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FACTORS INCREASING THE RISK OF HEARING LOSS AMONG HYPERTENSIVE PATIENTS: A PROSPECTIVE STUDY

Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

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Abstract

Background: Hearing loss and hypertension are leading causes of disability, affecting over 360 million people. The aim of this study was to assess the impacts of factors such as vitamin D and sleep disorder on the risk of hearing loss among hypertensive patients.

Material and methods: This prospective cohort study involved 885 patients aged between 25 and 65 years old who visited our ENT and Endocrinology departments. The study was based on biochemical tests, physical examination, hearing assessment, and Pittsburgh Sleep Quality Index test. Statistical analysis used bivariate and multivariate stepwise regression.

Results: Of 855 hypertensive patients, 184 (21.5%) had hearing loss. There were statistically significant differences between hypertensive patients with and without hearing loss in terms of BMI, smoking, family history of diabetes, tinnitus, vertigo, and headache. Moreover, there were statistically significant differences between hypertensive patients with hearing loss versus those with normal hearing in terms of vitamin D, calcium, magnesium, potassium, fasting glucose, HbA1C, HDL, systolic and diastolic blood pressure, microalbuminuria, and sleep quality. Among hypertensive patients, a multivariate regression analysis (stepwise method) indicated that vertigo, systolic blood pressure, vitamin D deficiency, numbness in the hand, tinnitus, vigorous activity, metabolic syndrome, sleep disturbance, and obesity were all risk predictors of hearing loss.

Conclusions: Controlling hypertension, vitamin D level, sleep, and lifestyle might lower the risk of hearing loss among hypertensive patients.

Keywords: hypertension • hearing loss • epidemiology • vitamin D • sleep

CZYNNIKI PODWYŻSZONEGO RYZYKA NIEDOSŁUCHU WŚRÓD PACJENTÓW Z NADCIŚNIENIEM TĘTNICZYM: BADANIE PROSPEKTYWNE

Streszczenie

Wprowadzenie: Niedosłuch i nadciśnienie tętnicze to najczęstsze przyczyny niepełnosprawności, dotykają ponad 360 mln osób. Celem tego badania była ocena wpływu takich czynników jak poziom witaminy D i zaburzenia snu na ryzyko wystąpienia niedosłuchu u pacjentów z nadciśnieniem.

Materiał i metody: W tym prospektywnym badaniu kohortowym uczestniczyło 885 osób w wieku od 25 do 65 lat, pacjentów naszych klinik ORL i endokrynologicznej. W badaniu wykorzystano testy biochemiczne, badanie fizykalne, ocenę słuchu oraz badanie kwestionariuszem Pittsburgh Sleep Quality Index. W analizie statystycznej wykorzystano model regresji krokowej dwuczynnikowej i wielorakiej.

Wyniki: Z grupy 855 pacjentów z nadciśnieniem niedosłuch miało 184 (21,5%). Występowały statystycznie istotne różnice między pacjentami z nadciśnieniem, którzy mieli niedosłuch, a słyszącymi w zakresie BMI, palenia, występowania cukrzycy w historii rodziny, szumów usznych, zawrotów głowy i bólu głowy. Ponadto między pacjentami z nadciśnieniem, którzy mieli niedosłuch, a słyszącymi występowały istotne statystycznie różnice pod względem poziomu witaminy D, wapnia, magnezu, potasu, poziomu cukru we krwi na czczo, HbA1C, HDL, skurczowego i rozkurczowego ciśnienia krwi, mikroalbuminurii i jakości snu. Wieloraka analiza regresji (krokowa) wykazała, że w grupie pacjentów z nadciśnieniem czynnikami ryzyka dla niedosłuchu były: zawroty głowy, skurczowe ciśnienie krwi, niedobór witaminy D, drętwienie rąk, szumy uszne, aktywność fizyczna, zespoły metaboliczne, zaburzenia snu i otyłość.

Wniosk: Ryzyko wystąpienia niedosłuchu u pacjentów z nadciśnieniem mogą obniżać: właściwa kontrola ciśnienia krwi, poziomu witaminy D, snu oraz odpowiedni styl życia.

Słowa kluczowe: nadciśnienie • niedosłuch • epidemiologia • witamina D • sen

Introduction

Hearing loss and hypertension are leading cause of disability, affecting over 360 million people [1]. Among hypertensive patients, hearing loss is a significant health concern [2,3]. Hearing loss and its relation with hypertension has been well documented [2,4–6]. As blood pressure increases, the level of hearing diminishes [2,4,5,7,8]. Several authors have investigated the risk factors of hypertension and hearing loss [2,4,5,9–14]. Bao et al. determined that increases in long-term blood pressure were related to hearing loss [12], and there are several reports that hearing impairment can impact even the simplest functions of daily life [2–7,13,14].

Similarly, there is accumulating evidence for a relationship between impaired sleep and hypertension, suggesting that reduced sleep duration or quality may make existing hypertension worse. However, to our knowledge there are no studies looking at whether hypertensive patients are likely to have reduced vitamin D levels or sleep disorders as well as hearing loss [5,13,14]. The present study addresses these possible connections by assessing the impacts of hypertension, vitamin D, and sleeping disorders on the risk of hearing loss.

Material and methods

This is a prospective cohort study based on patients aged 25 to 65 years who visited the ENT and Endocrinology clinics at the Medipol Hospitals between May 2017 and March 2020. A calculated sample size of 1,117 was based on the previous reported prevalence of impaired hearing among hypertensive patients of 25%, assuming 99% confidence interval with 3% error of estimation [2]. However, in practice only 885 (79.2%) agreed to participate in this research. Ethical approval was obtained from the Istanbul Medipol University, Faculty of Medicine (RP# 10840098-772.02.01-E.49746).

Physical examination and measurements

Hypertension has been described by the World Health Organization (WHO) [2]. On examination, hypertension was confirmed if systolic blood pressure (SBP) was 140 mmHg or more, diastolic DBP was 90 mmHg or more, and/or antihypertensive drugs were regularly used. Serum 25(OH)D levels were detected using competitive radioimmunoassay (RIA) (DiaSorin, Stillwater, MN, USA). Participants were divided into three categories: vitamin D deficiency, insufficiency, or normal/optimal level [5,15].

Hearing assessment

Pure-tone audiometry was used to measure hearing sensitivity. Two digital audiometers (Grason Stadler GSI 61 and Interacoustics AC40 were used to diagnose hearing loss; they were regularly calibrated to international standards and operated by trained technicians. Thresholds were measured at 0.25, 0.5, 1, 2, 4, and 8 kHz in a sound-isolated room, standardized according to the manufacturer's instructions. Pure tone average (PTA) was determined based on the air-conduction average threshold levels in each ear (in decibels) at 0.5, 1, 2, and 4 kHz. Hearing was categorised as normal (< 26 dB) or with hearing loss (≥ 26 dB) [2,16].

Pittsburgh Sleep Quality Index (PSQI)

Buysse et al. [17] developed the PSQI to subjectively assess sleep disturbance over the past month. Participants were classified as having "Good sleep quality" if the PSQI total score was ≤ 5, "Average sleep quality" if PSQI 6–8, and "Poor sleep quality" if PSQI ≥ 9 [17]. A global PSQI ≥ 5 has a diagnostic sensitivity of 89 and specificity of 86 in distinguishing "poor sleepers" from "good sleepers".

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS Statistics for Windows, Version 25.0; IBM Corp, Armonk, NY). The significance of differences between mean values of two continuous variables was determined by Student's *t*-test for normally distributed data. A chi-square test was used for the differences in proportions of categorical variables between two or more groups. Multivariate stepwise regression was used to assess the importance of risk factors for hearing loss. A level of $p < 0.05$ was considered as significant.

Results

Of 855 hypertensive patients, 184 (21.5%) had hearing loss. **Table 1** gives socio-demographic and clinical properties of hypertensive patients with and without hearing loss. The majority of hypertensive patients with hearing loss were over 50 years old (54.8%) and 63.6% were female. There were statistically significant differences between hypertensive patients with and without hearing loss: BMI, ($p = 0.023$), smoking ($p = 0.007$), tinnitus ($p < 0.001$), family history of diabetes ($p = 0.049$), vertigo ($p < 0.001$), and headache ($p = 0.005$).

Table 2 shows clinical biochemistry values for hypertension patients with and without hearing loss. Statistically significant differences were found between those with hearing loss versus those with normal hearing for the values of vitamin D ($p < 0.001$), calcium ($p = 0.005$), magnesium ($p < 0.001$), potassium ($p = 0.019$), fasting glucose ($p < 0.001$), HbA1C ($p < 0.001$), HDL ($p = 0.016$), potassium ($p = 0.019$), systolic blood pressure ($p < 0.001$), diastolic blood pressure ($p < 0.001$), micro albuminuria ($p = 0.005$), ATP III metabolic syndrome ($p = 0.013$), IDF metabolic syndrome ($p = 0.024$), and PSQI sleep quality ($p < 0.001$).

Table 3 shows results of multivariate regression analysis using the stepwise method. They indicate that vertigo ($p < 0.001$), systolic blood pressure ($p = 0.001$), vitamin D deficiency ($p < 0.001$), numbness in hand ($p < 0.001$), tinnitus ($p < 0.001$), vigorous activity ($p < 0.001$), ATP III metabolic syndrome ($p = 0.007$), sleep disturbance ($p = 0.022$), and obesity ($p = 0.034$) can be considered as risk predictors of hearing loss among hypertensive patients.

Discussion

This research has confirmed that hypertension, vitamin D deficiency, and sleeping disorders are important risk

Table 1. The socio-demographic and clinical characteristics of hypertensive patients with and without hearing loss (n = 885)

	Hypertensive with		*p*-value
	Hearing loss ≥ 26 dB (n = 184)	Normal hearing < 26 dB (n = 701)	
Age groups (in years)			
< 40	45 (24.5)	179 (25.5)	0.633
40–49	38 (20.7)	154 (22.0)	
50–59	51 (27.7)	162 (23.1)	
> 60	50 (27.2)	206 (29.4)	
Gender			
Male	67 (36.4)	270 (36.2)	0.601
Female	117 (63.6)	431 (63.8)	
BMI (kg/m²)			
Normal (< 25 kg/m²)	44 (23.9)	230 (32.8)	**0.023**
Overweight (25–30 kg/m²)	80 (43.5)	300 (42.8)	
Obese (> 30 kg/m²)	60 (32.6)	171 (24.4)	
Physical activity			
Yes	33 (17.9)	210 (30.0)	**< 0.001**
No	151 (81.1)	491 (70.0)	
Smoking status			
Yes	41 (22.3)	99 (14.1)	**0.007**
No	143 (77.7)	602 (85.9)	
Frequent use of mobile phone			
Yes	172 (93.5)	607 (86.6)	**0.010**
No	12 (6.5)	94 (13.4)	
Hearing TV sounds clearly			
Yes	168 (91.3)	596 (85.0)	**0.027**
No	16 (8.7)	105 (15.0)	
Family history of diabetes			
Yes	51 (27.7)	141 (20.1)	**0.049**
No	133 (72.3)	560 (79.9)	
Family history of numbness in hand			
Yes	59 (32.1)	101 (14.4)	**< 0.001**
No	125 (67.9)	600 (85.6)	
Tinnitus			
Yes	72 (39.1)	143 (20.4)	**< 0.001**
No	112 (69.9)	558 (79.6)	
Vertigo and/or dizziness			
Yes	96 (53.2)	87 (12.4)	**< 0.001**
No	88 (47.8)	614 (87.6)	
Headache			
Yes	105 (57.1)	319 (45.5)	**0.005**
No	79 (42.9)	382 (54.5	

factors for hearing loss. This is similar and confirms the results reported by several studies [2,4–6]. Moreover, Bener et al. found strong correlation between high blood pressure and hearing loss in populations of Turkey [2] and Qatar [4,5]. Kuang et al. [18] found that increasing years of hearing loss was significantly associated with increases in systolic and diastolic blood pressure.

There is a widespread literature showing an association between hypertension and hearing loss as well as tinnitus [2,4,8,9,12–14,18,19]. Recently, Bao et al. found that 46.8% of people with hearing loss had hypertension [12]. According to a systematic review, there is broad evidence of an association between tinnitus and arterial hypertension [8]. One study found an association between tinnitus and arterial hypertension which was particularly strong in older patients [14], complementary to a study in China which evaluated the relationship between hypertension and hearing disorders of the elderly [11]. Auditory thresholds increased gradually in proportion with age, especially in hypertensive patients.

Two studies in Brazil observed that hypertension had the greatest influence on hearing [6,7]. One meta-analysis determined that hypertension might be a risk factor for tinnitus and its control should be considered as a prevention strategy [9].

The results of the present research are consistent with previous studies relating to hypertension and tinnitus

Table 2. Clinical biochemistry variables in hypertensive patients with and without hearing loss (n = 885)

	Hypertensive with		
	Hearing loss ≥ 26 dB Mean ± SD	**Normal hearing < 26 dB Mean ± SD**	***p*-value**
Vitamin D (ng/mL)	17.11 ± 8.07	21.50 ± 9.02	**< 0.001**
Hemoglobin (g/dL)	12.30 ± 2.20	12.95 ± 2.15	0.282
Magnesium (mmol/L)	0.68 ± 0.08	0.93 ± 0.09	**< 0.001**
Potassium (mmol/L)	3.43 ± 0.40	4.89 ± 0.28	**0.019**
Calcium (mmol/L)	1.62 ± 0.10	1.98 ± 0.11	**0.005**
Phosphorus (mmol/L)	1.26 ± 0.30	1.28 ± 0.26	0.826
Creatinine (mmol/L)	75.26 ± 15.44	74.14 ± 14.19	0.362
Fasting glucose (mmol/L)	7.75 ± 1.24	7.29 ± 1.03	**< 0.001**
HbA1c	7.79 ± 1.13	7.22 ± 0.87	**< 0.001**
Cholesterol (mmol/L)	4.72 ± 098	4.79 ± 0.79	0.308
HDL (mmol/L)	1.06 ± 0.90	1.14 ± 0.25	**0.016**
LDL (mmol/L)	1.81 ± 0.76	1.89 ± 0.65	0.339
Albumin (mmol/L)	41.37 ± 3.25	42.36 ± 7.93	0.205
Bilirubin (mmol/L)	7.57 ± 1.49	7.27 ± 2.56	0.164
Triglyceride (mmol/L)	1.64 ± 0.75	1.61 ± 0.59	0.870
Uric acid (mmol/L)	275.3 ± 62.64	283.1 ± 67.37	0.157
Systolic blood pressure (mmHg)	144.40 ± 10.60	126.91 ± 8.89	**< 0.001**
Diastolic blood pressure (mmHg)	87.58 ± 8.20	79.20 ± 7.75	**< 0.001**
Microalbuminuria	12.20 ± 3.81	7.68 ± 1.86	**< 0.001**
	***n* (%)**	***n* (%)**	
Vitamin D level			
Deficiency 25(OH)D < 20 ng/mL	123 (66.8)	348 (49.6)	**< 0.001**
Insufficiency 25(OH)D 20–29 ng/mL	32 (17.4)	233 (33.2)	
Optimal 25(OH)D 30–80 ng/mL	29 (15.8)	120 (17.2)	
ATP III metabolic syndrome			
Yes	45 (24.5)	116 (16.5)	**0.013**
No	139 (79.5)	585 (83.52)	
IDF metabolic syndrome			
Yes	62 (33.7)	178 (25.4)	**0.024**
No	122 (66.3)	523 (74.6)	
Sleep quality			
Good sleep (PSQI score < 5)	63 (34.3)	293 (41.8)	**0.026**
Average sleep (PSQI score 6–8)	49 (26.6)	205 (29.2)	
Poor sleep (PSQI score > 8)	72 (39.1)	203 (29.0)	

Table 3. Multivariate stepwise regression analysis for predictors of hearing loss among hypertensive patients

Independent variables	Unstandardized coefficients		Standardized coefficients Beta	*t*-test	*p*-value
	Beta	Standard error			
Vertigo and/or dizziness (Yes)	0.386	0.032	0.385	11.882	**< 0.001**
Systolic blood pressure (mmHg)	–0.462	0.112	–0.846	4.67	**0.001**
Vitamin D deficiency (< 20 ng/mL)	0.496	0.107	0.115	4.593	**< 0.001**
Numbness in hand	0.147	0.35	0.136	4.440	**< 0.001**
Tinnitus (Yes)	0.135	0.033	0.135	4.048	**< 0.001**
ATP III metabolic syndrome	0.192	0.054	0.149	3.539	**0.001**
Vigorous activity	–0.088	0.028	–0.097	–3.205	**< 0.001**
Obesity and overweight	–0.310	0.120	–0.090	–2.689	**0.007**
Sleep disturbance (Yes)	0.024	0.011	0.077	2.288	**0.022**

[2,4,5,8,9,13], including four studies which found that hearing impairment was more common in patients with hypertension and diabetes [2,4,5,7].

The present prospective cohort study found that, among hypertensive patients, there was also a strong correlation with hearing loss, sleeping disorders, vertigo, and tinnitus.

Several studies have reported that cigarette smoking is associated with hearing loss [20–22], and is a well-established risk factor for many adverse health outcomes [20–23]. In the current study, cigarette smoking appeared to be a predictor of hearing loss among hypertensive patients.

Several studies have investigated whether sleep disorders are related to hearing loss and tinnitus [24,25]. These results were consistent with our study. In Japan, hearing loss has been related to longer sleep duration and cardiometabolic risk factors [26].

Dawes et al. found that as vitamin D levels increase, hearing problems also decrease [15]. It might therefore be beneficial to increase vitamin D levels and make dietary adjustments. Vitamin D deficiency has been related to hearing loss among the elderly [27] and among diabetic patients [2]. These results are compatible with our findings. Vitamin D is important for the human auditory system, and a deficiency can have a deleterious effect on the inner ear [13]. In general, the current study suggests that hypertension, vitamin D deficiency, and sleep disorder are all causal risk factors for hearing loss. Therefore, an immediate strategy for preserving hearing may be to modify these factors.

Although many researchers have investigated the link between hypertension and hearing loss [4,11]; the underlying mechanism has not been found. The blood labyrinthine barrier (BLB) is a barrier between the vasculature and the inner ear fluids (endolymph and perilymph) [11,28]. Hypertension may alter the permeability of the BLB and have an effect on the osmotic pressure between endolymph and perilymph.

Strengths and limitations

A multistage, stratified random cluster sampling design was used to obtain a large, representative sample of the population. There were very good response rates to the sleep duration questions and to hypertension questions and measurements. At the same time, the current study has several limitations. The first is that the sleep duration data obtained from the questionnaire was subjectively rated. Second, the comparison study was not an ideal matched case and control, limiting causal or temporal conclusions between hearing loss and hypertension. Third, the study population may not reflect the target population. Fourth, the clinical assessment and tests performed for co-morbidity might be misclassified, and so the results should be interpreted with caution.

Conclusions

This study determined the links between hypertension, hearing impairment, vitamin D, and sleep quality. Controlling hypertension, vitamin D level, sleep, and lifestyle factors are suggested as a modifiable risks for enhancing quality of life and might lower the incidence of hearing loss among hypertensive patients.

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Informed consent

Written and verbal informed consent was obtained for this study.

Conflict of interest

The authors declare no conflict of interest.

Financial disclosure

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