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Research Article

Impact of Systemic Arterial Hypertension on Cochlear Function

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Abstract

Background: Systemic arterial hypertension is a highly prevalent disease that has been associated with cochlear impairment.

Aims: The purpose of our study is to evaluate hearing thresholds and to identify the presence of tinnitus and its severity in patients with hypertension and compare them with a healthy control group.

Methods: A cross-sectional and comparative study was performed, comparing 131 patients with hypertension to 331 healthy controls. Subjects underwent pure tone audiometry to evaluate hearing thresholds for low, mid, and high frequencies and speech audiometry. All subjects were evaluated for the presence of tinnitus. Tinnitus handicap index was completed to determine the severity and impact of tinnitus on quality of life.

Results: In the hypertension group mean hearing thresholds in low frequencies were 18.8 dB (± 8.06), 21.2 dB (± 9.72) in mid frequencies, and 35.9 dB (± 17.42) in high frequencies; for which a significant statistical increase was shown in low frequencies (p = 0.0001), mid frequencies (p = 0.0003), and high frequencies (p = 0.0001) compared with the control group. A significant difference (p = 0.0001) was found in the prevalence of tinnitus of hypertension patients (80%) compared with control subjects (17%). We observed a mean score 15.98 (± 17.67) in the tinnitus handicap index of patients with hypertension showing a significant difference compared to a mean score 4.55 (± 1.51) in the control group (p = 0.001).

Conclusion: A significant increase in hearing thresholds, prevalence, and severity of tinnitus in patients with hypertension was shown compared to a healthy control group. This study consolidates an association between systemic arterial hypertension and cochlear impairment.

Keywords: Systemic Arterial Hypertension; Hearing Loss; Tinnitus; Audiometry

Abbreviations

SAH: Systemic Arterial Hypertension; PTA: Pure Tone Audiometry; SP: Speech Audiometry; THI: Tinnitus Handicap Index; NHANES: National Health and Nutrition Examination Survey; SHL: Sensorineural Hearing Loss; AHA: American Heart Association's; DMT2: Diabetes Mellitus Type 2

Introduction

Systemic arterial hypertension (SAH) is a highly prevalent disease. It is estimated that 1.13 billion people have SAH worldwide [1]. Prevalence in the United States among adults was 45.4% during 2017 - 2018 according to the National Health and Nutrition Examination Survey (NHANES) [2]. Cochlear function impairment

has been advocated as a complication of SAH, as cochlear microvascular pathologic changes have been demonstrated in response to this chronic disease [3]. Moreover, a wide range of antihypertensive drugs commonly prescribed have deleterious effects on cochlear function [4].

Sensorineural hearing loss (SHL) and tinnitus are common signs of cochlear pathologies. SHL is the result of the impairment of any component in the auditory system from the cochlea to the auditory cortex. SAH has been claimed as an independent risk factor for hearing loss [5]. Most studies have found that the type of hearing loss related to SAH is a mild sensorineural hearing loss mainly in high frequencies [6-8].

Tinnitus is defined as the perception of sound in the absence of an acoustic stimulus. Its prevalence has been reported to range between 5.1% - 42.7% in the general population [9]. A recent systematic review showed a pooled prevalence of SAH of 17% in the patients who suffer from tinnitus. The majority of studies agree that hearing loss from cochlear degeneration leads to a tinnitus of sensorineural origin in this set of patients [10]. SHL leads to tonotopic rearrangement in the primary auditory cortex and to changes in spontaneous firing rate in neurons of the central auditory system, which might be involved in the perception of tinnitus [11,12]. Importantly, chronic tinnitus has been associated with anxiety, depression, shorter sleep duration and greater missed workdays, negatively impacting patients' quality of life [13,14].

Aim of the Study

The aim of this study is to evaluate hearing thresholds in low, mid and high frequencies as well as the presence and severity of tinnitus in patients with SAH and to compare them with a healthy control group.

Materials and Methods

A cross-sectional and comparative study was conducted over a period of 24 months from August 2018 to July 2020 at the University Center of Otolaryngology from the University Hospital in Monterrey, México. A group of patients diagnosed with SAH and a healthy control group were enrolled. The study was approved by the local Research and Ethics Committee, registered with the key OT16-00004. Informed consent was obtained from all subjects included in this study.

Inclusion criteria

The study included a group of 131 consecutive patients aged over 18 years diagnosed with SAH. These patients were diagnosed and referred from the Hypertension Clinic of the Cardiology Department of the same hospital. They were diagnosed per the American Heart Association's (AHA) 2017 Hypertension Clinical Guidelines [15].

Control group

The control group consisted of 331 healthy volunteers with similar age and gender distribution. All subjects were evaluated by the same otolaryngologist. A complete medical history and a detailed physical examination of ear, nose, throat, and neck were performed. Only subjects without a relevant medical history were included.

Exclusion criteria

The exclusion criteria for both groups were: age <18 years, history of ear infections, chronic noise exposure, use of ototoxic drugs, genetic/ hereditary hearing loss, family history of hearing loss, conductive hearing loss, barotrauma, otosclerosis, ear neoplasms, chronic neurological disease, stroke, traumatic brain injury and head and neck surgery.

Audiological evaluation

Subjects in both groups underwent pure tone audiometry (PTA) and speech audiometry (SP) to evaluate hearing function. PTAs were carried out by the same specialized medical audiologist using an Acoustic Systems soundproof chamber, manufactured in the USA, and an Interacoustics AC40 high-frequency audiometer. Thresholds of pure air-conduction tones were measured at conventional frequencies of 125, 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. Bone-conduction thresholds were measured from 500 - 4000 Hz. Each frequency was evaluated manually with increments of 5 dB in the test. Patients with conductive hearing loss were excluded at this point. An average of the pure air-conduction threshold at each frequency between both ears was obtained. Mean thresholds were obtained for low (125 - 250 Hz), mid (500 - 3000 Hz), and high (4000 - 8000 Hz) frequencies. Hearing loss is classified, as stated by the American Speech-Language-Hearing Association, as slight (16 - 25 dB), mild (26 - 40 dB), moderate (41 - 55 dB), moderately severe (56 - 70 dB), severe (71 - 90 dB) and profound (> 90 dB) [16].

The speech audiometry measured hearing thresholds for monosyllabic and trisyllabic word discrimination. Results were reported according to the American Academy of Otolaryngology-Head and Neck Surgery and its Committee of Hearing and Equilibrium, which classifies speech audiometry curves in A, B, C and D, depending

on word recognition. Classified as A if it recognized > 70% of the words in < 30 dB, B > 50% between 30 and 50 dB, C > 50% in > 50 dB, and D < 50% at any intensity volume [17].

The presence of tinnitus was defined as an episode of ringing of ears occurring in the last two weeks for at least one hour. Subjects who reported tinnitus completed the Tinnitus Handicap Inventory (THI). Its purpose is to evaluate the impact of the severity of tinnitus on patients' quality of life. This instrument consists of 25 questions and each answer is classified with a score of 0, 2 or 4. A greater score indicates a more severe handicap. No handicap exists when final score results are < 16, mild handicap is considered from 18 - 36 moderate from 38 - 56, severe from 58 - 76 and catastrophic from 78 - 100 [18].

Statistical analysis

Hearing thresholds, speech audiometry, and the presence of tinnitus and its severity in both groups were compared. The Kolmogorov-Smirnov test was used to evaluate data normality. Central tendency and dispersion data were obtained, expressed as mean and standard deviation for parametric data, and as median and percentiles in non-parametric data. Comparisons between the different study groups were made using a two-tailed Student´s t-test and one-way ANOVA for parametric data, and Mann-Whitney U and the Kruskal-Wallis test for nonparametric data. A ≤ 0.05 P value was considered statistically significant. SPSS version 20 (IBM, Armonk, NY) for Windows 7 was used for statistical analysis.

Results

Demographic data

We evaluated a group of 131 patients with SAH and compared them to 331 healthy controls. Audiological profiles were analyzed in both groups, as well as the presence and severity of tinnitus. Our study group of patients diagnosed with SAH was composed of 42 (31.2%) female and 89 (67.9%) male subjects. The age in this group ranged from 18 to 82 years, with a mean of 58.2. Time since diagnosis ranged from 1 to 84 months with a mean of 10.58. The number of antihypertensive drugs used in this population ranged from 0 to 4, with a mean of 1.41. Twelve (9.2%) patients also had been diagnosed with diabetes mellitus type 2 (DMT2), 10 (7.6%) had a regular intake of alcohol and, 16 (9.9%) were active smokers.

A control group of 331 subjects was included. This group was composed of 93 (28.1%) female and 238 (71.9%) male subjects, with an age ranging between 19 to 75 years, with a mean of 56. No significant difference was observed regarding gender (p = 0.28) or age (p = 0.19) when comparing the subjects with SAH to the control group (Table 1).

	SAH (n = 131)	Healthy controls (n = 331)	p value
Gender			0.28
Female, n (%)	42 (31.2)	93 (28.1)	
Male, n (%)	89 (67.9)	238 (71.9)	
Mean Age (range)	58.24 (18 - 82)	56 (19 - 75)	0.19
Mean time since diagnosis months (range)	10.58 (1 - 84)	-	-
History of DMT2, n (%)	12 (9.2)	-	-
History of smoking, n (%)	16 (9.9)	-	-
History of alcohol intake, n (%)	10 (7.6)	-	-

Table 1: Demographic characteristics of patients with systemic arterial hypertension and healthy controls.
Abbreviations: SAH: Systemic Arterial Hypertension; DMT2: Diabetes Mellitus Type 2.

Pure tone audiometry (PTA)

The mean hearing thresholds in SAH patients were 18.8 dB (± 8.06) in low, 21.2 dB (± 9.72) in mid and, 35.9 dB (± 17.42) in high frequencies. In patients that had SAH and DMT2 we found hearing thresholds of 15.4 dB (± 3.55) in low, 17.8 (± 4.39) in mid, and 37.8 dB (± 18.65) in high frequencies. Patients who also referred a regular intake of alcohol had thresholds of 18.9 dB (± 8.17) in low, 21.2 dB (± 9.96) in mid, and 35.9 dB (± 17.64) in high frequencies. Those who were active smokers were observed to have mean thresholds of 18.9 dB (± 8.39) in low, 21 dB (± 10.02) in mid and, 35.9 dB (± 17.74) in high frequencies. Patients in the control group showed hearing thresholds of 11 dB (± 2.33) in low, 12.2 dB (± 2.34) in mid, and 15.5 dB (± 5.26) in high frequencies (Figure 1). A significant difference was observed in low (p = 0.0001), mid (p = 0.0003), and high frequencies (p = 0.0001) when comparing both groups (Table 2).

Subjects were stratified by decades of life and their audiological profiles were analyzed. A significant increase of hearing thresholds in patients with SAH who were in the fifth, sixth and seventh

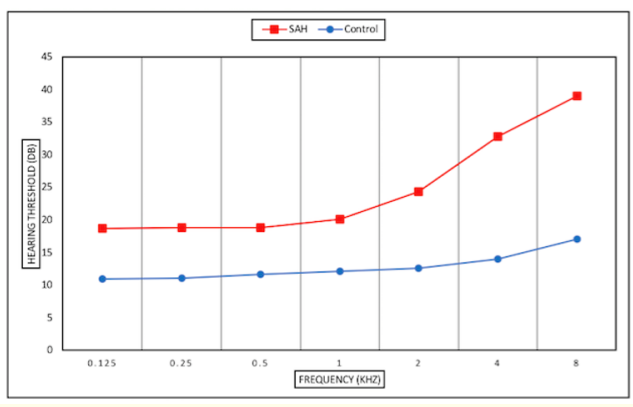

Figure 1: Hearing thresholds of subjects with systemic arterial hypertension (SAH) compared with healthy controls by pure tone audiometry.

	SAH (n = 131)	Healthy controls (n = 331)	p value
Hearing thresholds (dB)			
Low Frequencies	18.8 (± 8.1)	11.0 (± 2.3)	0.0001*
Mid Frequencies	21.2 (± 9.7)	12.2 (± 2.3)	0.0003*
High Frequencies	35.9 (± 17.4)	15.5 (± 5.3)	0.0001*
Presence of tinnitus, n (%)	105 (80.2%)	26 (7.9%)	0.0001*
THI score	15.98 (± 17.6)	4.55 (± 1.5)	0.001*

Table 2: Mean hearing thresholds (dB), prevalence of tinnitus and, mean Tinnitus Handicap Index score in patients with systemic arterial hypertension compared with healthy controls. Abbreviations: SAH: Systemic Arterial Hypertension; dB: Decibels; THI: Tinnitus Handicap Index.

*Statistically significant.

decade of life was observed when compared with subjects in the control group (Table 3).

We found a significant increase in high-frequency hearing thresholds in patients with more than 12 months since SAH diagnosis when compared to patients with a more recent diagnosis. No significant hearing thresholds differences were observed for low and mid frequencies hearing thresholds (Table 4).

Age (years)	Frequencies (Hz)	SAH	Healthy controls	p value
		(n = 131)	**(n = 331)**	
		n = 1	**n = 1**	
18 - 20	Low	22.5 (± 0)	10 (± 0)	-
	Mid	19.2 (± 0)	4.2 (± 0)	-
	High	17.5 (± 0)	3.8 (± 0)	-
		n = 2	**n = 36**	
21 - 30	Low	15 (± 0)	10.1 (± .4)	0.000*
	Mid	12.1 (± 1.8)	11.7 (± 2.5)	0.847
	High	15 (± 0)	12.5 (± 3.5)	0.327
		n = 8	**n = 101**	
31 - 40	Low	18.9 (± 8.2)	10.3 (± 1.1)	0.000*
	Mid	12.9 (± 4.2)	11.7 (± 1.6)	0.425
	High	22.9 (± 10.9)	14.4 (± 3.4)	0.063
		n = 22	**n = 108**	
41 - 50	Low	17.5 (± 7.9)	10.8 (± 1.9)	0.000*
	Mid	16.8 (± 6.1)	11.9 (± 1.5)	0.001*
	High	21.3 (± 6.7)	15.2 (± 5.1)	0.000*
		n = 33	**n = 48**	
51 - 60	Low	18.5 (± 7.3)	11.7 (± 2.9)	0.000*
	Mid	20.8 (± 8.6)	12.7 (± 7.3)	0.000*
	High	32.7 (± 9.5)	16.3 (± 9.6)	0.000*
		n = 49	**n = 32**	
61 - 70	Low	18.5 (± 7.6)	13.6 (± 3.6)	0.000*
	Mid	22.5 (± 7.9)	14.3 (± 4.3)	0.000*
	High	41.9 (± 16.9)	20.7 (± 5.9)	0.000*
		n = 13	**n = 5**	
71 - 80	Low	22.6 (± 12)	14.5 (± 3.8)	0.165
	Mid	26.7 (± 14.3)	13.8 (± 2.5)	0.008*
	High	51.3 (± 16.4)	29 (± 8)	0.011*
		n = 2	**n = 0**	
81 - 90	Low	23.8 (± 0)	-	-
	Mid	49.2 (± 0)	-	-
	High	85 (± 0)	-	-

Table 3: Mean hearing thresholds (dB) in patients with systemic arterial hypertension compared with healthy controls stratified by age.

Abbreviations: dB: Decibels; SAH: Systemic Arterial Hypertension; Hz: Hertz.

*Statistically significant.

Frequency range	Less than 12 months n = 86 (65.6%)	More than 12 months n = 45 (34.4%)	p value
Low frequencies	19.1 (± 8.4)	18.17 (± 7.3)	0.503
Mid frequencies	20.28 (± 9.4)	22.81 (± 10.6)	0.159
High frequencies	33.11 (± 16.1)	41.22 (± 19.3)	0.011*

Table 4: Hearing thresholds (dB) by frequency range (Hz) according to time since systemic arterial hypertension diagnosis. Abbreviations: dB: Decibels; Hertz: Hz. *Statistically significant.

Speech audiometry

In the SAH group, 119 (90.8%) obtained a type A speech audiometry, 12 (9.16%) type B, and there were neither type C nor D. All subjects in the control group had a type A speech audiometry. These results were compared, finding a significant difference (p = 0.0001) between both groups.

Tinnitus and Tinnitus Handicap Index (THI)

Among subjects with SAH, 105 (80.2%) presented tinnitus, in contrast with 26 (7.9%) in the control group, showing a statistically significant difference (p = 0.0001) (Table 2). The mean score of the THI was 15.98 (± 17.67) in the SAH group. Nine (75%) subjects in the SAH group who also had DMT2 reported tinnitus with a mean THI score of 14.89 (± 16.37). Tinnitus was present in 9 (90%) subjects with SAH that also reported a regular intake of alcohol, with a mean THI score of 20.67 (± 16.92). Among active smokers with SAH, 13 (81.25%) presented tinnitus, with a mean THI score of 20 (± 18.01). The mean THI in the control group was 4.55 (± 1.51). We found a statistically significant higher THI score in patients with SAH in contrast with the control group (p < 0.001) (Table 2). THI score in patients with SAH was 16.58 (± 19.32) and 6.65 (± 4.59) for male and female subjects, respectively (p < 0.001). There was no significant difference between smokers and non-smokers in the THI score (p = 0.281), between subjects with DMT2 and non-DMT2 (p = 0.847), and between alcohol consumers and non-consumers (p = 0.928).

The mean time since SAH diagnosis in patients with tinnitus was 9.8 (± 8.81) months compared with 13.66 (± 16.61) in subjects who did not report tinnitus. No significant difference was observed (p = 0.264).

Relationship between hearing loss and tinnitus

In subjects with SAH and tinnitus, the mean hearing thresholds in low frequencies for patients with THI score < 16 were 13.95 dB (± 7.89) and 21.11 dB (± 7.37) for those with a score > 16 (p < 0.001). Thresholds for mid frequencies for subjects with THI score < 16 were 15.36 dB (± 8.41) and 23.5 dB (± 9.05) for those with a score > 16 (p < 0.001). Thresholds in high frequencies in subjects with THI score < 16 were 25.5 dB (± 16.29) and 38.39 dB (± 18.09) for those with score > 16 (p < 0.001).

Discussion

The objective of our study was to determine if patients with SAH had significantly more cochlear impairment than healthy controls. We found that the hearing thresholds for low, mid and, high frequencies were significantly increased in patients with SAH. Tinnitus was significantly more prevalent among patients with SAH and within these patients, the THI score was also significantly higher.

Degenerative changes in the inner ear may occur in patients suffering from systemic diseases [19,20]. Both sensorineural hearing loss and tinnitus have a multifactorial etiology and whether a significant association with SAH exists continues to be controversial. It has been postulated that SAH may induce tinnitus through damage to the cochlear microcirculation [10]. In this setting, Tachibana., *et al.* [3] examined the function and morphology of the cochlea of hypertensive rats. Electrocochleography demonstrated that the function of the cochlea in these rats declined with age to a greater extent compared with normotensive rats. Moreover, the electronmicroscopy showed that the primary site of deterioration was the vascular stria, which irrigates the organ of Corti. Ionic modifications in cell potentials and the impairment of nutrient transport that result from a decrease in capillary blood flow are also implicated in the pathogenesis of cochlear impairment in patients with SAH [21].

Thomas Przewozny., *et al.* [5] reviewed a study that included 1500 older adults with a self-reported history of cardiovascular disease to evaluate cochlear impairment through otoacoustic emissions. It was demonstrated that female patients who referred a history of ischemic heart disease have twice the risk of having cochlear hearing loss. De Moraes., *et al.* [7] performed PTA and blood pressure measurements in middle-aged people. They found a prevalence of 46% in patients with hearing loss, compared with 29% in normal hearing subjects. Mild sensorineural hearing loss was the most common pattern in this subset of patients and SAH was identified as an independent risk factor for hearing loss.

Our sample of patients with SAH presented a statistically significant increase in hearing thresholds in low, mid, and high frequen-

cies in comparison with healthy controls (Table 2). Many studies performing PTA in patients with SAH support our results and have also found a significant increase in hearing thresholds, mainly for high frequencies [6,22,23]. Tan., *et al*. [22] suggested that cochlear microangiopathy might result in hearing loss in patients with SAH after observing a significant increase in hearing thresholds in high frequencies in patients with hypertensive retinopathy compared with a group of healthy subjects [22]. Similarly, Esparza., *et al*. [23] underwent a similar study in which they also found worse evoked OAE in patients with hypertensive retinopathy. Taken together these results suggest the cochlea as another target organ in patients with SAH. Other authors have denied any association between SAH and hearing loss [24,25]. These discrepancies in results may be explained by heterogeneity between compared groups, including age, sex, or comorbidities. In our study, no significant difference was shown for age and gender between the SAH population and the control group.

It is reasonable to consider that SAH and frequent coexisting conditions, such as DMT2, smoking or, obesity, might have a synergistic pathological effect on microcirculation, thus worsening or accelerating hearing loss. We found a similar auditory impairment in subjects with only SAH, and those who also had been diagnosed with DMT2, active smokers and those who reported a regular intake of alcohol. This points to SAH as the main risk factor for hearing loss. Similarly, Chávez-Delgado., *et al*. [26], studying a group of 385 subjects with chronic diseases, did not find any difference in the prevalence of hearing loss between patients with only SAH versus those with the coexistence of SAH, DMT2 and, dyslipidemia. On the other hand, another study compared hearing thresholds in patients with SAH and DMT2 and only DMT2. A significant increase was observed within the former group in all frequencies. Adjusted to age, this difference was only significant in high frequencies [27].

It is important to assess the impact of age in our results, as this is the most important risk factor for hearing loss. Noteworthy, presbycusis has a similar audiometric pattern as hearing loss due to SAH: symmetrical mild sensorineural hearing loss in high frequencies. To avoid the effect of this confounding variable, we stratified our sample by decades of life. We observed that patients with SAH who are between 41 - 50, 51 - 60 and 61 - 70 showed a significant increase in hearing thresholds for low, mid, and high frequencies compared to controls of the same age (Table 3). Thomas Przewozny., *et al*. [5], suggest that in some patients, cochlear dysfunction is too profound to be caused only by age in patients with SAH. Acceleration of the aging effect in the cochlea by SAH has been hypothesized. Rolim., *et al*. [28] compared an initial and subsequent audiometry performed after 4 years between 4 groups: one group had DMT2, the second group had SAH, the third group DMT2 and SAH, and a fourth group of healthy subjects. They found a greater increase in hearing thresholds in the SAH group. These results suggest that SAH has a greater influence in hearing loss compared to DMT2 and that SAH has a progressive deleterious effect over hearing function.

Our SAH population was divided into two subsets, one with < 12 months and the other > 12 months since diagnosis, and their hearing thresholds were compared. We observed significantly increased hearing thresholds in those patients that had more than one year since SAH diagnosis (Table 4). Nicholas S Reed., *et al*. [29] investigated the association of midlife hypertension with late-hearing impairment. They performed PTA in 248 subjects aged 67 - 89 years in 2013 and look back to their study visits since 1983. They found that high blood pressure measured at earlier visits in midlife was associated with poorer hearing in late life.

The frequency of human speech mainly ranges between 500 - 4000 Hz. Although we have discussed that SAH impairs hearing mainly for high frequencies, the comparison between speech audiometry of the subjects with SAH and controls showed a greater auditory and language recognition repercussion in the former group. This finding supports that cochlear impairment due to SAH is extensive and not limited to the region where high frequencies are represented.

Rodrigues Figueiredo., *et al*. [10] observed that the prevalence of SAH in patients with tinnitus ranged between 15 - 49% among five studies. Conversely, the prevalence of tinnitus in patients with SAH ranged between 8 - 52% between five studies. A systematic review and meta-analysis found 8 of 19 studies showing a significant association between tinnitus and SAH. Pooled OR was 1.37 (95% CI 1.16 - 1.62) [30]. We identified a tinnitus prevalence of 80.2% in SAH patients compared to 7.9% in healthy controls, a statistically significant difference (Table 2). A 75% prevalence of tinnitus in the study group among patients who also had DMT2 found, 90% in patients that reported regular intake of alcohol, and 81% in active smokers.

Tinnitus is a bothersome symptom and has previously been related to a decrease in quality of life [13,14]. A study with 19,000 subjects evaluated the quality of life of patients with hearing loss and tinnitus compared to a control group. The authors concluded, using the EuroQol scale, that patients with tinnitus and hearing

loss have a greater risk of having a worse quality of life compared to patients with only hearing loss and also compared with healthy subjects [31]. In a similar manner, another study by Ribero Texeira., *et al*. [32], concluded that quality of life in advanced age patients is influenced by discomfort caused by tinnitus. A study with more than 320 patients reported that no correlation exists between the intensity of tinnitus measured subjectively by audiometry and the impairment that it could generate, measured by the THI score. They state that the impact of tinnitus depends on the severity of psychologic distress, referred as anxiety, depression, irritability, and phobias [33].

All subjects who reported tinnitus in both groups completed the THI to evaluate the impact of tinnitus on quality of life. We observed a mean THI score of 15.98 in patients with SAH and tinnitus, compared to healthy controls in which the mean score was 4.55. This difference was statistically significant (Table 2), however, both results were classified as with no handicap. Interestingly, the THI score in patients with SAH was significantly higher in males than females ($p < 0.001$). We did not find significant differences in the THI score between smokers and non-smokers, subjects with DMT2 and non-DMT2, and alcohol consumers and non-consumers.

Tinnitus is importantly related to age and presbycusis [34,35]. Presbycusis can be a confounding factor in certain studies, however in ours the mean ages of our groups were similar, and no significant difference was observed. We suggest considering tinnitus as a symptom associated with SAH based on our findings and the evidence discussed.

Thiazides, calcium antagonists, angiotensin converting enzyme inhibitors, angiotensin II receptors antagonists, and alpha-blockers are commonly prescribed for patients with SAH. Certain studies have found a significant association between these medications and hearing loss or tinnitus [36,37]. One of the main limitations of our study is the lack of information about antihypertensive drugs used in our population with SAH, thus we cannot define the degree of hearing loss and tinnitus due to their use.

Conclusion

A significant increase in hearing thresholds was observed in patients with SAH when compared to healthy controls. Moreover, the prevalence of tinnitus and its severity is higher in patients with SAH. This evidence consolidates an association between SAH and cochlear impairment, thus we suggest including audiometric studies within the routine protocol in the assessment of patients with SAH and consider bilateral tinnitus as a symptom of this entity. Further research is needed in this area and we hope to encourage new research teams to follow-up patients to identify audiological complications associated with SAH.

Conflict of Interest

The authors have no relevant financial or non-financial interest to disclose.

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