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An Analysis of The Incidence of Sensorineural Hearing Loss Based on Type 2 Diabetes Mellitus and Obesity Factor

Yan Wirayudha[1], Yuni Prastyo Kurniati[2*)], Natasya Salsa Dilla[3], Siti Soekiswati[4]

[1]Department of Otorhinolaryngology Head and Neck Surgery, PKU Muhammadiyah Hospital, Surakarta, Indonesia
[2]Anatomical Pathology Laboratory, Faculty of Medicine, Universitas Muhammadiyah Surakarta, Indonesia
[3]Faculty of Medicine, Universitas Muhammadiyah Surakarta, Indonesia
[4]Department of Family Medicine and Public Health, Faculty of Medicine, Universitas Muhammadiyah Surakarta, Indonesia
Corresponding author: Yuni Prastyo Kurniati. E-mail: ypk134@ums.ac.id

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**) Corresponding author:*
E-mail: ypk134@ums.ac.id

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Abstract

Indonesia ranks fourth in Southeast Asia, with a 2.3% prevalence of sensorineural hearing loss, a condition that may result from various risk factors, including diabetes mellitus (DM) and obesity. Diabetes Mellitus can impair cochlear vascularization, while obesity significantly affects vascular function, potentially impacting the auditory system. This study aimed to analyze the relationship between type 2 DM and obesity with sensorineural hearing loss. An observational analytic study with a cross-sectional approach was conducted on 64 participants, aged 18–60 years, selected via purposive sampling. Type 2 DM was diagnosed by internal medicine consultants, and obesity was assessed using waist-to-hip ratio measurements. Data were analyzed using Fisher's exact test and logistic regression. The study was ethically approved by the Health Ethics Committee of PKU Muhammadiyah Hospital, Surakarta (No. 05/KEPK/RS.PKU/X/2024). The results showed a significant correlation between type 2 DM and sensorineural hearing loss (p=0.037) and between obesity and sensorineural hearing loss (p=0.001). The odds ratio for type 2 DM was 12.031, while for obesity it was 58.059, indicating that obesity posed a substantially higher risk. In conclusion, type 2 DM and obesity are significantly correlated with the occurrence of sensorineural hearing loss, suggesting that addressing these risk factors may help reduce its prevalence.

Keywords: Diabetes Melitus Tipe 2, Obesitas, Gangguan Pendengaran Sensorineural, Faktor Risiko.

Introduction

Data from the World Health Organization (WHO) shows that approximately 5.3%, or 360 million people in the world, are suffering from hearing loss, with 90% of them presenting sensorineural hearing loss (Rahayuningrum et al., 2016). Indonesia is fourth in Southeast Asia, with 2.3% suffering from sensorineural hearing loss (Ela Ambar & Suraya, 2022). Sensorineural hearing loss reduces the ability to hear soft sounds, and even louder sounds can become unclear or muffled (Wardhani & Mukono, 2020). Sensorineural hearing loss can be caused by several risk factors, including age, genetics, viral infections, intensity of noise exposure, hypertension, hypercholesterolemia, alcohol consumption, and obesity (Young, 2020). Several studies also shows that diabetes mellitus can cause vascular disorders of the cochlea, that cause microangiopathic disorders in the inner ear and affecting hearing loss (Salim & Nasution, 2021). Type 2 diabetes mellitus has a close correlation with sensorineural hearing loss, primarily in diabetic neuropathy (Wirayudha et al., 2024). The reduction of hearing in type 2 diabetes mellitus patients usually occurs gradually, bilaterally, and sensorineural, mainly in high frequency (Gioacchini et al., 2023). This study is supported by Sonia and Nasution (2021), who stated that DM patients have a 10.286 times greater risk of experiencing sensorineural hearing loss. Krismanita et al. (2017) reported different results, stating that the duration of diabetes mellitus was not significantly associated with the occurrence of sensorineural deafness. Obesity is also associated with a risk of sensorineural hearing loss. Obesity has a significant effect on vascular function that can affect organs with complex vascular structures, such as the auditory system (Hu et al., 2020). This study is supported by Sibagariang et al. (2020), who stated that there is a significant correlation between obesity and sensorineural hearing disorder of 49.09%. Research conducted by Jung and Lee (2016) reported different results, indicating that no significant correlation was found between body mass index and low, medium, or high frequency hearing thresholds Several studies discussing type 2 diabetes mellitus and hearing disorders have been conducted. However, there is no study that specifically discusses the correlation between type 2 diabetes mellitus and obesity on the incidence of sensorineural hearing loss.

Methods

Research design

This research employed an analytical observational design, with a cross sectional approach, to assess the association between type 2 diabetes mellitus and obesity with the incidence of sensorineural hearing loss.

Population

The target population was adult patients diagnosed with sensorineural hearing loss. The actual population consisted of individuals aged ≥18 years, with confirmed sensorineural hearing loss based on audiometric testing. The study was conducted at the ENT outpatient clinic from September to November 2024.

Sampling Technique and Sample Size Determination

Samples were selected using a non-probability purposive sampling method, based on pre-determined inclusion and exclusion criteria. The minimum required sample size was calculated using a two-proportion hypothesis test based on prior studies, resulting in a total of 64 participants.

Restriction criteria

Participants were eligible if they were adults (≥18 years old) diagnosed with sensorineural hearing loss and had a medical diagnosis of type 2 diabetes mellitus if applicable, with a maximum age of 60 years. They were also required to have measurable waist and hip circumferences to calculate waist-to-hip ratio (WHR). Individuals were excluded from the study if they had a history of hypertension, hypercholesterolemia, congenital hearing impairment, previous ear infections, or if they worked in environments with high noise exposure, such as factories.

Measurements

Type 2 diabetes mellitus was identified based on diagnosis by an internal medicine consultant and confirmed through medical records. Obesity was assessed using the waist-to-hip ratio (WHR), calculated by dividing the waist circumference by the hip circumference, with thresholds of ≥1.0 for males and ≥0.95 for females indicating obesity risk. WHR is preferred over BMI because it provides a more accurate picture of body fat distribution, especially abdominal fat, which is closely associated with the risk of various diseases. In contrast, BMI only offers a general indication of weight status without considering fat distribution. Sensorineural hearing loss was diagnosed through pure tone audiometry, performed by trained audiologists using an audiometer. The diagnosis was confirmed when air conduction (AC) and bone conduction (BC) thresholds were both elevated (above 25 dB), without an air-bone gap, especially at higher frequencies ranging from 4000 to 8000 Hz.

Statistical analysis

All statistical analyses were conducted using SPSS software. Descriptive statistics were used for univariate analysis. Bivariate analysis to determine correlations between variables was conducted using Fisher's exact test. Multivariate analysis was then performed using logistic regression to evaluate the strength and independence of correlations.

Ethical clearance

This study received ethical approval from the Health Research Ethics Committee of PKU Muhammadiyah Hospital, Surakarta (Reference No. 05/KEPK/RS.PKU/X/2024)

Results

Based on the results of the study, the characteristics of the respondents are presented in Table 1. Table 1 shows that late elderly is higher than late adulthood and early elderly, with a percentage of 48.44%. The mean age of the samples was 53.5 years, with an age range of 38 to 59 years. Females were higher than males, with a percentage of 65.6%. Most of the samples were suffering from type 2 diabetes mellitus, with a percentage of 82.8%. The majority of samples had a risk of having obesity with waist-to-hip ratio (WHR) of males ≥1.0 or females ≥0.95 with a percentage of 71.9%. Diagnosis of sensorineural hearing loss using audiometry showed that most samples were positive for sensorineural hearing loss (79.7%). The highest degree of severity for dextra sensorineural hearing loss was moderate hearing loss (29.7%), while for sinistra sensorineural hearing loss was moderate to severe hearing loss (21.9%).

Based on Table 2, type 2 diabetes mellitus factor and the incidence of sensorineural hearing loss in adult patients using Fisher's Exact Test showed a significant effect with a p-value of 0.037 ($p<0.05$). The table above also shows that samples in no-sensorineural hearing loss and sensorineural hearing loss groups are found to be more prevalent in type 2 diabetes mellitus groups, with a percentage of 12.5% and 70.3%, respectively.

Based on Table 3, the obesity factor and the incidence of sensorineural hearing loss in adult patients using Fisher's Exact Test showed a significant effect with a p-value of 0.001 ($p<0.05$). The table above also shows that no-sensorineural hearing loss samples are found to be more prevalent in the obesity no-risk group (17.2%). Meanwhile, the sensorineural hearing loss group was mostly found in the obesity risk group (68.8%).

Table 4 shows that the obesity factor has a more significant correlation with the incidence of sensorineural hearing loss in adult patients than the type 2 diabetes mellitus factor with a p-value of 0.001 ($p<0.05$). Obesity had an OR (Odds Ratio) value of 58.059. This result indicated that the obesity variable provided a 58.059 times greater risk of sensorineural hearing loss in adult patients. Table 4 shows that the Nagelkerke R-square of this study was 0.579 or 57.9%. This indicates that the collaboration of type 2 diabetes mellitus and obesity had an effect of 57.9% on the incidence of sensorineural hearing loss in adult patients in this study. Meanwhile, the other 42.1% can be influenced by other variables not studied in this study.

Table 1. Characteristics of Research Samples

Variable	Frequency (n)	Percentage (%)
Gender		
Male	22	34.4
Female	42	**65.6**
Age		
Late Adulthood (36-45 years old)	9	14.06
Early Elderly (46-55 years old)	24	37.50
Late Elderly (56-60 years old)	31	**48.44**
Type 2 Diabetes Mellitus		
Not Suffering from Type 2 Diabetes Mellitus	11	17.2
Type 2 Diabetes Mellitus	53	**82.8**
Obesity		
No Risk (WHR W= <1.0 and L= <0.95)	18	28.1
Risky (WHR W= ≥1.0 and L= ≥0.95)	46	**71.9**
Sensorineural Hearing Loss in Adult Patients		
No Sensorineural Hearing Loss	13	20.3
Sensorineural Hearing Loss	51	**79.7**
Degree of Dextra Sensorineural Hearing Loss		
Normal (0-15 dB)	20	31.3
Slight Hearing Loss (16-25 dB)	0	0
Mild Hearing Loss (26-40 dB)	9	14.1
Moderate Hearing Loss (41-55 dB)	19	**29.7**
Moderate to Severe Hearing Loss (56-70 dB)	10	15.6
Severe Hearing Loss (71-90 dB)	5	7.8
Profound Hearing Loss (≥91 dB)	1	1.6
Degree of Sinistra Sensorineural Hearing Loss		
Normal (0-15 dB)	21	32.8
Slight Hearing Loss (16-25 dB)	1	1.6
Mild Hearing Loss (26-40 dB)	9	14.1
Moderate Hearing Loss (41-55 dB)	11	17.2
Moderate to Severe Hearing Loss (56-70 dB)	14	**21.9**
Severe Hearing Loss (71-90 dB)	7	10.9
Profound Hearing Loss (≥91 dB)	1	1.6

Table 2. Analysis Between Type 2 Diabetes Mellitus Factor and Sensorineural Hearing Loss

Type 2 Diabetes Mellitus	**No Sensorineural Hearing Loss**		**Sensorineural Hearing Loss**		**OR**	**CI 95%**		**P value**
	F (n)	**(%)**	**F (n)**	**(%)**		**Lower**	**Upper**	
Type 2 Diabetes Mellitus	5	7.8	6	9.4				
Type 2 Diabetes Mellitus	8	**12.5**	45	**70.3**	4.688	1.150	19.104	0.037
Total	13	20.3	51	79.7				

Table 3. Analysis Between Obesity Factor and Sensorineural Hearing Loss.

Obesity	**No Sensorineural Hearing Loss**		**Sensorineural Hearing Loss**		**OR**	**CI 95%**		**P value**
	F (n)	**(%)**	**F (n)**	**(%)**		**Lower**	**Upper**	
No Risk	11	**17.2**	7	10.9				
Risk	2	3.1	44	**68.8**	34.571	6.286	190.136	0.001
Total	13	20.3	51	79.7				

Table 4. Correlation Between Type 2 Diabetes Mellitus and Obesity Factors with Sensorineural Hearing Loss.

Variable	Beta Coefficient (B)	P-value (Sig.)	OR (ExpB)	CI 95%		Nagelkerke R-square
				Lower	Upper	
Type 2 Diabetes Mellitus	2.487	0.042	12.031	1.090	132.730	0.579
Obesity	4.061	**0.001**	**58.059**	6.453	522.402	
Constant	-2.569	0.040	0.077			

Discussion

Correlation Between Type 2 Diabetes Mellitus and Sensorineural Hearing Loss

The findings of this study revealed that both the non-sensorineural and sensorineural hearing loss groups had a higher prevalence among individuals with type 2 diabetes mellitus, with rates of 12.5% and 70.3%, respectively. Bivariate analysis indicated a significant association between type 2 diabetes mellitus and sensorineural hearing loss. These results align with the study by Sonia and Nasution (2021), which reported that individuals with diabetes mellitus are 10.286 times more likely to experience sensorineural hearing loss compared to healthy individuals. Similarly, Rajamani et al. (2018) found a high prevalence (51.3%) of sensorineural hearing loss among diabetic patients, with a significant correlation related to the duration of diabetes and glycemic control. In contrast, the study by Krismanita et al. (2017) showed no significant relationship between the duration of diabetes and elevated hearing thresholds, reporting p-values of 0.390 in the right ear and 0.060 in the left ear. Type 2 diabetes mellitus is a chronic disease associated with numerous complications, one of which is hearing loss. This condition is primarily caused by microangiopathic changes in the capillaries of the stria vascularis. Such microangiopathy can also affect the internal auditory artery, the modiolus, the vasa nervorum of the spiral ganglion, and may lead to demyelination of the auditory nerve. These changes can result in atrophy of the organ of Corti and a reduction in hair cells. Additionally, neuropathy may occur due to microangiopathy in the vasa nervorum of the eighth cranial nerve and the spiral ligament, which can cause atrophy of the spiral ganglion and demyelination of the auditory nerve fibers (Sonia & Nasution, 2021).

Correlation Between Obesity and Sensorineural Hearing Loss

The results of the study showed that no-sensorineural hearing loss samples were found to be more prevalent in the obesity no-risk group (17.2%). Meanwhile, sensorineural hearing loss samples were found to be more prevalent in the obesity risk group (68.8%). he results of this study are in line with the study by Sibagariang et al. (2020), who stated that the relationship between obesity and hearing loss showed significant results ($p<0.05$). Another study conducted by Lee et al. (2015) showed that samples with BMI ≥27.5 kg/m2 had 1.95 times (95% CI 1.17-2.16) higher to have sensorineural hearing loss than samples with BMI <27.5 kg/m2. In contrast with the study conducted by Jang & Lee (2016), they stated that there was a significant correlation between BMI and low, medium, and high-frequency hearing thresholds. Obesity has a close correlation with sensorineural hearing loss. This is caused by impaired vasoconstriction to the inner ear. Reduced blood flow to sterocilia and inner hair cells of the cochlea contributes to sensorineural hearing loss (Dhanda & Taheri, 2017). Obesity is also associated with changes in the immune system, which causes an increase in the number and size of fat cells (adipocytes). Enlarged fat cells can have stress and cell death, thus triggering an inflammatory response. Enlarged adipocytes will also produce various pro-inflammatory molecules, such as TNF-α and IL-6, that can interfere with insulin signals in cells, thus increasing insulin resistance. Insulin resistance can damage the endothelium, thus reducing the production of endothelial nitric oxide. Low nitric oxide causes inhibition of vasodilation, and then microangiopathy occurs, so the blood perfusion to the cochlea is impaired (Pangemanan et al., 2021).

Correlation Between Type 2 Diabetes Mellitus and Obesity with Sensorineural Hearing Loss

This result indicated that obesity provided a 58.059 times greater risk of sensorineural hearing loss in adult patients. Table 4 shows that the Nagelkerke R-square of this study was 0.579 or 57.9%. This indicates that the collaboration of type 2 diabetes mellitus and obesity had an effect of 57.9% on the incidence of sensorineural hearing loss in adult patients in this study. Meanwhile, the other 42.1% can be influenced by other variables not studied in this study. Obesity can cause changes in the immune system that contribute to the increase in insulin resistance, where the body's cells will be less sensitive to insulin and cause increased blood sugar levels. Increased blood sugar levels can damage the auditory nerve and cause sensorineural hearing loss (Telaumbanua et al., 2020). Type 2 diabetes mellitus and obesity are able to increase oxidative stress and inflammation. This creates a synergistic effect that is able to damage auditory nerve cells (Jusuf, 2014). Obesity is a condition that can affect the circulatory system, which can lead to hearing loss. The ear is a part of the body that depends on adequate blood flow. Obesity can inhibit blood flow because it narrows blood vessels by limiting blood flow to the cochlea. This will make the heating chamber in the inner ear prevent the ear from recovering after damage, thus disrupting its function. Moreover, when blood flow is obstructed due to obesity, the ear works with a low level of blood, thus leading to permanent damage (Stadler & Marsche, 2020)

Overall, this study demonstrates a significant correlation between type 2 diabetes mellitus and obesity with the incidence of sensorineural hearing loss, with obesity being the most dominant risk factor. However, this study has limitations, including a relatively small sample size and data collected from only one hospital, which may restrict the generalizability of the findings.

Conclusion

There is a significant correlation between type 2 diabetes mellitus and obesity on the incidence of sensorineural hearing loss. Obesity is a factor with the most significant correlation causing sensorineural hearing loss. The results of this study can serve as an additional insight for policymakers, especially clinicians dealing with patients with type 2 diabetes mellitus and obesity, allowing them to consider the implementation of sensorineural hearing screening.

Conflict of Interest

No potential competing interest was reported by the authors in relation to the manuscript titled An Analysis of the Incidence of Sensorineural Hearing Loss Based on Type 2 Diabetes Mellitus and Obesity Factor.

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Author contribution

Yan Wirayudha conceptualized and designed the study, supervised data collection, and contributed to the analysis and interpretation of findings. Yuni Prastyo Kurniati contributed to the study design, data analysis, and drafted the manuscript. Natasya Salsa Dilla was responsible for data collection, initial data processing, and assisted in preparing the literature review. Siti Soekiswati provided expertise in public health perspectives, reviewed the manuscript critically for important intellectual content, and contributed to the final revision. All authors read and approved the final version of the manuscript and take public responsibility for its content.

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