

Determining Eustachian Tube Function in Mucosal Ear Disease Using Cost-Effective, Consistent, Constant, Convenient Tests: A Hospital Based Study

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ABSTRACT

Objective: Using a range of methods, the aim of this study was to measure the patency of the eustachian tube for its effectiveness in all cases of mucosal ear disease. The eustachian tube plays a pivotal role connecting the middle ear with the nasopharynx. It preserves the equilibrium between the middle ear and the outer air and protects the ear from various nasopharyngeal pressure changes, mounting secretions and microorganisms. Healthy eustachian tube functions and patency are prerequisites for effective graft uptake and successful tympanoplasty. The most common reason behind failure of graft uptake is abnormal function of the eustachian tube, where mucosal ear disease is present in the main pathology.

Materials and Methods: 100 patients in the ENT OPD of the Subbaiah Institute of Medical Sciences, Shivomogga, were selected and screened and their tubal function was evaluated and equated with a few tests.

Results: The results were tabulated based on 5 tests: Valsalva maneuver, siegalisation test, ear drops test, nasopharyngoscopy and tympanometry to which all selected patients were subjected. The outcomes were tabulated accordingly.

Conclusion: Of all the tests carried out in this study, Toynbee was the only test which was accurate regarding the function of the eustachian tube as an opening and closing mechanism for the regulation of air pressure in the middle ear.

Keywords: Eustachian tube, mucosal ear disease, tympanometry, toynbee maneuver

INTRODUCTION

The eustachian tube (ET) forms a vital bridge connecting the middle ear (ME) with the nasopharynx. It maintains the equilibrium between ME and the outer air and protects it against variations in nasopharyngeal pressure as well as ascending secretions and microorganisms. This triad makes the tube in question a complex organ. Any midline infections of nose and throat are the prime cause of ME infections which have to be dealt with first.

Mucosal ear disease is one of the most common ear conditions encountered in any hospital set up of Otorhinolaryngology practice with abnormal ET function being its main etiology. Though there are many prerequisites for a successful graft uptake in tympanoplasty, the most effective of them all is good preoperative tubal function.

With the aid of good diagnostic procedures, it has now become easy, cost effective, consistent and convenient to find out the cause behind the failure of tympanoplasty i.e ET dysfunction.

This study aims to evaluate eustachian tube patency in all cases of mucosal ear disease, to examine the effectiveness of different methods used for assessing eustachian tube patency, and lastly to assess the most accurate method of measuring eustachian tube function.

MATERIALS AND METHODS

A cross sectional study of 100 out-patients was conducted at Subbaiah Institute of Medical Sciences, Shivamogga, over one year. The patients were screened for ear discharge and deafness. After a thorough history and detailed clinical

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examination, several tests were conducted to determine ET function. These tests included Valsalva maneuver, siegalisation test, ear drops method, nasopharyngoscopy and tympanometry with Toynbee maneuver. The criteria specified the inclusion of patients with mucosal ear disease. Excluded were traumatic cases, postoperative cases, cases of tubercular otitis media & eosinophilic otitis media and squamosal ear disease. The study was conducted after obtaining institutional ethical clearance and written /informed consent from the patients. The procedure (tests) that were conducted on all the patients mentioned above were performed according to universally standard, acceptable and approved protocols.

RESULTS

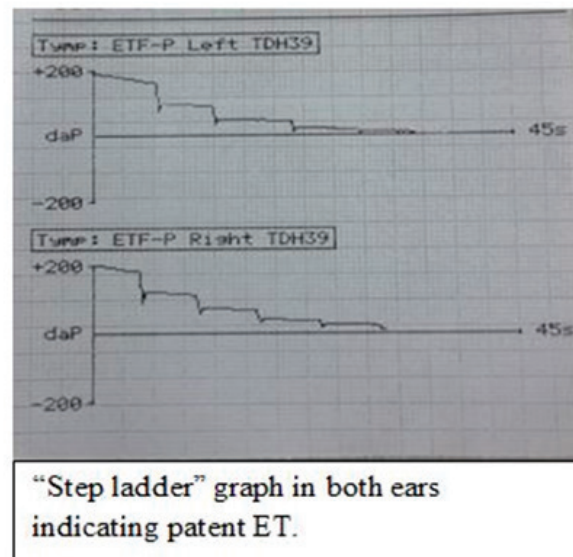
After conducting the Valsalva maneuver on the patients included in the study it was found that in 84 patients an air leak was present indicating ET patent, while in 16 patients no air leak was found indicating a blocked ET. As for the results of the pneumatic otoscopy, in 86 patients there was active mobility of tympanic membrane in the drum with small to moderate perforation indicating patent ET, while in the remaining 14 patients, the tympanic membrane did not move. This was due either to ET block or to inability to assess mobility due to large perforation. In the ear drops method test, in 87 patients, a bitter sensation was felt in the throat within a few minutes indicating patent ET and good mucociliary clearance of ET, but the remaining 13 patients did not feel the presence of the drops in the throat due to a block in the ET or diminished mucociliary mechanism of the ET. In the tympanometry test, in 75 patients, pressure could not be built up indicating patent ET while in the remaining 25 patients, a pressure build-up was seen suggesting a blocked ET. These patients then underwent Toynbee's maneuver. In Toynbee's test, 16 patients showed "step-ladder" graph (Graph A) suggesting normal ET function while 9 patients showed "flat" graph (Graph B) indicating temporary ET block due to various ENT conditions as mentioned below in Figure 1.

In the nasopharyngoscopy test, 80 patients showed a normal active ET opening indicating good ET function. In 12 patients, there was inflammation around the ET opening due to allergic rhinitis and chronic sinusitis and in the remaining 8 patients, the ET opening was not seen due to adenoid hypertrophy, cleft palate, or soft tissue in the nasopharynx all causing obstruction at the nasopharyngeal end of the tube indicating poor ET function. These results are depicted in tabulation form in Table 1 and diagrammatically in Figure 2. The demographic data and clinical characteristics of the patients are summarized in Table 1.

DISCUSSION

Valsalva is a technique for ME pressure equalization and is a highly sensitive and specific test. It also indicates patency of ET (8). It is both easy and convenient and does not need expensive equipment. It evaluates ET function accurately and is fit for a basic level hospital (20). Its efficiency when performed alone for the assessment of the ET opening and closing function is

A



B

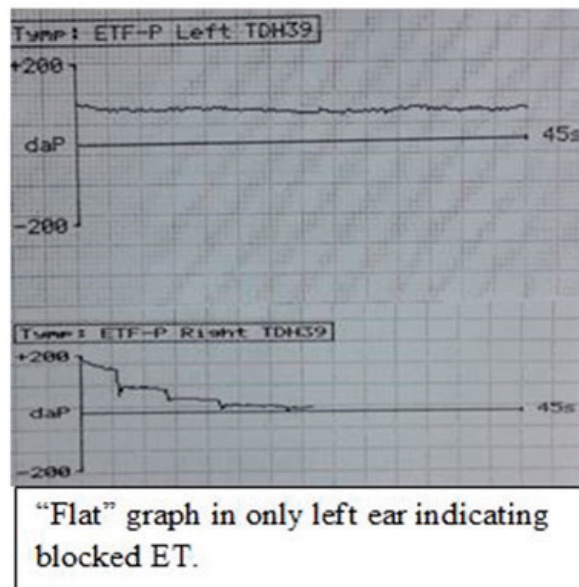


Figure 1: Graph A shows patent ET in the form of "Step ladder" graph while Graph B shows blocked ET in the form of "Flat" graph

of less prognostic value though it yields good success when combined with Toynbee due to common physiology (24). As per Dhingra, failure of this test does not prove tube block because only 65% of subjects can successfully perform this test. This test always gives good results when performed both pre- and post-operatively in cases of mucosal disease following surgery in order to assess tubal function irrespective of graft material and surgery performed. Pre-operatively, the results of this test on the assessment of tubal function were 30% (22). This test is a reliable tool among all the tests for ET function which evaluate the pressure opening and closing functions of ET both qualitatively and quantitatively (1). In

Table 1: Summary of all tests among all the patients

Gender distribution	52 - males	48 - females
Age-wise distribution	1 to 10 years - 7 , 11 to 20 years - 20 , 21 to 30 years - 23 , 31 to 40 years - 32 , 41 to 50 years - 18 .	
Size of perforation	86 : small to moderate perforation, 14 : large perforation.	
Valsalva maneuver	84 : air leak present indicating ET patent, 16 : no air leak due to blocked ET. (biased and dependent on patient's response) .	
Pneumatic otoscopy	86 - active mobility of TM with small - moderate perforation indicating patent ET. 14 - TM did not move either due to ET block or inability to assess mobility due to large perforation. (does not hold good for large central perforation as appreciation of mobility of TM is difficult) .	
Ear drops test	87 - felt bitter sensation in throat within few minutes indicating patent ET and good mucociliary clearance of ET. 13 - did not feel presence of drops in throat due to block in ET or diminished mucociliary mechanism of ET. Duration of result varies depending on size and site of perforation.	
Tympanometry test	75 - pressure could not be built up indicating patent ET. 25 - pressure build-up was seen suggesting blocked ET. These patients then underwent Toynbee's maneuver.	
Toynbee maneuver	16 - "step-ladder" graph (Graph A) suggesting normal ET function (64%) 9 - "flat" graph (Graph B) indicating temporary ET block due to: allergic rhinitis (1 case), enlarged adenoids (5 cases), cleft palate (2 cases), nasopharyngeal mass (1 case) (36%)	
Nasopharyngoscopy	80 - normal active ET opening indicating good ET function. 12 - inflammation around ET opening due to allergic rhinitis & chronic sinusitis. 8 - ET opening not seen due to adenoid hypertrophy, cleft palate, soft tissue in nasopharynx all causing obstruction at nasopharyngeal end of tube indicating poor ET function.	

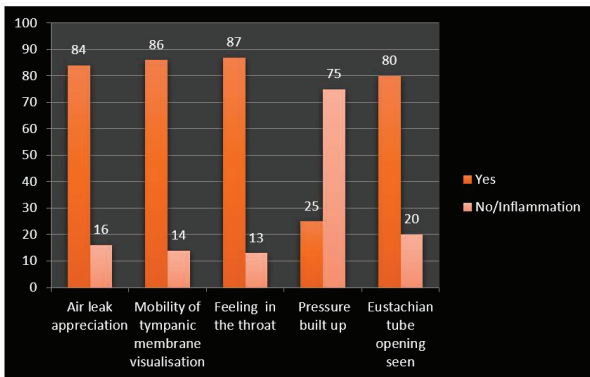


Figure 2: Diagrammatic representation of the entire study, where all 5 tests conducted in this study are represented in the form of Clustered column representation

children with cleft palate, the ability to alter ME pressure is disrupted. As a result, they have high prevalence of developing ME disease. So, one of the reasons for functional obstruction of ET is anatomical abnormality (1, 37). As cases of mucosal ear disease are common in the institute where this research was conducted, 100 patients were clinically evaluated to look for tubal patency. Here, 84 % showed good results in terms of air leak appreciation. The results were better compared to a study done by Uzun et al. Also, the result showing 2 cases of cleft palate correlates with the study quoted by Doyle et al.

Otitis media (OM) and otitis media with effusion (OME) are common childhood disorders. Tube dysfunction plays an important role in OM. Pneumatic otoscopy is used to evaluate tubal function in cases with otitis media (21). A normal

appearance of TM does not mean a normal functioning tube, but normal TM mobility on siegalization indicates good patency of tube. In any ME disease, the presence of high negative ME pressure or both are determined by pneumatic otoscopy giving presumptive evidence of ET dysfunction (19). Here, 86% showed movement of TM with small to moderate perforation indicating good tubal patency. The remaining members of the sample group had a large central perforation; thus mobility of TM could not be assessed.

An ear drops test is done to look for patency of ET. It is one of the simplest, cost effective and valuable diagnostic tools to assess the mucociliary function of the tube and hence assess tubal patency (3-5, 13). The ear drops test in 100 patients showed that 84 patients could feel a bitter sensation in their throat as they had a dry ear. Three patients had a delayed response, and the rest could not feel the drops in the throat. As regards the 84 patients, the travel of the drop was fast, but the remaining patients had various conditions which prevented them from feeling the drop, such as a blocked tube, inability to make a response, or a delayed response. Depending on the condition of ME mucosa, patients with a dry ear felt a bitter sensation in their throat comparatively earlier than those with a wet ear. In keeping with the study conducted by Shreyas et al., nearly 87.5% patients had a good ET function with an inactive ear that correlates well with this study.

As mentioned by Uzun et al., Jestic et al., Benne et al., tympanometry is used to assess ET function (22-24). In a good tubal function the ME pressure is between 0 to -250mm H2O when swallowing whereas a condensed tubal opening is seen when the ME pressure is below the optimal level of 0 to

-200mm H₂O. These levels are evaluated by tympanometry. Impedance audiometry is a reliable tool to evaluate the pressure opening and closing functions of ET both qualitatively and quantitatively. During this study, the pressure in the case of 75 patients could not be built up indicating patent ET, while in 25 patients, a build-up of pressure was seen suggesting blocked ET. These patients then underwent Toynbee's maneuver, the results of which were very similar to the above-mentioned studies. Tympanometry is a readily available procedure that may be useful in patients to prevent chronic ME disease. It is also a very practical and easy test (21). Frequent recurrence of ME infection is due to anatomic and craniofacial abnormalities, enlarged adenoids, previous episodes of acute otitis media, allergic rhinitis, and chronic sinusitis, all of which contribute to ET dysfunction. Diagnostic evaluation by tympanometry plays a pivotal role that has proved to be more efficient than other air equalization methods in assessing the course and prognosis of OM and also in evaluating tubal function (14). Tympanometry is based on acoustic immittance that measures positive and negative air pressure variations produced in external acoustic meatus that lead to changes in physical properties in the ME and TM. Immittance tests are also used to study the ventilatory function of ET and hence this pressure equalization swallow test is accurate to assess tube dysfunction (10). Modern impedance audiometer enables the physiological function of the ET to be ascertained, not only in intact TM but also in the presence of perforation. Its advantages are that it is quick, non-invasive, accurate and inexpensive. Another advantage is that patient compliance not required. The results of tympanometric assessment in the study was 80% (3). ET function is related to the duration, type and location of TM perforation in chronic suppurative otitis media. Impedance audiometry is a simple, invasion-free method to evaluate ET function. There is a strong association between the tube function and graft uptake and the Toynbee test proves whether the tube is patent or not. This suggests that the ET plays a major role in the success of tympanoplasty (2). When the 100 patients in our study who had a perforated tympanic membrane were subjected to tympanometry the results showed that in 75 of them pressure could not be built up, thus indicating patent ET. In the remaining 25, pressure was built up which suggested a blocked ET. Toynbee's test was then done in these 25 patients and among them 16 showed a "step-ladder" type of graph suggesting normal ET function while the remaining 9 showed, a "flat" graph indicating a temporary ET block due to allergic rhinitis, cleft palate, enlarged adenoids and nasopharyngeal mass. This study also shows good results (75%) which are very similar to the study by Shreyas et al.

Normal endoscopic results indicate good tubal function, while an abnormal result indicates organic tubal obstruction which is correctable. Any inflammation around the tube due to the presence of recurrent episodes of OM, URI, chronic sinusitis, enlarged adenoids, cleft palate and nasopharyngeal mass all make the opening of tube blocked and non-visualizable. Hence, nasopharyngoscope has been a diagnostic tool here (22). The morphological changes of pharyngeal ostium of the ET play an important role both in the beginning stage and in

the development of OM. Hence, nasopharyngoscope is a very useful tool in diagnosis and treatment of OM as it is an accurate, non-invasive test (17). ET dysfunction plays an important role in the development, persistence and recurrence of OME and chronic OM. To identify the characteristics of the dynamic function of the pharyngeal orifice of the tube in children, a transnasal endoscopic examination of the nasopharyngeal opening of the tube is conducted using a nasopharyngoscope (16). Nasopharyngoscope is an indispensable and diagnostic tool in localizing and treating hidden lesions responsible for obstruction (7). Here, similar results were seen in 80 patients where the tube opening was normal and visualized suggesting a good ET function. But in 20 patients, inflammatory changes were noted around tube opening. Of these, 12 had allergic rhinitis and chronic sinusitis. In the remaining 8, the tubal opening was not visualized due to the presence of enlarged adenoids, cleft palate and nasopharyngeal mass indicating poor tube function.

ET function is related to the duration, type and location of TM perforation in CSOM (4-5, 20). Cleft palate has a high prevalence of chronic OM due to the limited ability of the tensor veli palatini muscle to dilate the tube actively on swallowing, which is the cause of the functional obstruction of ET (23). Impairment in the active opening function of the tube was found both in children with OME (71.8%) and adults with chronic OM (51.8%). This impairment was due to the functional obstruction of the tube. However, organic obstruction was noted in 45.6% of adults with chronic OM and 28.2% of children with OME. Though functional obstruction of the tube was found to be the cause of ME diseases, organic obstruction is also related to pathogenesis of OME (24).

One of the main causes of tubal dysfunction is enlarged adenoids which is the reason behind recurrent OME. So, in such children, adenoidectomy is the surgical mode of intervention. Causative factors responsible for tube dysfunction in adults are rhinosinusitis, obstructive sleep apnea, craniofacial deformity, difficulty in deglutition, all of which can affect the overall quality of life. Hence treating the central cause is very important in order for ME infections to be healed (21, 22). The tubal mucociliary transport is important for the elimination of inflammation products from the ME and hence enabling the restoration of normal ME pressure. The association between the degree of mucosal defect and the time of mucociliary transport was evidenced in both types of chronic suppurative inflammation of ME (19, 23).

Enlarged adenoids and allergic rhinitis in the nose and nasopharynx cause ET dysfunction by blocking osteomeatal complex leading to chronic OM. This altered communicatory function of the tube plus ME with nasopharynx, nasal cavity, PNS has led to decreased elasticity of TM, hearing impairment and variations in ME pressure. Tubal function can be affected directly by histamine released in nasal mucosa or indirectly by nasal obstruction due to viral URI that may promote secondary bacterial infections by altered bacterial adherence, modulating host immune and inflammatory responses and impairing ET function (6, 11-12, 15, 18). ME infections are

commonly seen in 28-38% of pre-school children due to disorders of mucin production resulting from ME bacterial infection and ET dysfunction. This affects ME pressure, and damages the mucosal and mastoid system, as well as the ME ossicles. In cases of nasopharyngeal mass, tube dysfunction is characterized by high opening pressure and high active resistance (9).

CONCLUSIONS

Toynbee's test shows that ET is both patent and functioning. In 64% of patients a "step ladder" graph is seen, and 36% patients show a "flat type" of graph inferring a blocked tube at the time of the test. 89% patients had a patent eustachian tube in this study. All the above tests indicate the patency of the ET, but it is only Toynbee's test which gives an accurate idea of ET function, namely, that it is the opening and closing mechanism for the equalization of pressure in the ME. The purpose of this study was to draw attention to the amalgamation of old school methods and new ideas to assess both the patency and function of the ET, which is the topmost priority for successful graft uptake in tympanoplasty as well as maintaining acceptable and adequate ventilation of the middle ear and mastoid air cell system.

Ethics Committee Approval: This study was approved by Government of India Directorate General of Health Services Central Drugs Standard Control Organization Ethics Committee Registration Division (Date: 16.03.2020, No: EC/19/000405).

Informed Consent: Written informed consent was obtained.

Peer Review: Externally peer-reviewed.

Conflict of Interest: The authors have no conflict of interest to declare.

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