

Research Article

Effects of smoking on Eustachian tube functions

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Abstract

Background: Functions of Eustachian tube are essential for middle ear health, with impact on its equalization, ventilation, and protection. Smoking has been linked to altered Eustachian tube functions, thus, affecting its activities.

Objectives: To assess the impact- of tobacco smoking on the Eustachian tube functions.

Patients and methods: Cross-sectional study was conducted on 100 adults' participants, whom divided into: group A: 50 smokers, and group B: 50 non-smokers, the Eustachian tube function was assessed via tympanometry, stapedial reflexes test (SRT), 9-steps Eustachian tube (ET) function test; inflation/deflation tympanometry test, as well as, linear regression analysis, a statcal evaluation were studied, and compared.

Results: Middle ear Pressure: in group A; -1.93 ± 15.54 SD * dapa, and in group B; 2.86 ± 11.72 SD * dapa, compliance (ml): in group A; 3.94 ± 0.63 , in group B; 1.02 ± 0.58 , ear canal volume: in group A; 0.12 ± 0.36 , and in group B; 2.97 ± 3.84 , mean tympanometry peak pressure: in group A; basal -13.59 ± 8.47 , Valsalva -9.48 ± 32 , Toynbee -7.46 ± 9.83 , and in group B; basal -29.81 ± 5.37 , Valsalva -27.49 ± 6.75 , Toynbee -59.32 ± 1.14 , type C tympanometry curve in group A; (96%), and type A curve in group B; (94%), nine-step inflation/deflation tympanometry test: in group A; (94%), and in group B; (6%), stapedial reflex absent: in group A; (94%), in group B; (4%), the linear regression analysis: in group A; ($R^2 = 0.867$), with 1.62 [95% confidence interval, CI: 1.34-2.12], and in group B; ($R^2 = 0.0124$). with 4.73 [95% confidence interval, CI 7.96-5.23].

Conclusions: A statically significant impairment in Eustachian tube functions among smokers' group.

1. Introduction

The Eustachian tube (ET) connecting the mid-ear cavity to nasopharynx, its functions are included mid-ear cavity pressure equalization, mid-ear secretions drainage, and the mid-ear from high sounds and pathogens extension from nasopharynx protection. Eustachian tube dysfunction (ETD) could be classified into obstructive, barometric and patulous [1].

Incidence of adults' population of obstructive Eustachian tube dysfunction (OETD) is predestined 5%, its symptoms; likes; otalgia (earache), ear pressure sensation, and hearing impairment; those will lower patients' life quality [2].

Many investigations assess the function of ET, but there is non-agreement on the superior schedule for ETD diagnosis, as Oto-microscopy and tympanometry, which can objectively yields information on pressure of the mid-ear, but unsuccessful in achieving direct ET function, as well as, Valsalva maneuver provide with information about ET patency, yet, it is non-physiological, as several non-patients defeat this test too, also Toynbee measure is exceedingly physiological, but nearly fifty percent of the healthful people miss to pass this test, however, its repetition is lesser to the Valsalva maneuver, Trans-nasal video endoscopy support straight assessment of the ET's opening and utilized to reveal the pathologies of the opening and assess the muscular activity, yet, the whole ET orifice that can't assessed with endoscopy properly, so, now adays, Sonotubometry, together with tubomanometry (TMM), is account the major credible investigation for ET patency [3].

Tobacco smoking of cigarettes was commoner in males about (25.7%) than in females about (1.9%), also, the World Health Organization (WHO) classifies cigarette smoking based on the level of dependence and the impact on health. The classification focuses on the degree of addiction and the risk factors associated with smoking., here is a general breakdown of the classifications: Smoker Categories: Current Smoker: A person who is actively smoking cigarettes. Ex-Smoker: A person who has quit smoking, but was previously a smoker. Non-Smoker: A person who has never smoked or has smoked very little in their lifetime. Smoking Intensity (based on the number of cigarettes smoked): Light Smoker: Typically refers to someone who smokes < 10 cigarettes daily. Moderate Smoker: A person who smokes 10–20 cigarettes daily. Heavy Smoker: Someone who smokes > 20 cigarettes daily. Health Impact: The WHO highlights that any level of smoking has detrimental effects on health, including increased risks of lung cancer, heart disease, stroke, and respiratory diseases, the risks rise with the number of cigarettes smoked and the duration of smoking [4].

Impact of smoking on ETD is quite decided in relational clinical field, yet, the quantitative correlation between smoking and ETD has never been confirmed, ETD is declare that its un – successful appropriate ventilation of ET, and even non–pressure balance between the mid–ear and nasopharynx, lead to “obstructive eustachian tube dysfunction” (OETD), the most common subtype, is happen because of the incapability to efficaciously ET dilatation, so, OETD diagnosis is made by a collection of its symptoms, together with clinical examination results and tympanometry investigation “type C tympanogram or a peak pressure < –100 deca pascals” [5, 6].

Cigarette tobacco smoking might impact hearing, via its consequences on antioxidative techniques or on vasculature providing the auditory system, also it disturbs normal ear-canal exoneration system, can establish squamous metaplasia of ET mucosa and causing exhaustion to the ET mucociliary function [7].

So, deficiency of this mucociliary clearance mechanisms, and the allergic reaction of the mucosa to tobacco smoke substances, cause chemical and gross agitation immunosuppressive consequences [8].

Different tests were applied to evaluate the ET function have generated as; tympanometry, pneumatic otoscopy, sonotubometry, and 9-step test, as well as, tubomanometry, and, none has been revealed to be fully credible, while in clinical field the ETD diagnosis is mainly depends on precise patient’s history and accurate clinical examination together with tympanometry results, since, the major issue in investigate ET is that investigation accessible to scout about its orifice under certain situations as a substitute signal for ET function, in fact, this complicated structure and has an energetic functioning and doesn’t definitely open with each swallowing, furthermore, variation in its mucosal congestion can led to remarkable alteration in its patency [9].

Since, there are shortage in clinical parameters on the consequences of tobacco smoking in the development of the middle ear pathogenesis in the adult population, so, the current study aimed to the analysis of the consequences of tobacco smoking on the ET functions.

2. Patients and methods

Cross-sectional study enrolled 100 adults’ participants, consecutively from Otolaryngology clinic, and were divided into groups; group A; consist of 50 smokers, whom smoked at least 10 cigarettes per day over a year, and group B; consist of 50 non-smokers, whom were had no smoking history or quit for over 12 months “control group”, those healthy volunteers were taken from the institutional employee and their relatives, a statial evaluation of both groups were studied, and compared, also, it performed in accordance with the Declaration of Helsinki.

Study protocol was number 187 at 03-01-2024, and was approved by the institutional ethical committee, as well as, their verbal consents were obtained.

Inclusion criteria: Adults, no acute or chronic otologic diseases, nasal or sinus infections, or structural anomalies of the nose and middle ear.

Exclusion criteria: Children, as their age < 18 years, noise exposure, ototoxicity, tinnitus, acute or chronic rhinosinusitis, systemic diseases, chronic middle ear pathologies, and present or previous ear and head trauma.

All participants were subjected to complete medical history, and precise (Ear, Nose, and Throat) ENT examination, then they were subjected to an audiological evaluation likes; pure tone audiometry, basal tympanogram, stapedial (acoustic) reflexes, and 9-steps, while the ET function test was done through inflation/deflation tympanometry test (Valsalva and Toynbee), as well as, linear regression analysis.

Smoking history, in the current study, the smoker participants included, were smoking at least 10 cigarettes daily over year, (1 pack=20 cigarettes) was defined as pack-year and calculated, thus, “Total pack-years smoked” was measured as the number of cigarettes smoked daily multiplied by the number of smoking years.

Conventional tympanometry testing, uses a probe tone at a frequency of 220 Hz, for evaluation of Eustachian tube function, with Intra acoustics AZ 26 (A/S, Assens, Denmark), in sound-proof chamber. Standard tympanometry was carried out to estimate mid-ear pressure parameter, so the initial consequence of Eustachian tube obstruction was noted; as a peak mean mid-ear pressure < –100 daPa.

The nine-steps inflation/deflation tympanometry test regarding to these points: it starts with a baseline tympanogram to measure it as a principle value, then pressure ear-canal elevated to +200 mm/H₂O, meaning, the tympanic membrane (TM) retracted in the direction of mid-ear, (at this spot, patients were instructs to swallow 3 times to bring into or keep in equilibrium the mid-ear overpressure, through the ET), If this succeeds, the second tympanogram curve performed to established mid-ear under pressure (reach its highest point at a negative pressure) was done, then, to normalizes the mid-ear pressure once more, by asking the participant again to swallow 3 times, then, to demonstrate the mid-ear pressure post re-equiponderating, the tympanogram was repeated (the peak pressure get back to 0 daPa), similar technique was done with –200 mm/H₂O ear canal pressure, here, in this status the predicted pressure being alter to positive value.

When there was un-successful result to change mid-ear pressure at minimum 10 mm/H₂O with swallowing, here this was considered, as ETD, but when it was successful, then the Eustachian tube function was considered normal.

So, Valsalva maneuver was usually done by closing mouth and nose, in order to forceful attempt of opening the Eustachian tube, while the Toynbee maneuver was done via swallowing motion with the nose closed, that’s leads to pressure changes in the middle ear.

This study assessment was done, to assess the qualitative variables, as; participants number with tubal dysfunction, and to compare them between the 2 studied groups, whereas, binary logistic linear regression test, was done to evaluate the Eustachian tube dysfunction, with cigarette exposure, taking tympanometry as dependent variable, and smoking as independent variable.

Statistical analysis

Data were analyzed using SPSS software (Inc., La Jolla, California, USA). Descriptive statistics (mean $\pm$ standard deviation) were computed for all variables. Independent t-test, and relative risks (RRs) were used to compare the Eustachian tube function between smokers and non-smokers. A p-value of < 0.05 was considered statistically significant.

3. Results

Among 100 participants involved in this study, which were divided into 2 groups (group A= 50 smoker, and group B= 50 non-smoker).

Demographic characteristics

Age group was between 18-50 years, there were 74 males (74%), and 26 females (26%), were being in group A; 36 males (72%), and 14 females (28%), and in group B; were 38 males (76%), and 12 females (24%).

The mean age (37.26 ± 1.48 SD years), as being; in smoker group A; (39.28 ± 1.64 SD years), and in non-smokers group B; (38.26 ± 1.98 SD).

About the residency

From urban area: in group A; were 38 participants (76%), and in group B; 36 participants (72%), and from rural area: in group A; were 12 participants (24%), and in group B; 14 participants (28%).

Regarding the age, gender, and the residency, there were no significant differences were detected in the 2 studied groups, as the P values were > 0.05 .

Regarding, the ears sites (right or left) were also studied, and this study found non- significant differences in comparing them in both groups, and also, in each group, as the P values were > 0.05 .

Smoking pack number per year scoped 10-40, with an average 27.63 ± 1.58 SD pack-year, a significant result was detected of the effect of smoking with increased consumption of cigarettes smoking, associated with high level of risks, with $P < 0.005$, as shown in Table 1.

Table 1: Relative Risk of smoking history with Attributable Risk

Smoker	Relative risk [95% CI]	Attributable risk (%)
10 pack/year	24.29 [3.64, 1.83]	5.76
20 pack/year	29.43 [3.91, 1.84]	5.92
30 pack/year	31.41 [2.57, 2.42]	6.63
40 pack/year	34.98 [4.86, 3.27]	6.98

There was a significant result in smoker ears with P values were < 0.005 , and the illustrative statics of clinical mid-ear parameters for both studied groups were shown in Table 2.

Table 2: Descriptive statistics and P-values for comparisons of studied groups

Parameter	Mean $\pm$ SD	Mean $\pm$ SD	P -value
	Smokers	Non-smokers	
Tympanometry	Group A	Group B	
Compliance (ml)	3.94 ± 0.63	1.02 ± 0.58	0.0025 ^s
Middle ear Pressure (dapa)	$-1.93 \pm 15.54^*$ dapa	$3.86 \pm 11.72^*$ dapa	0.0012 ^s
Ear Canal volume (ml)	0.12 ± 0.36	2.97 ± 3.84	0.0015 ^s

^s Significant, SD= Standard Deviation * Range of the middle ear pressure (dapa)

The mean tympanometry peak pressures between studied groups, revealed impaired tubal function in smokers group A, compared to non-smokers group B, as shown in Table 3. Type C tympanometry curve in smokers group A; was seen in 48 participants (96%), and type A curve was seen in 2 participants (4%), while in non-smokers group B; type A tympanometry curve was found in 47 participants, (94%), and type curve was found in (6%), with statistically significant, as $P=0.0013$.

The nine-step inflation/deflation tympanometry test was presented in smokers group A; found in 47 participants (94%), which stated as an impaired tubal function, while 3 participants (6%) in the group of non-smokers "group B", with difference was statistically significant, as $P=0.00015$.

Table 3: Evaluation of mean tympanometry peak pressures between studied groups

	Smokers Group A			Non-smokers Group B		
	Basal	Valsalva	Toynbee	Basal	Valsalva	Toynbee
	-13.59 ± 8.47	-9.48 ± 32	-7.46 ± 9.83	-29.81 ± 5.37	-27.49 ± 6.75	-59.32 ± 1.14
P value	0.001	0.002	0.012	0.003	0.003	0.004

Incidence of Stapedial (Acoustic) reflex in the 2 studied groups was statistically significant, as $P=0.0025$ in smoker ears, as shown in Table 4.

Table 4: Incidence of Stapedial Reflex in both smokers and non-smokers groups

Stapedial Reflex	Smokers Group A	Non smokers Group B	P-Value
Absent	47 (94%)	2 (4%)	$P=0.0025$
Present	3 (6%)	48 (96%)	

Eustachian tube function test analysis through Valsalva and Toynbee tympanometry test, with statistically significant results, as P values were < 0.05 , as revealed in Table 5.

Table 5: Evaluation of mean tympanometry peak pressures between studied groups

	Smokers Group A			Non-smokers Group B		
	Basal	Valsalva	Toynbee	Basal	Valsalva	Toynbee
	-13.59± 8.47	-9.48±32	-7.46±9.83	-29.81±5.37	-27.49±6.75	-59.32±1.14
P value	0.001	0.002	0.012	0.003	0.003	0.004

Linear regression test, revealed a significant relation between Eustachian tube functions and tobacco smoking, with more slope in smokers group A; where it was ($R^2 = 0.867$), with 1.62 [95% confidence interval, CI: 1.34-2.12], than in non-smokers group B; as it was ($R^2 = 0.0124$), with 4.73 [95% confidence interval, CI 7.96-5.23].

4. Discussion

Many researches had detected the impact of smoking on mid-ear, so long-time of cigarette smoke exposure has found to be led to squamous metaplasia in the ET and resulted in intense elevated negative pressure outcomes [10].

The findings in the current study, goes in line with the results of other studies, that smoking causes significant impact on Eustachian tube functions [7, 9, 10].

In this study, regarding; the age, gender, ear's site, and the residency, there were no significant differences between the both studied groups, while, there was a significant result detected of the effect of smoking with increased consumption of cigarettes smoking, these detections were agreed with other studies [8, 10, 11].

[11] in their study stated that, the wideband tympanometry tests are very common in middle disease diagnosis and follow-up; therefore, cigarette smoking must be considered and asked about during assessment of its outcomes, since fails to notice smoking might cause to ignoring their effect and then misreading these parameters.

In addition, [7] reported that, there were a several routes that smoking might impacts the function of the ET, and tympanometry results; as, a direct consequence of tobacco smoke on mid-ear and ET mucosal lining, and elevated respiratory tract infection (RTI), single research elucidated that, mid-ear ciliary clearance impairment was resulted from long-time tobacco smoke exposure, while, others researches revealed that Valsalva induced tympanometry peak pressure changes of smokers were lowers than non-smokers, thus his study aimed was to assess the correlation between smoking and the tympanometry results in 20-50 years old healthy males, his findings revealed a statistically significant difference between smokers and non-smokers ($P < 0.001$).

Also, a study done by [8], they found that smokers were significantly higher incidence of developing obstructed Eustachian tube dysfunction, which noted, as non-capability to change mid-ear pressure by 10 mm/ H_2O in process of swallowing.

Moreover [12], detected in their study, that generally, the Eustachian tube tests reveals inferior repetition activity, and it may be affected by short-lived variation although it occurs in healthy ears, so they concluded that, no test is determined to reveal the ET orifice totally.

[12, 13] studies, revealed so as to perform an systematic estimation of the tubal function, they utilized 9-steps inflation/deflation test, that had the usefulness to be done with a tympanometry, a tool which available in every institution, and doesn't require an auxiliary and costly instrument, it was noticed as credible test, as revealed ET orifice in about 81% of healthy ears, and easy method for evaluating eustachian tube function; it is normally used to evaluate the diving mid-ear pressure arrangement.

While a study performed by [14], reported that, the 9-step inflation and deflation test to assess the eustachian tube function, although it has found to be higher dependability than the simple tympanometry, but it reveals inferior replicability and so, another test; for instance, tubomanometry or a subjective questionnaire, like Eustachian tube score, must be joined to the diagnostic schedule.

Gaur found in his research, that mid-ear pathologies were significantly commoner in smokers [15].

[16] study stated, that, the impact of smoking on mid-ear was assessed in lab setting, also its correlation to otitis media in practical field, revealed that, the widely mentioned absorbance structures gives a fundamental acquaintance about the mid-ear function.

The study done by [17] on the adult males whom smoking-type called narghile, recorded that tympanometry variations were non-significant in both smokers and non-smokers.

[9], they suggest that smokers could be higher suitability to recurrent otitis media and barotrauma, results from problems in pressure equalization, this is especially remarkable for those who performs a professional or recreational diving, yet, more investigations were required to assure that the dysfunction of ET, might be regarded as hazard item for middle ear pathologies.

In current study, the relation between exposure to cigarette smoking, and ET function was widely assessed, and revealed the existence of a large smokers numbers complaining from ETD, this had fundamental clinical association, and it might lead to elevated prevalence of middle ear pathologies.

Limitations

Small sample size, and single study center, so, a longitudinal study with improved assessment of smoking, time exposure, body mass index (BMI), and blood levels of nicotine, as well as, the severity grades of hearing problem with its symptoms, must be assessed.

5. Conclusions

A statically significant impairment in Eustachian tube functions, based upon classical tympanometry, stapedial reflexes test, 9-steps Eustachian tube function test (inflation/deflation tympanometry test) results, (higher negative mid-ear pressure) in smokers' group, than those in non-smokers group.

Article Information

Disclaimer (Artificial Intelligence): The author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.), and text-to-image generators have been used during writing or editing of manuscripts.

Competing Interests: Authors have declared that no competing interests exist.

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