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Research Article

# Methods to Improve the Efficacy of Autoinflation Procedures and to Classify Eustachian Tube Patency

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## Abstract

We describe three methods to improve the efficacy of autoinflation procedures. The subjects were examined after flight with otoscopy and tympanometry. If the middle ear pressures after flight were negative, the passengers were asked to perform a Valsalva maneuver after which tympanometry was repeated. If still negative, the passengers were instructed to perform an extended Valsalva maneuver. If middle ear pressure was still negative, the passenger then was instructed to perform autoinflation using a nasal balloon. Among the ears with initial negative middle ear pressure, 14% normalized the middle ear pressure after Valsalva's maneuver. In the passengers with a remaining negative pressure, the pressure was equalized to zero or positive pressure in 46% following an extended Valsalva maneuvre. In the ears with remaining negative middle ear pressure after both Valsalva and extended Valsalva maneuver, 69% could normalize the middle ear pressure after nasal balloon inflation.

**Keywords:** valsalva's maneuver; extended valsalva's maneuver; nasal balloon autoinflation, middle ear ventilation; eustachian tube patency classification.

## Introduction

As described by Feldman [1] and Black [2] the first anatomical description of the nasopharynx-middle ear tube was done by Eustachio (1520-74) in 1563. He regarded the tube, which was named after him, only as a pathway for draining pathological material from the tympanic cavity. Du Verney (1648-1730) [3] in 1683 realized that an important function of the tube was replacing and adjusting the pressure of the air in the tympanic cavity. He thought that the tube is permanently open, thus offering a vent to the middle ear, when the tympanic membrane moves inwards and outwards. Valsalva (1666-1723) [1,2] in 1704 discovered a muscle for opening the tube and presumed that in the process of hearing this muscle would come into action. Valsalva described the maneuver that is named after him as a method to expel pus from the tympanic cavity into the external auditory canal. Now the Valsalva's maneuver is widely known as a method to equalize or "clear" the middle ear in the case of negative pressure. It has been shown that long-lasting negative middle ear pressure predisposes to chronic ear disease including cholesteatoma [4].

Today the three known functions of the Eustachian tube are pressure regulation, protection and drainage of the middle ear. The pressure regulation and protection are accomplished by active and passive functions of the Eustachian tube. The active function is tubal opening after active inferior -lateral traction of the tensor veli palatini muscle. If there is a pressure difference between the nasopharynx and the middle ear this will equalize when the tube opens. Closing the tube after termination of muscle tensor veli palatini activity is a passive event due to the elasticity of the surrounding tissue and if the pressure exceeds the closing forces around the lumen, the tube may open passively and the gas will flow through the tube.

The Valsalva maneuver is recommended in cases of Eustachian tube dysfunction: In children with glue ear, as a method to avoid barotrauma in aviation and in SCUBA diving. In patients who have undergone middle ear surgery, the procedure is advised in as a method to ventilate the middle ear, and hereby to prevent retractions and adhesions of the tympanic membrane or the graft to the promontory. Furthermore, satisfactory autoinflation is essential in professional aviation in obtaining safe flight. Disregarding this is a serious hazard leading to pilot incapacitation and to compromise aviation safety [5,6].

### Aim of the study:

From clinical experience with Valsalva's maneuver, we have described a method, by which it is possible to improve the effectiveness of Valsalva's maneuver [7]. We call the method the extended Valsalva maneuver. In this report we also include the nasal balloon inflation method, which has

shown to be an effective tool, to improve middle ear ventilation in the treatment of otitis media with effusion (OME) and as a treatment and as a prevention of barotitis during and after flight. [8,9]. We also like to describe the different steps of autoinflation, as a method to classify the Eustachian tube patency. In a study on balloon dilatation of the Eustachian tube, our proposed classification of the Eustachian tube patency was evaluated [10].

## Subjects and Methods

The subjects of the study comprise 134 adult passengers, with a negative middle ear pressure in at least one ear after air-flight at the arrival gate in Copenhagen airport [9]. The passengers were examined with an otoscopy and tympanometry at the gate in Heathrow airport before departure, and after arrival at the airport gate in Copenhagen airport. At the examination all subjects with negative middle ear pressures after air-flight, were asked to perform a Valsalva's maneuver, after which tympanometry was repeated. In case of residual negative middle ear pressure after Valsalva, the extended Valsalva's maneuver was performed, and tympanometry was repeated. In cases of continued negative middle ear pressure after the extended Valsalva's maneuver, nasal balloon autoinflation was performed again after which tympanometry was repeated.

### Valsalva's maneuver:

The Valsalva's maneuver is performed by pressing air into the nasopharynx, with the mouth closed and the nostrils compressed with the fingers (**Figure. 1**).

***Figure 1:*** *Valsalva maneuver*

### Extended Valsalva's maneuver:

The maneuver is performed as the ordinary Valsalva's maneuver, but first the neck is stretched maximally by forward flexion, and then the head is turned, positioning the ear to be inflated upwards. In this position the Valsalva maneuver is performed, increasing the chance of inflation in the uppermost ear. When the opposite ear is to be inflated, the head is turned in the opposite position (**Figure. 2**).

**Figure 2:** Extended Valsalva maneuver

**Nasal balloon inflation:**

The (Otovent®) set, developed by one of the authors (Stangerup SE), consists of a nose tube mounted with a special membrane. The nose tube is held airtight to one nostril, the opposite nostril is compressed with a finger, and with the mouth closed, the balloon is inflated through the nose. During the inflation phase, a positive pressure of 600 dPa. is created in the nose and nasopharynx, which can equalize the middle ear pressure through the eustachian tube, the normal opening pressure of which is approximately 400 dPa.(**Figure. 3**).


***Figure 3:*** *Nasal balloon inflation (Otovent©)*

## Results:

Middle ear pressure after Valsalva's maneuver:

Among the 134 ears with initial negative middle ear pressure, ranging from –5 dPa. to –210 dPa., 19 ears (14%) normalized the pressure (to zero or positive), after Valsalva's msaneuver (Table 1).

Middle ear pressure after extended Valsalva's maneuver:

In the 114 ears with remaining negative pressure after Valsalva's maneuver, 52 passengers (46%), could equalize the pressure by performing the extended Valsalva's maneuver. In 62 ears the pressure was still negative (Table 1).

Middle ear pressure after nasal balloon inflation:

In the 62 ears with remaining negative pressure after extended Valsalva's maneuver, 43 passengers (69%), could equalize the pressure by performing nasal balloon inflation using the Otovent set. In 19 ears the pressure was still negative (**Table 1**).

| Middle ear Pressure | Tympanometry | | |
|---|---|---|---|
| | After Valsalva n. (%) | After extended Valsalva n. (%) | After nasal balloon inflation n. |
| Zero or Positive | 19 (14) | 53 (46) | 43 (69) |
| Negative | 115 (86) | 62 (54) | 19 (31) |
| Total | 134 (100) | 115 (100) | 62 (100) |

***Table 1:*** *Middle ear pressure after Valsalva's maneuver, extended Valsalva's maneuver and After nasal balloon inflation,n in 134 ears with negative pressure after flight*

## Efficacy of the autoinflation procedures:

Of the 134 ears with negative middle ear pressure after flight, the combination of the different autoinflation procedures, 115 passengers (86%) could equalize their middle ear pressures (Table 1).

Proposed classification of the Eustachian tube patency (Table 2).

| | Middle ear pressure after | | |
|---|---|---|---|
| Class | Valsalva | Extended Valsalva | Nasal balloon inflation |
| 1 | 0 or Positive. | | |
| 2 | Negative | 0 or Positive | |
| 3 | Negative | Negative | 0 or Positive |
| 4 | Negative | Negative | Negative |

***Table 2:*** *Proposed classification of the Eustachian tube patency*

Class 1: 0 or positive pressure after Valsalva.

Class 2: Negative pressure after Valsalva, but 0 or positive after extended Valsalva.

Class 3: Negative pressure after extended Valsalva, but 0 or positive after balloon inflation.

Class 4: Still negative pressure after balloon inflation.

## Discussion

Only few subjects in this study had significant negative pressure of clinical relevance. The majority of ears with negative pressure had pressures ranging from –10 to –80 dPa. If the Eustachian tube is normally functioning and passable, the subjects should be able to equalize this to zero or positive pressure, by performing the Valsalva's maneuver. It is a surprise that only 14% of this adult age group were able to equalize the middle ear pressure in this way.

We cannot explain why stretching the neck and turning the head improves the effectiveness of Valsalva's maneuver. But it is possible that during this maneuver, the parapharyngeal muscles stretches, and thereby improves the opening of the tubal orifice. Another point of interest with the extended Valsalva's maneuver is that it is possible to "direct" the ventilation to the one ear in focus and to avoid the ventilation of the contralateral ear. This may be of clinical importance since many children, especially children with unilateral adhesions in the middle ear, where the opposite ear needs no ventilation, are afraid to perform autoinflation because of ear pain during the procedure. If this direction effect is due to improved opening of the tube to the ear in focus or is due to "blockage" of the contralateral tube, we do not know. Why nasal balloon inflations are so much more effective compared to Valsalva maneuvers could be explained by the fact that many patients are not aware of how the procedure is correctly performed or might be afraid of discomfort during the maneuver and may even perform a Toynbee maneuver (applying a negative pressure) by mistake. Inflating a balloon ensures that the

procedure is performed correctly because of the visual feedback of the growing size of the balloon.

## Conclusion

In cases of significant negative pressure the sequential steps of autoinflation should be used. Valsalva, extended Valsalva and nasal balloon inflation. We also advocate these steps as a method to classify the Eustachian tube patency.

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