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Pure-Tone Audiometry and Vestibulometry Characteristics in Post-COVID Patients

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SUMMARY

The aim of this study was to investigate the specifics of audiovestibular symptoms and pure-tone audiometry and vestibulometry findings in post-COVID patients. This was a retrospective study including 136 subjects with audiovestibular post-COVID. All subjects underwent pure-tone audiometry and those with vertigo underwent vestibulometry. In the group of 136 subjects, the most common audiologic symptoms were new-onset (χ^2=42; p<0.001) and bilateral (χ^2=29.7; p<0.001) tinnitus, and gradual (χ^2=55.5; p<0.001) and bilateral (χ^2=22.8; p<0.001) hearing loss. In the group of subjects who had vertigo (n=42), benign paroxysmal positional vertigo (BPPV) was more common (64%). Statistically significant differences according to tinnitus (χ^2=28; p<0.001), side of tinnitus (χ^2=11.4; p=0.023), vertigo (χ^2=16.1; p=0.003), hearing loss (χ^2=30.9; p<0.001), and side of hearing loss (χ^2=27; p<0.001) were recorded among particular age groups. The most common loss of individual frequencies was at 4 (59.6%) and 6 (44.8%) kHz. In conclusion, there were statistically significant differences in audiovestibular symptoms among age groups. The main characteristic and specific in pure-tone audiometry was bilateral sensorineural hearing loss at high frequencies of 4 and 6 kHz in patients with gradual hearing loss and new-onset bilateral tinnitus. In vestibulometry findings, vestibular neuritis and BPPV were the most common findings.

KEYWORDS

Tinnitus; Hearing loss; Vertigo; Audiovestibular symptoms; Post-COVID; COVID-19 complications

Introduction

The COVID-19 pandemic has changed the image of the entire world. It is caused by SARS-CoV-2, the seventh human coronavirus discovered in Wuhan, Hubei Province, China, during a pneumonia epidemic in January 2020. Since then, the virus has spread throughout the world. The global spread of the virus, which caused high mortality, led to the pandemic declaration by the World Health

Organization on March 11, 2020[1]. In Croatia, total lockdown was in force from March 16, 2020 until May 4, 2022[2]. The new SARS-CoV-2 virus most commonly affects the upper respiratory system with symptoms such as fever, cough, sore throat, and fatigue. Severe complications such as pneumonia, respiratory insufficiency, and multiorgan failure often occur. However, a large number of cases have a mild clinical presentation or are even asymptomatic[3].

As the pandemic progressed in time, causing several waves and mutations of the virus and affecting an increasing number of people, symptoms that are not closely related to the respiratory tract began to appear and to be observed, e.g., symptoms such as loss of smell and taste, neurological deficits, vascular, gastroenterological and dermatological symptoms, and inner ear symptoms such as hearing loss, tinnitus and dizziness[4].

The post-COVID syndrome is defined as a set of physical and neuropsychiatric symptoms that last more than 12 weeks after the illness caused by the SARS-CoV-2 virus, and cannot be explained by another condition or disease. Symptoms may persist from the onset of the disease or may develop after recovery from the disease caused by the SARS-CoV-2 virus[5,6].

Previous research indicates that the pathogenesis of post-COVID syndrome is multifactorial and the main mechanisms are inflammation, nervous system dysfunction, endothelial damage, and thromboembolism[7,8]. Audiovestibular post-COVID syndrome also exists[9].

Various authors described audiovestibular post-COVID syndrome in their studies, but most of the researches have many limitations, and since the pandemic was present still at the time of the study, we did not have definitive data on the severity and duration of symptoms and the specifics of pure-tone audiometry and vestibulometry.

We already know that various viruses can cause vestibular dysfunction and mild or severe unilateral or bilateral sensorineural hearing loss. The most common mechanism of these damages is direct or indirect damage to the structures of the inner ear[10]. Focusing on severe and life-threatening conditions, audiovestibular symptoms can remain unrecognized and untreated, which can lead to permanent hearing damage, chronic vestibular disturbances and tinnitus, and ultimately to reduction in the quality of life[11].

That is why it is very important to know the specifics of pure-tone audiometry and vestibulometry in post-COVID patients, to detect potential hearing or balance damage in time, and to start therapy and rehabilitation as early as possible.

Materials and Methods

Structure of the study

The proposed research was a retrospective study in which patient data were gathered from the protocol of the Division of Audiology, Department Otorhinolaryngology, and Head and Neck Surgery in the period from January 1, 2021 until January 1, 2022. The study was approved by the Ethics Committee of the Split University Hospital Center (no.: 2181-147/01/06/M.S.-22-02). There were 136 subjects between the ages of 20 and 86, who were divided into 3 age groups (20-40, 41-60 and 61-86 years), with symptoms of hearing loss, tinnitus and dizziness after SARS-CoV-2 infection. All of them had symptoms during the active phase of the disease, and those symptoms were still present three months after the infection, and all subjects had a mild form of the disease. The subjects were selected according to the symptoms of hearing loss (sudden or gradual, unilateral or bilateral), tinnitus (new-onset or with exacerbation, unilateral or bilateral), and vertigo. After coming out of isolation, all subjects underwent pure-tone audiometry, and those with vertigo underwent vestibulometry. All were treated according to the protocol for hearing loss, tinnitus and vertigo with corticosteroids and/or betahistine.

Inclusion criteria

A total of 136 subjects between the ages of 20 and 86 were referred and reported to the Division of Audiology between January 1, 2021 until January 1, 2022 after self-isolation due to SARS-CoV-2 infection, with symptoms of hearing loss, tinnitus and dizziness that persisted for more than 3 months. All of them had symptoms during the active phase of the disease and those symptoms were still present three months after the infection, and all of them had a mild form of the disease.

Exclusion criteria

Patients younger than 20 years and older than 86 years, patients with chronic acoustic trauma, chronic otitis media, previous ear surgery, otosclerosis, head trauma, Meniere's disease and previous vestibular disorders.

Materials

Research materials were the results of pure-tone audiometry and vestibulometry from the registry of the Division of Audiology. The findings also included data on the patient age and gender, history data on audiologic and vestibular symptoms, otoscopic findings, and the established diagnosis. With pure-tone audiometry, we examined hearing thresholds, severity of damage, and type of hearing loss. We determined the type of dizziness through balance tests. Classic vestibular tests were used to diagnose vertigo. These included examination of spontaneous and induced nystagmus, and the caloric test. Dix-Hallpike test was used to exclude benign paroxysmal positional vertigo (BPPV).

Statistical analysis

We inserted data for the research into an Excel table. Data were processed in the MedCalc program (v. 20.110, MedCalc Software, Ostend, Belgium). We presented qualitative data as absolute and relative numbers. We compared qualitative data with contingency tables and the χ^2-test. We examined the normality of distribution of quantitative data using the Kolmogorov-Smirnov test. Our quantitative data did not follow normal distribution, so we presented them with median (Q1-Q3; min-max). We determined difference in quantitative data between two groups using the Mann-Whitney U test. The level of statistical significance was set at $p<0.05$.

Results

The research included 136 subjects with hearing problems, tinnitus or dizziness who had recovered from COVID-19 and had symptoms that persisted for 3 months after recovery. The subjects were treated at the Department of Otorhinolaryngology, Split University Hospital Center. Of the total number, there were 62 (46%) men and 74 (54%) women. The median age of the subjects was 49 years (Q1-Q3: 39-59; min-max: 20-86). The median age of women was 48.5 years (Q1-Q3: 36-62; min-max: 20-86) and of men 49 years (Q1-Q3: 41-57; min-max: 25-76). There was no statistically significant age difference between men and women (Z=0.116; p=0.908).

The results of tinnitus analysis are presented in Table 1. Comparison of distribution of subjects according to tinnitus in relation to the expected uniform distribution (expected frequency was 45.3 subjects or 33.3%) yielded a statistically significant difference (χ^2=42; p<0.001). New-onset tinnitus appeared in 73 (53.7%) subjects, which was 28 subjects more than the expected number (n=45). By comparing distribution of subjects according to the side of tinnitus in relation to the expected uniform distribution (expected frequency was 45.3 subjects or 33.3%), we obtained a statistically significant difference (χ^2=29.7; p<0.001). Bilateral tinnitus appeared in 68 (50%) subjects, which was 23 subjects more than the expected number (n=45).

The results of vertigo analysis are presented in Table 2. The largest number of subjects in this group was without dizziness (χ^2=80; p<0.001). In the group of subjects who had dizziness (BPPV and vestibular neuritis together; n=42), BPPV was more common, occurring in 27 (64%) subjects.

The results of hearing loss analysis are presented in Table 3. By comparing distribution of subjects according to hearing loss in relation to the expected uniform distribution (expected frequency was 45.3 subjects or 33.3%), we obtained a statistically significant difference (χ^2=55.5; p<0.001). Gradual hearing loss occurred in 77 (56.6%) subjects, which was 32 subjects more than the expected number (n=45).

By comparing distribution of subjects according to the side of hearing loss in relation to the expected uniform distribution (expected frequency was 45.3 subjects or 33.3%), we obtained a statistically significant difference (χ^2=22.8; p<0.001). Bilateral hearing loss occurred in 64 (47.1%) subjects, which was 19 subjects more than the expected number (n=45).

Table 4 shows the association of audiovestibular symptoms with the post-COVID patient gender. We did not find a statistically significant difference in the distribution of subjects according

TABLE 1. Number (%) of subjects according to tinnitus variables

		n (%)	p*
Tinnitus	No tinnitus	51 (37.5)	
	New-onset	73 (53.7)	<0.001
	Exacerbation	12 (8.8)	
Side of tinnitus	No tinnitus	51 (37.5)	
	Unilateral	17 (12.5)	<0.001
	Bilateral	68 (50.0)	

*χ^2-test

TABLE 2. Number (%) of subjects according to vertigo variables

		n (%)	p*
Vertigo	No vertigo	94 (69.1)	<0.001
	BPPV	27 (19.9)	
	Vestibular neuritis	15 (11)	

*χ^2-test; BPPV = benign paroxysmal positional vertigo

TABLE 3. Number (%) of subjects according to hearing loss variables

		n (%)	p*
Hearing loss	No hearing loss	52 (38.2)	<0.001
	Gradual	77 (56.6)	
	Sudden	7 (5.1)	
Side of hearing loss	No hearing loss	52 (38.2)	<0.001
	Unilateral	20 (14.7)	
	Bilateral	64 (47.1)	

*χ^2-test

TABLE 4. Number (%) of subjects according to audiovestibular symptoms according to gender

		Gender		p*
		Male	Female	
Tinnitus	No tinnitus	23 (37)	28 (38)	0.950
	New-onset	33 (53)	40 (54)	
	Exacerbation	6 (10)	6 (8)	
Side of tinnitus	No tinnitus	23 (37)	28 (38)	0.990
	Unilateral	8 (13)	9 (12)	
	Bilateral	31 (50)	37 (50)	
Vertigo	No vertigo	47 (76)	47 (64)	0.070
	BPPV	7 (11)	20 (27)	
	Vestibular neuritis	8 (13)	7 (9)	
Hearing loss	No hearing loss	21 (34)	31 (42)	0.287
	Gradual	36 (58)	41 (55)	
	Sudden	5 (8)	2 (3)	
Side of hearing loss	No hearing loss	21 (34)	31 (42)	0.585
	Unilateral	9 (14)	11 (15)	
	Bilateral	32 (52)	32 (43)	

*χ^2-test; BPPV = benign paroxysmal positional vertigo

to tinnitus (χ^2=0.103; p=0.950), side of tinnitus (χ^2=0.020; p=0.990), dizziness (χ^2=5.3; p=0.070), hearing loss (χ^2= 2.5; p=0.287) and side of hearing loss (χ^2=1.07; p=0.585).

Table 5 shows the association of audiovestibular symptoms with the post-COVID patient age. In the distribution of subjects according to tinnitus, there was a statistically significant difference among age groups (χ^2=28; p<0.001). The share of subjects with new-onset tinnitus was 2.8 times higher in the 20-40 age group than in the 61-86 age group. The share of subjects without tinnitus was 2.6 times higher in the 61-86 age group than in the 20-40 age group.

In the distribution of subjects according to the side of tinnitus, there was a statistically significant difference among age groups (χ^2=11.4; p=0.023). The share of subjects with bilateral tinnitus in the 20-40 age group was 1.5 times higher than in the 61-86 age group.

In the distribution of subjects according to hearing loss, there was a statistically significant difference among age groups (χ^2=30.9; p<0.001). The share of subjects with gradual hearing loss in the 61-86 age group was 2.2 times higher than in the 20-40 age group. In the 20-40 age group, not a single subject had sudden hearing loss, whereas in the 61-86 age group, 5 (16%) subjects had this type of hearing loss.

In the distribution of subjects according to the side of hearing loss, there was a statistically significant difference among age groups (χ^2=27; p<0.001).

TABLE 5. Number (%) of subjects with audiovestibular symptoms according to age groups

		Age group (years)			p*
		20-40	41-60	61-86	
Tinnitus	No tinnitus	6 (17)	31 (44)	14 (45)	<0.001
	New-onset	29 (83)	35 (50)	9 (29)	
	Exacerbation	0	4 (6)	8 (26)	
Side of tinnitus	No tinnitus	6 (17,1)	31 (44)	14 (45.2)	0.023
	Unilateral	4 (11.4)	11 (16)	2 (6.4)	
	Bilateral	25 (71.4)	28 (40)	15 (48.4)	
Vertigo	No vertigo	29 (83)	38 (54)	27 (87)	0.003
	BPPV	5 (14)	19 (27)	3 (10)	
	Vestibular neuritis	1 (3)	13 (19)	1 (3)	
Hearing loss	No hearing loss	22 (63)	29 (41)	1 (3)	<0.001
	Gradual	13 (37)	39 (56)	25 (81)	
	Sudden	0	2 (3)	5 (16)	
Side of hearing loss	No hearing loss	22 (63)	29 (41.4)	1 (3)	<0.001
	Unilateral	2 (6)	12 (17.1)	6 (19)	
	Bilateral	11 (31)	29 (41.4)	24 (78)	

*χ2-test; BPPV = benign paroxysmal positional vertigo

The share of subjects with unilateral hearing loss in the 61-86 age group was 3 times higher than in the 20-40 age group. The share of subjects with bilateral hearing loss in the 61-86 age group was 2.5 times higher than in the 20-40 age group.

In the distribution of subjects according to the occurrence of dizziness, there was a statistically significant difference among age groups (χ^2=16.1; p=0.003). The proportion of subjects with BPPV was 1.9 times higher in the 41-60 age group than in the 20-40 age group and 2.7 times higher than in the 61-86 age group. The share of vestibular neuritis in the 41-60 age group was 6 times higher than in the 20-40 age group and 61-86 age group, where we had only one subject with the mentioned problem.

TABLE 6. Number (%) of subjects according to the frequency of hearing loss occurrence

Frequency (kHz)	n (%)
No hearing loss	51 (37.5)
4	24 (17.6)
6	2 (1.5)
4, 6	23 (16.9)
6, 8	2 (1.5)
2, 4, 6	19 (14)
4, 6, 8	2 (1.5)
2, 4, 6, 8	1 (0.7)
All frequencies	12 (8.8)

TABLE 7. Number (%) of subjects according to individual frequencies of hearing loss occurrence

Frequency (kHz)	n (%)
2	32 (23.5)
4	81 (59.6)
6	61 (44.8)
8	17 (12.5)

Table 6 shows the number (%) of subjects according to frequencies at which hearing loss occurred in the group of 136 subjects. Table 7 shows individual frequencies at which hearing loss occurred in the group of 136 subjects. Figure 1 shows distribution of frequencies (kHz) in bilateral gradual hearing loss (n=62), and Figure 2 shows distribution of frequencies (kHz) in bilateral new-onset tinnitus (n=56).

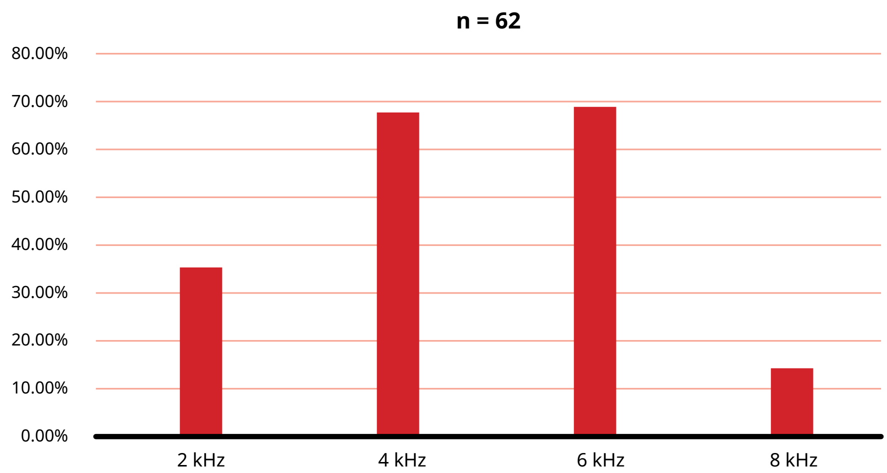

FIG. 1. Distribution of frequencies present in bilateral gradual hearing loss.

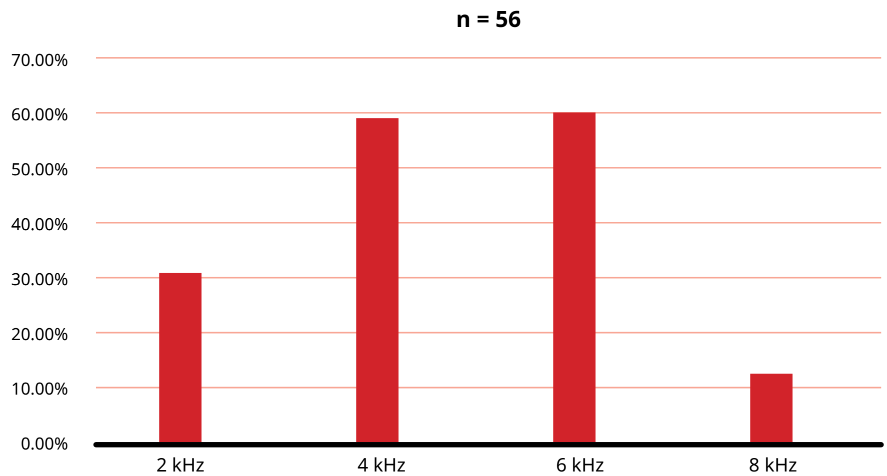

FIG. 2. Distribution of frequencies present in bilateral new-onset tinnitus.

Discussion

Audiovestibular post-COVID syndrome is a new syndrome that arose in the SARS-CoV-2 virus pandemic. These are auditory and vestibular symptoms that appeared during the active phase of the disease, and which persist even 3 months after the infection. As the pandemic progressed, scientists and clinicians began to take great interest in the impact of COVID-19 on the inner ear, and on the duration and description of symptoms[12-14]. In this study, we tried to present and analyze the main characteristics and specificities of the audiovestibular post-COVID syndrome. As previously known, the inner ear is susceptible to viral infection, so it does not surprise us that the SARS-CoV-2 virus is associated with hearing loss, tinnitus and dizziness. These symptoms can be long-lasting, cause significant morbidity, and reduce the quality of life[15].

In this study, the most common post-COVID audiovestibular symptom was tinnitus. New-onset tinnitus is significantly more common than exacerbation of the existing tinnitus, and so is bilateral tinnitus compared to unilateral tinnitus. The proportion of subjects with new-onset tinnitus was significantly higher in the youngest age group (20-40 years) compared to the oldest age group (61-86 years). Also, bilateral tinnitus was significantly more common in the youngest age group compared to the oldest. Such results can be explained by isolation and lockdown, reduced movements, and fear of the elderly population from leaving the house and going to examinations. Furthermore, elderly people often have chronic tinnitus and they got used to it, so they do not associate the symptoms of COVID-19 with it. At the same time, they were focused on the main symptoms of the disease while worrying about their own health. People of younger age were generally not exposed to more severe noxae that could cause tinnitus and most often did not have any comorbidities, so when they noticed the new condition, they reported it to the audiology clinic. Psychosocial triggers of tinnitus that appeared in the pandemic, such as isolation, loneliness, insomnia, depression and anxiety, can play a significant role in the development of this symptom[16]. Other authors also found a significantly higher number of post-COVID patients with bilateral tinnitus in the younger population due to fear of poverty, job loss, emotional disturbances, and psychological disorders[17]. In patients with exacerbation of the existing tinnitus, it is not entirely clear whether these changes occurred due to the direct impact of the virus. Other factors can also play a significant role, such as the use of drugs or vitamins for improvement of the immune response. In a study by Beukes *et al.*, such a group of patients had exacerbation of the existing tinnitus[18]. Disorders of cochlear function caused by various risk factors such as long exposure to noise, ototoxic drugs, aging, and genetic predisposition alongside with neural alterations are considered initial causes of tinnitus in COVID-19 infection[19].

Furthermore, the results of recent studies show that the COVID-19 infection has a harmful effect on the outer auditory hair cells in the organ of Corti. Damage to these cells was recorded through otoacoustic emission. Damage to the auditory system associated with viral infection is mostly intracochlear. The mechanisms of damage to the peripheral auditory system include direct viral damage to the organ of Corti[20].

Approximately one third of the subjects in this study experienced dizziness during the acute phase of the disease, which persisted even three months after the infection. The most common causes of vertigo are BPPV and vestibular neuritis. The distribution of subjects according to the occurrence of dizziness was statistically significantly different in relation to age groups. The distribution of subjects with BPPV and vestibular neuronitis was highest in the 41-60 age group, and BPPV was more prevalent in women.

We believe that BPPV in post-COVID patients is associated with the use of ototoxic and vestibulotoxic drugs, prolonged bed rest, and direct viral damage to the peripheral vestibular system, especially the otolith membrane due to the cytopathic effect of the virus and inflammatory response. Also, cytokine storm or vascular events can lead to tearing of the otoconium from its bed due to vasospasm in the inner ear[21,22].

Vestibular neuritis caused by COVID-19 can be explained by the presence of angiotensin-converting enzyme 2 (ACE2) receptors in the middle and inner ear. These receptors can represent the door for virus entry and vestibular nerve lesions. The potential mechanisms may be ischemia of the *vasa nervorum* and demyelination caused by the inflammatory process[23]. The study by Liotta *et al.* recorded 29.7% of cases of dizziness during the pandemic in general, which roughly corresponds to our results (30.8%)[24].

Our results related to hearing loss show that the largest number of subjects had bilateral gradual hearing loss. We did not find a statistically significant difference in hearing loss between genders, but we found statistically significant differences among age groups. The proportion of subjects with gradual hearing loss was 2.2 times more frequent in the oldest age group than in the youngest age group. Bilateral and unilateral hearing loss were significantly more common in the oldest compared to the youngest age group. The most frequently affected frequencies were 4 and 6 kHz, followed by 2 and 8 kHz, which corresponds to hearing damage due to various acute noxae. According to the available literature, COVID-19 can lead to damage to the outer hair cells, especially those in the high-frequency region[25]. Several hypotheses have been proposed about the mechanism of hearing loss, namely hypoxia, immune-mediated reaction, coagulation diseases, and direct viral invasion of the inner ear, but a combination of several mechanisms may also be involved in the etiopathogenesis[26]. The neuroinvasive theory of the virus is supported by the fact that the olfactory nerve may represent an entry route into the central nervous system, as about 25% of these patients had reduced or lost sense of smell and taste, and disorders of the facial nerve were also described. A mechanism proposed to explain the direct damage associated with SARS-CoV-2 infection involves the ACE2 receptor. It is a binding factor for SARS-CoV-2 in human cells, required for interaction with viral spike proteins. ACE2 receptors are found in the eustachian tube, middle ear, and cochlea. This explains the sensitivity of these tissues to SARS-CoV-2 infection. We found sudden hearing loss in only seven subjects in our study. Only rare studies report on a few isolated cases of sudden hearing loss during the pandemic, and their number is small most likely due to wearing of medical protective masks and social isolation. At the same time, these measures prevented the spread of other viruses that can cause sudden hearing loss. As the cochlear blood supply is terminal with various variants, microvascular disturbances associated with infection and inflammation can cause sudden unilateral hearing loss and ischemic damage[27].

Correct differential diagnosis is required in the approach to the patient with hearing loss that may be related to COVID-19. It is important to link the time at the onset of hearing loss and confirmed SARS-CoV-2 infection through the polymerase chain reaction test, and then regular follow-up of the patient is needed in order to gain an insight into the effectiveness of therapy and duration of these symptoms. Given that the diagnosis in patients with COVID-19 infection is mostly delayed due to isolation and lockdown, timely treatment and therapeutic effect are often missing, resulting in later partial or complete recovery. Previous studies have shown that only about 12% of patients have full recovery. Further research over a longer period of time will show whether recovery or improvement will still occur during this time[28].

Limitations of the study were the small number of subjects, short time of patient follow-up, the pandemic itself reduced the number of visits to the hospital and number of follow-up examinations, so we still do not know the prevalence of individual audiovestibular symptoms. Also, we do not have input parameters or previous hearing or balance tests. Furthermore, the study also included elderly people who probably already had damage to the inner ear, hearing loss, tinnitus or vertigo disorders, so we could not interpret the results with complete accuracy.

Conclusions

The SARS-CoV-2 infection has revealed new clinical manifestations that can last longer than three months. Although we discovered a connection between the coronavirus and hearing loss, tinnitus and dizziness, we still do not know their prevalence because focus was on life-threatening conditions, and hearing and balance disorders were often not recognized as symptoms of the disease or were ignored. Greater attention was paid to these symptoms when they lasted for a long period of time despite therapy. Bilateral new-onset tinnitus and bilateral gradual hearing loss were the most common audiologic symptoms, while the most common vestibular symptoms were BPPV and vestibular neuritis. There was no statistically significant difference in audiovestibular symptoms between genders, but it was recorded among age groups. The main characteristics and specifics in pure-tone audiometry were bilateral sensorineural hearing loss at high frequencies of 4 and 6 kHz in patients with gradual hearing loss and new-onset bilateral tinnitus. On vestibulometry, vestibular neuritis and BPPV were the most common findings. Further research with a larger number of patients and over a longer period of time is needed in order to understand better the impact of the virus on the audiovestibular system, possible complications, and recovery. ■

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SAŽETAK

Specifičnosti nalaza tonske audiometrije i vestibulometrije u post-COVID bolesnika

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Cilj ovog istraživanja bio je istražiti specifičnosti audiovestibularnih simptoma, razliku u audiovestibularnim simptomima te utvrditi glavne karakteristike i specifičnosti u nalazima tonske audiometrije i vestibulometrije u post-COVID bolesnika. Radi se o retrospektivnoj studiji u kojoj su korišteni i obrađivani podatci 136 ispitanika s audiovestibularnim post-COVID simptomima. Svim ispitanicima napravljena je tonska audiometrija, a onima s vrtoglavicom i vestibulometrija. U skupini od 136 ispitanika najčešći audiološki simptomi bili su novonastali (χ^2=42; p<0,001) i obostrani (χ^2=29,7; p<0,001) šum te postupni (χ^2=55,5; p<0,001) i obostrani (χ^2=22,8; p<0,001) gubitak sluha. U skupini ispitanika koji su imali vrtoglavicu (n=42) najčešća je paroksizmalna pozicijska vrtoglavica (*paroxysmal positional vertigo*, BPPV) (64%). Po dobi dokazali smo statistički značajnu razliku razdiobe prema šumu (χ^2=28; p<0,001), strani pojave šuma (χ^2=11,4; p=0,023), vrtoglavici (χ^2=16,1; p=0,003), gubitku sluha (χ^2=30,9; p<0,001) i prema strani gubitka sluha (χ^2=27; p<0,001). Najzastupljeniji gubitak pojedinih frekvencija bio je na 4 (59,6%) i 6 (44,8%) kHz. Zaključno, postojale su statistički značajne razlike u audiovestibularnim simptomima među dobnim skupinama. Glavne karakteristike i specifičnosti u tonskoj audiometriji su obostrani senzoneuralni gubitak sluha u visokim frekvencijama na 4 i 6 kHz kod bolesnika s postupnim gubitkom sluha i novonastalim obostranim tinitusom. U nalazima vestibulometrije vestibularni neuronitis i BPPV su najčešći nalazi.

KLJUČNE RIJEČI

Tinitus; Gubitak sluha; Vrtoglavica; Audiovestibularni simptomi; Post-COVID; Komplikacije COVID-19