

Significance of audio-vestibular evaluation in diabetes mellitus patients- A study

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Abstract

Introduction: Diabetes mellitus (DM) has a projected rise in its affected population to almost double by the year 2035 in India. Ongoing research regarding its microvascular complications has led to a disparity of opinion about involvement of the audio-vestibular system. Hence to evaluate the audio-vestibular functions in patients with diabetes mellitus and determine their correlation with duration and control of the disease, this study was conducted.

Materials & Methods: 97 DM patients were included in this prospective, cross-sectional study and all of them underwent clinical examination, Dix-Hallpike maneuver and investigations like Pure tone audiometry (PTA) and Videonystagmography (VNG).

Results: 64 of 97 patients, had varying degrees of sensorineural hearing loss on PTA and 16 patients had vestibular hypofunction noted on caloric test of VNG. It was identified that the occurrence of bilateral hearing loss and vestibular hypofunctioning were statistically significant with chi square test (p value 0.028 and <0.001 respectively), when 5years duration of DM was taken for cut off. Analysis of symptoms with PTA and VNG, found significant correlation of tinnitus and hearing loss (p value 0.03 and <0.001 respectively) with abnormal findings in both the investigations, revealing a subclinical nature of the vestibular dysfunction. However, there were no significant correlations found with the glycaemic control of DM.

Conclusions: It is advisable to consider audio-vestibular evaluation with PTA and VNG, as screening tests for long term DM patients with or without symptoms of giddiness and hearing loss as a step for early identification of microvascular complications of the inner ear, though larger studies in other populations needs to be done for further confirmation of the correlation.

Keywords: Diabetes mellitus, hearing loss, vestibular dysfunction, Pure tone audiometry (PTA), Videonystagmography (VNG).

Introduction

Diabetes mellitus (DM) is a chronic metabolic disease associated with high levels of blood glucose and it is considered a personal, social and economic burden for the patients, families, and institutions. India is considered the diabetes capital of the world.¹ Yesudian et al² outlined the economic burden of diabetes in India, which reviewed 19 studies from different parts of India and this study projected a sharp rise of DM affected people, from 65.1 million in 2013 to rise to 109 million by 2035 making it a national health concern.

As a result, there has been a vast amount of ongoing research devoted to DM and complications associated with the disease. People with diabetes often develop multiorgan anatomic and functional changes due to microvascular and macrovascular complications.³ Some of the recent studies show suspicion of alterations in audio-vestibular (AV) systems in patients with DM.⁴ It is proposed that the microvascular abnormalities in complicated diabetes

mellitus are causing the auditory system failure and thereby hearing. However, due to discordance in literature the result remains unsettled. While few studies reported no correlation between DM and hearing loss,^(5,6) other studies found positive correlation.⁷⁻⁹

An animal model study was conducted by Myers SF, Ross MD in 1987¹⁰ on Sprague-Dawley rats to identify the morphological evidence of vestibular pathology in long-term experimental diabetes mellitus II, found that there was an increased incidence of secondary lysosomes within the connective tissue cells as well as an accumulation of intracellular lipid droplets that increased with the level of hyperglycaemia. Many clinical studies have been conducted to know the relationship between diabetes and vestibular function, some were questionnaire based,¹¹ others used VEMP¹².

Diagnosis of audio-vestibular (AV) dysfunction in DM is based on detailed history including balance abnormalities and recent history of falls.¹³ The clinical

examination along with videonystagmography (VNG) and pure tone audiometry (PTA) are essential to confirm the condition. VNG is the best tool to evaluate vestibular dysfunction¹⁴. The present study was planned with the above background with an objective to assess the presence of AV dysfunction in DM patients and the need to screen them for same.

Materials and Methods

The study was an observational, prospective, cross sectional study at a tertiary care center in the western coast of South India with 97 patients in the study group. It included all adult patients presenting with diabetes mellitus to Dept. of ENT, both in-patients and out-patients. Patients with middle ear/external ear disease, head injury or trauma to ear, patients on or having history of consumption of ototoxic drugs and patients with cervical radiculopathy were excluded. The objectives of the study were explained to the participants, following which written informed consent was taken. Institutional ethics committee approval was obtained prior to commencement of the study. Detailed history of these patients regarding the duration of the disease, medications were noted and history of any recent falls or balance disorders or other systemic diseases along with detailed clinical otolaryngology examination which include ear, nose, throat examination and Dix Hallpike maneuver was done. Patients' blood glucose status was established by checking their glycosylated Hemoglobin levels and fasting and post prandial blood glucose levels. All the patients were subjected to Videonystagmography (VNG) and Pure tone audiometry (PTA)

Pure tone audiometer

Pure tone audiometry was done, using a calibrated Inter-acoustics Clinical audiometer-AC-40 (Denmark). TDH 39 Supra Aural Headphone was used with the transducer – Radio Ear B 71 bone vibrator. The threshold estimation was done using Modified Hughson-Westlake procedure (ASHA 1978). It was in accordance to the American National Standard Institute (ANSI) and was taken for all the frequency octaves from 250 Hz to 8000 Hz.

Severity of the hearing loss was quantitatively calculated based on the Clark's (1981) modification of Goodman classification of severity of hearing loss (1965). Categories of Degrees of Hearing Loss, based on Air Conduction Pure-Tone Average at 500, 1000, and 2000 Hz.

Degree of hearing loss	Pure-Tone Average Range
Normal hearing sensitivity	-10 dB HL to 15 dB HL
Slight hearing loss	16 dB HL to 25 dB HL
Mild hearing loss	26 dB HL to 40 dB HL
Moderate hearing loss	41 dB HL to 55 dB HL
Moderately severe hearing loss	56 dB HL to 70 dB HL
Severe hearing loss	71 dB HL to 90 dB HL
Profound hearing loss	91 dB HL to equipment limits

Videonystagmography

Videonystagmography was performed using BIOMED eVNGUSB (software version 1.1.5.2, Germany), with the help of camera attached to the infrared goggles worn by the patient.

Tests included

1. Calorie test (Temperature from 20-degree Celsius to 47-degree Celsius)
2. Smooth pursuit test
3. Saccade Test
4. Optokinetic nystagmus

Results

The data were tested for its distribution using the Shapiro–Wilk test of normality using Statistical Package for Social Sciences (version 22.0). The results showed that the data were not normally distributed. Hence, non-parametric tests were used for within- and between-group comparisons. Chi square test was used to check the association between the parameters. $p < 0.05$ was considered significant. Table 1 summarizes the demographic characteristics of participants.

Table 1: Demographic characteristics of participants:

Patient parameters	Value (%)
Age – Mean (in years)	54.68 (± 10.68)
Male	54 (55.67%)
Female	43 (44.33%)
Diabetes Mellitus	
Duration:	
<5 years	77 (79.38%)
>5 years	20 (20.62%)
Diabetes Control:	
HbA1C <7	46 (47.42%)
HbA1C >7	51 (52.58%)

Table 2: Comparison of symptoms, PTA, VNG results with diabetes duration:

Symptoms	Duration of DM				p value
	≤ 5years	%	> 5 years	%	
HEARING LOSS	19	55.88	15	44.11	
TINNITUS	24	68.57	11	31.43	
GIDDINESS	38	77.55	11	22.45	
PTA					
U/L	7	100	0	0	0.687
B/L	39	68.42	18	31.58	0.028*
NORMAL	31	93.94	2	6.06	
VNG (caloric- normal)	71	88.89	10	11.11	<0.001*
VNG (caloric- hypo)	6	37.5	10	62.5	

*signifies statistically significant values

On analysing the data, when duration of diabetes mellitus of 5 years was used as a cut off, it was identified that the occurrence of bilateral hearing loss and hypo functioning noted on caloric test of VNG were statistically significant with chi square test (p value 0.028 and <0.001 respectively). On assessing individually as well, there was a significant correlation with duration of diabetes and caloric test performed on right and left ear respectively (p value <0.001 for both ears). The above details are tabulated in table 2. However, there was no association noted with gaze, saccades and optokinetic nystagmus.

There was no correlation with control of diabetes and hearing loss (bilateral/unilateral). Also, there was no correlation with control of diabetes and videonystagmography- caloric test, gaze, saccades and optokinetic nystagmus.

Table 3: Correlation of symptoms with investigations:

Symptoms (no. of patients)	Investigation				p value
	PTA U/L	PTA B/L	VNG (Caloric-U/L)	VNG (Caloric-B/L)	
HEARING LOSS (34)	0	32	1	13	<0.001*
TINNITUS (35)	2	27	0	11	0.03*
GIDDINESS (49)	4	30	1	12	0.433

*signifies statistically significant values

Table 3 describes the correlation of symptoms with results of PTA and VNG. It shows that the patients who presented with hearing loss and tinnitus had objective hearing loss measured by pure tone audiometry (p value <0.001) than those who presented with giddiness. It was also identified that VNG showed hypofunction in patients who presented with hearing loss or tinnitus without complaints of giddiness (p value <0.001).

Discussion

Several studies have proposed that DM may exacerbate hearing loss and vestibular dysfunction and extensive investigations have been conducted in order to identify the pathophysiology. The proposed mechanisms in AV dysfunctions found in DM are probably an effect of angiopathy, neuropathy or both, as of the anatomic studies in animals conducted by Myers et al (1985 & 1998) and Costa OA (1967).¹⁵⁻¹⁷

Microangiopathy of the vascular striae seems to be the major cause as supported by all related studies, mentioned earlier.

The results of the present study of 97 patients reveals mean age of 54.68+/-10.687 (from 30-77 years) among whom 54 were males. 64 of the 97(66%) DM patients examined had some degree of SNHL, which is consistent with other studies.^{5,9,18-20} Tay et al¹⁸ in 1994 reported a higher incidence of hearing loss among DM patients as compared to non-diabetics with a significance of P < 0.001. In a meta-analysis, Akinpelu et al (2014) reported a significant incidence (44-69.7%) in type 2 DM patients.²⁰ Karkarlapudi et al, in 2003²¹ reported a 13.3% of hearing loss in diabetes mellitus patients than the subjects without DM. Among the patients with hearing loss in the present study, 89% had bilateral SNHL indicating that the hearing complications implicated in DM have a bilateral distribution. This result is consistent with

similar studies; however, the proportion of the population with bilateral SNHL was highest in our study in comparison to others.^{9,19,21}

The possible factors that influence the worsening of hearing thresholds in diabetics were evaluated. Presbycusis was ruled out by the nature of the audiological curves in PTA, which were mostly involving both the lower and higher frequencies in our patients, whereas in presbycusis, higher frequencies are commonly affected earlier in the process of hearing loss.²² In correlation studies, we found that the duration of the DM and hearing loss was found to be statistically significant ($p < 0.001$) when 5 year duration was considered as cut off. Some studies support this, by stating that the hearing threshold increases with increase in duration of diabetes,^{23,24} while others state no relation between hearing threshold and the duration.^{19,25,26}

There was no correlation between the glycemic control and hearing loss. This was in consistency with studies by Cullen R et al²⁶ and Deviprasad et al.²⁷ Although it was found to be significant in Type 1 DM patients in a study by Okhovat SA et al²⁸ and Panchu P.¹⁹ We also observed no gender differences regarding hearing loss. This finding was consistent with other studies, where no gender differences were observed amongst participants⁹, but there are reports of male diabetics having a greater deterioration of hearing as compared to females.²⁶

However, relatively few studies have focused on the effects of DM on the vestibular functions. There are clinical studies demonstrating balance disorders in patients with DM^{11,29}, which have a positive correlation of vestibular dysfunction with duration and control of DM. In Insulin-dependent-diabetes mellitus patients, Alessandrini et al³⁰ noted significantly longer saccadic eye movement latency. Nicholson et al³¹ observed that both IDDM and NIDDM patients had abnormal gaze-holding, vestibulo-ocular reflex (VOR) and optokinetic nystagmus. Whereas, Di Nardo et al³² found normal findings in electronystagmography (ENG) in DM (Insulin dependent) patients with and without peripheral neuropathy. Klagenberg et al³³ reported that vestibular assessment was within normal limits in patients with IDDM. Results of the present study have demonstrated that statistically significant alterations were present in VNG in DM patients when considering the caloric test whereas the gaze, saccade, and optokinetic nystagmus were normal.

Another surprise correlation, in the present study was that of the symptoms and the PTA-VNG findings. Even though giddiness was the most common symptom followed by tinnitus and hearing loss, the

latter complaints had a statistically significant correlation with positive VNG and PTA findings. This may be attributed to the subclinical vestibular dysfunction in patients who have symptoms of tinnitus and hearing loss. Among 49 patients with giddiness, only 26.53% had positive VNG finding which is like the study by Fonseca AS et al²⁹ which had 40%. Similar disparity was observed by Klagenberg et al³³ where only 16.6% of total patients had giddiness and 60% of them were positive for VNG.

Conclusion

The statistically significant correlation between hearing loss and vestibular dysfunction in chronic DM patients of more than 5 years duration which is attributed to the microvascular complications of angiopathy in the inner ear makes it worthy to consider audio-vestibular evaluation as a screening tool along with other screening tests regularly used in practice. The subclinical nature of vestibular dysfunction in these patients is notable as it may lead to significantly increased risk of fall. With a projected sharp rise of the DM affected population in the Indian subcontinent, it becomes more important to take remarkable steps to prevent the complications by implementing a regular audio-vestibular evaluation in these patients. However, large scale studies in various populations needs to be conducted to overcome the confusions that exists regarding the correlation.

Conflicts of interest

There are no conflicts of interest.

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None.

Ethical approval

“All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional ethics committee (YEC 241/2018) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.”

Informed consent

“Informed consent was obtained from all individual participants included in the study.”

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