Journal of Otorhinolaryngology Disorders and Treatments
Open Access

RESEARCH ARTICLE

Volume 1 - Issue 1

Comparison of Hearing Threshold in Hypertensive and Non Hypertensive Type 2 DM

Osuji AE[1,*], Da Lilly-Tariah OB[1], Unachukwu CN[2], and Nwankwo BE[3]

[1]Ear, Nose and Throat Department, University of Port Harcourt Teaching Hospital, Nigeria
[2]Department of Internal Medicine, University of Port Harcourt Teaching Hospital, Nigeria
[3]Department of Ear, Nose and Throat, Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Nigeria

[*]**Corresponding author:** Osuji AE, Ear Nose and Throat Department, University of Port Harcourt Teaching Hospital, Rivers state, Nigeria, Tel: 2348030849107; E-mail: osujiliz@yahoo.com

Received: 18 May, 2020 | **Accepted:** 17 Jun, 2020 | **Published:** 24 Jun, 2020

Citation: Osuji AE, Da Lilly-Tariah OB, Unachukwu CN, Nwankwo BE (2020) Comparison of Hearing Threshold in Hypertensive and Non Hypertensive Type 2 DM. J Otorhinolaryngol Disord Treat 1(1): dx.doi.org/10.16966/jodt.109

Abstract

Introduction: Chronic illnesses like DM and hypertension increase with advancing age. This can lead to high prevalence of systemic alterations in the inner ear, leading to hearing loss. The relationship between diabetes and hypertension is very vital and its consideration is paramount in the management of both health conditions. DM is a factor that contributes to the development of uncontrolled blood pressure, such that individuals with DM are twice at risk of developing hypertension and the presence of hypertension, invariably, makes achieving a good glycaemic control more challenging. The aim of this study was to compare the hearing threshold levels among hypertensive and non-hypertensive type 2 DM Adults in the University of Port Harcourt Teaching Hospital (UPTH), Rivers State, Nigeria.

Patients and Methods: This study was a prospective cross-sectional study conducted in UPTH, Port Harcourt, Rivers State, Nigeria. Group A comprised of 129 individuals with diabetes mellitus as well as hypertension and group B comprised of 129 individuals with diabetes mellitus, who were normotensive. Subjects in the two groups were age and sex matched. Each participant had a general examination, blood pressure taken, and fasting blood glucose level was estimated. Otoscopy was done, blood sample for glycosylated haemoglobin was taken and pure tone audiometry carried out in a soundproof booth.

Result: The age range of the participants was from 21-89 years. The mean age of the 258 participants was 55 ± 13.17 years, while the Mean age for Group a (hypertensive) was 57 ± 10.62 years, and for Group B (non-hypertensive) was 54 ± 6.80 years. There were 104(40.3%) males and 154 (59.7%) females that participated in the study. The prevalence of hearing loss in the hypertensive group A (45.0%) was significantly higher than that in non-hypertensive group B (20.9%), with chi-square p-value=0.0001. An adjusted Odds Ratio=3.1, at a 95% Confidence Interval of 1.7-5.3.

Conclusion: Adult persons living with diabetes mellitus, who are also hypertensive, have a 3 times increased risk of having hearing loss as compared to those who have DM alone. Also, as an adult with type 2 DM ages, the hearing acuity worsens, however, the hypertensive diabetics are more likely to suffer a greater severity of hearing loss when compared to the non-hypertensive diabetics, and hearing loss gets worse as duration of DM and duration of hypertension increases.

Keywords: Diabetes mellitus; Hypertension; Hearing loss; Hearing threshold; Pure tone audiometry

Introduction

Chronic illnesses like DM and hypertension increase with advancing age. This can lead to high prevalence of systemic alterations in the inner ear, leading to hearing loss [1]. Diabetes mellitus results from insufficient production of insulin by Beta cells of the pancreas, or due to ineffective utilization of the insulin available in the body, and it's characterized by chronic hyperglycaemia [2]. There are two main types of primary diabetes mellitus: Type 1- is due to auto immune destruction of the beta cells of the pancreas, while Type 2- results from disorder of insulin secretion or metabolism, and can be related to genetic predisposition [3]. Several other factors can impair insulin secretion and metabolism, and DM due these factors is called Secondary Diabetes e.g. Drug use, other endocrine diseases, and gestational diabetes [2]. DM is associated with various complications involving the heart, eye, ear, kidneys, neurological system, infections and other aspects of the human body [3]. Hypertension is defined as a sustained rise in blood pressure equal to or above 140/90 mmHg, normally read as systolic blood pressure (SBP) and diastolic blood pressure (DBP) respectively [4]. SBP being pressure when the heart is

contracted to push out blood, and DBP referring to pressure when the heart is relaxed, at rest in between contractions.

Usually in the presence of type 2 diabetes, hypertension, hyperlipidemia and obesity (abdominal) are common, and a cluster of these medical conditions is referred to as 'metabolic syndrome' [4]. Gibrin and Melo in their study to evaluate the possible association of DM and Hypertension with hearing loss noted that irrespective of age, DM, and hypertension, can cause inner ear alterations [1]. This can be related to micro-circulatory insufficiency, attributed to vascular occlusion by embolism, vasospasm or haemorrhage [5]. These can be caused by micro-angiopathy as a result of DM or hypertension [5,6]. DM angiopathy can cause hearing loss both directly *via* reducing transport through capillary walls and eventually reducing blood supply to the cochlea, or indirectly *via* secondary degeneration of the eight cranial nerve [7,8].

The relationship between diabetes and hypertension is very vital and its consideration is paramount in the management of both health conditions. DM is a factor that contributes to the development of uncontrolled blood pressure, such that individuals with DM are twice at risk of developing hypertension [1]. On the other hand, hypertension is known to cause an increased level of insulin resistance [1]. As a result of this, the presence of hypertension, invariably, makes achieving a good glycaemic control more challenging [1,6].

The aim of this study was to compare the hearing threshold levels among hypertensive and non-hypertensive type 2 DM Adults in the University of Port Harcourt Teaching Hospital (UPTH), Rivers State, Nigeria.

Patients and Methods

This study was a prospective cross-sectional study conducted in UPTH, Port Harcourt, Rivers State, Nigeria. The UPTH is a tertiary health facility with 500 beds, and catchment area for its patients include Rivers, Bayelsa, Delta, Imo, Abia, and Cross Rivers states [9]. Written Informed consent was obtained from the respective participants that were selected and Ethical approval was obtained from the UPTH Health Review and Ethics Committee. Confidentiality was maintained throughout the study, and serial numbers were attached to the participants instead of their names for data collection. Each patient had the right not to be included in this study, to decline or withdraw from it at any time, without any harm, and were still accorded the right to treatment irrespective of their withdrawal from the study. Sample collection was done from January to October 2018.

Inclusion criteria for Group a (DM+ Hypertension) (Case group) was Patients seen in the medical out-patients clinic diagnosed with type 2 diabetes mellitus according to the World Health Organization (WHO) diagnostic criteria [10]. Fasting plasma glucose ≥ 7 mmol/l or Hb A1C ≥ 6.5%, Participants who are aged 18 years and above, Participants with raised blood pressure ≥ 140/90 mmHg. Hypertension was diagnosed in the participants using WHO criteria, [11] and Patients who were previously diagnosed as being hypertensive according to the criteria stated above, but with controlled B.P. levels due to use of antihypertensive medications, were enlisted as hypertensive subjects. Inclusion criteria for Group B (DM only) (Control group) are Patients seen in the medical out-patients clinic diagnosed with type 2 diabetes mellitus according to the World Health Organization diagnostic criteria [10]. Fasting plasma glucose ≥ 7 mmol/l or Hb A1C ≥ 6.5%, and Participants that are aged 18 years and above.

Study participants with diabetes mellitus who met the eligibility criteria was enrolled into the study and placed in group B (Diabetes only group). Study participants with diabetes and hypertension meeting the group a eligibility criteria were matched with a participant in group B (matching was done by sex and age +/- 2years) and placed in group A (Diabetes and Hypertension group). 258 participants with Group A comprised of 129 individuals with diabetes mellitus as well as hypertension and group B comprised of 129 individuals with diabetes mellitus, who were normotensive. Demographic data of each participant was obtained through an interviewer administered questionnaire. Each participant had a general examination, their blood pressure taken, and fasting blood glucose level was estimated. Otoscopy was done, blood sample for glycosylated haemoglobin was taken and pure tone audiometry carried out in a soundproof booth.

The equipment used for data estimation in this study includes an interviewer-administered questionnaire, which was originally designed for this study, Accoson mercury sphygmomanometer made by AC Cossor & Son (Surgical) Ltd. Essex, UK. It has an adult cuff for maximum arm circumference of 34.3 cm, latex-free bulb for inflation, and a mercury reservoir with isolation valve. It measures blood pressure ranging from 0-300 mmHg. Accu check glucometer and strips, made by Viva Chek laboratories Inc. Wilminton, DE, 19085, USA, with a measurement range of 0.6-33.3mmol/L. Fresh capillary blood of sample volume about 0.5ul was used and test time was about 5 seconds, Fine care 201 HbA1C analyser system was used to analyse HBA1C, made by Radiometer group Copenhagen Denmark in April 2013. It measures a range of 20-130 mmol/mol (IFCC) or 3.0-24.0% (NGSP). Heine mini 3000 hand-held battery-operated otoscope. Made by Hiene Optotechnik GmBH & Co. KG. Herrsching, Germany, and ITERA audiometer, manufactured by MADSEN, GN Otometrics A/S, 2630Taastrup, Denmark in November 2004.

The frequencies tested for included 250, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz for air conduction, and 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz were tested for bone conduction, however frequencies analyzed were restricted to 500, 1000, 2000 and 4000 Hz, which are the frequencies involved in calculating the pure tone average according to WHO 2015 [12]. The hearing level for each frequency was recorded as air and bone conduction, separately for the right ear and left ear of each participant. Hearing loss was determined according to WHO classification as pure tone hearing threshold >25dBHL in the better ear of the subjects, and hearing threshold at 500, 1000, 2000, and 4000Hz were used to calculate the pure tone average, and the mean values were compared between the two groups.

The degree of hearing loss was categorized according to WHO criteria for degree of hearing loss [12,13]. The statistical analysis for each group was based on number of subjects. Normal hearing and types of hearing loss was interpreted as thus: subjects with audiogram showing air and bone conduction threshold ≤ 25 dbHL were reported as having normal hearing. Subjects with audiogram showing air conduction thresholds above 25 dbHL, with bone conduction threshold <25 dbHL, but with an air bone gap ≥ 10 dbHL was reported as having conductive hearing loss. Subjects with audiograms showing air and bone conduction thresholds above 25 dbHL with no air bone gap, or with air bone gap ≤ 10 dbHL, was reported as sensorineural hearing loss. Subjects with audiograms showing air and bone conduction thresholds above 25dbHL, with air bone gap >10 dbHL, was reported as mixed hearing loss. Results were analysed using SPSS 23, presented in tables and figures, Pearson's correlation was used to find association between variables, and a p-value of ≤ 0.05 was considered significant.

Results

The age range of the participants was from 21-89 years. The mean age of the 258 participants was 55 ± 13.17 years, while the Mean age

for Group a (hypertensive) was 57 ± 10.62 years, and for Group B (non-hypertensive) was 54 ± 6.80 years. The difference in the mean age of the two groups was not statistically significant with a chi square p-value of 0.701. [Table 1a and b]

There were 104(40.3%) males and 154 (59.7%) females that participated in the study. The number of males and females in the two groups were similar, with 52 males and 77 females in the hypertensive group, and 52 males and 77 females in the non-hypertensive group. The male: female ratio was 1:1.4 in Group A and Group B respectively. The difference in the male and female distribution was not statistically significant with a chi square P-value=1.

The prevalence of hearing loss in the hypertensive group A (45.0%) was significantly higher than that in non-hypertensive group B (20.9%), with chi-square p-value=0.0001. An adjusted odds Ratio=3.1, at a 95% Confidence Interval of 1.7-5.3.

Table 2 below shows both air and bone conduction mean hearing thresholds of the hypertensive Group A was significantly higher than that of the non-hypertensive Group B, with T-Test p-values < 0.05. The hearing thresholds of the participants in the hypertensive group A were also significantly higher at 4000Hz as compared to that of the participants in the non-hypertensive group B.

Figure 1 shows the degree of hearing loss according to the hearing thresholds in the better ear of the 2 groups. It shows that the number of subjects with normal hearing threshold was greater in the non-hypertensive group 102 (79.1%), than in the hypertensive group 71 (55.0%). This difference was statistically significant (Fischer exact p-value=0.0001).

Figure 2 below shows types of hearing loss in the two groups. The difference between the two groups was statistically significant, with a Fischer exact p-value=0.0001. The sensorineural type of hearing loss was predominant in the two groups, but significantly greater in the hypertensive Group A (p-value=0.0001).

Table 1a: Frequency distribution of the two groups of participants by age category.

	Group A	Group B	
Age category (years)	Hypertensive N (%)	Non-Hypertensive N (%)	**Total** N (%)
20-29	1(0.8%)	2(1.6%)	3(1.2%)
30-39	15(11.6%)	19(14.7%)	34(13.2%)
40-49	18(14.0%)	21(16.3%)	39(15.1%)
50-59	34(26.4%)	37(28.7%)	71(27.5%)
60-69	37(28.7%)	33(25.6%)	70(27.1%)
70-79	18(14.0%)	14(10.9%)	32(12.4%)
80-89	6(4.7%)	3(2.3%)	9(3.5%)
Total	129(100)	129(100)	258(100)
Fischer exact p-value=0.823			

Table 1b: Frequency distribution by age of the two groups of participants in ≤ 59 years and ≥ 60 years age categories.

Age group	Non-Hypertensive	Hypertensive	Total
≤ 59yrs	79(61.2%)	68(52.7%)	147(57.0%)
≥ 60yrs	50(38.8%)	61(47.3%)	111(43.0%)
Total	129(100%)	129(100%)	258(100%)
Chi square p-value=0.167			

Table 3 below shows the mean pure tone air and bone conduction hearing threshold in the better ears for each age category in the two groups. The mean hearing thresholds increased with age in both groups. The highest thresholds were seen in the age groups 70-79 years, and 80-89 years. In most age categories, the mean hearing threshold of the hypertensive Group A was higher than that of non-hypertensive Group B.

A positive association was noted between hearing threshold and age in the two groups. There was a significant moderately strong association (more in hypertensives) between hearing threshold and age in the hypertensive group (r=0.5, p-value-0.0001) and in the non-hypertensive group (r=0.4, p-value=0.0001)

Table 4 below shows the Pearson's correlation of hearing threshold and glycaemic control, indicating no significant association between hearing threshold and glycaemic control in the two groups

Table 2: Mean pure tone hearing threshold levels at 500, 1000, 2000, and 4000 Hz in the better ears of the two groups.

Frequency tested (Hertz)		Mean Pure tone hearing threshold levels (DbHL)		
		Group A	Group B	T-test p-value
		Hypertensive ± SD	Non-hypertensive ± SD	
500	AC	22.95 ± 10.62	20.66 ± 6.80	0.040*
	BC	19.73 ± 9.32	18.33 ± 6.13	0.157
1000	AC	26.43 ± 11.89	22.44 ± 7.48	0.001*
	BC	23.84 ± 13.48	19.34 ± 7.19	0.001*
2000	AC	27.13 ± 13.23	22.91 ± 9.39	0.003*
	BC	25.58 ± 12.08	21.98 ± 9.09	0.007*
4000	AC	35.85 ± 16.06	29.88 ± 13.19	0.001*
	BC	32.87 ± 14.75	27.67 ± 13.24	0.003*
AC-Air conduction; BC-Bone conduction; SD-Standard deviation *statistically significant				

Table 3: Mean pure tone air and bone conduction hearing threshold levels according to age in the two groups.

Age category		Hypertensive	Non-Hypertensive	T-test P-values
20-29	AC	19.00 ± 0.00	16.00 ± 4.24	0.667
	BC	18.00 ± 0.00	14.50 ± 4,93	0.667
30-39	AC	23.53 ± 8.70h	18.16 ± 3.58	0.260
	BC	21.53 ± 6.99	16.00 ± 4.64	0.090
40-49	AC	21.28 ± 7.68	21.62 ± 6.06	0.878
	BC	19.39 ± 7.02	20.29 ± 6.32	0.677
50-59	AC	25.91 ± 9.95	22.24 ± 5.40	0.055
	BC	23.15 ± 7.32	20.32 ± 5.03	0.061
60-69	AC	30.08 ± 8.56	26.73 ± 8.72	0.110
	BC	27.14 ± 8.59	24.06 ± 8.46	0.137
70-79	AC	33.50 ± 14.69	28.21 ± 7.99	0.233
	BC	29.67 ± 13.39	25.57 ± 7.20	0.310
80-89	AC	44.00 ± 18.99	30.33 ± 5.51	0.275
	BC	41.50 ± 19.65	26.00 ± 4.36	0.233
BC-Bone conduction; AC-Air conduction				

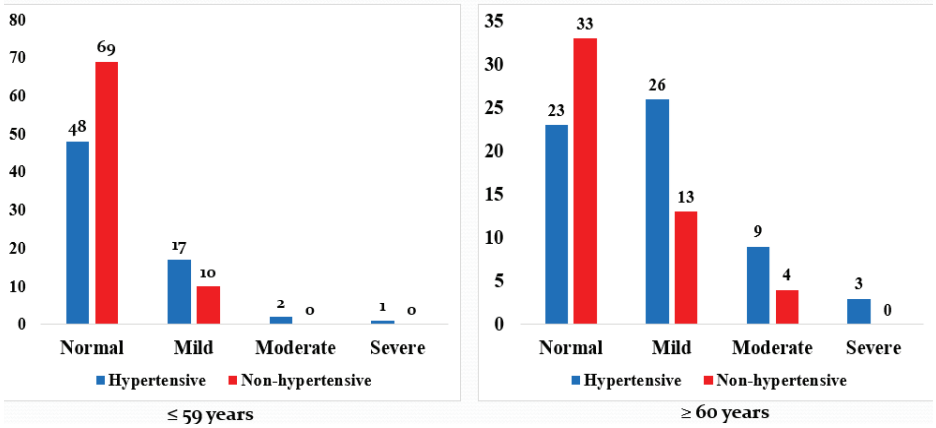

Figure 1: Degrees of air conduction hearing threshold levels in the hypertensive and Non hypertensive groups.

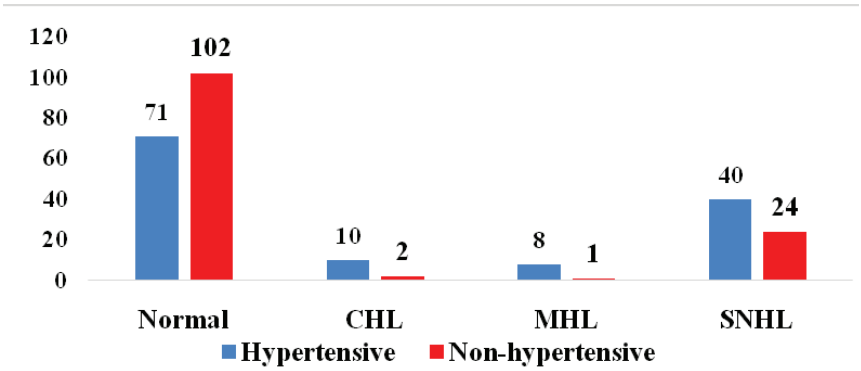

Figure 2: Types of hearing loss in the hypertensive and non hypertensive groups.
CHL-conductive hearing loss; MHL-mixed hearing loss; SNHL-sensorineural hearing loss.

Table 4: Pearson's Correlation of hearing threshold and glycaemic control in two groups.

Pearson's correlations coefficient (r)	Group A		Group B	
	Hypertensive		Non-Hypertensive	
	HBA1C	FBG	HBA1C	FBG
R	0.04	-0.025	-0.004	0.043
p-value	0.688	0.776	0.963	0.626
N	129	129	129	129
r- Pearson's Coefficient of correlation. *statistically significant. N-number of subjects				

A significant weak positive association was noted between hearing threshold and duration of DM in both groups. The strength of the association was stronger in the hypertensive group A, with Pearson's correlation coefficient r=0.3, p-value=0.002, as against r=0.2, p-value=0.004 in the non-hypertensive group B. A significant weak association was also seen between hearing threshold and duration of hypertension in the Group A with a Pearson's correlation coefficient of r=0.2, and p-value=0.015

Discussion

The difference in the hearing thresholds of males and females in the two groups was not statistically significant, with p-value of 0.154. This may suggest that gender has no significant effect on hearing thresholds in this study. Yikawe, et al. [14] and Bhaskar, et al. [15] found no association between gender and hearing loss. However, Ogundiran and Olaosun who worked on hearing loss in elderly population with DM found a positive association between sex and hearing loss [16]. Some authors have stated that the hearing loss depend on factors such as the duration of DM, and individual genetic predisposition to complications of DM and hearing loss, and not on the gender of an individual [15,17].

From the findings in this study, it is obvious that the hypertensive (case) group had a higher prevalence of hearing loss (45.0%), as compared to the non-hypertensive (control) group (20.9%). This difference in the prevalence of hearing loss between the two groups was statistically significant with a p-value=0.0001 and the case group also have an increased risk of hearing loss, with an Odds Ratio=3.1, at a 95% Confidence Interval of 1.7-5.3. This shows that adults living with DM and co-morbid hypertension, are 3 times more likely or at odds of having hearing loss when compared to their non-hypertensive counterparts. Similarly, Chavez-Delgado MS, et al. in their study of cochlea-vestibular dysfunction in patients with DM, hypertension and dyslipidemia, noted that subjects with DM and hypertension had higher hearing thresholds when compared to those with DM alone [18]. This may be due to the similarity in the micro-angiopathy caused

by both DM and hypertension on the ear, thereby magnifying the insult on the ear in subjects in the hypertensive group. Rolim et al in their retrospective study in 2014 also noted the highest mean hearing threshold in persons with DM and Hypertension [19]. They had 80 subjects aged 60 years and above, who were separated into 4 groups, namely control-no disease, DM only, Hypertension (HPT) alone, and DM+HPT. They compared the hearing thresholds of the subjects in these four groups at various frequencies from 250 to 8000Hz and had a mean pure tone hearing threshold level for each group. Their findings were in keeping with this work, such that the group with DM and hypertension had the highest mean pure tone hearing thresholds when compared to the other groups [19].

Severity of hearing loss in this study shows that the proportion was greater in the hypertensive group A, similar to Rolim, et al who noted a worse severity of hearing loss at all frequencies in their group with DM and co-morbid hypertension, when compared to the other 3 groups in their work. However, because their analysis included frequencies higher than 4000 Hz, they noted worse degree of hearing loss at 6000 and 8000 Hz [20]. Fukushima in his study on DM and its effect on cochlea structure, reported that there can be a situation where the atrophy of the stria vascularis is only in the lower and middle turns, and no changes in the apical turns [16]. In this case, the lower frequencies are spared. Gibrin and Melo stated that effect of hypertension is mainly in the basal turn of cochlea, affecting the hearing thresholds at higher frequencies [1]. This probably explains why the higher frequencies are more affected, due to dual effect of both DM and hypertension.

It was noted that the pure tone hearing threshold of the elderly population were higher than that of the younger population, and this was similar in the case group A and the control group B. This is probably due to effect of ageing, but this may not be attribute it to age alone, when even among the elderly population, those hypertensive diabetics had poorer hearing levels. This finding is in keeping with the reports of Gibrin PCD, Melo JJ, et al. [1] Chavez-Delgado MS, et al. [18] and Rolim LP, et al. [19].

Sensorineural hearing loss was the predominant type of hearing loss seen in both groups, however, it was significantly higher in the hypertensive group, than in the non-hypertensive group (Fischer exact p-value=0.0001). However, this damage will be greater in the hypertensive diabetics, due to the poor glycaemic control caused by the presence of hypertension, which subsequently worsens the severity of neuropathy and other complications of DM [9]. In addition to this is the primary effect of hypertension on the cochlea [1], causing a sensorineural hearing loss and the microangiopathy to an extent, mimics the effect of DM which also causes sensorineural hearing loss. This study also noted the presence of all 3 types of hearing loss in the study participants, similar to the finding by Meena R, et al. [21] Adebola SO, et al. [22] and Yikawe S, et al. [23] who studied the type of hearing loss in persons with DM, noted only the presence of sensorineural hearing loss in their respective study population. Nwosu and Chime, also had a greater proportion of sensorineural hearing loss in their study of persons with DM alone [24]. The presence of conductive hearing loss may be because people with DM develop some level of immune-compromise, mucocilliary function may be impaired, and change in canal pH, predisposes them to ear canal and middle ear infection [21] Kumari MS, et al. in their study of 170 subjects with DM reported conductive hearing loss in 44.3%, and sensorineural hearing loss in 38.5%. Conductive hearing loss was the highest type of hearing loss in their work. [25] Chavez-Delgado ME, et al. reported mixed and sensorineural type of hearing loss in their study population with hypertension and hearing loss. [18] Similarly, in this study mixed hearing loss was seen only in the hypertensive group, both for the older and younger age groups. The effect of hypertension leads to cochlea-vestibular degeneration, and does not necessarily predispose affected individual to external or middle ear infection [1], so the presence of conductive hearing loss in the hypertensive group A may be attributed to the presence of DM [18].

Cayonu M, et al. [26] and Zaffar MZ, et al. [27] noted the presence of a greater proportion of hearing loss in 60 years and above, same was observed in this study. This finding is supported by the presence of a statistically significant positive relationship found to exist between Hearing threshold and Age, which was stronger for the hypertensive group A (r=0.5, p=0.0001), than for the non-hypertensive group B (r=0.4, p=0.0001), as seen in the Pearson's correlation coefficient (r) value. This is probably due to the presence of an additional effect on the hearing threshold of participants in this Group A, which may be the hypertension. If it were solely due to age, or the presence of DM, the number and severity of hearing loss would be similar in both groups, judging from the similarity of both age and presence of DM in the 2 groups. However, as age of respondents increased, hearing threshold also increased for both groups, but with a worse severity in the hypertensive group. Cayonu M, et al. in 2014 [26] , showed that elderly people living with type 2 DM, have poorer hearing levels when compared to age and sex matched non DM subjects [28,29]. Panchu P, in his work with non-elderly people aged 35-55 years, found a significant higher proportion of hearing loss in his group with type 2 DM, as against his non-diabetic control group [28]. Horikawa C, et al. in their study in the non-elderly population, stated that ageing is not a factor responsible for hearing loss, but rather hearing loss in DM is a result of the disease progression, which they think requires a more precise investigation [28].

The glycaemic control was assessed as good and poor control in this study using the fasting blood glucose and the glycosylated haemoglobin. It was noted that the number of subjects with poor control were higher in the hypertensive diabetic group than in the non-hypertensive diabetic group, and the hearing thresholds were higher in the hypertensive case group A too. This is in line with report by Odum and Orluwene, which states that there is a relative insulin resistance which predominates in the presence of hypertension in a person with DM [9]. Shafeeq M, et al. showed a strong association between blood glucose level, glycosylated haemoglobin, and severity of hearing loss [30]. Similarly, Thimmasettaiah NB, et al. in their prospective study observing blood glucose and hearing loss, found that maximum incidence of SNHL occurred with high glucose level, when compared to normal range [31].

This is supported by the finding in this study, where the hearing threshold according to HBA1C of the subjects with poor control is higher in the hypertensive groups, and also statistically significant. However, combining this with the Pearson's correlation which shows no positive association between glycaemic control and hearing threshold in this study, it indicate that in the presence of poorly controlled DM, the hearing acuity is at risk, but the damage becomes obvious with disease progression. Consequently, among the subjects with poorly controlled DM, it was observed that those with longer duration of disease have poorer hearing thresholds. Mozzafari M, Austin T, et al. [3] in their work, found no association between glycaemic control and hearing threshold, which made them believe that duration of DM is a greater determinant of hearing loss, summing up the effect of repeated episodes of raised blood glucose [32].

A statistically significant but weak linear relationship was found to exist between Hearing threshold and Duration of living with

diabetes mellitus. As the duration of DM for respondents increased, hearing threshold also increased for the hypertensive group A (r=0.3, p=0.002) and the non-hypertensive group B (r=0.2, p=0.004). This association was stronger in the hypertensive diabetic group A, as seen in the Pearson's correlation coefficient (r) value stated above. A similar finding was reported in the study done by Rolim LP, et al [19]. who did their study with a similar study design. They stated that the stronger association was due to the significant effect of the duration of hypertension on hearing. Agarwhal S, et al. also found a significant association between duration of hypertension and hearing loss [33]. The relative insulin resistance conferred by the presence of hypertension in these individuals results in poor control of the diabetes, leading to more episodes of hyperglycaemia, thereby exposing the affected individual to the complications of poorly controlled DM as the disease progresses. Therefore, the duration of DM becomes a greater determinant of hearing threshold as regards the effect of raised blood sugar [33].

This study found a positive association between duration of hypertension and pure tone hearing threshold, as duration of hypertension increased, hearing threshold increased. Agarwhal, et al and Rolim, et al in their respective studies found a positive association between duration of hypertension and hearing threshold [19,33]. This is attributable to the microangiopathy caused by hypertension which leads to cochleo-vestibular degeneration [1,23]. As a result of this, hypertensive individuals are expected to have a progressively worse hearing threshold as the disease progresses. This study did not compare the level of control of blood pressure with hearing threshold, this may be a limitation to this study.

Conclusion

Adult persons living with diabetes mellitus, who are also hypertensive, have a 3 times increased risk of having hearing loss as compared to those who have DM alone. Also, as an adult with type 2 DM ages, the hearing acuity worsens; however, the hypertensive diabetics are more likely to suffer a greater severity of hearing loss when compared to the non-hypertensive diabetics.

Recommendation

Enhanced health education on the effect of DM and hypertension on hearing is recommended to boost awareness on the increased risk of hearing loss in people living with these conditions. The need for serial monitoring of their hearing at regular intervals cannot be overemphasized, for early identification and treatment, in the bid to reduce co-morbidity of hearing loss in these individuals.

References

1. Paula Carolina Dias Gibrin, Juliana Jandre Melo, Luciana Lozza de Moraes Marchiori (2013) Prevalence of tinnitus complaints and probable association with hearing loss, diabetes mellitus and hypertension in elderly. Codas 25: 176-180.
2. Bainbridge K (2009) Hearing impairment an under-recognized complication of diabetes. Diabetes voice 54: 9.
3. M Mozaffari, A Tajik, N Ariaei, F Ali-Ehyaii, H Behnam (2010) Diabetes mellitus and sensorineural hearing loss among non-elderly people. East Mediterr Health J 16: 947-952.
4. Frier BM, Truswell AS, Shepherd J, De Looy A, Jung R (1999) Diabetes mellitus, and nutritional and metabolic disorders. Davidson's Principles and Practice of Medicine. Christopher H, Edwin RC, John AAH, Ncholas AB (eds) 8th Edition, Churchill Livingstone 471-542.
5. Luciana Lozza de Moraes Marchiori, Eduardo de Almeida Rego Filho, Tiemi Matsuo (2006) Hypertension as a factor associated with hearing loss. Braz J Otorhinolaryngol 72: 533-540.
6. Jayson Nagaoka, Marcelo Ferreira dos Anjos, Thales Takeo Takata, Renan Moukbel Chaim, Flavia Barros, et al. (2010) Idiopathic Sudden sensorineural hearing loss: evolution in the presence of hypertension diabetes mellitus and dyslipidemias. Braz J Otorhinolaryngol 76: 363-369.
7. A Asma, M Nor Azmi, A Mazita, M B Marina, H Salina, et al. (2011) A Single Blinded Randomized Controlled Study of the effect of Oral Hypoglycaemic agents *versus* Intensive Short Term Insulin Therapy on Pure Tone Audiometry in type II Diabetes Mellitus. Indian J Otolaryngol Head Neck Surg 63: 114-118.
8. Elizabeth P Helzner, Jane A Cauley, Sheila R Pratt, Steven R Wisniewski, Joseph M Zmuda, et al. (2006) Race and sex differences in age-related hearing loss: The health, aging and body composition study. J Am Geriatr Soc 53: 2119-2127.
9. University of Port Harcourt Teaching Hospital (UPTH) Medical World Nigeria-MWN.
10. J Mayfield (1998) Diagnosis and Classification of Diabetes Mellitus: New Criteria. Am Fam Physician 58: 1355-1362.
11. Genevieve M Gabb, Arduino A Mangoni, Craig S Anderson, Diane Cowley, John S Dowden, et al. (2016) Guideline for the diagnosis and management of hypertension in adults-2016. Med J Aust 205: 85-89.
12. Tian H, Lu C, Yang J, Banger K, Huntzinger DN, et al. (2012) WHO global estimates on prevalence of hearing loss.
13. World Health Organization (2020) WHO: Deafness and hearing loss.
14. Stephen Semen Yikawe, Kufre Robert Iseh, Anas Ahmad Sabir, Mfon Ime Inoh, Joseph Hassan Solomon (2017) Cardiovascular risk factors and hearing loss among adults in a tertiary centre of Northwestern Nigeria. World J Otorhinolaryngol Head Neck Surg 4: 253-257.
15. Bhaskar KN, Chalihadan S, Vaswani R, Abdul Rehaman CP (2014) Clinical and audiometric assessment of hearing loss in diabetes mellitus. Int J Sci Stud. 2: 1-16.
16. Olawale Ogundiran, Adedayo O Olaosun (2017) Lifestyle, Hypertension, Diabetes Mellitus and Hearing Loss in the Elderly - A Review. SAS J Med 9: 239-243.
17. Lois E Donovan, Naomi E Severin (2006) Maternally Inherited Diabetes and Deafness in a North American Kindred: Tips for Making the Diagnosis and Review of Unique Management Issues. J Clin Endocrinol Metab 91: 4737-4742.
18. María Estela Chávez-Delgado, Irma Vázquez-Granados, Manuel Rosales-Cortés, Víctor Velasco-Rodríguez (2012) Cochleovestibular dysfunction in patients with diabetes mellitus, hypertension, and dyslipidemia. Acta Otorrinolaringol Esp 63: 93-101.
19. Laurie Penha Rolim, Camila Maia Rabelo, Ivone Ferreira Neves Lobo, Renata Rodrigues Moreira, Alessandra Giannella Samelli (2015) Interaction between diabetes mellitus and hypertension on hearing of elderly. Codas; 27: 428-432.
20. Hisaki Fukushima, Sebahattin Cureoglu, Patricia A Schachern, Michael M Paparella, Tamotsu Harada, et al. (2006) Effects of type 2 diabetes mellitus on cochlear structure in humans. Arch Otolaryngol Head Neck Surg 132: 934-938.
21. Ramlakhan Meena, Divij Sonkhya, Nishi Sonkhya (2016) Evaluation of hearing loss in patients with type 2 diabetes mellitus. Int J Res Med Sci 4: 2281-2287.

22. Stephen Oluwatosin Adebola, Micheal A Olamoyegun, Olusola A Sogebi, Sandra O Iwuala, John A Babarinde (2016) Otologic and audiologic characteristics of type 2 diabetics in a tertiary health institution in Nigeria. Braz J Otorhinolaryngol 82: 567-573.

23. Stephen Yikawe, Kufre Iseh, Anas Sabir, Joseph Solomon, Caleb Manya, et al. (2017) Effect of duration of diabetes mellitus on hearing threshold among type 2 diabetics. Indian Journal of Otology 23: 113.

24. Jones Ndubuisi Nwosu, Ethel Nkechi Chime (2017) Hearing thresholds in adult Nigerians with diabetes mellitus: a case-control study. Diabetes Metab Syndr Obes 10: 155-160.

25. Manche Santoshi Kumari, Koralla Raja Meganadh , Jangala Madhavi, Akka Jyothy (2016) Prevalence of Otological Disorders in Diabetic Cases with Hearing Loss. J Diabetes Metab 7: 866.

26. Melih Çayönü, Mustafa Çapraz, Aydın Acar, Aytuğ Altundağ, Murat Salihoğlu (2014) Hearing loss related with type 2 diabetes in an elderly population. Int Adv Otol 10: 72-75.

27. Zafar MZ, Riaz M, Asim M, Bashir T, Ahsan M, et al. (2017) Prevalence of complexities hypertension associated with type 2 diabetes: a cross-sectional study. Diversity and equality in healthcare 14: 313-315.

28. Chika Horikawa, Satoru Kodama, Shiro Tanaka, Kazuya Fujihara, Reiko Hirasawa, et al. (2013) Diabetes and risk of hearing impairment in adults: a meta-analysis. J Clin Endocrinol Metab 98: 51-58.

29. Pallavi Panchu (2008) Auditory acuity in type 2 diabetes mellitus. Int J Diabetes Dev Ctries 28: 114-120.

30. Mohammed Shafeeq, Mohammed NA, Gangadhara Somayaji, Mubeena, Hebin H Kallikkadan (2015) Sensorineural hearing loss in type 2 diabetes mellitus. IORS-JDMS 14: 56-61.

31. Nagaraj Bangalore Thimmasettaiah, Ravi Shankar, Ravi GC, Somasundar Reddy (2012) A one year prospective study of hearing loss in diabetes in general population. Translational Biomedicine 3: 1-7.

32. Donald F Austin, Dawn Konrad-Martin, Susan Griest, Garnett P McMillan, Daniel McDermott, et al. (2009) Diabetes-related changes in hearing. Laryngoscope 119: 1788-1796.

33. Saurabh Agarwal, Aseem Mishra, Mohan Jagade, Vimal Kasbekar, Smita K Nagle (2013) Effects of Hypertension on Hearing. Indian J Otolaryngol Head Neck Surg 65: 614-618.