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The relationship between duration suffering diabetes mellitus and hearing threshold based on audiometric examination

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ABSTRACT

Background: Chronic hyperglycemia is associated with a long term damage, dysfunction or failure of several organs, which is a degenerative disorder caused by persistent hyperglycemia. Complications also can cause interference with the threshold of hearing. These degenerative changes include atrophy of axons, demyelinization, and loss of nerve fibers.
Objective: This study aimed to determine the relationship between long suffering diabetes mellitus and hearing thresholds based on its frequency.
Methods: This study was a cross sectional design on patients with diabetes mellitus in the Internal Medicine Clinic and Otorhinolaryngology Department Dr. Sardjito General Hospital Yogyakarta from early November 2010 until the end of June 2011. Inclusion criterion were: 1) >50 years old 2) normal physical ENT examination, 3) all DM types, 4) Sensorineural (Perceptive) Hearing Loss, 5) Right and left ear gap audiogram less than 15dB, and 6) agreed to participate. Mean difference such as age and duration of DM were assessed by using independent t test and Mann Whitney test. Distribution of sex and educational level were assessed by using Chi square test and Fisher's Exact test. Correlation between duration suffering diabetes mellitus and hearing threshold was assessed by the Spearman and Pearson method.
Results: Subjects participated in this research were 25 (41.7%) men and 35 (58.3%) women. Result of this study showed that there were correlation between long suffering DM and hearing thresholds at 2000Hz : (r=0.459, p=0.097), 4000Hz (r=0.4966, p=0.098), and 6000Hz (r=0.757, p=0.422), respectively.
Conclusion: It is can be concluded that there is a positive correlation between long suffering DM and hearing threshold, especially after 6 years.

Latar Belakang: *Hiperglikemia kronis berkaitan dengan kerusakan jangka panjang, disfungsi atau kegagalan beberapa organ, karena neuropati diabetes, yang merupakan gangguan degeneratif disebabkan oleh hiperglikemia persisten. Perubahan degeneratif ini meliputi atrofi akson, demyelinisasi, dan hilangnya serabut saraf.*
Tujuan Penelitian: *Penelitian ini bertujuan untuk menentukan hubungan antara lama menderita diabetes melitus dan ambang pendengaran berdasarkan frekuensinya.*
Metode: *Desain penelitian ini cross sectional pada pasien diabetes mellitus di Klinik Penyakit Dalam dan Departemen Ilmu Kesehatan Telinga Hidung Tenggorok Kepala Leher Rumah Sakit Umum Dr. Sardjito Yogyakarta mulai awal November 2010 sampai akhir Juni 2011. Kriteria inklusi adalah: 1) usia> 50 tahun untuk mengurangi bias akibat presbiakusis fisiologis, 2) pemeriksaan THT fisik normal, 3) semua tipe*

DM, 4) Sensorineural (Perceptive) Hearing Loss, 5) perbedaan antara telinga kanan dan kiri kurang dari 15 dB, 6) setuju untuk berpartisipasi. Semua subjek dilakukan audiometri dan pemeriksaan glukosa darah. Perbedaan rata-rata usia dan durasi DM dinilai dengan menggunakan uji t tidak berpasangan dan uji Mann Whitney. Distribusi jenis kelamin dan tingkat pendidikan dinilai dengan menggunakan uji Chi square dan uji Fisher's Exact. Korelasi antara durasi menderita diabetes mellitus dan ambang pendengaran dinilai dengan uji Spearman dan Pearson.

Hasil: *Sebanyak 60 subyek penelitian, terdiri atas 25 (41.7%) pria dan 35 (58.3%) wanita. Hasil penelitian menunjukkan terdapat korelasi antara lama menderita DM dan ambang dengar pada masing-masing 2000Hz, 4000Hz, dan 6000Hz: r: 0,459 (p = 0,097), r: 0,4966 (p = 0,098) dan r: 0,757 (p = 0,422).*

Kesimpulan: *Berdasarkan hasil penelitian dapat disimpulkan bahwa terdapat korelasi positif antara DM yang menderita DM dan ambang pendengaran, terutama setelah 6 tahun.*

INTRODUCTION

The main problem facing adults who have hearing loss is the difficulty in verbal communication. This situation will interfere with daily activities in the family, social community and work environment. This condition can also cause psychological problems not only for the patient but also for his family. One of the risk factors for adult hearing loss is diabetes mellitus (DM), which is a group of metabolic abnormalities characterized by chronic hyperglycemia due to absolute (DM type 1) and relative (DM type 2) insulin deficiency, with primary disorders of carbohydrate metabolism and secondary disorders of fat and protein metabolism.[1-3]

The association of DM with hearing loss was first reported with varied incidence of sensorineural hearing loss in patients with DM, ranging from 0% to 93%. In this study the incidence of diabetes with loss of hearing and balance in 69 diabetic patients was 28 patients with sensorineural deafness (40.5%) associated with diabetes. Other factors that may have caused sensorineural hearing include age, exposure to noise, and ototoxicity.[2,4] Hearing examination in DM patients has never been done routinely, so the correlation between long suffering from DM with the threshold value of hearing is not known. Objective this study was to determine the relationship between the duration of diabetes mellitus and the hearing threshold based on its frequency.

METHODS

Ethical consideration

The study started after receiving approval from the Medical and Health Research Ethics Committee (MHREC) Faculty of Medicine, under number KE/FK/0196/EC/2017.

Study design

This study was a cross sectional design. This study used a cross sectional design on patients with DM in the internal medicine clinic and otorhinolaryngology department Dr. Sardjito General Hospital Yogyakarta from early November 2010 until the end of June 2011.

Population and Subjects

The sample of this study were diabetes mellitus patients at the diabetic clinic of internal medicine in a tertiary referral hospital in Indonesia. The inclusion criteria were: 1) age less than 50 years old, 2) normal ENT physical examination, 3) diabetes mellitus of all types, 4) sensorineural (perceptive) hearing loss, 5) right and left ear gap audiogram less than 15dB, and 6) agreed to participate in the research. The exclusion criteria were: 1) work in a noisy environment or ever exposed by explosion, 2) have experienced head injury, 3) never use ototoxic medicine, and 4) there is a history of deafness in the family. Sample size was calculated using hospital-based study sample size formulation for cross sectional study or hypothesis testing for correlation intervariable, with error type I (α) 5% one-tailed hypothesis, and error type II (β) 20%. The recommended sample size were 60 samples.

Measurement

All of samples performed ENT examination that included an otoscopy, a tuning fork, and a

pure tone audiometry test. The audiometric test results was the bone conduction threshold in a multiple of 5 dB which can still be responded to by the patient at a frequency of 2000Hz, 4000Hz, and 6000Hz. Length of suffering diabetes mellitus by patients was recorded continuously from 1 year, 2 years, 3 years, and so on.

Data Analysis

Characteristic data of research subjects are presented as proportion, mean and standard deviation. To assess the different distribution such as sex and educational level chi square test and Fisher's Exact test were used, while to assess the mean difference such as age and duration of DM independent t test was used when the data have normal distribution and Mann Whitney test if the data had no normal distribution. Correlation was assessed by the Spearman and Pearson method.

RESULTS

Table 1 shows more female than male research subjects participated in this research with 25 (41.7%) men and 35 (58.3%) women (Table 1). The lowest length of suffering from

Table 1. Characteristics of research subjects.

Variable	N (%)
Age (year old):	
≤ 29	3 (5)
30-39	8 (13.3)
40-49	49 (81.7)
Sex:	
Male	25 (41.7)
Female	35 (58.3)
Long suffering DM (years):	
≤ 6	37 (61.7)
6- 10	16 (26.7)
11- 15	4 (6.7)
16- 20	2 (3.3)
21- 25	1 (1.6)
Bone conduction hearing level (2 kHz)	28.16 ± 9.78
Bone conduction hearing level (4 kHz)	28.25 ± 13.83
Bone conduction hearing level (6 kHz)	29.00 ± 16.69

Table 2. Distribution of subjects according to long-term diabetes mellitus.

Variable	Mean (dB)	SD (dB)	R	p
Long suffering DM≤ 6 years				
Bone conduction hearing level (2 kHz)	22.5	6.44	0.015	0.911
Bone conduction hearing level (4 kHz)	18.78	7.49	0.051	0.700
Bone conduction hearing level (6 kHz)	17.70	9.76	0.020	0.879
Long suffering DM > 6 years				
Bone conduction hearing level (2 kHz)	37.95	6.106	0.459	0.081
Bone conduction hearing level (4 kHz)	43.47	5.31	0.4966	0.005
Bone conduction hearing level (6 kHz)	47.17	5.60	0.422	0.030

DM was 1 year and the longest was 22 years. The average duration of DM was 5.06 years with SD : 4.59 years. There a relationship between the length of suffering DM and the threshold of hearing, especially high frequency after 6 years suffering from DM. Hearing threshold after suffering DM 6 years at frequencies 2000Hz, 4000Hz, and 6000Hz were 37.95±6.106 dB, 43.47±5.31 dB, and 47.17±5.60 dB, respectively (Table 2).

Figure 1 shows the correlation between the length of DM suffering and the hearing threshold value at 2000Hz, 4000Hz, and 6000Hz frequencies after suffering from DM. In this study, it was reported that the patients developed into neuropathy after 6 years of diagnosis of DM, so that there was some relationship between the duration of DM and the hearing threshold value at all observed frequencies beginning with the higher ranges culminating in hearing loss in the normal range.

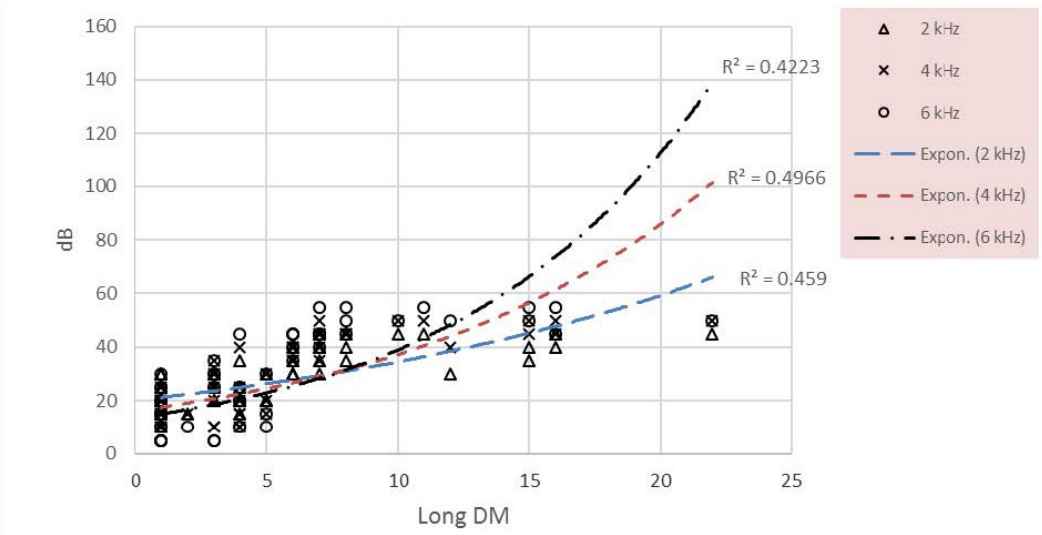

Figure.1 The correlation between the length of DM suffering and the hearing threshold value at 2000Hz, 4000Hz, and 6000Hz frequencies.

DISCUSSION

Diabetic microangiopathy and neuropathy have an important role in causing abnormalities in capillary blood vessels such as retinal capillary blood vessels in diabetic retinopathy, renal capillary blood vessels in diabetic nephropathy and abnormalities in peripheral nerves. One of the chronic complications of DM on nerves is diabetic neuropathy, including the auditory nerve. This complication is a degenerative disorder caused by persistent hyperglycemia. These degenerative changes include atrophy in the axon, demyelinization, loss of nerve fibers that can develop even in the early stages.[3-4]

The auditory system requires glucose and high-energy utilization for its complex signal processing. Hearing loss in the context of type 2 diabetes may result from microangiopathic processes that follow deposition of glucoprotein due to hyperglycemia in small blood vessels, impacting neurological function. Hyperglycemia can cause microvascular damages involving sudden increases in blood viscosity and embolic and thrombotic episodes.[4]

Current meta-analysis suggests that the higher prevalence of hearing impairment in diabetic patients compared with nondiabetic patients was consistent regardless of age. Data were obtained from 13 eligible studies (20,194 participants and 7,377 cases). Overall pooled OR (95% confidence interval) of hearing impairment for diabetic participants compared with

nondiabetic participants was 2.15 (1.72–2.68). OR was higher in younger participants (mean age, <60 year) than in those over 60 year among which the OR remained significant (2.61 and 1.58, p = 0.008). The strength of the association between diabetes and prevalence of hearing impairment was not significantly influenced by whether participants were matched for age and gender (p= 0.68) or whether participants chronically exposed to noisy environments were excluded (p= 0.19).[5]

This present study was limited to patients less than 50 years, thereby reducing the influence of presbycusis, or early hearing loss due to age. Another study reported the incidence of diabetic type sensorineural hearing loss was very broad depending on the boundaries of normality and statistical methodology. Decreased hearing acuity in patients with DM usually occurs gradually so it is not considered by patients and doctors until the disturbance occurs in verbal communication. At this stage because the abnormalities which occur in the inner ear have entered an irreversible stage, the only hearing rehabilitation that can be done is the provision of hearing aids, which is expected to improve verbal communication disorders and reduce the psychological burden of patients.[6,7]

In a previous study, it was mentioned that the patients developed into neuropathy after 9 years of DM diagnosis, showing no relationship between DM duration and hearing threshold value at observed frequency (except in frequency of 2000Hz right ear) because of the limited distribution of subjects according to the length of suffering DM. These limited findings were also reached by conducting an analysis on the subject of the study who only suffered DM over 9 years.[8]

Joshi et al. (2017) showed a decline in free field hearing, which are further adversely affected by duration of diabetes and patient's age. Overall pure tone thresholds were not significantly higher in diabetics, however the thresholds were higher in diabetics in older age groups. The hearing loss appears at an early age in diabetics but gradually becomes indistinguishable from age-related hearing loss.[8] Another study found association between hearing threshold and diabe¬tes mellitus. Hearing threshold in diabetics is increased and there is direct correlation between high blood glucose level and high hearing threshold.[9-11]

In this study, the analysis obtained correlation coefficients as r:0.459 (2000 Hz), r: 0.4966 (4000 Hz), r: 0.4223 (6000Hz) respectively. These results showed the relationship between the length of suffering DM and the threshold of hearing, especially high frequency after 6 years suffering from DM. The mean pure tone increases with increase in duration of diabetes, the difference in means of various intervals of duration of type 2 DM was found to be statistically significant, but did not specify each frequency.[12-13]

Pemmaiah et al. (2011) obtained the correlation between duration of DM and sensorineural hearing loss at 2000 Hz and 4000 Hz. They showed a statistically significant correlation at 0.01 level (Pearson coefficient r = 0.561 and r = 0.727 respectively). In other frequencies no significant correlation was found. Coefficient of determination was R2=0.31(31%) and R2=0.52(52%) respectively between duration of DM and hearing loss at 2000Hz and 4000Hz.[14] Significant hearing differences reported at all frequencies for noninsulin-dependent DM (NIDDM) subjects, but for insulin-dependent DM (IDDM) subjects, differences were at 1,000 Hz and below, and 10,000 Hz.[15]

The diabetics had higher thresholds for all frequencies (except 0.25 kHz) compared to the controls. Although there were significant differences at low frequencies, such as 0.5 and 1 kHz, the differences were most pronounced at 2, 4, and 8 kHz. The thresholds for speech reception were significantly higher in the diabetics than in the controls. Also, there were no side differences between the right and left ears in the diabetics or the controls, and the diabetics had lower speech discrimination scores than the controls. At high frequencies due to complications due to DM, degenerative neuropathy can occur in the organ of hearing, especially in the basal cochlea, where it is known that the high frequency is concentrated on the tip of the basal cochlea.

It has also been demonstrated in the presence of cochlear basal thickening in diabetic rats and supported by the increase in thickness of capillary walls in basilar membrane and stria vascularis, external hair cell damage, especially basal section in autopsies of patients with DM.[16]

Cochlear microcirculation plays a very important role in cochlear physiology. Hyperglycemia and hyperlipidemia are associated with increased blood viscosity and circulation disorders. The higher incidence (85%) of hearing loss in patients with longer duration of diabetes (>10 years) had been previously reported. However, in patients with >15 years of duration no significant result was seen probably due to a relatively small sample size. Further as duration progressed the severity of hearing loss also increased in most of the cases.[17]

In-Hwan et al. (2014) reported that normal hearing was defined as a 0–25 dB range and hearing loss as ≥26 dB. Using these criteria, the prevalence of hearing loss increased with age, ranging from 1.6% for subjects in their twenties to 49.2% for subjects in their seventies. The most frequent degree of hearing loss was mild, although all levels of hearing loss increased with age. Abnormal findings at 6 kHz were observed in all age groups as age increased, abnormal findings were observed in the order 4 kHz, 2 kHz, 1 kHz and 500 Hz. These findings indicate that hearing loss starts at high frequency, occurring later at the frequency of normal human speech and then at low frequency. From their study, the prevalence of hearing loss increases with age and the presence of DM. Hearing loss was greatest at high frequencies. In all age groups, mild hearing loss was the most common form of hearing loss.[7]

Batham et al. (2017) performed study to assess the usefulness of brainstem evoked response audiometry (BERA) in early detection of hearing impairment in type 2 diabetic patients. In this study, significant differences were observed in BERA latencies in type 2 diabetic patients when compare to healthy individuals. This indicate that patients with type 2 diabetes mellitus may suffer from hearing impairment sooner or later, however if detected early further deterioration in auditory function.[18]

Hearing thresholds and speech test results were significantly worse in participants with DM than in non DM patients. Hearing threshold and speech test results were not significantly different between the DM and non DM groups after adjusting for age, gender, and presence of hypertension, and the number of participants with hearing loss (HL)either low to middle range frequencies or high-range frequencies in the adjusted model. The lack of an association between diabetes and HL in this study may be because the study population was relatively young and most subjects had adequate glycemic control. It can be assumed that these participants did not have advanced microangiopathy and their cochlear tissues were not directly affected by diabetes due to good control of the condition. Diabetes with more than 5 years suffering in 84 patients had complications including neuropathy (44%), nephropathy (29%), retinopathy (25%).8 Another study obtained the mean duration of DM was significantly longer among diabetic patients with SNHL (11.7 ±7.6 years).[9]

In order to generalize the results of this study, it is necessary to conduct research to be done at different locations and samples to determine the consistency this study results. It is also necessary to conduct research by analyzing other variables that can contribute to the correlation long of DM with hearing thresholds, such as age at diagnosis, gender, cholesterol, triglycerides levels, blood pressure, stress levels, haemoglobine A1c (HbA1c).

CONCLUSION

From the results of this research, there is positive correlation between long suffering from DM and hearing threshold value based on audiometric examination. So it can be concluded that there is a positive correlation between long suffering DM and hearing threshold, especially after 6 years.

CONFLICT OF INTEREST

We declare that there is no conflict of interest.

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REFERENCES

1. Hong O, Buss J, Thomas E. Type 2 diabetes and hearing loss. Disease-a-Month. 2013;59(4):139–46.
2. Deli G, Bosnyak E, Pusch G, Komoly S, Feher G. Diabetic Neuropathies: Diagnosis and management. neuroendocrinology. 2013;98(4):267–80.
3. Joshi KD, Galagali JR, Singh SK. A study on effects of diabetes mellitus on auditory system. Romanian Journal of Diabetes, Nutrition and Metabolic Diseases. 2017;24(1):49–55.
4. Izenberg A, Perkins BA, Bril V. Diabetic neuropathies. Seminar Neurology. 2015;35(04):424–30.
5. Horikawa C, Kodama S, Tanaka S, Fujihara K, Hirasawa R, Yachi Y, et al. Diabetes and risk of hearing impairment in adults : Journal of Clinical Endocrinology & Metabolism. 2015; 98(January 2013):51–8.
6. Kaur N. Diabetic autonomic neuropathy: pathogenesis to pharmacological management. Journal of Diabetes & Metabolism. 2014;05(07).
7. Oh I-H, Lee JH, Park DC, Kim M, Chung JH, Kim SH, et al. Hearing loss as a function of aging and diabetes mellitus: a cross sectional study. PLoS ONE. 2014;9(12):e116161.
8. Samelli A, Santos I, Moreira R, Rabelo C, Rolim L, Bensenõr I, et al. Diabetes mellitus and sensorineural hearing loss: is there an association? Baseline of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). Clinics. 2017;72(1):5–10.
9. Mozaffari M, Tajik A, Ariaei N, Ali-Ehyaii F, Behnam H. Diabetes mellitus and sensorineural hearing loss among non-elderly people. Eastern Mediterranean Health Journal. 2010;16(9).
10. Ryu OH, Choi MG, Park CH, Kim DK, Lee JS, Lee JH. Hyperglycemia as a potential prognostic factor of idiopathic sudden sensorineural hearing loss. Otolaryngology - Head and Neck Surgery (United States). 2014;150(5):853–8.
11. Limberger a, Beck M, Delgado-Sanchez S, Keilmann a. Hearing loss in patients with Fabry disease. Hno. 2007;55(3):185–9.
12. Thimmasettaiah NB, Shankar R, Ravi GC, Reddy S. A one year prospective study of hearing loss in diabetes in general population. Translational Biomedicine. 2012;3(2).
13. Yikawe S, Iseh K, Sabir A, Solomon J, Manya C, Aliyu N. Effect of duration of diabetes mellitus on hearing threshold among type 2 diabetics. Indian Journal of Otology. 2017;23(2):113.
14. Pemmaiah K.D SD. Hearing loss in diabetes mellitus. International Journal of Collaborative Research on Internal Medicine & Public Health. 2011;3(10):725–31.
15. Austin DF, Konrad-Martin D, Griest S, McMillan GP, McDermott D FS. Diabetes-related changes in hearing. Laryngoscope. 2009;119(9):1788–96.
16. Çayönü M, Çapraz M, Acar A, Altundağ A, Salihoğlu M. Hearing loss related with type 2 diabetes in an elderly population. Journal of International Advanced Otology. 2014;10(1):72–5.
17. Xipeng L, Ruiyu L, Meng L, Yanzhuo Z, Kaosan G, Liping W. Effects of diabetes on hearing and cochlear structures. Journal of Otology. 2014;8(2):82–7.
18. Batham C, Choudhary AK, Yousuf PS. Brainstem auditory evoked responses with duration of type-ii diabetes mellitus. Annals of Medical and Health Science. 2017;7(2):40–5.