Effect of Different Positions of the Head on Tympanometry Results: An Exploratory Study

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ABSTRACT

Introduction

Tympanometry is an objective measure of middle ear function that has been an integral part of the audiological evaluation test battery, for nearly three decades. The parameters of the tympanogram obtained are influenced with many factors such as introduction of positive or negative air pressure, speed of recording tympanogram, etc. This study was aimed to explore the influence of head positioning on tympanometric findings in normal ears.

Materials and Methods

Thirty ears of fifteen normal hearing subjects (mean age 22.8 years) and five ears of subjects (mean age 23 years) with high negative middle ear pressure were selected for the study. Tympanometry was done in four postures: head erect, head bent forward (chin touching the chest), head in supine and head lateralized towards one side.

Results

Two different results were obtained. It was interesting to note that the results significantly changed when the tympanogram was recorded after ten minutes in different head positions compared to those taken immediately after changing the head position.

Discussion

The possible explanation for the effect of duration in different head positions on tympanogram is discussed.

Conclusion

No significant changes were observed on static compliance, middle ear pressure, ear canal volume and pressure gradient when the tympanogram were recorded immediately bringing head in the particular posture. When head was held in the changed position for ten minutes, significant reduction in the pressure gradient was observed. Further extensive studies may be required to document the relationship between head positioning and tympanometric results.

Keywords:

Acoustic Impedance Tests; Tympanogram; Posture

Tympanometry is defined as the dynamic measure of acoustic immittance in the external ear canal as a function of change in air pressure in the ear canal. The peak compensated static acoustic admittance describes the height of the tympanogram measured at the plane of tympanic membrane. This measure is useful because certain disease process can increase or decrease the normal height of the tympanogram. Tympanogram Peak pressure (TPP) is the pressure at which the peak of the tympanogram occurs and is assured to be the point at which the pressure in the ear canal equals the middle ear pressure.[1]

Tympanometry gradient is an objective measure that described the steepness of the slope of the tympanogram near the peak.[1] Several investigators have noted that fluid in the middle ear reduces the gradient of the tympanogram expressed as a ratio[2] and also described that increasing gradient ratios of 0 to 0.3 had increasing sensitivities of 23 to 93% and decreasing specificities of 98 to 38% in identifying middle ear effusion in children scheduled for Myringotomy.[3] Tympanometric width (TW) is another measure used to quantify tympanogram shape

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in the vicinity of the peak and is sometimes also called the tympanogram gradient. Middle ear effusions can widen the tympanogram without substantially reducing the height.[4] No gender differences have been noted[2,5] although TW does increase with advancing age in the adult population.[5] Theoretically, pathologic conditions can either widen or narrow the TW. Although changes in the surface of the tympanic membrane e.g. atrophic scarring and tympanosclerotic plaques[6] can narrow tympanometric width, the only middle ear disorder that has been noted to narrow the TW in ossicular fixation.[1] Middle ear (ME) is a cavity filled with air spaces. If the cavity shape is altered relatively with tympanic membrane, the air, the mass of the middle ear content is influenced on tympanometric finding.[7] It is also found that maintaining head posture in one position prevents or accelerates blood flow and can lead to sense of fullness (increase in pressure) within the head. In view of this, the present study is aimed to explore the influence of head positioning on tympanometric findings in normal persons and cases with middle ear disorders. It was of interest of the authors to determine, whether there are changes in tympanometric results in head positioning in different postures. In this study four postures were used to study variance in tympanometric results.

Materials and Methods

The study was done in four different postures; head erect, head bent forward, supine, and head lateralized towards one side. To observe the effect of duration on tymapanogram two recordings were obtained. The first recording was done in simultaneous posture shift followed by tympanometry. The second condition was posture shift followed by tympanometry after 10 minutes delay. Thirty ears of fifteen normal hearing subjects (mean age 22.8 years) and five ears of subjects (mean age 23 years) with negative middle ear pressure were selected for the study. All the subjects had no history of asthma, hypertension, diabetes, and normal body mass index. Average neck length of the subjects was 10-12cm.

Tympanometry was done in four postures: head erect, head bent forward, supine, and head lateralized towards one side. (Fig. 1) Same procedure was repeated by holding the subjects head in above-mentioned four postures for ten minutes.

Results

Tympanometric tests were done with head held in four different positions. The results of tympanogram parameter obtained in ears without middle ear pathology; immediately in four different head position are shown in Table I.

The mean static compliance, mean middle ear pressure and mean gradient in the four different head position with head held in that position for 10 minutes is shown in Table II.

Inter-examiner reliability was obtained by applying Kappa correlation (r=0.82) in all measured parameters

Table I : Tympanogram parameter recorded immediately in four different head position for normal ears

TYMPANOGRAM PARAMETERS	HEAD ERECT	HEAD BENT FOR-WARD	HEAD IN SUPINE POSITION	HEAD LATERALIZED TOWARDS ONE SIDE
Mean static compliance (ml)	0.833	0.941	0.858	0.875
Mean middle ear pressure (dapa)	15.583	16.251	16.666	17.083
Mean Gradient	74.583	92.916	73.333	66.666

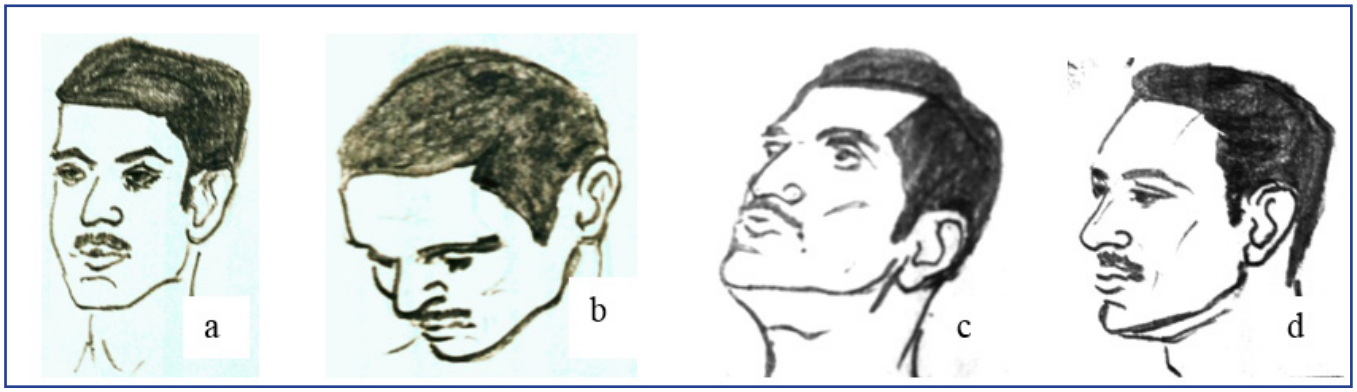

Fig.1. Different postures of the head used in this study

in triplet trials.

Discussion

This study made an attempt to find if the head positioning (head held erect, head bent forward, head in supine position and lateralized towards one side) had any significant changes in normal ears and in cases with middle ear pathology. A similar study on effect of body position in distortion product oto-acoustic emission had reported positive findings.[8] Assuming the volume of a normal ME cleft as 8 mL and following Boyle's law, an ME volume alteration of about 17 mL was required to induce such pressure change.

When the testing was done immediately, there was only change in pressure gradient of tympanogram in various head positions, as seen in Table I. There was a slight increase of pressure gradient (74.583 to 92.916) from head erect to head bent forward position and slight decrease from head erect to head lateralized (74.583 to 66.666). As tympanometric testing takes only few seconds any noticeable change in the physiological or biochemical/gravitational effect may not be observed.

When the head position was held in a particular position and held in that position for 10 minutes the significant changes were observed on at least one parameter of the Tympanogram ($p = 0.05$, t test). From the obtained results it was found that there was a significant change in tympanometric pressure gradient in normal ear as well as in cases with middle ear pathology when compared to head in erect position to head bent forward position. When the head was held in head bent forward position for 10 minutes the pressure gradient reduced by 28.16% (92.916 to 66.75) in normal ears as compared to the pressure gradient in same position

Table II : Tympanogram parameter recorded 10 minutes after head held in four different positions for normal ears

TYMPANOGRAM PARAMETERS	HEAD ERECT	HEAD BENT FOR-WARD	HEAD IN SUPINE POSITION	HEAD LATERALIZED TOWARDS ONE SIDE
Mean static compliance (ml)	0.833	0.850	0.875	0.883
Mean middle ear pressure (dapa)	15.583	15.416	16.250	18.333
Mean Gradient	74.583	66.75	72.083	72.916

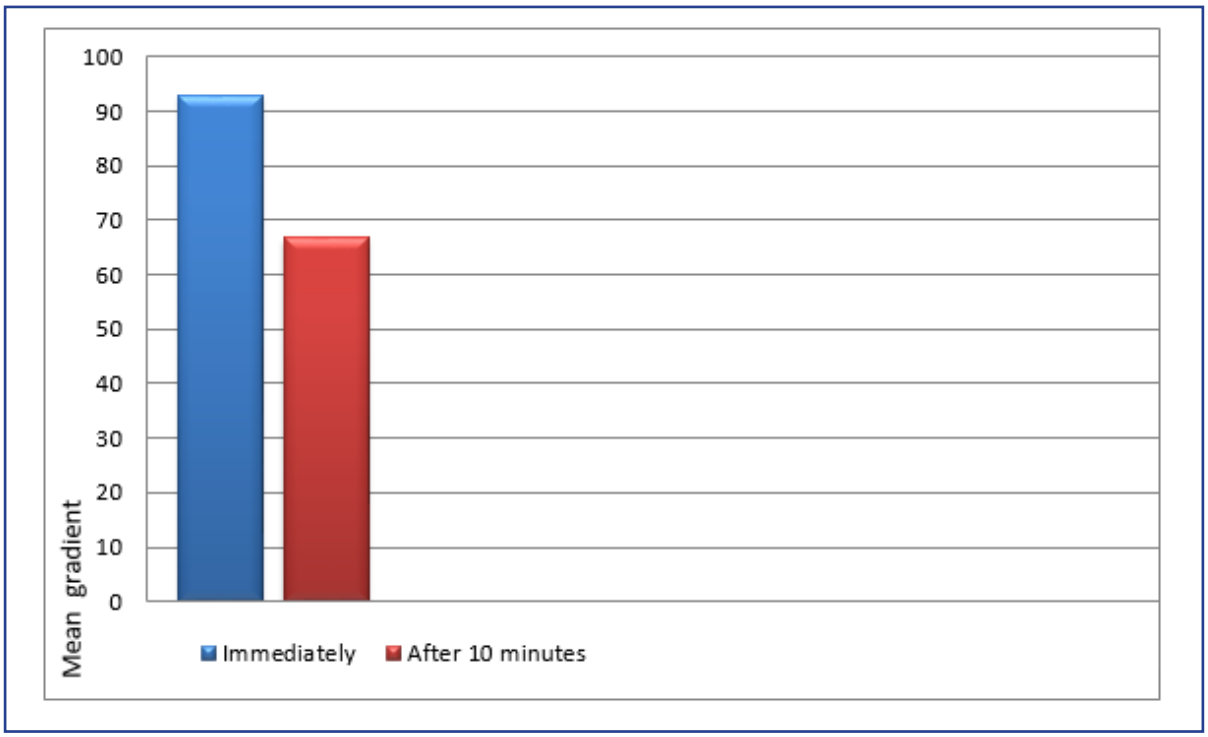

Fig.2. Difference in mean gradient in head bent forward position immediately and after 10 minutes in normal ears

measured immediately. (Fig. 2)

One possible explanation may be that when the head is bent forward and held in that position for 10 minutes the gravitational force may bring on the tympanic membrane extra weight, thus increasing the mass of the middle ear system. It will be interesting to see if any changes in the pressure gradient in cases with fixation of ossicular chain occur.

Other possible explanation is if the blood supply to the ear is reduced, Positional pressure changes were within the range of normal daily ME pressure variations. The instantaneous pressure changes and reversibility may be explained by filling and emptying of blood vessels within the ME cleft, following gravity causing an alteration of the aerated volume. Once a recumbent ear was repositioned upright it demonstrated an immediate pressure drop and regaining the initial ME pressure.[9] Head bent in forward position and held in that position for ten minutes may cause reduction in the blood supply to the middle ear and thus the increase in the mass of the middle ear.[9] However, more evidence has to be gathered before concluding the inferences from this study.

Conclusion

Tympanometric results are known to be influenced by factors like the starting point of the air pressure, recording speed, age and gender.[1,2,7,10] This study was an attempt to observe changes in three parameters of Tympanometric results with different head positions (head erect, head bent forward, head in supine and prone position). No significant changes were observed on static compliance, middle ear pressure, ear canal volume and pressure gradient when the tympanogram were recorded immediately bringing head in the particular posture, however there was significant change in pressure gradient when recorded after 10 minutes. With this exploratory study we hope to generate awareness amongst health care professionals about the variance in tympanogram on differing head positions. This may aid to do further research and help to standardize stringent tympanogram protocol taking head position into account.

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