



**IJCRR**

Vol 06 issue 08

Section: Healthcare

Category: Research

Received on: 05/02/14

Revised on: 02/03/14

Accepted on: 30/03/14

## PURE TONE AUDIOMETRIC EVALUATION IN NON-INSULIN DEPENDENT DIABETIC PATIENTS

S. Vijayasundaram, P. Karthikeyan, V. Nirmal Coumare

Department of ENT, Mahatma Gandhi Medical College and Research Institute, Pondicherry, India

E-mail of Corresponding Author: vijay72sundaram@rediffmail.com

### ABSTRACT

The prevalence of hearing defects in the Indian population is estimated to be about 6%. The risk factors are age, noise, cardiovascular system disorders, Diabetes mellitus and social factors.

**Aims:** The aims of the study were to find out the prevalence and type of hearing loss among diabetic subjects, to establish if there was a relationship between age, duration, severity and complications of Diabetes to the changes in hearing threshold and to establish if there was a relationship between height, weight, family history, diet, blood pressure, blood group and blood cholesterol.

**Materials and methods:** This study included 100 diabetic patients (NIDDM) and 200 normal subjects (controls) in the age group of 30 – 59 years, and the controls were matched for age and sex. A detailed clinical examination was performed using a diabetic proforma and screened for complications. The diagnosis was established with the help of tuning fork tests and audiometric analysis. Diabetic patients were categorized into groups and subgroups and were analyzed for statistical significance.

**Results:** It was found that diabetics have an increased mean threshold of hearing at higher frequencies than non-diabetics. The type of hearing loss is typically bilateral and symmetrical, involving higher frequencies. The complications of the disease, sex, weight, height, family history, diet, blood pressure, blood group and blood cholesterol had no significant correlation with the type of hearing loss and with mean average hearing threshold.

**Conclusion:** A relationship exists between the hearing impairment in diabetic patients and other aspects of the disease, which include age, duration and control of Diabetes mellitus.

**Keywords:** Pure tone audiometry, Non-insulin dependent Diabetes mellitus, Hearing loss

### INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder with an incidence of 1-2% which is classified as non-insulin-dependent diabetes mellitus or insulin-dependent diabetes mellitus, which corresponds to the previous labels of adult onset diabetes mellitus (Type II) and juvenile onset diabetes mellitus (Type I).

They are suspected to be two separate entities from the pathogenesis, with the non-insulin type probably the result of breakdown of interaction of regulatory mechanisms, while insulin-dependent diabetes mellitus may be related to partial

destruction of B cells in the pancreas and may be modified by polygenic (suspected to be a specific HLA antigen) and environmental (thought to be a viral infection) factors. An autoimmune component is thought to be responsible for the destruction of the B cells. Pathologically it constitutes the triad of neuropathy, retinopathy and nephropathy.<sup>1</sup>

Complications from insulin-dependent diabetes are more commonly microvascular, resulting in small vessel disease of the kidneys, retina and the skin as well as neuropathy, and less commonly, macrovascular.

Non-insulin-dependent diabetes is more common in obese and older patients with a strong genetic predisposition. Fewer microvascular complications are seen; there is a higher risk of large vessel atherosclerosis, coronary disease and peripheral vascular disease.<sup>2</sup>

The literature exhibits many contradictions concerning the correlation between hearing impairment and diabetic manifestations. It is evident that good control and regular surveillance for complications enables the patients to lead a normal life.

The typical hearing loss described is a progressive, bilateral. Sensorineural deafness of gradual onset affects predominantly the higher frequencies and older patients. There is a decrease in auditory acuity which is similar to that of presbycusis, but those affected show a hearing loss greater than that expected at that age.<sup>3,4</sup>

Worldwide the prevalence of hearing impairment is estimated at about 440 million people. Age is the primary risk factor in the population. Other risk factors include noise, cardiovascular disease, Diabetes mellitus and social factors.

Non-insulin dependent Diabetes mellitus accounts for almost three quarters of all cases of diabetes. Angiopathy and peripheral neuropathy are well recognized complications. It is reasonable to expect these lesions to affect the inner ear leading to hearing impairment.<sup>8,9,10</sup>

The oculomotor, trochlear and facial nerve palsies seen in diabetic subjects further suggest that besides autonomic and peripheral neuropathy there is definitely some neuroendocrine defect which contributes to central neuropathy.<sup>5</sup>

## MATERIALS AND METHODS

This study was undertaken on patients who attended the outpatient departments of General Medicine and ENT of Mahatma Gandhi Medical College and Research Institute, Pondicherry, over a period of one year.

The aims of the study were to find out the prevalence and type of hearing loss among

diabetic subjects, to establish if there was a relationship between age, duration, severity and complications of Diabetes to the changes in hearing threshold and to establish if there was a relationship between height, weight, family history, diet, blood pressure, blood group and blood cholesterol. The inclusion criteria were: (i) diagnosis of Diabetes mellitus based on National Diabetic Data Group of the National Institute of Health (NDDG) criteria and (ii) cases receiving anti-diabetic treatment showing even a normal range of blood sugar. The exclusion criteria included: (i) history of congenital deafness in the family, (ii) history of head injury and intake of ototoxic drugs, (iii) history of chronic suppurative otitis media, (iv) history of previous ear surgery and (v) history of acoustic trauma and noise induced hearing loss.

In this study, 200 age and sex matched healthy subjects formed the control group (Group I) and were evaluated along with 100 diagnosed cases of Non-Insulin Dependent Diabetes Mellitus (NIDDM) without (Group II) and with complications (Group III) such as peripheral neuropathy, non-healing ulcer, diabetic retinopathy, hypertension, nephropathy, congestive cardiac failure or ischaemic heart disease.

All patients included in the study were subjected to a thorough systemic and ENT examination to rule out any organic pathology in the external and middle ear. Tuning fork tests were done using 256 Hz, 512 Hz and 1024 Hz tuning forks. All patients were screened for diabetic retinopathy in the retina clinic by direct and indirect ophthalmoscopic examination of the fundus. Audiological evaluation was done by Pure Tone Audiometry (PTA) in the Department of ENT using Arphi Digital model 500 MK III audiometer. Both air and bone conduction were tested. Audiograms were recorded for each patient. Patients were examined by a neurologist to rule out peripheral neuropathy, which was confirmed by nerve conduction study. Biochemical estimation of blood

urea and serum creatinine was carried out to rule out nephropathy.

The patients were categorized into groups according to age, sex, duration, severity and complications of diabetes. Hearing loss was assessed purely based on tuning fork tests and audiometric readings only.

Statistical data was analysed using epidemiological information package developed by WHO. To find out the statistical significance, Kruskal-Wallis H test (equivalent to Chi square test) was used since the observations were normally distributed and a large sample was taken. Mean, standard deviation and 'p' value were calculated and tests of significance carried out.

The bone/air conduction thresholds were measured for both right and left ears in all patients and taken for each frequency 250 to 8000 Hz. The mean was further categorized according to the group and analysed statistically.

## RESULTS

A total of 300 patients were included in the study, of which, 142 were male and 158 were female, with the age ranging from 30 – 59 years.

Table I shows the distribution of hearing impairment among the study population. Hearing impairment among the diabetic population is 48% in comparison with non-diabetic population. Diabetes mellitus is the risk factor which contributes four times more risk of hearing loss in comparison with the control population.

Table II shows the average hearing threshold for different frequencies for the study population. The mean threshold at each frequency of all control subjects and diabetic patients were calculated, tabulated and compared. The average thresholds in different frequencies were highly significant. The p value is <0.01 both for bone conduction and air conduction in both ears. An average 40% of people were affected by the average threshold in the diabetic group in higher frequencies in both ears, especially in bone conduction.

The age distribution of the diabetic cases included in the study is shown in Table III. The age distribution of diabetic patients ranged from 30 to 60 years and included 47 males and 53 females. A statistically significant relationship was established in relation with age and hearing impairment in diabetic patients.

Table IV shows the age-wise distribution of the type of hearing impairment while Table V shows the age-wise distribution of average hearing thresholds in different frequencies of the diabetic subjects. 48 out of 100 diabetic patients were found to have hearing impairment, of which, 25 had sensorineural hearing loss, 18 had mixed hearing loss and 5 had conductive hearing loss. Only one ear was affected in 4 patients while both ears were affected in 44 patients. The mean hearing threshold levels in higher frequencies were affected in both ears in diabetic patients.

The duration of Diabetes mellitus, type of hearing loss and percentage of hearing loss were analysed and tabulated in Table VI. The number of years as a diabetic significantly affected the average hearing threshold in higher frequencies, especially more in the 10 – 20 years duration group (53.3%), with a P value of <0.05. 8 out of 30 patients in the 10 – 20 years duration group were affected by bilateral high-tone sensorineural hearing loss.

The correlation between duration of Diabetes mellitus and the average hearing threshold in different frequencies is shown in Table VII. The mean average threshold in 20 – 30 years duration group in higher frequencies was increased and statistically significant.

The relationship between control of Diabetes mellitus with average hearing threshold and type of hearing loss was tabulated and analysed and is shown in Tables VIII and IX. 25 patients with hearing impairment were found to have poor glycemic control and of these, 12 were found to have sensorineural hearing loss and 13 were found to have mixed hearing loss.

The average hearing threshold is calculated by analysis of variance technique. There is marked

reduction in hearing threshold from good to moderate in patients with poor control of diabetes, which is highly significant in higher frequencies (P value <0.001)

The correlation between complications of Diabetes mellitus and type of hearing loss and average hearing threshold in different frequencies is shown in Table X and Table XI. The patients with no complications had a relatively high threshold in low and high frequencies than those with no complications (speech frequency equal). There was no statistical significant relationship found.

## DISCUSSION

In this study, the average hearing thresholds for higher frequencies of 40% of patients in the diabetic group were found to be affected, especially in bone conduction. Similar results were seen in studies carried out by Axelsson<sup>3</sup>, Taylor *et al*<sup>7</sup>, Costa<sup>19</sup>, Kurien *et al*<sup>11</sup>, Kutty<sup>25</sup>, Agarwal<sup>1</sup> and Sharma<sup>23</sup>.

A positive relationship between age and hearing impairment among diabetics was reported by Kutty<sup>25</sup>, Agarwal<sup>1</sup> and Sharma<sup>23</sup>. In our study, 48% of diabetic patients were found to have hearing impairment and these patients fell in the 40 – 60 years age group, most having sensorineural or mixed type of hearing loss, with both ears being affected in the majority.

A positive correlation between duration of diabetes mellitus and hearing loss was reported by Zelenka *et al*<sup>6</sup>, Axelsson *et al*<sup>3</sup>, Tay<sup>26</sup> and Sharma<sup>23</sup>. Kurien *et al*<sup>11</sup> and Cullen *et al*<sup>12</sup> and few other studies<sup>20,21,22,27,28</sup> did not find such a relationship. Duration of diabetes mellitus significantly affected the average hearing threshold in higher frequencies, which was found to be especially significant in the 10 – 20 years duration group.

Our study showed a marked reduction in hearing thresholds from good to moderate in patients with poor control of diabetes, which was highly significant in higher frequencies. A similar relationship was reported by Agarwal<sup>1</sup> and

Sharma<sup>24</sup>. Krocks collaboration study group (1984)<sup>13</sup> and other studies<sup>14-18</sup> stated that good control of Diabetes mellitus would decrease or postpone the angiopathic changes in the end organs.

Axelsson<sup>4</sup>, Tay<sup>26</sup> and Kutty<sup>25</sup> found no relationship between severity of the disease and the hearing threshold. Jorgenson<sup>5</sup>, Kurien<sup>11</sup>, Agarwal<sup>1</sup>, Sharma<sup>23,24</sup> showed a distinct relationship between diabetic retinopathy, neuropathy and microangiopathy and the hearing threshold. Our study showed no statistical significant relationship between complications of diabetes mellitus and type of hearing loss and average hearing threshold in different frequencies.

## CONCLUSION

The study showed that diabetics have an increased mean threshold at higher frequencies in comparison to non-diabetics. Older age groups, longer duration of diabetes and poor control of diabetes showed strong correlation with significant bilateral high frequency hearing impairment as compared to presbycusis. No statistically significant relationship was found between hearing impairment and complications of diabetes, weight or other parameters.

## CONFLICT(S) OF INTEREST: NONE

## ACKNOWLEDGEMENT

The authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors/ editors/ publishers of all those articles, journals and books from where the literature for the article has been reviewed and discussed.

## REFERENCES

1. Agarwal MK. Otorhinolaryngological studies in diabetics. *IJO & HNS* 1998;50:116-121.
2. Verma A, Bisht MS, Ahuja GK. Involvement of central nervous system in diabetes mellitus.

- Journal of Neurology, Neurosurgery and Psychiatry 1984;47:414-416.
3. Axelsson A, Fagerberg SE. Auditory function in diabetics. *ActaOtolaryngologica* 1968;66:49-64.
  4. Axelsson A, Fagerberg SE. Hearing in diabetics. *ActaOtolaryngologica* 1978;356:1-23 (supplement).
  5. Jorgensen MD, Buch NH. Studies on inner ear functions and cranial nerves in diabetics. *ActaOtolaryngologica* 1961;53:350-364.
  6. Zelenka J, Kozak P. Disorder in the bloodsupply of the inner ear as an early symptom of diabetic angiopathy. *JLO* 1965;79:314-319.
  7. Taylor IG, Irwin J. Some audiological aspects of diabetes mellitus. *JLO* 1978;92:9-13.
  8. Gibbin KP, Davis CG. A hearing survey in diabetes mellitus. *Clinical Otolaryngology* 1981;6(3):345-350.
  9. Robin PE. Deafness and Diabetes (Editorial). *Clinical Otolaryngology* 1981;6:309.
  10. Miller JJ, Beck L, Davis A, Jones DE, Thomas AE. Hearing loss in patients with diabetic retinopathy. *AJO* 1983;4:342-346.
  11. Kurien M, Thomas K, Bhanu TS. Hearing thresholds in patients with diabetes mellitus. *JLO* 1989;103:164-168.
  12. Cullen JR, Cinnamon MJ. Hearing loss in diabetics. *JLO* 1993;107:179-182.
  13. KrocsCollaboration Study Group. Blood glucose control and the evolution of diabetic retinopathy and albuminuria. *NEJM* 1984;311:365-376.
  14. Olsen S, Noffsinger D. Comparison of one new and three old tests of auditory adaptation. *Archives of Otolaryngology* 1974;99:94-99.
  15. Friedman SA, Schulman RH, Weiss S. Hearing and diabetic neuropathy. *Archives of Internal Medicine* 1975;135:573-576.
  16. Sieger A, White NH, Skinner MW, Spector GJ. Auditory function in children with diabetes mellitus. *Annals of Otolaryngology and Laryngology* 1983;92:237-241.
  17. Wilson R, Soeldner JS. The relationship of idiopathic sudden hearing loss to diabetes mellitus. *Laryngoscope* 1982;92:155-160.
  18. Snashall SE. Bakesey audiometry and tone and reflex decay tests in diabetes. *Archives of Otolaryngology* 1977; 103:342-343.
  19. Costa OA. Inner ear pathology in experimental diabetes. *Laryngoscope* 1967;77:68-75.
  20. Virtaniemi J, Laakso M, Nuutien J. Auditory brainstem latencies in type I (IDDM) diabetic patients. *AJO* 1993;14(6):413-418.
  21. Rudolph. Inner ear damage secondary to Diabetes mellitus. *Arch Otolaryngol Head Neck Surg* 1990;117:635-640.
  22. Wackym PA, Linthicum FH. Diabetes mellitus and hearing loss: clinical and histopathological relationship. *AJO* 1986;7:176-182.
  23. Sharma R et al. Brain stem evoked response in patients with diabetes mellitus. *IJO* 2000;52:223-228.
  24. Sharma R. Audiovestibular changes in diabetes mellitus. *IJO & HNS* 1999;51:40-43.
  25. Kutty SR et al. Hearing loss in diabetes mellitus. *IJO & HNS* 1998;4:131-135.
  26. Tay HL, et al. Diabetes mellitus and hearing loss. *ClinOtolaryngol* 1995;20(2):130-4.
  27. Huang YM, Pan CY, Rui G, Cai XH, Yu LM, Chou CY. Study on the hearing impairment in diabetic patients. *Chinese Journal of Otorhinolaryngology* 1990;25:354-356.
  28. Carmen RE, Svihovec DA, Gocka EF, Gay GC, House LR. Audiometric configuration as a reflection of low plasma glucose and diabetes. *AJO* 1989;10:372-379.

## TABLES

**Table I: Distribution of hearing impairment among the study subjects**

Group	Normal	With hearing impairment					
		SN	M	C	BE	R/L	Total (%)
Diabetic	52	25	18	5	44	2/2	48 (48%)
Control	27	0	0	6	6	0	6 (3%)

**Table II: Average hearing threshold in different frequencies (dB) in the study population**

Group	Frequencies (dB)													
	250		500		1000		2000		4000		6000		8000	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L
100 diabetic patients														
BC	20	19	20	19	20	20	25	26	24	27				
AC	28	29	28	29	28	29	30	30	34	36	40	40	54	54
200 Controls														
BC	10	10	15	10	10	10	05	10	10	10				
AC	15	16	15	15	15	15	10	15	10	12	05	10	10	10

P value = &lt;0.01

**Table III: Age distribution of diabetic patients**

Age range (years)	Patients with Diabetes mellitus			No. of cases with hearing loss (%)
	Male	Female	Total	
31 – 40	11	12	23	12 (52.2%)
41 – 50	20	25	45	21 (46.67%)
51 - 60	16	16	32	15 (46.9%)

**Table IV: Age-wise distribution of type of hearing impairment**

Age	Normal	Sensorineural	Mixed	Conductive	BE	R/L	%
30 – 40	11	6	6	0	12	0	52
41 – 50	24	10	8	3	19	2	46
51 – 60	17	9	4	2	13	2	46



**Table V: Age-wise distribution of average hearing thresholds in different frequencies**

Age		Frequencies (Hz)														
	No. of persons		250		500		1000		2000		4000		6000		8000	
			R	L	R	L	R	L	R	L	R	L	R	L	R	L
30-40	23	BC	20	21	20	21	21	20	21	23	25	26				
		AC	30	30	32	32	32	32	33	33	38	39	44	44	50	51
41-50	45	BC	20	19	20	19	19	20	21	22	25	25				
		AC	29	30	29	30	28	29	30	34	35	41	42	42	47	53
51-59	32	BC	18	18	18	18	20	20	19	20	22	23				
		AC	32	31	33	31	31	26	30	30	36	35	44	44	54	56

**Table VI: Correlation of duration of Diabetes mellitus and associated hearing loss and type of hearing loss**

Duration of DM	Total	Hearing loss	N	SN	M	C	BE	R/L	%
0-5 years	21	8	13	6	2	0	6	2	38.1%
5-10 years	45	22	23	11	7	4	21	1	48.89%
10-20 years	30	16	14	8	7	1	16	0	53.33%
20-30 years	4	2	2	0	2	0	1	1	50%

**Table VII: Correlation of duration of Diabetes mellitus and average hearing threshold in different frequencies (dB)**

Duration of DM	No. of persons		Frequencies													
			250		500		1000		2000		4000		6000		8000	
			R	L	R	L	R	L	R	L	R	L	R	L	R	L
0-5	30	BC	21	20	22	21	23	23	23	22	28	26				
		AC	31	31	32	32	33	32	37	33	44	44	49	49	49	49
5-10	45	BC	18	18	19	19	18	19	18	19	22	23				
		AC	26	27	27	28	27	28	28	29	31	33	37	37	43	45
10-20	21	BC	18	18	19	19	20	20	21	21	25	26				
		AC	28	29	30	30	30	34	35	38	40	42	44	40	52	54
20-30	4	BC	17	17	18	19	20	21	22	23	32	32				
		AC	26	25	27	28	24	25	30	30	35	36	44	46	56	55

P value = <0.012

**Table VIII: Correlation between control of diabetes mellitus and type of hearing loss**

Blood sugar level	No. of patients	Normal	Hearing impairment (%)	Sensorineural	Mixed	Conductive
Mild (80-140)	23	10	13 (56%)	6	5	2
Moderate (140-200)	35	25	10 (28%)	7	0	3
Severe (>200)	42	19	25 (24%)	12	13	0

**Table IX: Correlation between control of diabetes mellitus and average hearing threshold in different frequencies**

Control of DM	No. of persons	Frequencies															
		250		500		1000		2000		4000		6000		8000			
		R	L	R	L	R	L	R	L	R	L	R	L	R	L		
Mild	23	BC	18	17	19	18	20	20	19	20	22	23					
		AC	26	26	27	27	27	28	29	28	31	34	36	38	43	46	
Moderate	35	BC	19	18	20	19	20	19	19	19	22	23					
		AC	27	27	28	28	29	29	29	28	42	42	44	43	56	54	
Severe	42	BC	19	19	20	20	22	20	20	20	23	25					
		AC	28	29	29	30	28	29	30	33	36	40	44	46	48	56	

**Table X: Correlation between complications of Diabetes mellitus and type of hearing loss**

	No. of patients	Normal	Sensorineural	Mixed	Conductive	BE	R/L	%
Uncomplicated	87	46	24	17	2	39	2	47
Complicated	13	8	1	1	3	3	2	38

**Table XI: Correlation between complications of Diabetes mellitus and average hearing threshold in different frequencies (dB)**

Severity of DM	No. of persons	Frequencies															
		250		500		1000		2000		4000		6000		8000			
		R	L	R	L	R	L	R	L	R	L	R	L	R	L		
Uncomplicated	87	BC	19	18	20	19	20	19	20	20	25	23					
		AC	27	28	28	29	28	29	30	30	40	44	44	46	54	58	
Complicated	13	BC	19	18	20	19	20	19	20	20	25	23					
		AC	25	28	26	29	26	29	26	30	40	42	44	42	52	54	