International Journal of Research in Medical Sciences
Kumar P et al. Int J Res Med Sci. 2023 Jul;11(7):2605-2610
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20232107

Original Research Article

Correlation between value of Hba1c and degree of sensorineural hearing loss in type 2 diabetics

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Received: 14 May 2023
Revised: 07 June 2023
Accepted: 09 June 2023

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ABSTRACT

Background: Diabetes mellitus and hearing loss are common public health problems. Sensorineural hearing loss in Type 2 diabetes mellitus patients is an underestimated complication. The aim was to study the correlation between level of HbA1c and degree of sensorineural hearing loss.
Methods: It was a cross sectional study carried on 130 known cases of T2DM, aged 25-50 years. Various confounding factors such as coexisting hypertension, ear disease, ototoxic drug intake, any neuropathic disorder was excluded in advance. All patients underwent clinical ear examination and pure tone audiometry test. Their level of HbA1c was measured. This value of HbA1c was correlated with the hearing threshold.
Results: Out of 130, 58 subjects had normal hearing while 72 had hearing impairment. Among subjects (72 out of 130) having hearing impairment, significant correlation (p-value 0.035 for right ear and 0.029 for left ear) between hearing threshold and HbA1c was found. Also, level of HbA1c significantly (p-value 0.049) correlated with degree of hearing loss.
Conclusions: Hearing loss is an underestimated complication of T2DM. This needs to be addressed with periodic hearing assessment of diabetes patients.

Keywords: HbA1c, Pure tone audiometry, Type 2 diabetes mellitus, Sensorineural hearing loss

INTRODUCTION

Hearing is a vital part of day-to-day life enabling us to communicate, interact with people, work comfortably and live a healthy personal and social life. It also forms an integral part of speech development and defense mechanism of body. Any impairment in hearing will lead to physical, mental and social stress to the person; compromising the work, education, employment opportunities and quality of life.[1,2] Hearing impairment is of three types-conductive, sensorineural, mixed types. Diabetes mellitus is a non-communicable metabolic disorder that is growing at an unprecedented rate.[3] Of all the known complications of diabetes mellitus hearing impairment is an established but less explored one. Diabetes is known to cause sensorineural hearing loss. Various mechanisms have been put forward to find causative association such as microangiopathy, oxidative stress, free radical damage, brain stem involvement, precipitates in straia vascularis, spiral ligament, atrophy of spiral ganglion, loss of hair cells, nerve demyelination; but a strong correlation is yet to be proven.[4,5,6,7] The hurdles in investigating the association between diabetes mellitus and hearing loss are the presence of various confounding factors such as age, hypertension, and occupational noise exposure. A glycosylated hemoglobin (HbA1c) of >6.5% HbA1c (glycosylated Hb i.e., hemoglobin to which glucose is bound); formed by non-

enzymatic and slow glycolysis of hemoglobin.[5,7] It is increased in the RBCs of persons with poorly controlled diabetes. Since glucose remains attached to hemoglobin for the life of RBC (120 days), the level of HbA1c reflects the average blood glucose level of the past three months. HbA1c has several advantages over fasting plasma glucose and oral glucose tolerance tests such as no requirement of fasting, greater preanalytical stability, fewer variations during stress, and change in diet or illness. These advantages however may be offset by low sensitivity, higher cost, and limited availability in some areas. [8-11]

The relationship between diabetes and sensorineural hearing loss has been investigated for more than 150 years although, but there are conflicting results in earlier studies regarding this. Also, there is a lack of sufficient studies establishing a definite correlation between the value of HbA_1C and the degree of sensorineural hearing loss. This study is based on the hypothesis that the value of HbA_1C correlates with the degree of sensorineural hearing loss in type 2 diabetes mellitus patients. The advantage of this is that it will help identify this complication at an early stage and thus decrease morbidity in diabetics. The objective of the study is to correlate between value of HbA1c and degree of sensorineural hearing loss.

METHODS

This is a cross-sectional observational study carried out in the department of ENT, IGIMS from December 2020 to December 2022 on known diabetic patients. Based on previous studies, keeping alpha error <0.5 and beta error <0.2, with a power of study 80%, 130 known and willing cases of type 2 diabetes mellitus whose age was 25-50 years were included in this study. Exclusion criteria were non-willing, age less than 25 and more than 50 years, having other neurologic/autoimmune/malignant diseases, having any conductive hearing loss, h/o surgery or trauma to the ear, h/o ototoxic drug intake, smokers and alcoholics, hypertensive.

Methodology

Proper approval by Institutional Research and Ethical Committee was taken. Informed consent was obtained from all cases who were recruited in the study. All patients underwent detailed history, examination, and investigations as per predesigned performa. History included the history of addiction, chronic illness such as hypertension, chronic kidney disease, any neuropathy, autoimmune disorder, malignancy, occupational noise exposure, ototoxic drug intake, trauma. Examination included detailed ear, nose, throat examination, general and systemic examination. Routine tests such as CBC, LFT, KFT; blood sugar profile – FBS, PPBS, HbA1c and PTA (Pure tone audiometry) were done.

Audiometry was performed using Modified Hughson Westlake procedure, also known as UP 5dB-DOWN 10dB procedure in a soundproof room with minimal background noise. Subjects were seated in the same room with a partition of see-through glass in between. Interacoustics model AA222 was used for doing pure tone audiometry. For measuring air conduction TDH 39-49 and DD65 circum-aural headphones and for measuring bone conduction B71 model headphones were used.

HbA1c or glycosylated hemoglobin was measured using BECKMAN COULTER DxC 700 AU and BECKMAN COULTER AU 5800 by NORUDIA N HbA1c method.

Statistical analysis

The data was collected, coded and fed in SPSS (IBM version 23). The descriptive statistics included mean, standard deviation, frequency and percentages. The inferential statistics included Chi square test and Pearson's correlation for comparison of variables. The level of significance was set at 0.05 at 95% confidence interval.

RESULTS

A total of 130 subjects as per the inclusion and exclusion criteria were included in this study. The age of the subjects ranged from 25-50 years. The mean age was 44.4385 years with a standard deviation of 6.31843 years. Both male and female subjects were included in this study. Out of 130 subjects, 80 (61.5%) were male and 50 (38.5%) were females (Table 1).

Table 1: Showing the age and gender distribution of subjects.

Age group (years)	Number of subjects (%)	Percentage (%)
25-30	05	3.84
31-35	09	6.92
36-40	17	13.07
41-45	28	21.53
46-50	71	54.61
Total	130	100
Mean age : 44.4385 (SD 6.31843)		
Gender		
Male	80	61.5
Female	50	38.5

In each subject duration of diabetes was noted and analyzed. It was less than five years in 61 subjects; between five to ten years in 56 subjects and more than ten years in 13 subjects. The mean duration was 5.7846 years with a standard deviation of 4.54731. Duration of diabetes was found to be an important factor influencing hearing threshold as reflected by an increase in the incidence of sensorineural hearing loss with increase in

the duration of diabetes (39.34% among those with disease duration less than 5 years, 64.28% among those with diabetes for 5-10 years and 92.30 % among diabetics with duration more than 10 years). The level of HbA1c was analyzed in each subject and categorized into three groups as per ADA (American Diabetes Association) guidelines. 24 subjects had HbA1c less than 6.5; 36 subjects had HbA1c between 6.5 and 8, while 70 subjects had HbA1c more than 8. The mean HbA1c was 8.7594 with SD 2.40961.

The degree of SNHL was analyzed in each ear and graded into those with high-frequency loss, mild, moderate, moderately severe, severe, and profound SNHL. Among 130 right ears analyzed 68 had a normal hearing with a mean threshold of 21.64 dB (SD 2.53); 11 had only high-frequency loss with a mean threshold of 21.66 dB (SD 2.68); 30 had mild SNHL with a mean threshold 32.38 dB (SD 4.25); 13 had moderate SNHL with mean threshold 48.71 dB (SD 3.73); 7 had moderately severe SNHL with mean threshold 56.90 dB (SD 18.16); 1 subject had profound sensorineural hearing loss of 88.3 dB. The overall mean threshold of the right ear was 29.2452 dB with SD 13.0047 (Figure 1).

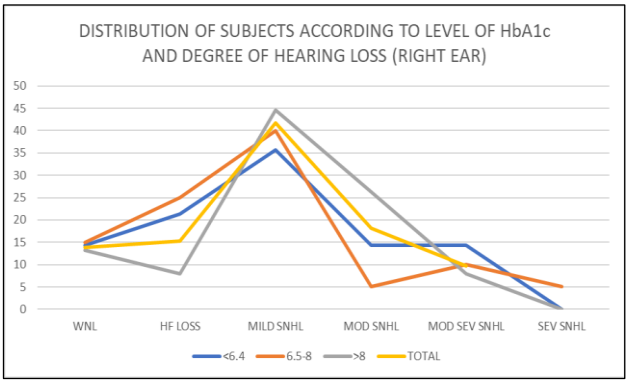

Figure 1: Distribution of subjects according to degree of hearing loss (right ear).

Among 130 left ears analyzed 67 subjects had a normal hearing with a mean threshold of 21.68 dB (SD 2.84); 12 had high-frequency loss with the mean threshold of 22.07 dB (SD 3.11); 35 had a mild loss with a mean threshold of 32.34 dB (SD 3.93); 10 had moderate SNHL with a mean of 69.16 dB (SD 1.18); one subject had severe hearing loss of 76.66 dB; 3 subjects had profound SNHL with mean 117.2167 dB (SD 0.96417). The overall mean threshold of the left ear was 30.0883 dB with an SD of 17.34304 (Figure 2).

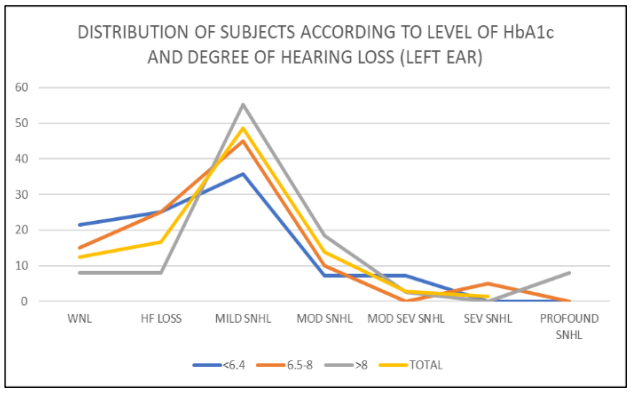

Figure 2: Distribution of subjects according to degree of hearing loss (left ear).

It was observed that among subjects having hearing loss, most (55.55%) had a mild degree of loss (35 out of 63).

Out of 130 subjects, 11 had unilateral hearing loss involving either left or right ear. Four subjects had normal hearing with complaints of tinnitus, which is considered to be an early symptom of diabetes-associated sensorineural hearing impairment. Overall, 58 subjects were found to have normal hearing and 72 subjects had hearing impairment. Among those having normal hearing, there was a non-significant correlation between hearing threshold and HbA1c in both the right and left ears. The mean threshold in the right ear (subjects with normal hearing) was 21.5879 dB (SD 2.54194) and the mean HbA1c was 8.7810 (SD2.33249). The correlation coefficient (r-value) came out to be 0.020 which indicates a very weak correlation with p- value of 0.880 which was non-significant. Similarly, the mean threshold in the left ear (subjects with normal hearing) was 21.7719 dB (SD 2.85329), and the mean HbA1c was 8.7810 (SD 2.33249). The correlation coefficient (r-value) came out to be -0.160 which indicates a negative correlation with p- value of 0.229 which was non-significant (Table 2).

Table 2: Statistical correlation between HbA1c and hearing threshold of right and left ear.

RIGHT EAR		N	Mean	SD	Correlation coefficient (r)	Significance
No hearing loss	HbA1c	58	8.7810	2.33249	0.020	0.880(NS)
	Threshold	58	21.5879	2.54194		
With hearing loss	HbA1c	72	8.7194	2.45653	0.327	0.035(S)
	Threshold	72	35.4135	14.67685		
Left ear						
No hearing loss	HbA1c	58	8.7810	2.33249	-0.160	0.229(NS)
	Threshold	58	21.7719	2.85329		
With hearing loss	HbA1c	72	8.7194	2.45653	0.257	0.029(S)
	Threshold	72	36.7876	20.92705		

Among subjects (72 out of 130) having hearing impairment, there was a significant correlation between hearing threshold and HbA1c in both ears. The mean threshold of the right ear was 35.4135 dB (SD 14.67685) and the mean HbA1c was 8.7194 (SD 2.45653). The correlation coefficient (r- value) was 0.327 which indicates a weak but positive correlation with p- value of 0.035 which was statistically significant. Similarly, in the left ear, the mean threshold was 36.7876 dB (SD 20.92705), and the mean HbA1c was 8.7194 (SD 2.45653). The correlation coefficient (r- value) was 0.257 which indicates weak but positive correlation with p- value of 0.029 which was statistically significant (Table 2).

Further, all 130 subjects were classified into three categories according to the value of HbA1c i.e. those having HbA1c <6.5; 6.5-8 and >8. Among 58 subjects having normal hearing 10 (17.2%) had HbA1c <6.5; 16 (27.6%) had HbA1c between 6.5-8; 32 had >8 HbA1c. Among 72 subjects with hearing impairment 14 (19.4%) had HbA1c <6.5; 20 (27.8%) had HbA1c between 6.5-8; 38 (52.8%) had >8 HbA1c. These levels of HbA1c correlate positively with the degree of hearing loss in diabetic patients indicated by the increase in the number of subjects having hearing loss with increasing levels of HbA1c. The chi-square value came out to be 2.119 with a p- value of 0.049 which was statistically significant (Table 3).

Table 3: Statistical correlation between hba1c and degree of hearing loss.

HbA1c	Without hearing loss	Hearing loss	Chi square value	Significance
<6.4	10 (17.2)	14 (19.4)	2.119	0.049 (S)
6.5-8	16 (27.6)	20 (27.8)		
>8	32 (55.2)	38 (52.8)		

DISCUSSION

Hearing loss is major public health problem and a leading cause of morbidity, next only to locomotor disability. There are many causes of hearing loss and diabetes mellitus is one of them. However, hearing loss as a complication of diabetes is under-recognized. This is due to the various confounding factors such as aging (presbyacusis), occupational noise exposure, ototoxic drug intake, hypertension. Keeping these in mind and excluding them we carried out the study. The prevalence of hearing loss in diabetes in other cross-sectional studies shows wide variations.[8-13] In our study out of 130 subjects, 11 had unilateral hearing loss involving either the left or right ear. Four subjects had a normal hearing with complaints of tinnitus. Overall, 58 subjects were found to have normal hearing and 72 (55.53%) had hearing impairment (Table 4).

Table 4: Comparative observation of prevalence of hearing loss in diabetes in different studies.

Author	Type of study	Sample size	Subjects	Prevalence (%)
Bainbridge et al, 2008[8]	Cross sectional	5140	Non institutionalized adults 20-69 years	21
Garber et al, 2012[9]	Cross sectional	47 cases, 47 controls	Early onset T2DM, 30-50 years	21.7
Pemmaiah et al, 2011[10]	Cross sectional	110	Type 2 diabetes mellitus patients	43.6
Srinivas et al, 2016[11]	Cross sectional	50	Type 2 diabetes mellitus patients	66
Dalton et al, 1998[12]	Cross sectional	3571	NIDDM	59
Sakuta et al, 2007[13]	Cross sectional	699	Type 2 diabetic patients	60.2
Present study	Cross sectional observational	130	T2DM patients	55.53

Among subjects having normal hearing, there was non-significant correlation between hearing threshold and HbA1c in both the right (correlation coefficient r-value 0.020 with p- value 0.880) and left ears (correlation coefficient r-value -0.160 with p- value of 0.229). Among subjects having hearing impairment, there was a significant correlation between hearing threshold and HbA1c in both ears. For right ear correlation coefficient r- value was 0.327 with p-value 0.035 and for left ear correlation coefficient r- value 0.257 with p- value of 0.029. There was no significant correlation between gender and hearing loss found. Most other cross-sectional studies found an association between diabetes mellitus and prevalent hearing loss.[14-17,12,18] In our study levels of HbA1c correlate with the degree of hearing loss in diabetic patients indicated by the increase in a number of subjects having hearing loss with increasing level of HbA1c. The chi-square value came out to be 2.119 with a p- value of 0.049 which is statistically significant [Table 2]. The findings of various studies concluding a correlation between diabetes and hearing loss (Table 5).

Several strengths that add relevance to our study are; firstly, young and the middle-aged population was taken, with no previous hearing loss or any other comorbidity. Our results are thus less likely to be affected by biases

induced by comorbidities and age-related hearing loss. Secondly, we used hearing threshold in the clinical audiogram range (0.5, 1.0, 2.0 kHz) As the criteria for categorizing subjects. This is critical for speech understanding and has a clear implication for quality of life and clinical management. We also assessed the hearing for higher frequencies (4000 Hz, 8000 Hz) which are the common frequencies affected earliest in diabetes.[8,19,20] Further, inclusion of the younger age group (25-50 years) in the study underscores the importance of screening diabetic patients of the most productive age group of society for hearing loss along with the screening for other neuropathies and angiopathies. This will help in early prevention and improvement in the quality of life.

Table 5: Correlation between diabetes mellitus and hearing loss in different studies.

Author	Type of study	Subjects	Correlation between diabetes and hearing LSS
Ooley et al, 2017[16]	Retrospective analysis	175 diabetes mellitus patients with retinopathy	Significant in both ears (p= 0.18 and 0.007 in right and left ear)
Nagahama et al, 2018[17]	Prosepective cohort	131689 male, 71286 female	Significant for higher frequencies
Dalton et al, 1998[12]	Systematic analysis	3571 participants, 344 NIDDM subjects	Significant after controlling for confounders (OR 1.41, 95% CI 1.05 – 1.88)
Horikawa et al, 2013[14]	Systematic literature search of cross – sectional studies	20194 participants, 7377 diabetic cases	Significant, Pooled OR of hearing loss 2.15(95%CI) , Not influenced by age, gender, noise exposure
Akinpelu et al, 2014[15]	Systematic review and Meta-analysis	18 studies	Significant as compared to control Incidence 44-60% (OR 1.91; 95% CI 1.47-2.49), Mean PTA threshold (p = 0.0002), ABR latency (p<0.00001)
Uchida et al, 2010[18]	Population based, Cross – sectional	2306 DM patients, 40-86 years	Significant
Present study	Cross – sectional observational	130 T2DM patients	Significant for hearing threshold in both ears (Right p= 0.035, Left p=0.029) ; between HbA1c and degree of SNHL (P=0.049)

Limitations

This study has few limitations. More studies with larger sample sizes and other audiometric tools are needed to understand this correlation better.

CONCLUSION

The inclusion of the younger age group (25-50 years) in the study underscores the importance of screening diabetic patients of the most productive age group of society for hearing loss. This will help in early prevention and improve the quality of life. By way of the present study, we conclude that there exists a correlation between the value of HbA1c and the degree of sensorineural hearing loss, even after excluding the confounding factors.

ACKNOWLEDGEMENTS

Authors would like to thank Prof. (Dr) Manish Mandal, Medical superintendent for giving administrative support to write the manuscript.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kumar P, Mishra SK, Prakash V, Singh RK. Correlation between value of Hba1c and degree of sensorineural hearing loss in type 2 diabetics. Int J Res Med Sci 2023;11:2605-10.