International Journal of Scientific Research and Engineering Development-– Volume 4 Issue 3, May -June 2021

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Pressure Changes Leading to Eustachian Tube Dysfunction: A Review

Bhumika Khanna[1], Manroop Sahota[2], Zaiba Akhtar[3], Mala Thakur
[1,2](Xavier University School of Medicine, Oranjestad, Aruba
[3] (American University School of Medicine, Oranjestad, Aruba

----------**********----------

Abstract:

Eustachian tube dysfunction (ETD) is a disorder of the eustachian tube to effectively open and close. The eustachian tube can infrequently present with abnormalities that lead to irregular pressure equalization. ETD can lead to long-term sequelae and has also been linked to some cardiovascular pathologies. Currently, the diagnosis of ETD is based on nonspecific symptoms or incidental examination findings. There are several treatment options for ETD; however, there is little consensus on definitive treatment, which is problematic when conducting case studies for further research. This study aims to determine the correlation between states that lead to pressure changes in the ear, leading to long-term effects on the eustachian tube. In addition, the paper will be discussing current treatments.

Keywords **—Eustachian tube dysfunction, ear pressure**

----------**********----------

I. INTRODUCTION

The Eustachian tube (ET) is a robust tubular structure that usually only opens to facilitate the middle ear's negative gas pressure. Furthermore, the ET prevents the spread of nasopharyngeal pathogens travelling from the nose to the ear [1]. Eustachian tube dysfunction (ETD) is diagnosed when pressures between both ears are not appropriately regulated. The two forms of ETD that have been categorized are Obstructive ETD (OETD) and patulous ETD (PETD). In OETD, the opening is reduced, whereas in PETD the ET is extensively open [2]. ETD can present with various nonspecific symptoms, making it challenging to diagnose the root cause. Most ETD cases are diagnosedbased on clinical history, ear and nasopharynx exam, and routine tests [1]. This paper will be discussing some

causes that lead to pressure alterations in the ear, along with changes in ear membrane integrity; Patients often describe ETD as “ear fullness” which is a very unpleasant condition [3]. Other nonspecific symptoms of ETD include pain, muffled hearing, popping of ears, or tinnitus [4]. After the onset of an infectious or inflammatory condition; pressure abnormalities between ears can occur which lead to discomfort and other symptoms [5]. In various cases, the Eustachian tube's epithelial lining can become inflamed, leading to a narrowing of the ET [5]. Han et al., found that 71.7% of patients with chronic otitis media had ETD, while ETD was observed in just 34.9% of the control group [6]. This study suggested that ETD may be associated with middle-ear disease [6].
which is a very unpleasant condition [3]. Other nonspecific symptoms of ETD include pain, muffled hearing, popping of ears, or tinnitus [4]. In various cases, the Eustachian tube's epithelial lining can become inflamed, leading to a narrowing of the ET [5]. Han et al., found that 71.7% of patients with chronic otitis media had ETD, while ETD was observed in just 34.9% of the control group [6]. This study suggested that ETD may be associated with middle-ear disease [6].

Epidemiology

There is currently very little research on ETD, making it difficult to determine which tests should be used to diagnose it. Furthermore, the number of reported cases for ETD have not been sufficient to have funding. From a recent study conducted by Shan et al., a sample of 5620 US adults was taken; from which it was found that the overall prevalence of adults with ETD in the United States was about 4.6%, displaying 11 million affected individuals [7]. Of the affected, prevalence was higher in older male adults and surprisingly lower in Hispanics [7]. Also, it was reported that ETD incidence is extremely high in patients with cleft palate [5]. This disproportionality may be because cleft palate patients are at higher risk for dysfunctional or malformed eustachian tubes. Other risk factors include tobacco, smoke, and radiation exposure and interestingly with sex not being a factor[5]. Nasal septal deviation has also been seen with ETD, which was observed in studies where patients could not equalize the ear pressure during deep water activities. In another study by Yoon et al., it was suggested that there might also be a high prevalence of ETD in infants because their ET is structurally much shorter and more horizontal than in adults. The Eustachian tube takes roughly seven years to reach adult configuration [8]. In addition, the family history of hearing loss was significantly correlated with ETD (P<.001), which was noted by Alshehri et al. This study by Alshehri et al looked at the prevalence of ETD in the Jeddah community in Saudi Arabia. The study found that adults between

the ages of 19-29 had the highest prevalence in this community [9]. Figure 1 illustrates the ear; it shows how narrow the area is between the eustachian tube is. A slight insult to the membrane integrity can cause severe discomfort and a feeling of ear fullness.

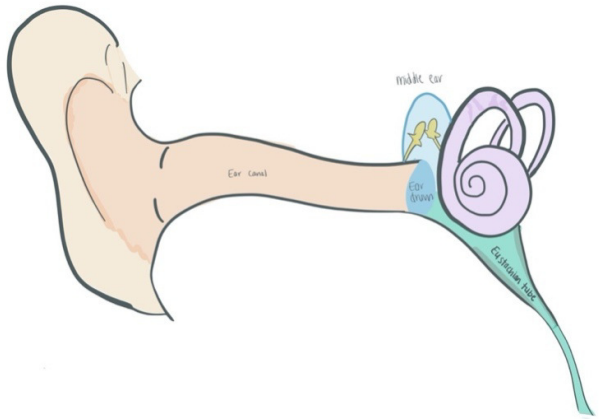

Figure 1: Illustration of the ear.

Treatment

ETD symptoms are commonly seen in all ages and often resolve after a couple days. Exercises such as swallowing, chewing, or forced exhalation against a closed system can equalize pressures and resolve the symptoms [7]. However, if symptoms remain, it would be ideal to take a different approach with treatment. Various non-surgical and surgical treatment options aim to improve Eustachian tube function [7].

Non-surgical management strategies include periodic acts of swallowing or yawning. These are temporary relief to the pain, but it helps minimize the ear's pressure and the feeling of aural fulness. Another method may be the Valsalva maneuver that helps equalize the middle ear pressure [7]. The Valsalva maneuver is accomplished by expiration while keeping the mouth and nose closed; this is done until ear pressure lessens [7]. Some options such as antihistamines and corticosteroids have also been used to reduce the nasal congestion and inflammation of the ET [7]. Lastly, a drug currently being investigated is Simethicone, which is a surfactant. This drug has been known to decrease flatulence in the GI tract. Studies suggest that Simethicone can help breakdown any bubble formation that could block the passageway in the eustachian tube.

One of the standard surgical procedures is tympanostomy, inserted into a patient's eardrum through a small incision. The tube, on average, is replaced after 6–9 months. The difficulty with this approach is that it increases the chance for infections and may even lead to tympanic membrane perforation. Also, other possible method is the balloon dilatation of the Eustachian tube. The process involves a balloon catheter being placed inside the E through the nose. Once inside, the balloon aids by keeping the ET open. Balloon dilation of the ET has been suggested as a popular

treatment. In the study by Cutler et al., a randomized control trial validated its efficacy [10]. Balloon dilatation is a long-term solution compared to medical management. Meyer et al stated, that their results do show that balloon dilation has been favourable over medical management through follow-up's [10]. The participants examined for 29 months after balloon dilation showed a large decrease in the mean ETDQ-7 score [11].

Cardiovascular

Atherosclerosis is a condition where arteries transferring oxygenated blood and nutrients from the hearts to other parts of the body become stiff and thick [12]. Arteries are supposed to be elastic and flexible to transfer sufficient blood to the body organs. When cholesterol, fats, and other substances accumulate on the walls of the arteries, they tend to get thick and stiff. As the artery walls thicken, blood will be restricted from flowing sufficiently. When the condition gets severe, the arteries may burst to cause blood clots. Atherosclerosis is not just limited to arteries in the heart as it affects arteries in different parts of the body. Eustachian tube dysfunction is a condition where the mucus lining of the tube is inflamed and unable to open and normally close [2]. ETD may cause body imbalance, reduced hearing, and pain. Atherosclerosis is a contributing factor to heart attack, affecting blood supply to the ear and can easily lead to ETD [13].

In addition, heart failureoccurs when blood is hindered from getting to the heart. Blockage occurs when arteries feeding the heart are congested and hardened by substances such as fats, cholesterol, and tobacco consumed by smokers. In severe cases, the arteries may rupture, causing blood clots' formation and extensive damage to the heart. Some of the symptoms observed in a person suffering from heart attack include difficulty breathing, sweating, fatigue, dizziness, nausea, abdominal pain, general body pain and pressure around the chest area [14]. The Symptoms and severity of ETD vary from one patient to another, It is based on the underlying problem.

The correlation between heart disease and ETD, has been found for years. The blood flow has an impact on the functioning of the inner ears as they are very sensitive to blood flow. Heart diseases can cause an accumulation of plaque in the vessels and restrict the blood flow, leading to ETD. With this plaque, the tube is strained because of reduced blood flow leading to ETD. In addition, poor circulation of blood due to heart attack can reduce oxygen supply, causing damage to the delicate nerves in the cochlea, which play an essential part in translating sounds into electrical impulses to the

brain. David R. Friedlandexplained in one of his studies that due to the ear being sensitive to blood flow, the first changes in cardiovascular system may be seen first in the ears compared to other parts of the body *[15]*. In essence, taking care of cardiovascular health may reduce ones risk of hearing loss. Research has that impaired heart health has a negative impact on hearing as blood flow is affected, especially in old adults. This requires for increased physical activity and a healthy diet to improving cardiovascular health.

In addition, Altitude changes from hiking, traveling through mountains, flying on a plane, and riding an elevator can lead ETD. This is concerning to high and low pressure around the ears, which is influenced by altitude changes which can present with a difference in pressure on the tympanic membrane. Because of the difference in pressure due to altitude change, one may feel pressure and blockage in the ears. People can experience ETD from time to time; however, some people are more susceptible to the condition such as the obese, smokers, and people with allergies, as they are more exposed. Additionally, children are at a greater risk of ETD since their Eustachian tubes are smaller, making them more prone to trapping mucus and germs [2].

Hypertension is a widespread disease and a dynamic risk factor for causing hearing loss [16]. This due to underlying pathophysiological processes transpiring in the cochlea, which is a decrease of the oxygen partial pressure [17]. Hypertension is a genetic abnormality, which causes many effects on the human body. hypertension can affect the kidney; in particular, it causes a predicament in excreting metabolites such as sodium [18]. As a result, the damaged natriuretic hormone interrupts inner ear potassium recycling [17]. The primary purpose of this recycling is to maintain the inner ear electrochemical gradients [19]. In the cochlea of mammals, there are two kinds of gap junctions: the epithelial gap junction and the connective tissue gap junction[20]. These gap junctions, together, create a path by which K+ ions travel through sensory cells. When these cells re-enter the sensory cells, they can be recycled and placed back into the endolymphatic sac. They are released into the organ of Corti's extracellular space, granting them entryway into cochlear supporting cells [20]. Disturbance to this crucial mechanism results in muffled or impaired hearing [21], a main clinical feature of inner ear disease. [2]. Furthermore, hypertension has been correlated to a decrease in the vascular supply, affecting

the stria vascularis directly [16]. The purpose of this supply is to enable gas exchange and filter out specific compounds. The decrease in the supply impairs the mechanism of gas exchange [22], which is a primary mechanism by which the eustachian tube maintains pressure equalization [2]. Moreover, damage of the stria vascularis causes a decline in the end cochlear potential, which is essential for hearing[23]. As a result of the reduced potential, the cochlear amplification is deemed to be insufficient, and degenerative effects occur in the cochlea [23]. The physiological features of hypertension cause changes to strong electrochemical gradient and gas exchange mechanisms in the inner ear [17].

Meniere's disease (MD) is a multi-factorial and chronic condition affecting the vestibular system [24]. The primary cause of episodes of MD have been believed to be due to abnormal pressure in the inner ear, which a disturbance may accompany in ion homeostasis. Moreover, both conditions share clinical presentations of sensorineural hearing loss symptoms, tinnitus, and vertigo [22]. Current progression in the epidemiologic studies of Meniere's disease has shown significant data for cardiovascular risk and interest in further studies [25]. A cross-sectional and retrospective research created by Rego et al. looked at 31 Meniere's disease patients and their potential cardiovascular risk. The parameter set in this study for cardiovascular risk focused on excessive BMI, and the presence of dyslipidemia, type 2 diabetes, and hypertension. Findings of the study revealed there was an approximately 2:1 preponderance of females. Further, they found, much like how the prevalence of Meniere's disease increases with age, the risk of cardiovascular in Meniere's disease displayed an increase with age. Additionally, it was noted that patients who reported having had more MD episodes in the last six months, had higher cardiovascular risks [24]. Meniere's Disease and Eustachian Tube Dysfunction have similar pathophysiology and clinical presentation [2]. Due to the noticeable results of the study done by Rego et al., it is a point of curiosity on whether cardiovascular risks may also influence the prevalence of patients affected by Eustachian Tube Dysfunction. Moreover, due to the common diagnosis of Eustachian Tube Dysfunction [2], if a correlation between the two were accurate, it could allow for earlier and more informed diagnosis for patients worldwide.

Ear infections, or known as otitis media (OM), are among the most common inflammatory disorders in the world. They are most prevalent in children under the age of three, however can affect any age group. There are three types of Otitis media, which are: otitis media with effusion (OME), acute otitis media (AOM), and chronic otitis media with effusion [26]. The pathophysiological changes in AOM and OME will be a focus in this portion. The most common contributing bacteria for AOM and OME are Streptococcus pneumoniae, Haemophilus influenza, and Moraxella catarrhalis [26]. Clinical diagnosis can be made when a bulging or full tympanic membrane is visualized alongside middle ear effusion [27]. OME is more severe- however, both conditions share the swelling of the tympanic membrane as a clinical symptom. Middle ear effusion occurs in AOM as a by-product of bacteria; whereas, it occurs in OME due to inflammation [26]. Despite being a common symptom, definitive pathogenesis of middle ear effusion has not yet been determined. Currently, researchers have concluded Eustachian Tube Dysfunction to be the sole consistent cause of middle ear effusion [28]. As Eustachian Tube Dysfunction is a defect in the maintenance of ear pressure in the middle ear [2], there is a significant link between the disease and primary findings of common ear infections.

CONCLUSION

Eustachian Tube Dysfunction is a difficult diagnosis to make because the symptoms are very nonspecific. The epidemiology is not understood, and much further research needs to be conducted in on this topic. EDT has many limitations as it is not highly prevalent and may have many different etiologies. Without this knowledge, it is unclear whether there are sufficient cases to allow forfuture clinical trials to occur.

REFERENCES

1. Smith M, Takwoningi Y, Deeks J, E et al.: "Eustachian tube dysfunction: a diagnostic accuracy study and proposed diagnostic pathway." *PloS one* 13.11 (2018): e0206946.

2. Schilder AGM, Bhutta MF, Butler CC, et al.: "Eustachian tube dysfunction: consensus statement on definition, types, clinical presentation and diagnosis." *Clinical Otolaryngology* 40.5 (2015): 407.

3. Newman, A. C., Omrani, K., Higgins, T. S., et al. (2020). The prevalence of eustachian tube dysfunction symptoms in temporomandibular joint disorder patients. *The Laryngoscope*, *130*(4), E233-E236.https://doi.org/10.1002/lary.28162

4. Todd, N. Wendell. "There are no accurate tests for eustachian tube function." *Archives of Otolaryngology–Head & Neck Surgery* 126.8 (2000): 1041-1042. doi:10.1001/archotol.126.8.1041

5. Llewellyn A, Norman G, Harden M, et al.: "Interventions for adult Eustachian tube dysfunction: a systematic review." (2014).

6. Han WG, Yoo J, Yoon C.R, et al.: "Analysis of eustachian tube dysfunction by dynamic slow motion video endoscopy and eustachian tube dysfunction questionnaire in chronic otitis media." *Clinical and experimental otorhinolaryngology* 10.4 (2017): 315.

7. Shan A, Ward B.K, Goman A.M, et al.: "Prevalence of Eustachian tube dysfunction in adults in the United States." *JAMA Otolaryngology–Head & Neck Surgery* 145.10 (2019): 974-975.

8. Yoon P.J, Scholes M.A, Herrmann B.W, et al.: "Ear, Nose, & Throat." *Current Diagnosis & Treatment: Pediatrics, 25e* Eds. William W. Hay Jr., et al. McGraw-Hill, 2020, https://accessmedicine.mhmedical.com/content.aspx?bookid=2815&sectionid=244260113.

9. Alshehri, Khalid A., et al. "Prevalence of and Factors Associated With Eustachian Tube Dysfunction Among the Public in Jeddah, Saudi Arabia: Cross-Sectional Survey-Based Study." *Interactive Journal of Medical Research* 9.4 (2020): e14640. 10.2196/14640

10. Cutler J.L, Meyer T.A, Nguyen S.A, et al. "Long-term outcomes of balloon dilation for persistent Eustachian Tube dysfunction." *Otology & Neurotology* 40.10 (2019): 1322-1325

11. Meyer, T.A, O'Malley E.M, Schlosser R.J, et al.: "A randomized controlled trial of balloon dilation as a treatment for persistent eustachian tube dysfunction with 1-year follow-up." *Otology & Neurotology* 39.7 (2018): 894. 10.1097/MAO.0000000000001853

12. Hajar, R. (2017). Risk factors for coronary artery disease: historical perspectives. *Heart views: the official journal of the Gulf Heart Association*, *18*(3), 109.

13. Pezzoli, M., Lofaro, D., Orione, M., et al (2017). Effects of smoking on eustachian tube and hearing. *The international tinnitus journal*, *21*(2), 98-103.

14. Lu, L., Liu, M., Sun, R., Zheng, Y., & Zhang, P. (2015). Myocardial infarction: symptoms and treatments. *Cell biochemistry and biophysics*, *72*(3), 865-867.

15. Walter, L. (2011). Safety Leadership. *American Heart Month: The Heart-Hearing Connection*. Retrieved from https://www.ehstoday.com/health/article/21903988/american-heart-month-the-hearthearing-connection

16. Lin, Brian M et al. (2016). Hypertension, diuretic use, and risk of hearing loss. *The American journal of medicine*, *129*(4), 416-422.https://doi.org/10.1016/j.amjmed.2015.11.014

17. De Wardener, H E. "The concept of the natriuretic hormone and its relation to hypertension." *Clinical and experimental hypertension. Part A, Theory and practice* vol. 7,5-6 (1985): 647-62. doi:10.3109/10641968509077218

18. Przewoźny T, Gójska-Grymajło A, Kwarciany M et al.: "Hypertension and cochlear hearing loss." *Blood pressure* 24.4 (2015): 199-205.

19. Weber, P C et al. "Potassium recycling pathways in the human cochlea." *The Laryngoscope* vol. 111,7 (2001): 1156-65. doi:10.1097/00005537-200107000-00006

20. Kikuchi, Toshihiko, et al. "Potassium ion recycling pathway via gap junction systems in the mammalian cochlea and its interruption in hereditary nonsyndromic deafness." *Medical electron microscopy* 33.2 (2000): 51-56. https://doi.org/10.1007/s007950070001

21. Zdebik, Anselm A., PhilineWangemann, and Thomas J. Jentsch. "Potassium ion movement in the inner ear: insights from genetic disease and mouse models." *Physiology* 24.5 (2009): 307-316. https://doi.org/10.1152/physiol.00018.2009

22. Buckey, Jay C. "Use of gases to treat cochlear conditions." *Frontiers in cellular neuroscience* 13 (2019): 155. https://doi.org/10.3389/fncel.2019.00155

23. Keithley, Elizabeth M. "Pathology and mechanisms of cochlear aging." *Journal of neuroscience research* vol. 98,9 (2020): 1674-1684. doi:10.1002/jnr.24439

24. Rego, Â.R, Dias D, Pinto A, et al.: "The cardiovascular aspects of a Ménière's disease population–A pilot study." *Journal of otology* 14.2 (2019): 51-56.

25. Sajjadi, Hamed, and Michael M. Paparella. "Meniere's disease." *The Lancet* 372.9636 (2008): 406-414.

26. Prasad, A., Hasan, S., &Gartia, M. R. (2020). Optical Identification of Middle Ear Infection. *Molecules (Basel, Switzerland)*, *25*(9), 2239 https://doi.org/10.3390/molecules25092239

27. Pichichero M. E. (2013). Otitis media. *Pediatric clinics of North America*, *60*(2), 391–407. https://doi.org/10.1016/j.pcl.2012.12.007

28. Grote, J., &Kuijpers, W. (1980). Middle ear effusion and sinusitis. *The Journal of Laryngology & Otology, 94*(2), 177-183.doi:10.1017/S0022215100088642

