Review Article

The risk factors of hearing loss in diabetes mellitus

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ABSTRACT

Background: Hearing loss is considered as one of the complications in diabetic patients. However, studies reported conflicting results on the relationship between diabetes and hearing loss. **Objectives:** This study aimed to investigate and compare the prevalence of hearing loss in patients with diabetes mellitus and a group of non-diabetic people. **Materials and Methods:** This study was conducted on 80 patients with diabetes and 80 non-diabetic subjects. Subjects in the case group were selected among the diabetic patients registered in the diabetes centers of Isfahan province. Subjects in the control group were selected among non-diabetic individuals referring to the blood bank to donate blood. The instrument used for data collection included of questions on the subjects demographics and a special form for recording the results of the subjects' laboratory examinations including HbA1c, TSH, Cr and the result of the audiometric examinations. Data analysis was performed using descriptive statistics, chi-square test and t-test or nonparametric equivalents. **Results:** Compared with non-diabetic subjects, hearing loss in sounds with high frequencies was more common in patients with diabetes (P value = 0.001), the mean creatinine was significantly different in diabetic patients with and without hearing loss at noise frequencies of 4 KHz and 8 KHz (P value< 0.05). However, hemoglobin A1C, duration of diabetes and BMI were not significantly associated with hearing loss. **Conclusion:** Hearing impairment in high frequency sounds is more common in diabetics than healthy individuals. The severity of hearing loss in patients with diabetes is also associated with the levels of creatinine.

Keywords: Hearing Loss, Diabetes mellitus, Audiometry

INTRODUCTION

Diabetes mellitus is a heterogeneous group of metabolic diseases characterized by chronic hyperglycemia and impaired metabolism of carbohydrate, fat and protein. It is the result of defects in insulin secretion, insulin action or both [1, 2]. The prevalence of diabetes was estimated to be 140 million at the end of the twentieth century and it is predicted that this figure will reach 300 million in 2025 [3]. Complications associated with diabetes such as blindness, nephropathy, neuropathy and non-traumatic amputation have key roles in endangering public health and increasing the economic burden for the countries [4, 5].

Hearing loss is also considered as one of the complications in diabetic patients and in many studies, its prevalence was higher in patients with diabetes than those without diabetes [6, 7]. On the other hand, studies demonstrated conflicting results [8, 9]. These controversies might caused by problems in matching the study groups. In fact, complications such as kidney involvement, hypertension and atherosclerosis in one hand and patients' problems in the control of diabetes on the other hand, make it difficult to match the case and the control groups in many studies. Therefore, designing studies with appropriate matching might be helpful in determining the factors affecting hearing loss in patients with diabetes.

OBJECTIVES

This study aimed to investigate the prevalence of hearing loss in patients with diabetes mellitus. We attempted to investigate the relationship between hearing loss and factors such as the levels of creatinine (Cr), hemoglobin A1C, body mass index (BMI) and duration of diabetes.

MATERIALS AND METHODS

A case control study was conducted to compare the prevalence of hearing loss in patients with type II diabetes and those without diabetes. Subjects in the case group were selected among the 2,300 diabetic patients registered in the diabetes centers of Isfahan province and referred for their routine treatment follow-up. Subjects in the control group were selected among non-diabetic (healthy) individuals referring to the blood bank to donate blood. Inclusion criteria for the patients in the case group were having a medical diagnosis of diabetes mellitus (based on the criteria of American Diabetes Association), being under treatment with anti-diabetic medications or insulin, age between 20 to 50 years, TSH< 3.5 and HbA1c <5.7, not having an active otitis, and not having a history of disorders such as head injury, syncope or coma, complicated otitis media, hypertension, untreated hypothyroidism, not having a history of ear surgery or receiving ototoxic drugs (i.e. Gentamicin,…), and lacking a job with high levels of noise pollution. Inclusion criteria for the control group were the same unless they were not known as diabetic patients. The two groups were matched for age and sex.

The instrument used for data collection included of questions on the subjects age, gender, height, weight, BMI, duration of diabetes and the name drugs used. Also there was a special form for recording the results of the subjects' laboratory examinations including HbA1c, TSH, Cr and the result of the audiometric examinations.

A blood sample was obtained of each subject after eight hours of fasting for measuring the levels of HbA1c, TSH and Cr. Moreover an audiometry was performed for each subject and the results of all tests were recorded. The blood pressure was measured for all subjects after at least five minutes of resting on a bed, immediately before the blood sample is obtained and the subjects were not recruited if they had a high blood pressure. The study instrument was completed for all subjects through individual interviews in a private environment at the diabetes clinics or in the blood bank.

Ethical Considerations

Regional Research Ethics Committee approved the study protocol. All subjects were briefed about the study objectives before the start of the study and they all signed an informed consent. All subjects were also assured of the confidentiality of their personal information.

Data analysis

Data analysis was performed using the SPSS 13 (SPSS, Inc., Chicago, IL, USA), Descriptive statistics were calculated. Moreover, chi-square tests and t-test or nonparametric equivalents used to analyze the data. P value less than 0.05 was considered as significant in all testes.

RESULTS

Totally 80 diabetic patients and 80 non-diabetic subjects were recruited in this study. The two groups were matched for age and sex. No significant difference was observed between the mean age of the diabetic patients and non-diabetic ones (44.97 ± 6.21 vs. 43.42 ± 5.80, P= 0.182). Moreover, the two groups were not significantly different in terms of gender (P= 0.069). The mean duration of diabetes in the case group was 7.92 ± 5.22 years ranging from 1 to 20 years. The highest and the lowest frequencies were in those in age range of 1-5 years and 16-20 years, respectively. The majority of the case group was overweight while most of the non-diabetic subjects had normal weight (Table 1).

In diabetic patients, an increase in the prevalence of hearing loss was observed with increasing in the noise frequency; so that the prevalence of hearing loss was increased from 11.2% in the noise frequency of 250 Hz to 41.2% in the frequency of 8 KHz.

Comparison of the mean hearing threshold in the right ears of the two groups showed that the diabetic and non-diabetic people were significantly different in all noise frequencies except for the frequency of 250 Hz. In non-diabetic subjects the mean hearing threshold was within the normal range at all frequencies, however, in diabetic patients the mean hearing threshold was out of the normal range in frequencies of 1 KHz to 8 KHz that signifies the hearing loss in high frequencies. Moreover, comparison of the mean

hearing threshold of the left ears in the two groups showed that the diabetic and non-diabetic people were significantly different in all noise frequencies over 1 KHz. In non-diabetic subjects the mean hearing threshold was within the normal range at all frequencies, while, in diabetic patients the mean hearing threshold was out of the normal range in frequencies of 2 KHz and over.

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

The mean creatinine and GFR were not significantly different in the two groups. However, the mean HbA1c was significantly higher among the diabetic patients that signifies inappropriate diabetes control (P= 0.001) (Table 2).

Table 1: The distribution of BMI status in the study groups

Variable	Group	
	Diabetic	Non-diabetic
Underweight	0 (0)	2 (2.5)
Healthy weight	31 (38.7)	40 (50)
Overweight	32 (40)	34 (42.5)
Obesity I	9 (11.3)	4 (5)
Obesity II	8 (10)	0 (0)
Extreme Obesity	0 (0)	0 (0)
Total	80 (100)	80(100)

**All data are presented as N (%)*

Table 2: Comparison of the mean Creatinine and GFR in two groups

Variable	Group		P value
	Diabetic	Non-diabetic	
Creatinine	1.01 ± 0.21	0.99± 0.21	0.556
GFR	88.82 ± 23.62	91.22 ± 24.67	0.613
HbA1c	9.09 ± 2.03	3.84 ± 0.67	0.001

**All data are presented as Mean ± SD*

Table 3: The distribution of hearing loss among the two groups

Sounds Intensity	Level of Hearing	Diabetic	Non-diabetic
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 (0)
1 KHz	Normal	68 (85)	80 (100)
	Hearing loss	12 (15)	0 (0)
2 KHz	Normal	65 (81.3)	80 (100)
	Hearing loss	15 (18.7)	0 (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)

**All data are presented as N (%)*

Table 4: Comparison of the mean Creatinine diabetic patients with and without hearing loss

Sounds Intensity	Level of Hearing	N	Mean ± SD	P value
250 Hz	Normal	71	1.02 ±0.21	0.628
	Hearing loss	9	0.97±0.24	
500 Hz	Normal	69	1.0±0.20	0.218
	Hearing loss	11	1.19±0.26	
1 KHz	Normal	68	0.99±0.19	0.098
	Hearing loss	12	1.14±0.27	
2 KHz	Normal	65	0.98±0.19	0.055
	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	

DISCUSSION

The present study showed that hearing loss at high frequency noises was more common in patients with diabetes compared with non-diabetics subjects who were matched for age. Furthermore, high levels of creatinine might not only be a sign of poorly controlled diabetes, but also is associated with severe hearing loss. However, no significant relationships were observed between hearing loss and the levels of hemoglobin A1C, the duration of diabetes and BMI.

Previous studies showed that hearing loss is associated with reduced social relationships, depression, cognitive disorders and poor quality of life [10- 16]. Several factors such chronic exposure to excessive noise, chemical, ototoxic drugs, cigarettes smoking, alcohol and high blood pressure and a history of head trauma, are among the risk factors for hearing impairment [17- 22]. However, studies on the relationship between diabetes and hearing impairment are controversial.

Several studies have shown that hearing loss is more common in diabetics than in non-diabetic people. In a study Taziki et al. have reported that hearing impairment in people with diabetes is three times more than the general population [7]. Malucelli et al. also reported the same findings [5]. Conversely, Salvinelli [8] and Sieger [9] could not find a significant relationship between diabetes and hearing impairment. The controversies between studies might be attributed to the inconsistencies in methods, lack of appropriate matching and problems in studying the effects of some co-morbidities such as hypertension and atherosclerosis on hearing of patients with diabetes. On the other hand, the quality of diabetes control might independently affect on patients hearing mechanisms. For this reason, studies with larger sample sizes and accurate matching are necessary.

Several possible mechanisms such as microangiopathic lesions in the inner ear, auditory nerve neuropathy and even mutations in mitochondrial genes have been listed as possible causes of hearing impairment in diabetes [23]. Studies have also stressed on the need to determine the subtypes of diabetes that are at risk for hearing impairment [24]. Considering the results of this study, the high levels of creatinine in diabetic patients might explain a potential mechanism for hearing impairment in these patients. The eardrum is lacking blood vessels, therefore, its nutrition and waste material removal is mostly done through diffusion. Therefore, any changes in osmolarity of the body fluids, might directly affect the process of diffusion through the eardrum. Increasing in the concentration of substances with greatest impact on osmolarity of body fluids, may result in an osmotic shock in the eardrum which consequently decreases its elasticity and reduces its ability to conduct sound vibrations [25].

CONCLUSION

Hearing impairment in high frequency sounds is more common in diabetics than healthy individuals. The severity of hearing loss in patients with diabetes is also associated with the levels of creatinine.

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Conflict of Interest
The authors have no conflict of interest to disclose.

Authors' Contribution

Fatemeh Tabatabaei developed the study concept and design and the acquisition of data, interpretations of data, and drafting of the manuscript. Davood Kheirkhah, Zahra Soleimani and Saeed Nouri developed the protocol, analysis of data and drafting of the manuscript.

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