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Clinical Feature of Patulous Eustachian Tube and Correlation with Nasal Cavity Volume

Hyun-Keun Kwon, MD, Eui-Kyung Goh, MD, Se-Joon Oh, MD, Il-Woo Lee, MD and Soo-Keun Kong, MD

Department of Otorhinolaryngology-Head and Neck Surgery, Pusan National University School of Medicine, Busan, Korea

－ ABSTRACT －

Background and Objectives：Patulous Eustachian tube (PET) is are caused by abnormal, non-attenuated sound transmission from the pharynx to the middle ear via an open Eustachian tube (ET). Our objective was to identify the causes, clinical feature, medical treatment of PET and analyze the correlation between nasal cavity volume and PET. **Materials and Methods**：A retrospective chart review was performed on 100 patients with a diagnosis of PET from March 1, 2010, to July 31, 2011. Anti-cholinergic nasal spray (Ipratropium bromide, Rhinovent®) was used as the medical treatment. Acoustic rhinometry and paranasal sinus computed tomography (CT) was prospectively performed to examine the correlation between nasal cavity volume. **Results**：There were 56 males and 44 females, and overall mean age at diagnosis was 38.9 years. Thirty-three patients had bilateral PET and 67 patients had unilateral PET. 77 patients has no identifiable cause and 17 patients has weight loss. Anti-cholinergic nasal spray treatment (Rhinovent®) was carried out on 64 of 100 patients and 34 of the 64 patients (53.1%) achieved an improvement. AR, paranasal sinus CT was revealed no statistically significant correlation between nasal cavity volume and PET. **Conclusion**：Unilateral PET was found to be twice as common as bilateral PET. Weight loss was found to be the most common cause and autophony to be the most common symptom. Anti-cholinergic nasal sprays can be used appropriately for early treatment. No correlation was found between nasal cavity volume and PET occurrence. **(J Clinical Otolaryngol 2013;24:194-200)**

KEY WORDS：Patulous eustachian tube · Anticholinergics · Nasal cavity · Volume.

Introduction

The Eustachian tube (ET) is ordinarily closed in the resting position and dilates to the open position typically while swallowing, yawning, or during other voluntary or involuntary efforts.[1] Patients with a patulous ET (PET) have various ear symptoms such as autophony, ear fullness, and hearing their own breathing. These symptoms are caused by abnormal, non-attenuated sound transmission from the pharynx to the middle ear via an open ET.[2]

PET is believed to be caused by a loss of tissue within the cartilaginous portion of ET, and is commonly reported in patients with weight loss, especially in patients with a chronic wasting illnesses.[3,4] It has also been associated with pregnancy,[5] the use of high-dose oral contraceptives,[6] and estrogen therapy for carcinoma of the prostate,[7] and with conditions that cause atrophy or scarring within the nasopharynx and musculature, such as, adenoidectomy, radiotherapy, poliomyelitis, multiple sclerosis, neuromuscular diseases, cerebrovascular incidents, temporomandibular joint dysfunction, malocclusion, iatrogenic trauma, and craniofacial abnormalities.[6,8,9] Nevertheless, in up to one

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부산대학교 의과대학 이비인후과학교실
전화 : (051) 240-7536 · 전송 : (051) 240-8668
E-mail : entkong@gmail.com

third of PET patients have had no identifiable cause.[10)]

PET seems to be caused by loss of tissue in the superior aspect of the anterolateral wall with in the tubal valve[1)] but, etiology of PET is uncertain. There was no large study to analyze the clinical feature of PET and no study about correlation between nasal cavity volume and PET. Authors made hypothesis that more air flow through the wider nasal cavity can cause or aggravate the opening of tubal valve.

The primary objective of this study was to identify the causes, clinical feature, and treatment of PET. The secondary objective was to analyze the correlation between nasal cavity volume and PET based on acoustic rhinometry (AR) and paranasal sinus computed tomography (CT) findings.

Materials and Methods

Clinical analysis

A retrospective chart review was performed on 100 patients with a diagnosis of PET that were treated at Pusan National University Hospital in Korea from March 1, 2010, to July 31, 2011. Patient with autophony or ear fullness and whose tympanic membrane was observed to move medially and laterally with regular or forced inspiration and expiration through one nostril was diagnosed as having PET. Clinical medical records were reviewed for age, sex, cause, clinical presentation, duration from symptom onset to diagnosis, and medical treatment outcomes.

In this study, anti-cholinergic nasal spray (Ipratropium bromide, Rhinovent®) was used as the medical treatment. Of the 100 patients, 64 received medical treatment and the clinical features of the improved and not improved groups were analyzed. Patients treated medically for at least 3 months and exhibited a reduction in symptom duration or severity were allocated to the improved group. The reduction of symptom severity was assessed by visual analog scale (VAS).

Correlation between nasal cavity volume and PET

Nasopharyngoscopy was routinely performed to identify the wider nasal cavity. AR was prospectively performed to examine the correlation between nasal cavity volume and PET in 19 patients of unilateral PET and 11 patients of bilateral PET whose symptom of the unilateral side was dominant. Dominant side was defined as the side of higher VAS score. A transient-signal acoustic rhinometer (RhinoMetrics A/S, Industrivej 9, DK-3540 Lynge, Denmark) was used to perform the acoustic measurements of nasal cavity volume. For each subject, a properly fitted nosepiece was selected to prevent any acoustic leakage from the junction between the nostril and the nosepiece. All AR measurements were repeated at least three times to ensure results were reproducible. Nasal cavity volume was analyzed using affected side volume/non-affected side volume ratio (ANR). More than one ANR meant that nasal cavity volume of affected side was wider than non affected side.

To more objectively analyze nasal cavity volume, paranasal sinus CT was prospectively carried out on 17 unilateral PET patients. Paranasal sinus CT was performed by use of a multislice scanner (Somatom Sen-

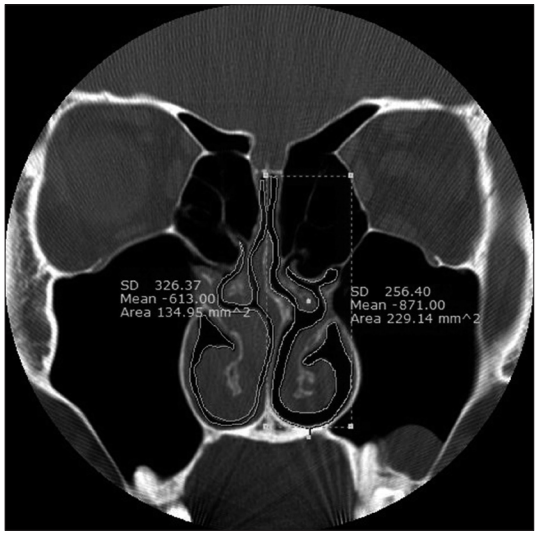

Fig. 1. Examples of CT sections from scans were used to calculate the cross-sectional areas of the middle part of the nasal cavity. Numbers on figure refer to the standard deviation in Housfield units (first row), mean density (second row), and the measured cross-sectional area in mm^2 (third row).

sation 16, Siemens, Erlangen, Germany) with tube voltage of 120 kVp and a current of 147 mA. Axial CT scanning was performed parallel to the floor of the nose using 2 mm slice thickness, and these images were subsequently reconstructed at 1 mm intervals using a bone algorithm. To determine actual cross-sectional areas of nasal cavities, inner passageway borders were manually traced on each coronal CT sections to calculate cross-sectional areas (Fig. 1). Nasal cavity volumes were then calculated by summing cross-sectional areas from the anterior nasal spine to the choanae. Nasal cavity volume was analyzed using affected side volume/non-affected side volume ratio (ANR). Patients with a paranasal sinus infection, or a history of nasal surgery were excluded.

Statistical analysis

Statistical analysis was performed using SPSS version 18.0 (SPSS, Chicago, IL). Comparisons between sample means were performed using the student's t-test, and sample rates were compared using the χ^2-test. Differences were considered significant when p values were <0.05, and results are presented as means ± standard deviations.

Results

Clinical analysis

Between March 1, 2010, to July 31, 2011, a total of 100 PET patients were treated at our hospital. There were 56 (56%) males and 44 (44%) females, and overall mean age at diagnosis was 38.9 years (range 15−78). Thirty-three patients (33%) had bilateral PET and 67 patients (67%) had unilateral PET, average duration from symptom onset to diagnosis was 50.4 months (range 0.25−360).

No significant differences were observed between the unilateral and bilateral PET groups in terms of sex, age, or duration from symptom onset to diagnosis (Table 1).

Analysis by age in all study subjects, revealed a predilection for those aged between 20 and 40 (69%). There was no identifiable cause in 77% of the 100 patients. Weight loss was found to be the most common cause, and pregnancy, adenoidectomy, radiotherapy for nasopharyngeal cancer, and facial palsy were found to contribute (Table 2).

The most common presenting symptom was autophony of one's own voice or/and breathing (79 patients, 79%). Fifty patients (50%) complainted of ear fullness and 4 patients (4%) with tinnitus (Table 3).

Anti-cholinergic nasal spray treatment (Rhinovent®) was carried out on 64 of 100 patients and 34 of the 64 patients (53.1%) achieved an improvement. A comparison of the improved and not improved groups showed that duration from symptom onset to diagnosis was shorter in the improved group. However, there was no

Table 2. Cause of patulous eustachian tube occurance (n=100)

Cause	N
No identifiable cause	77
Weight loss	17
Pregnancy	2
Adenoidectomy	2
Radiation therapy	1
Facial palsy	1

Table 3. Symptom complaints of patulous eustachian tube (n=100)

Symptom	N
Autophony	79
Ear fullness	50
Tinnitus	4

Table 1. Comparison between unilateral patulous eustachian tube and bilateral patulous eustachian tube (n=100)

	Unilateral (n=67)	Bilateral (n=33)
Male : Female	39 : 28	17 : 16
Age(yrs)	40.2±14.6 (15−78)	36.4±15.7 (16−69)
Duration from symptom onset to diagnosis (months)	44.1±81.3 (0.25−360)	63.3±73.7 (1−240)

Table 4. Comparison between improved group and not improved group from anti-cholinergic nasal spray treatment (N=64)

	Improved (n=34)	Not improved (n=30)	p value
Male : Female	14 : 20	14 : 16	0.659
Age (yrs)	41.8±14.8 (16-78)	39.3±13.9 (17-66)	0.501
Duration from symptom onset to diagnosis (months)	25.4±63.6 (0.25-360)	42.7±67.1 (0.25-240)	0.294
Unilateral : bilateral	27 : 7	19 : 11	0.153

Table 5. Nasal cavity volumes as determined from AR

Patient	Affected side (dominant side)	Affected side volume/ non-affected side volume ratio (ANR)
1	Both (left)	0.95
2	Both (left)	0.57
3	Both (left)	1.04
4	Both (left)	1.25
5	Both (left)	1.53
6	Both (left)	1.14
7	Both (left)	1.10
8	Both (right)	0.93
9	Both (right)	1.20
10	Both (right)	1.63
11	Both (right)	1.14
12	Left	0.85
13	Left	0.77
14	Left	0.67
15	Left	0.75
16	Left	0.94
17	Left	0.77
18	Left	1.71
19	Left	1.24
20	Left	1.02
21	Right	0.98
22	Right	0.74
23	Right	0.76
24	Right	0.94
25	Right	0.76
26	Right	0.54
27	Right	1.36
28	Right	1.47
29	Right	1.68
30	Right	2.30
Mean±SD		1.09±0.40

AR : acoustic rhinometry, SD : standard deviation

Table 6. Nasal cavity volumes as determined from paranasal CT

Patient	Affected side	Affected side volume/ non-affected side volume ratio (ANR)
1	Left	1.62
2	Left	2.04
3	Left	1.07
4	Right	1.03
5	Right	1.17
6	Right	0.86
7	Left	1.27
8	Right	1.21
9	Left	0.84
10	Right	0.86
11	Left	0.64
12	Left	1.69
13	Right	0.86
14	Right	0.85
15	Right	0.33
16	Right	1.09
17	Right	1.10
Mean±SD		1.09±0.41

CT : computed tomography, SD : standard deviation

statistical significance. No significant difference was found for sex or age (Table 4).

Correlation between nasal cavity volume and PET

Nasopharyngoscopy was conducted routinely when PET patients first visited our outpatient department. In 37 of 50 patients (74%) with either unilateral PET or bilateral PET whose symptom of the unilateral side was dominant, a positive correlation was found between the direction of the symptom and nasal cavity width.

AR was conducted on 30 patients with unilateral PET

or bilateral PET whose symptom of the unilateral side was dominant. However, no correlation was found between nasal cavity volume and PET (p=1.000)(Table 5).

The paranasal sinus CT was conducted on 17 patients with unilateral PET. However, no statistically significance correlation was found between nasal cavity volume and PET (p=0.622)(Table 6).

Discussion

The incidence of PET has been reported as low as 0.3% in the general population by Zollner,[11] and as high as 6.6% by Munker[12] who diagnosed the condition in 100 women with normal ears.

The most common symptoms of PET are autophony and ear fullness. Autophony is described as hearing one's own voice or/and breathing noises, which are related to the free passage of air and sound from the pharynx to the middle ear. This symptom is most prominent when pronouncing /M/ or /N/. Ear fullness and a sense of ear blockage can be misdiagnosed as dilatory dysfunction of the ET, and thus, many PET patients are initially treated with medications targeting dilatory dysfunction that fail to adress or even aggravate symptoms. Accordingly, the differential diagnosis of ear fullness should be performed carefully before decisions are made regarding treatment.

PET is usually diagnosed clinically, though the tympanic membrane and middle ear appear normal in the majority of patients. However, when the tympanic membrane is observed to move medially and laterally with regular or forced inspiration and expiration through one nostril, the diagnosis is irrefutable. If a patient does not have autophony at examination, it can be induced by physical activity, and excursions of the tympanic membrane can be enhanced by closing the contralateral or bilateral nostrils during nasal breathing. Nasopharyngeal endoscopy in the ET lumen should reveal a concave longitudinal defect in the superior aspect in the anterolateral wall of the tubal valve, rather than normal convexity.[13] Impedance tympanometry while the patient experiences autophony may be successful in documenting fluctuations in tracings synchronous with breathing but normal tracings during breath-holding.[14] Sonotubometry can directly measure ET patency.[15,16] During examination, a sound is emitted in the nasal cavity and recorded by a microphone located in the external auditory canal of the examined ear. As the ET opens, the sound recorded in the external auditor canal intensifies, and an increase of 5 dB or more is considered to reflect opening of the ET reliably.[17]

There was no way of achieving complete, permanent recovery although a number of treatment methods had been attempted. Symptoms can often be relieved by conditions that support tubal closure by increasing venous congestion in tubal tissues. Placing the head between legs, lying supine for a few minutes, and applying pressure to the ipsilateral internal jugular vein are highly effective in most patients.[1] When a patient has a correctable etiology, specific corrective treatment can be initiated. For example, weight gain, discontinuation of decongestants and nasal steroid sprays, good hydration, and nasal saline irrigation may be found useful. Various medical treatments are directed toward the augmentation of periluminal tissue by inducing congestion, irritation, or inflammation of the tubal orifice. A conjugated estrogen preparation (Premarin) can be administered as a nasal solution to cause mucosal edema,[18] and a saturated solution of potassium iodide (SSKI), an expectorant, has been used to enhance the viscosity of mucus.[10,18] A powder of boric and salicylic acid (4 : 1 ratio) insufflated to the nasopharynx or instilled with a catheter can also be used to causes local irritation and edema.[10] Other reported local irritants include silver nitrate, nitrate acid, and phenol.[10,18] However, many of these treatments provide effective but, temporary improvements.

Morita et al.[19] suggested that the topical administration of anti-cholinergics provides an effective treatment for PET. They administered intra-tubal topical atropine, an anti-cholinergic, at a dose of 0.5 mg by catheter air insufflation, and found that almost all complaints disappeared or were alleviated 30 min af-

ter treatment, and that these improvements persisted for 3−6 days. Tjernstrom et al.[20] reported that atropine reduces Eustachian tube function supposedly by inhibiting the secretion of fluid, such as S-carboxymethylcysteine,[21] from glands induced by the direct action of atropine against the cellular muscarinic receptors whose AChE positive nerves have been observed round the inlet of the eustachian tube to the middle ear.[22]

In this study, 64 patients were treated with the anticholinergic nasal spray (Ipratropium bromide, Rhinovent®), which was administered twice daily to the symptomatic nostril. Thirty-four (53.1%) of these patients experienced a symptomatic improvement. The duration from symptom onset to diagnosis was shorter in the improved group than in the not improved group. However, there is no statistical significance. We suggest that a larger-scale long-term follow up study be conducted on anti-cholinergic nasal spray treatments.

The etiology of PET has not been determined, though loss of tissue volume from within the tubal lumen is cited as the most common pathogenesis and in usually encountered in combination with weight loss.[3,4] Simonton[23] grouped etiologies into positive and negative contributory factors. Positive factors were defined as factors that actively reducing tissue volume, such as with scarring from previous procedures, inflammation, and radiation.[6,9,24] Negative factors were defined as factors that cause passive loss of tissue around the pharyngeal orifice, loss of tonic action of the tensor veli palatini muscle, and conceivably reduced ET coiling. Hormonal factors include pregnancy,[5] high-dose oral contraceptives,[6] and estrogen treatment for prostate cancer.[7,25] Reflux of gastric contents, allergies, adenoidectomy, radiotherapy, poliomyelitis, multiple sclerosis, and other neuromuscular diseases, cerebrovascular accident, temporomandibular joint dysfunction, malocclusion, iatrogenic trauma, and craniofacial abnormalities.[1,6,8,9]

Poe[1] concluded that PET appears to be caused by loss of tissue from the superior aspect of the anterolateral wall with in the tubal valve. These authors used nasopharyngoscopy in almost all patients included in this study but, anterolateral wall tissue loss was not always observed.

No study has previously addressed the correlation between nasal cavity volume and PET. In the present study, we found that PET and wider nasal cavity are correlated by nasopharyngoscopy, which supports the hypothesis that greater air flow through a wider nasal cavity aggravates opening of the tubal valve. To assess the effect of nasal cavity volume objectively, we used AR and CT. However, no significance.

Various causes of PET have been suggested in the literature but not one has been proven. However, various anatomical features can lead to PET and thus, we suggest that further studies be conducted to identify the causes of PET.

Summary

Gender was not found to affect PET occurrence but, PET was found to show a predilection for those in their 20s to 40s. Furthermore, unilateral PET was found to be twice as common as bilateral PET. No identifiable cause was identified in most patients, but weight loss was found to be the most common cause and autophony to be the most common symptom. Anti-cholinergic nasal sprays can be used appropriately for early treatment and may be effective in patients that present promptly after symptom onset. No correlation was found between nasal cavity volume and PET occurrence. We suggest that a larger-scale, long-term follow-up study will be needed in the future.

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