Diabetes mellitus and sensorineural hearing loss among non-elderly people

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السكري وفقدان السمع الحسي العصبي بين السكان من غير المسنين

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الخلاصة: يمثّل ضعف السمع أحد مضاعفات السكري المعروفة. وتسعى هذه الدراسة المقارنة التي أجريت في مدينة طهران في جمهورية إيران الإسلامية إلى تقييم التـرابُط بين السكري وبين فقدان السمع الحسي العصبي في غير المسنين من السكان. ومن بين 160 شخصاً كانت أعمارهم أقل من 60 سنة ولم يسبق لهم التعرض لضوضاء مهنية (ثمانون منهم مصابون بالسكري، وثمانون غير مصابين بالسكري وهم يماثلونهم في العمر والجنس)، شوهد لدى 45٪ من السكريـين و20٪ من الشواهد فقدان سمع حسي عصبي (نسبة الأرجحية 3.5، فاصلة الثقة ٪95: 1.6–6.6). وتـرافقت سِنُّ ظهور داء السكري مع مدة المرض بفقدان السمع الحسي العصبي. وتدلُّ الدراسة على أن السكري يمكن أن يكون عامل اختطار لفقدان السمع بغض النظر عن العمر والتدخين. ويمكن أن يؤدي تحديد سبب فقدان السمع الحسي العصبي في السكريـين إلى ابتكار خيارات علاجية أفضل.

ABSTRACT One of the known complications of diabetes is hearing impairment. This comparative study in Tehran, Islamic Republic of Iran, aimed to evaluate the association of diabetes mellitus and sensorineural hearing loss (SNHL) among a non-elderly population. Among 160 subjects aged < 60 years with no history of occupational noise exposure (80 diabetics and 80 age- and sex-matched non-diabetic controls), 45% of diabetic patients and 20% of controls had SNHL (OR 3.5, 95% CI: 1.6–6.6). Age at onset and duration of diabetes were associated with SNHL. Diabetes mellitus may be a risk factor for hearing loss regardless of age and smoking. Determining the cause of SNHL in diabetic patients may lead to development of better treatment options.

Diabète sucré et perte auditive neurosensorielle chez le sujet non âgé

RÉSUMÉ La déficience auditive constitue l'une des complications connues du diabète. Cette étude comparative réalisée à Téhéran, en République islamique d'Iran, visait à évaluer l'association du diabète sucré et de la perte auditive neurosensorielle au sein de la population non âgée. Parmi les 160 sujets âgés de moins de 60 ans ne présentant aucun antécédent d'exposition professionnelle au bruit (80 diabétiques et 80 sujets témoins non diabétiques appariés selon l'âge et le sexe), 45 % des patients diabétiques et 20 % des témoins étaient atteints de perte auditive neurosensorielle (OR 3,5 ; 95 % IC : 1,6 – 6,6). Il est apparu que l'âge au moment de la survenue du diabète et la durée de celui-ci sont associés à la perte auditive neurosensorielle. Le diabète sucré peut constituer un facteur de risque de perte d'audition, quel que soit l'âge ou le statut tabagique. La détermination de la cause de la perte auditive neurosensorielle chez les patients diabétiques peut permettre le développement d'options thérapeutiques plus efficaces.

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Introduction

Diabetes mellitus (DM) is a noncommunicable chronic disease with numerous cardiovascular [1,2], neurological [3], infectious [4] and other complications. One of the known complications of DM is hearing impairment, especially hearing loss and tinnitus [5–7], which leads to a decreased quality of life among those affected [8]. Therefore, prevention and treatment of sensorineural hearing loss (SNHL) among diabetic patients is important [9,10]. Some of the most important etiological hypotheses are neuropathy [11], microangiopathy [12] and an inevitable consequence of the ageing process (presbycusis) [13]. In previous reports evaluating the association between DM and SNHL, elderly age and other confounding factors such as smoking, occupational noise exposure, sex and ethnicity were significantly different among case and control groups [14–16].

In the Islamic Republic of Iran, despite the existence of a national diabetes prevention and control programme [17–19], we are nevertheless challenged with a large burden of diabetes. According to existing records, the current prevalence of DM in the country is 7.8%–14.5% [20–22]. We designed this study to evaluate the correlation of DM and sensorineural hearing loss in a non-elderly population with no positive history of occupational noise exposure or smoking.

Methods

The current study was a comparative cross-sectional survey of known cases of DM and non-diabetic healthy subjects. The medical ethics committee of Azad University of Medical Sciences, Tehran, Islamic Republic of Iran approved the survey.

Sample

The care of all diabetic patients in Islamic Republic of Iran is coordinated by the Iranian Diabetes Association (IDA) and their medical history is recorded in a central database in Tehran. Patients from Tehran aged 20–60 years with DM according to existing medical documents in the IDA registry were included in the sample. Using random number tables and the IDS list we randomly selected 130 patients from among a larger population attending diabetes clinics and invited them by telephone to participate in our study; 114 subjects (87.7%) accepted. All these patients were asked to attend with at least 2 close relatives aged < 60 years to be used as control subjects if they fulfilled the inclusion criteria.

Our main inclusion criteria were age < 60 years and never having smoked tobacco. Insulin and/or oral glucose-lowering agents were used to control diabetes in the case group. Exclusion criteria were: older than 60 years, current and/or previous smoking, alcohol consumption, using any ototoxic drugs, current and/or previous work in jobs or situations with noise exposure, and history of hearing disorders such as anatomical inner and middle ear disorders and unilateral conductive deafness. Occupational noise exposure was defined as a self-report of holding a job that required them to speak in a raised voice to be heard or working without a cap in jobs usually needing to use an acoustic cap apart from seasonal and occasional jobs and activities. Confounding background diseases such as anatomical inner and middle-ear disorders and unilateral conductive deafness were assessed by a question about the hearing status of the patient as a preliminary self-report.

Simple random sampling was used to select a control group with similar demographic characteristics who met all the inclusion and exclusion criteria.

A total of 80 DM patients and 80 age- and sex-matched control subjects who met the inclusion criteria were recruited to the study.

Data collection

The key variables analysed in relation to DM were: age, sex, presence of SNHL and the type (1- or 2- sided) and severity of SNHL.

Patients' age, sex, smoking history, history of alcohol consumption and previous medical history were available from the IDA registry. Similar data were obtained from control subjects by questionnaire. Other variables that were evaluated specifically for this study only in diabetic patients included duration of DM, age at onset, type of diabetes (type 1 or 2), glycaemic control [defined as glycosylated haemoglobin (HbA1C) < 8%], mean fasting blood glucose (FBG) level from at least 2 measurements and presence of DM complications. FBG was determined by the glucose oxidase-peroxidase aminophenazone phenol enzymatic colorimetric test using venous blood samples obtained after 12 hours of fasting. Data on patients' type and duration of DM and diabetes complications were taken from the IDA registry and were based on clinical examinations performed by general practitioners and specialists. These included presence of nephropathy, retinopathy, neuropathy, cerebrovascular disease, cardiovascular disease and other reported complications. The association of these factors with SNHL and its type and severity were also separately evaluated among the 80 DM patients.

An otoscopic evaluation of patients and controls was made using pure-tone air- and bone- conduction audiometry by 2 experienced otorhinolaryngologists. We used the same AC9 2-channel clinical audiometer (Weltone, Tehran) and the same examiner to reduce confounding factors. Pure-tone air-conduction thresholds were obtained for each ear at 250, 500, 1000, 2000,

3000, 4000, 6000 and 8000 Hz. Bone-conduction threshold was measured at 500 and 4000 Hz. We defined hearing loss as having pure-tone average (PTA) thresholds greater than 25 dB in the worse ear at 0.5, 1, 2 and 4 kHz frequencies. Severity of SNHL was classified from 1 to 5 (Table 1) [23].

Table 1 Classification of severity of sensorineural hearing loss

Category	Hearing loss (dB)	Severity
Normal	0–15	–
Slight	16–25	–
Mild	26–40	1
Moderate	41–55	2
Moderate to severe	56–70	3
Severe	71–90	4
Profound	> 90	5

Analysis

Data were analysed using *SPSS*, version 13.0 software. Differences were tested by analysis of variance (ANOVA), chi-squared, Fisher exact, independent samples *t*-test, logistic regression analysis and Mann-Whitney U-tests and were considered statistically significant at *P* values < 0.05.

Results

The mean age of our subjects was 45.0 [standard deviation (SD 9.9)] years in the DM group and 45.1 (SD 9.8) years in the healthy control group ($P = 0.990$), range 21–59 years. In both DM and control groups 51 subjects (63.8%) were female and 29 (36.3%) were male ($P = 1.00$). Of the diabetic patients, 9 (11.3%) had type 1 and 71 (88.8%) type 2 DM.

According to the PTA readings, SNHL was present in 36 DM patients (45.0%) and 16 non-diabetics (20.0%) ($P < 0.001$). The odds ratio of DM for the presence of hearing loss was 3.5 (95% confidence interval 1.6–6.6, $P < 0.001$). However, the type of involvement (1- or 2-sided) and severity of SNHL were not related to the presence of SNHL ($P = 0.771$ and $P = 0.644$ respectively) (Table 2).

The mean age of diabetic patients with SNHL was 47.7 (SD 8.07) years and in diabetic patients without SNHL was 42.3 (SD 10.12) years. There was a borderline statistically significant association between presence of SNHL and age in DM patients ($P < 0.05$). However, the type and severity of SNHL were not related to patient's age ($P = 0.804$ and $P = 0.217$ respectively).

The mean duration of DM was significantly longer among diabetic patients with SNHL [11.7 (SD 7.6) years] than those without SNHL [7.3 (SD 5.4) years] ($P = 0.001$) (Table 3). Age at onset of DM and FBG level, however, were not associated with presence of SNHL. Mean FBG was higher in diabetic patients with SNHL than in those without SNHL [175.3 (SD 83.3) mg/dL versus 157.7 (54.9) mg/dL] but the difference was not statistically significant ($P = 0.247$). The FBG level was not significantly related to severity of SNHL, but lower age at DM onset and longer duration of diabetes were related to higher severity of SNHL ($P = 0.042$ and $P = 0.007$ respectively).

Of the 34 patients uncontrolled DM 19 (55.9%) had SNHL and 15 did not (44.1%) but the difference was not statistically significant ($P = 0.110$). Type and severity of SNHL were not associated with glycaemic control in diabetics. SNHL frequency, severity or type also showed no statistically significant associations with the presence of DM complications (Table 4). SNHL severity was associated with type of DM, with 1/4 (25%) of type 1 patients with SNHL having grade 5 SNHL compared with 0/12 (0%) of the type 2 patients with SNHL ($P = 0.032$)

Discussion

In the current survey the rate of SNHL was compared in a case group of patients

Table 2 Comparison of sensorineural hearing loss (SNHL) type and severity between diabetic patients and non-diabetic healthy controls

Variable	Diabetic ($n = 80$)		Non-diabetic ($n = 80$)	
	No.	%	No.	%
Presence of SNHL				
Yes	36	45.0	16	20.0
No	44	55.0	64	80.0
SNHL type				
1-sided	12	33.3	6	37.5
2-sided	24	66.7	10	62.5
SNHL severity				
1	14	39.0	9	56.3
2	17	47.2	6	37.5
3	3	8.3	1	6.3
4	1	2.8	0	0.0
5	1	2.8	0	0.0

Table 3 Association of sensorineural hearing loss (SNHL) type and severity with diabetes mellitus (DM)-related characteristics among patients with DM

Variable	No. of patients	DM duration (years) Mean (SD)	Age at onset (years) Mean (SD)	FBG level (mg/dL) Mean (SD)
Presence of SNHL				
Yes	36	11.7 (7.6)	35.6 (8.9)	175.3 (83.3)
No	44	7.3 (5.4)	35.8 (12.3)	157.7 (54.9)
		$P < 0.001$	$P = 0.946$	$P = 0.247$
SNHL type				
1-sided	12	9.3 (6.6)	39.3 (11.2)	161.7 (56.2)
2-sided	24	12.9 (7.9)	33.8 (10.4)	182.1 (85.3)
		$P = 0.064$	$P = 0.203$	$P = 0.343$
SNHL severity				
1	14	10.1 (7.1)	35.1 (8.4)	169.1 (78.4)
2	17	10.7 (7.2)	39.0 (11.1)	173.9 (60.2)
3	3	24.0 (12.9)	29.3 (6.2)	227.3 (97.2)
4	1	19.0 (–)	3.0 (–)	115.0 (–)
5	1	7.0 (–)	38.0 (–)	190.0 (–)
		$P = 0.007$	$P = 0.042$	$P = 0.496$

FBG = fasting blood glucose; SD = standard deviation; – = not applicable.

with DM and a healthy control group. Our findings showed a relationship between some aspects of SNHL and DM. This is similar to findings reported by Kakarlapudi et al. in the United States [14]. DM had no statistically significant correlation with the severity of SNHL, suggesting that DM only may act as an initiating factor and that the progression of hearing loss is related to other features. Neither FBG nor glycaemic control were associated with the occurrence or severity of SNHL. While the FBG level was higher in diabetic patients with SNHL (175.3 versus 157.7 mg/

Table 4 Comparison of sensorineural hearing loss (SNHL) type and severity among patients with diabetes mellitus (DM) by type, complications and glycaemic control

Variable	DM type				DM complications[a]				Glycaemic control[b]			
	Type 1		Type 2		Yes		No		Yes		No	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Presence of SNHL												
Yes	4	44.4	32	45.1	9	64.3	27	40.9	17	37.0	19	55.9
No	5	55.6	39	54.9	5	35.7	39	59.1	29	63.0	15	44.1
	$P = 1.0$				$P = 0.093$				$P = 0.11$			
SNHL type												
1-sided	0	0.0	12	37.5	2	22.2	10	37.0	6	35.3	6	31.6
2-sided	4	100.0	20	62.5	7	77.8	17	63.0	11	64.7	13	68.4
	$P = 0.278$				$P = 0.813$				$P = 0.414$			
SNHL severity												
1	3	75.0	11	34.4	2	22.2	12	44.4	9	52.9	5	26.3
2	0	0.0	17	53.1	5	55.6	12	44.4	6	35.3	11	57.9
3	0	0.0	3	9.4	2	22.2	1	3.7	1	5.9	2	10.5
4	1	25.0	0	0.0	0	0.0	1	3.7	1	5.9	0	0.0
5	0	0.0	1	3.1	0	0.0	1	3.7	0	0.0	1	5.3
	$P = 0.032$				$P = 0.227$				$P = 0.332$			

[a]*Nephropathy, retinopathy, neuropathy, cerebrovascular disease, cardiovascular disease and other reported complications.*
[b]*Glycosylated haemoglobin (HbA1C) < 8%.*

dL) and the proportion with SNHL was higher among subjects with uncontrolled DM (55.9% versus 44.1%), these differences were not statistically significant. This demonstrates that glucose metabolism may not be the most important issue in the development of SNHL and perhaps only acts as an aggravating factor. We did not measure the insulin level of patients, but it has been reported that neither insulin resistance nor decreased insulin secretion are association with SNHL [5]. Despite the small number of patients with type 1 DM in the current study, these patients were significantly more likely to have a severe grade of SNHL than patients with type 2 DM. However, there was no significant correlation between type of DM and presence of SNHL.

Most previous surveys on this subject have been carried out among patients of all ages, whereas our study was performed only in non-elderly subjects aged < 60 years. Sakuta et al. reported a statistically significant higher prevalence of hearing loss among diabetic and non-diabetic middle-aged men (60.2% and 45.2% respectively) [15]. Dalton et al. showed a higher incidence of hearing loss among diabetic subjects compared with a control group, but they reported no significant association between hearing loss and DM type 2 [16].

We also found that the age of onset and duration of DM were associated with occurrence of SNHL. Therefore, the role of DM progression and ageing should be considered more carefully [14,24]. In the current study the age of diabetic patients had only a borderline association with severity of SNHL ($P = 0.042$) suggesting that ageing is not a factor in SNHL in these patients and that the role of disease progression should be investigated more precisely. Patients' sex was matched with controls in the current study to diminish its confounding role [25]. Also, none of our patients were ever smokers [26] and/or had previous or current exposure to noise pollution. All of these factors allowed us to eliminate some of the possible confounding factors in the role of DM in SNHL development.

Since many people worldwide are living in communities with a high rate of undiagnosed DM [27] and since hearing loss can be considered to be a consequence of diabetes, a metabolic assessment may be useful for patients presenting with hearing loss. On the other hand, routine screening for hearing loss in diabetic patients may also be helpful to diminish comorbidities among these patients, with a consequent improvement in their quality of life. Determining the cause of SNHL in diabetic patients may lead to development of better treatment options for both conditions [28].

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WHO activities to prevent and control diabetes

WHO aims to stimulate and support the adoption of effective measures for the surveillance, prevention and control of diabetes and its complications, particularly in low- and middle-income countries. To this end, WHO:

- provides scientific guidelines for diabetes prevention;
- develops norms and standards for diabetes care;
- builds awareness on the global epidemic of diabetes; including partnership with the International Diabetes Federation in the celebration of World Diabetes Day (14 November);
- conducts surveillance of diabetes and its risk factors.

The WHO Global Strategy on Diet, Physical Activity and Health complements WHO's diabetes work by focusing on population-wide approaches to promote healthy diet and regular physical activity, thereby reducing the growing global problem of overweight and obesity.

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