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Hearing Loss and Associated Factors in Iranian Patients with Type 2 Diabetes: A Case-Control Study

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Abstract

Background: Hearing loss is an important impairment that occurs in the diabetics and affects their quality of life. There is still a paucity of studies on the relationship between diabetes and hearing loss.
Objectives: This case-control study compared the prevalence of hearing loss in a sample of diabetics with that in an age and sex matched group of healthy controls.
Methods: Cases were consecutively selected from the diabetics registered in two diabetes centers during February to December 2013. Controls were age and sex matched healthy volunteers admitted to a blood bank. Pure tone audiometric test (PTA) was performed by audiometer for the evaluation of hearing impairment. Then, the existence of hearing impairment in different intensities was compared between the two groups considering the effect of diabetes duration, BMI, and serum creatinine (Cr) level.
Results: Eighty diabetics and eighty healthy controls were included. Hearing loss in sounds with high frequencies was more common in the diabetics than the controls. The mean serum creatinine level was significantly higher in the diabetics with hearing loss than those without hearing loss at noise frequencies of 4 KHz and 8 KHz ($P < 0.05$). Meanwhile, hemoglobin A1C, duration of diabetes, and body mass index were not associated with hearing loss.
Conclusions: According to the results, hearing impairment in high frequency sounds was more common in the diabetics than the healthy individuals. Also, the severity of hearing loss in patients with diabetes was associated with the levels of creatinine (diabetic nephropathy). The hypothesis of the relationship between diabetes and hearing loss through nephropathy should be more examined in future studies

Keywords: Hearing Loss, Glycosylated Hemoglobin A, Creatinine, Glycosylated Hemoglobin A, Body Mass Index

1. Background

Diabetes mellitus is a metabolic disorder characterized by chronic hyperglycemia and impaired metabolism of carbohydrate, fat and protein (1). The prevalence of diabetes is increasing rapidly (2). Diabetic complications have great socioeconomic impacts on the public health (3-5). Hearing loss is an impairment in the diabetics that lowers their quality of life. There are controversial results regarding its association with diabetes (6-9). Age, levels of kidney function impairment, hypertension, atherosclerosis, and glycemic control are the proposed factors that could be associated with hearing loss in diabetics (6-9). It seems to be a logical approach to evaluate the relationship between hearing loss and diabetes by considering the above mentioned factors.

The aims of the study were: 1) to compare the prevalence of hearing loss among the diabetics with that among the healthy controls. 2) to define the relationship between hearing loss and serum creatinine (Cr), hemoglobin A1c, body mass index (BMI), and the duration of diabetes.

2. Methods

2.1. Patient and Control Enrolment

This case-control study was conducted during February to December 2013. Subjects in the case group were consecutively selected from the diabetics who referred for diabetic control to Golabchi and Naghavi diabetes centers in Kashan University of Medical Sciences. The inclusion criteria for the case group were a medical diagnosis of diabetes mellitus (based on the criteria of American diabetes association 2013), being under treatment with antidiabetic medications or insulin, and an age between 20 to 50 years. The exclusion criteria were as follows: 1) existing excessive ear wax in the ear canal or any abnormality in the eardrum detected by otoscopy, 2) active otitis media, 3) complicated otitis media, 4) history of ear

surgery, cerebrovascular accident, meningitis, otosclerosis, measles, mumps, and rubella, 5) history of receiving ototoxic medications (i.e. aminoglycosides), 6) history of having a job with high levels of noise pollution, 7) history of hypothyroidism (serum thyroid stimulating hormone (TSH) level more than 5 (U/mL)), 8) history of head injury, 9) known causes of chronic renal failure other than diabetic nephropathy.

Subjects in the control group were selected among healthy individuals admitted to Kashan's blood bank to donate blood. A biostatistician matched the cases and the controls (block matching method) with regard to age and sex.

2.2. Audiometric Studies

Hearing loss was defined if there was decreased sensitivity to the sounds in the speech frequencies (8). Normal hearing threshold was set at the power of 20 decibel (dB) in this study (8). Pure tone audiometric test (PTA) was performed by an audiometer that was capable of producing acoustic tones in adjustable frequencies. To avoid the inter-observer variability of the audiometric findings, the test was performed by an expert audiology technician. This test evaluated the patients' hearing status, diagnosed different hearing disorders, and helped the patients to use assistive hearing devices. The frequency distribution of different hearing impairments was obtained.

2.3. Laboratory Measurements

A blood sample was obtained from each subject after eight hours of fasting to measure the levels of HbA1c, TSH, and Cr. The laboratory assays were performed by enzyme-linked immunosorbent assay (ELISA) method (using Pars Azmoon Kit, Tehran, Iran) according to the manufacturer's instruction. All laboratory data were collected in duplicate at a standard laboratory environment regarding temperature and humidity. The inter-assay variability of the measured laboratory findings was less than 10% in this project. The checklist used for clinical data collection included data on the subjects' age, gender, height, weight, BMI, duration of diabetes, and the name of the drugs used. Also, there was a special form for recording the results of the subjects' laboratory examinations including HbA1c, TSH, Cr, glomerular filtration rate (GFR), and the result of the audiometric examinations. The study protocol was completed for all the subjects through individual interviews in a private environment at the diabetes clinics or in the blood bank.

Patients were divided into healthy weight, overweight, and obese according to their BMI.

2.4. Ethical Considerations

Research ethics committee of Kashan University of Medical Sciences approved the study protocol (registration number: 9155). All subjects were briefed about the study objectives before the start of the study. They all signed a written informed consent before enrolment. All subjects were also assured of the confidentiality of their personal information.

2.5. Sample Size Calculation

The sample size was expected to be 81 in each study group in view of mean prevalence of hearing loss in the diabetics (P = 27%, α = 0.05, z = 1.96, and d = 0.2).

2.6. Statistical Analysis

Kolmogorov-Smirnov test was used for analyzing the normal distribution of data. Two-sample t-test was used to compare the mean values of continuous variables (age, creatinine, GFR, and HbA1c) in the diabetics with those in the healthy volunteers. Chi-square test was used to compare categorical variables of the study groups. P value (two-sided) less than 0.05 was considered as the significant level all through the statistical analysis. Data analysis was performed using SPSS 19 (IBM, Inc., Armonk, NY).

3. Results

One hundred and eighty diabetic patients were visited in the mentioned diabetic centers. The number of the excluded patients and the cause of their exclusion is shown in Figure 1.

Finally eighty diabetic patients and eighty age and sex matched healthy subjects were recruited in this study. The mean duration of diabetes in the case group was 7.92 ($\pm$ 5.22) years, ranging from 1 to 20 years. The patients' characteristics are shown in Table 1. The mean creatinine and GFR were not significantly different in the study groups (P > 0.05). However, the mean HbA1c was significantly higher among the diabetic patients, which signifies inappropriate glycemic control (9.09 vs. 3.84, P < 0.001). The distribution of hearing loss among the two study groups is demonstrated in Table 2. The comparison of mean serum creatinine level in the diabetic patients with and without hearing loss is provided in Table 3.

In all of the sound frequencies, no significant differences were observed between the diabetics with and without hearing loss in terms of mean diabetes duration, HbA1C, and BMI. However, the mean creatinine was significantly different in the diabetics with and without hearing loss at the sound frequencies of 4 KHz and 8 KHz (Table 3).

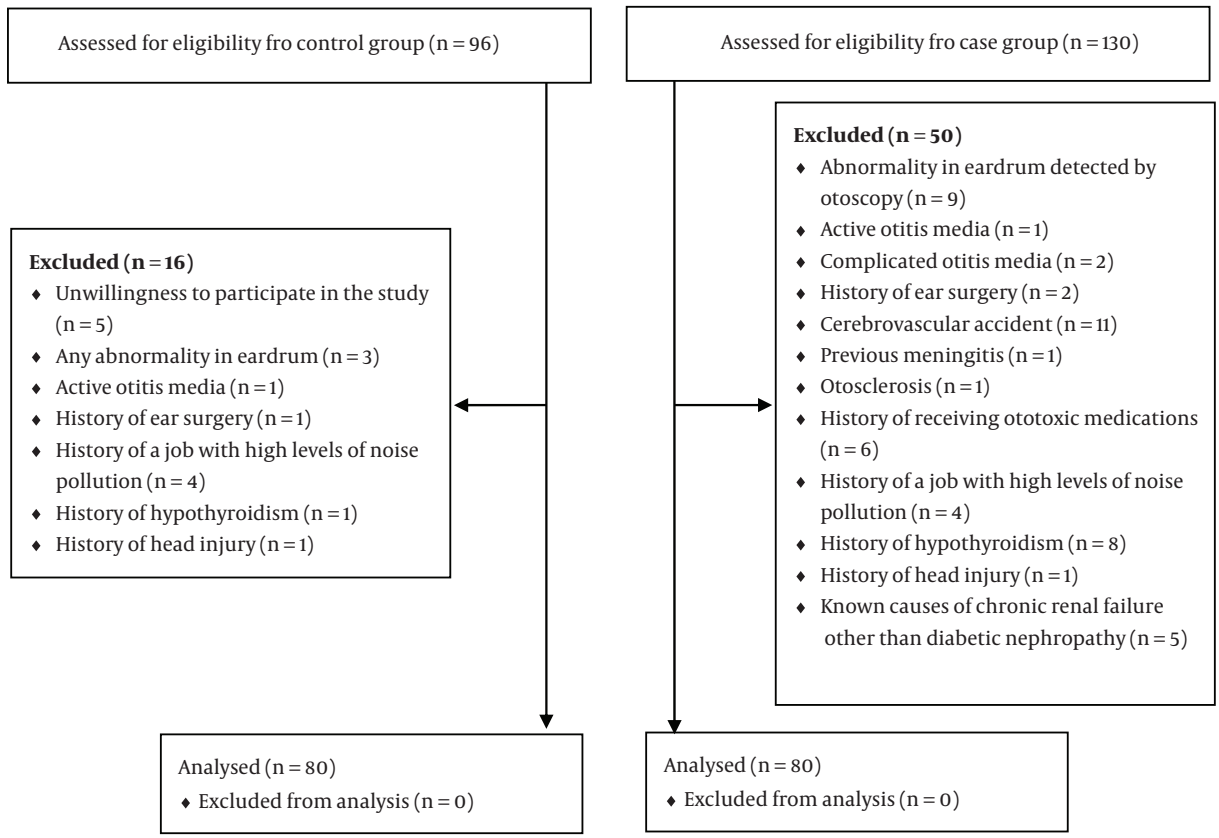

Figure 1. The Number of Excluded Patients and the Cause of Exclusion in Both Groups

4. Discussion

The present study showed that hearing loss in high frequency sounds was more common in the diabetics compared with healthy controls. Among the diabetics, an increase in the prevalence of hearing loss was observed with an increase in the sound frequency. The prevalence of hearing loss was increased from 11.2% at the sound frequency of 250 Hz to 41.2% at the frequency of 8 KHz. The comparison of the mean hearing threshold in the right ears of the two groups showed that the diabetics and the controls were significantly different in all sound frequencies except for the frequency of 250 Hz. The mean hearing threshold was within the normal range at all the frequencies among the controls. At the same time, the mean hearing threshold in the diabetics was out of the normal range at the frequencies of 1 KHz to 8 KHz. This finding signifies the hearing loss at high frequencies among the diabetics. The comparison of the mean hearing threshold of the left ears in the two groups showed that the diabetic and the non-diabetic people were significantly different in all sound frequencies over 1 KHz. The mean hearing threshold was within the normal range at all sound frequencies in the controls. Meanwhile, the mean hearing threshold was out of the normal range in the frequencies of 2 KHz and more among the diabetics.

High levels of serum creatinine might not only be a sign of poorly controlled diabetes, but also they are associated with severe hearing loss.

Previous studies have shown that hearing loss is associated with reduced social relationships, depression, cognitive disorders, and the poor quality of life (10-16). Chronic exposure to excessive noise, chemical, ototoxic drugs, cigarette smoke, alcohol, high blood pressure, and a history of head trauma are among the risk factors of hearing impairment (17-22). The review of literature shows controversial results on the relationship between diabetes and hearing impairment. Several studies have shown that hearing loss is more common in the diabetics than in the non-diabetic people (6, 7). On the other hand, there are studies that did not find a significant relationship between diabetes and hearing impairment (8, 9). The controversies among the results might be due to the inconsistencies in

Table 1. The Patients' Characteristics in the Two Study Groups[a]

Variable	Group		P Value
	Diabetics	Controls	
Age, y	44.97 ± 6.21	43.42 ± 5.80	0.18
Gender			0.07
Male	35 (43.75)	37 (46.25)	
Female	45 (56.25)	43 (53.75)	
BMI, kg/m²			0.04
Healthy weight	31 (38.7)	42 (52.5)	
Overweight	32 (40)	34 (42.5)	
Obese	17 (21.3)	4 (5)	
Creatinine, mg/dL	1.01 ± 0.21	0.99 ± 0.21	0.56
Glomerular Filtration Rate	88.82 ± 23.62	91.22 ± 24.67	0.61
HbA1c, mg/dL	9.09 ± 2.03	3.84 ± 0.67	< 0.001

Abbreviations: Kg/m², kilogram per square meter; mg/dL, milligram per deciliter.
[a]Values are expressed as mean ± standard deviation (SD) or No. (%).

Table 2. The Distribution of Hearing Loss Among the Two Study Groups[a]

Sounds Intensity	Hearing status	Diabetic	Controls
250 Hz	Normal	71 (88.8)	78 (97.5)
	Hearing loss	9 (11.2)	2 (2.5)
500 Hz	Normal	69 (86.3)	80 (100)
	Hearing loss	11 (13.7)	0
1 KHz	Normal	68 (85)	80 (100)
	Hearing loss	12 (15)	0
2 KHz	Normal	65 (81.3)	80 (100)
	Hearing loss	15 (18.7)	0
4 KHz	Normal	52 (65)	78 (97.5)
	Hearing loss	28 (35)	2 (2.5)
8 KHz	Normal	47 (58.8)	72 (90)
	Hearing loss	33 (41.2)	8 (10)

[a]Values are expressed as No. (%).

the methods, lack of appropriate matched controls, and the problems in studying the effects of confounders (such as hypertension, atherosclerosis, and glycemic control) on the hearing of the diabetics. Therefore, well designed studies considering the possible confounders in the hearing loss of the diabetics are suggested.

Microangiopathic lesions in the inner ear, auditory nerve neuropathy, and even mutations in the mitochondrial genes have been listed as the possible causes of hearing impairment in diabetes (23). The previous research stressed on the need to determine the subtypes of diabetes that are at risk of hearing impairment (24). Considering the results of this study, high levels of creatinine in the diabetic patients might explain a potential mechanism for hearing impairment in these patients. The eardrum lacks blood vessels. Its nutrition and waste material removal is mostly done through diffusion. Therefore, any changes in the osmolarity of body fluids, might directly affect the process of diffusion through the eardrum. Increase in the concentration of the substances with the greatest impact on the osmolarity of the body fluids, may result in an osmotic shock in the eardrum which consequently decreases its elasticity and reduces its ability to conduct sound vibrations.

4.1. Clinical Implication

Appropriate audiometric screening is recommended for the diabetics especially in those with increased serum creatinine level. Timely management of the hearing impairment in these high risk patients could result in the improvement of their quality of life.

4.2. Conclusions

According to the results of the present study, hearing impairment in the high frequency sounds was more common in the diabetics than healthy individuals. Also, the severity of hearing loss in patients with diabetes was associated with the levels of creatinine (diabetic nephropathy). The hypothesis of the relationship between diabetes and hearing loss through nephropathy should be examined more in future studies.

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Footnotes

Authors' Contribution: Saeed Nouri and Kurosh Gharagozli: study concept, study design, and data collection; Raika Jamali, Mohammad Reza Sharif, and Bardia Jamali: performing statistical analysis, interpretation of the data, drafting the manuscript, critical revision of the manuscript for important intellectual content, and study supervision.

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Table 3. The Comparison of Mean Serum Creatinine Level in the Diabetic Patients with and Without Hearing Loss

Sounds Intensity	Hearing Status	Number	Creatinine[a]	P Value
250 Hz	Normal	71	1.02 ± 0.21	0.63
	Hearing loss	9	0.97 ± 0.24	
500 Hz	Normal	69	1.0 ± 0.20	0.22
	Hearing loss	11	1.19 ± 0.26	
1 KHz	Normal	68	0.99 ± 0.19	0.09
	Hearing loss	12	1.14 ± 0.27	
2 KHz	Normal	65	0.98 ± 0.19	0.05
	Hearing loss	15	1.13 ± 0.26	
4 KHz	Normal	52	0.96 ± 0.17	0.01
	Hearing loss	28	1.11 ± 0.26	
8 KHz	Normal	47	0.95 ± 0.17	0.005
	Hearing loss	33	1.10 ± 0.24	

[a]Values are expressed as mean ± standard deviation (SD).

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