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Research Article

Hearing Complaints and Audiometric Findings in Post-covid-19 Patients - A Preliminary Study

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Abstract

Introduction: COVID-19 originates from the infection of the new severe acute respiratory syndrome, coronavirus 2, which spread rapidly around the world, until, in March 2020, it was classified as a pandemic. The classic symptoms are fever, dry cough and shortness of breath, but other associated symptoms such as anosmia, dysgeusia and others may appear. Studies and case reports have been investigating the possibility that COVID-19 also causes hearing loss. Because it is a viral infection, it can damage structures of the inner ear, causing hearing loss. The aim of this study is to identify hearing complaints and correlate them with possible changes in pure tone audiometry in patients infected with COVID-19.

Methods: This is a clinical, observational, cross-sectional and descriptive study. Men and women aged between 18 and 59 years old who were positive for SARS-CoV-2 infection participated in the research, including those who contracted the disease, even without diagnostic confirmation. The anamnesis was answered in person and/or through an electronic form on Google Forms. Bilateral otoscopy, pure tone audiometry by air and bone conduction, vocal audiometry and discomfort threshold investigation were performed.

Results: The sample consisted of 70 participants, of which 11 underwent audiometric tests. The auditory symptoms most reported by the 70 participants were, respectively: sensation of plugged ear, dizziness, hyperacusis, vertigo and difficulty in understanding speech. Of the 11 participants who underwent audiometric tests, all of them had hearing within normal limits and only 1 patient had an alteration in the Speech Recognition Percentage Index. Regarding the results of the discomfort threshold test, 7 patients presented mild to moderate alterations.

Conclusion: Hearing complaints are present in individuals infected by COVID-19, however the sample of individuals who underwent the audiometric examination was small, and it was not possible to correlate hearing complaints with audiometric alterations.

Keywords: Coronavirus Infections; Hearing Loss; Audiology; Audiometry

Introduction

The coronavirus (COVID-19) originates from the infection of the new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and, in December 2019, it spread through China. In January 2020, the World Health Organization (WHO) officially declared the epidemic of this disease as a public health emergency of an international nature, and a pandemic was declared in March 2020.

Since then, the COVID-19 infection continues to wreak havoc. Many countries continue to suffer from the various waves of outbreaks of this virus. Several variants of SARS-CoV-2 have been reported, and some are of more concern than others, namely: "Alpha (B.1.1.7): first variant of concern described in the UK in late December 2020; Beta (B.1.351): first reported in South Africa in December 2020; Gamma(P.1): first reported in Brazil in early January 2021; Delta (B.1.617.2): first reported in India in December 2020; Omicron (B.1.1.529): first reported from South Africa in November 2021" [1].

Although many vaccines have been developed and introduced in virtually every country, the disease has caused several waves of infection across the world, thus increasing the number of infected individuals [2].

The transmission of SARS-CoV-2 occurs through respiratory droplets expelled during speech, coughing or sneezing, which happens during contact with people or contaminated surfaces [3].

The infection caused by SARS-CoV-2 can be asymptomatic or not, ranging from mild or severe symptoms that can progress to death, affecting more severely individuals with associated chronic diseases, such as diabetes, hypertension, heart disease, lung diseases, smoking, advanced age, among others. The classic symptoms of this disease are fever, dry cough and shortness of breath, but other symptoms such as nasal congestion, sputum production, sore throat, runny nose, fatigue, myalgia, headache, diarrhea, nausea, vomiting, among others, may appear [4].

Olfactory and gustatory disorders are also related as clinical manifestations of viral infections. Anosmia was widely observed in patients positive for the coronavirus without other symptoms, leading the loss of taste and smell to the list of symptoms that can appear in contaminated people [4].

Viral infections can cause hearing loss, which may lead to the development of an acquired or congenital, uni or bilateral hearing loss. Studies and case reports have been investigating the possibility that SARS-CoV-2 can also cause hearing loss. Because it is a viral infection, it can damage structures of the inner ear, cause inflammation, and increase the ease of bacterial or fungal infections, which may cause hearing loss. "Typically, virus-induced hearing loss is sensorineural, although conductive and mixed hearing losses can be seen following infection with certain viruses" [5].

COVID-19 can impact the auditory system, be it by directly affecting the inner ear causing labyrinthitis/neuritis, by developing a thrombus/embolus, by causing microcirculation in the inner ear, or by damaging the auditory center in the temporal lobe. xx2021).

For Umashankar, Prakash and Prabhu [2], Pure Tone Audiometry must be the standard audiological test used to assess hearing sensitivity in individuals with COVID-19.

In view of the above, the objective of the present study is to identify hearing complaints and relate them to possible changes in the pure tone audiometry of patients who were infected by COVID-19.

Methods

This is a study with preliminary data from a research project entitled Audiological and Vestibular Assessment in post-COVID-19 patients, approved by the Ethics Committee of Veiga de Almeida University (UVA), under opinion 4,826,883.

This is a clinical, observational, cross-sectional and descriptive study of patients with a previous diagnosis of SARS-CoV-2 infection, carried out at the teaching clinic of Veiga de Almeida University, in the city of Rio de Janeiro, Brazil. All participants received guidance regarding the type of study and accepted to participate by signing a Free and Informed Consent Form either virtually or in person.

Data were collected from May 4, 2021, to November 10, 2021. Men and women aged between 18 and 59 who were positive for SARS-CoV-2 infection, participated in the research, as well as those who did not undergo the confirmatory test, but had specific symptoms of the disease after living with family members that were confirmed positive by laboratory tests.

The research exclusion criteria were: individuals with a history of hearing loss prior to SARS-CoV-2 infection, otoscopy examination outside the normal range, and age from 60 onwards, thus excluding the natural aging process of the auditory organ [6].

In view of the difficulty of an in-person anamnesis data collection, imposed by the isolation itself, the researchers sent an electronic form on Google Forms, allowing a greater number of participants in this stage. The anamnesis collected data regarding the clinical history of the course of the COVID-19 infection and the report of the presence of associated auditory symptoms. The questions analyzed by the research were only related to hearing complaints, without taking other symptoms into account, such as dysgeusia, anosmia, etc., also questioned in the anamnesis.

Patients who attended the teaching clinic in person were submitted to bilateral otoscopy, followed by an audiometric test that consisted of pure tone audiometry by air and bone conduction, in addition to a discomfort threshold survey. Speech Recognition Percentage Index data were also collected. For the classification of the hearing loss degree, the parameters of the World Health Organization 2020 (WHO, 2020) were used, and for the classification of hyperacusis, the Johnson Quotient Scale of the Dynamic Range of Hyperacusis [7] was used.

Data from the present study underwent descriptive and inferential analysis. The software used was SPSS 25.0. The description of the nominal qualitative variables was performed by percentage relative frequency and absolute frequency.

Results

The sample consisted of 70 participants, of which 77.14% (n = 54) had a positive laboratory result for COVID-19 and 22.85% (n = 16) did not undergo an exam to confirm the disease. Out of the total number of participants, 11 underwent the audiometric test, of which 4 did not undergo a laboratory test to confirm COVID-19. The mean age of the participants was 30.7 years, 68.67% were female (n = 48) and 31.43% were male (n = 22). The results presented below (Table 1) show the description of the auditory symptoms reported by the participants:

Categories	n	%
Earache		
No	67	95.71
Yes	3	4.29
Dizziness		
No	49	70.00
Yes	21	30.00
Vertigo		
No	60	85.71
Yes	10	14.29
Secretion in the ear		
No	68	97.14
No	2	2.86
Sensitivity to loud sounds		
No	59	84.29
Yes	11	15.71
Tinnitus		
No	64	91.43
Yes	6	8.57
Clogged ear		
No	48	68.57
Yes	22	31.43
Hearing Loss		
No	67	95.71
Yes	3	4.29
Difficulty Understanding Speech		
No	60	85.71
Yes	10	14.29
Difficulty in Group Conversation		
No	66	94.29
Yes	4	5.71
Difficulty Hearing on the Phone		
No	66	94.29
Yes	4	5.71
Difficulty Hearing the TV		
No	64	91.43
Yes	6	8.57

Table 1: Descriptive analysis of variables related to auditory symptoms in post-COVID-19 patients.

Subtitles: n = Absolute Frequency; % = Percentage Relative Frequency.

The most frequent auditory symptoms were characterized respectively by: sensation of clogged ear (31.43%); dizziness (30.00%); sensitivity to loud sounds (15.71%); vertigo (14.29%); difficulty understanding speech (14.29%); tinnitus (8.57%); difficulty listening to TV (8.57%); difficulty in group conversation (5.71%); difficulty hearing on the phone (5.71%); earache (4.29%); hearing loss (4.29%) and secretion (2.86%).

Tables 2, 3 and 4 show the results and analyzes of the 11 patients who underwent audiometric testing. They were analyzed in alphabetical order and named respectively as P1, P2, P3, P4, P5, P6, P7, P8, P9, P10 and P11, to preserve their identity, being 7 female and 4 male.

In table 2 below, we observe the patients' classification of their degree of hearing according to the parameters of the WHO (2020) and the Speech Recognition Percentage Index (SRPI). The results show that all participants had hearing within the normal range and only 1 patient (P4) showed alteration in the SRPI (88%) with slight/discreet difficulty in understanding speech with the right ear (OD), even with normal hearing [8].

Patients	Right Ear		Left Ear		Hearing Loss Degree (WHO, 2020)
	AC	SRPI	AC	SRPI	
P1	10 dB	100%	13 dB	100%	Normal Hearing
P2	9 dB	100%	5 dB	100%	Normal Hearing
P3	19 dB	100%	15 dB	100%	Normal Hearing
P4	4 dB	88%	3 dB	100%	Normal Hearing
P5	5 dB	100%	-2 dB	100%	Normal Hearing
P6	6 dB	100%	8 dB	100%	Normal Hearing
P7	3 dB	92%	0 dB	92%	Normal Hearing
P8	13 dB	100%	10 dB	100%	Normal Hearing
P9	8 dB	100%	10 dB	100%	Normal Hearing
P10	-5 dB	100%	0 dB	100%	Normal Hearing
P11	19 dB	92%	13 dB	92%	Normal Hearing

Table 2: Quadritonal Mean; Speech Recognition Percentage Index (SRPI); Hearing Loss Degree (WHO, 2020).

Legend: QA = Quadritonal Mean; AC = Air Conduction; RE = Right Ear; LE = Left Ear; SRPI = Speech Recognition Percentagem Index; dB = Decibels.

Table 3 below correlates the symptoms reported in the 11 patients evaluated. In it, we can see that 2 patients (18.18%) did not present any of the aforementioned symptoms, while symptoms such as vertigo and secretion were not reported. The most prevalent complaint was difficulty in understanding speech (45.45%), followed by dizziness (36.36%), sensitivity to loud sounds and feeling of clogged ear, with 3 complaints each (27.27%). Complaints such as earache, tinnitus, and difficulty hearing the TV had 2 reports (18.18), while the complaint for difficulty hearing on the phone and talking in a group had only 1 report each (9.09%).

Symptoms	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Earache										X	X
Dizziness		X				X	X			X	
Vertigo											
Secretion in the ear											
Sensitivity to loud sounds				X						X	X
Tinnitus										X	X
Clogged ear				X						X	X
Hearing Loss											X
Difficulty Understanding Speech	X		X	X					X		X
Difficulty Hearing on the Phone											X
Difficulty Hearing the TV			X								X
Difficulty in Group Conversation										X	

Table 3: Hearing complaints of patients who underwent audiometry.

Table 4 below shows the mean distribution of the 11 participants' hearing thresholds by air and bone conduction, by frequency in each ear. We observed that the values of the minimum and maximum thresholds are at -10dB and 50dB, respectively.

The result of the discomfort thresholds of the 11 patients, according to the Johnson Quotient of the Dynamic Range for Hyperacusis scale, can be seen in Table 5. Patients P2, P5, P7 and P9 had no alterations in their results, whereas patient P1 had a light al-

	Variable (Hz)	Average	Minimum	Maximum	Median
	250	8.64	-5.00	25.00	10.00
	500	7.73	-5.00	25.00	10.00
	1000	7.73	-5.00	20.00	5.00
AC	2000	5.45	-10.00	15.00	5.00
Right Ear	3000	8.18	-5.00	20.00	5.00
	4000	10.45	-5.00	25.00	10.00
	6000	13.18	-5.00	50.00	15.00
	8000	14.55	-5.00	45.00	15.00
	500	0.91	-10.00	15.00	0.00
BC	1000	1.82	-5.00	20.00	0.00
Right Ear	2000	0.91	-10.00	15.00	0.00
	3000	4.55	-10.00	20.00	5.00
	4000	8.64	-5.00	25.00	10.00
	250	9.55	-10.00	20.00	10.00
	500	8.18	-10.00	20.00	15.00
	1000	5.91	-5.00	15.00	5.00
AC	2000	4.09	-5.00	10.00	5.00
Left Ear	3000	6.36	0.00	15.00	5.00
	4000	7.73	-5.00	20.00	10.00
	6000	16.82	10.00	35.00	15.00
	8000	13.64	5.00	35.00	15.00
	500	3.18	-10.00	15.00	5.00
BC	1000	1.36	-5.00	15.00	0.00
Left Ear	2000	0.91	-10.00	10.00	0.00
	3000	4.09	-10.00	15.00	5.00
	4000	6.36	-10.00	15.00	10.00

Table 4: Descriptive analysis of variables related to audiometric examination in post-COVID-19 patients.

Legend: AC = Air Conduction; BC = Bone Conduction; RE = Right Ear; LE = Left Ear.

teration only in the right ear, and a normal result in the left ear. Subjects P3, P8 and P10 presented mild results bilaterally. Patient P6 had mild results in the right ear and moderate in the left ear, while P4 and P11 had moderate results bilaterally.

Patients	Right Ear	Left Ear
P1	Mild	Normal
P2	Normal	Normal
P3	Mild	Mild
P4	Moderate	Moderate
P5	Normal	Normal
P6	Mild	Moderate
P7	Normal	Normal
P8	Mild	Mild
P9	Normal	Normal
P10	Mild	Mild
P11	Moderate	Moderate

Table 5: Results of the discomfort thresholds by the Johnson Quotient of the Dynamic Range of Hyperacusis, related to the audiometric exam of the 11 patients.

Discussion

According to Iannella., *et al.* [9], upper respiratory infections are capable of causing nasopharyngeal inflammation, leading to occlusion and malfunction of the Eustachian tube, generating negative pressure in the middle ear, which may explain the sensation of clogged ear (31.43%) as the symptom most reported by subjects who participated in the online survey.

In the sample of patients who underwent the audiometric examination, individuals P4, P10 and P11 presented a sensation of clogged ears. Literature has been describing several cases of otitis due to SARs-VOC-2, which explains the sensation of clogged ears reported by participants [10].

A study conducted by Saniasiaya and Kulasegarah [11] showed that dizziness has been seen as a relevant clinical manifestation in patients who have been infected by COVID-19. Although not a specific symptom of the disease, it has a history of association with viral infections and should be taken into account. This study observed that dizziness was the second most reported symptom (30%), in agreement with the aforementioned authors. According to Viola., *et al.* [12] viral infections can cause vertigo, as this symptom can occur due to ischemia in the inner ear, a region prone to this type of occurrence. Therefore, complementary studies are be-

ing carried out to find out more about the association of vasculitis with COVID-19. Karimi-Galougahi., *et al*. [13] says that there is still the possibility that ototoxic drugs, such as azithromycin and hydroxychloroquine, used in the treatment of COVID-19, contribute to balance and hearing disorders. Furthermore, vertigo and dizziness in these COVID-19 cases may have the same etiopathogenesis [14].

Dizziness was observed in subjects P2, P6, P7 and P10 who participated in the audiometry. According to the literature, other diseases have already confirmed vestibular disorders of central origin, and it is likely that COVID-19 is capable of having some association with the imbalance disorders reported by patients, due to the propagation of the virus in the vestibular pathways [14].

The term hyperacusis is defined as an intolerance to environmental sounds, even though the individual's hearing thresholds are within the normal range [15]. One of Coey and Jesus' [16] studies on sensitivity to loud sounds, reports that adults are more likely to be at risk of developing hyperacusis due to psychological effects during a stressful life span, which makes it possible to consider that hyperacusis may emerge during the pandemic, as it has been a troubled period in the lives of individuals. The study by Umashankar, Prakash and Prabhu [2] suggests that the COVID-19 virus can cause a change in hearing sensitivity, impacting the individual's hearing quality, and further studies are needed to prove that this symptom is directly linked to COVID-19.

Participants who underwent audiological tests and complained of sensitivity to loud sounds were P4, P10 and P11. When evaluated by Johnson's Ratio for Hyperacusis, we observed that patient P10 had a mild result in both ears, and patients P4 and P11 had a moderate result in both ears. Although the other patients did not complain of hyperacusis, we observed that 4 had altered results by the Johnson Quotient scale.

Concerning speech comprehension difficulties, this needs to be very well investigated, as it may be related to central auditory processing disorder. According to Silva and Barbosa [17], central auditory processing disorder is any change or difficulty in processing what you hear. Another hypothesis for this complaint could even be an undiscovered hearing loss, being noticed only now with the use of face masks, a personal protective equipment (PPE) that came to help in the fight against COVID-19, but which reduced the possibility of orofacial reading and impaired the acoustic transmission of sound. Perhaps this hearing complaint has no correlation with the virus in question TRECCA; GELARDI; CASSANO [18]. A study reports that each mask model causes different acoustic attenuation, depending on the type of material used to manufacture them, which directly impacts the highest acoustic frequencies (2000 - 7000 Hz). The medical mask can reduce from 3 to 4 dB, while the N95 mask reduces almost 12 dB. Thinking of a noisy environment, communication becomes even more difficult, implying worse speech understanding ,HULZEN; FABRY [19].

Among the 11 patients who underwent the audiometric exam, and correlating them with the symptoms of difficulty understanding speech, talking on the phone, hearing the TV, and talking in a group conversation, which are complaints about the same causal factor, difficulty understanding speech, at least one of them was found in patients P1, P3, P4, P9, P10 and P11. Despite all of them having hearing within the limits of normality, it is observed in Table 4 that P3 has a significant lowering in the frequencies of 6000Hz and 8000Hz (which are not included in the quadritonal mean established by the WHO 2020). However, this fact did not interfere with their Speech Recognition Percentage Index, which was 100%, shown in table 2.

A study carried out by Mustafa [5] identifies that there was a worsening in the thresholds of high frequencies pure tones in patients positive with COVID-19. Patient P4 presented a result of 88% in the SRPI, a result that is considered a slight alteration, which justifies his/her complaint about understanding speech.

Participants P1, P9, P10 and P11 did not show significant changes in the test results, both in the pure tone audiometry and in the SRPI. However, this does not imply that the individual has the ability to process and interpret auditory information, which may justify a central auditory processing disorder, because in order to have excellent communication, it is necessary to have the complete integrity of the central and peripheral auditory system ,SANGUEBUCHE; FISH; GARCIA [20].

Regarding the symptom of earache, 2 case reports were found in the literature. The same number as this sample (patients P10

and P11). According to Miri and Ajalloueyan [21], two women who tested positive for COVID-19, they had only otalgia as a symptom. Although they were not diagnosed with otitis media, which could be the cause of the reported complaint, the authors concluded that otalgia is a high-risk warning symptom in viral epidemics.

The complaint and tinnitus in individuals P10 and P11 were also noted, but they did not present hearing loss. Articles show that patients with tinnitus without hearing loss often complain of difficulty understanding speech, BUZO; LOPES [22]. Tinnitus can be a significant indication of future hearing loss, or even a sign of an existing alteration, however not yet identified by conventional methods, and can be better investigated by high-frequency audiometry tests or suppression of otoacoustic emissions RIBEIRO; SILVA [23].

The sensation of hearing loss was reported only by subject P11, but the audiometric examination of the same does not match the complaint. However, the patient had this symptom during the COVID-19 infection. According to Satar [24], hearing loss is likely to occur at the peak of the infection, or after 3 to 4 weeks of it. In this case, a complementary investigation through exams such as high frequency audiometry and otoacoustic emissions is necessary.

Conclusion

It is possible to conclude that hearing complaints are present in individuals infected by COVID-19. However, as the sample of individuals who underwent the audiometric examination was small, it was not possible to correlate hearing complaints with audiometric alterations. Therefore, it is necessary not only to have a larger sample, but also to carry out additional tests.

Final Considerations

During this research, we noticed that symptoms and hearing complaints related to the COVID-19 virus are very recent subjects, requiring more research related to the topic.

Since no significant changes were found in the audiometry exams in relation to the complaints, complementary exams such as immitanciometry and the investigation of otoacoustic emissions become necessary. Due to the fact that many patients present relevant speech comprehension complaints, otoacoustic emissions should be part of the basic audiologic test battery, since they are able to early detect imperceptible cochlear damage in audiometry, or in central auditory processing assessments.

In view of this, our hypotheses will continue to be investigated by the project entitled "Audiological and Vestibular Assessment in post COVID-19 patients", responsible for the preliminary results of which this article consists.

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