MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.10.551.556

Study to Find Out an Association Between Type II Diabetes and Sensory Neural Hearing Loss

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ABSTRACT

Individuals with diabetes frequently experience vertigo, tinnitus and hearing loss due to vestibulo-cochlear disease as a result of abnormal glucose metabolism. The incidence of hearing loss in type II diabetes mellites patients is two times that of the general population, predominantly manifesting as high-frequency sensory neural hearing loss, which may frequently go unnoticed. Present study was aimed to study association between type II diabetes and sensory neural hearing loss. Present study was cross-sectional comparative study, conducted in patients diagnosed with type II diabetes mellites for more than five years compared with non-diabetic individuals. Auditory functions were assessed using Tuning fork tests and brainstem evoked response audiometry (BERA). Body mass index and sensorineural hearing loss was significant in the diabetic groups. Also, the diabetic group showed a substantially deranged lipid profile values and sugar profile as compared to controls and difference was statistically significant. Comparison of AL between the control and diabetic groups reveals differences in auditory processing, particularly in the latency of different waves of ABR. Diabetic group consistently exhibits higher interwave latencies compared to the non-diabetic group across all measured waves and sides, with statistical significance variations (p-values between 0.036 and 0.001). Higher percentage of type II diabetes mellites patients with HbA1c levels greater than 8 have sensory neural hearing loss, with 47.4% of sensory neural hearing loss cases in this group. In contrast, the majority of patients with HbA1c levels below 7 do not have sensory neural hearing loss, highlighting a probable correlation between elevated HbA1c levels and the presence of sensory neural hearing loss. The study reveals a heightened risk of sensory neural hearing loss among diabetic individuals, emphasizing the importance of optimal glycemic control in preserving auditory function.

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Key Words
SNHL, diabetic individuals, glycemic control, auditory function, BERA

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Received: 28 August 2024
Accepted: 05 September 2024
Published: 21 September 2024

Citation: Deepika Yadav, Vinay Singh, Anant Prakash Pandey, R.N. Yadav and Azhar Ali khan, 2024. Study to Find Out an Association Between Type II Diabetes and Sensory Neural Hearing Loss. Res. J. Med. Sci., 18: 551-556, doi: 10.36478/makrjms.2024.10.551.556

INTRODUCTION

Type II diabetes mellitus (T2DM) is a long-term health disorder characterized by high blood sugar levels caused by the body's insulin resistance and insulin deficiency. In 2017, there were around 22.9 million new diagnoses and 476.0 million impacted people worldwide, with forecasts that these figures will rise to 26.6 million new cases and 570.9 million affected people by 2025[1]. Research suggests a link between Type II diabetic mellitus (T2DM) and hearing loss[2]. Diabetes patients typically have vertigo, tinnitus and hearing loss (HL) due to vestibulo-cochlear illness caused by improper glucose metabolism. Hearing loss in Type II diabetes mellitus (T2DM) patients is twice as common as in the general population[2], with the majority of cases presenting as high-frequency sensorineural hearing loss (SNHL), which can often go unreported[1]. People with diabetes are also more likely to develop SNHL, which advances slowly and affects both ears, with severity increasing with frequency[3]. Early therapies aimed at physiological abnormalities in the cochlea are critical for addressing diabetes-related hearing impairment. Brainstem evoked response audiometry (BERA) is a non-invasive approach for detecting diabetes-related damage to the auditory nerve and brainstem[4]. BERA is especially useful for detecting lesions outside of the cochlea, providing vital information on early brainstem and auditory nerve deterioration[3]. Diabetes, particularly Type II diabetes mellites (T2DM), has been linked to an increased risk of hearing loss, according to research. This is most likely due to diabetes-related micro vascular and nerve issues, which affect the cochlea and auditory pathways[5]. The current study aims to investigate the link between type II diabetes and sensory neuronal hearing loss.

MATERIALS AND METHODS

Present study was cross-sectional comparative study, conducted in department of ENT, at Nehru Hospital, B.R.D. Medical College, Gorakhpur, India. Study duration was of a six-month period (02 Aug 2023 -02 Feb 2024). Study was approved by institutional ethical committee.

Inclusion Criteria for Cases:

- Patients aged 35-65 years, both genders, Diagnosed with T2DM for more than five years according to the ADA criteria, willingness to participate and continue in the study.

Inclusion Criteria for Controls:

- Non-diabetic individuals aged 35-65 years, both genders, comparable age group to diabetic participants, Willingness to participate and continue in the study.

Exclusion Criteria for Both Groups:

- Presence of ear diseases, head injuries, or significant ear trauma.
- History of ear surgeries or chronic ear discharges.
- Consumption of ototoxic drugs such as aminoglycosides.
- Deafness History in family.
- Presence of COPD, allergic rhinitis.
- Use of tobacco or smoking habits.
- Patients with systemic illnesses that could affect CNS functioning.
- Previous treatments involving radiotherapy or chemotherapy.
- Unwillingness to participate.

The sampling technique employed in this study falls under the category of stratified random sampling. All cases and controls enrolled as per our strict inclusion and exclusion criteria, comprehensive clinical and demographic data were collected for each participant, including a detailed medical history and a complete ENT examination. Routine medical investigations were conducted, encompassing blood glucose levels (fasting, postprandial, HbA1c), lipid profile, liver function tests (LFT), kidney function tests (KFT) and Electrocardiogram (ECG). ADA diagnostic criteria for diabetes[6] was used in present study (A fasting blood sugar level of 126mg/dl or higher, or a HbA1c level of 6.5% or above).

Auditory functions were assessed using Tuning fork tests and BERA-'Neurosoft' The Dual Channel Diagnostic BERA - 'Neurosoft' device (software version 1.0.104.1 from 07-02-2019) was used for assessing auditory brainstem responses by recording brain electrical activity in response to sound stimuli. It supported various tests including ABR, Auditory Steady-State Response (ASSR), Otoacoustic Emissions (OAE), Vestibular Evoked Myogenic Potentials (VEMP), and additional auditory and vestibular evaluations. AL of waves I, III and V and IPLs (I-III, III-V and I-V) were meticulously recorded and analyzed. Statistical methods were employed to compare auditory function between the diabetic and non-diabetic groups. The choice of tests depended on data distribution and specific research objectives, aiming to identify significant differences or relationships between diabetes and auditory measures. GraphPad QuickCalcs online t-test calculator was used for statistical analysis. Mean values and standard deviations of BERA wave parameters-AL of Wave 1, Wave 3, Wave 5 and IPL of Waves 1-3, 3-5 and 1-5 were assessed at 2 kHz frequency and 80 dB sound levels in both diabetic patients and controls. Student's unpaired t-test was utilized for comparisons, with statistical significance set at $P<0.05$.

RESULTS AND DISCUSSIONS

Majority of individuals both the control and diabetic groups include individuals aged between 46 and 55 years. The average age is slightly higher in the diabetic group (50.83±6.27 years) than in the control group (45.66±7.34 years), However, there is no significant difference statistically (p-value 0.082). Males constituting a slightly higher percentage in both groups (56.7% in the control group and 60.0% in the diabetic group). The BMI distribution among participants in the control and diabetic groups highlights significant differences in weight status between the two cohorts. (control group 24.53±4.8 years vs 29.24±6.4 years) (p-value 0.042). The comparison of noise exposure history among the diabetic and non- diabetic groups reveals similar patterns in both cohorts. A significantly higher prevalence of sensorineural hearing loss was observed among individuals with T2DM. (diabetic group 63.3% vs non-diabetic group 10.0 %) (Table 1).

In present study, the diabetic group showed a substantially higher mean fasting blood sugar level of 150.48±96.45mg/dl, postprandial sugar level of 262.32±8.62mg/dl and a mean HbA1c level of 8.24±2.24 %, which was higher than control and difference was statistically significant. Also, the diabetic group showed a substantially deranged lipid profile values, as compared to controls and difference was statistically significant. These findings indicate that individuals with T2DM exhibit a more atherogenic lipid profile, potentially increasing their risk of cardiovascular complications (Table 2). Comparison of AL between the control and diabetic groups reveals differences in auditory processing, particularly in the latency of different waves of ABR.

- **Wave I Latency:** There is a tendency towards delayed Wave 1 latencies in both ears of diabetic individuals compared to the control group, although these differences do not attain statistical significance (p=0.066 and p=0.072, respectively).
- **Wave III Latency:** When comparing the diabetic group to non-diabetic group, there is a substantial delay in the right ear's Wave 3 latency (p=0.042). Likewise, the diabetic group exhibits a notable delay in Wave 3 latency in the left ear (p=0.048). There is statistical significance for both values.
- **Wave V Latency:** The most noticeable variations are found in Wave V's latency. Diabetic people have noticeably longer Wave 5 latencies in both their ears than the non-diabetic group (p=0.002 and p=0.003, respectively). There is statistical significance for both values (Table 3).

Diabetic group consistently exhibits higher interweave latencies compared to the non-diabetic group across all measured waves and sides, with statistical significance variations (p-values between 0.036 and 0.001) (Table 4).

The average number of years with diabetes was 12.6±4.2. For the duration range of 5 to 10 years, Wave III Right and Wave V Right latencies indicate that certain results fall within this range of significance (p=0.025 and 0.043, respectively), whereas some measurements do not. Wave 5 Right, Wave 5 Left, Wave 3 Right and Wave 3 Left latencies are all statistically significant (p<0.05) in the group with a duration of 10-15 years. Similarly, all measurements (p-values ranging from 0.002-0.056) for durations longer than 15 years are statistically significant, with the exception of Wave I Left (Table 5). Higher percentage of T2DM patients with HbA1c levels greater than 8 have SNHL, with 47.4% of SNHL cases in this group. In contrast, the majority of patients with HbA1c levels below 7 do not have SNHL, highlighting a probable correlation between elevated HbA1c levels and the presence of SNHL (Table 6).

Understanding the association between T2DM and auditory dysfunction is crucial for early detection and intervention to mitigate the impact of diabetes- related complications on auditory health. BERA is a significant non-invasive tool for locating the area of lesions in the auditory cortex and the eighth nerve. When it comes to identifying the first signs of brainstem dysfunction, BERA, which represents the series of electrical activities that are generated along the auditory pathway, can be quite important. The current investigation was carried out against the backdrop of the scant information that was available regarding the BERA findings in T2DM patients[7,8]. In our study the latency of wave 1 was not changed statistically significantly between our study's controls and the 8th nerve, suggesting that T2DM patients' access to the cochlear nucleus is unaffected (p>0.05). The impaired transmission of auditory stimuli in diabetics' auditory pathways at the brainstem and midbrain levels is correlated with the significant delay in AL of waves 3 and 5 and interwave latencies 1-3, 3-5, 1-5 by BERA in both ears, with a significant difference between T2DM patients and controls (p<0.05). This suggests neuropathy in the brainstem and midbrain regions involved in the auditory signaling pathway. The involvement of the central neuronal axis in T2DM patients is indicated by the histopathological findings of degenerating neuronal changes, such as loss of spiral ganglion neurons and organ of Corti cells and demyelinative changes in the auditory nerve[9] and vascular abnormalities, such as micro vascular changes in the stria vascularis capillaries, increasing the thickness of the basilar membrane, narrowing of the internal auditory artery[7,8,10,11]. Thus, it is evident from the above that diabetes negatively affects every aspect

Table 1: General Characteristics

Characteristics	Control group (n=60)	Diabetic group (n=60)	p-value
Age (in years)			
35-45years	14 (23.3)	11 (18.3)	
46-55 years	28 (46.7)	30 (50.0)	
56-65 years	18 (30.0)	19 (31.7)	
Mean	45.66±7.34	50.83±6.27	0.082
Gender			
Male	34 (56.7%)	36 (60.0%)	
Female	26 (43.3%)	24 (40.0%)	
BMI (kg/m2)			
Underweight 16.5-18.4	11 (18.3%)	8 (13.3%)	
Normal 18.5-24.9	30 (50.0%)	12 (20.0%)	
Overweight 25-30	14 (23.3%)	26 (43.3%)	
Obese>30	5 (8.3%)	14 (23.3%)	
Mean±Std.	24.53±4.8	29.24±6.4	0.042
Noise exposure history			
Yes	35 (58.3%)	36 (60.0%)	
No	25 (41.7%)	24 (40.0%)	
Sensorineural hearing loss			
Present	6 (10.0%)	38 (63.3%)	<0.001
Absent	54 (90.0%)	22 (36.7%)	

Table 2: Laboratory Parameters

Parameters tested	Control group (n=60)	Diabetic group (n=60)	p-value
Sugar levels			
Fasting blood sugar (mg/dl)	88.12±8.87	150.48±96.45	0.001
Sugar PP (mg/dl)	134.26±6.42	262.32±8.62	0.001
HbA1c (%)	4.32±1.26	8.24±2.24	0.003
Lipid profile			
Cholesterol mg/dl	143.68±28.64	168.92±50.16	0.026
Triacylglycerol mg/dl	104.14±46.76	135.56±57.32	0.004
HDL mg/dl	38.22±6.82	45.46±13.84	0.012
LDL mg/dl	60.24±36.93	108.21±37.12	0.001

Table 3: Comparison of Absolute Latency with 80db Stimulus

Absolute latency	Control group (n=60)	Diabetic group (n=60)	p-value
Wave I			
Right Ear	1.42±0.2	1.8±0.4	0.066
Left Ear	1.43± 0.3	1.8±0.3	0.072
Wave III			
Right Ear	3.42±0.14	3.79±0.2	0.042
Left Ear	3.56±0.24	3.77±0.2	0.048
Wave V			
Right Ear	5.34±0.32	5.83±0.28	0.002
Left Ear	5.31±0.26	5.68±0.16	0.003

Table 4: Comparison of Inter-Wave Latency with 80db Stimulus Among.

Inter-wave latency	Control group (n=60)	Diabetic group (n=60)	p-value
Wave I-III			
Right Ear	2.03±0.12	2.46±0.15	0.036
Left Ear	2.01±0.11	2.44±0.14	0.032
Wave III-V			
Right Ear	1.73± 0.18	2.0±0.12	0.001
Left Ear	1.69±0.16	3.92±0.21	0.001
Wave I-V			
Right Ear	3.90± 0.26	4.21±0.32	0.002
Left Ear	3.84±0.22	4.16±0.26	0.001

A p-value <0.05 indicates statistical significance.

Table 5: Comparison of Duration of Diabetes and Als.

Duration of Diabetes (years)	No. of cases (percentage)	Measure	F-statistic	P-value
5-10 years	19 (31.7%)	Wave I Right Ear	2.35	0.130
		Wave I Left Ear	1.58	0.210
		Wave III Right Ear	4.12	0.043
		Wave III Left Ear	3.07	0.084
		Wave V Right Ear	5.18	0.025
		Wave V Left Ear	2.20	0.140
10-15 years	31 (51.6%)	Wave I Right Ear	3.56	0.065
		Wave I Left Ear	2.42	0.120
		Wave III Right Ear	6.45	0.011
		Wave III Left Ear	4.89	0.029
		Wave V Right Ear	7.33	0.007
		Wave V Left Ear	4.55	0.037
>15 years	10 (16.7%)	Wave I Right Ear	4.81	0.029
		Wave I Left Ear	3.67	0.056
		Wave III Right Ear	8.30	0.004
		Wave III Left Ear	6.25	0.014
		Wave V Right Ear	9.44	0.002
		Wave V Left Ear	7.12	0.009

A p-value less than 0.05 indicates statistical significance.

Table 6: Distribution of SNHL with their HBA1c Levels in the T2DM Patients

HbA1c	SNHL		
	Absent (n=22)	Present (n=38)	p-value
<7	14 (63.6%)	7 (18.4%)	<0.001
7-8	6 (27.3%)	13 (34.2%)	
>8	2 (9.1%)	18 (47.4%)	

of the auditory system, the majority of which are imperceptible. A previous study similar to our study Siddiqi[12] further noted that individuals with long-standing diabetes showed a delay in the AL of wave 3, 5 and IPLs 1-3, 1-5 by BERA, indicating a malfunction at the level of the brainstem and midbrain that was more pronounced in those with neuropathy. The results of the research conducted by Suresh[13] also correlated with the present study findings. Shanthimalar[14] in a cross-sectional study reported that the AL of wave 3 and wave 5, IPL of 1-3, 1-5, 3-5 and AL of wave 5 were prolonged in the diabetics as compared to the non-diabetic group for matching testing stimuli. In a study Kiran[15] observed that there was no significant difference in the AL of wave 1 and 2 among the groups., but the ALs of both right and left ear stimulation, the diabetes group showed significant increases in waves 3, 4 and 5 relatives to the non-diabetic group. Upon comparing diabetics to non-diabetics, it was observed that those who received stimulation to both the right and left ears were statistically more likely to have significantly raised IPL 1-3, 1-5, 3-5. The observed differences in auditory processing between individuals with T2DM and non-diabetics highlight a potential relationship between T2DM and auditory dysfunction. The significant delays in Wave 3 and Wave 5 latencies among diabetic individuals suggest impairments in the auditory pathway, possibly linked to neuropathic changes associated with diabetes. These results imply that T2DM may be involved in changes in auditory function, diabetes can affect both the peripheral and central neurological systems, which include auditory nerve and brain stem[16,17].

These results highlight the significance of regular audiological assessments and comprehensive hearing screenings in individuals with T2DM to facilitate early detection and intervention for auditory dysfunction. Clinicians should prioritise glycemic control as a crucial component of managing T2DM to mitigate the risk of hearing impairments associated with poor blood glucose management. Additionally, awareness of the heightened risk of auditory dysfunction in diabetic individuals can inform personalized treatment plans and enhance patient care strategies in clinical practice. One limitation of this study is its hospital-based design, which restricted the sample size, potentially limiting the generalizability of the finding. The reliability and significance of the study would have risen with a bigger sample size. Furthermore, the lack of follow-up assessments precludes an understanding of long-term effects of diabetes on auditory function. Furthermore, the study's use of self-reported data for certain variables, such as noise exposure history, may introduce recall bias.

CONCLUSION

The study reveals a heightened risk of SNHL among diabetic individuals, emphasizing the importance of optimal glycemic control in preserving auditory function. Additionally, alterations in auditory processing, as evidenced by delays in ABR latencies, suggest neuropathic changes associated with T2DM. These findings underscore the need for early detection, intervention and comprehensive diabetic care practices to mitigate the impact of diabetes-related complications on auditory health. Additionally, the study offers insightful information on the complex nature of managing diabetes, which can help to develop diabetic care practices and public health initiatives that raise awareness and encourage screening for auditory issues in diabetic populations. All things considered, the study advances our knowledge of the intricate interactions between type 2 diabetes and auditory health, opening up new directions for investigation and treatment options aimed at enhancing the quality of life for diabetics. Contribution to the field-The findings of this study contribute significantly to the field in several ways:

Understanding of Auditory Dysfunction in T2DM: The study highlights the prevalence of SNHL in diabetic individuals, clarifying the connection between auditory impairment and type 2 diabetes. This contributes to the increasing amount of research that shows diabetes can cause sensory issues other than neuropathy and eye problems.

Clinical Implications for Diabetic Management: The association between glycemic control, as indicated by HbA1c levels and SNHL prevalence underscores the importance of optimal diabetes management in preserving auditory function. These results highlight the need of comprehensive diabetic care and give clinicians important new information about the possible influence of glycemic control on auditory health outcomes.

Identification of Auditory Biomarkers: The study identifies delays in auditory processing, as evidenced by prolonged Wave 3 and Wave 5 latencies, in diabetic individuals. These delays serve as potential biomarkers

for assessing auditory dysfunction in diabetic populations, aiding in early detection and intervention to mitigate the impact of diabetes-related complications on auditory health.

Implications for Public Health Interventions: By establishing the relationship between T2DM and auditory impairment, the study underscores the significance of public health initiatives aimed at promoting awareness, screening and management of auditory complications in diabetic individuals. Such interventions can help reduce the burden of hearing impairments in diabetic populations and improve overall quality of life.

Advancements in Diabetic Care Practices: The study's findings on the prevalence of comorbidities and metabolic parameters among diabetic individuals provide valuable insights into the multifaceted nature of diabetes management. These insights can inform the development of holistic care practices that address not only glycemic control but also the prevention and management of associated complications, including auditory dysfunction.

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