Dysfunction of the Eustachian tube – types of dysfunction, diagnostic algorithms, and disease evaluation.

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Abstract:
The dysfunction of the eustachian tube is a global problem that affects 1–5% of the adult population. The disease has several forms and many related conditions that can cause one form or another. Currently, there are no globally accepted diagnostic algorithms. In this medical paper, we want to shed some light on the different forms of this disease, some common symptoms, and some diagnostic pointers.

Key words:
ET dysfunction, diagnosis, treatment

Introduction:

The eustachian tube (ET) is a narrow tubular structure connecting the epipharynx to the middle ear. In the resting position the tube closed, and when swallowing, yawning, or chewing it opens temporarily. The ET has three main functions: to protect the middle ear from pathogenic microorganisms, to ventilate the tympanic cavity, and to drain secretions from it. In addition, the ET protects the inner ear from excessively loud sounds by equalizing the pressure on both sides of the tympanic membrane and thus promotes optimal perception of sound waves(1).

The pressure in the tympanic cavity is maintained by two complementary mechanisms. The first is gas exchange (2) achieved actively through the middle ear mucosa and as a result of the opening of the ET in the nasopharynx (2,6). According to recent studies, the middle ear pressure slowly decreases. The pressure rises to atmospheric via periodic opening of the ET in the nasopharynx. The second mechanism is the drainage of the tympanic cavity by peristaltic movements of the ET and the function of the so-called „mucociliary escalator" (3). The dysfunction of the ET is caused by a plethora of diseases and conditions.

Materials and Methods:

PubMed, Scopus, Web of Science, and Google Scholar databases were scoped. Inclusion criteria were articles with main topic – Eustachian tube dysfunction. Years of publications included in the review article were from 2011 to 2024. More than 80 articles were reviewed and 18 articles were included.

The hallmark of eustachian tube dysfunction:

The dysfunction of ET is the inability or limitation to perform these functions. About 2–6% of people suffer from one form of ET dysfunction of one form or another. It can occur with oedema of the ET mucosa, and there can be a failure in the act of opening or closing the ET. In these conditions, symptoms such as muffled hearing, pain, tinnitus, decreased hearing of the auditory conduction type, sensation of fullness in the ear, and perceived balance problems are possible. Complications such as otitis media with effusion in the tympanic cavity and viscous exudate, middle ear atelectasis and tympanic membrane retraction, chronic otitis media, etc. may occur (5).

Ventilation of the cavum tympani is also increasingly associated with gas exchange through the cavum mucosa, so conditions historically associated with ET dysfunction are increasingly not associated with this pathology. An abnormally long time of open ET is a separate condition called „patulous“ ET. The normal time of opening of the ET is 0.2÷0.4 sec. One in every 4–5 swallows results in the opening of the tube. When this time is exceeded or complete closure is not possible, a “patulous” ET is suspected. As symptomatology, it is possible to hear echoes of the patient’s pulse when speaking and forced breathing, the sensation of respiratory excursions of the tympanic membrane when breathing, the sensation of fullness and discomfort, and sometimes autophony (6,7).

Types of ET dysfunction:

According to a consensus developed by an international panel in 2015. (5,8)

1. Acute

2. Transient with symptoms and complaints related to the condition lasting less than 3 months (9).

3. Chronic dysfunction – symptoms and complaints related to the condition lasting over 3 months (9).

1. Obstructive ET dysfunction, subdivided into subtypes (10,16).

1.1 Functional dysfunction.

1.2 Dynamic dysfunction - musculature problem.

1.3 Anatomical obstruction (tumor).

2. Patulous ET.

3. ET with dysfunction caused by pressure change (baro-challenge-induced ET dysfunction)

Etiological causative agents:

The ET mucosa may have local oedema, and this, in turn, leads to dysfunction, the cause may be an infectious agent colonizing the upper airways. Allergic rhinitis or chronic rhinosinusitis can lead to difficulty in ET function. Some authors also add nasal septum deviation to a condition contributing to ET dysfunction. ET dysfunction may also be associated with a defect in the muscles associated with tube function. External compression of the ET due to inflammation of structures in the epipharynx or enlargement of the nasopharyngeal tonsil and tumors may lead to a similar condition. Patients with a cleft soft and/or hard palate have a much higher incidence of ET dysfunction. Potential factors that are aggravating the condition or may be triggers are: radiation exposure (post radiation-induced ET dysfunction), severe GERD, use of tobacco products, and use of inhaled and topical drugs.

Symptoms of ET dysfunction:

In order to diagnose ET dysfunction, the patient must have symptoms of improper pressure equalization in the affected middle ear, symptoms such as a feeling of fullness or popping. The feeling of discomfort, tension, or pain. Patients also report sensations such as hearing underwater, cracking, ringing, autophony, or muffled hearing.

1. Acute obstructive ET dysfunction is preceded by upper respiratory tract infections, possibly triggered by exacerbation of allergic rhinitis. Some patients reported preceding unrepeated otitis media.

2. Patulous ET is associated with symptoms of a sensation of fullness in the ear, autophony, with symptoms worsening in the supine position or with upper respiratory tract infections. They may worsen with physical exertion. Patulous ET is associated with a defect in the muscular valve that closes it (10). In this type of pathology, the ET remains open. Sound travels from the nasal cavity and epipharynx to the ears, which can result in autophony, noise from the pumping function of the heart, and loud audibility of one’s own breathing. Often patients acquire a habit of sniffing constantly. ET is almost constantly patent (11,12).

3. ET dysfunction with pressure change – fullness in the ear, crackling in the ear, discomfort or continuous pain with pressure change is found. Symptoms typically occur when diving, descending from a height, but can also occur with discrete pressure changes (13). Patients are usually without complaints (14), but with significant pressure fluctuation, middle ear discharge and even haemotympanum may occur.

Diagnostic methods:

No international standard has yet been established for the diagnosis of ET dysfunction with all its variations. At the current stage of development, it is based on a meticulous patient history (15) and examination looking for a condition leading to an ET problem. In a study carried out in the UK, patients with established ET dysfunction had pressure inside the tympanic cavity of ≤ 100 mm H_2O and an air-bone gap of 15dB(16), with peak to negative pressure values in the tympanogram. Anamnestically, patients reported an inability to „pop“ the ear with a change in barometric pressure, as well as other symptoms such as a sensation of fullness in the ear, muffled hearing, and pain. Multiple investigations support or reject the diagnosis such as tympanometry, endoscopy of the epipharynx, etc. The ETDQ-7 scale (14,15) completed by patients is used and gives good reliability for the assessment of the condition. In patients with underlying upper airway and paranasal sinus pathology, it is desirable to complete the SNOT-22 questionnaire as well(17). The diagnosis is based on detailed patient history, objective status, and objective examinations – tympanometry, otoendoscopy or otomicroscopy, reflexometry, tubometry, scintigraphy, CT scans, and MRI-T1 and T2 sequences.

Clinical assessment – signs of ET dysfunction.

1. Otoscopy/otomicroscopy – evidence of retraction of the tympanic membrane, thinning of the tympanic membrane or evidence of hypoventilation of cavum tympani.

2. Tympanometry – indicating a peak to negative values

3. Tuning fork tests – Rhine and Weber, less commonly used Schwabach, Gelle tests.

4. Audiometry

5. Nasopharyngoscopy

6. Tubomanometry (18).

For the diagnosis of obstructive ET dysfunction, it is necessary to have negative pressure on tympanometry (type D tympanogram with a peak to negative values).

The ability of air to enter the middle ear in the Valsalva and Toynbee maneuvers (6,8) confirms the patency of the ET, but this ability to self-equilibrate pressure by these maneuvers is of little clinical significance and is not specifically informative enough to rule out ET dysfunction (8).

When ET dysfunction is due to pressure changes, otoscopically there may be no changes, as well as the presence of a normal tympanogram at normal altitude. Diagnosis relies primarily on anamnestic data. In dysfunction of the patulous ET type, otoscopic micromovements of the tympanic membrane during respiration were found.

Imaging studies:

It is also possible to study ET by other methods. There is not yet a gold standard for ET imaging. MRI and CT have different modalities and are complementary (18).

Which structures are possible to identify and examine radiologically?

Bone, cartilaginous elements, and soft tissue elements are examined with CT, T1, and T2 sequences of MRI. A problem with the CT scan is the position of the patient. In the supine position, the complaints of patients with patulous ET disappear or decrease, which is associated with the closure of the ostium.

Role of functional tests on ET and rating scale

A unified method for assessing ET dysfunction is not yet available. A large number of tests have been developed: tubomanometry, sonotubometry, nine-point inflation-deflation test, and variable pressure chamber tests. The ETDQ-7 questionnaire has been developed to serve as a basis for comparing patients' symptoms, as well as helping to classify them. ETS (eustachian tube score) helps to assess the status of ET.

Evaluation of the questionnaire is performed as well as interpretation of the tubomanometry values for different values of pressure used, R is normal when less than or equal to 0, when R is greater than 1 delayed opening is present which supports the diagnosis of ET dysfunction.

Completion of the ETDQ-7 questionnaire by McCoul ED et al.(cut-off ≥ 14.5)

The Seven-Item Eustachian Tube Dysfunction Questionnaire.

Over the past 1 month, how much has each of the following been a problem for you?	No Problem		Moderate Problem			Severe Problem	
1. Pressure in the ears?	1	2	3	4	5	6	7
2. Pain in the ears?	1	2	3	4	5	6	7
3. A feeling that your ears are clogged or "under water"?	1	2	3	4	5	6	7
4. Ear symptoms when you have a cold or sinusitis?	1	2	3	4	5	6	7
5. Crackling or popping sounds in the ears?	1	2	3	4	5	6	7
6. Ringing in the ears?	1	2	3	4	5	6	7
7. A feeling that your hearing is muffled?	1	2	3	4	5	6	7

Figure 1.

For a suspected patulous ET, the PHI-10 questionnaire by Kobayashy et al may help with proper diagnosis and measuring the severity of the condition.

No	Question	Yes: 4 Sometimes: 2 No: 0
1	Because of your symptom is it difficult for you to concentrate?	
2	Does the loudness of your symptom make it difficult for you to hear people?	
3	Does your symptom make you angry?	
4	Do you feel as though you cannot escape your symptom?	
5	Does your symptom interfere with your ability to enjoy social activities?	
6	Because of your symptom do you feel frustrated?	
7	Does your symptom interfere with your job or household responsibilities?	
8	Do you feel that your symptom has placed stress on your relationships with members of your family and friends?	
9	Do you find it difficult to focus your attention away from your symptom and on to other things?	
10	Does your symptom make you feel anxious?	

Figure 2.

the epipharynx is possible, this approach is always recommended.

Conclusion:

A standard and unified approach in the investigation of Eustachian tube function has not yet been established. Many and varied physical methods are available, as well as imaging studies in different modalities. The backbone of a correct diagnosis remains a correct history, the experience of the clinician as well as the completion of standardized questionnaires ETDQ-7, PHI, and an auxiliary role has the questionnaire SNOT-22. By its characteristic, the cause of ET dysfunction is extremely extensive, this suggests to a wide range of examinations and functional tests. When an endoscopic view of

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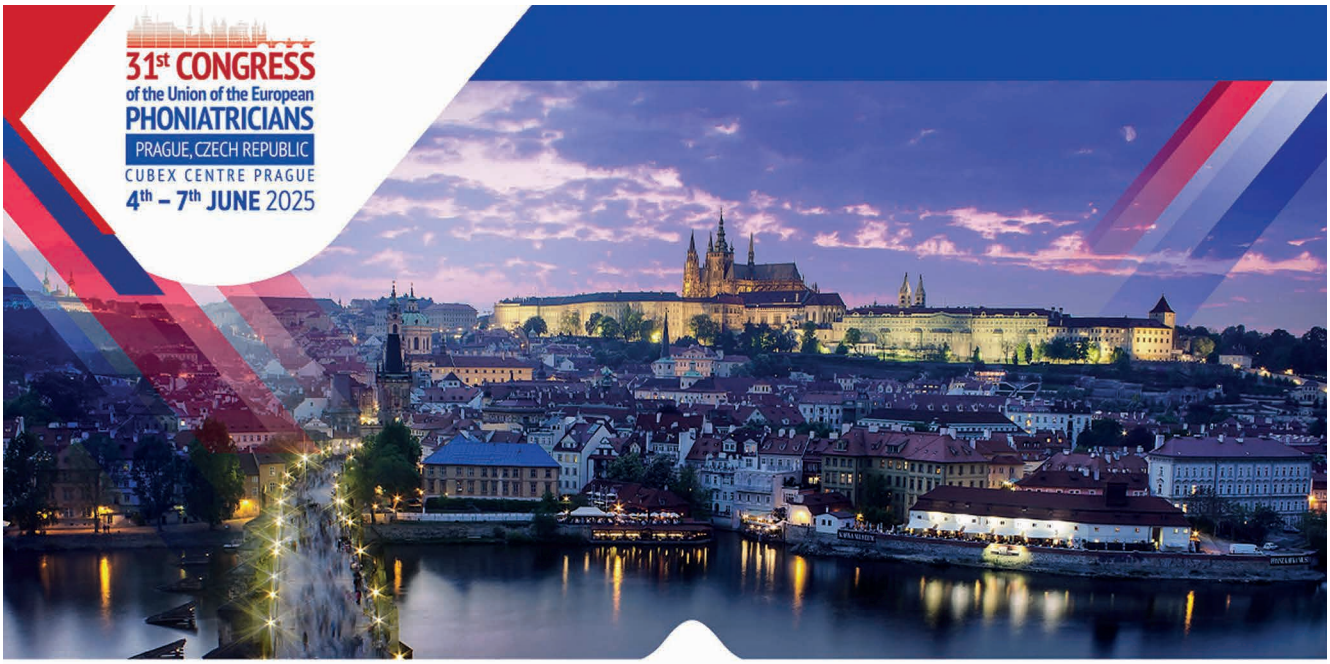
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Figures and charts:

Figure 1 – McCoul ED, Anand VK, Christos PJ. Validating the clinical assessment of eustachian tube dysfunction: The Eustachian Tube Dysfunction Questionnaire (ETDQ-7). *Laryngoscope*. 2012;122(5):1137-1141. doi:10.1002/lary.23223

Figure 2 – Suzuki, Yoko & Ikeda, Ryoukichi & Hidaka, Hiroshi & Miyazaki, Hiromitsu & Honkura, Yohei & Sato, Takeshi & Kawase, Tetsuaki & Katori, Yukio & Kobayashi, Toshimitsu. (2018). Incidence of Functional Nasal Voice in Patients With Patulous Eustachian Tube. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 39. 10.1097/MAO.0000000000001981.



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