

Effects of Air Pressure Change Rate in the Ear Canal on 1000-Hz Tympanometry: A Preliminary Report

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Abstract. The middle ear, a part of the hearing organ, transfers sounds into the inner ear. Tympanometry is a clinical procedure that assesses middle ear function, in which the acoustic admittance is measured with the ear canal air pressure systematically varied. In recent years, tympanometry using 1000-Hz probe tone was suggested to be more reliable in testing infants. Absent research on procedural variables has resulted in difficulties in establishing clinical norms. This study provided the first set of data in 23 adults showing that air pressure change rate significantly alters 1000-Hz tympanograms. This effect generally depends on admittance components measured and tympanogram pattern.

1. Introduction

The middle ear transforms airborne sound into mechanical energy, as the eardrum is vibrated, before it is transferred into the inner ear. A normal functioning middle ear is crucial for maintaining normal hearing. In clinical practice, middle ear pathologies are among the most prevalent issues. Accurate diagnosis and screening of middle ear diseases are dependent on a reliable clinical technique.

Tympanometry is a commonly applied technique in audiological practice that indirectly assesses the condition of the middle ear. It measures acoustic admittance (Y_a) in response to a 226-Hz tone with air pressure varied via a probe placed in the ear canal [1]. The Y_a is defined as the ease of sound energy flow; it includes two components: acoustic susceptance (B_a) and conductance (G_a). The outcome of tympanometry is known as - tympanogram, which is the magnitude of Y_a , B_a and G_a as a function of ear canal pressure.

In recent years, research has been increasing on tympanometry using 1000-Hz probe tone. Several studies have suggested that 1000-Hz tympanometry is more reliable in testing infants and young children [2, 3]. However, little is available concerning the effect of procedural variables on outcomes. One of the important variables is air pressure change rate in the ear canal, i.e., the speed at which the air pressure is varied in the ear canal. This may result in difficulties in comparing data from studies using different pressure rates and in establishing widely acceptable clinical norms.

Previous studies have demonstrated significant effects of air pressure rate on tympanograms tested with 226- and 678-Hz probe tone [4, 5, 6]. For example, higher rates increase the magnitude of admittance components. The purpose of this study was to investigate the effect of ear canal air pressure rate on 1000-Hz tympanograms in adults. Multiple measures were examined, including tympanogram peak pressure (TPP) and all acoustic admittance components— Y_a , B_a , and G_a . This was expected to be a step for conducting further research in young children.

2. Experiment, Results, Discussion, and Significance

Experiment:

Twenty-nine young adults (18-35 years) were recruited. Twenty-three were qualified (11 males and 12 females; mean age: 24.7 years, standard deviation: 3.7 years) with normal hearing and middle ear function according to the negative screening results from the following clinical tests: otoscopy, history of middle ear pathologies, air- and bone-conduction audiometric thresholds, and 226-Hz tympanometry. One ear was tested for each subject. Testing was conducted at the Wichita State University Evelyn Hendren Cassat Speech-Language-Hearing Clinic in a double-walled, sound-treated booth. The hearing thresholds were tested with a GSI 61 audiometer and supra-aural headphones and a bone vibrator were used. Tympanometry was assessed with a Tymptstar (Version 2) Middle-Ear Analyzer (Grason-Stadler Inc.).

A repeated measures design was applied. For each subject, fourteen tympanograms were acquired. The experiment included two parts: (1) Six consecutive 226-Hz tympanograms (to minimize effects of repetitive tympanometry and to screen subjects); (2) four 1000-Hz B_a/G_a and Y_a tympanograms, respectively, with randomized ear canal air pressure sweep rates (12.5, 50, 200, and 600 daPa/s). With 1000-Hz probe tone in adults, two patterns of tympanograms usually occur, single-peak and notched. For all tests, the pressure was varied from +200 to -400 daPa. The TPP, Y_a , B_a , and G_a were measured at the peak of single-peak tympanograms and at the notch and the larger peak of notched tympanograms.

Results:

Analysis of mean data revealed that, for Y_a , B_a and G_a tympanograms in both single-peak and notch types, TPP increased with increasing the air pressure rate. The changes were up to 25 daPa at 600 daPa/s, which were statistically significant ($p < 0.05$, one-way repeated measures ANOVA).

Mean change of admittance measures are shown in Fig. 1. For single-peak tympanograms, peak Y_a and G_a increased (~ 0.3 and 0.4 mmho) with increasing the rate, while peak B_a had minimal change. For notched tympanograms, notch Y_a and B_a significantly decreased (~ -0.3 and -0.5 mmho) with increasing the rate ($p < 0.05$), while change in G_a was minimal. Peak Y_a , B_a , and G_a exhibited small changes with increasing the rate, but not significant.

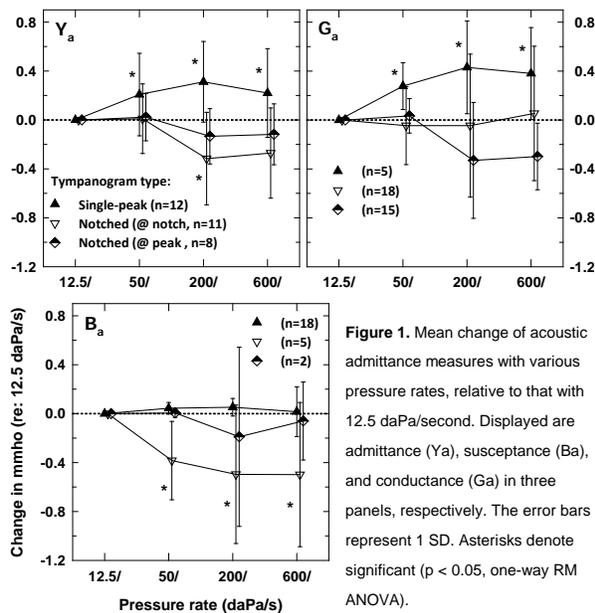


Figure 1. Mean change of acoustic admittance measures with various pressure rates, relative to that with 12.5 daPa/second. Displayed are admittance (Y_a), susceptance (B_a), and conductance (G_a) in three panels, respectively. The error bars represent 1 SD. Asterisks denote significant ($p < 0.05$, one-way RM ANOVA).

Discussion:

Raising the pressure rate generally increases TPP regardless of tympanogram type, but the change is small for rates ≤ 200 daPa/s. It also increases peak Y_a and G_a in single-peak tympanograms and decreases notch Y_a and B_a in notched tympanograms. Our study revealed that these effects in 1000-Hz tympanograms on TPP are different from, and on admittance measures are similar to, those reported in 226- and 678-Hz tympanograms [6].

Significance:

This study has provided the first set of data showing significant effect of ear canal air pressure sweep rate on 1000-Hz tympanograms in adults. This is an initial step with data collected from adults before research is conducted in young children.

3. Conclusions

The air pressure change rate in the ear canal significantly influences the outcome of acoustic admittance measures in 1000-Hz tympanogram. This effect should be taken into account when adopting clinical norms that were established with different pressure sweep rates.

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5. References

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