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The Rate of Eustachian Tube Dysfunction in Adult Patients With Chronic Inflammatory Middle Ear Disease Is Low

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Objective: To assess the rate of dilatory (chronic obstructive) eustachian tube dysfunction (ETD) in adult patients scheduled for surgery for chronic inflammatory middle ear disease.

Patients: We included adult patients with chronic inflammatory middle ear disease (chronic suppurative otitis media, adhesive otitis media [middle ear atelectasis], cholesteatoma). We excluded patients with pathologies that do not stem from ETD (e.g., noninflammatory chronic middle ear disease [e.g., otosclerosis], tumors, solely external auditory canal conditions), patients scheduled for implantable electronic hearing devices independent of disease, patients with otitis media with effusion and scheduled paracentesis or ventilation tubes only, patients with previous radiotherapy or previous balloon eustachian tuboplasty, and children and patients unable to complete questionnaires.

Intervention(s): We evaluated ETD with Valsalva maneuver and in case of negative or unclear Valsalva with the eustachian tube score (ETS). A negative Valsalva maneuver and an ETS score of 5 or lower were used to define dilatory (chronic obstructive) ETD.

Main Outcome Measure(s): Rate of ETD in the included patients.

Results: From a total of 482 consecutive patients, 350 patients had positive Valsalva maneuver or ETS score higher than 5. From the 193 patients with negative or unclear Valsalva maneuver, 77 patients had an ETS score of 5 or lower, and 55 rejected further diagnostics with ETS.

Conclusions: Based on a large cohort of adult patients with chronic inflammatory middle ear disease scheduled for middle ear surgery, the majority (82%) seems to have no dilatory (chronic obstructive) ETD that can be detected with current routine clinical methods and tubomanometry. Common pathophysiological explanations should be questioned critically, especially in the context of communication with patients.

Key Words: Balloon eustachian tuboplasty—Chronic inflammatory middle ear disease—Eustachian tube—Valsalva maneuver.

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There are various causes of chronic inflammatory middle ear diseases. These include, for example, chronic infection, colonization of the nasopharynx with bacterial otopathogens, autoimmune diseases, trauma, specific dysventilation of the posterior or anterior tympanic pathways, environmental or genetic risk factors, or reduced ventilation of the middle ear by dysfunction of the eustachian tube (ET). The clinical picture is based on a chronic inflammation of the tympanic cavity and the mastoid mucosa. A disturbance of middle ear ventilation is suspected as one of the causes (1). There is a relationship between the pressure in the middle ear and the function of the ET, and it is believed that periodic opening of the ET allows an air flow between the middle ear and the nose to equal air pressure between the tympanic cavity and the atmosphere (2). Furthermore, the ET also plays an important role in the clearance of middle ear secretions and serves to protect the middle ear from infection and gastroesophageal reflux (3). The incidence of eustachian tube dysfunction (ETD) in adults is reported to be 1%, whereas in children, it is reported to be nearly 40% (4,5). The term "tubal dysfunction," however, is used ambiguously. According to Schilder et al. (3), three subtypes of ETD are described: the dilatory ETD, the baro-challenge–induced ETD, and the patulous ETD.

Here, we focus on dilatory (chronic obstructive) ETD, which includes "functional obstruction," "dynamic obstruction," and "anatomical obstruction." Tubal dysfunction is considered a cause in the development of tympanic effusions in childhood and in chronic inflammatory middle ear diseases. A feeling of pressure in the ears or the inability to perform a Valsalva maneuver may also be included in the category of tubal dysfunction. The extent to which chronic

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inflammatory middle ear disease is related to tubal dysfunction is not yet understood.

We report on the rate of dilatory (chronic obstructive) ETD detected with currently established standard clinical methods in patients with chronic inflammatory middle ear disease scheduled for middle ear surgery.

METHODS

From all consecutive patients scheduled for "ear surgery" (excluding paracentesis and/or tympanostomy tubes) in our tertiary university referral center, we selected patients with chronic inflammatory middle ear disease to evaluate for eligibility of a possible additional balloon eustachian tube (BET) dilatation along with the planned middle ear surgery.

Inclusion criteria were chronic inflammatory ear disease (chronic suppurative otitis media, adhesive otitis media [middle ear atelectasis], cholesteatoma) and an age greater than 18 years.

Exclusion criteria included previous BET, technically unfeasible tubomanometry (e.g., due to inability to understand instructions for performing tests), inability to complete questionnaires, craniofacial or middle ear malformations including cleft palate, previous radiotherapy of the cranium or in the head and neck area, otitis media with effusion with planned paracentesis and/or tympanostomy tubes only, implantation of electronic hearing devices, age less than 18 years, and diseases that do not stem from ETD (noninflammatory chronic middle ear disease [e.g., otosclerosis], tumors, solely external auditory canal conditions, etc.).

ET function in the 482 patients with chronic inflammatory middle ear disease was firstly evaluated with the Valsalva maneuver. In those patients in whom the Valsalva maneuver was clearly and immediately positive, it was assumed that there was no (relevant) chronic obstructive ETD and that an additional BET would thus not be useful. In the other patients, ET function was further investigated with the eustachian tube score (ETS) (6). These patients had a negative Valsalva maneuver or a test result that was considered unclear, for example, a slowed response or a difficult to perform Valsalva maneuver. Patients who did not hear a positive ear noise during the Valsalva maneuver or patients who did not credibly understand the maneuver were also included in ETS analysis. The ETS score is composed of the evaluation of the Valsalva maneuver, the clicking sound when swallowing, and the opening latency index (R value) at the pressure values 30, 40, and 50 mbar during tubomanometry according to Estève (DTF Medical, Saint-Étienne, France; Fig. 1, Table 1, (7)). The diagnosis of chronic obstructive ETD can be made for an ETS of 5 or less (6).

For the tubomanometry according to Estève, pressure was applied via the nasopharynx, and pressure changes in the external auditory canal were simultaneously measured during swallowing (6,8–11). The tubomanometry according to Estève can be performed in both patients with an intact ear drum and in the presence of a tympanic membrane defect. For both conditions, the ear canal must be completely sealed with the ear canal probe. An adjustment must be made on the device in cases of a tympanic membrane defect. The R value (opening latency index) indicates the latency between the application of pressure in the nasopharynx and the measurement of a pressure change in the ear canal. A nonmeasurable or negative R value indicates obstruction of the ET. An immediate opening ($R < 1$) indicates a good ET function, and a restricted tube function shows a delayed opening ($R > 1$).

Data were analyzed descriptively.

RESULTS

From June 2015 to January 2020, a total of 1,621 consecutive patients with planned "ear surgery" (without paracentesis and/or tympanostomy tubes) were admitted to our hospital. Approximately 50% of the patients (n = 802) did not have diseases that are expected to stem from ETD. Of those with chronic inflammatory middle ear disease (n = 819), approximately one-fourth (n = 198; 24%) were children, and 43 (5%) could not be included, for example, because of a language barrier. Another 43

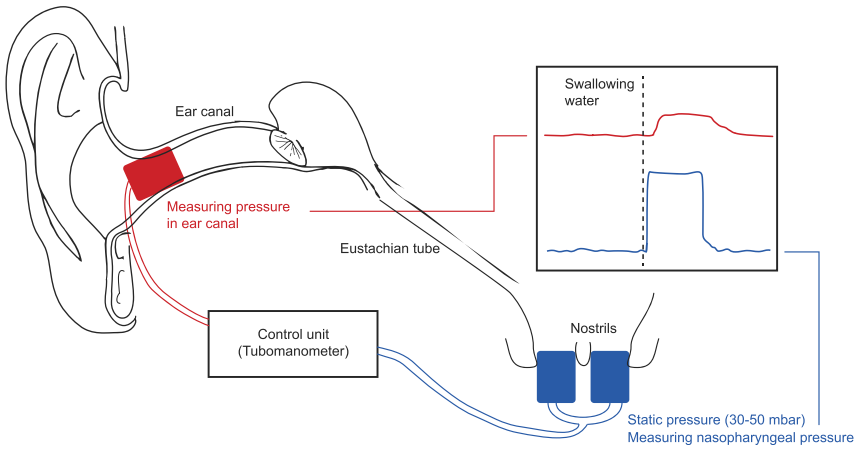

FIG. 1. Tubomanometry (TMM) examination by Estève. Pressure probes are sealed in the nose and the external ear canal to measure nasopharyngeal (blue) and ear canal pressure changes (red) after swallowing water.

TABLE 1. *Eustachian tube score*

Symptom/Finding	2 Points	1 Point	0 Points
Clicking sound when swallowing	Always	Sometimes	Never
Positive Valsalva's maneuver	Always	Sometimes	Never
TMM at 30 mbar	$R < 1$	$R \geq 1$	No *R*
TMM at 40 mbar	$R < 1$	$R \geq 1$	No *R*
TMM at 50 mbar	$R < 1$	$R \geq 1$	No *R*

Calculation of the eustachian tube score ranging from 0 to 10 points.
R indicates opening latency index; TMM, tubomanometry according to Estève.

patients (5%) had anatomical anomalies or irradiation in the head and neck area. Patients excluded based on anatomic anomalies included those with severe septal deviation, adenoids, polyps obstructing the ear canal, or ear canal stenosis. Six patients with cleft lip and palate were also excluded. Previous BET had been performed in 53 patients (6%). Details are shown in the patient flowchart (Fig. 2).

Of the remaining 482 patients, 289 patients had a prompt positive Valsalva maneuver. The other 193 patients examined showed a negative or unclear Valsalva maneuver. These were further evaluated for ETD using the ETS score.

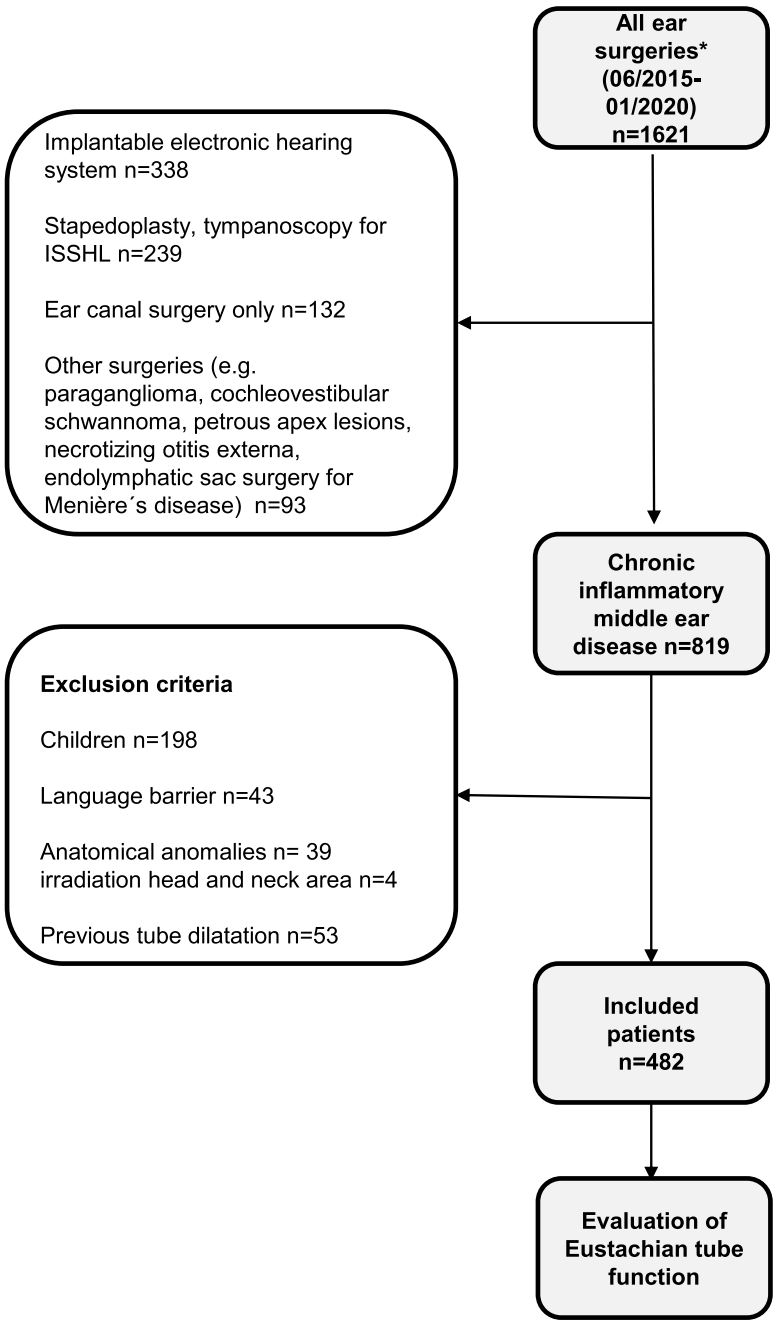

FIG. 2. Patient flowchart.

Although 55 patients refused further diagnostics, so that no explicit statement regarding the result was possible, 138 patients were tested with the ETS. Of these, 61 patients had a score higher than 5, and they were thus considered to have good ET function. The other 77 patients had an ETS of 5 or lower and—according to the definition—a chronic obstructive ETD (Fig. 3). Thus, 82% (350 of 482) of the patients with chronic inflammatory middle ear disease we studied had no measurable dilatory (chronic obstructive) ETD (excluding the 55 patients with examination refusal). Details of the studied patient population in terms of age, sex, and individual disease process are shown in Table 2.

DISCUSSION

Using established and standardized measurement procedures, we found a low percentage of adult patients with chronic inflammatory middle ear disease and concurrent tubal dysfunction. This observation clearly demonstrates that factors other than a dilatory (chronic obstructive) ETD independently constitute a risk for developing chronic middle ear disease in many cases and further supports a multifactorial pathogenesis of chronic middle ear disease. These include risk factors such as an increased rate of respiratory infections, history of allergies, family history of otitis media, social and environmental influences, and immunological factors and inflammatory systemic diseases.

Anatomical factors include the auditory tube angle, the tubotympanic angle, and Körner's septum. Elibol and Baran (12) investigated a relationship between chronic otitis media and the auditory tube angle, that is, the angle between the line of the tympanic and pharyngeal orifices of the ET and Reid's plane and the tubotympanic angle. The tubotympanic angle is the angle between the line originating from the tympanic opening the ET and the longitudinal axis originating from the center of the external auditory canal. There is evidence that changes in the auditory tube angle and the tubotympanic angle may reduce the protective functions of the ET and lead to changes in the ventilation of the middle ear and thus to an increased risk of developing chronic middle ear diseases (12). Regarding the auditory tube angle, the correlation with chronic middle ear disease is ambiguously described. In a study by Dinç et al. (13), no significant relationship between chronic otitis media and the auditory tube angle was reported. A study by Takasaki et al. (14), showed no difference in children with and without chronic otitis media in terms of auditory tube angle. In contrast, there is also research that shows a relationship between chronic ear disease and the auditory tube angle. Aksoy et al. (15) demonstrated a relationship between a reduced auditory tube angle and the occurrence of chronic ear diseases. Elibol and Baran (12) and Yang et al. (16) found a relationship between a chronic ear disease and a narrower auditory tube angle. Masita et al. (17) found that the auditory tube angle was lowest in patients with cholesteatoma, followed by those with chronic otitis media mesotympanalis and highest in those without middle ear diseases.

Correlations between anatomy and disease were also reported regarding the tubotympanic angle. In studies by

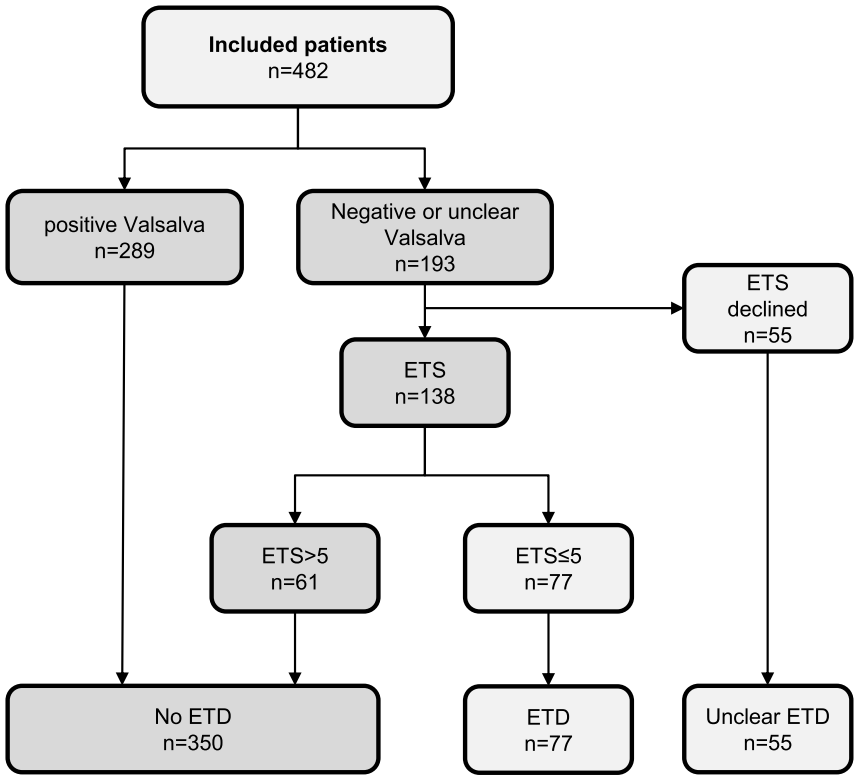

FIG. 3. Diagnostic flowchart for evaluation of eustachian tube function in target cohort.

TABLE 2. *Patient demographics and disease*

	Total	Valsalva Positive	Valsalva Negative or Unclear		
			ETS > 5	ETS Declined	ETS ≤ 5
All patients					
N	482	289	61	55	77
Male	235 (49%)	141 (49%)	32 (52%)	23 (42%)	39 (51%)
Female	247 (51%)	148 (51%)	29 (48%)	32 (58%)	38 (49%)
Age, mean ± SD (yr)	50.9 ± 15.7	50.5 ± 15.7	53.1 ± 15.3	48.7 ± 19.2	52.5 ± 13.4
Pathology subgroups					
Chronic suppurative Otitis media	265 (55%)	156 (54%)	44 (72%)	24 (44%)	41 (53%)
Adhesive otitis media/middle ear atelectasis	31 (6%)	17 (6%)	4 (7%)	5 (9%)	5 (7%)
Cholesteatoma	186 (39%)	116 (40%)	13 (21%)	26 (47%)	31 (40%)

ETS indicates eustachian tube score; SD, standard deviation.

Nemade et al. (18) and by Elibol and Baran (12), the value of the tubotympanic angle was higher in patients with chronic otitis. The influence of the ET length should also be considered. The length of the ET was reported as being shorter in ears with cholesteatoma compared with patients with a tympanic membrane with retraction pockets (13).

Another factor influencing the development of chronic middle ear disease is the persistence of the lamina petrosquamosa (Körner's septum). This lamina marks the junction of the squamous and the petrous part of the temporal bone (19). In a study presented by Elibol and Baran (12), the incidence of chronic otitis was significantly higher in patients with a Körner's septum than in those without. It was also shown that the auditory tube angle was narrower and the tubotympanic angle wider in the patients with Körner's septum. Göksu et al. (20) reported that the frequency of the bony lamina was significantly higher in patients with chronic otitis media (12).

Because computed tomography was not part of the standard preoperative diagnostic workup for chronic middle ear inflammatory disease in our patients and only done in selected cases, we were not able to investigate the relation of radiological anatomy to ET function in this cohort.

A selective epitympanic dysventilation syndrome in the development of attic retraction pockets or attic cholesteatomas despite normal tubal function was postulated by Marchioni et al. (21). An open tympanic isthmus or an incomplete tensor fold may be necessary at least for epitympanic recess ventilation (21,22).

In the patients of our cohort without detectable dilatory (chronic obstructive) ETD, it is also conceivable that a dysfunction existed in childhood or/and adolescence, which was no longer present or detectable at the time of the planned middle ear surgery. We have tried to obtain information about recurrent acute middle ear infections and repeated insertion of tympanostomy tubes in childhood from our patient charts. We found that the documentation quality with respect to possible tympanostomy tubes in the past (especially during childhood) was too poor to estimate this. This was also because without a therapeutic consequence (no ETD), such data were unfortunately not recorded in a reliable manner.

In addition to the pathophysiological mechanisms of protection and ventilation of the middle ear by anatomical conditions, environmental and genetic factors also play a role in the development of chronic middle ear processes.

If evidence of ETD exists on testing, then balloon dilatation of the ET may be considered as an adjunct therapy, but a lot of patients (based on our observations: 82%) do not have evidence of ETD at the time of ear surgery.

It should be considered, however, that currently available clinical standard measurement methods and scores may not be sufficiently suited to detect tubal dysfunctions. One solution would be to apply more advanced testing for ETD, for instance, pressure chamber test. We did not perform pressure chamber test in this patient cohort from clinical routine practice. However, already established measurement procedures of ET function should be evaluated and developed further to correctly assess the informative value of the different measurement procedures and thus to increase the informative value of the measurements in their entirety.

CONCLUSIONS

Based on a large cohort of adult patients with chronic inflammatory middle ear disease scheduled for middle ear surgery, the majority (82%) seems to have no dilatory (chronic obstructive) ETD that can be detected with current routine clinical methods and tubomanometry. Common pathophysiological explanations should be questioned critically, especially in the context of communication with patients.

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