Section: General Medicine and ENT

Original Research Article

AUDIOMETRIC ASSESSMENT OF HEARING LOSS IN PATIENTS WITH TYPE II DIABETES MELLITUS: A COMPARATIVE STUDY

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ABSTRACT

Background: Diabetes mellitus (DM) has become a global health concern, with type 2 diabetes mellitus (T2DM) accounting for the vast majority of cases. While the cardiovascular complications of T2DM are well-recognized less attention is given to other systemic effects such as hearing loss. Emerging evidence suggests that T2DM contributes to subtle auditory dysfunction primarily due to microangiopathy and neuropathy affecting the cochlea and auditory nerve. These early changes in hearing are often undetected without audiometric screening. This study aims to evaluate the prevalence and severity of hearing impairment in T2DM patients.

Materials and Methods: This comparative observational study was conducted in the Department of General Medicine and ENT at a tertiary care medical college. A total of 50 patients diagnosed with type 2 diabetes mellitus (Group A) were enrolled based on predefined inclusion and exclusion criteria, alongside 50 age-matched healthy individuals (Group B) as controls. Demographic data, medical history, and comorbidities were recorded for both groups. A detailed ENT examination was performed to rule out ear conditions affecting hearing. Audiometric testing, including air and bone conduction, was conducted at frequencies ranging from 250 to 8000 Hz using a pure tone audiometer. Data were analyzed using SPSS software, with a p-value of <0.05 considered statistically significant.

Results: Patients with type 2 diabetes mellitus (T2DM) had significantly higher systolic (149.82 mmHg vs. 140.15 mmHg, P = 0.0016) and diastolic (90.76 mmHg vs. 85.34 mmHg, P < 0.0001) blood pressure compared to healthy controls. Fasting blood sugar, triglycerides, waist circumference, and BMI were also elevated, while HDL cholesterol was lower in the diabetic group (P < 0.0001 for all). Bone and air conduction hearing thresholds were consistently higher in T2DM patients across all tested frequencies for both ears, demonstrating significant auditory impairment compared to controls (P < 0.05 for all frequencies).

Conclusion: Patients with type 2 diabetes mellitus (T2DM) were found to have significant auditory impairment as evidenced by higher bone and air conduction thresholds compared to healthy controls. Regular hearing screenings in T2DM patients, particularly those with poor glycaemic control, are crucial for early detection and prevention of further hearing loss, thereby improving patient outcomes and quality of life.

Keywords: Type 2 Diabetes Mellitus, Audiometry, hearing loss, screening.

INTRODUCTION

Diabetes mellitus (DM) has reached pandemic proportions and is becoming one of the most prevalent non-communicable diseases worldwide. According to the International Diabetes Federation, over 500 million adults are currently living with diabetes and this number is projected to cross 800 million mark by 2045.[1] Type II diabetes mellitus (T2DM) is the most common form of the disease, accounts for approximately 90-95% of all diagnosed cases. This surge is attributed to a combination of genetic predisposition and environmental factors such as sedentary lifestyles, unhealthy diets, and obesity. Age, family history, ethnicity, and insulin resistance further contribute to the rising incidence of type II diabetes. T2DM places an immense burden on global health systems due to the high costs of management and the severe complications associated with its progression.[2]

T2DM is responsible for significant adverse impact on cardiovascular health which remains a major concern in diabetic patients. Hyperglycemia leads to endothelial dysfunction, inflammation, and oxidative stress all of which contribute to atherosclerosis.[3] Diabetics are two to four times more likely to suffer from cardiovascular diseases (CVD) such as coronary artery disease, stroke, and peripheral artery disease compared to non-diabetics. Moreover, diabetes accelerates the progression of pre-existing cardiovascular conditions often resulting in further complications. Hyperglycemia also disrupts lipid metabolism and leads to hypertension thereby further increasing cardiovascular risks. As a result, cardiovascular events remain a leading cause of morbidity and mortality in patients with T2DM.[4]

It must be emphaised that though the cardiovascular side effects are major concern in patients of T2DM however long-term consequences of diabetes extend beyond cardiovascular complications. Chronic hyperglycemia leads to microvascular damage affecting every system of body. Diabetic nephropathy, retinopathy and neuropathy are common. If proper glycemic control is not maintained all these side effects may culminate into catastrophic consequences such as end-stage renal disease, blindness, and debilitating neuropathic pain.[5] Additionally, diabetic patients are at heightened risk for infections due to impaired immune function, which can exacerbate existing comorbidities. Poor glycaemic control also leads to progressive damage to the peripheral nerves, contributing to sensory deficits and an increased risk of falls and injuries. These long-term consequences make diabetes a multisystem disease with widespread impacts on a patient's quality of life and lifespan.[6]

Another less-discussed but significant complication of diabetes mellitus is its association with hearing loss. Recent studies have shown that diabetes can lead to subtle changes in auditory function which often go unnoticed in the early stages.[7] The proposed mechanism involves microangiopathy and neuropathy which is similar to the pathophysiology observed in other complications of diabetes. Chronic hyperglycemia causes vascular damage to the small blood vessels supplying the cochlea, leading to reduced oxygenation and gradual degeneration of cochlear hair cells.[8] Neuropathy impairs the auditory nerve's ability to transmit sound signals effectively. If not detected early, this subtle hearing loss can progress resulting in significant communication difficulties and social isolation for the affected individuals. Audiometric testing can detect these early changes, yet hearing loss in diabetic patients is often underdiagnosed and undertreated.[9]

Despite the growing evidence linking diabetes mellitus to hearing impairment, there remains a significant gap in the understanding of the precise mechanisms and the prevalence of hearing loss in diabetic patients.[10] This study intends to bridge this gap by providing a comprehensive audiometric assessment of hearing loss in patients with type II diabetes mellitus.

MATERIALS AND METHODS

This was a comparative observational study conducted in the department of general medicine and ENT of a tertiary care medical college. 50 patients diagnosed with type 2 Diabetes mellitus were included in this study on the basis of a predefined inclusion and exclusion criteria. 50 age matched healthy individuals were also enrolled as control group. The sample size was determined using the formula N = (Z α2) X SD2 / d2 calculated with the OPENEPI software version 3. The sample size was determined on the basis of number of cases in pilot study done on the topic of auditory acuity in patients with type II diabetes mellitus. Assuming a statistical power of 90% and a confidence interval of 95% the required sample size was 40 patients with type II diabetes therefor we included 50 cases of diabetes mellitus along with an equal number of healthy individuals serving as the control group.

Group A: 50 diagnosed cases of Type 2 Diabetes Mellitus included on the basis of inclusion and exclusion criteria.

Group B: 50 healthy adults were enrolled in control group.

Demographic information such as age, gender, and occupation was recorded. For the case group, the duration of diabetes and the specific oral hypoglycemic medications being used were documented. The presence of co-morbid conditions, such as hypertension or other systemic illnesses, was also noted. A comprehensive general and systemic examination was carried out for all participants. A detailed ENT examination was done to look for conditions which may affect hearing

such as A detailed ENT examination was done to look for conditions that may affect hearing, such as otitis media, otosclerosis, ear wax impaction, tympanic membrane perforation, cholesteatoma, Meniere's disease, acoustic neuroma, and eustachian tube dysfunction. Routine investigations, including blood sugar levels, complete blood count and glycosylated hemoglobin were performed in all cases. Additionally, audiometric testing was conducted on all subjects, which included assessments of cochlear function, air conduction as well as bone conduction for both ears.

The audiometry procedure was carried out using a pure tone audiometer in a soundproof room to ensure accurate results. Air and bone conduction thresholds were measured across various frequencies, specifically at 250, 500, 1000, 2000, 4000, 6000, and 8000 Hertz, to assess both high and low-frequency hearing capabilities. In both group A (patients with diabetes mellitus) and group B (healthy controls), the average thresholds for air and bone conduction were determined for each frequency. The mean hearing threshold for speech frequencies which are critical for communication (between 500 to 4000 Hertz) was also calculated for both ears in each individual.

After gathering the data, the mean air conduction threshold, mean bone conduction threshold, and mean hearing threshold for speech frequencies were compared between the two groups to evaluate any significant differences in hearing ability. This comprehensive assessment allowed for a detailed analysis of auditory function and helped to detect any early signs of hearing impairment associated with diabetes.

Statistical analysis was performed using SPSS version 21.0 software. Quantitative data, such as mean air conduction thresholds, mean bone conduction thresholds, and mean hearing thresholds for speech frequencies (500–4000 Hz), were presented as mean and standard deviation. Qualitative data, including the presence of co-morbid conditions (e.g., hypertension) and patient-reported symptoms related to hearing, were presented in incidence and percentage tables. For comparisons of quantitative data between the two groups (Group A: Type 2 diabetes patients and Group B: healthy controls), the chi-square test was applied. A p-value of less than 0.05 was considered statistically significant indicating a meaningful difference in hearing function between diabetic and non-diabetic individuals.

Inclusion Criteria

1. Diagnosed cases of Type 2 Diabetes Mellitus.
2. Age above 18 years.
3. Ready to give informed and written consent to be part of study.
4. Same number of Healthy individuals enrolled as control group.

Exclusion Criteria

1. Age less than 18 years
2. Refusal to give consent to be part of study
3. Patients with conditions that may affect hearing, such as otitis media, otosclerosis, ear wax impaction, tympanic membrane perforation, cholesteatoma, Meniere's disease, acoustic neuroma, and eustachian tube dysfunction.
4. Patients on oto-toxic drugs.
5. Patients with significant psychiatric illnesses or cognitive dysfunction likely to affect assessment of auditory functions.

RESULTS

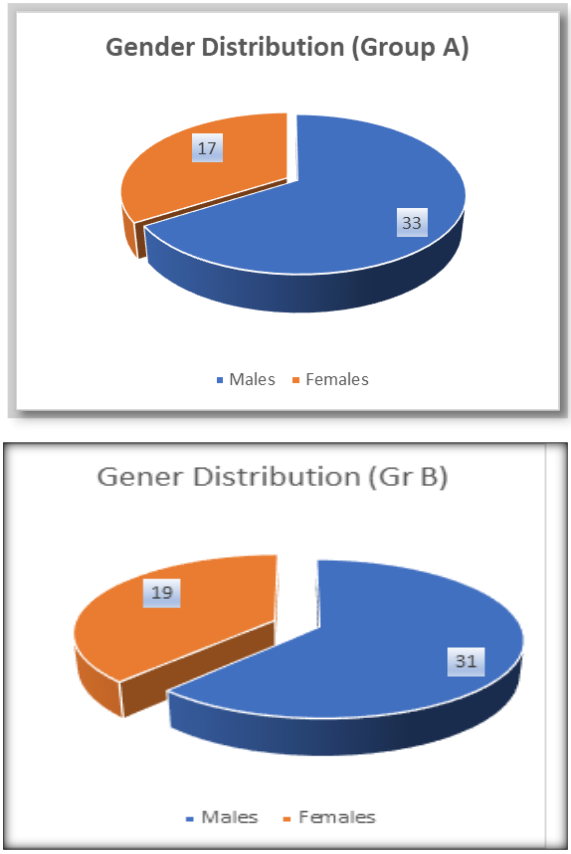

Figure 1: Gender Distribution of Studied cases

Out of the 50 patients in Group A, there were 33 males (66%) and 17 females (34%), resulting in a male-to-female ratio of 1:0.51. In Group B, there were 31 males (62%) and 19 females (38%), with a male-to-female ratio of 1:0.61. Both groups were comparable in terms of gender distribution, with no statistically significant difference (P = 0.8352). [Table 1]

The analysis of the age distribution of patients in Group A and Group B showed that in both groups, the majority of patients were between the ages of 51-60 years, with 34% (17 patients) in Group A and 32% (16 patients) in Group B. The second most common age groups in both were those aged 41-50 years and over 60 years, each comprising 26% (13 patients) in Group A, and in Group B, the 41-50 age group had 24% (12 patients) while the same proportion was found in the over-60 group. The

mean age for Group A was 51.76 years ± 10.95, while for Group B, it was 50.34 years ± 11.83. [Table 1]

Systolic blood pressure (SBP) was higher in the Group A (T2DM) (149.82 ± 16.05 mmHg) as compared to healthy individuals (140.15 ± 15.22 mmHg), and this difference was statistically significant (P = 0.0016). Similarly, diastolic blood pressure (DBP) was elevated in individuals in group A (90.76 ± 7.14 mmHg) compared to the healthy group (85.34 ± 6.05 mmHg), with a statistically significant difference (P < 0.0001). Fasting blood sugar (FBS), Serum triglyceride levels (TG), waist circumference (WC), and body mass index (BMI) were also higher was also significantly higher in T2DM patients (group A) as compared to healthy individuals (Group B) (P < 0.0001). HDL cholesterol (HDL-C) was lower in the T2DM group (35.12 ± 4.05 mg/dl) compared to the healthy group (39.89 ± 3.98 mg/dl) and this difference was also statistically significant (P < 0.0001). [Table 2]

The analysis of bone conduction hearing thresholds in the right ear at different frequencies revealed that Group A consistently had higher thresholds compared to Group B across all tested frequencies. For instance, at lower frequencies like 250 Hz and 500 Hz, Group A had thresholds around 19.6 dB and 21.0 dB, while Group B showed significantly lower thresholds around 7.7 dB and 7.8 dB. As frequencies increased with Group A reaching thresholds as high as 30.1 dB at 8000 Hz. There was a statistically significant difference in bone conduction threshold of right ear between both the groups at all frequencies (P<0.05). [Table 3]

The analysis of bone conduction hearing thresholds in the left ear across various frequencies demonstrated that Group A consistently exhibited higher thresholds compared to Group B. At lower frequencies, such as 250 Hz and 500 Hz, Group A had thresholds around 20.3 dB and 21.3 dB, while Group B's thresholds were significantly lower, around 7.4 dB and 7.8 dB, respectively. This pattern continued at higher frequencies, with Group A reaching up to 29.6 dB at 8000 Hz. There was a statistically significant difference in bone conduction threshold of left ear between both the groups at all frequencies (P<0.05). [Table 4]

The analysis of air conduction hearing thresholds in the right ear across different frequencies revealed that Group A had consistently higher thresholds compared to Group B. At lower frequencies, such as 250 Hz and 500 Hz, Group A exhibited thresholds around 30.4 dB and 31.6 dB, while Group B had significantly lower thresholds of 20.6 dB and 21.6 dB, respectively. This trend continued at higher frequencies, with Group A reaching up to 37.5 dB at 6000 Hz and 37.2 dB at 8000 Hz. There was a statistically significant difference in air conduction threshold of right ear between both the groups at all frequencies (P<0.05). [Table 5]

The analysis of air conduction hearing thresholds in the left ear across various frequencies showed that Group A consistently had higher thresholds than Group B. At lower frequencies such as 250 Hz and 500 Hz, Group A's thresholds were around 30.7 dB and 32.0 dB, while Group B's thresholds were significantly lower, at approximately 21.7 dB and 22.0 dB. This pattern persisted at higher frequencies, with Group A reaching up to 38.6 dB at 8000 Hz. There was a statistically significant difference in air conduction threshold of left ear between both the groups at all frequencies (P<0.05). [Table 6]

Table 1: Comparison of age groups in studied cases

Age Group	Group A		Group B	
	No Of Patients	Percentage	No Of Patients	Percentage
18-30 years	2	4.00%	3	6.00%
31-40 years	5	10.00%	7	14.00%
41-50 years	13	26.00%	12	24.00%
51-60 years	17	34.00%	16	32.00%
> 60 years	13	26.00%	12	24.00%
Total	50	100.00%	50	100.00%
	Mean Age: 51.76 +/- 10.95		Mean Age: 50.34 +/- 11.83	
P = 0.5348 (Not significant)				

Table 2: Comparison of blood pressure, fasting blood sugar, Lipid profile and BMI

Variables	Group A	Group B	P value
SBP (mm/Hg)	149.82 ± 16.05	140.15 ± 15.22	P = 0.0016
DBP (mm/Hg)	90.76 ± 7.14	85.34 ± 6.05	P < 0.0001
FBS (mg/dl)	120.34 ± 15.92	98.85 ± 14.58	P < 0.0001
TG (mg/dl)	198.45 ± 28.89	170.56 ± 25.34	P < 0.0001
HDL C (mg/dl)	35.12 ± 4.05	39.89 ± 3.98	P < 0.0001
WC (cm)	106.14 ± 7.94	90.12 ± 7.05	P < 0.0001
BMI (kg/m²)	35.45 ± 3.58	30.12 ± 3.04	P < 0.0001

Table 3: Comparison of Bone Conduction (Right Ear) amongst the studied groups

Frequency (Hz)	Group A (dB)	Group B (dB)	P-value
250	19.6 ± 2.1	7.7 ± 1.0	< 0.05*
500	21.0 ± 2.3	7.8 ± 1.1	< 0.05*
1000	21.9 ± 2.4	8.7 ± 1.2	< 0.05*

2000	22.7 ± 2.5	9.0 ± 1.3	< 0.05*
4000	25.6 ± 2.6	9.8 ± 1.4	< 0.05*
6000	28.3 ± 2.7	10.1 ± 1.5	< 0.05*
8000	30.1 ± 2.8	11.5 ± 1.6	< 0.05*

Table 4: Comparison of Bone Conduction (Left Ear) amongst the studied groups

Frequency (Hz)	Group A (dB)	Group B (dB)	P-value
250	20.3 ± 2.2	7.4 ± 0.9	< 0.05*
500	21.3 ± 2.1	7.8 ± 1.0	< 0.05*
1000	22.2 ± 2.3	8.6 ± 1.1	< 0.05*
2000	22.9 ± 2.4	9.3 ± 1.2	< 0.05*
4000	24.8 ± 2.5	10.3 ± 1.3	< 0.05*
6000	27.9 ± 2.6	10.5 ± 1.4	< 0.05*
8000	29.6 ± 2.7	11.4 ± 1.5	< 0.05*

Table 5: Comparison of Air Conduction (Right Ear) amongst the studied groups

Frequency (Hz)	Group A (dB)	Group B (dB)	P-value
250	30.4 ± 2.9	20.6 ± 1.8	< 0.05*
500	31.6 ± 3.0	21.6 ± 1.9	< 0.05*
1000	32.3 ± 3.1	19.9 ± 1.7	< 0.05*
2000	33.7 ± 3.2	18.9 ± 1.6	< 0.05*
4000	36.9 ± 3.4	19.9 ± 1.7	< 0.05*
6000	37.5 ± 3.5	20.2 ± 1.8	< 0.05*
8000	37.2 ± 3.3	21.3 ± 1.9	< 0.05*

Table 6: Comparison of Air Conduction (Left Ear) amongst the studied groups

Frequency (Hz)	Group A (dB)	Group B (dB)	P-value
250	30.7 ± 3.0	21.7 ± 1.9	< 0.05*
500	32.0 ± 3.1	22.0 ± 2.0	< 0.05*
1000	32.7 ± 3.2	20.1 ± 1.8	< 0.05*
2000	33.9 ± 3.3	19.9 ± 1.7	< 0.05*
4000	37.2 ± 3.5	21.5 ± 1.8	< 0.05*
6000	38.0 ± 3.6	22.0 ± 1.9	< 0.05*
8000	38.6 ± 3.7	22.5 ± 2.0	< 0.05*

DISCUSSION

Hearing loss is a multifactorial condition influenced by various genetic, environmental, and systemic factors. Among the systemic conditions type 2 diabetes mellitus (T2DM) has been increasingly recognized as a potential risk factor for auditory dysfunction. Patients with T2DM experience subtle forms of hearing loss that can easily go undetected without appropriate screening. This is especially concerning as the early stages of hearing impairment may be mild, often not noticeable to the patient, yet progressive over time.[11] If regular auditory assessments are not conducted, these subtle deficits may be missed thereby delaying diagnosis and intervention. Previous studies suggest that the severity of hearing impairment could correlate with the duration of diabetes and the level of glycaemic control but the exact mechanisms remain poorly understood. Routine hearing screening for individuals with T2DM is critical to detect early signs of auditory dysfunction potentially preventing further progression.[12]

In this study, both groups were comparable in terms of gender distribution, with no statistically significant difference (P = 0.8359). The majority of participants in both groups were aged between 51-60 years, followed by those aged 41-50 years and over 60 years. The mean age for Group A (diabetic patients) was 51.76 years ± 10.95, while for Group B (healthy controls) it was 50.34 years ± 11.83, with no significant difference between the groups (P = 0.5348). In this study Systolic and diastolic blood pressures were significantly higher in the T2DM group compared to healthy controls (P = 0.0016 and P < 0.0001, respectively). T2DM patients also had elevated fasting blood sugar, serum triglyceride levels, waist circumference, and body mass index, all significantly higher than the healthy group (P < 0.0001). HDL cholesterol was lower in T2DM patients compared to controls, and this difference was also statistically significant (P < 0.0001). et al and et al reported similar higher blood pressure and triglyceride levels in diabetic patients as compared to healthy individuals. Mooradian A et al,[13] and Jia G et al,[14] also reported similar differences in blood pressure values and lipid profile of patients with Type 2 Diabetes mellitus as compared to non-diabetic individuals.

The analysis of bone and air conduction hearing thresholds in both ears revealed that patients in Group A (T2DM) consistently exhibited higher thresholds across all tested frequencies compared to Group B (healthy controls). For bone conduction, significant differences were observed at all frequencies, with Group A showing higher thresholds (e.g., 19.6 dB at 250 Hz and 30.1 dB at 8000 Hz for the right ear). Similarly, air conduction thresholds were significantly elevated in Group A, with values ranging from 30.4 dB at 250 Hz to 38.6

dB at 8000 Hz, compared to much lower thresholds in Group B. These differences were statistically significant ($P < 0.05$) across all frequencies for both ears.

Khalid Al-Rubeaan et al. conducted a cross-sectional study to investigate hearing loss in patients with type 2 diabetes mellitus and assess associated risk factors.[15] A total of 157 patients aged 30-60 underwent ear examinations and audiological evaluations, including otoacoustic emissions, tympanometry, and pure-tone audiometry. Hearing loss was observed in 67% of patients, with 49.7% having mild, 38.2% moderate, 8.8% severe, and 3.3% profound loss. A higher prevalence of hearing loss was associated with poor glycemic control (HbA1c ≥8%) and longer diabetes duration. On the basis of these findings, the authors concluded that hearing loss is a common comorbidity in type 2 diabetes, and regular hearing assessments are recommended, especially with poor glycemic control and hypertension. Similarly the authors such as Kumar P et al,[16] and Spankovich C et al,[17] also emphasized on the importance of assessing auditory functions in cases of diabetes mellitus.

IN another study Kim MB et al included 253,301 adults with normal hearing who were followed for a median of four years. Incident hearing loss was defined by pure-tone audiometry thresholds >25 dB.18 The rate of hearing loss per 1000 person-years was 9.2 for DM patients, compared to 1.8 for normal glucose levels. Multivariable-adjusted hazard ratios for hearing loss were 1.36 for DM participants. On the basis of these findings, the authors concluded that DM moderately increases the risk of hearing loss. Similar incidence of hearing loss in patients with diabetes mellitus was also reported by the authors such as Mishra UP et al,[19] and Samocha-Bonet D et al.[20]

CONCLUSION

Patients with type 2 diabetes mellitus (T2DM) often experience subtle hearing loss that may go undetected without routine screening. This study demonstrates significantly higher bone and air conduction thresholds in diabetic patients compared to healthy controls which is suggestive of early auditory dysfunction. Regular hearing assessments are essential for detecting these subtle deficits, especially in patients with poor glycaemic control or long-standing diabetes. Early detection and intervention can prevent the progression of hearing loss thereby improving overall patient outcomes and quality of life. Routine screening for hearing loss should be a key component of managing individuals with T2DM.

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