Review Article

Acute Barotitis Media in Flight: Pathophysiology, Symptoms, Prevention, Treatment

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Abstract: Acute barotitis media or aerotitis media is one of the most prevalent medical issues caused during flight. This is the reason that the incidence of aerotitis media increases not only among aviation crews but among common travelers due to the increasing airplane transportation. Its pathophysiology is completely explained by Boyle’s law, since the gas volumes in our body and in the airplane cabin change during the flight. In fact, the problem is caused by the dysfunction of equilibrium between the air in the middle ear and the surrounding environment. The main symptoms are severe otic pain and partial hearing loss, mainly during the descent. There are many predisposing factors for this medical condition such as a concomitant upper respiratory infection. Many preventive measures can be used to avoid otic barotrauma, like the Valsalva maneuver. The treatment is generally symptomatic, but there are also ongoing relevant research projects.

Key words: barotitis media, otic barotrauma, aerotitis, eustachian tube

Introduction

In our days, acute aerotitis media consists one of the most common problems in flight. Taking into consideration the progress of aviation and the increasing use of airplane as a means of transportation, the importance of the increasing incidence of this condition is easily appreciated. It occurs in conditions with severe rapid changes of the surrounding atmospheric pressure as in flights, in diving and in hypobaric chambers [1, 2].

The first man who noted this condition is Charles, a French physicist, in 1783, when whilst in his first flight with a hydrogen balloon- he experienced severe pain in his right ear during descent [3, 4, 6].

Materials and methods

Our aim is to review the pathophysiology, the mechanisms, symptoms, the preventive measures and the treatment of acute barotitis media. A literature search of relevant published articles was performed.

Results

Pathophysiology

According to Boyle’s law, in a constant temperature, the volume and the pressure of a gas are inversely related [5]. The mathematical expression of this is the following: \( P_1/P_2 = V_2/V_1 \), where \( P_1 \) is the initial pressure of the gas, \( P_2 \) is the final pressure, \( V_1 \) is the initial volume and \( V_2 \) is the final volume [5, 6].

The pressure of the atmosphere is 760mmHg, according to the International Civil Aviation Organization (ICAO) in sea level and at 15º C. Because of Boyle’s law as described above, this pressure decreases gradually as we ascend above sea level. At 18,000 ft the atmospheric pressure is 380mmHg, half of that at sea level (ICAO), while in 33,700 ft the pressure is 190mmHg [6, 7].

However, the airplane’s cabin is designed to pressurize the air in it about three quarters of that of the atmospheric pressure at sea level [3, 6].

During the ascent the pressure in the airplane’s cabin reduces at the above levels and the air in the middle ear dilates. If there are functional bilateral eustachian tubes, there is a passive air escape through the tubes and equalization of the ambient pressure with the middle’s ear pressure. [3, 4, 7-10]. This passive opening happens in differential pressure of 15 mmHg and about every 400-500 ft of ascent [3, 6, 12].
During the descent, according to Boyle’s law, the ambient pressure rises while the pressure in the middle ear decreases. Unfortunately, air cannot passively re-enter the eustachian tube and there is a need for an active muscular movement for the equalization of these two pressures on both sides of the tympanic membrane [3, 6-10]. Such movements are swallowing, yawning, jaw movements, Valsalva’s maneuver and Frenzel’s maneuver [3-10]. If the above techniques do not prove successful, because of an eustachian tube dysfunction, the air passenger feels severe ear discomfort at a differential pressure of 60mmHg [3, 9]. When the differential pressure gets to approximately 90mmHg, an irreversible block of the eustachian tube occurs [4, 7, 13, 14] and beyond this level a rupture of the tympanic membrane is possible. This situation is rare and its incidence is estimated about 4% [4].

Symptoms
The most prevalent and usually the first symptom of a patient with barotitis is the ‘blockage’ of the ears. If this is not reversed with techniques like Valsalva’s maneuver, it is usually followed by otic pain. The pain may be severe and can be accompanied with headache, nausea, numbness, vomiting, vertigo, tinnitus and conductive hearing loss [2-4, 8, 15, 16]. The hearing loss is usually acute and transient, especially when it follows a rupture of the tympanic membrane, which mostly heals spontaneously without any ear dysfunction [4, 11, 17]. More rare complications are effusion and bleeding into the middle ear cavity and sensorineural hearing loss [1, 15-17]. Intracranial epidural hematoma, perilymphic fistula, pneumocephalus and parenchymal and extra-axial haemorrhage have also been mentioned in the literature, but these conditions are exceptionally rare [12].

The otoscopic findings often include oedema of the mucosa of the middle ear, capillary dilation, flushing of the tympanic membrane and transudate fluid in the middle ear cavity [18]. In more severe cases, perforation of the drum with or without hemorrhage can be seen [3, 4, 12].

Predisposing Factors
There is a clear association between any kind of eustachian tube obstruction or dysfunction and the incidence of aerotitis media [13]. It is more often observed when the passengers in the airplane are sleeping during the descent. Medical conditions like upper respiratory infections, even subclinical, or any abnormality of ear, nose or throat (ENT) can be the underlying cause of barotrauma. Enlarged adenoids, nasopharyngeal carcinoma, nasal polyps, allergic or vasomotor rhinitis, idiopathic dysfunction of the eustachian tube predispose for aerotitis [18, 19]. Some researchers found an increasing incidence of otic barotrauma in cases of higher differential pressure, i.e. in higher altitudes [20] and in rapid changes of ambient pressure, frequent in air force flight maneuvers [15]. Aerotitis is particularly frequently observed in a speed of descent more than 500 ft per min from the level of 6000-8000 ft above the sea level [6]. Moreover, there is higher prevalence in women than in men and in people less than 40 years old [20]. In children, the frequency of aerotitis is significantly higher than in adults at the same travelling conditions [14]. However, ‘chronic ears’, such as secretory otitis media, atelelectasis and previously operated cholesteatoma are not predisposing factors for barotrauma [21].

Preventive Measures
Because of the pathophysiology as explained above, it is recommended that airplane passengers do not travel with an
upper respiratory infection [22]. Jaw movements, swallowing and yawing are simple techniques for the equalization of the pressure [3, 4, 8-10]. Valsalva’s and Frenzel’s maneuvers are used for the same reason [2-4, 7, 12, 17]. The first one is performed with a forced expiration, while keeping both nose and mouth closed. The second one consists of the person attempting to say the letter ‘k’ with closed nose and mouth. Frenzel’s maneuver is more difficult than the Valsalva’s, but it is more effective and it does not cause elevation of the intracranial pressure as the Valsalva’s maneuver does [3, 4, 12, 23].

Moreover, it is essential to mention that Valsalva’s maneuver can cause alternobaric vertigo or convulsive syncope in pilots with low ‘G’ tolerance, which can be seen, although extremely rarely, in air force pilots during demanding maneuvers [8]. The above practices are recommended to be performed every few seconds, especially every time the feeling of ear fullness returns. The opposite technique is the Tonbee maneuver, which can be performed by swallowing with closed nose and it is used to force the air out of the middle ear cavity and can be used in ascent in case of a difficult equalization [3, 12, 23].

Another method that is selected mostly in children and simulates Valsalva’s maneuver is the ‘Otovent’ [14]. This is a balloon full of air that is applied in each nostril, with the other nostril closed with the hand, the inflation of which is capable of opening the eustachian tube. It is important to mention the feeding technique for young children and babies during the descent that eliminates the incidence of barotitis media [3, 14].

When it is possible, especially in aviation crews, in private flights and hypobaric chambers, it is suggested to stop the descent and equalize the pressure in the middle ear with the ambient in higher altitude than that the otic pain started [12]. Unfortunately this technique is not applicable in commercial flights.

Another way for easier equilibration are the Air Plugs, which are silicon ear plugs with ceramic insert, that decreases the rapid movement of the environment air in contact with the tympanic membrane [11]. However, the common earplugs are not recommended during the flight because they can roll deeper into the auditory canal due to the increasing pressure and cause direct trauma in the tympanic membrane [9].

Another preventive measure is the use of decongestants. Researchers suggest that the use of an oral decongestant, such as pseudoephedrine, 30 minutes before the flight departure is a statistically important preventive mean for aerotitis media in adults, but it is not effective in children [24, 25]. As far as topical decongestants are concerned, the use of a nasal spray (eg oxymetazoline) is recommended one hour before the departure and 30 minutes before the expected arrival with uncertain results [2, 3, 24].

Systemic antihistamins could be used for the prevention of acute aerotitis media, mainly in virus infections of the upper respiratory and in allergic rhinitis.

When there is high risk of aerotitis media and air transport is unavoidable, there is the option of ventilation of the ear by myringotomy, with or without grommets [3].

Finally, a new possible promising technique for the prevention of acute aerotitis media is laser eustachian tuboplasty, which can provide flights free of otic pain in patients predisposed to otic barotraumas [3].

Treatment

It is important for the patient not to fly, dive or have a challenge in a hypobaric pressure chamber until the symptoms subside [9]. Treating the possible underlying condition, such as an infection,
helps the prevention and the cure of aerotitis. For the opening of the eustachian tube in case of persistent otic pain because of aerotitis media, middle ear inflation with Politzer’s bag or Valsalva’s maneuver can be used [3, 12, 14]. Oral and topical decongestants are recommended for the treatment of otic barotrauma. The use of antihistamins is not well established. In constant transudate fluid in the middle ear, needle aspiration is suggested, while in more severe cases myringotomy is preferred [10, 12]. The use of antibiotics is not necessary unless signs of infection are obvious. Although in most cases of tympanic rupture spontaneous healing occurs, sometimes the healing is slow and difficult. For these cases tympanoplasty is recommended [10]. Moreover, there is an interesting perspective for the use of artificial eustachian tube surfactant in the treatment of acute aerotitis media but this therapeutic option is still at research level [26].

Discussion

Acute barotrauma of the middle ear is a common health problem in our days, and anyone may experience associated severe pain. Nevertheless, it is almost always a condition that can be prevented with simple measures that anyone can perform. Informing the air-passengers about this condition is important, as well as their education about the preventive measures. Treatment is mainly symptomatic, while more research has to be done at this domain.

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