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Original article

The effect of glycoregulation on hearing loss in patients with diabetes mellitus type 2

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Summary

Introduction. Hyperglycemia causes the well-known microvascular complications of diabetes mellitus (DM) such as diabetic retinopathy, polyneuropathy and nephropathy, but it can also affect the inner ear, and hearing loss (HL) can be considered as one of the microvascular complications. The aim of the study was to evaluate association between HL and values of glycated hemoglobin A1c (HbA1c) in patients with diabetes mellitus type 2 (DMT2).

Methods. In this retrospective-observational cross sectional study, we included 80 patients divided into two groups: experimental group consisting of 40 patients with DMT2 and control group consisting of 40 patients who were not previously diagnosed with DM. Data were retrieved from electronic medical records of patients treated in outpatient clinic of the Ear, Nose and Throat Department, University clinical center of Republic of Srpska (UCC RS) from 2023 to 2024.

Results. Out of 40 patients from experimental group, 15 were males (37.5%) and 25 were females (62.5%). Regarding glycoregulation patterns in experimental group, patients were stratified into three subgroups: HbA1c < 7% (N 17; 42.5%), HbA1c-9% (N 17; 42.5%) and HbA1c > 9% (N 6; 15%). In the experimental group, a significant ($p<0.000$) greater number of patients had HL, and significant greater number of patients had bilateral HL (N 32; 80%, $p<0.05$) with predominantly pronounced sensorineural HL (N 36; 90%, $p<0.05$).

Conclusion. Patients with DMT2 had a higher incidence of HL compared to controls. The sensorineural type of HL showed a significantly high prevalence among patients with DMT2. HbA1c levels may be a potentially significant predictor of HL in DMT2.

Key words: diabetes mellitus, hearing loss, pure tone average

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyperglicaemia caused by defect in insulin secretion, insulin action or both. While hyperglicaemia causes well known microvascular complications of DM such as diabetic retinopathy, polyneuropathy and nephropathy, it also affects inner ear and hearing disturbances can be considered as one of the microvascular complications [1].

Vascular defects in inner ear associated with poor glycoregulation are one of the causes of the sensorineural hearing loss (SNHL) [2]. Hearing impairment caused by diabetes is also referred as DM related HL which was first proposed by Axelsson et al. in 1978, and it is described as SNHL which is distinct from conductive deafness [3]. Studies have shown that HL is more common in patients with DM than in general population, and its onset is slow so diagnosis is often made when hearing disorder is severe. In systematic review conducted by Teng et al., diabetes type 1 was associated with higher incidence of HL compared to healthy controls. The authors was found that signal transduction efficiency of the central and peripheral auditory pathways, particularly the former, may be slowed down in type 1 diabetes [4]. A similar study was also conducted by Shen et al. who found that HbA1c levels were significantly correlated with the severity and types of SNHL [5].

Although there is significant amount of data regarding DM and HL, there is not enough data on effect of glycemic control on level of HL. Therefore, to add to the previous knowledge, the main objective of this study was to evaluate association between HL and values of HbA1c in patients with DMT2. The second objective was to assess the frequency, as well as the types and degree of HL in patients with DMT2 compared with otherwise healthy adult patients referred to an otorhinolaryngologist.

Methods

The research was a retrospective-observational cross sectional study, which included 80 patients of both sexes (M 34, F 45), age above 18, divided into two groups: study group consisting of 40 patients with DMT2 and control group consisting of 40 patients (who were not previously diagnosed with DM). Data were retrieved from electronic medical records of patients treated in outpatient clinic of the Ear, Nose and Throat Department, University clinical center of Republic of Srpska (UCC RS) in period between November 2023 and April 2024. The study was approved by the Ethics Committee of the UCC RS.

Inclusion criteria for experimental group were age above 18, both sexes, previous diagnosis of DMT2. Inclusion criteria for control group were age above 18, both sexes and without DM. Exclusion criteria for both groups were DM type 1, previous ear infections, patients currently treated with chemotherapy and radiotherapy, trauma of the inner ear and history of ear surgery. All patients underwent a detailed ENT (Ear, Nose, and Throat) examination and were referred for audiological evaluation. Pure-tone audiometry was used to evaluate the presence and degree of HL. Pure tone average (PTA) values were expressed in decibels and calculated using four standard speech frequencies: 0.5, 1, 2, and 4 kHz.

Audiometric values were interpreted according to guidelines proposed by Committee on Hearing and Equilibrium, the American Academy of Otorhinolaryngology - Head and Neck Surgery Foundation [6]. Pure-tone audiometry was conducted with AC 40 Clinical Audiometer (*Inter Acoustics A/S, Assens, Denmark*). Glycoregulation in experimental group was expressed in HbA1c values, and data regarding duration of DM were obtained in all patients.

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 17.0 for Windows. Results were considered significant if the p value was < 0.05.

Results

Out of 40 patients from experimental group, 15 were males (37.5%) and 25 were females (62.5%), average age 68.25 years. There were no statistically significant differences between the two groups in terms of the sex. Regarding glycoregulation patterns in experimental group, patients were stratified into three groups: those with HbA1c levels < 7% (N 17; 42.5%), those with HbA1c levels 7–9% (N 17; 42.5%) and those with HbA1c levels > 9% (N 6; 15%). A statistically significant ($p<0.05$) lower number of patients had HbA1c levels > 9%, compared to the other groups (Table 1).

Table 1. Distribution of patients according to glycoregulation patterns

Values of HbA1c	N	%	Chi-square ($\chi 2$) test
HbA1c <7%	17	42.5	
7%–9%	17	42.5	$\chi 2$ =6.050; p=0.049
>9%	6	15.0	
Total	40	100.0	

HbA1c; glycated hemoglobin A1c

In the experimental group, the statistically significant ($p<0.000$) greater number of patients had HL compared to control group ($p<0.005$). The statistically significant greater number of

Table 2. Hearing status according to pure-tone audiometric test in the study groups

		Group				
		Experimental		Control		
		N	%	N	%	p
Hearing loss	None	4	10.0%	12	30.0%	0.038*
	Bilateral	32	80.0%	27	67.5%	
	Unilateral	4	10.0%	1	2.5%	
Sensorineural hearing loss	No	4	10.0%	12	30.0%	0.048*
	Yes	36	90.0%	28	70.0%	
Hearing loss right ear	Normal hearing	6	15.0%	12	30.0%	0.558**
	Slight 16–25 dB	8	20.0%	3	7.5%	
	Mild 26–40 dB	8	20.0%	8	20.0%	
	Moderate 41–55 dB	14	35.0%	13	32.5%	
	Moderately severe 56–70 dB	4	10.0%	3	7.5%	
	Severe 71–90 dB	0	0.0%	1	2.5%	
	Profound >90 dB	0	0.0%	0	0.0%	
Hearing loss left ear	Normal	6	15.0%	12	30.0%	0.402**
	Slight 16–25 dB	6	15.0%	3	7.5%	
	Mild 26–40 dB	12	30.0%	8	20.0%	
	Moderate 41–55 dB	8	20.0%	13	32.5%	
	Moderately severe 56–70 dB	6	15.0%	3	7.5%	
	Severe 71–90 dB	2	5.0%	1	2.5%	
	Profound >90 dB	0	0.0%	0	0.0%	

*Chi-square test, **Mann Whitney U test

patients had bilateral HL (N 32.80%, p<0.05) with dominantly pronounced SNHL (N 36.90%, p<0.05) (Table 2). In the total sample, conductive and mixed types of HL wer found in 16 patients, of which 12 were related to controls, and only four to patients with DMT2.

There was the statistically significant difference (p<0.05) between the control and experimental groups as for distribution of patients with SNHL in favor of experimental group. However, there was no statistically significant difference (p>0.05) between the left and right ears in the patients of the experimental group regarding c (Table 2).

The average duration of DM in the experimental group was 114.95 months, and there was no statistically significant correlation between the duration of the disease and significant HL. Additionally, glycoregulation patterns were not significantly associated with HL (Table 3).

Table 3. Hearing status according to glycoregulation and duration of the disease in the group of diabetic mellitus type 2 patients

		PTA (dB) right ear	PTA (dB) left ear	Hearing loss right ear	Hearing loss left ear
Glycoregulation	r	.206	.105	.101	.131
	p	.201	.519	.535	.419
	N	40	40	40	40
Duration of DMT2	r	0.174	0.239	0.228	0.239
	p	0.282	0.137	0.157	0.137
	N	40	40	40	40

PTA - pure tone average, dB - decibel, DMT2 - diabetes mellitus type 2

Discussion

Connection between HL and DMT2 is well known and already established. Having in mind that SNHL can be considered as one of the microvascular complications of diabetes, this should not come as a surprise. Still, there is not enough data regarding association between glycoregulation and degree of HL. Diabetes may impact both the vestibular and cochlear systems; however, the mechanisms, pathophysiology and specific characteristics of its effects on the cochlear system are not yet fully understood. In a review of the literature, very few studies have been published that focused on the association between glycemic control status and HL, or compared so many other variables in poorly controlled and well-controlled diabetics [7].

Conducted studies have reported a relationship between HbA1c and SNHL [7–9]. This study showed that patients with diabetes had higher incidence of SNHL compared to controls which correlated with literature data published so far [10]. However, no significant correlation was found regarding degree of HL and glycoregulation which could be attributed to small number of participants. Akinpelu et al. conducted a systematic review investigating the effects of DMT2 on hearing function and found that patients with DMT2 may be at higher risk for developing especially mild HL compared to control subjects [11]. Elibol et al., also found that pure-tone audiometric tests revealed involvement in both high and low frequencies as HbA1c values increased in patients. The severity of diabetes could be a determining factor for hearing impairment based on this hypothesis [12].

In large longitudinal study, DMT2 was associated with a modestly higher risk of moderate or worse HL. Furthermore, longer duration

of diabetes was associated with a higher risk of moderate or worse HL [13]. Hearing acuity screening should be a part of routine screening for diabetes patients, and should be conducted on a regular basis in order to avoid the devastating consequences of this often-overlooked medical condition [14].

The limitation of this study was a relatively small number of participants, and the fact that we did not take into account comorbidities other than diabetes. Nevertheless, further research is needed in order to assess the necessity for integrating audiological assessment into screening protocols for patients with diabetes.

Conclusion

Patients with DMT2 had a higher incidence of HL compared to controls. The sensorineural type of HL showed a significantly higher prevalence among patients with diabetes mellitus. HbA1c levels may be a potentially significant predictor of HL in DMT2.

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Ethical approval. The Ethics Committee of the University Clinical Center of Republic of Srpska, Bosnia and Herzegovina, approved the study (No. 01-19-160-2/24, 19.06.2024) and informed consent was obtained from all individual respondents. The research was conducted according to the Declaration of Helsinki.

Conflicts of interest. The authors declare no conflict of interest.

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Uticaj glikoregulacije na gubitak sluha kod pacijenata sa dijabetes melitusom tip 2

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Uvod. Hiperglikemija uzrokuje dobro poznate mikrovaskularne komplikacije dijabetes melitusa (DM) kao što su dijabetička retinopatija, polineuropatija i nefropatija, ali može uticati i na unutrašnje uho, a gubitak sluha se može smatrati jednom od mikrovaskularnih komplikacija. Cilj istraživanja je bio da se procijeni povezanost između gubitka sluha i vrijednosti glikoliziranog hemoglobina A1c (HbA1c) kod pacijenata sa dijabetes melitusom tip 2 (DMT2).

Metode. U ovu retrospektivno-opservacijsku studiju poprečnog presjeka uključili smo 80 pacijenata podijeljenih u dvije grupe: eksperimentalnu grupu, koja se sastojala od 40 pacijenata sa DMT2 i kontrolnu od 40 pacijenata, kojima ranije nije dijagnostikovan DM. Podaci su preuzeti iz elektronske medicinske dokumentacije pacijenata liječenih u ambulantama Klinike za bolesti uha, grla i nosa, Univerzitetskog kliničkog centra Republike Srpske u periodu od 2023. do 2024. godine.

Rezultati. Od 40 pacijenata iz eksperimentalne grupe, 15 je pripadalo muškom (37,5%), a 25 ženskom (62,5%) polu. Po pitanju obrasca glikoregulacije u eksperimentalnoj grupi, pacijenti su kategorisani u tri grupe: HbA1c <7% (N 17; 42,5%), HbA1c 7–9% (N 17; 42,5%) i HbA1c >9% (N 6; 15%). U eksperimentalnoj grupi, statistički značajno ($p<0,000$) veći broj pacijenata je imao gubitak sluha. Takođe, statistički značajno veći broj pacijenata je imao obostrani gubitak sluha (N 32; 80%, $p<0,05$) s dominantno izraženim senzorneuralnim tipom oštećenja (N 36; 90%, $p<0,05$).

Zaključak. Pacijenti sa DMT2 imaju veću incidenciju gubitka sluha u odnosu na kontrolnu grupu. Senzorneuralni tip gubitka sluha pokazuje značajno višu prevalenciju među pacijentima sa DMT2. Nivo HbA1c može biti potencijalno značajan prediktor gubitka sluha kod DMT2.

Ključne riječi: dijabetes melitus, gubitak sluha, prosječni prag sluha