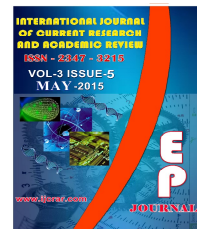




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Clinical application of tympanometry in the topic diagnosis of hearing loss – A study from Bulgaria

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A B S T R A C T

The study aims to demonstrate the clinical implementation and usefulness of tympanometry in diagnosis of hearing loss, focusing on the localization of the pathological process. The results elucidate the clinical diagnosis, contributing to build an adequate treatment and facilitating the evaluation of effectiveness in the follow-up period. The clinical study was conducted in the Audiology Sector of the Department of Otorhinolaryngology, Medical University – Sofia, for a period of two years, comprising 714 ears of 379 patients. The patients were divided in 2 groups: 1. Pediatric - aged between two months and 18 years – 336 ears (47%), and 2. Adult – from 18 years old up to the age of 87 – 378 ears (53%). The following equipment was used - impedancemeters (Siemens SD 30, Interacoustics AT 235 H); portable tympanometer (Welch-Allyn). For establishment of hearing impairment additional methods have been used - tonal audiometry, OAE, evoked response audiometry. The results were assessed as: conductive, sensoneural and combined hearing loss. The results were interpreted according to the following criteria: admittance, Tympanometric Peak Pressure, peak amplitude, the volume of the ear canal, compliance (ml/cc), peak pressure (daPa), and the change in gradients (%). Patients with conductive hearing loss were divided in 4 groups: a) middle ear effusion – 179 children and 26 adults; b) Eustachian tube dysfunction – 32 children and 34 adults; c) ossicular chain adhesions – 18 children and 85 adults; d) tympanic membrane perforations – 48 children and 27 adults. Based on the clinical results from the current study we could estimate the tympanometry as an objective and informative method for daily diagnosis of hearing loss.

Introduction

The process of hearing begins with a simple interaction between the mechanical energy of the sound wave and the hearing analyzer. Clinical audiology uses different methods of

testing and techniques for the accurate diagnosis of the hearing function. Acoustic impedancemetry gives us information about the functional capacity of the hearing

analyzer and abnormalities in hearing. The concept of acoustic immittance is introduced to connect the changes in the middle ear, which occur on the transfer of sound energy, and the moving of the system, which consists of several different mechanical components, which react in different ways to the forces applied in the external ear canal. The term “acoustic immittance” is used to present admittance or impedance, or both of them together (ANSI, 1987). The sound pressure of the tone, which is applied in the outer ear canal (SPL) is an indirect expression of acoustic immittance. The acoustic immittance of the tympanic membrane in a normal ear changes inadvertently, when the air pressure to the outer ear canal deviates up or down from the normal surrounding level. The standard connection between the changes in air pressure and the immittance level is an expression of the deviations, caused by diseases of the middle ear.

Tympanometry is the measurement of the eardrum’s mobility, when the air-pressure varies from +200 to -200 daPa. The results obtained are situated graphically, as the “x”-axis represents the air-pressure, while the vertical ‘Y’-axis represents the immittance or compliance, in other words – the conductance. It is in fact true that the impedance meter measures the admittance (compliance), rather than the impedance.

The tympanometer measures the energy of the noise signal as reflected by the tympanic membrane after application of various levels of pressure. The compliance, the conduction of the eardrum is measured in cm³, while the pressure in the ear canal – in daPa.

In 1990, ASHA (American Speech-language Hearing Association) recommended immittance-testing to screen middle-ear diseases. Silman *et al.* (1992) created an immittance protocol for the early detection

of otitis media with effusion in children, in which the main focus was: tympanometry width, the absence of a counter-lateral acoustic reflex, peak pressure, recorded in tympanometry, and static admittance of the middle ear. Katz (1994) defines this study as a routine, objective and sensitive method for determining pathologies in the middle ear, while Harrison *et al.* (2005) apply this for quantification of the hearing function. The interpretation of the results is part of the entire audiological assessment, combined with other hearing tests. Some authors describe the advantages of tympanometry as:

- An easy procedure;
- Comparable data from the different laboratories;
- The measurement of immittance has certain advantages, especially combined with other methods;
- The documented results prove objectively the occurrence of change in the middle ear, and the results of treatment.

Tympanometry is the measurement of acoustic immittance as a function of the air pressure in the ear canal. This function is systematically influenced by ear diseases, and is a vital component in the evaluation of the hearing function. Tympanometry measures admittance (compliance) through the application of variable pressure in the outer ear canal. The obtained data is routinely used in the audiological assessment and are the fundamentals of differential diagnosis, and the classification of middle ear diseases.

Thus, tympanometry measures the energy of the reflected sound, while the tympanometer automatically shows the volume of the ear canal. The data obtained from tympanometry are an accurate reflection of the changes occurring in the mechano-

acoustic characteristics and the ear function caused by various diseases, while the tympanogram is a graphic expression of these interdependencies.

The aim to apply the capacity of the method of impedance audiometry to define the topic of damage of the hearing analyzer.

The goal of this study is to demonstrate the importance of this test for the objectification of hearing loss.

We used data from the tympanometry for accurate diagnosis of the state of the middle ear, the deviations in sound conduction, and to define the damage topic. This eases clinical diagnosis, based on other objective and subjective methods, and to determine the adequate means of treatment; surgical or conservative.

Material and Methods

We present results and interpretations of the tests, conducted at the Medical Academy, Department of Otorhinolaryngology-Audiology, Sofia. We tested 714 ears of 379 patients over a period of 2 years (from 2003 to 2005). These were:

Children, aged from 2 months up to 18 years
- 336 ears (47%)

Adults from 19 to 87 years of age – 378 ears
(53%)

This is a representation of the tested patients according to age (Table 1). This group contains only ears with abnormalities in testing by tympanometry or other examination methods, such as conventional audiometry, OAE, BERA (Figure 1). We registered conductive, sensory-neural and combined hearing losses.

We used the following methods:

- Anamnesis
- Thorough ORL examination

Audiological tests (We determined the hearing level through tonal audiometry, speech audiometry, play audiometry when possible). By using the BERA method and OAE, we tested the hearing function objectively, when the application of psycho-acoustic methods was impossible, due to the absence of the subject and active participation on his part.

The examination by immittance tests included: tympanometry, reflexometry and testing the function of the Eustachian tube.

The following equipment was used: impedancemeters (Siemens SD 30, Interacoustics AT 235 H); portable tympanometer (Welch-Allyn).

Results and Discussion

The data obtained from the results of testing was used for interpretation:

- The static admittance peak (Ya)
 - Tympanometric Peak Pressure - TPP, which represents the dislocation of the peak of the pressure axis measured in daPa (decapascals).
 - The volume of the outer ear canal, measured in cm³, which measures the value of admittance – EVC (+200 Vea).
 - Tympanometric Gradient GR - which measures the width of the peak in daPa.
- The important components of the tympanogram are also:
- The point of peak pressure, which represents, or approximately represents the surrounding pressure.
 - Amplitude of the tympanogram – (peak value) as an answer to compliance or the elasticity of the system.

Admittance data

The table (Table 2) presents the results obtained from evaluating admittance of the tested children and adults.

Admittance

(Figure 2) This is a comparison between ears with normal and abnormal admittance, counted in number and reflected as a percentage.

According to peak position

TPP (Tympanometric Peak Pressure) – the data is presented as follows:

No clear peak – 289 ears (40% of all ears tested)

Peak with normal location – 227 ears (32% of all ears tested)

Abnormal peak location – 198 ears, irrespective of positive or negative zones (28 %). The mean average was considered 150 daPa for children and -50daPa for adults. (Table 3)

Tympanometric Peak Pressure (Figure 3)

According to peak amplitude

Static admittance peak – (Ya Peak) – This is the peak value of admittance of the tympanogram, measured in miliomes. In comparison to the accepted mean averages, this is an accurate indicator for middle ear diseases, registering pressure in the middle ear and the normal functioning of the Eustachian tube. This is a representation of the equalization of the pressure in the ear canal under the conditions of maximum conduction. The peak value reflects the mobility or density of the eardrum and the middle ear (Table 4).

The data obtained from the ears tested can be interpreted as high, low and unchanged in the infant and adult groups. Figure 4 shows the Peak Amplitude results.

D. According to the volume of the ear canal measured under conditions of $P = 200$ daPa. Norm for children: 0.5 to 1.0 ml; for adults – 0.6 to 2.0 ml.

Equivalent ear canal volume- (ECV при +200Vea) – reflects admittance values under pressure of +200 daPa in the ear canal or a certain acoustic volume of the ear canal, measured in cm³. The higher equivalent volume from the mean averages of a flat tympanogram allows for the presence of a perforation in the tympanic membrane or the ventilation tubes. A lesser volume is recorded in the presence of obturation of the outer ear canal by earwax, a foreign object as such. The mean averages of that volume depend on age and coincide with the volume of air with the same acoustic admittance as the ear canal/middle ear system on application of the same pressure. Generally, the volume varies from 0,5 to 2,0 cm³ or ml. Every measuring device has the mean average values preset (Table 5).

Apart from the elaborate metric data from tympanometry, we also tracked the function of the Eustachian tube, as well as acoustic reflexes of the examined ears.

Based on the tests conducted on 336 ears of children up to 18 years and 379 ears of adult patients with a registered pathology, we analyzed the combined results of combined results of all testing, we divided the patients with conductive hearing loss according to the following criteria: admittance, Tympanometric Peak Pressure, peak amplitude, the volume of the ear canal, compliance (ml/cc), peak pressure (daPa), and the change in gradients (%).

Table.1 Representation of the tested patients according to age

Patients	Number	%	Ears	%
Up to 18 years	184	48.6	336	47
Over 18 years	195	51.4	378	53
Total	379	100	417	100

Table.2 Results obtained from evaluating admittance of the tested children and adults

Admittance	children		adults		total	
	ears	% from overall	ears	% from overall	ears	%
With abnormalities	272	38	196	27	468	65
Normal	64	9	182	26	246	35
Total	336	47	378	53	714	100

Table.3 Tympanometric Peak Pressure

TPP	children			adults			total	
	ears	% overall	% from group	ears	% overall	% from group	number	%
norm	75	10	22	152	22	40	227	32
absence	206	29	61	83	11	22	289	40
altered P+/P-	55	8	17	143	20	38	198	28
Total	336	47	100%	378	53%	100	714	100

Table.4 The data obtained from the ears tested can be interpreted as high, low and unchanged in the infant and adult groups

admittance	children			adults			total	
	ears	% overall	% from group	ears	% overall	% from group	No.	%
unchanged	64	9	19	182	26	14	246	35
high	26	4	8	54	7	38	80	11
low	246	34	73	142	20	48	388	54
total	336	47	100	378	53	100	714	100

Table.5 Apart from the elaborate metric data from tympanometry, we also tracked the function of the Eustachian tube, as well as acoustic reflexes of the examined ears

volume	children			adults			total	
	ears	% overall	% from group	ears	% overall	% from group	No.	%
normal	193	27	57	328	46	87	521	73
high	97	14	29	38	5	10	135	19
low	46	6	14	12	2	3	58	8
total	336	47	100	378	53	100	714	100

Figure.1 Comparison between ears with normal and abnormal admittance, counted in number and reflected as a percentage

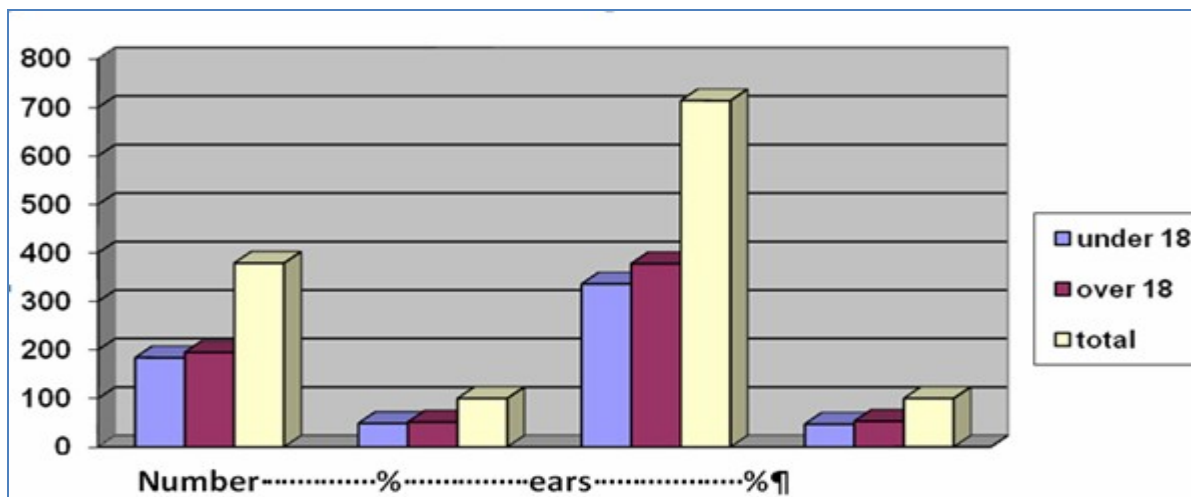


Figure.2 Tympanometric Peak Pressure

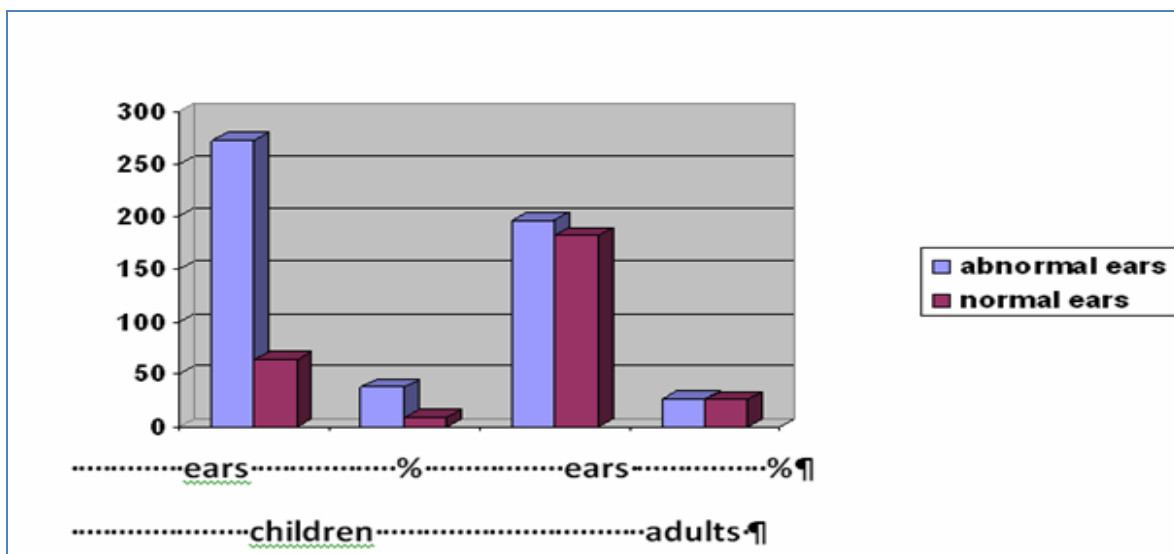


Figure.3 Peak Amplitude results

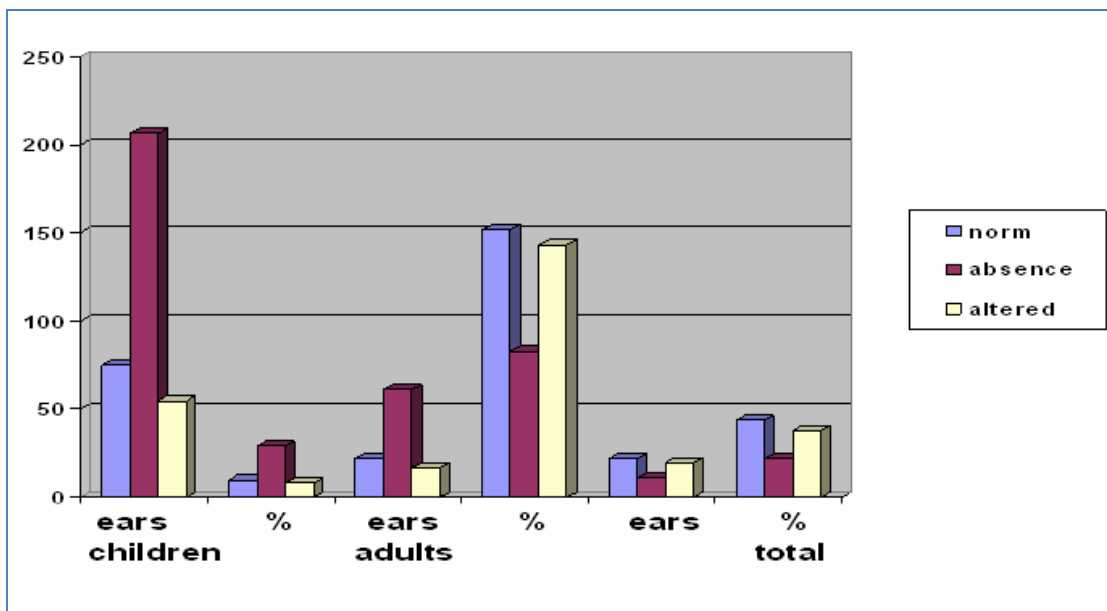
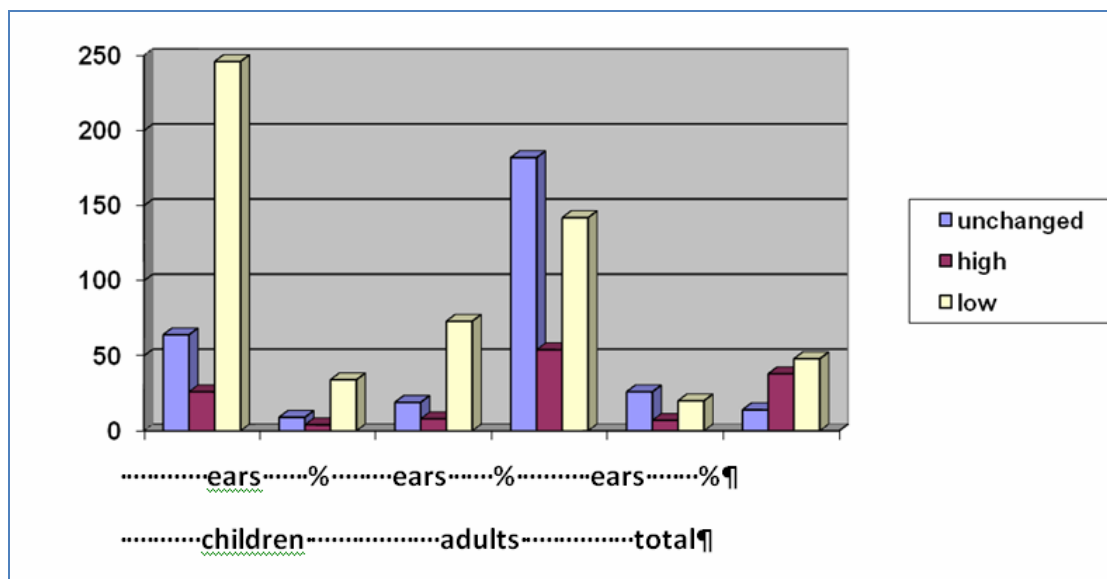


Figure.4 Tympanic membrane perforations (with or without tubes)



Patients with conductive hearing loss were divided in 4 groups:

- Middle ear effusion – 179 children and 26 adults;
- Eustachian tube dysfunction – 32 children and 34 adults;
- Ossicular chain adhesions – 18 children and 85 adults;

-Tympanic membrane perforations – 48 children and 27 adults.

The great clinical advantage of the method is that it is not influenced by the behavior or the answer and does not require the active involvement of the patient. Unlike most audiological techniques it is possible to apply this method to babies and infants

successfully, as well as patients that are difficult to test.

The tests we conducted have made it possible to group the ears examined, for both children and adults, according to the topic and nature of the pathological process as follows:

- Otitis media with effusion in the middle ear,
- Tympanic membrane perforations, with or without tubes,
- Tympanosclerosis,
- Hyper-mobility of the tympanic membrane,
- Dysfunction of the Eustachian tube,
- Otosclerosis,
- Discontinuation of the hearing chain,
- Neurinoma n. statoacustici,
- Constituted hearing loss,
- Brainstem disorders.

Upon interpreting the data obtained from the testing applied, we can classify the patients with conductive hearing losses as follows:

Group 1: with effusion in the middle ear – 179 children and 26 adults.

Group 2: with dysfunction of the Eustachian tube: 32 children and 34 adults

Group 3: with adhesions of the hearing chain ossicles – 18 children and 85 adults.

Group 4: with tympanic membrane perforations (with or without tubes) – 48 children and 27 adults. (Table 6) (Figure 5)

Conclusion

By virtue of applying this method of examination in testing, it is possible to make a valid identification of the lesion's location in complex audiological evaluation of the state of the hearing analyser and make a differential diagnosis.

Based on the clinical results from the current study we could define tympanometry as an objective and informative method for daily diagnosis of hearing loss. The conducted series of tests made it possible for us to evaluate the tested ears of children and adults, according to the topic and nature of the pathological process. The use of different audiological tests in addition to the measurement of impedance is vitally important for defining the state and the functional capability of the hearing system.

Impedance audiometry as an objective and easy to perform method is applicable for different groups of patients. We recommend impedance audiometry as a quick and cost-effective method for mass application in analyzing the hearing function.

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