EUSTACHIAN TUBE FUNCTION IN GERIATRIC SUBJECTS

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' What does " old age " mean? To a child of 4 years, a tall child of 12 years seems " old ", to a teenager, a worker,-aged 40 is "old". These are individuals who appear at a age of 50 years, to be ' old' in regard to their activity, vitality and their state of health. On the other hand, there are individuals at the age of 70 years who appear to be young in terms of their health, social activity and general vitality' (Hull, 1978). Therefore, ' old age ', then, is, indeed, arbitrarily defined.

Health statistics on hearing and ageing use 65 years as reference point for ageing. However, the beginnings of ageing in relation to the auditory system starts much before the age of 65 years (Hull, 1978). Therefore, in this research work, 60 years is considered as a reference point for ageing.

Ageing begins before birth and continues throughout life at different rates for different individuals and for different parts of the body (Etholm and Belal, 1974). In assessing the functional status of the middle ear mechanism in the elderly, especially geriatric subjects, the changes occurring with the age should be considered in differentiating normal from pathological ears. Although the hearing loss is not a direct cause of death, it can profoundly diminish the quality of life of the older adult (Butler and Gastel, 1979).

Physiological changes consequent to the ageing process occur throughout the human auditory system. Presbycusis is a collection of different entities occurring in various combinations affecting the entire auditory system from the middle ear through and including the central nervous system (Giled and Glorig, 1979). Sensori-neural hearing loss is most often associated with presbycusis. But the incidence of conductive disorders in the older adult population is quite high. It was observed by many investigators (Milne, 1977; Etholm and Belal, 1974).

Nixon, Glorig and High (1962) regarded the conductive hearing loss in the elderly as probably caused by degenerative changes in the ear drum, the ossicular chain and the muscles in the ear. According to these authors, the reason for the conductive hearing loss in the elderly is by the loss of mechanical integrity in the joints of the ossicular chain which results in dissipation of vibratory energy at these joints.

Farrior (1963), reported that the elderly are also susceptible to otosclerosis. Farrior (1963) observed sclerotic stapes fixation in more than one-third of 125 Cases, after 50 years of age. Goodhill (1969), also reported bilateral mixed hearing loss in a 71 year-old male patient due to ossicular chain atrophy.

Acoustic immitance techniques have also been applied to gain further insight into the effect of ageing on the conductive mechanism. But these studies reported conflicting and confusing results.

Blood and Greenberg in 1977 investigated the effect of age on acoustic admittance in a geriatric population ranging in age from 50 to beyond 70 years. Their result demonstrated a significant decrease in admittance for the 70 years-old group when compared to 50 to 59 year-old individuals. The change was primarily attributable to a decrease in susceptance.

According to Jerger, Jerger and Mauldin (1972), average impedance decreases until the 30 to 39 year of age range and then there is a tendency towards increasing impedance with increasing age. They also observed that compliance in males was consistently higher than in females in all age decades. Bicknell and Morgan (1968), commented that the compliance values for males were higher than those in females. Zwislocki and Feldman (1970) reported that static compliance in mate ears is consistently higher than that for females for low frequences. They also observed that, as the probe frequency approached resonance, the compliance values for females exceeded those for males. This lower resonant frequency in female ears may be due to anatomical differences in middle ear size.

Beattie and Leamy (1975) reported data on admittance values (inverse of impedance) in a geriatric population. The admittance values for their 60 to 70 year group were markedly higher than their 17 to 29 year group, suggesting that the middle ear becomes more complaint with increasing age.

Nerbonne, Bliss and Schow (1978) conducted puretone, otoscopic and impedance testing with subjects ranging from 20 to 29, 60 to 69 and 70 to 79 years of age. Results revealed a slight, but non-significant, tendency for static compliance value to decrease with age. Thomson, Sills, Recke and Bui (1979) reported no significant variation of acoustic admittance across age decades.

Hinchcliffe (1962) reported structural changes occurring in the auditory mechanism with increasing age. He noticed changes in pinna size, atrophic changes in supporting walls of external auditory meatus, non-specific ostietis of auditory ossicles, neuro-epithelial degeneration of inner ear, angiosclerosis, calcification of basement membrane in basal turn, degeneration of spiral ganglion cells and brain cellular degeneration. .

Etholm and Belal (1974), studied the incudostapedial and incudomelleal joints histologically in 125 ears from 86 individuals varying in age from infancy to 96 years. The earliest changes observed were fraying and fibrillation, followed by thinning and calcification. The joint capsule showed atrophy and hyalini-: zation and the articulatory disc showed hyaline deposits in severe cases. Audiogram on 55 years showed that arthritic changes in these joint did not impair sound transmission through middle ear.

A general decrease in the number, size, strength, endurance and agility of muscle fibres consequent to ageing was reported by Grob (1978).

An adequately functioning eustachian tube is of vital importance to' the integrity of the middle ear (Bluestone, 1975, 1980). The earlier reported observations of alternations in middle ear structures, such as thinning of the tympanic membrane, middle ear infections etc., can also be sequlae of inadequate eustachian tube function. The generalized decrease in synergistic muscle activity and strength were also decreased in the aged (Grob, 1978).

The integrity of the middle ear mechanism relies upon adequate function of tensor velipalatini, levator velipalatini, superior pharyngeal constrictor, salpingopharyngeal and tensor tympani muscles which contribute to the opening of the eustachain tube (Proctor, 1973). Therefore, one might expect eustachian tube function, which is dependent upon proper muscle action, to falter consequent to ageing.

Williams (1975), proposed a tympanometric pressure swallow test to assess eustachian tube function behind an intact tympanic membrane. Same procedure has been utilised with children (Seidemann and Givens, 1977) as well as in a normal young adult population (Seifert, Seidemann and Givens, 1979). The above authors have demonstrated the validity and sensitivity of William's tympanometric pressure swallow test procedure and support the use of the measurement technique in evaluating eustachian tube ventilating efficiency,

Chermak and Moore (1981), investigated the effects of ageing process on adequacy of eustachian tube function in older adults using electroacoustic immittance measurement. They tested a total of 32 subjects (16 males and 16 females) divided into three groups with equal numbers of male and female members in each group (20 to 75 years of age).

Newman and Spitmer (1981), studied the effects of age on eustachian tube efficiency, using a tympanometric swallow procedure. Ten aged males (67 to 89 years) and ten young controls (17 to 29 years) served as subjects.

Purpose of the present study

Present study was undertaken to test the hypothesis that the eustachian tube efficiency of geriatric subjects differs from that of young controls, using electro-acoustic immittance measurement.

Methodology

Subjects

Two groups of subjects participated in this study. The experimental group (Geriatric group) consisted of 28 subjects (18 males and 10 females) ranging in age from 60 to 75 years (x=65.93). Control group consisted of 23 subjects (10 males and 13 females) ranging in age from 18 to 30 years (X=21.65). In total, 40 ears were tested for each group. The subjects were selected based upon the following criteria.

1. Control group presented puretone averages of 20 dB HTL or better bilaterally (500 to 8000 Hz, ANSI, 1969).

2. Experimental group presented puretone average between 25 dB HTL to 80 dB HTL, bilaterally (500 to 8000 Hz, ANSI 1969). No air-bone gap greater than 5 dB was present in any of them. Members of experimental group were healthy and active older adults.

3. No history or external or middle ear pathology.

4. No history of any neuromuscular impairment.

5. Negative otological findings.

6. A normal tympanogram (A type) with a single-poaked tracing falling within normative values for point of maximum compliance and middle ear pressure (between $\pm$100 mm H_2O) (Jerger 1970 and Bluestone, Beery and Paradise, 1973).

7. Negative history and/or present status suggestive of the existence of any known pharyngeal and/or palatal abnormality.

8. Negative history of upper respiratory infections.

9. A measurable reflex at a maximum level of 125 dB HL, at least to a single frequency, ruling out any middle ear pathology.

The purpose of comparing the old with the young, is described elsewhere in this study.

Equipment

Puretone thresholds were obtained using a commercially available Maico Diagnostic Audiometer Model MA 22 (with its associated transducers [TDH-39] and Cushions MX-41/AR) and a Beltone Audiometer, Model 200 C, with its associated transducers (TDH-49) and Cushions, (MX-41/AR) calibrated to ANSI 83.6, 1969 standards.

A Madsen Electroacoustic Impedance Bridge, Model ZO 73 and its associated Hewlett Packord X-Y plotter, Model 7010 B were used for tympanometric measurements and recordings. Contralateral reflex thresholds were elicited using Telex (1470) earphone, enclosed in its associated ear cushion (MX-41/AR).

Calibration Procedure

The electro-acoustic impedance bridge's probe frequency, intensity, water pressure and compliance were calibrated prior to experimental use.

Test Environment

All testings were performed in the newly constructed sound treated rooms of All India Institute of Speech and Hearing, Mysore. The noise level in the test room was far below the interference level as measured by the sound level meter (Bruel and Kjaer, 2209) and its associated octave filter (B and K 1613).

Procedure

All subjects were tested by both conventional and impedance audiometry as a routine part of their clinical evaluation by the Audiology service of the All India Institute of Speech and Hearing, Mysore. Otoscopic examination and impedance screening were performed prior to actual experiment to accurately rule out the influence of any unnoticed external or middle ear pathology.

Madsen electroacoustic impedance bridge (Model ZO 73) in conjunction with an X-Y plotter (Model 7010 B Hewlett-Packord) was used to create and monitor air pressure changes for testing eustachian tube function.

To assess eustachian tube function, the investigator used a combination of techniques based on Newman and Fanger (1973) and Williams (1975).

Results and Discussion

Analysis of the resultant tympanometric data included two variables, i.e., middle ear pressure and function change. Both middle ear pressure and function were analysed relative to the amount, direction and range, following the eustachian tube test. When the tympanic membrane was pushed toward the middle ear cavity by a positive pressure of 300 mm H_2O, a mechanical pressure will be generated against the aural opening of the eustachian tube in the middle ear. During swallowing, air will be forcefully expelled through the eustachian tube. With the eustachian tube closed, after swallowing, the amount of air remaining in the middle ear will be less than it was before swallowing. Consequently, when the tympanogram was retraced, there will be shift in the peak pressure point to a negative direction (T_2) reflectively reduced middle ear air pressure, when compared to the initial base line tympanogram (T_1). This is the expected negative direction pressure change when positive pressure was induced into the external auditory meatus.

When the tympanic membrane was under stress from a negative air pressure of -300mm H_2O, it will be drawn toward the ear canal. Now opening of the eustachian tube during swallowing will allow air to be drawn into the middle ear cavity through the eustachian tube. This opening of the eustachian tube creates greater amount of air in the middle ear cavity. Consequently, when the tympanogram was retraced, there will be a shift in the peak pressure point to a positive direction (T_3) when compared to the initial base line tracing (T_1), reflecting increased middle ear air pressure. This is the expected positive direction pressure change when negative pressure was induced into the external auditory meatus.

The magnitude of middle ear function (tympanometric amplitude) change (FC per cent) was calculated utilizing the following equation suggested by Siedmann and Givens (1977).

$$FC\ \% = \frac{FD_2 - FD_1}{FD_1} \times 100$$

where FD_1 = represents the difference in middle ear function between peak amplitude and the point of tracing at 200mm H_2O with respect to base line tyrnpanogram (T_1).

FD_2 = represents the difference in middle ear function (compliance) between the peak pressure point and 200mm H_2O point obtained in condition T_2 following the eustachian tube test.

With the use of this equation, the expression of the magnitude of function change was not limited by instrument specificity. According to Siedirann and Givens (1977), this procedure facilitates a comparison of tympanometric amplitude changes without regard to the calibration standard, or unit of measurement—admittance, impedance or compliance-,

Seidmann and Givens (1977) and Seiiert, Seidmann and Givens **(1979)** considered a pressure change of 20 mm H_2O and a function change of 5 per cent as evidence of adequate eustachian tube function. Seidmann and Givens (1977) analysed expected negative pressure change and function change, only under induced pressure of 400mm H_2O. Seifert, Seidmann and Givens (1969) analysed both expected positive and negative pressure change and function change, under both induced positive and negative pressure. Williams (1975) also reported **a** pressure change of 15 to 20mm H_2O as evidence of adequate eustachian tube function. He analysed both expected positive and negative pressure change only under induced pressure of i400mm H_2O. Chermak and Moore (1981), while studying eustachian tube function in the older adults, analysed both pressure and function change only under -400mm H_2O. But Newman and Spitzer (1981), while studying eustachian tube efficiency of geriatric subjects, analysed pressure and function change underi400mm H_2O.

TABLE 1

Means, Ranges and Standard Deviations of resting middle ear pressure (extracted from the baseline tympanogram)

	Control group	*Geriatric group*
Mean	29.9	30.66
Range	+ 70 to —4	+100 to —84
Standard Deviation	16.77	33.80

In the present study, both pressure and function changes were analysed under ±300mm H_2O, for both control and geriatric groups. Resting middle ear pressure for geriatric group (X=30.66,S.D.=33.8) was slightly higher than that of control-group (X= 29.9,S.D.== 16.77). There was no significant difference between these two means, but geriatric group showed more ability.

TABLE 2

Means, Ranges and Standard Deviations for the point of maximum compliance (in mm H2O) for each of the three tympanometric conditions .. ....

Subject group	Tympanometric condition		
	T_1	T_2	T_3
Control			
Mean	29.9	43.4	11.9
Range	+70 to —4	+ 8 to+116	+ 64 to —30
S.D.	16.77	21.77	22.90
Geriatric			
Mean	30.66	26.53	21.85
Range	+100 to —84	+75 to — 60;	+180 to —120
S.D.	33.80	31.44	51.64

There was non-significant difference between control,and geriatric groups for the point of maximum compliance (in mm H_2O) for two (T_1 and T_3 *)* out of three tympanometric conditions. There was significant difference only for T_2 swallow under induced positive external auditory meatus pressure condition. Here too geriatric population showed more variability.

TABLE 3

Means, Ranges and Standard Deviations for the magnitude of middle ear function change

Subject group	***Mean***	*Range*	*S.D.*
Control	0.38	— 13 to 13.3	6.79
Geriatric	0.22	—11.7 to 23.61	9.51

Mean magnitude of middle ear function change for control group (X=0.38, S.D.=6.79) was slightly higher than that of geriatric group (x=0.22; S.D. =9.51). There was non-significant difference between these two means. But here also geriatric group showed more, variability.

TABLE 4

Per cent of expected pressure change following eustachian tube testing (No. of ears (n) and per cent of the total No. of ears)

Subject group	Direction of pressure exerted	>20mra H_2O		<20mm H_2O		No change	
		n	%	n	%	n	%
Control	Positive	1	2.5	32	80.0	7	17.5
Geriatric		12	30.0	25	62.5	3	7.5
Control	Negative	1	2.5	34	85.0	5	12.5
Geriatric		7	17.5	31	77.5	2	5.0

2.5 per cent of the control group ears (2.5 per cent for positive and 2.5 per cent for negative induced pressure swallow) showed pressure change of>20mm H_2O. 83 per cent of ears (80 per cent for positive and 85 per cent for negative pressure swallow) showed pressure change of <20 mm H_2O and 15 per cent of the ears did not show any change. Whereas 24 per cent of the geriatric group ears (30 per cent for positive and 17.5 per cent for negative induced pressure swallow) showed pressure change of>20mm H_2O. 70 per cent of ears (62.5 per cent for positive and 77.5 per cent for negative) showed pressure change of<20mm H_2O and 6 per cent of the ears did not show any change. Geriatric groups demonstrated better ventilating efficiency than control group. The incidence of > 20mm of pressure change after eustachian tube testing in the geriatric population 24 per cent of the present study is similar to that of children (22 per cent, Seidmann and Givens, 1977) and adult/older adult ears (28 per cent, Chermak and Moore, 1981).

TABLE 5

Per cent of function change (FC%) following eustachian tube testing (No. of ears (n) and per cent of the total No. of ears)

Subject group	5%		<5%		No change	
	n	%	n	%	n	%
Control	13	32.5	26	65	1	2.5
Geriatric	10	25.0	29	72.5	1	2.5

In the present study, control group ears showed better per cent of function change of>5 per cent (32.5 per cent) following eustachian tube testing than geriatric group ears (25 per cent). Seidmann and Givens (1977) reported function changes of>5 per cent in 79 per cent of the paediatric ears tested. Chermak and Moore (1981) reported function changes of>5 per cent of 41 per cent of the adult/older adult ears tested.

TABLE 6

Means, Ranges and Standard Deviations for Tympanogram Amplitude (in arbitary units) for each of the three Tympanometric Conditions

There was no significant difference between the tympanogram amplitude (in arbitary units) for each of the three conditions (T_1, T_2, T_3) among both groups. However, in the present study, T_2 condition produced the highest mean amplitude for both control and geriatric ears. This was contrast to Newman and Spitzer (1981) study. In their study, T_3 condition produced the highest mean amplitude for both control and geriatric subjects. In the present study, larger standard deviations in the Geriatrics' data indicated greater amplitude variability than among controls.

In the present study, expected pressure direction change following eustachian tube testing for control group was 14 per cent and for geriatric group it was 29 per cent. Chermak and Moore (1981) reported that 75 per cent of the adult/older adult ears showed expected direction of pressure change. Seifert, Seidmann and Givens (1979) reported 80.8 per cent for their adult group. Seidmann and Givens (1977) reported expected pressure change in only 33.7 per cent of their paediatric subjects. Therefore, expected pressure change observed in the present study is in agreement with Seidmann and Givens (1977). No reasonable explanation for unexpected pressure changes in the same direction as induced pressure is available. This may be because of differential sensitivity of this procedure for different populations, Expected function changes following eustachian tube was observed in 77.5 per cent of control ears and 83.75 per cent of geriatric ears. Here more function change was observed in geriatric ears. Chermak and Moore (1981) reported 65 per cent of ears evaluated presented positive function change. Seidmann and Givens (1977) found 83 per cent of the ears evaluated presented expected function change (The present study report agrees with this).

In the present study,77,5 per cent of the control ears and 90 per cent of the geriatric ears exhibited change in both parameters of middle ear measurement (function and pressure) after eustachian tube testing. Seidmann and Givens (1977) reported that, 62.9 per cent of their sample of paedaitric ears yielded changes in both parameters. Chermak and Moore (1981) found only 8 per cent of their adult/older adult ears showed changes in both parameters.

Summary and Conclusion

This investigation examined the effects of age on the adequacy of eustachian tube efficiency. 28 geriatric subjects (X=65.93 years) consisting of 18 males and 10 females, presenting normal hearing sensitivity and sensorineural hearing loss served as experimental group. 23 subjects with normal hearing sensitivity (X=21.65 years) consisting of 10 males and 13 females, served as control group. In total 40 ears were tested for eaeh group.

Tympanograms were analysed relative to middle ear pressure and function (amplitude) changes after eustachian tube testing. Statistical analysis of the data did not show any significant difference between the two groups. But on the whole, the observation presented an evidence that the geriatric group performed slightly better than the control group in the pressure swallow test. This may be because of differential sensitivity of the Williams pressure swallow procedure or because of sample size and the possibility of (unknown) sampling bias or the geriatric population, as group may exhibit' normal' eustachian tube function and it seems abnormal when compared to normal adult subjects. Therefore, a separate norm for geriatric population is needed.

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