Effect of nasal obstruction surgery on middle ear ventilation

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Aim
The purpose of this study was to reveal the role of nasal surgeries in changing Eustachian tube function (ETF) and middle ear ventilation.

Methods
This prospective study involved 30 patients with diffrent nasal pathologies causing nasal obstruction. The patients were subjected to diffrent nasal surgeries for treating their nasal obstruction. ETF tests in the form of (Valsalva and Toynbee manuvers) together with tympanometery were performed the day before the operation, and then repeated 30 days after removal of the nasal packs. Pre and postoperative Valsalva and Toynbee tubal function tests, tympanometery and ear fullness sensation were evaluated for both ears of each patient.

Results
Preoperatively, 47 (78.3%) ears were type A, 24 ears of them had poor ETF and 23 ears had good ETF. Thirteen (21.6%) ears were type C, all of them had poor ETF. The postoperative results of ETF tests were significantly better than preoperative results ($P < 0.002$).Significant improvement in tympanometeric values was also found ($P < 0.05$). Preoperatively, 28 patients (93.3%) had sensation of ear fullness. At 30 days after removal of nasal packs, 20 patients (66.7%) still had sensation of ear fullness, with significant improvement ($P < 0.001$).

Conclusion
We suggest that nasal obstruction has a definite relationship with EFT. Surgery for nasal obstruction has a favorable effect on the middle ear pressure and EFT. Type A tympanogram not always means a good EFT but the patient may have poor EFT with Eustachian tybe dysfunction inspite of type (A) tympanogram.

Keywords:
Eustachian tube function, Valsalva, Toynbee, nasal obstruction, middle ear pressure, tympanometery

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Introduction

The Eustachian tube has at least three physiologic functions with respect to the middle ear: ventilation of the middle ear to equilibrate air pressure in the middle ear with atmospheric pressure, drainage and clearance into the nasopharynx of secretions produced within the middle ear, and protection from nasopharyngeal sound pressure and secretions. Also, it is involved in ensuring air exchange in the middle ear [1,2].

Maintaining the physiological pressure in the middle ear depends on the gaseous balance between air intake through the Eustachian tube and gas diffusion from the middle ear to the systemic circulation. The adequacy of ventilation through the tube plays a central role in preserving pressure equilibrium. When the tube opens during swallowing, air reaches the middle ear, equalizing the pressure between the external and the internal surface of the tympanic membrane [3,4].

Tympanometry and Eustachian tube function (ETF) tests (Valsalva and Toynbee maneuvers) can assess the ETF; thus, they have been used widely in clinical and basic research investigations. Patients with tubal dysfunction often complain of a sensation of ear fullness, which is a consequence of the functional impairment of the Eustachian tube resulting from a ventilatory disturbance. However, despite the sensation of ear fullness, most patients show normal middle ear pressure as measured by tympanometry [5].

The tube is frequently involved in the pathological processes of the nasal, paranasal, and rhinopharynx cavities; therefore, nasal obstruction can alter ETF [6]. The pathogenesis of otitis media has been related to the presence of previous or concurrent nasal diseases, such as upper respiratory tract viral infection and allergy. In particular, allergic rhinitis is known to be one of the main causes of chronic nasal obstruction [7–11]. It has been reported that patients with even a minimal septal deviation have a tubal dysfunction with a consequent middle ear pressure depression [12].

Most of the patients complaining of nasal obstruction require surgery for relief in their nasal obstruction. Are these surgeries that can lead to improvement in the

ETF, middle ear pressure, and sensation of ear fullness? The aim of this work is to investigate the effect of nasal obstruction surgery on ETF and middle ear ventilation.

Patients and methods

Patients

This prospective study included 30 patients who presented to the otolaryngology outpatient clinic at El-Minia University Hospital with a complaint of unilateral or bilateral nasal obstruction; they were surgically operated for correction of their nasal obstruction between July 2012 and July 2013.

Patients had different nasal pathologies causing their nasal obstruction such as chronic rhinosinusitis, marked deviated septum, antrochoanal polyp, chronic hypertrophic rhinitis, and bilateral nasal polyposis. Twenty-eight of our patients had a sensation of ear fullness. After the nasal surgery, anterior merocel nasal packs (8 and 10 cm long in each nostril, pope epistaxis packing; Medtronic, Tallahassee, Florida, USA) were left *in situ* for 2 days.

Patients with tympanic membrane perforation, acute rhinitis, and one or a recent history of middle ear infection were excluded from the study. A total of 60 ears of 30 patients were examined. Detailed assessment of medical history was performed for each patient with a full ENT examination.

Design

ETF tests in the form of (Valsalva and Toynbee maneuvers) together with tympanometry were performed the day before the surgical operation, and then repeated at 30 days after the removal of nasal packs.

Equipment

Zodiac 401 (Madson-Zodiac 401, GN. Otometrics, Denmark) middle ear analyzer was used. The tympanograms were classified in the standard manner according to Jerger [13]. A tympanogram with middle ear pressure peak between +50 and −100 daPa was classified as type A. Tympanogram with middle ear pressure peak of −100 daPa or more negative was classified as type C. A tympanogram with a flattened peak of less than 0.3 ml admittance was classified as type B.

Eustachian tube function tests

Valsalva maneuver

To evaluate the ability to inflate the middle ear actively, patients were asked to pinch the nose and inflate the checks through forced expiration with the mouth closed until a sensation of fullness was achieved in the ears. Patients were then instructed to release the nose and refrain from further swallowing or mandibular movement and an experimental tympanogram was obtained in each ear. A tympanometric peak pressure shift (generally positive) between baseline and experimental tympanogram less than 10 daPa indicated poor ETF, whereas a tympanometric peak pressure shift greater than 10 daPa indicated a good ETF [14].

Toynbee maneuver

To evaluate the capacity to equalize the middle ear pressure and the rhinopharyngeal pressure, patients were asked to swallow while pinching the nose. Patients were then instructed to release the nose and refrain from further swallowing and mandibular movement, and an experimental tympanogram was obtained from each ear. Tympanometric peak shift (generally negative) between baseline and experimental tympanogram less than 10 daPa indicated poor ETF, whereas a tympanometric peak pressure shift of greater than 10 daPa indicated a good ETF.

The study was approved by the Institutional Review Board at El-Minia University. Because the study involved no deviation from existing standard therapy for these patients and no new drugs, individual consent was not required by the board; however, an explanation of the research was provided to each patient.

Statistical analysis

The Statistical Package for Social Science (SPSS) (Illinois, Chicago, USA) was used for data analysis. Mean, median, and SD were used to describe quantitative data. Qualitative data were summarized using frequency and percentage. The χ^2-test was used to detect associations between qualitative data. A *t*-test was used for comparison between the middle ear pressure value by tympanometry preoperative and 30 days after pack removal. The comparison between preoperative and postoperative ETF tests was performed using the χ^2-test. Differences were considered significant when *P* value was 0.05 or less.

Results

The study was carried out on 30 patients who presented to the otolaryngology outpatient clinic at El-Minia University Hospital complaining of unilateral or bilateral nasal obstruction. All patients were operated on according to the cause of the nasal obstruction as shown in Table 1.

Patients' characteristics

There were 19 male patients (63.3%) and 11 female patients (36.3%). The age of the patients ranged from 18 to 60 years, mean age 34 years (Table 2). The different preoperative complaints of patients are shown in Table 3.

The relation between the laterality of nasal obstruction and preoperative tympanometry and ETF is shown in Table 4, with no significant correlation between the laterality of nasal obstruction and tympanometric type and ETF.

The relation between the preoperative nasal obstruction, middle ear pressure, and ETF: Preoperatively, the values of middle ear pressure ranged from −150 to 5 daPa, mean −22 daPa, with a significant association between nasal obstruction and negative middle ear pressure ($P < 0.001$). Also, 23 patients (76.6%) had poor ETF in at least one ear and seven patients (23.4%) had good ETF, with a significant correlation between nasal obstruction and the results of ETF.

The relation between the preoperative type of tympanometry and ETF: 47 (78.3%) ears were type A, 24 of these ears had poor ETF, and 23 ears had good ETF. Thirteen (21.6%) ears were type C, and all had poor ETF.

Table 1 Type of nasal surgery

Types of operation	Number of cases [*n* (%)]
FESS	9 (30)
Submucous resection of nasal septum (SMR)+bilateral inferior turbinectomy	8 (26.7)
FESS+SMR	6 (20)
Excision of antrochoanal polyp	2 (6.7)
Excision of antrochoanal polyp+SMR	2 (6.7)
FESS+bilateral inferior turbinectomy	1 (3.3)
SMR+excision of nasal polyps	1 (3.3)
Excision of nasal polyps+bilateral inferior turbinectomy	1 (3.3)
Total	30 (100)

FESS, functional endoscopic sinus surgery.

Table 3 Patient complaints

Patient complaints	Duration	*n* (%)
Nasal obstruction	1–7 years	30 (100)
Ear fullness	1–4 years	28 (93.3)
Diminution of hearing	1–2 years	12 (40)
Tinnitus	1–2 years	6 (20)
Ear pain	1–2 months	2 (6.6)

Table 5 Tympanometeric type preoperatively and at 30 days after removal of nasal pack

Types	Preoperative [*n* (%)]	30 days [*n* (%)]	*P* value
Type A	47 (78.3)	54 (90)	<0.0001
Type C	13 (21.6)	6 (10)	
Total	60 (100)	60 (100)	

The relation between the tympanometric type preoperatively and at 30 days after removal of nasal packs is shown in Table 5, with a significant improvement in tympanometric type from C to A ($P < 0.05$).

The relation between the middle ear pressure preoperatively and at 30 days after removal of nasal packs is shown in Table 6, with a significant improvement in middle ear pressure ($P < 0.05$). The relation between the ETF preoperatively and at 30 days after the removal of nasal packs is shown in Table 7, with a significant improvement in ETF after the nasal surgery ($P < 0.002$).

Preoperatively, 28 patients (93.3%) had a sensation of ear fullness. At 30 days after the removal of nasal packs, 20 patients (66.7%) still had a sensation of ear fullness, with significant improvement ($P < 0.001$).

Six patients (20%) had poor ETF postoperatively, four patients had pan sinusitis with bilateral nasal polyposis and underwent endoscopic sinus surgery, whereas two patients had maxillary sinusitis and marked deviated septum and had endoscopic sinus surgery plus septoplasty. Four of these patients already had poor ETF preoperatively, whereas two patients had good ETF preoperatively.

Discussion

Nasal obstruction has long been associated with middle ear diseases. It has been shown previously that nasal

Table 2 Population characteristics

Age group (years)	Number (*n*)			
		Male	Female	%
18–25	8	3	5	26.6
26–35	11	6	5	36.6
36–45	4	3	1	13.3
46–55	4	4	–	13.3
56–60	3	3	–	10
Total	30	19	11	

Table 4 Relation between laterality of nasal obstruction and preoperative tympanometry

Nasal obstructions	*n*	Tympanometric type			
		Right ear		Left ear	
		A	C	A	C
Bilateral	18	12	6	15	3
Left side	9	8	1	6	3
Right side	3	3	0	2	1

Table 6 Middle ear pressure preoperatively and 30 days after pack removal

Category	Preoperative (daPa)	30 days (daPa)	*t*-test
Range	−150 to 5	−75 to 5	$P = 0.0281$
Mean	−122	−13 166	

Table 7 Eustachian tube function tests preoperatively and at 30 days after pack removal

Category	Patients [*n* (%)]		*P* value
	Poor	Good	
Preoperative	23 (76.6)	7 (23.3)	0.0016
30 days	16 (53.3)	14 (46.6)	

obstruction alters the function of the Eustachian tube and can influence middle ear pressure [15].

A negative intratympanic pressure has been considered a sign of impairment in tubal function. The middle ear pressure can be assessed behind an intact ear drum by tympanometry, which has been used widely with great success in the diagnosis and follow-up of middle ear disease [16]. The aim of this study was to evaluate the effect of surgery of nasal obstruction on ETF and middle ear ventilation.

The results of our study showed that there was a positive effect of nasal surgery for nasal obstruction at 30 days postoperatively. On the basis of the results of this study, there was no significant relation between the laterality of nasal obstruction and the results of middle ear pressure and ETF. These results are similar to that obtained by Salvinelli *et al.* [16], who did not find a correlation between the side of nasal obstruction and tympanometric or ETF values.

Also, from our results, it was clear that nasal obstruction had an effect on middle ear pressure and ETF. These findings are similar to the results obtained by Bonding and Tos [1]. However, these results differ to some extent from the results obtained by McCurdy [17]. Three mechanisms were postulated for Eustachian tube dysfunction after nasal obstruction: first, airflow turbulence may lead to deposition of microorganisms and air pollutants in the region of Eustachian tube opining, resulting in tubal epithelium or peritubal inflammation and mechanical obstruction. Second, tubal mucous viscosity and surface tension may be increased by the drying effects of altered air currents, leading to increased tubal opening pressure. The third postulated mechanism is that the postnasal mechanical receptors' end on autonomic nerve supply to the Eustachian tube may be stimulated by altered air currents, leading to a reflex alteration in ETF [18].

Also, the results of our study showed that there is an effect of nasal obstruction surgery on the type of tympanometry and middle ear pressure, which became less negative. These results are similar to those reported by Low and Williatt [12]. However, these results differ from those of Salvinelli *et al.* [16], who found that there were no significant differences between the results of middle ear pressure in the preoperative and postoperative periods up to the 90th day. When we assessed the changes in ETF postoperatively, there was a significant improvement; this was similar to the results of Salvinelli *et al.* [16].

From the above results, it is clear that chronic nasal obstruction is a frequent cause of Eustachian tube dysfunction that can lead to middle ear hypoventilation, and that surgery for nasal obstruction improves tubal function and middle ear ventilation at least 1 month after the surgical procedure. Our data support the results of Salvinelli *et al.* [19], who suggested that tympanoplasty and nasal surgery should not be performed at the same time and that middle ear surgery should be carried out at least 3 months after nasal surgery when the anatomy and physiology of nasal, pharyngeal, and tubal mucosa have returned to normal because the Eustachian tube dysfunction and the consequent hypoventilation of middle ear are among the most frequent causes of failure of middle ear surgery. Moreover, failures in middle ear surgery are more likely to occur in patients with nasal function impairment.

Conclusion

Nasal obstruction has a definite relationship with ETF. Surgery for nasal obstruction has a favorable effect on the middle ear pressure and ETF. Type A tympanogram does not always mean a good ETF, but the patient may have poor ETF with Eustachian tube dysfunction despite type A tympanogram.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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