Eustachian Tube Anatomy, Rehabilitation and Treatment protocols

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The Eustachian tube is a 3-4 cm tube which links the nasal pharynx (back of the throat) and the ear. Dysfunction of the Eustachian tube causes many common symptoms like blocked ear or pressure in the head, clicking, popping or painful ears.

In children under seven the Eustachian tube is almost horizontal, and this explains why children are so prone to ear infections. In adults the tube tilts to 45° making it easier for fluid to drain out of the ear.

The tube is wider at the ends the narrower in the middle. It is a bony tube lined with cartilage and mucous glands. The upper end is lined with little hair cells which help to move fluid out of the middle ear.

Nerve supply

The function of the Eustachian tube plays an important role in aspects of our hearing and speech. It is supplied by multiple nerves, which may explain the potential for referred pain to other regions of the head and neck. When the Eustachian tube does not function normally it causes discomfort in a number of areas.

One of the supplying nerves is the glossopharyngeal nerve which is also involved in communications with the eardrum, the pressure system of the inner ear and the tongue.

Muscles of the Eustachian Tube

There are four muscles involved in the function of the Eustachian tube. These include the tensor veli palatini, levator veli palatini, salpingopharyngeus, and the tensor tympani.

The ***tensor veli palatini***, referred to as the dilator tubae muscle, is probably responsible for actively opening the Eustachian tube by moving the membranous wall of the tube.

The ***levator veli palatini*** runs parallel to the tube, and attaches to the back of the soft palate. It is thought to assist in opening the tube and also provides support.

The ***salpingopharyngeus*** links the Eustachian tube to the palatopharyngeus muscle, which lifts the soft palate.

The ***tensor tympani*** muscle controls the tension on the eardrum. The veli palatini, which opens the Eustachian tube, is a sub-branch of this muscle.

Normal Function

The normal Eustachian tube is closed when it is at rest, with slight negative pressure present in the middle ear. It opens during swallowing, sneezing, and yawning.

The Eustachian tube has three functions: ventilation, drainage, and protection. When the tube is open it allows ventilation of the middle ear and equalization of pressure in the middle ear with atmospheric pressure. It also allows the middle ear to clear unwanted secretions. By staying

closed as a general rule, it protects the middle ear from phlegm and other nasopharyngeal secretions, as well as from sound.

Eustachian Tube Dysfunction

The Eustachian tube may become blocked with mucous and phlegm due to allergy or infection. It could also be blocked by a growth or tumor, and this will be checked by your doctor or ENT specialist.

Obstruction due to malfunction of the muscles is more difficult to diagnose and often results in long-term annoying disorders which cannot be successfully treated. This type of condition is usually somewhat of a mystery to doctors and ear specialists say you are unlikely to be offered any adequate treatment.

Evaluating Eustachian Tube Function

There are many methods for evaluating the condition of the Eustachian tube, which reflect its deep location and complex physiology.

In the Clinic:

Several maneuvers can be easily performed in clinic that may indicate the openness of the Eustachian tube. These include the Valsalva test, the Toynbee test, the Politzer test, and Eustachian tube catheterization.

To do the Valsalva test, the doctor observes your eardrum while the Eustachian tube and middle ear are inflated by having you blow out through your nose while holding your nose closed. The Doctor observes your eardrum to see if it is pushed outwards by the air pressure or whether air is escaping from a hole in the eardrum.

The Politzer test is one where a rubber tube attached to an air bag is inserted into one nostril. You are asked to hold the other nostril closed and repeat the letter K or swallow while air is pumped into the nasal cavity. Meanwhile the Doctor watches your eardrum to see if the pressure in the nasal cavity is reaching the middle ear.

Performing these tests will force air into the middle ear and can be temporarily beneficial if the middle ear is in a state of vacuum.

In the Toynbee Test, the Doctor observes the eardrum and asks you to swallow while holding your nose. If the Eustachian tube is opening this well create a positive pressure in the middle ear followed by a negative pressure in the Doctor will be able to see the movement in the eardrum. This test usually indicates if there is normal Eustachian tube function. However there are exceptions where people have normal function but cannot equalise their ears by this method.

Eustachian tube catheterization can be performed, and also can indicate that the Eustachian tube is able to open.

In the Lab:

There are several more complex methods of evaluating Eustachian tube function but most involve the use of complex equipment, and are mainly used in a research setting.

Tests used where eardrum has been damaged:

- The Inflation-Deflation test
- Forced Response test
- clearance test

Tests used where eardrum is intact:

- pressure chamber technique
- sonometry
- tympanometry

Clinical Examples Of Eustachian Tube Dysfunction
Here are a small sample of the clinical scenarios where Eustachian tube dysfunction is important:

OTITIS MEDIA WITH EFFUSION (fluid buildup)
Middle Ear Infection with Fluid Buildup

Obstruction may result in a persistent vacuum or negative middle-ear pressure. If pressure equalization does not occur, collapse of the eardrum or middle ear, and middle ear infections with fluid buildup, can occur. If the constant negative pressure is overcome, it can suck in secretions from the nasopharynx resulting in an acute middle ear infection.

Serous ear infections with fluid buildup can result from either inadequate ventilation of the middle ear or from reflux of unwanted nasopharyngeal (mucosal) secretions into the middle ear. Both types of Eustachian tube dysfunction can result in ear infections (otitis media), abnormal openness or obstruction.

This is common in children and infants probably due to the configuration of their Eustachian tube, shorter length, and lower efficiency of their tensor veli palantini muscle.

While serous otitis media is something that many of us treat on a daily basis, Dr. Gacek of Syracuse reminds us, in an article entitled "A Differential Diagnosis of Unilateral Serous Otitis Media", of the potentially serious nature of this condition. Clinicians need to maintain a high index of suspicion, particularly in adults, in unilateral cases, and in persistent or recurrent cases. From Dr. Gacek's article, it is important to remember:

1. The Eustachian tube opening can be obstructed and this is usually from inflammatory, allergic or functional disorders.
2. The nasopharynx (back of the throat) is usually obstructed by adenoid swelling, but extensive nasal polyps, benign and malignant tumors may also be present in this location.
3. Obstruction may occur from cysts or lesions in the surrounding tissues

Because of the potential associated risks we want to reinforce the importance of a thorough head and neck examination including the nasopharynx, CT scan of the head including the neck in any child or adult patient with one-sided, repeated or persistent serous ear infection without an obvious explanation for Eustachian tube obstruction.

NASOPHARYNGEAL CARCINOMA
Patients with nasopharyngeal carcinoma frequently have complications that relate to their Eustachian tube. They frequently present with middle ear infection with fluid buildup.

If you have been subjected to radiation treatment of the ear, function of your Eustachian tube may have been affected and it could take many months to recover normal function, if you recover at all.
Studies have shown decreased dynamic function and ability to open the Eustachian tube at six months after radiotherapy, but improvements were seen at 5 years.

Radiation may cause inflammation and paralysis to the nerves, resulting in reduced circulation and muscle function. It is likely that recovery will be speeded and enhanced by the gentle physical therapy for the ear provided by Sound Therapy.

PATULOUS EUSTACHIAN TUBE
Patulous Eustachian tubes is the name of a rare physical disorder where the Eustachian tube which is normally closed, instead stays intermittently open.
This condition often presents a frustrating problem for patients and clinicians. The incidence is reported to be between 0.3-6.6% of the general population.

Patients with patulous Eustachian tubes complain of aural fullness, humming tinnitus, and autophony (where your own voice of sounds much to loud.) They also may hear their own breath sounds, which is known as tympanophonia. The sound keeps time with your breathing and stops when you are lying down. The sounds may be aggravated by chewing.

The normal Eustachian tube is usually closed, and closure is maintained by the elasticity of its cartilage, mucosal lining, surrounding muscles and fat. Alteration of any of these anatomic components may cause patulous Eustachian tubes.

Conditions associated with patulous eustachian tubes include: radiation therapy, hormonal therapy, pregnancy, nasal decongestants, fatigue, stress, and weight loss.

Patulous Eustachian tubes in the most severe form may be open at all times, whereas a less severe form has been reported, where the tube is anatomically closed at rest, but may open easily during exercise or if there is a reduction in fluid in the surrounding cavities.

Some questionable medical treatments are offered such as

- gaining weight
- using a nasal spray containing irritants to cause swelling of the tissues in the eustachian tube
- electrocauterization of the Eustachian tube opening
- Injecting the tube with gelfoam, paraffin, or teflon paste
- surgically restructuring the muscles surrounding the tube and then puncturing the eardrum and inserting a ventilation tube (known as a grommet)
- insertion of a catheter ventilation tube through or close to the eardrum.

The close anatomic relationship of the eustachian tube and the carotid artery should be noted by clinicians who plan to inject materials into the eustachian tube orifice, as injection of telfon paste into the carotid artery has been reported.

In many cases these risky and invasive procedures could be avoided with Sound Therapy, a safe, simple, inexpensive and much more effective treatment to simply rehabilitate the muscles of the Eustachian tube.

HYPERBARIC OXYGEN THERAPY
Another clinical situation where proper Eustachian tube function is important is in the use of hyperbaric oxygen therapy, particularly in patients who require multiple sessions.

Hyperbaric oxygen therapy involves intermittent inhalation of 100% oxygen under greater than 1 atmosphere of pressure and is being used increasingly in patients with decompression sickness, osteomyelitis, carbon monoxide poisoning, crush injuries, radiation necrosis, and poorly healing wounds.

Many of these patients develop ear ache and aural fullness that may be long-standing. Reports in the literature indicate that the incidence of middle ear barotrauma ranges from 5% to 28% of all patients.
As a precaution, if you are undergoing this therapy make sure that you are taught clearing techniques so that you can equalise your own ear pressure by holding your nose and blowing etc. You may need to supplement this with a nasal decongestants. After precautions include using slower compression rates, or possibly have ventilation tubes placed. (Fernau, et al 1992)

In a study of 33 patients undergoing hyperbaric oxygen therapy by Fernau, et al. in 1992, 82% of patients developed fullness in their ears, 52% developed serous otitis media, and 21% developed ear pain requiring ventilation tubes. Of 11 patients managed with decongestants,10 patients resolved their fluid buildup and pain and did not require further therapy. 45% of 33 patients had evidence of pre-existing eustachian tube dysfunction. Of these patients 100% developed aural fullness, 87% developed middle ear infections, and 47% required grommets (a tube which punches the eardrum to allow air to pass through it.) Fernau, et al, identified a history of Eustachian tube dysfunction as a risk factor for middle ear infection with fluid buildup in patients undergoing hyperbaric oxygen therapy.

An article by Presswood, et al, points out that the middle ear complication rate in intubated patients receiving hyperbaric oxygen therapy is 94% compared to 46% of non-intubated patients. (Hemotympanum and otalgia) They state that the use of nasal decongestants in this population is controversial, and probably of no value in patients who are intubated. They recommend ventilation tubes should be placed in their ears prophylactically.

OTHER CLINICAL SITUATIONS

Specialists agree that Eustachian tube disorders continue to represent some of the most challenging management problems faced by otolaryngologists. Many of these conditions, often the ones most puzzling to the doctors, could be easily remedied with a course of Sound Therapy treatment, and it is hoped in the future that more doctors will be referring clients for this therapy.

Summary
The Eustachian tube (or auditory tube) is a bony and cartilaginous tube that links the pharynx (back of the throat) to the middle ear. It fulfils three important roles, which are to ventilate, protect, and drain the middle ear.
In adults the Eustachian tube is approximately 35 mm long. It is named after the sixteenth century anatomist Eustachius. Some modern medical books call this the pharyngotympanic tube.

During development the Eustachian tube lengthens and the angle between it and the skull base increases from 10 degrees in infancy to 45 degrees in adulthood.
Eustachian tube dysfunction can be caused by mechanical obstruction such as infection or inflammation swelling or tumor, or by a functional obstruction due to inappropriate muscle performance.
Middle ear infection with fluid buildup is a common result of Eustachian tube dysfunction, and rehabilitation should be introduced as early as possible to prevent further trauma and lasting damage to the ear.

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