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ORIGINAL PAPER

The Incidence of Sudden Sensorineural Hearing Loss (SSNHL) in COVID-19 Patients in Tertiary Care Referral Units

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Abstract

COVID-19 is a new pandemic infectious disease that emerged in Wuhan, China, at the end of 2019. We aimed to evaluate the sudden sensorineural hearing loss (SSNHL) prevalence after COVID-19 infection or even vaccination. This is a two-center retrospective, observational cross-sectional study performed at tertiary care referral Audiovestibular Medicine Units at the period between August 1, 2020, and October 31, 2021. All SSNHL patients diagnosed in a period of a month with COVID-19 or vaccinated with a COVID-19 vaccine were included in this study. Fifty-three cases with confirmed COVID-19 and one patient vaccinated with a COVID-19 vaccine 1 week before, who reported sudden sensory neural hearing loss, were included in this study. Forty-eight patients had unilateral hearing loss and 6 patients had bilateral hearing loss. Forty-nine patients had typical COVID-19 symptoms; one patient discovered them after complaining of anosmia and ageusia and one patient after COVID-19 vaccination; and three patients were complaining only from hearing loss and had a PCR test for nasopharyngeal swabs to prove infection. Different degrees of SSNHL ranged from mild to severe and most of the patients had severe hearing loss. With more patients, COVID-19 may be a potential factor in sudden sensorineural hearing loss. It should be kept in mind that SSNHL may be the only indicator used to identify COVID-19 cases.

Keywords SSNHL · Post COVID hearing loss · Incidence

Abbreviations

CNS	central nervous system
CSOM	chronic suppurative otitis media
dB HL	decibel hearing level
HL	hearing loss
Hz	hertz
ICU	intensive care unit
KHz	kilohertz
OME	otitis media with effusion
PCR	polymerase chain reaction
PTA	pure tone audiometry
RT-PCR	reverse transcription polymerase chain reaction
SARS	severe acute respiratory syndrome
SNHL	sensorineural hearing loss
SPSS	Statistical Package for Social Sciences
SRT	speech reception threshold
SSNHL	sudden sensorineural hearing loss
WDS	Ward discrimination score

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Background

One of the most frightening experiences for people is sudden sensorineural hearing loss (SSNHL), which they might interpret as a potentially fatal condition that could result in profound hearing loss. A hearing loss of greater than 30 dB at three frequencies in a row for no lower than 3 days was referred to as SSNHL [1].

This disease's etiology, proper assessment, and treatment have all been hotly debated over the years, illustrated by the fact that a lot of etiologies have been proposed for this disorder [2]. According to estimates, there are 5 to 20 individuals of sudden SNHL per 100,000 persons each year [3].

The severe acute respiratory syndrome coronavirus (SARS-CoV-2) that causes COVID-19 is an emerging pandemic infectious disease that first appeared in Wuhan, China,

at the end of 2019. This new coronavirus, which was discovered in human airway epithelial cells, was isolated [4]. Its incubation duration varies from 2 to 7 days and can go up to 14 days [5–9].

A third of the cases may be asymptomatic, hastening the disease's spread [10, 11]. Cough, diarrhea, sore throat, fever, muscle pain, headache, and dyspnea are among COVID-19's most typical symptoms. Respiratory arrest and pneumonia have been linked to COVID-19 [12, 13].

Viruses have been linked to neurological symptoms involving facial paralysis, anosmia, and SSNHL [14, 15]. Coronaviruses have been linked to a sense of smell and taste's loss as a result of neural injury [16].

Harenberg et al. reported that more data became available on the coincidence of SSNHL and SARS-CoV-2 infection [17]. The latter has been associated with various thrombosis-related complications, both venous and arterial, leading to systemic multiorgan conditions [18]. The associated viral sepsis affects many organs via angiotensin-converting enzyme 2 (ACE2) receptors and ultimately results in multiple fatal organ failures [19], which may contribute to the pathophysiology of SSNHL. SSNHL is caused by viral infection, vascular occlusion, abnormal cellular stress responses within the cochlea, and immune-mediated mechanisms [20]. SARS-CoV-2 enters the cell via ACE2 receptor [21], and can infect many organs, including the central nervous system, peripheral nervous system, and hearing center in the temporal lobe [22]. The virus promotes excess cytokine release and induces hearing damage [23], endotheliitis, and systemic impaired microcirculatory function [24]. The virus also invades the cochlear nerve, causing neuritis, and soft tissues of the cochlea, causing cochleitis [25].

Occlusion of the cochlear bloodstream can cause sudden hearing loss because of sudden-onset SNHL and the fact that the cochlea is dependent on a single terminal division of the posterior cerebral circulation [26].

Many case reports, case series, cross-sectional studies, and meta-analysis papers reported the association between SSNHL and COVID-19 in the last 2 years. One of the first papers published to examine the correlation between COVID-19 and SSNHL was by Kilic et al. in Turkey in May 2020 when they found one out of five cases diagnosed with sole SSNHL with positive PCR of the COVID-19 virus [27].

Koumpa et al. in September 2020 published a case report of a 45-year-old male who had SSNHL when he was admitted in the hospital after 10 days of being positively diagnosed with COVID; 1 week after extubation and after he was transferred out of the ICU, sudden-onset hearing loss was noted [28].

Five subjects who experienced SSNHL throughout COVID-19 were the subjects of a case study presented by Ricciardiello et al. No patient had SSNHL as their first symptom of COVID-19; instead, they demonstrated audiovestibular symptoms greater than 6 days after the SARS-CoV-2 diagnosis. Adult COVID-19-positive participants with mild clinical manifestations were chosen as patients [29].

Three patients with SSNHL were noted by Jeong et al. within 3 days of receiving the COVID-19 vaccination, and they hypothesized a correlation between them [30]. After vaccination, viral antigens may cause an immunologic reaction that releases antibodies and cytokines, which in turn triggers an autoimmune response in the cochlea and may cause the cochlea's vasculitis and vascular ischemia [31].

We sought to assess the prevalence of sudden sensorineural hearing loss (SSNHL) following infection with COVID-19 or even vaccination.

Materials and Methods

This was a two-center retrospective, observational cross-sectional study performed at tertiary care referral Audiovestibular Medicine Units at two university hospitals at the period between August 1, 2020, and October 31, 2021. All SSNHL patients diagnosed in a period of a few days to few weeks with COVID-19 or vaccinated with a COVID-19 vaccine were included in this study and followed up for a few months. The diagnosis was done through detailed history about the hearing loss onset and course, temporal relation to COVID infection, and the duration.

The eligible candidates presented with SSNHL which was characterized as a hearing loss of more than 30 dB at least three consecutive frequencies over a time of less than 3 days [1].

Because we do not have the baseline audiogram of the patients, we depend on the temporal relationship between hearing loss and COVID-19 infection, based on the patient's history, reporting that the hearing condition was normal before the COVID attack and deterioration of hearing after infection.

Inclusion Criteria

- All COVID-19 patients who complained of sudden hearing loss were evaluated and followed up.
- Before being admitted to the COVID hospital, all of the study participants' reverse transcription polymerase chain reaction (RT-PCR) findings for SARS-CoV-2 were positive.
- Patients were considered for the study if they had recently developed sudden SNHL, were recovering from it (2 negative PCR), had been hospitalized, or were being treated as home isolates.

Exclusion Criteria

- Patients who did not meet the criteria for COVID-19 diagnosis.
- COVID patients with abnormal middle ear function due to OME or CSOM.
- Patients with risk factors like hypertension, diabetes mellitus, cardiovascular disease, drug ototoxicity, head trauma, renal diseases, and thyroid dysfunction that could be claimed as a factor for SSNHL, so COVID patients with such factors were excluded from the study.

The aim of such exclusion criteria was to look for the sole effect of COVID-19 on the sensorineural hearing affection only, without adding other risk factors for developing SSNHL.

Methods

Initial Assessment and Evaluation

- A full detailed personal history included age, sex, occupation, residency, and special habits.
- Medical history including history of the ear trauma, surgeries, chronic inflammation, drug ototoxicity, noise exposure, meningitis, hypertension, thyroid diseases, diabetes mellitus, and kidney diseases.
- Detailed history about the SARS-CoV-2 infection (onset, course, duration, and complications).
- Detailed history of hearing loss, onset, course, duration, and relation to COVID infection.
- Otoscopic examinations prior to audiological testing.

Audiological Evaluation

Basic audiological assessment involved the following:

❖ Pure tone audiometry at octave frequencies between 250 and 8000 Hz; PTA was done using an Interacoustics AC 40 two-channel pure tone audiometer with a locally manufactured sound-treated booth.

❖ Speech audiometry, such as Ward discrimination scores (WD percent), utilizing Arabic phonetically balanced words for adults [32], and speech reception threshold (SRT), utilizing Arabic spondee words for adults [33].

❖ Acoustic immittance measurements including tympanometry and acoustic reflex threshold measurements at 0.5–4 KHz by the Interacoustics AT 235.

Basic audiological evaluations were conducted with all safety procedures for the COVID-19 pandemic. The average values for the hearing threshold at 500, 1000, 2000, and 4000 Hz were calculated, and the pure tone average higher than 25 decibels was regarded as hearing loss (HL) [34]; HL was classified into the following:

- Mild HL (26–40 dB HL),
- Moderate HL (41–55 dB HL),
- Moderately severe HL (56–70 dB HL),
- Severe HL (71–90 dB HL), and
- Profound HL (more than 91 dB HL).

Statistical Analysis

The Statistical Package for Social Sciences (IBM-SPSS/PC/VER 24) was used to verify, code, and analyze the gathered data [35]. Statistically descriptive data calculations included means, medians, standard deviations, ranges, and proportions. Significance test: A post hoc test was estimated utilizing Bonferroni corrections for pairwise comparisons between the study groups for continuous variables with more than 2 groups in order to test the data's mean differences that pursue a normal distribution and have replicated measures. A p value of 0.05 or less was considered significant.

Results

Fifty-three cases with confirmed COVID-19 and one patient vaccinated with a COVID-19 vaccine (BioNTech Vaccine) 1 week before reporting SSNHL were included in this study. Among these patients, the mean age was 47.81 (± 16.8) years with range from 13 to 75 years, and both genders were included in the study with equal proportion 1:1 (Table 1).

Forty-eight cases had unilateral hearing loss, while 6 patients had bilateral hearing loss. The mean duration of SSNHL was 22.39 (± 21.28) days ranging from 1 day after deafness to 90 days before seeking medical advice (Table 2).

Different degrees of SSNHL ranged from mild to profound hearing loss, and most of the patients had profound hearing loss (21). Tinnitus was the irritant symptom (100%) that drove the patients to seek medical advice. Neurological manifestations were observed in two patients and were diagnosed as meningoencephalitis (Table 3).

Table 1 Demographic and clinical characteristics of the study cohort

Parameter		$n = 54$
Age in years	• **Mean ± SD**	47.81 ± 16.8
	• **Median (range)**	50 (13–75)
Sex	• **Female**	27 (50%)
	• **Male**	27 (50%)

Table 2 Hearing loss–related characteristics of the study cohort

Parameter			$n = 54$
COVID-19 symptoms		• **Only symptom**	3 (5.6%)
		• **Taste and smell**	1 (1.9%)
		• **Post-vaccination**	1 (1.9%)
		• **Typical COVID-19**	49 (90.6%)
	Duration of HL/days	• **Mean ± SD**	22.39 ± 21.28
		• **Median (range)**	14 (1–90)
	Onset of HL Post-COVID	• **Mean ± SD**	8.15 ± 5.17
		• **Median (range)**	7 (3–30)
	Side of HL	• **Left**	21 (38.9%)
		• **Right**	27 (50%)
		• **Bilateral**	6 (11.1%)

Table 3 Hearing loss–related clinical characteristics of the study cohort

Parameter			$n = 54$
	Severity	• **Mild**	2 (3.7%)
		• **Moderate**	4 (7.4%)
		• **Moderately severe**	13 (24.1%)
		• **Severe**	14 (25.9%)
		• **Profound**	21 (38.9%)
	Associated symptoms	• **Tinnitus**	54 (100%)
		• **Vertigo**	18 (33.3%)
	Neurological manifestations	• **Yes**	2 (3.7%)
		• **No**	52 (96.3%)
	Tympanogram acoustic reflex	• **Type A**	54 (100%)
		• **Present**	19 (35.2%)
		• **Absent**	25 (64.8%)

Table 4 Pure tone audiometry thresholds among patients

Frequency	PTA threshold	*p*-value**		
• 250 Hz (1)	60.25 ± 6.2	1 vs 2= 0.313	2 vs 4= 0.490	**4 vs 5< 0.001**
• 500 Hz (2)	63.25 ± 6.3	1 vs 3= 0.205	**2 vs 5= 0.003**	**4 vs 6= 0.020**
• 1000 Hz (3)	66.25 ± 6.8	1 vs 4= 0.293	**2 vs 6= 0.021**	5 vs 6= 0.915
• 2000 Hz (4)	64.00 ± 7.6	**1 vs 5= 0.003**	3 vs 4= 0.856	
• 4000 Hz (5)	67.90 ± 7.4	**1 vs 6= 0.013**	**3 vs 5= 0.005**	
• 8000 Hz (6)	69.25 ± 7.5	2 vs 3= 0.287	**3 vs 6= 0.049**	
p-value*	**0.021**			

***One-way repeated measure ANOVA was used to compare the mean differences over time

**Post hoc test with Bonferroni corrections was used for pairwise comparisons

Bold values denote statistical significance at the $p < 0.05$ level

Most of hearing loss occurred in the high frequencies and most of the patients had profound hearing loss at 4000 and 8000 Hz according to statistical analysis (Table 4; Fig. 1).

Discussion

Hearing is one of the most important senses of the human body. SSNHL is a catastrophe and a life-threatening disorder that can occur at any age in short time.

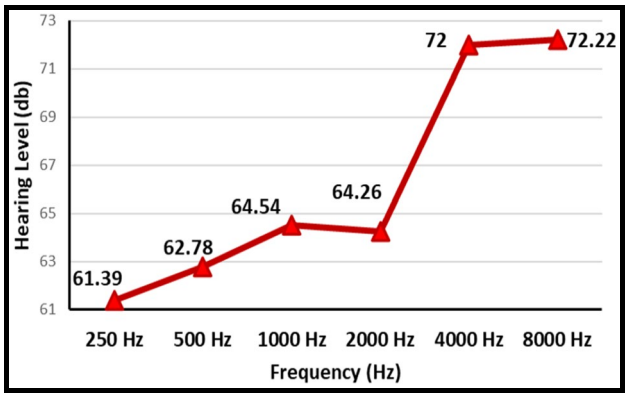

Fig. 1 Pure tone audiometric findings among cases

Viral infections are common causes of hearing loss, like CMV, herpes, measles, and mumps, so it is speculated that coronavirus can cause hearing loss [36].

COVID is both respiratory and vascular diseases as it is well known that coronaviruses cause anosmia and neurological manifestations, so it is suggested that it can affect other sensory systems particularly the audiovestibular system. There are three mechanisms associated with the incidence of SSNHL in viral infections, namely (1) neuritis induced by auditory nerves or cochlea's viral infection; (2) the perilymphatic tissues' viral involvement; and (3) stress response that occurred by antigens' cross-reactions of the inner ear [37]. Induction hearing loss caused by various viruses in animal studies has been documented either indirectly by the cerebrospinal fluid or directly by the inner ear structures [38, 39]. Another possible cause is occlusion of the labyrinthine artery which is one of the end arteries in the body [40].

After about four waves of the COVID-19 pandemic, and more expected to come, many disorders were discovered every day to be caused by CoV-SARS-2 virus infection. The mechanism by which the CoV-SARS-2 virus causes many neurological manifestations is not well understood, but this virus causes vasculitis and predisposes to coagulative occlusion of arteries; SARS-CoV-2 intranasal delivery has demonstrated neuroinvasion and encephalitis [19] or is due to neural injury proved in a previous SARS outbreak [16, 41].

Cerebrospinal fluid studies from the time of the prior MERS-CoV and SARS-CoV outbreaks revealed the viral nucleic acid, and autopsy studies' existence revealed neurological inclusion [42, 43]. Similarly, SARS-CoV-2 autopsy findings in patients demonstrated hyperemic and edematous brain tissue with neuronal deterioration; autopsy seems to be the only way to definitively establish a basis for understanding the neural loss brought on by the virus [44].

Numerous reports have addressed a wide range of neurological signs in light of the neurological involvement of SARS-CoV-2. The neuro-evolving COVID molecular, systemic, and cellular mechanisms, which are classified as the short- and long-term neurological impacts of COVID-19, were discussed by Jesuthasan et al. [45]. They focused especially on demyelinating, cerebrovascular, and encephalitic presentations, cytokine storm mechanisms, and potential genetic and environmental risk factors for neuro-COVID. Patients who only had non-specific neurological symptoms like vertigo, ataxia, or stroke without odor or taste disturbances, as well as neuralgia brought on by damage to the peripheral cranial nerves, were described by Mao et al. in their report [22]. According to recent data, patients who only have SSNHL as a symptom may also benefit from the same treatment strategy.

This retrospective cross-sectional observational study included fifty-four patients who were diagnosed to have the infection by CT chest and/or PCR of nasopharyngeal swabs except the vaccinated patient that complained 1 week after vaccination. Of the 54 patients, twenty-seven were females (50%). The subjects' average age was 47.81 ± 16.8 years (mean ±SD) with a wide range (13 to 75 years).

The mean duration of hearing loss before seeking medical advice was 22.39 ± 21.28 days. Three of the patients (5.6%) had SSNHL as the only symptom of COVID-19 infection and had a PCR test for nasopharyngeal swabs to prove infection, one patient (1.9%) had loss of smell and taste senses and one patient (1.9%) 1 week after vaccination, and the rest of the patients (49) (90.6%) had typical symptoms of COVID-19 infection (fever, headache, cough, sore throat, dyspnea, and muscle pain). Most of the patients experienced the HL in the first week of infection (8.15 ± 5.17 days) (median 7 days) with one patient after 1 month of infection.

Ear examination showed normal tympanic membrane in all patients; SSNHL was more in the right ear (27 patients, 50%) than in the left ear (21 patients, 38.9%) and six patients had bilateral hearing loss (11.1%). Very wide range of hearing loss was found in patients with 21 (38.89%) of them reaching profound hearing loss, with all patients having normal middle ear (type A tympanogram). Tinnitus was the motivating symptom for all the patients to seek medical advice. Eighteen patients (33.3%) had vertigo and disequilibrium that improved after receiving medical treatment.

Neurological manifestations were detected in two patients and diagnosed as meningoencephalitis. Zubair et al. (2019) reported that among the central nervous system (CNS) signs, impaired consciousness/meningoencephalopathy is a broadly noted manifestation of COVID-19 [46]. According to Zubair et al., the hypothesis that the virus introduces into the brain via the olfactory bulb received significance providing from the finding that anosmia is a reasonably constant symptom of initial COVID-19. Hematogenous infection is another suggested method for the virus to enter the brain. Meningoencephalitis in COVID-19 is a clinical symptom that should be expected, given the potential for SARS-CoV-2 to pervade the central nervous system and our

prior knowledge of MERS and SARS-CoV. In fact, there have been numerous reports of meningoencephalitis linked to COVID-19 in the past few months [47].

Most of the patients had more hearing loss in the high frequencies than in low and mid frequencies with a statistically significant difference between the mean of hearing loss degree between low and mid in one hand and high frequencies on the other hand.

To our knowledge, this study has the largest number of cases of hearing loss that may be induced by COV-SARS-2 virus infection (53) or vaccination in the literature. In the period of the study, 4733 cases were examined in tertiary-based referral units for hearing loss with suspected post-COVID-19 hearing loss in 54 cases with incidence of 11.4/1000 case examined in the audiovestibular medicine units; the high incidence rate may be due to the nature of high selection, and hearing loss may not be documented in patients with severe morbidity; also, we cannot assess the patients with spontaneous recovery of HL.

In a previous cross-sectional study in India done by Swain et al., 16 (2.45%) patients were diagnosed with SSNHL out of 652 patients diagnosed with COVID-19; the SSNHL's prevalence among COVID-19 patients was 2.45%, where most of them were associated with respiratory symptoms [48].

When Parrino et al. compared the annual incidence prevalence of SSNHL and sudden vestibular disorders 2 years before the COVID-19 pandemic, they found that while there was no statistically significant difference between the pandemic period and earlier periods, the SSNHL's overall prevalence and merged acute cochlear-vestibular participation were significantly extreme throughout the pandemic time frame than it had been in the earlier periods [49].

In agreement to previously published studies, our results suggest the association between the increasing number of cases infected by COV-SARS-2 virus and increasing incidence of SSNHL; the mechanism of which is not understood. It should be kept in mind that neuroinvasion of the virus may contribute to many neurological symptoms.

In the present study, SSNHL was noted in three COVID-19 patients, and it was the only symptom that lacked any prior risk variables associated with hearing loss. This finding is significant because it demonstrates that infected patients can also introduce in clinics with signs other than those that have been previously noted in the literature. According to Kilic et al., SSNHL may be the only indicator of a COVID-19 case [27].

We hope that by facilitating these cases' early detection, their isolation, avoidance of their infectiousness in the early duration, and early medical medication, this study would benefit the fields of epidemiology and otorhinolaryngology and audiovestibular medicine.

Conclusion

With an elevating number of patients, COVID-19 may be a contributing factor to sudden sensorineural hearing loss, and it should be kept in mind that SSNHL may not be the only symptom of COVID-19. During this pandemic, knowledge of such a non-specific presentation (SSNHL) of COVID-19 is essential for the isolation of affected individuals and the quick start of COVID-19-treatment.

Recommendation

(1) Long-term follow-ups and increase the number of the sample study. (2) Assessment of the non-affected ears by TEOAEs to detect any subtle insult. (3) Adding the audiovestibular assessment to the test battery of COVID patients after recovery.

Limitation of the Study

- The clinical data of this study is restricted by its small numbers, and the incidence of SSNHL in COVID-19 patients is uncertain because the universal hearing assessment has not been adopted throughout the pandemics.
- Hearing loss may not be noted in patients with severe morbidity.
- The study was only collecting patients who actually complained of hearing loss and missed patients who experienced hearing loss but did not notice or complain.
- Also, we cannot assess the patients with spontaneous recovery of HL.
- Other advanced and objective investigations such as ABR and TEOAEs were not used. This may be related to the fact that all patients were reliable in the study and the suspicion of retro-cochlear pathologies was excluded.

Availability of Data and Materials The data of the current study are available from the corresponding author on reasonable request.

Code Availability Not applicable.

Author Contribution All authors contributed in the study design, writing the original manuscript, and data analysis. All authors read and approved the final manuscript.

Declarations

Ethical Approval and Consent to Participate Verbal consent was taken from all patients to participate in this study and all data were kept confidential. The study was performed in accordance with the Helsinki Declaration of 1975 and its amendments. The study protocol was approved by the Research Ethics Committee and the Institutional Review Board

at Faculty of Medicine, Assiut University, Egypt with IRB approval number 17300724.

Consent for Publication Not applicable.

Competing Interests The authors declare no competing interests.

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