

Comparison of Sensorineural Hearing Loss Degree between Controlled and Uncontrolled Type 2 Diabetes Mellitus Patients

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Abstract

Objective: The objective of this study was to determine the degree of sensorineural hearing loss in patients with type 2 diabetes mellitus (T2DM) between good and poor glycemic control.

Materials and Methods: This was a cross-sectional study of 70 patients with T2DM who admitted between February and May 2018 at Haji Adam Malik General Hospital. Based on examination of hemoglobin A1c (HbA1c), this study will be divided into two groups, good glycemic control (HbA1c <7) and poor glycemic control (HbA1c ≥7), and each group consists of 35 patients. Routine ear, nose, and throat and pure tone audiometry examination were done to know the degree of sensorineural hearing loss.

Results: The results of the study showed that the majority in the controlled group of T2DM had normal hearing thresholds compared with the group of uncontrolled T2DM. There was a significant difference in proportion of the hearing threshold between controlled and uncontrolled T2DM patients in the right ear ($P = 0.004$) and the threshold on the left ear ($P = 0.008$).

Conclusion: Uncontrolled T2DM patients are more susceptible to hearing loss. Patients with T2DM are advised to better control of blood sugar levels to prevent hearing loss.

Key words: Hemoglobin A1c, Pure tone audiometry, Sensorineural hearing loss, Type 2 diabetes mellitus

INTRODUCTION

The relationship between diabetes mellitus (DM) and hearing loss has been debated in recent years. DM prevalence is very high in many countries in the world, and the World Health Organization (WHO) reports that Indonesia ranks the fourth largest in the number of DM patients with a prevalence of 8.6% of the total population after India, China, and the United States.^[1] The WHO estimates that the prevalence will increase to 21.3 million in 2030.^[1,2] Health research and development agency of the ministry of health in 2013 stated that there was an increase in prevalence in DM patients, which is 1.1% in 2007–1.5% in 2013.^[3]

Macrovascular and microvascular complications of DM have been widely studied. DM can damage nerve cells and blood vessels. Neural networks play an important role in the function of the auditory organs, so DM can also have a negative impact on the hearing organ. It is very possible that there is a relationship between the function of auditory organs and DM because this disease affects organs that are rich in blood vessels such as the cochlea and/or the central nerve including the brain that plays a role in the auditory pathway. Impaired cochlear function can cause hearing loss.^[2]

The main mechanism of hearing loss in diabetes is associated with microangiopathy in the inner ear. Several studies have concluded the risk of hearing loss in DM. One study in the United States found sensorineural hearing loss that was more frequent in DM patients compared with non-DM.^[4] Research in Iran was obtained from 455 patients with DM who had hearing loss as many as 80 patients. In Brazil, it was found that statistically significant values increased in patients with DM who had sensorineural

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www.ijss-sn.com

Month of Submission : 09-2018
Month of Peer Review : 10-2018
Month of Acceptance : 11-2018
Month of Publishing : 11-2018

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hearing loss compared to the control group.^[5] In India, it was found that, of 110 patients with type 2 DM (T2DM), 48 patients had bilateral sensorineural hearing loss at high frequencies of 2000 Hz–5000 Hz, 7 patients with severe hearing loss, and 25 patients with moderate hearing loss.^[6]

A study in Nigeria (2016) found a relationship between hearing loss and diabetes control level using haemoglobin A1c (HbA1c) criteria. This shows that diabetes has a significant effect on the sharpness of hearing, showing a significant relationship between the level of control and the degree of hearing level. As reported in several other studies, it was found that hearing loss in T2DM patients was also exacerbated by poor glycemic control. The accumulation of prolonged glycation products in the inner ear, especially the function of external hair cells, has been considered responsible for hearing loss associated with poor glycemic control among T2DM patients.^[7] In contrast, Ferrer's study in 1991 did not find a significant relationship between hearing threshold and HbA1c.^[8]

This study aims to determine the relationship between the hearing degree of patients with controlled T2DM rather than uncontrolled. This is related to the handling of the patient's glycemic status to prevent complications.

MATERIALS AND METHODS

This was an analytical study with a cross-sectional design and single center to determine the differences in hearing degrees in patients with T2DM. This study was carried out by taking data on controlled and uncontrolled T2DM outpatients who came to the Endocrine Clinic of the Department of Internal Medicine, Haji Adam Malik Hospital, Medan. Other inclusion criteria were patients aged 40–65 years, not having congenital deafness, no history of external ear and middle ear disease known through history taking and otoscopic examination, no history of trauma capitis, no history of post-mastoidectomy, no history taking drugs that are ototoxic, and not working in noisy places. Exclusion criteria in this study were patients with anemia and patients with signs of sensorineural hearing loss due to noise and presbycusis which were known through audiometric examination.

The researcher will ask the subject to complete the questionnaire sheet, consent sheet, and informed consent. Then, the subject will be examined ear, nose, and throat (ENT) and recorded the value of HbA1c. Subjects will be divided into two groups based on HbA1c value: Group 1 is controlled T2DM patients (HbA1c <7%) and Group 2 is uncontrolled T2DM patients (HbA1c ≥7%). If there are no abnormalities in the outer ENT, the subject is asked to perform a pure tone audiometry examination. All of this data will be carefully and systematically recorded.

The categorical variable is presented with the number or frequency (*n*) and percentage (%). The numerical variables are assigned with mean and standard deviation (SD) values for normally distributed data, while numerical data that are not normally distributed use the median (middle value), which is then compared with student's *t*-test or Mann–Whitney *U*-test. Univariate analysis was performed by displaying data in both the groups (patients with controlled and uncontrolled T2DM). Statistical data analysis was performed using statistical software, and *P* < 0.05 is considered to be statistically significant.

RESULTS

The study followed 70 T2DM subjects who were divided based on blood sugar control according to HbA1c levels into two groups, each amounting to 35 patients for controlled subject groups and 35 patients for uncontrolled subjects who had met the inclusion criteria.

Most subjects (54.3%) in the controlled T2DM group were male, whereas in the uncontrolled group most female subjects (60%) [Table 1]. The mean age of subjects was not significantly different, in the controlled group with an average of 52.69 years and in the uncontrolled group with an average age of 52.89 years.

Table 2 shows that, of 35 uncontrolled T2DM subjects, 21 patients (60%) had sensorineural hearing loss, whereas from 35 controlled T2DM subjects, only 9 patients (24.7%) had sensorineural deafness in the right ear. Using the Chi-square test, it was proved that there was a significant difference in the proportion of hearing threshold

Table 1: Demographic characteristic

Demographic Characteristic	T2DM		<i>P</i>
	Controlled	Uncontrolled	
Sex Category or Gender			
Male	19 (54.3)	14 (40)	0.231
Female	16 (45.7)	21 (60)	
Age, mean (SD), years	52,69 (6.04)	52,89 (6.54)	0.995

T2DM: Type 2 diabetes mellitus, SD: Standard deviation

Table 2: Differences in proportion of right ear hearing threshold between controlled and uncontrolled T2DM groups

T2DM	Right ear hearing threshold		<i>P</i>	95% confidence interval
	Hearing loss	Normal		
Uncontrolled	21 (60)	14 (40)	0.004	2.333 (1.569–4.358)
Controlled	9 (24.7)	26 (74.3)		

T2DM: Type 2 diabetes mellitus

between uncontrolled and controlled T2DM subjects ($P = 0.004$) with a prevalent ratio of 2.333 which meant that uncontrolled T2DM subjects tended to have a 2.3 greater risk of having sensorineural hearing loss in the right ear compared to controlled T2DM subjects.

Table 3 shows that, of 35 uncontrolled T2DM subjects, 21 patients (60%) had sensorineural hearing loss, whereas from 35 controlled T2DM subjects, only 10 patients (28.6%) had sensorineural deafness in the left ear. Using Chi-square test, it was proved that there was a significant difference in the proportion of hearing threshold between uncontrolled and controlled T2DM subjects ($p=0.008$) with a prevalent ratio of 2.1 which meant that uncontrolled T2DM subjects tended to have a 2.1 greater risk of having sensorineural hearing loss in the left ear compared to controlled T2DM subjects.

The right ear hearing threshold in patients with controlled T2DM was 26.46 dB (SD = 6.38 dB) while in patients with uncontrolled T2DM with a higher mean of 36.82 dB (SD = 14.68 dB). The results of the analysis using Mann–Whitney test showed that there were significant differences in right ear hearing threshold between the two study groups ($P = 0.001$) [Table 4]. On the left ear, it also showed that the mean hearing threshold in patients with controlled T2DM was lower than that of uncontrolled T2DM patients, i.e. 27.04 dB (SD = 6.48 dB) versus 37.14 dB (SD = 14.6 dB). Mann–Whitney test results showed that there were significant differences in hearing thresholds between the two study groups ($P < 0.001$).

Table 5 shows the results of hearing threshold examination on the right ear of the study subjects. From the results of the

Table 3: Differences in proportion of left ear hearing thresholds between controlled and uncontrolled T2DM groups

T2DM	Left ear hearing threshold		P	95% CI (Confident Interval)
	Deafness	Normal		
Uncontrolled	21 (60)	14 (40)	0.008	2.100 (1.165–3.787)
Controlled	10 (28.6)	25 (64.1)		

T2DM: Type 2 diabetes mellitus

Table 4: Differences in right ear and left ear hearing threshold between controlled and uncontrolled T2DM groups

Hearing thresholds	T2DM		P
	Controlled	Uncontrolled	
Right ear	26.46 (6.38)	36.82 (14.68)	0.001
Left ear	27.04 (6.48)	37.14 (14.6)	<0.001

T2DM: Type 2 diabetes mellitus

examination, it appears that the average hearing threshold of the right ear of controlled T2DM subjects for all frequencies is lower than uncontrolled T2DM subjects. Using the Mann–Whitney test, it appears that the right ear hearing threshold differed significantly for each frequency ($P < 0.05$).

Table 6 shows the results of hearing threshold examination on the left ear of the study subjects. From the results of the examination, it appears that the left ear hearing threshold average also shows results that are not much different from the right ear of the study subjects. Using Mann–Whitney test, it appears that the left ear hearing threshold was significantly different for all frequencies ($P < 0.05$).

The results showed that the majority (74.3%) in the controlled T2DM group had a normal hearing threshold, whereas in the uncontrolled group of T2DM patients, only 40% showed a normal hearing threshold. Results that are not much different also appear on the left ear. Most (71.4%) controlled T2DM patients had a normal threshold and only 40% of patients with uncontrolled T2DM showed a normal hearing threshold [Table 7].

DISCUSSION

This study produces characteristics and analysis data on research subjects that can provide information, support, or refute the theories that have been raised from previous

Table 5: The difference in frequency of right ear hearing threshold between controlled and uncontrolled T2DM groups

Frequency of right-ear hearing threshold	Type 2 DM		P
	Controlled	Uncontrolled	
250 Hz	16.29 (4.26)	23.43 (11.93)	<0.001
500 Hz	19.29 (5.96)	28.57 (14.22)	<0.001
1000 Hz	23.57 (5.23)	32.14 (14.52)	0.001
2000 Hz	28 (4.41)	35.71 (14.56)	0.012
4000 Hz	32 (8.42)	42.86 (15.11)	0.001
8000 Hz	36.57 (9.61)	46.14 (13.99)	<0.001

T2DM: Type 2 diabetes mellitus

Table 6: The difference in frequency of left ear hearing threshold between controlled and uncontrolled T2DM groups

Frequency of left ear hearing threshold	T2DM		P
	Controlled	Uncontrolled	
250 Hz	16.86 (4.39)	23.71 (12.09)	0.002
500 Hz	20.29 (5.93)	29.57 (14.32)	<0.001
1000 Hz	24.57 (5.47)	33.14 (14.71)	0.003
2000 Hz	28.14 (4.86)	36 (14.84)	0.01
4000 Hz	33.14 (9.63)	42.86 (15.11)	0.002
8000 Hz	37.71 (10.1)	46.14 (13.99)	0.003

T2DM: Type 2 diabetes mellitus

Table 7: Right ear and left ear hearing threshold frequency distribution between controlled and uncontrolled T2DM groups

Hearing threshold	T2DM	
	Controlled	Uncontrolled
Right ear, n (%)		
Normal	26 (74.3)	14 (40)
Mild deafness	8 (22.9)	10 (28.6)
Moderate deafness	1 (2.9)	9 (25.7)
Severe deafness	0	1 (2.9)
Very severe deafness	0	1 (2.9)
Left ear, n (%)		
Normal	25 (71.4)	14 (40)
Mild deafness	9 (25.7)	10 (28.6)
Moderate deafness	1 (2.9)	9 (25.7)
Severe deafness	0	1 (2.9)
Very severe deafness	0	1 (2.9)

T2DM: Type 2 diabetes mellitus

studies regarding differences in hearing degrees in patients with controlled and uncontrolled T2DM. The total number of subjects in this study was 70 patients who were divided into two groups based on blood sugar control according to HbA1c levels.

In 2015, the veterans administration also conducted a study of hearing loss in diabetic patients whose severity was divided based on the HbA1c value, where the results showed that hearing dysfunction in T2DM patients could be slowed or prevented by controlling blood sugar levels tightly. Previous studies from the Veterans Health Administration in 2006 analyzed 302 veterans and compared patients to non-insulin-dependent diabetes mellitus, insulin-dependent diabetes mellitus, and non-diabetic patients. This study divides the severity of diabetes based on insulin dependence and risk factors, not based on HbA1c values, and concludes that diabetes correlates with the occurrence of hearing loss, and this relationship is stronger in patients with younger ages. In our study, the division of diabetes severity was based on the HbA1c value, where diabetes was considered controlled if the HbA1c value was <7%.^[9]

The risk of cochleopathy increases proportionally with an increase in hemoglobin levels. The value of glycated hemoglobin and the occurrence of diabetic cochleopathy depend on strict glycemic control, possibly predicting the occurrence of cochleopathy based on the value of glycated hemoglobin, which is routinely carried out periodically in individuals with diabetes.^[10]

In our study, most of the controlled subjects were male, whereas in the uncontrolled group most female subjects. The mean age of subjects was not significantly different where the mean age in both groups was \pm 52 years.

This basic data finding is similar to the study by Handzo *et al.* in 2016 conducting retrospective studies between 2000 and 2008 in patients with or without diabetes who were admitted to hospitals with the results of the study that diabetic patients were directly correlated with the degree of hearing loss in the female patient population. Hearing loss occurred significantly in the male population at all ages compared to the female population, but this did not show a difference between controlled and uncontrolled T2DM patients.^[9] Kakarlapudi *et al.* in 2003 found that sensorineural hearing loss was more common in diabetic patients than patients without diabetes. This study also found that the degree of hearing loss correlated with disease progression.^[4]

Our study found differences in the proportion of significant hearing thresholds between uncontrolled and controlled T2DM subjects in which uncontrolled T2DM subjects tended to have a 2.3 times greater risk of having a hearing threshold of sensorineural hearing loss in the right ear and also 2.1 times greater risk in the ear left compared to controlled T2DM subjects.

Other studies conducted in India also found that T2DM patients with uncontrolled blood sugar levels increased the incidence of 76.6% of sensorineural hearing loss compared to patients with controlled blood sugar levels.^[11] In addition, another study said that patients with good HbA1c levels (HbA1c \leq 7.5%) had a better hearing levels in both ears compared to T2DM patients with poor glycemic control.^[2]

Our study also showed that there were significant differences in the right ear and left ear hearing threshold, with the right ear hearing threshold in patients with controlled T2DM being 26.46 dB, whereas in patients with uncontrolled T2DM with a higher mean of 36.82 dB, while the left ear hearing threshold value of the controlled T2DM group had a lower value than uncontrolled T2DM patients, i.e., 27.04 dB versus 37.14 dB.

From the results of the hearing threshold examination, it appears that the average hearing threshold of the right and left ears of controlled N,N-Dimethyltryptamine (DMT) subjects for all frequencies is lower than uncontrolled DMT2 subjects, and also the hearing thresholds of the right and left ears differ significantly for each frequency. The results of this study also showed that the majority in the controlled T2DM group had normal hearing thresholds.

Sathianesan and Premaraja in 2016 showed that T2DM would increase the hearing threshold at all frequencies (250–8000 Hz) in both the groups. In the uncontrolled T2DM group (HbA1c > 8%), the hearing threshold will be higher than the uncontrolled T2DM group. These results

illustrate that the effects of prolonged hyperglycemia on auditory acuity are explained as a result of microangiopathy and diabetic neuropathy in the inner ear. The results of this study are in line with our research, but in our study, we have divided diabetes severity using a 7% HbA1c cutoff value.^[12]

Ferrer's in 1991 found no significant relationship between hearing threshold and HbA1c.^[8] This was also found in research conducted by Dalton *et al.* and Bainbridge *et al.* who did not find a relationship between hemoglobin levels with hearing impairment.^[13,14] Our study is not in line with the results obtained by the three previous studies because HbA1c levels can cause a direct impact on the hearing threshold.

Hearing loss associated with diabetes is a progressive, bilateral, and sensorineural disorder with a gradual onset and generally points a higher frequency. Sensorineural hearing loss is caused by chronic and persistent hyperglycemia. When hyperglycemia status is controlled in diabetic patients, the severity of hearing loss will be minimal. Hearing loss should be assessed earlier in T2DM patients to prevent the severity of hearing loss which can also occur due to age.^[13]

CONCLUSION

Uncontrolled T2DM patients are more susceptible to hearing loss. Patients with T2DM are advised to better control of blood sugar levels to prevent hearing loss.

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How to cite this article: Anindita R, Adnan A, Munir D, Syafril S, Ashar T. Comparison of Sensorineural Hearing Loss Degree between Controlled and Uncontrolled Type 2 Diabetes Mellitus Patients. *Int J Sci Stud* 2018;6(8):1-5.

Source of Support: Nil, **Conflicts of Interest:** None declared.