Journal of
Modern Rehabilitation

January 2022, Volume 16, Number 1

Research Paper: Auditory and Vestibular Complaints Among COVID-19 Patients: A Descriptive Survey of 300 Young Patients Over a 3-Month Follow-up Period

Zahra Shahidipour[1], **Nematollah Rouhbakhsh**[1], **Elham Tavanai**[1*]

1. Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.

Use your device to scan and read the article online

Citation: Shahidipour Z, Rouhbakhsh N, Tavanai E. Auditory and Vestibular Complaints Among COVID-19 Patients: A Descriptive Survey of 300 Young Patients Over a 3-Month Follow-up Period. Journal of Modern Rehabilitation. 2022; 16(1):69-76. https://doi.org/10.18502/jmr.v16i1.8564

https://doi.org/ https://doi.org/10.18502/jmr.v16i1.8564

Article info:
Received: 02 Mar 2021
Accepted: 07 May 2021
Available Online: 01 Jan 2022

Publisher

Tehran University of Medical Sciences

ABSTRACT

Introduction: COVID-19 is a pandemic disease caused by a novel coronavirus, presenting a wide range of symptoms. Most of the reported symptoms are commonly related to the respiratory system; however, over time, the disease has shown new diverse signs and symptoms. Recent studies have suggested that COVID-19 may affect the auditory and vestibular systems. Besides, little is known about symptoms that persist after the recovery. This study aimed to investigate the general characteristics and especially auditory and vestibular symptoms in young COVID-19 patients over a 3-month follow-up.

Materials and Methods: A total of 300 participants aged 25-45 years took part in this cohort study. They were diagnosed with COVID-19, according to radiographical abnormalities on CT scan and or PCR test, and were in good health based on medical history. Patients who had a history of hearing loss, vertigo, tinnitus, or any disease associated with auditory and vestibular disorders and who were hospitalized and received drugs were excluded. We collected patients' demographics, some common symptoms, and their complaints (acute phase), and 1 month and 3 months later (follow-up phases) using a checklist of symptoms. The participants were asked to describe their chief complaints and, in particular, whether they had any complaints of hearing problems, tinnitus, rotatory vertigo, and aural fullness, or even changes in these symptoms over these periods.

Results: Auditory and vestibular symptoms were observed in a small percentage of COVID-19 patients and were not their chief complaints. Overall, among 300 patients, only about 5% of patients (15 cases) expressed rotatory vertigo, 4% (12 cases) aural fullness, 2.66% (8 cases) tinnitus, and 2.66% (8 cases) hearing problem in the acute phase. However, these symptoms disappeared almost in all participants in the follow-up phases (0 to 3 cases). In addition, none of these symptoms were the patients' chief complaints.

Conclusion: Only a small percentage of COVID-19 patients complained of auditory and vestibular symptoms. It needs to be determined whether these complaints are due to the effects of the virus itself, medications, or stress. The persistence of some symptoms, such as fatigue even after 3 months, indicates the long-term impact of the COVID-19 virus, which necessitates further studies.

Keywords: COVID-19 virus, Auditory, Vestibular

*** Corresponding Author:**
Elham Tavanai, PhD.
Address: *Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 77530636*
E-mail: *etavanai@sina.tums.ac.ir*

1. Introduction

COVID-19 is a pandemic infectious disease caused by a novel coronavirus that started from the city of Wuhan in China and then quickly spread worldwide [1]. At present (26 December 2021), 6,184,762 COVID-19 patients with 131,400 dead cases have been formally reported in Iran. Coronavirus affects different body organs and is associated with a wide range of symptoms and signs, including respiratory, cardiologic, and gastrointestinal, as well as olfactory and gustatory symptoms [2]. It has also become a serious health threat worldwide as mortality increases dramatically [1].

Although respiratory symptoms comprise shortness of breath, coughing, and sore throat, common symptoms among the infected patients, some evidence demonstrates that the coronavirus may also lead to some neurological complications. This is a mysterious virus, and new symptoms are being discovered, and perhaps other symptoms are on the way. In a study of 214 COVID-19 patients with varying degrees of respiratory involvement, 36.4% had symptoms of neurologic manifestations that involved the central nervous system, peripheral nervous system, and skeletal muscles [3]. Among neurological symptoms, olfactory symptoms, ageusia, and headaches were the most common symptoms, but dizziness, neuralgia, altered mental status, paresthesia, gait abnormalities, ocular symptoms have also been observed [4].

Recently, some cross-sectional and case-report studies suggest that COVID-19 may involve the auditory and vestibular systems [1, 5-16]. Symptoms mentioned in the literature indicate the involvement of auditory and vestibular systems in COVID-19 patients include hearing loss, tinnitus, and rotatory vertigo, or a sense of imbalance. Interestingly, brainstem involvement was reported several years ago for other types of coronavirus [17]. Some studies also suggest neuro-auditory involvement in the new COVID-19 virus [1, 2]. Guillain-Barre syndrome, which is a neurological disease associated with COVID-19, is also shown auditory neuropathy [18]. COVID-19 patients often complain of smell and taste disorders that suggest a direct neuropathic effect of the COVID-19 virus [6].

Although several pathophysiological theories have been suggested for the effects of the COVID-19 virus on the auditory and vestibular systems [2, 19], the coincidence of hearing loss or audio-vestibular disorders with COVID-19 does not provide enough evidence for the effects of the virus on the auditory and vestibular system. Some factors other than the COVID-19 virus may impact the auditory and vestibular systems. In cases who complain of tinnitus or Sudden Sensory-Neural Hearing Loss (SSNHL), factors like anxiety and stress have a close relationship with tinnitus [20], SSNHL [21], and vertigo [22]. Therefore, auditory and vestibular complications cannot be attributed solely to the effects of COVID-19 on these systems. On the other hand, there is also concern about the medications used to treat COVID-19 symptoms that pose potential jeopardy to the auditory system. This study aimed to investigate the general characteristics besides auditory and vestibular symptoms in young patients with COVID-19 in a 3-month follow-up period to shed light on the possible short-term and long-term effects of the COVID-19 virus on general health especially on the auditory and vestibular system.

2. Materials and Methods

In this descriptive cohort study, 300 young adults aged 25-45 years were recruited. They were diagnosed with COVID-19 according to Reverse Transcription-Polymerase Chain Reaction test (RT-PCR) and or Computed Tomography (CT) and were in good health based on medical history. We enrolled a homogeneous group of relatively healthy and non-hospitalized individuals. The patients who reported a history of hearing loss, vertigo and tinnitus or any risk factor for auditory and vestibular system disorders (e.g. noise exposure, use of ototoxic drugs) and also who were hospitalized and received any ototoxic drugs were excluded to preclude the impact of aging, ototoxicity, and any contributing factors. Health status (diabetes and high blood pressure, anemia, thyroid disease) was also checked. They were recommended to rest, quarantined for 2 weeks, and use a lot of liquids. After the acute phase, all patients who met the World Health Organization (WHO) criteria for discontinuation of quarantine were followed up for after 3 months from May to August 2020. We collected and calculated demographics, symptoms on admission (acute phase) and after 1 month and 3 months (follow-up phases) using a well-design checklist (face-to-face interview in acute phase and a phone survey in follow-up phases).

The checklist was specially designed to quantify the common symptoms and auditory and vestibular symptoms in these individuals. The subjects were simply asked about all symptoms they experienced in each period. They were asked to explain common symptoms such as dizziness, fatigue, fever, malaise, olfactory symptoms, dry cough, ageusia, dyspnea, headache, nausea and vomiting, chest pain, and anorexia, sore throat, breathing difficulty, diarrhea, ear pain, memory dysfunc-

tion, and skin complications or other symptoms that they experienced during each phase and determine their chief complaints. In addition, the patients were asked if they had any symptoms of the auditory and vestibular systems, such as aural fullness, tinnitus, rotatory vertigo, hearing problems, or changes in these symptoms in these periods. The checklist included questions explicitly asking about the type of dizziness they experienced to differentiate true vertigo with vestibular origin from other causes of dizziness. We asked the patients to describe the feelings of true vertigo (the sensation of spinning or rotational movement of the self or the surroundings), which originate from the vestibular system or other feelings of dizziness (unsteadiness, imbalance, disequilibrium, swimming, light-headedness, and floating) that has a non-vestibular origin. In addition, questions about when the symptoms began, how often the symptoms occurred, how long the symptoms last, and questions about provoking factors, associated symptoms, drug, and medical history were also asked. The obtained data were analyzed using descriptive statistics.

3. Results

The Mean±SD age of the patients was 37.3±16.55 years. Almost all patients presented with at least one of the symptoms, and none of them were asymptomatic. The participants had no history of any disease related to audio-vestibular disorders (e.g. diabetes, high blood pressure). Table 1 presents the frequency of self-reported auditory and vestibular symptoms compared with the other common symptoms. The frequency of general and audio-vestibular symptoms is clearly illustrated in Figures 1 and 2, respectively.

When the patients were asked to describe if they have any signs of audio-vestibular disorders such as tinnitus, rotatory vertigo, aural fullness, hearing problem, or changes in these symptoms, only about 14.33% of patients generally expressed complaints of these symptoms. In the acute phase, rotatory vertigo was the most common complaint among the patients (5%), and some patients expressed other symptoms, including aural fullness (4%), tinnitus, and hearing problem (2.66%) (Table 1 and Figure 2). The patient's audio-vestibular complications reduced significantly in the follow-up phases, especially after 3 months, so that some of the symptoms, like the hearing problem, disappeared completely. After 3 months, rotatory vertigo, tinnitus, and aural fullness were observed in just one or two patients. These participants expressed no severe sudden hearing loss. All patients who had complained of a change in hearing condition expressed that as being slight or mild.

Tinnitus was explained as a high-pitched or a low-pitched sound with no specific pattern and was not bothersome. As mentioned, dizziness was more common than rotatory vertigo among participants. This condition was mainly explained as imbalance, disequilibrium, swimming, and light-headedness. None of the audio-vestibular symptoms were patients' chief complaints, and they were associated with other common symptoms. In addition, there was no relationship between each audio-vestibular symptom and other common symptoms. The results were quite variable; for example, a patient with aural fullness complained of cough, light-headedness, fatigue, and the other patient expressed symptoms such as headache, fever, and olfactory symptoms. None of the patients who were negative for audio-vestibular symp-

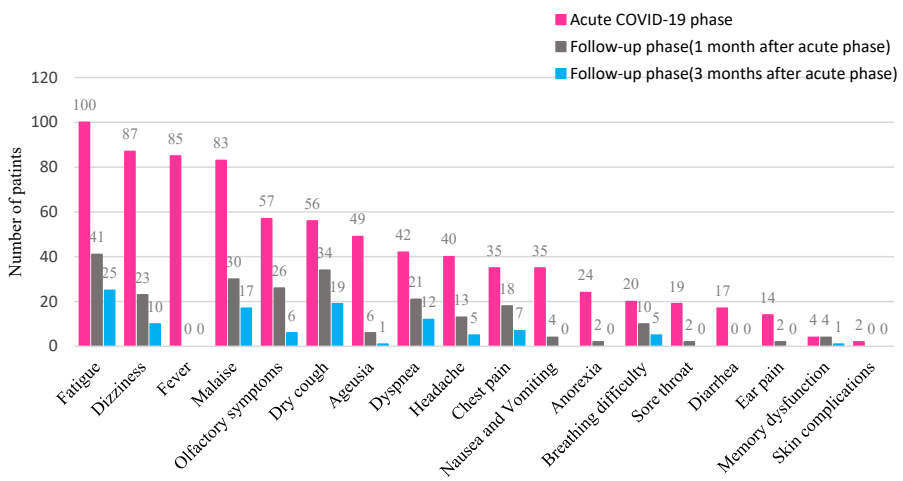

Figure 1. General complaints of patients with COVID-19 infection in the acute and follow-up phases

Table 1. Patient's complaints following COVID-19 infection in acute and follow-up phases (n=300)

Symptoms		Infection Phase, No. (%)		
		Acute	Follow-Up (After 1 Month)	Follow-Up (After 3 Months)
Audio-vestibular	Rotatory vertigo	15(5)	3(1)	2(0.66)
	Aural fullness	12(4)	2(0.66)	1(0.33)
	Tinnitus	8(2.66)	2(0.66)	1(0.33)
	Hearing problem	8(2.66)	2(0.66)	0(0)
Other symptoms	Fatigue	100(33.33)	41(13.66)	25(8.33)
	Dizziness	87(29)	23(7.66)	10(3.33)
	Fever	85(28.33)	0(0)	0(0)
	Malaise	83(27.66)	30(10)	17(5.66)
	Olfactory symptoms	57(19)	26(8.66)	6(2)
	Dry cough	56(18.66)	34(11.33)	19(6.33)
	Ageusia	49(16.33)	6(2)	1(0.33)
	Dyspnea	42(14)	21(7)	12(4)
	Headache	40(13.33)	13(4.33)	5(1.66)
	Chest pain	35(11.66)	18(6)	7(2.33)
	Nausea and Vomiting	35(11.66)	4(1.33)	0(0)
	Anorexia	24(8)	2(0.33)	0(0)
	Breathing difficulty	20(6.66)	10(3.33)	5(1.66)
	Sore throat	19(6.33)	2(0.66)	0(0)
	Diarrhea	17(5.66)	0(0)	0(0)
	Ear pain	14(4.66)	2(0.66)	0(0)
	Memory dysfunction	4(1.33)	4(1.33)	1(0.33)
	Skin complications	2(0.66)	0(0)	0(0)

JMR

toms in the acute phase developed such problems in follow-up phases.

4. Discussion

The findings of the present study showed that among 300 young COVID-19 patients, only a few of them complained of auditory and vestibular symptoms in the acute phase as well as follow-up phases, and most had complaints of other symptoms. In exploring auditory and vestibular complaints, about 5% of patients (15 cases) expressed rotatory vertigo, 4% (12 cases) aural fullness, 2.66% (8 cases) tinnitus, and 2.66% (8 cases) hearing problems in the acute phase. However, these symptoms were reduced to 0 to 3 cases in follow-up phases. None of these symptoms were the chief complaint of patients. They did not exist alone and were accompanied by other symptoms.

According to the available literature, some studies investigated the auditory and vestibular complications due to the COVID-19 infection; they have primarily included case reports and cross-sectional studies. Preliminary reports were obtained from a case or several cases. Recent studies have reported auditory and vestibular symptoms

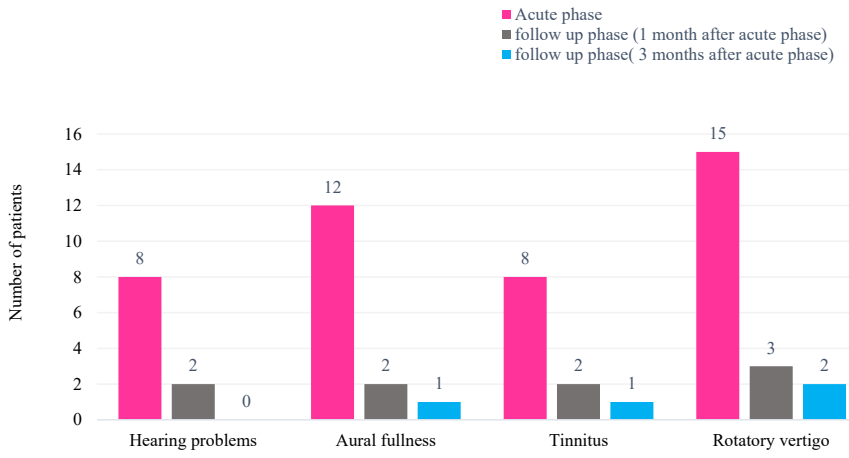

Figure 2. Auditory and vestibular complaints of patients with COVID-19 in the acute and follow-up phases

JMR

in one or a group of COVID-19 patients [1, 5-16]. Collectively, auditory and vestibular complaints in patients following COVID-19 infection were reported in the literature, including hearing problems, acute otitis media, otitis externa, tinnitus, and rotatory vertigo.

Rahman and Wahid described a 52-year-old who was confirmed positive for COVID-19 with a complaint of sudden onset left-sided hearing loss that was preceded by gradually worsening tinnitus. The patient has no ear pain, discharge, dizziness, vertigo, and no history of head trauma or ototoxic medications during his quarantine [11]. In contrast, Degen et al. reported a 60-year-old man who was positive for COVID-19, but the patient had received two medications during his treatment with reported ototoxic effects (azithromycin and furosemide). The patient had no previous episodic or chronic hearing impairment. His audiological assessment revealed complete deafness on the right side and profound sensorineural hearing loss on the left side, along with tinnitus. Magnetic Resonance Imaging (MRI) scan showed pronounced contrast enhancement in the right cochlea and a partially decreased fluid signal in the basal turn of the right cochlea. Adjacent to the temporal bone, meningeal contrast enhancement was seen at the base of the right temporal lobe. Cochlear implant and intratympanic triamcinolone were used to treat auditory disorders in this patient [7]. Fidan reported unilateral CHL in a young case associated with otalgia and tinnitus [5]. Similarly, Sun et al. also reported tinnitus in both ears of a COVID-19 patient [10]. Sriwijitalai and Wiwanitkit reported a patient with a coincidence of neurosensory hearing loss with COVID-19 [2]. In Iran, a survey was performed on 6 young cases with no previous medical problem or ototoxic drug history. Four patients had developed acute tinnitus and unilateral SNHL, and two cases complained of vertigo. They suggested that these otological symptoms are directly related to COVID-19 [7]. Kilic et al. also reported unilateral SNHL in five cases that were confirmed positive for COVID-19 [10].

There are also studies with larger sample sizes. Mustafa evaluated 20 young patients who were confirmed positive for COVID-19 but had no known symptoms. They had no history of hearing loss or a history of any known cause of hearing loss. Transient Evoked Otoacoustic Emissions (TEOAEs) were recorded, and it has been found worst high-frequency pure-tone thresholds and the worst TEOAE amplitudes in this group. He suggested that COVID-19 infection could have deleterious effects on cochlear hair cell functions despite being asymptomatic [9]. Lechien et al. evaluated 1420 young COVID-19 patients and observed that 6 and 5 cases complained of rotatory vertigo and tinnitus, respectively [14]. Elibol et al. explored otolaryngological symptoms in 155 young COVID-19 patients and reported cough, anosmia, and sore throat as the most common symptoms and tinnitus as the least common Ear, Nose and Throat symptoms [16]. They reported ear pain, tinnitus, and SSNHL in 4, 2, and 1 patient, respectively [16]. Another study by Korkmaz et al. on 116 young and elderly COVID-19 hospitalized patients reported hyposmia/anosmia (37.9%) and hypogeusia/ageusia (41.37%) as the most common otolaryngological findings. They also reported dizziness in 31.8%, tinnitus in 11%, true vertigo in 6%, and hearing impairment in 5.1% of patients [17]. According to studies, despite some audio-vestibular symptoms, a few COVID-19 patients complain of these symptoms.

In addition, we also followed the patients for any delayed symptoms of the auditory and vestibular system. The results showed a reduction of audio-vestibular

symptoms in the follow-up phases, especially after 3 months, so that some of the symptoms, such as hearing loss, disappeared completely. No other studies have investigated the incidence and rate of audio-vestibular symptoms in several phases.

Although the pathophysiology of this involvement is not known precisely, some theories have been suggested. One of these theories suggests that the incidence of hearing loss following a viral infection that appears several years after the infection could lead to a variable degree of mild to profound hearing loss depending on the type of virus and treatment [2]. They also suggested some theories about the possible mechanisms underlying the effect of the COVID-19 virus on the auditory system as follows. First, severe acute respiratory syndrome coronavirus 2 causes cytokine release when it binds to the surface receptor Angiotensin-Converting Enzyme 2 (ACE2). This condition involves the hearing center when the inflammatory mediators' released bind to the surface receptors in the temporal lobe. Because ACE2 has been abundant in the temporal lobe, this may involve the hearing centers. Second, as SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) deoxygenates the erythrocytes, there is a possibility that hypoxia in the auditory center may lead to permanent damage and hearing loss. Third, reduced perfusion to the auditory organs due to ischemia [2]. In addition, the DNA of the herpes simplex virus has been found in the vestibular nerve fibers in patients with vertigo secondary to vestibular neuritis [6].

However, it has been suggested that the quality of current theories is poor to explain the effect of COVID-19 on the auditory and vestibular system due to underreporting, and there are major limitations [23]. Some studies just reported hearing and vestibular symptoms without further details. In addition, it is possible that factors other than the COVID-19 virus had an impact on the auditory system. Stress, anxiety, and the ototoxicity of medications are important factors considered. Tinnitus and its relation to stress and depression is a common cause that makes it more likely that these patients experience tinnitus or make their tinnitus worse. There is also a relationship between vertigo and SSNHL with stress and anxiety. As mentioned before, many COVID-19 patients may experience stress, anxiety, and depression as well.

Furthermore, there is concern about the medications which are used for the treatment of COVID-19 symptoms and should be considered, especially in hospitalized COVID-19 patients. Ototoxicity is a feature among some drugs proposed for the COVID-19 treatment. In particular, chloroquine and hydroxychloroquine, azithromycin, and antiviral drugs such as remdesivir, favipiravir, and lopinavir can potentially have ototoxic side effects [24]. Among them, chloroquine and hydroxychloroquine have been widely used during the pandemic; previous studies have shown side effects of these drugs, such as sensorineural hearing loss, tinnitus, and or persistent imbalance. These side effects are sometimes temporary but sometimes permanent [24-27]. However, the ototoxicity of these drugs has been debatable. In some cases, certain combinations may lead to additive ototoxicity as an adverse effect [27]. It has been suggested that the most recent trial of quine family, hydroxychloroquine, has a lower risk of ototoxicity [28]. Therefore, it is necessary to monitor the usage of such drugs because hearing loss and or tinnitus resulting from ototoxicity can be irreversible. Such side effects can be corrected if the medication is stopped and appropriate therapy is instituted.

We performed our survey on a healthy young group of patients that were not hospitalized and had no history of ototoxic drug use to preclude the effects of ototoxicity and aging on auditory and vestibular symptoms. We also followed up patients for 3 months to observe any long-term symptoms of the COVID-19 virus, especially on the auditory and vestibular systems. Auditory and vestibular complaints were observed in a few COVID-19 patients in all phases. The reported auditory and vestibular symptoms in COVID-19 patients probably resulted from either ototoxicity of drugs or other psychological factors like stress, anxiety, and depression that have a close relationship with auditory and vestibular disorders. The most common complaint among these participants in all phases was fatigue. It is necessary to follow-up patients for these types of common symptoms. High-quality studies are needed to investigate the effect of COVID-19 on the auditory and vestibular systems and pinpoint exactly whether the new coronavirus affects the auditory and vestibular system as well as other organs of the body in short and long periods.

5. Conclusion

In this study, auditory and vestibular complaints were observed only in a small percentage of patients diagnosed with COVID-19 in a 3-month follow-up period. It needs to be determined whether these complaints are due to the effects of the virus itself, medications, or stress. The persistence of some symptoms even after 3 months indicates the long-term impact of COVID-19 and needs further studies.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this paper. The patients were informed of the purpose of the research.

This study was approved by the Ethics Committee in research of Tehran University of Medical Sciences with IR.TUMS.FNM.REC.1399.205.

Funding

This research received no specific grant from any funding agency in the public, commercial, or non-profit sectors.

Authors' contributions

Methodology, data collection, data analysis, and writing the original draft: Zahra Shahidipour and Elham Tavanai; Writing, review, and editing: Nematollah Rouhbakhsh.

Conflict of interest

The authors declared no potential conflict of interest.

Acknowledgements

We would like to thank all COVID-19 patients and the doctors who sacrificed their lives in the fight against COVID-19.

References

[1] Sriwijitalai W, Wjwanitkit V. Hearing loss and COVID-19: A note. American Journal of Otolaryngology. 2021; 41(3):102473. [DOI:10.1016/j.amjoto.2020.102473] [PMID] [PMCID]

[2] Saniasiaya J. Hearing loss in SARS-CoV-2: What do we know? Ear, Nose & Throat Journal. 2021; 100(2_suppl):152S-4S. [DOI:10.1177/0145561320946902] [PMID] [PMCID]

[3] Mao L, Jin H, Wang M, Hu Y, Chen S, He Q, Chang J, et al. Neurologic manifestations of hospitalized patients with Coronavirus disease 2019 in Wuhan, China. JAMA Neurology. 2020; 77(6):683-90. [PMID]

[4] Gupta I, Reddy MK, Hussain MM, Murthy PM, Robert CA. Atypical neurological manifestations of COVID-19. Cureus. 2020; 12(6):e8518. [DOI:10.7759/cureus.8518] [PMID]

[5] Fidan V. New type of corona virus induced acute otitis media in adult. American Journal of Otolaryngology. 2020; 41(3):102487. [DOI:10.1016/j.amjoto.2020.102487] [PMID] [PMCID]

[6] Karimi-Galougahi M, Naeini AS, Raad N, Mikaniki N, Ghorbani J. Vertigo and hearing loss during the COVID-19pandemic-is there an association? Acta Otorhinolaryngologica Italica. 2020; 40(6):463-5. [PMID]

[7] Degen CV, Lenarz T, Willenborf K. Acute profound sensorineural hearing loss after COVID-19pneumonia. Mayo Clinic Proceedings. 2020; 95(8):1801-3. [DOI:10.1016/j.mayocp.2020.05.034] [PMID] [PMCID]

[8] Mustafa MWM. Audiological profile of asymptomatic Covid-19 PCR-positive cases. American Journal of Otolaryngology. 2020; 41(3):102483. [DOI:10.1016/j.amjoto.2020.102483] [PMID] [PMCID]

[9] Kilic O, Kalcioglu MT, Cag Y, Tuysuz O, Pektas E, Caskurlu H, et al. Could sudden sensorineural hearing loss be the sole manifestation of COVID-19-19? An investigationinto SARS-COV-2 in the etiology of sudden sensorineural hearing loss. International Journal of Infectious Diseases. 2020; 97:208-11. [DOI:10.1016/j.ijid.2020.06.023] [PMID] [PMCID]

[10] Sun R, Liu H, Wang X. Mediastinal emphysema, giant bulla, and pneumothorax developed during the course of COVID-19 pneumonia. Korean Journal of Radiology. 2020; 21(5):541-4. [DOI:10.3348/kjr.2020.0180] [PMID] [PMCID]

[11] Abdel Rhman S, Abdel Wahid A. COVID-19 -19 and sudden sensorineural hearing loss, a case report. Otolaryngology Case Reports. 2020; 16:100198. [DOI:10.1016/j.xocr.2020.100198] [PMCID]

[12] Cui C, Yao Q, Zhang D, Zhao Y, Zhang K, Nisenbaum E, et al. Approaching otolaryngology patients during the COVID-19-pandemic. Otolaryngology--Head and Neck Surgery. 2020; 163(1):121-31. [DOI:10.1177/0194599820926144] [PMID] [PMCID]

[13] Lechien JR, Chiesa-Estomba CM, Place S, Van Laethem Y, Cabaraux P, Mat Q, et al. Clinical and epidemiological characteristics of 1420 European patients with mild-to-moderate coronavirus disease 2019. Journal of Internal Medicine. 2020; 288(3):335-44. [PMID]

[14] Han W, Quan B, Guo Y, Zhang J, Lu Y, Feng G, et al. The course of clinical diagnosis and treatment of a case infected with coronavirus disease 2019. Journal of Medical Virology. 2020; 92(5):461-3. [DOI:10.1002/jmv.25711] [PMID] [PMCID]

[15] Elibol E. Otolaryngological symptoms in COVID-19. European Archives of Oto-Rhino-Laryngology. 2021; 278(4):1233-6. [DOI:10.1007/s00405-020-06319-7] [PMID] [PMCID]

[16] Özçelik Korkmaz M, Eğilmez OK, Özçelik MA, Güven M. Otolaryngological manifestations of hospitalised patients with confirmed COVID-19 infection. European Archives of Oto-Rhino-Laryngology. 2021; 278(5):1675-85. [DOI:10.1007/s00405-020-06396-8] [PMID] [PMCID]

[17] Wege H, Watanabe R, ter Meulen V. Relapsing subacute demyelinating encephalomyelitis in eats during the course of coronavirus JHM infection. Journal of Neuroimmunology. 1984; 6(5):325-36 [DOI:10.1016/0165-5728(84)90022-5] [PMID]

[18] Wong V. A neurophysiological study in children with Miller Fisher syndrome and Guillain-Barre syndrome. Brain & Development. 1997;19(3):197-204. [DOI:10.1016/S0387-7604(96)00554-2] [PMID]

[19] Rahimi V, Asiyabar MK, Rouhbakhsh N. Sudden hearing loss and coronavirus disease 2019: The role of corticosteroid intra-tympanic injection in hearing improvement. The Journal

of Laryngology & Otology. 2021; 135(5):464-6. [DOI:10.1017/S0022215121001080] [PMID]

[20] Tavanai E, Mohammadkhani G. A different view on the link between tinnitus and cognition; is there a reciprocal link? The International Journal of Neuroscience. 2018; 128(12):1188-98. [PMID]

[21] Chung SD, Hung SH, Lin HC, Sheu JJ. Association between sudden sensorineural hearing loss and anxiety disorder: A population-based study. European Archives of Oto-Rhino-Laryngology. 2015; 272(10):2673-8 [DOI:10.1007/s00405-014-3235-8] [PMID]

[22] Monzani D, Casolari L, Guidetti G, Rigatelli M. Psychological distress and disability in patients with vertigo. Journal of Psychosomatic Research. 2001; 50(6):319-23. [DOI:10.1016/S0022-3999(01)00208-2] [PMID]

[23] Almufarrij I, Uus K, Munro KJ. Does coronavirus affect the audio-vestibular system? A rapid systematic review. International Journal of Audiology. 2020; 59(7):487-91. [PMID]

[24] Ciorba A, Corazzi V, Skarżyński PH, Skarżyńska MB, Bianchini C, Pelucchi S, et al. Don't forget ototoxicity during the SARS-CoV-2 (COVID-19) pandemic! International Journal of Immunopathology and Pharmacology. 2020; 34:2058738420941754. [DOI:10.1177/2058738420941754] [PMID] [PMCID]

[25] Bortoli R, Santiago M. Chloroquine ototoxicity. Clinical Rheumatology. 2007; 26(11):1809-10. [DOI:10.1007/s10067-007-0662-6] [PMID]

[26] Prayuenyong P, Kasbekar AV, Baguley DM. Clinical implications of chloroquine and hydroxychloroquine ototoxicity for COVID-19-19 treatment: A mini-review. Frontiers in Public Health. 2020; 8:252. [DOI:10.3389/fpubh.2020.00252] [PMID] [PMCID]

[27] Skarzynska MB, Krol B, Czajka N, Czajka L. Ototoxicity of drugs used in the treatment of covid-19. Journal of Hearing Science. 2020; 10(1):9-20. [DOI:10.17430/JHS.2020.10.1.1]

[28] Seçkin U, Ozoran K, Ikinciogullari A, Borman P, Bostan EE. Hydroxychloroquine ototoxicity in a patient with rheumatoid arthritis. Rheumatology International. 2000; 19(5):203-4. [DOI:10.1007/s002960000054] [PMID]