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Research Article

DYNAMIC VIDEO ENDOSCOPY IN EUSTACHIAN TUBE DYSFUNCTION: IS IT BETTER THAN IMPEDANCE AUDIOMETRY?

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ABSTRACT

Objectives: 1. To find out which among dynamic slow motion video endoscopy (DSVE) and impedance audiometry is a better investigation for diagnosis of Eustachian tube dysfunction in the cases of middle ear disorders. 2. To correlate the Eustachian dysfunction with nasal pathology.
Material and methods: A case control study done on a total of 84 patients (168 ears) where ear complaints either unilateral or bilateral (total 95 ears) having middle ear disease were taken as cases. Patients without any ear and nasal complaints and normal ears of the case group were taken as controls (total 73 ears). DSVE was performed in cases and controls to compare the incidence of Eustachian dysfunction in the two groups. Impedance audiometry was performed in all cases by William's or Toynbee's test, depending on the presence of perforation. Nasal pathologies were identified by endoscopy or CT-scan.
Results: On comparing DSVE findings with impedance audiometry, a strong association was found by applying Mc Nemar Chi square test. However, no significant correlation was found between results obtained on impedance audiometry with middle ear disease. In the mechanical type of dysfunction, we found nasal, paranasal or nasopharyngeal pathology in all the cases. In unilateral otitis media, the contralateral healthy ear was also associated with Eustachian dysfunction.
Conclusion: DSVE is a better investigation than impedance audiometry for diagnosing Eustachian dysfunction in cases of chronic otitis media, especially the functional type. Nasal, paranasal or nasopharyngeal pathologies should be looked for in all cases of mechanical type of dysfunction and adequately addressed.

INTRODUCTION

Abnormal function of Eustachian tube appears to be the most important factor in the causation of different types of chronic middle ear pathology, ranging from otitis media with effusion to retraction pockets and frank cholesteatoma.(1,2,3)Eustachian tube dysfunction has been linked to pathology within the cartilaginous portion, more often than those of the bony portion. (4)This could be classified into mechanical or functional dysfunction. The mechanical type of dysfunctionis attributable to conditions of infective, allergic or obstructive nature in the nose, nasopharynx or the paranasal sinuses.(3,4)The functional dysfunction, which isdue to inherent weakness of tubal muscle,has recently drawn attention in the causation of middle ear pathology. (5,6)

Most tests of Eustachian tube dysfunction cannotclassify the type of eustachian dysfunction.Hence, there is an ongoing search for an ideal tool for assessing Eustachian dysfunction. Dynamic slow motion video endoscopic analysis (DSVE) of Eustachian tubeaids in understanding the pathophysiology of cartilaginous end of Eustachian tube by direct visualization of the active opening of the nasopharyngeal end of the Eustachian tube at rest and during swallowing, and yawning. This helps in classifying Eustachian dysfunction into functional and mechanical.(3, 7, 8) In this aspect, it appears to be superior to impedance audiometry and has the added advantage of being able to identify nasal, nasopharyngeal or paranasal sinus pathologies including nasal anatomical variations, condition of nasal mucosa, nasal discharge, adenoid and turbinate hypertrophy at the same time. (9)

The present study was undertaken to compare DSVE and impedance audiometry as tests of Eustachian dysfunction intwo groups of subjects- cases with chronic otitis media and controls with normal tympanic membrane.

MATERIAL AND METHODS

This was a case control study done on total 84 patients (168 ears) of whom cases included 95 ears of 64 patients with perforated or retracted tympanic membranes on otoscopy.Normal ears of the case group (33 ears) and remaining 20 patients without any auralor nasal complaints (40 ears) were taken as controls(total 73 ears) after taking informed consent. Prior Institutional Ethics Committee Approval was obtained.

A detailed history was noted.Depending upon otoscopic and examination under microscope findings, middle ear disease of case group was classifiedaccording to Browning classification. Routine investigations and relevant radiological investigations were carried out for the case group patients. Then hearing assessment was done by pure tone audiometry. (ALPS advanced digital audiometer AD2000). Eustachian tube function was tested by impedance audiometry (MAICO impedance audiometer) - William's test for patients with intact ear drum and Toynbee's test for patients with perforated drum. (10)

Nasal endoscopywas done under local anesthesia by 30 degrees, rigid Henke Sass, Wolf nasal endoscope of 4 mm diameter and Dynamic slow motion videoendoscopy (DSVE) recording was done with help of Honestech TV tunner card. Transnasal endoscopic examination of the nasopharyngeal opening of the Eustachian tube during rest, swallowing and yawning was carried out to study its dilatory movements.Tubal movements were classified into four grades based upon the appearance of tubal mucosa, movement of the medial and lateral cartilaginous lamina, lateral movement and dilatory wave of the lateral pharyngeal wall forassessment of tensor veli palatine and dilator tube muscle function,opening of the tubal lumen with manoeuvres and the presence of concavity in the superior third of tube (patulous tubes). (7,8) (Table 1)

Associated nasal, paranasal or nasopharyngeal pathologies were identified on 1st, 2nd and 3rd pass of nasal endoscopy. The main points of observation were adenoid hypertrophy, deviated nasal septum and its type, concha bullosa, blocked osteo-meatal complex due to other anatomical abnormalities like paradoxical middle turbinate, purulent discharge in middle meatus, hypertrophic rhinitis, etc. CT Scan of paranasal sinuses was undertaken when indicated.

All the subjects with DSVE grades 0 and 1 were assumed to have normal ET function, whereas grades 2 and 3 and patulous tubes were assumed to be dysfunctional. Findings were correlated with ear finding on history, examination and impedance audiometry. Eustachian dysfunction was correlated with the nasal pathologies.Statistical analysis was done by using chi square test and Mc Nemar's test of significance.

Observation and Results:

Our study comprised of a total of 84 patients (168 ears), which included 29 males and 35 females, aged 10 to 50 years, who came to department of ear, nose and throat. Case group comprised of 64 patients (95ears)with 31 patients having bilateral disease (62 ears) and 33 patients with unilateral disease (33 ears). Control group comprised of remaining 20 patients (40 ears) with normal tympanic membrane on otoscopic examination and who did not have aural or nasal complaints. Control group also includedthe normal ears of the case group (33 ears) making a total of 73 ears.The highest number of patients was in age group of 31 to 40 years (34.40%), followed by 21 to 30 years (32.80 %).The youngest subject was of age 10 and the oldest was of age 50 with mean age of 28.46 years.

On endoscopic analysis of 73 tubes in control group, normal Eustachian function was found in 52 tubes (71.23%) and 24 tubes (28.77%) were found to be dysfunctional (19 out of 24 dysfunctional eustachian tubes of the control group were found to be ofthe contralateral normal ear of the case group).On correlating the DSVE findings of Eustachian tube in both case and control groups, p value of <0.0001(chi square=17.08)was obtained, which is significant, suggestive of higher incidence of abnormal Eustachian tube function in cases of middle ear disorders as compared to controls.(Table2.)

DSVE Eustachian tube findings were correlated with impedance audiometry findings using Mc Nemar chi square test in the case group. We found that, in the case group, out of 36 tubes with normal tubal function on DSVE, only 19 tubes (52.78%) had normal Eustachian tube function by impedance and 17 tubes were diagnosed as abnormal. While in 59 tubes with abnormal Eustachian tube function on DSVE, 40 tubes (70.17%) were dysfunctional and 19 tubes (32.20%) were diagnosed as normal on impedance audiometry. (Table3) Thus, 59 tubes showed complete agreement and 36 tubes showed disagreement. On applying Mc Nemar's chi square test, the p value of 0.021 was obtained which implies significant association between diagnostic nasal endoscopy and impedance audiometry for diagnosing Eustachian tube dysfunction.

However, on comparing Impedance audiometry findings among cases and controls, in the case group, normal Eustachian tube function was found in 38 tubes, (40%) whereas abnormal function was found in 57 tubes (60%). (Table4)In the control group, 32 tubes (43.83%) had normal function whereas, as high as 41 tubes (56.17%) were dysfunctional. (Table5). On applying chi square test for dysfunction of Eustachian tube, P value of 0.117 which is > 0.05 was obtained, which is statistically not significant. Hence, no significant correlation was found between Eustachian tube dysfunction and middle ear disease by impedance audiometry. Another important finding in our study was that out of the ears diagnosed with normal Eustachian function in the case group on impedance audiometry, DSVE diagnosed gross dysfunction of functional type (Patulous and 3B) in 8 cases.

In our study, DSVE diagnosedabnormal Eustachian tube function in 25 ears (53.20%) out of a total of 47 cases (ears) of Mucosal Chronic Otitis Media, with remaining 22 ears (53.02%) as normal Eustachian tube function. Among 15 cases (ears) of Active Squamosal Pars Flaccida Cholesteatoma, abnormal Eustachian tube function was found in 9 ears (60%) and normal Eustachian function was found in 6 ears (40%). In cases of Active (Squamosal) Pars Tensa Cholesteatoma, 10 Eustachian tubes (76.30%) were dysfunctional whereas 3 tubes (23.7%) had normal function. In cases of Inactive Squamosal Pars Tensa retraction, 15tubes(75%) were found dysfunctional whereas 5 tubes (25%) had normal function. (Table6). Thus incidence of Eustachian dysfunction was higher in cases of squamosal otitis media as compared to mucosal disease. Moreover, cases with Pars Tensa Squamosal Disease (Both active and inactive) showed a higher incidence of Eustachian dysfunction than pars flaccida disease.

In the present study, considering Grade 0 and Grade 1 as normal,it was found that 29 tubes had

mechanical cause for dysfunction (Grades 2A -3A), whereas 30 tubes had functional cause for Eustachian tube dysfunction (Grades 2B,3B and patulous). In all cases of mechanical dysfunction, some underlying nasal causes of dysfunction were found. Amongst the nasal pathology, most commonly found pathology was high DNS in 7 tubes, while in 5 tubes it was DNS to one side with caudal dislocation. Concha bullosa also had a significant association with Eustachian dysfunction.(Table7)

Table 1- DSVE Grading of Eustachian tube (7,8)

Grade0:	Normal Eustachian tube without mucosal edema or congestion. Medialcartilaginous lamina and lateral wall motion are normal. Tubal lumen opens well on swallowing.
Grade 1:	Edema and congestion of mucosa limited to pharyngeal orifice of ET. Normal lateral wall motion, tubal lumen opens with swallowing
Grade 2A: (Mechanical dysfunction)	Reduced lateral wall motion due to edema and congestion involving lumen, tubal lumen opens partly with swallowing.
Grade 2B: (Muscular/ Functional dysfunction)	Reduced lateral wall motion due to abnormal tubal muscular contraction, tubal lumen opens partly with swallowing.
Grade 3A: (Mechanical dysfunction)	Tubal lumen fails to open with swallowing due to gross edema.
Grade 3B: (Muscular/ Functional dysfunction)	Tubal lumen fails to open with swallowing due to abnormal tubal muscle contraction.
Patulous(P): (Functional dysfunction)	Patulous tube with noticeable concavity in the superior portion of the lateral wall of Eustachian tube lumen and persistent patency of the lumen, extending towards the isthmus with medial and lateral cartilaginous lamina remaining separate even at rest.

Table no 2: Correlation between dynamic ET endoscopy findings and middle ear disease in cases and control group (n=168)

DSVE Findings	Cases No. (%)	Control No. (%)	Total No. (%)	Significance X2 test
Normal	36 (37.89)	52(71.23)	88	X2 =17.08 P<0.0001
Abnormal	59(62.11)	21(28.77)	80	
Total	95	73	168	

Table No. 3: Correlation of DSVE finding with impedance in case group

DSVE findings	Impedance Findings No of ET tubes		Total	Significance
	Normal	Dysfunctional		McNemar's X2 test
Normal ET	**19 (52.78%)**	**17 (47.32%)**	**36 (100%)**	**P=0.021**
Dysfunctional ET	**19 (32.20%)**	**40 (70.17%)**	**59 (100%)**	
Total	**38 (40%)**	**57 (60%)**	**95 (100%)**	

Table No. 4: Impedance findings in case group in diseased ears

Impedance Findings	Frequency (no of ears)	Percentage
Normal	38	40.00%
Partially Impaired	28	29.47%
Grossly Impaired	29	30.53%
Total	95	100.00%

Table No.5 Correlation of Impedance findings in cases and controls

Impedance Findings	Cases	Control	Total	Significance X2 test
Normal	38 40%	32 43.83%	70 41.67%	P =0.117(>0.05)
Abnormal	57 60%	41 56.17%	98 58.33%	
Total	95 100%	73 100%	168 100.00%	

Table No. 6: Correlation of ET dysfunction with the type of chronic otitis media.

Diagnosis	DSVE Findings (No of ears)		Total
	Normal	Abnormal	
Mucosal COM	22 (46.80%)	25 (53.20%)	47 (100.00%)
Active (Squamosal) Pars Flaccida Cholesteatoma	6 (40%)	9 (60%)	15 (100.00%)
Active (Squamosal) Pars Tensa cholesteatoma	3 (23.7%)	10 (76.30%)	13 (100.00%)
Inactive squamosal Pars Tensa retraction	5 (25%)	15 (75%)	20 (100.00%)
Total	36 (37.89%)	59 (62.11%)	95 (100.00%)

Table no 7: Correlation of mechanical type of Eustachian dysfunction with nasal pathology

Nasal pathology	Grade 2A/GRADE 3A	Percentage
High DNS	7	24.13%
DNS to one side with caudal dislocation	5	17.24%
DNS with sinusitis	5	17.24%
DNS with adenoids	2	6.89%
Only adenoids	1	3.44%
Concha bullosa	4	13.79%
Allergic rhinitis	3	10.34%
S shaped DNS	2	6.89%
TOTAL	29	100.00%

DISCUSSION

Bluestone stated that there are two types of Eustachian tube dysfunction: obstruction and abnormal patency. Obstruction could be functional or mechanical. Functional obstruction couldresult from inadequate active opening mechanism or persistent collapse of the Eustachian tube due to increased tubal compliance, or both. (6) Tensor VeliPalatini (TVP) muscle inserts into the cartilaginous portion of the Eustachian tube and is important for dilatation of the tube for equilibration of middle-ear pressure, during swallowing. An inefficient tensor velipalatini muscle will not effectively open the tube.(11) The other cause of failure of lumen of the cartilaginous portion of the tube to open during the activity of swallowing include persistent collapse of the Eustachian tube owing to increased tubal compliance (lack of stiffness or the tube is too floppy). An example of this is less cartilage cell density in infants and young children leading to lack of stiffness tubal cartilage (ie, the tube is too floppy) due to which the lumen may not open on contraction of tensor velipalatini muscle. Abnormal negative pressures at the nasopharyngeal end of the Eustachian tube might also result in opening failure of the tube, such as during habitual thumb sucking with the nose obstructed, sucking on a pacifier, or closed nose swallowing. Habitual sniffing can cause abnormal nasopharyngeal negative pressures that can cause tubal dysfunction and middle-ear disease. Mechanical obstruction may be due to either intrinsic or extrinsic factors. Abnormal patency of the eustachian tube (patulous Eustachian tube) with closing failure and the subsequent induction of negative middle ear pressure is also an important causative factor in the development of chronic ear disease. If a patient sniffs habitually in the presence of tubal closing failure, the middle ear cavity will be evacuated repeatedly with resultant negative pressure leading to tympanic membrane retraction.(12)

Diagnosis of Eustachian Tube (ET) dysfunction and its classification into mechanical or functional type is important for cases of chronic otitis media. ET dysfunction in middle ear disorders has two major implications. First one is the elucidation of its etiological role, especially for squamosal type of otitis media (parsflaccida and pars tensa

retractions and cholesteatoma). (1,2,6) Second concern is the impact of ET dysfunction on the results of tympanoplasty in both mucosal and squamosal type of chronic otitis media. Higher success rates after tympanoplasty have been noted in patients with normal ET function than in patients with ET problems. (13,14,15).Mechanical and functional dysfunction of Eustachian tube need to be addressed in a different way, as mechanical dysfunction is associated with pathology in nose, nasopharynx or paranasal sinuses whereas functional dysfunction may need Eustachian tuboplasty prior to tympanoplasty.(8) However, some authors have reported that the inability of the cartilaginous portion, to open during swallowing does not always correlate with the results of tympanoplasty as mastoid aeration also influencessurgical success. (16)

Diverse methods for the assessment of Eustachian tube (ET) functioninclude various clinical tests, tympanometry and a number of manometric approaches, such as the nine-step test, MRI studies, Endoscopy and Sonotubometry. The majority of studies have demonstrated that there is no ideal single test that is capable of reflecting all aspects of ET function. Though many have found clinical application, Gold standard for ET testing still has to be established.(17,18)

Impedance audiometry has been found to be a useful and widely accepted pre-operative test for identifying Eustachian dysfunction in cases of otitis media prior to tympanoplasty.(10,19)However, doubts have been raised regarding the reliability of tympanometry including the inflation-deflation manometric test,as this is an assessment of tubal patency only and not function.(20)Furthermore, inflation-deflation manometric tests have limitations of smallpressure shifts,along with a potential for instrument error, which limit their use as a test of tubal function (21).

With these observations in mind, we compared the results of DSVE with Impedance Audiometry (William's and Toynbee's test in intact and perforated drum respectively)for diagnosing eustachiandysfunction in cases of otitis media.In our study, we found significant association between DSVE findings and impedance audiometry in diagnosing Eustachian tube dysfunction by Mc Nemar's chi square test.This led us to conclude that DSVE is a valid and reliable tool for diagnosing Eustachian tube dysfunction. Our results were similar to previous studies which have also suggested DSVE as a potentially useful tool for diagnosing Eustachian dysfunction. (7,22,23,24). Previously, we have published our results of role of DSVE as a diagnostic tool in etiological correlation of Eustachian dysfunction in cases of chronic otitis media when compared with normal controls.(8) Independently, DSVE was found to be a useful tool in our previous study. In the present study, we have concluded its superiority over impedance audiometry, especially in functional type of dysfunction.A significant association could be established between middle ear disease and dysfunctional Eustachian tube by DSVE in terms of a significantly higher incidence of Eustachian dysfunction in cases of middle ear disease as compared to those without it.On the other hand, impedance audiometry failed to establish significant correlation between Eustachian dysfunction and chronic otitis media,both cases as well as controls showingmore number of dysfunctional tubes than normal Eustachian tubes.Mathew et al had tested only agreement and disagreement between the two tests, namely DSVE and tympanometry and could not establish superiority of one test over the other. (7)In our study, we concluded that as a standalone test, reliability of impedance audiometry as a test of Eustachian functionis questionable, in cases of chronic otitis media and should always be supplemented with DSVE, which is a better diagnostic modality. Chauhan et al also found videonasopharyngoscopy as a highly accurate and more reliable test for Eustachian tube function as compared to tympanometry.(23) In their study, Chauhan et al had compared tympanograms with DSVE in cases of intact tympanic membranes with retractions.

Augustine et al stated that DSVE over-diagnosedeustachian tube dysfunction when used as a standalone test of eustachian tube function. (25) We found DSVE to be a very reliable test, when correlated with history and clinical examination. Functional type of dysfunction is better diagnosed by DSVE than impedance audiometry.As many as 8 cases of chronic otitis media which were shown to have normal Eustachian function by impedance audiometry were,in fact diagnosed by DSVE, as having functional type of Eustachian dysfunction (Patulous and Grade 3B with completeopening failure of the cartilaginous end of ET).Functional type of dysfunction may need Eustachian tuboplasty or cartilage tympanoplasty for middle ear disease as simple tympanoplasty may have inferior results in these cases.

In all cases of mechanical type of dysfunction, some underlying nasal, paranasal or nasopharyngeal pathologies could be identified in our study. The most common pathology was high DNSin 7 tubes, in 5 tubes it was DNS to one side with caudal dislocation, while in other 5 tubes the pathology was DNS with sinusitis, rest other causes included adenoids, concha bullosa and allergic rhinitis.The proposed mechanism for Eustachian dysfunction in the above conditionsis that the lymphaticsof the Eustachian tube receiveafferents from nasal cavity, paranasal sinuses and nasopharynx. The inflammation and edema in these areas can lead to an obstruction in the flow of the peritubal plexus and rhino-pharyngeal nodes with resultant retrograde obstruction of the tubal lymphatics and consequent tubal dysfunction. In the absence of inflammation or edema, conditions like concha bullosa and deviated nasal septum causingincreased nasal resistance with resultant Toynbee phenomenon can also be viewed as another factor in causing tubal dysfunction. (26,27)

All the caseswith mechanical type of dysfunction who came for follow up after one month of medical and surgical treatment for nasal, paranasal or nasopharyngeal pathology showed both subjective and objective (by DSVE) improvement in the grade of Eustachian tube dysfunction.In mechanical Eustachian dysfunction, diagnosis and management of the underlying condition is important and so, DSVE is superior to all other investigations for Eustachian dysfunction including impedance audiometry.

Magnuson et al found no difference in the abilities of their healthy and diseased ears to equalize pressure, in the subjects with unilateral middle ear disease.(28) In our study, we had similar results as, out of total 33 contralateral normal ears in patients with unilateral otitis media taken as control group, 19 eustachian tubes were found to be dysfunctional. There was agreement in most of the findings of this group by both DSVE and impedance audiometry. Hence, it can be concluded that in unilateral otitis media, the contralateral healthy ear is also associated

with Eustachian dysfunction. Further research is needed in this area.

CONCLUSION

- As impedance is an easy and non- invasive test, itshould be done as a first line investigation of Eustachian function, but not as a standalone test. It should always be supplemented with Dynamic slow motion video-endoscopy for grading and classifying the type of Eustachian tube dysfunction.
- DSVE is a better investigation than impedance audiometry for diagnosing Eustachian dysfunction in cases of chronic otitis media, especially of the functional type.
- Nasal, paranasal or nasopharyngeal pathologies should be looked for in all cases of mechanical type of dysfunction and adequately addressed.
- In unilateral otitis media, the contralateral healthy ear is also associated with Eustachian dysfunction.

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