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ANALYSIS OF FACTORS ASSOCIATED WITH SENSORINEURAL HEARING LOSS IN SUBJECT WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT :

Diabetes Mellitus (DM) is a group of metabolic diseases characterised by hyperglycaemia caused by a disorder or defect in insulin secretion, insulin action, or both. Based on data from the International Diabetes Federation (IDF) in 2015, there were around 415 million adults with diabetes. This number is expected to increase by 2040 to 642 million sufferers. Complications arising from DM can include both macrovascular and microvascular disorders. Several studies have proven that diabetes mellitus (DM) is a risk factor for sensorineural hearing loss (SNHL), and factors that are believed to be associated with hearing loss in DM patients are age, duration of illness, hypertension, and hypertriglyceridemia. Hearing loss in patients with type-2 DM is progressive, bilateral, and is a cochlear type sensorineural type that can occur at all frequencies, from low, medium, to high, especially at high frequencies >3000Hz. However, the connection between hearing loss and DM remains a subject of debate. This study is aimed to analyze the factors associated with SNHL in type 2 DM patients.

Keywords: Type 2 diabetes mellitus, sensorineural hearing loss, risk factors, microvascular complication

INTRODUCTION

Diabetes Mellitus (DM) is a group of metabolic diseases characterized by hyperglycemia caused by disturbances or defects in insulin secretion, insulin action, or both.¹ Based on data from the International Diabetes Federation (IDF) in 2015, it was stated that around 415 million adults had diabetes. This number is expected to increase by 2040 to 642 million sufferers.² Complications that occur due to DM can include disorders of the blood vessels, both macrovascular and microvascular. Macrovascular complications of diabetes are mainly coronary artery, peripheral artery, and cerebrovascular and microvascular diseases such as retinopathy, nephropathy, and neuropathy.³

Hearing loss is a decrease in hearing acuity related to the structure of the ear, both mechanically and functionally. Based on the type, hearing loss is divided into three types, namely conductive, sensorineural and mixed.⁴ Several previous studies have proven that DM is a risk factor for sensorineural hearing loss (SNHL). Chavadaki et al's research found that the prevalence of SNHL in DM patients was 67.44%.⁵ Several factors that are believed to be associated with hearing loss in DM patients are age, duration of illness, hypertension and hypertriglyceridemia. Age plays a role in sensorineural hearing loss. Research by Rajamani et al suggests that increasing age, female gender, long suffering from diabetes and higher HbA1C levels are factors that influence the condition of sensorineural deafness.⁶

In addition to DM, several other risk factors are associated with the development of SNHL, including age, gender, nutritional status (specifically obesity), and smoking habits. The connection between hearing loss and Diabetes Mellitus (DM) remains a subject of debate. Some studies have found minimal or no correlation between DM and hearing loss. Additionally, a longitudinal study indicated that DM was linked to the prevalence of hearing loss, but not to its incidence.⁸ Hearing loss in type 2 DM sufferers is progressive, bilateral, and is a sensorineural cochlear type which can occur at all frequencies, from low, medium to high, especially at high frequencies >3000Hz.⁴ Based on the background above, the author is interested in conducting a study with the title analysis of factors associated with sensorineural deafness in type 2 DM patients.

MATERIALS AND METHODS

Approval for the research protocol was obtained from the Hasanuddin University Research Ethics Committee. The protocol was assigned the unique identifier UH23490722, signifying adherence to established ethical standards and procedures

This research represents an analytical study with a cross-sectional design method (cross sectional study). The research was carried out at the Endocrine and Ear, Nose, and Throat (ENT) polyclinic at Wahidin Sudirohusodo Hospital Makassar and Hasanuddin University Hospital. The research was carried out from October 2023 – March 2024.

The research population is all subjects undergoing outpatient treatment at the hospital polyclinic of Wahidin Sudirohusodo Hospital Makassar and Hasanuddin University Hospital and was diagnosed with type 2 DM. The research sample is subjects who meet the inclusion criteria that consists of (1) male or female gender, (2) aged 30-60 years, and (3) suffering from type 2 DM. Sampling for this study was conducted through consecutive sampling, a method whereby individuals meeting the predefined inclusion criteria were included in the study until the target sample size of 94 subjects was achieved.

Data analysis for this study was carried out using the version 25 of SPSS application. The analytical framework encompassed a twofold approach, comprising descriptive methods and statistical tests. Statistical analysis was performed by calculating the mean value and standard deviation (SD) as well as determining the frequency distribution. The Chi-Square test was employed for statistical testing, with significance defined as a p-value of less than 0.05.

Type 2 diabetes patients undergoing outpatient treatment who meet the inclusion criteria if they have hearing loss will be examined with PTA and tympanometry. If the patient is diagnosed with SNHL based on this examination, that is having scores of >25 dB, risk factors such as hypertension, chronic kidney disease, dyslipidemia, gender, age, obesity, and smoking habit will be investigated. Search results will be analyzed and reported.

RESULTS

Table 1.— Subject characteristics

Variables		n	%
Gender	Male	44	44.0
	Female	56	56.0
Age (years)	≥60	21	21.0
	<60	79	79.0
Obesity	Yes	26	26.0
	No	74	74.0
Smoking habit	Yes	33	33.0
	No	67	67.0
CKD	Yes	18	18.0
	No	82	82.0
Dyslipidemia	Yes	39	39.0
	No	61	61.0
Hypertension	Yes	52	52.0
	No	48	48.0
DM duration (years)	≥5	59	59.0
	<5	41	41.0
SNHL*	Yes	87	87.0
	No	13	13.0

SNHL: Sensorineural hearing loss; CKD: Chronic kidney disease; DM: Diabetes mellitus

*SNHL if one or both ears have SNHL

Table 1 provides a comprehensive overview of the research sample, which consisted of 100 subjects in total. The gender distribution of the subjects was relatively balanced, with 44 men (44.0%) and 56 women (56.0%). The sample also included individuals with various health conditions. Specifically, 26 subjects (26.0%) were identified as having obesity. Smoking habits were present in 33 subjects (33.0%), reflecting a significant portion of the sample. Chronic kidney disease (CKD) was observed in 18 subjects (18.0%), indicating the presence of serious underlying

health issues within the group. Dyslipidemia, abnormal levels of lipids in the blood, was present in 39 subjects (39.0%). A notable 52 subjects (52.0%) had hypertension, highlighting a common health concern among the participants. Additionally, diabetes mellitus (DM) for 5 years or more was prevalent in 59 subjects (59.0%), suggesting a high incidence of this metabolic disorder. Finally, sensorineural hearing loss (SNHL) was reported in a striking 87 subjects (87.0%), indicating a significant prevalence of hearing impairment within the research sample.

Table 2.— Analysis of risk factors for SNHL

Variable		SNHL				p*
		Yes		No		
		n	%	n	%	
DM duration (year)	≥5	58	98.3%	1	1.7%	0.000
	<5	29	70.7%	12	29.3%	
Hypertension	Yes	51	98.1%	1	1.9%	0.001
	No	36	75.0%	12	25.0%	
Dyslipidemia	Yes	34	87.2%	5	12.8%	0.966
	No	53	86.9%	8	13.1%	
CKD	Yes	17	94.4%	1	5.6%	0.300
	No	70	85.4%	12	14.6%	

*Chi Square test

SNHL: Sensorineural hearing loss; CKD: Chronic kidney disease; DM: Diabetes mellitus

Table 2 presents a comprehensive analysis of the risk factors associated with sensorineural hearing loss (SNHL). The data indicates that the duration of diabetes mellitus (DM) significantly affects the incidence of SNHL among the subjects, with 98.3% of individuals suffering from DM for more than five years experiencing SNHL compared to 70.7% of those with DM for less than five years ($p<0.001$). Similarly, 98.1% of subjects with hypertension experienced SNHL, indicating a significant correlation between hypertension and SNHL ($p<0.01$). Conversely, the analysis did not find significant associations between SNHL and other potential risk factors such

as dyslipidemia and chronic kidney disease (CKD), suggesting that while these conditions are prevalent, they do not significantly impact the incidence of SNHL.

Table 3.— Relationship between confounding factors and SNHL incidence

Variable		SNHL				p*
		Yes		No		
		n	%	n	%	
Gender	Male	42	95.5%	2	4.5%	0.026
	Female	45	80.4%	11	19.6%	
Age (years)	≥ 60	19	90.5%	2	9.5%	0.594
	< 60	68	86.1%	11	13.9%	
Obesity	Yes	20	76.9%	6	23.1%	0.076
	No	67	90.5%	7	9.5%	
Smoking habit	Yes	31	93.9%	2	6.1%	0.148
	No	56	83.6%	11	16.4%	

*Chi Square test

SNHL: Sensorineural hearing loss

Table 3 presents the results of the confounding factor analysis for sensorineural hearing loss (SNHL). The analysis indicates that the proportion of SNHL events was notably higher in men, with 95.5% of male subjects experiencing SNHL compared to 80.4% of female subjects. This gender difference was statistically significant, with a p-value of <0.05, underscoring a meaningful relationship between gender and the likelihood of developing SNHL. This finding suggests that men are at a higher risk of experiencing SNHL than women, highlighting gender as an important risk factor. However, the analysis also examined other potential confounding factors such as age, obesity, and smoking, but these did not show a statistically significant relationship with SNHL.

Table 4.— Relationship between gender and duration of DM with SNHL

Gender	DM duration (years)		SNHL		P	OR (95% CI)
			Yes	No		
Male	≥ 5	n	25	0	0.181	*
		%	100.0%	0.0%		
	<5	n	17	2		
		%	89.5%	10.5%		
	Total	n	42	2		
		%	95.5%	4.5%		
Female	≥ 5	n	33	1	0.000	27.0 (3.17 – 238.27)
		%	97.1%	2.9%		
	<5	n	12	10		
		%	54.5%	45.5%		
	Total	n	45	11		
		%	80.4%	19.6%		

Table 4 provides valuable insights into the relationship between gender, duration of diabetes mellitus (DM), and sensorineural hearing loss (SNHL). Among men, SNHL was observed in 100% of those with DM ≥ 5 years, compared to 89.5% among those with DM < 5 years, although this discrepancy was not statistically significant ($p > 0.05$). In contrast, among women, SNHL was prevalent in 97.1% of individuals with DM ≥ 5 years, significantly higher than the 54.5% prevalence among those with DM < 5 years ($p < 0.001$). Calculations of odds ratios (OR) revealed that women with DM ≥ 5 years face a 27-fold greater risk of SNHL compared to those with DM < 5 years.

Table 5.— Multivariate Analysis of SNHL Risk Factors

Step	Variable	B	S.E.	Wald	p	OR	95% C.I.	
							Lower	Upper
Step 1	Gender	1.855	0.858	4.670	0.031	6.4	1.19	34.37
	DM duration	2.673	1.185	5.089	0.024	14.5	1.42	147.64

	Hypertension	1.456	1.203	1.465	0.226	4.3	0.41	45.28
Step 2	Gender	2.026	0.849	5.698	0.017	7.6	1.44	40.01
	DM duration	3.428	1.086	9.958	0.002	30.8	3.67	259.12

SNHL: Sensorineural hearing loss; DM: Diabetes melitus, $p < 0.05$

Table 5 presents the findings of multivariate analysis regarding the risk factors for sensorineural hearing loss (SNHL). According to the Wald values, the duration of diabetes mellitus (DM) emerges as the most significant factor associated with the occurrence of SNHL in Type 2 DM. Individuals with DM lasting more than 5 years exhibit a staggering 30.8-fold higher risk of experiencing SNHL compared to those with DM duration less than 5 years (for the same gender). Furthermore, the gender of DM patients also plays a significant role in the occurrence of SNHL, with men being at a 7.6-fold higher risk of developing SNHL compared to women (for the same duration of DM).

DISCUSSION

In this study, there were 100 research subjects. Subjects consisted of 44 (44.0%) men and 56 (56.0%) women. The prevalence of various conditions among the subjects were obesity (26%), smoking (33%), chronic kidney disease (18%), dyslipidemia (39%), hypertension (52%), type 2 diabetes mellitus for 5 years or more (59%), and sensorineural hearing loss (87%). In previous studies, the prevalence of hearing loss in patients with DM ranged between 89.1% in men and 81.5% in women.⁹ Meanwhile, another study of type 2 DM in coastal India reported an even more surprising prevalence, namely 97.6% among study participants.¹⁰

In the analysis based on risk factors for SNHL (Table 2), the proportion of SNHL events was found to be higher in subjects suffering from DM >5 years (98.3%) compared to those with DM <5 years (70.7%). This difference is significant ($p < 0.001$) indicating a relationship between the duration of DM and the incidence of SNHL. A recent study conducted by Mishra et al in India on 198 type 2 DM patients found that there was a significant relationship between the duration of suffering from DM, HbA1c levels and complications with SNHL.¹¹

Hearing loss among individuals with type 2 Diabetes Mellitus (DM) stems primarily from microvascular complications attributed to prolonged hyperglycemia, a consequence of the non-enzymatic glycosylation process affecting proteins. Moreover, the glycosylation process gives rise

to the formation of free radicals, which are known to exert ototoxic effects. These free radicals disrupt the intricate transduction process within the organ of Corti, further exacerbating the impairment of auditory function.^{12, 13}

In Table 2 it can also be seen that patients with risk factors for hypertension (98.1%) also showed a significant relationship between hypertension and the incidence of SNHL ($p < 0.01$). Research by Santosa et al regarding the relationship between DM and SNHL found that patients with DM with comorbid hypertension did not have a significant relationship with the incidence of SNHL.¹⁴ A descriptive study on the prevalence of SNHL in diabetes and hypertension patients by Kumar et al reported that there was a relationship between the duration of suffering from hypertension with SNH.¹⁵ The pathomechanism elucidating the connection between hypertension and SNHL in both the general population and individuals with Diabetes Mellitus (DM) shares striking similarities. In essence, the underlying pathology involves diminished blood circulation to the cochlea, leading to a concomitant reduction in oxygen supply to this vital auditory organ. This compromised oxygenation, coupled with an augmented formation of free radicals, precipitates dysfunction within the inner ear, culminating in the manifestation of hearing loss and tinnitus.¹⁶

In Table 3 regarding the analysis of confounding factors for SNHL, significant results were obtained for the gender variable ($p < 0.05$). These results are not much different from the results of the study reported by Samelli et al which examined the relationship between diabetes and SNHL in ELSA-Brasil participants from the São Paulo research center. The study found significant differences between the variables evaluated, including demographic characteristics (age and gender).¹⁷ In general, women tend to exhibit superior pure tone audiometric thresholds compared to men; however, with advancing age, their auditory acuity tends to deteriorate more rapidly, particularly concerning low frequencies, particularly those falling below the range of 1000 to 2000 Hz. The exacerbation of hearing loss in women is often attributed to hormonal factors, with research consistently indicating that estrogen may confer protective effects against auditory impairment. Conversely, the onset of menopause, characterized by a decline in estrogen and progesterone production, has been associated with a notable escalation in the prevalence and severity of hearing loss. On the other hand, in men, the etiology of hearing loss is frequently linked to occupational exposures, recreational activities, and detrimental lifestyle habits such as smoking.¹⁸

In the present study, it was determined that there was no statistically significant correlation identified among the confounding variables of age, obesity, and smoking habits, despite the well-documented evidence from previous research studies which have consistently established such associations.^{19,20} However, it is noteworthy that the divergent findings observed in this study may be attributed to the non-uniform distribution of the sample population across the aforementioned variables.

Table 4 highlights a significant relationship between gender, duration DM, with the incidence of Sensorineural Hearing Loss (SNHL) in women. The connection between gender and SNHL remains ambiguous, as recent studies have produced inconsistent results. Clinical data indicate a potential gender disparity in SNHL, with men experiencing an earlier decline in hearing thresholds compared to women.⁹ Another opinion suggests that women have better hearing than men at frequencies above 2000Hz. Women have better pure tone audiometric thresholds but with increasing age, women are associated with poorer hearing abilities at low frequencies especially below the 1000 to 2000 Hz range compared to men, it is concluded that with increasing age women's hearing abilities are lower than in men.²¹

In this study, multivariate analysis in Table 5 revealed that the duration of Diabetes Mellitus (DM) was the most significant factor associated with the incidence of Sensorineural Hearing Loss (SNHL) in individuals with type 2 DM. Specifically, subjects who had been suffering from DM for more than 5 years were found to have a 30.8 times greater risk of developing SNHL compared to those with a DM duration of less than 5 years, within the same gender category. Additionally, the analysis indicated that gender also significantly influences the incidence of SNHL, with men facing a 7.6 times higher risk of developing SNHL than women, for the same duration of DM.

A comprehensive meta-analysis conducted by Horikawa et al. reported that the prevalence of hearing loss in individuals with diabetes was 2.1-fold higher than in those without the condition. Furthermore, the study highlighted a significant gender disparity, indicating that hearing loss was 2.39 times more common in males compared to females.²² Research conducted by Risyudhanti et al. found a significant relationship between the duration of suffering from DM and the incidence of SNHL. Their findings indicated that prolonged DM duration increases the risk of developing SNHL.²³ Similarly, another study corroborated these results, demonstrating a significant association between the length of time an individual has diabetes and the occurrence of SNHL.²⁴

This growing body of evidence underscores the critical impact of diabetes duration on auditory health.

CONCLUSIONS

This study investigated the relationship between type 2 diabetes mellitus (DM) and Sensorineural Hearing Loss (SNHL) among 100 research subjects. The findings revealed that 87% of the subjects suffered from SNHL, while 13% did not. A significant relationship was established between the duration of suffering from type 2 DM and the incidence of SNHL ($p=0.000$). Additionally, hypertension was identified as a significant risk factor for SNHL in patients with type 2 DM ($p=0.001$). The study also highlighted the significant impact of gender on SNHL incidence ($p=0.017$), with male patients having a 7.6 times greater risk of developing SNHL compared to female patients. Furthermore, subjects who had been suffering from DM for five years or more were found to have a 30.8 times greater risk of experiencing SNHL compared to those with a shorter duration of DM ($p=0.002$). To conclude, the risk factors that significantly increased the likelihood of SNHL in type 2 DM patients included a prolonged history of DM (>5 years), hypertension, and being male.

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