inflation-deflation test than non-obese subjects. There was no signifycant correlation between TPP shift and duration of OSA.

Conclusion: High prevalence of concomitant ETD was determined in patients with severe OSA and obese individuals. Tubal function testis suggested in patients referred for OSA evaluation.

Keywords: Eustachian tube dysfunction; inflation-deflation test; obesity; obstructive sleep apnea

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Introduction

Obstructive sleep apnea (OSA) is defined as a syndrome with recurrent respiratory tract obstructions causing decreased or ceased breathing [1]. Race, obesity, aging, male sex, smoking, alcohol intake, and upper airway dimensions are the risk factors for OSA [2-4]. The prevalence of patients at high risk for OSA ranges from 4.98% [5] to 27.3% [6] in Iran. This variation is due to the fact that the former study was performed on a higher number of women, much younger population, and larger sample size [5].

Eustachian tube [5] plays an important role in the maintenance of the normal middle ear pressure (MEP). The abnormal function of ET can lead to the middle ear under pressure and also otitis media and other related-ear diseases [7]. Various tests have been used to test ET function over the years. These include pneumatic otoscopy, manometric tests, sonotubometry, tubomanometry, endoscopy, radiological imaging, and electromyography [7-9]. Among these tests, manometric tests are the most widely used methods [7,9]. Nine-step inflation-deflation test was first described by bluestone [7]. This test is applied to evaluate ET when tympanic membrane is intact and there is no effusion in the middle ear. It is easy to administer and can be performed with a tympanometric device. Nine-step inflation-deflation test has been shown to detect ET opening in 81% of healthy ears [10]. This test predicted barotrauma in scuba divers with positive predictive value of 69%, negative predictive value of 72%, and efficiency of 71% [11].

Eustachian tube connects the middle ear cavity with the nasopharynx; therefore, it can be affectted by the repetitive obstruction of upper respiratory pathways caused by OSA. Moreover, upper airways disorders are common risk factors for both ETD and OSA. A previous study demonstrated the prevalence of the Eustachian tube dysfunction (ETD) reported as 32% in infants with OSA, which was much higher than the ETD prevalence of 4% in the general pediatric population [12]. Although etiologies for ETD and OSA in children and adults are partially different, we hypothesized that adult patients may also present some degrees of ETD. In this study, we evaluated ETD by nine-step inflation-deflation test in a population of patients examined in a snoring clinic and also investigated the correlation between ETD and sex, weight, body mass index (BMI), and duration of OSA.

Methods

Seventy eight patients were diagnosed with confirmed OSA by polysomnography. Based on respiratory disturbance index (RDI)>30 event per hour [13], 36 patients had severe OSA with no history of ear problems. Of 42 patients excluded from the study, 31 had mild or moderate OSA, 5 had oropharyngeal mass, 2 showed traumatic tympanic membrane perforation, 2 had palatal disorders, 1 had fungal otitis externa, and 1 patient had history of temporal bone fracture. Thirty six patients along with 20 normal volunteers with no history of snoring and otologic disorders were enrolled in this study. They signed written informed consent forms.

All participants underwent otoscopic examination and Eustachian tube function evaluation through inflation-deflation test. They were seated comfortably and explained about the procedures. The external ear canal was properly sealed with a rubber ear cuff. The probe set was connected to a commercial acoustic immittance system (ZS26-IB, Madsen, Denmark).

Tympanometric peak pressure (TPP) was measured at rest at 226 Hz. Tympanograms indicated type A when TPPs occurred between -100 to +50 dapa, type C when TPPs fell below -100 dapa, and type B when no measurable TPP was occurred.

For participants who showed type A tympanogram, inflation-deflation test was performed using +200 dapa (inflation) and -200 dapa (deflation) pressures, which was introduced to the ear canal of the subject. At each pressure, the participant was asked to swallow several times. Posttest tympanograms were recorded after both inflation and deflation. Tubal opening appeared as a shift in TPP in the opposite direction of applied pressure. TPP shift values less than 10 dapa in each test were considered abnormal [7,14].

BMI was calculated as kg/m^2. We used BMI cut-off point of ≥27 for obesity and <27 for non-obesity [4].

Data were expressed as mean (±SD). We used independent-sample t-test to compare TPP shifts between normal and OSA groups, as well as between obese and non-obese groups. We could not compare inflation-deflation test results between obese and non-obese patients with OSA because only five patients had BMI<27. Therefore, TPP shift values after inflation-deflation test were compared between all obese and non-obese participants with type A tympanograms. To compare TPP shifts between males and females within each group and between groups, we used Mann-Whitney U test. Spearman correlation test was used to determine the correlation between TPP shift and duration of OSA and weight. All data were analyzed using SPSS 23. The statistical significance level was set at $p<0.05$.

Results

Demographic characteristics of normal and OSA groups are presented in Table 1. There was no significant difference between right and left ear in all of the parameters; therefore, data from

Table 1. Demographic characteristics of participants in normal and obstructive sleep apnea groups

	Normal group (n =20)	OSA group (n=36)
Gender (n)		
Male/Female	6/14	25/11
Age (yr)		
Mean (SD)	51.15 (6.28)	48.72 (10.28)
Minimum	42	23
Maximum	62	70
Duration of OSA (yr)		
Mean (SD)	-	9.16 (7.96)
Minimum	-	0.5
Maximum	-	30.00
BMI (Kg/m2)		
Mean (SD)	26.10 (3.12)	33.76 (7.00)
Minimum	20.70	22.10
Maximum	33.70	55.30
≥27 (n)	7	31
Weight (Kg)		
Mean (SD)	70.10 (11.01)	91.79 (14.18)
Minimum	53	72
Maximum	92	125

OSA; obstructive sleep apnea, N; number, yr; year, BMI; body mass index

the right and left ears were averaged. The normal group showed type A tympanograms in both ears (40 ears), while 65 ears in the OSA group had normal TPPs (Table 2). TPPs in the normal group were significantly higher than TPPs of type A-OSA patients (p<0.001).

Post-inflation TPP shifts in the normal group were greater than the shifts in OSA patients with type A tympanograms (p<0.001), while post-deflation TPP shift values were not signifycantly different between the groups (p>0.05).

Compared to the lower normal limit of TPP shift values which is 10 dapa, ET dysfunction (including type C or type B tympanograms, or abnormal inflation/deflation test results) was demonstrated in both ears of 20 (55.56%) OSA patients, while in 9 (25%) patients it was detected in one ear. Only 7 (19.44%) patients had normal Eustachian tube function in both ears.

Post-inflation and deflation TPP values were not significantly different between males and females within each group and also between groups (p>0.05, Table 3).

Obese participants showed smaller TPP shift after both inflation and deflation tests than non-obese ones (inflation: 33.06±9.72 vs. 21.17±20.54, respectively, CI=3.25-20.52, p=0.008; deflation: 37.92±18.19 vs. 26.32±23.48, respectively, CI= 1.30-24.48, p=0.049).

Tympanometric peak pressure shifts after inflation and deflation were not significantly correlated with duration of OSA (p>0.05) and weight (inflation: r= -0.09, p>0.05; deflation: r= -0.32, p>0.05).

Discussion

In this study, more than 80% of patients with OSA presented Eustachian tube disfunction (ETD) at least in one ear associated with apnea during sleep. Their TPP shift values after inflation test were significantly smaller than those values in the normal group; however, deflation test results showed no significant between-group difference. In general, compared to non-obese subjects, obese participants had smaller TPP shifts after both inflation and deflation tests.

The prevalence of ETD has not yet been estimated in Iranian population. However, in UK adult population, the prevalence of ETD has been reported as 0.9%, confirmed by video endoscopy [15]. In this study, the ETD prevalence was obtained as 80% in patients with severe OSA which was much greater than the prevalence in the normal group. High prevalence of ETD can be attributed partially but not totally to lower sensitivity and specificity of inflation-deflation test compared to video endoscopy. It should be noted that all

Table 2. Mean (SD) tympanometric peak pressure and tympanogram types in normal and OSA groups

	Normal group (n=40 ears)	OSA group (n=72 ears)		
Tympanogram (n, %)				
Type A	40 (100)	65 (90.28)		
Type C	-	3 (4.17)		
Type B	-	4 (5.55)		
	Normal group (n=40 ears)	**OSA group with type A (n=65 ears)**	**p**	**95% Confidence interval (lower, upper)**
TPP at rest (dapa)				
Mean (SD)	-4.87 (8.28)	-17.85 (26.28)	<0.001	2.87, 21.60
Minimum	-25	-100		
Maximum	10	30		
TPP shift after inflation (dapa)				
Mean (SD)	32.50 (9.20)	20.40 (22.26)	<0.001	3.08, 20.42
Minimum	10	0		
Maximum	50	90		
TPP shift after deflation (dapa)				
Mean (SD)	31.38 (12.91)	27.02 (26.11)	0.266	-9.83, 12.75
Minimum	15	0		
Maximum	70	90		

OSA; obstructive sleep apnea, N; number, TPP; tympanometric peak pressure

participants in the normal group presented normal TPP shift values. Similarly, the ETD prevalence has been reported as 32% in infants with OSA compared to the general pediatric prevalence of 4% to 7% [12]. In the latter study, tubal dysfunction was determined by myringotomy and ventilation tube placement in 3-24 month old children.

Disorders in the upper respiratory pathways are a main risk factor for ETD. In general, patients with OSA have anatomically small airways [16]. Previously, it had been reported that abnormalities in the upper respiratory pathways such as narrowing of the pharyngeal lumen and changing of pharyngeal shape may lead upper-airway to collapse, which in turn causes snoring and sleep apnea [17-19]. Using computed tomography imaging during the Müller maneuver state, a recent study has shown transverse nasopharynx and anteroposterior nasopharynx decreased in patients with severe OSA. The mean cross-sectional area of nasopharynx among these patients was smaller. Moreover, patients with severe OSA presented more spherical shape at the level of nasopharynx based on their anteroposterior to transverse ratio at that level and also a strong positive association between OSA severity and the indices of upper-airway length was found [4].

It has been reported that recent drastic increases in the prevalence of OSA are associated with the increased prevalence of obesity [20]. In obese patients, increased adipose tissue in the pharyngeal structures can lead to increased

Table 3. Mean (SD) tympanometric peak pressure and tympanogram types in males and females with type A tympanograms

	Mean (SD) TPP shift after inflation (dapa)			Mean (SD) TPP shift after deflation (dapa)		
Group	**Male**	**Female**	**p***	**Male**	**Female**	**p***
Normal	29.58 (9.00)	33.75 (6.41)	0.253	25.92 (7.81)	35.00 (10.24)	0.091
OSA	17.02 (15.72)	29.44 (31.07)	0.282	27.14 (29.32)	36.39 (23.02)	0.409
p**	0.075	0.692	-	0.560	0.844	-

OSA; obstructive sleep apnea, TPP; tympanometric peak pressure, *Compared within group, **Compared between groups

tissue pressure on the pharyngeal wall and increased overall mass within these tissues that in turn can result in the airway collapse [16]. In addition, the number of adipose tissue-resident macrophages that are located in the middle ear increases secondary to obesity. These macrophages secrete agents such as cytokines and adipokines (e.g. leptin and adiponectin) that have an inflammatory effect on airways including Eustachian tube [21]. These factors may explain the high prevalence of concomitant ETD and obesity in OSA patients.

Individuals with ETD usually are represented with ear fullness, muffled hearing, or tinnitus. Clinical significance of inflation-deflation test results should be considered in association with the patients complaints.

Conclusion

Patients with severe OSA presented high prevalence of concomitant Eustachian tube dysfunction. Moreover, obese participants showed higher abnormal tubal function. Eustachian tube function evaluation and treatment are suggested in these patients.

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