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# Sensorineural hearing loss in post-COVID-19 patients

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**ABSTRACT**

**Background:** Hearing loss (HL) is one of the most common chronic conditions after hypertension and arthritis. Mounting indices suggest that sensorineural hearing loss (SNHL) may be one of the adverse effects of severe acute respiratory syndrome coronavirus 2.

**Objective:** This work aimed at studying SNHL in post-COVID-19 patients, alongside with exploring the relationship between severity of the disease and degree of hearing disability.

**Materials and methods:** This prospective cross-sectional study was conducted at Al-Azhar University Hospitals, Cairo, Egypt. It included 100 post-COVID-19 patients selected according to the study inclusion and exclusion criteria. Pure tone audiometry was done to confirm the presence of HL and to determine its degree.

**Results:** Hundred patients with recent oncent hearing symptoms after documented COVID-19 infection were included. Males (71%) were more affected than females (29%). The most of our cases had bilateral moderate HL (45%). Tinnitus was the most frequently associated otological symptom (96.96%). The time of HL onset varied from days to weeks (55% had time onset between 11-30 days post-confirmed infection). Higher thresholds were detected in all frequencies of affected ears with more deterioration of hearing as frequencies increase. All degrees of HL were detected; mild, moderate, severe and profound. There was no significant correlation between severity of COVID-19 infection and severity of HL.

**Conclusions:** SNHL is one of the extrapulmonary complications of COVID-19. COVID-19 patients may develop hearing affection regardless the severity of the infection. It is recommended to assess hearing functions in patients after COVID-19 for early detection and proper management.

**Keywords:** sensorineural, hearing loss, post-COVID-19

## INTRODUCTION

Viral infections may result in hearing loss (HL) which could be either unilateral or bilateral. The severity of this HL ranges from minor to profound [1]. The pathophysiology of HL may be contributed to direct viral invasion to the labyrinth and or the cochlear nerve, reactivation of latent virus housed in the spiral ganglia and moreover, some systemic immunoregulations against these infections may be engaged [2].

However, viral infection usually causes sensorineural hearing loss (SNHL), certain viruses have been reported to cause different types of HL [3]. As growing scientific and clinical evidence declared that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection (COVID-19) can influence different organs, viral-induced direct neural damage and damage the organ of corti, stria vascularis, and spiral ganglia may explain the chemosensory impairment. The olfactory nerve may be considered the viral vehicle to the central nervous system [5].

The link between SNHL and COVID-19 was firstly explained in April 2020 [6]. This impact might result in long-term morbidity and deterioration of the quality of life [7]. Since the available research data about SNHL and COVID-19 is limited with restricted number of cases, we aimed to study the pattern, type, severity and general characteristics of HL in post-COVID-19 patients and to find out the relation between severity of COVID-19 infection and degree of HL.

## MATERIALS AND METHODS

This retrospective, cross-sectional study was carried out at Al-Azhar University Hospitals, Cairo, Egypt, in the period between January 2021 to April 2023. A total number of 100 post-COVID-19 patients were included.

### Inclusion Criteria

Adult patients aged between 18 and 50 years, previously infected with COVID-19 based on the positivity of real time reverse transcriptase polymerase chain reaction (rt RT-PCR) in their upper respiratory tract swab, with negative history of hearing affection or any auditory symptoms prior to the infection. Yet, they started to complain of HL and auditory symptoms within few days to few weeks after being diagnosed as COVID-19 patients.

### Exclusion Criteria

A preliminary exclusion from the study was applied towards patients with otitis media, systemic conditions which may affect hearing acuity e.g., hypertension, diabetes mellitus (either old or recently diagnosed with COVID-19 infection), autoimmune diseases, iron deficiency anemia, chronic kidney disease, chronic liver disease, metabolic syndrome, etc., as well as those who had history of chronic ear diseases, head trauma, meningitis, ototoxicity(with either medications or any others ototoxic agents ) or frequent exposure to loud noise.

### Data Collection

All participants were subjected to detailed history taking in order to rule out any possibility of being excluded, and to collect profound data about HL onset, course and temporal relation to COVID-19 infection. Measurement of arterial blood pressure, calculation of body mass index (BMI) using the equation: BMI = body weight (kg) / squared height ($m^2$), together with laboratory investigations in the form of complete blood count, erythrocyte sedimentation rate, random blood glucose level, glycated hemoglobin, liver and kidney function tests, lipid profile and immunological tests (ANA, anti double-stranded DNA, rheumatoid factor) were also performed to all participants.

### Audiological Evaluation

A. Otoscopy to investigate the external auditory canal and the tympanic membrane was initially performed.
B. Immittancemetry and ipsilateral acoustic reflex thresholds at 1, 2, and 4 kHz were recorded using an immitancemeter Maico MI 44 (Macio Diagnostics GmbH, Sickingenstraße, Berlin, Germany).
C. Pure-tone audiometry was conducted for each ear by the clinical audiometer Piano Plus VRA (INVENTIS, PD, Padua, Italy), at octave intervals between 250 and 8,000 Hz. All Audiometric evaluations were completed in a specific sound-treated room.

Hearing sensitivity was estimated. Lower limit hearing perceptions of higher than 25 decibels (dB) were regarded as HL [8] and classified as follow:

- Mild HL (26-40 dB).
- Moderate HL (41-70 dB).
- Severe HL (71-90 dB).
- Profound HL (≥ 91 dB).

### Clinical Staging of COVID-19 Infection

After reviewing patients history and hospital files of the previous COVID-19 infection, clinical staging for the disease severity was done according to (WHO interim guideline).

#### *Mild disease*

Patients with any signs or symptoms of COVID-19 (e.g., fever, cough, muscle pain, etc.) but no shortness of breath or abnormal chest radiology.

#### *Moderate disease*

Patients with clinical and/or radiological evidence of lower respiratory tract infection with oxygen saturation ($SpO_2$) ≥ 94% on room air at sea level.

#### *Severe disease*

Patients with an $SpO_2$ < 94% on room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen ($PaO_2$ / $FiO_2$) < 300 mm Hg, a respiratory frequency > 30 breaths/min, or lung infiltration > 50%.

#### *Critical disease*

Patients who have ARDs, Sepsis with multiple organ dysfunction, or septic shock [9].

### Sample Size

We employed Epi-info program (Centers for Disease Control and Prevention [CDC], Atlanta, Georgia, USA) to calculate sample size, taking 20% as a prevalence of hearing impairment among COVID-19 patients relaying on previous study [10], with 95% confidence level and 80% power of study. The estimated minimal sample size was 82 patients. Additional ~22% of participants beyond the calculated sample size were recruited to guard against probable drop out, reaching a total study population of 100 patients.

### Statistics Analysis

Data processing and analysis were done by the aid of the program statistical package for social science version 21 (IBM corp., Chicago, IL, USA). Qualitative data were represented as frequencies and percentages, Chi-square test ($\chi^2$) was used for the comparison between such variables. Quantitative data were exemplified as mean ± standard deviation, independent sample t-test was utilized for comparing between two sets of numerical variables. The significance level was taken at $p < 0.05$.

### Ethical Considerations

The study was revised and approved by the Ethical Committee of Scientific Research (Al-Azhar University, Faculty of Medicine, Cairo, Egypt) with ethical approval number (Chest-70Med-00000070). Confidentiality was preserved for all participants, data were collected anonymously, and the right to refuse sharing or deciding to withdraw from the research was guaranteed without any interference with complete commitment to the Declaration of Helsinki. Informed consent was initially taken from all involved patients.

## RESULTS

In this study we assessed 100 patients who started to suffer from different degrees of HL or hearing symptoms after the proof of being infected with COVID-19. The majority of our patients aged more than 40 years to 50 years (58%). The preponderance of the study population were males (71%) and 55% were from rural areas (**Table 1**).

**Table 1.** Personal characteristics of studied patients

| Items | Frequency (N = 100) | Percentage |
|---|---|---|
| Age (years) | | |
| 18-20 | 3 | 3% |
| 21-20 | 7 | 7% |
| 31-40 | 32 | 32% |
| 41-50 | 58 | 58% |
| Sex | | |
| Male | 71 | 71% |
| Female | 29 | 29% |
| Residence | | |
| Urban | 45 | 45% |
| Rural | 55 | 55% |

**Table 2.** Time to onset of symptoms in post-COVID-19 patients

| Items | Frequency (N = 100) | Percentage |
|---|---|---|
| Onset of HL post-COVID-19 (day) | | |
| 1-10 | 29 | 29% |
| 11-20 | 32 | 32% |
| 21-30 | 23 | 23% |
| 31-40 | 10 | 10% |
| >40 | 6 | 6% |

Note. Mean ± standard deviation = 18.9 ± 12.9; Median= 17; & Interquartile range (Q3-Q1) = 25.75-8.25

**Table 3.** HL-related clinical characteristics of the studied students

| Items | Frequency (N = 100) | Percentage |
|---|---|---|
| Severity of COVID-19 infection | | |
| Mild | 35 | 35% |
| Moderate | 45 | 45% |
| Severe or critical | 20 | 20% |
| Side of HL | | |
| Left | 23 | 23% |
| Right | 32 | 32% |
| Bilateral | 45 | 45% |

**Table 4.** Interconnection between severity of COVID-19 and presence of associated ontological symptoms

| Severity | Frequency (N = 100) | Presence of symptoms | Percentage |
|---|---|---|---|
| Mild | 35 | 5 | 14.3% |
| Moderate | 45 | 15 | 33.3% |
| Severe or critical | 20 | 13 | 65.0% |

The time from confirmation of COVID-19 infection to the onset of HL varied from days to few weeks with a mean of 18.9 ± 12.9 days. 29% of patients developed HL within 1 to 10 days,32% of patients developed HL within 11 to 20days, 23% of patients developed HL within 21 to 30days, 10% of patients developed HL within 31 to 40days, while 6% of patients developed HL after 40 days from the confirmation of COVID-19 infection (**Table 2**).

In our study 35%, 45%, and 20% of the participants suffered from mild, moderate and severe or critical COVID-19 infection, respectively. Bilateral HL was evident in 45% of all patients, Rt sided HL in 32% of patients, while left sided HL in 23% of patients (**Table 3**).

Sixty five percent of those who had severe COVID-19 infection showed other ontological manifestations, 33.3% of patients with moderate COVID-19 showed other ontological symptoms, while 14.3% of patients with mild COVID-19 showed other ontological symptoms (**Table 4**).

**Table 5.** Distribution of associated ontological manifestations among symptomatic patients

| Parameter | Frequency (N = 100) | Percentage |
|---|---|---|
| Tinnitus | 32 | 96.96% |
| Vertigo | 15 | 45.45% |
| Neurological complications | 3 | 9.09% |

The most prevalent ontological symptom among our patients was tinnitus (96.96% of symptomatic patients), vertigo in 45.45% of symptomatic patients, while other neurological symptoms (anosmia and/or ageusia) in 9.09% of symptomatic patients (**Table 5**).

Higher thresholds were detected in all frequencies of affected ears with more deterioration of hearing as frequencies increase (**Table 6**).

All degrees of HL were detected among the studied patients; 26% had mild HL, 44% had moderate HL, 17% had severe HL and 13% had profound HL (**Table 7**).

Regarding the relation between severity of COVID-19 and the degree of HL, there was no significant correlation between severity of COVID-19 infection and severity of HL. Among mild COVID-19 patients; 25.7% had mild HL, 40% had moderate HL, 28.6% had severe HL and 5.7% had profound HL. Among moderate COVID-19 patients; 24.4% had mild HL, 46.7% had moderate HL, 13.3% had severe HL and 15.6% had profound HL. Among severe COVID-19 patients; 30% had mild HL, 45% had moderate HL, 5% had severe HL and 20% had profound HL (**Table 8**).

## DISCUSSION

Many people suffered from SARS-CoV-2 and its long-term complications [11]. SNHL, tinnitus and/or vertigo were reported to occur during and following the infection with COVID-19 [12].

In our study we investigated 100 patients complained of post-COVID-19 infection HL. The majority of cases aged more than 40 years. Our findings reconcile with in [13], as the average age of their patients was 43.1 years. Males were more affected accounting for 71%. This observation concur with the work of [14, 15], who reported that COVID-19-related mortality and morbidity are higher in men than women (**Table 1**).

The onset of HL varied from days to few weeks after the viral infection was confirmed with a mean of 18.9 ± 12.9 days (**Table 2**). This notice runs parallel to the study of [13], who stated that HL usually occurred within two months following the diagnosis of COVID-19. Forty five represented the percentage of our subjects either had a moderate intensity of COVID-19 infection or developed bilateral HL (**Table 3**). Similar findings were recorded in [10]. In that study, 40% of participants were of moderate illness regarding COVID-19 infection, while 65% of HL cases were bilateral. Alongside, in a small British case series of COVID-19 infected patients with sudden SNHL, it was concluded that three out of their four patients suffered from bilateral HL [16]. Moreover, it was accused ototoxicity to stand behind this bilateral hearing impairment [14]. On the flip side, it was declared that bilateral HL is an uncommon feature in the context of COVID-19 era [2].

Other ontological symptoms were observed in 65%, 33.3%, and 14.3% of severely, moderately, and mildly infected patients, respectively. Tinnitus was the most predominant

**Table 6.** Pure tone audiometry thresholds among studied post-COVID-19 patients with HL

| Frequency | Bilateral | | p-value | Unilateral Rt | | p-value | Unilateral Lt | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | Rt | Lt | | Rt | Lt | | Rt | Lt | |
| 250 HZ | 47.0 ± 16.3 | 46.5 ± 18.1 | 0.8 | 58.1 ± 22.3 | 21.9 ± 8.8 | < 0.001* | 18.5 ± 4.9 | 53.0 ± 20.1 | < 0.001* |
| 500 HZ | 52.1 ± 18.9 | 47.7 ± 14.9 | 0.1 | 60.9 ± 21.3 | 22.6 ± 10.5 | < 0.001* | 17.6 ± 4.2 | 56.1 ± 17.4 | < 0.001* |
| 1,000 HZ | 58.4 ± 18.8 | 54.9 ± 17.1 | 0.2 | 64.8 ± 25.2 | 23.1 ± 12.2 | < 0.001* | 16.5 ± 4.8 | 59.5 ± 21.4 | < 0.001* |
| 2,000 HZ | 58.4 ± 20.1 | 59.0 ± 20.6 | 0.9 | 65.3 ± 24.6 | 22.6 ± 13.4 | < 0.001* | 16.9 ± 4.9 | 60.4 ± 21.4 | < 0.001* |
| 4,000 HZ | 62.2 ± 19.1 | 65.2 ± 21.1 | 0.4 | 67.8 ± 27.1 | 24.4 ± 12.3 | < 0.001* | 18.7 ± 5.4 | 62.2 ± 23.2 | < 0.001* |
| 8,000 HZ | 67.4 ± 19.6 | 69.9 ± 19.1 | 0.4 | 73.1 ± 27.2 | 24.2 ± 13.7 | < 0.001* | 20.4 ± 4.5 | 67.8 ± 23.7 | < 0.001* |

**Table 7.** The degree of HL in post-COVID-19 patients

| Parameter | Frequency (N = 100) | Percentage |
|---|---|---|
| The degree of HL | | |
| Mild | 26 | 26% |
| Moderate | 44 | 44% |
| Severe | 17 | 17% |
| Profound | 13 | 13% |

**Table 8.** Association between severity of infection and degree of HL

| Degree of HL | Severity of COVID-19 infection | | | p-value |
|---|---|---|---|---|
| | Mild(35) | Moderate (45) | Severe or critical (20) | |
| Mild | 9 (25.7%) | 11 (24.4%) | 6 (30.0%) | 0.2 |
| Moderate | 14 (40.0%) | 21 (46.7%) | 9 (45.0%) | |
| Severe | 10 (28.6%) | 6 (13.3%) | 1 (5.0%) | |
| Profound | 2 (5.7%) | 7 (15.6%) | 4 (20.0%) | |

complaint followed by vertigo (**Table 4** and **Table 5**). Tinnitus is one of the most common associated symptoms with sudden SNHL (66-93%) [17]. This conclusion matches with the work of [12], which identified SNHL, tinnitus, and vertigo as complications of COVID-19.

Benign neurological complications in the form of anosmia and/or ageusia were detected in 3 patients (**Table 5**). This could be related to viral-induced inflammation [18]. This neuro inflammation provoked by SARS-CoV-2 may affect the brainstem resulting in sensory and motor insults, cranial nerve palsies, impaired consciousness, dysautonomia, and even respiratory failure [19].

Regarding pure tone audiometry, we revealed elevated thresholds both at low and high frequencies with marked deterioration of hearing at higher frequencies. As well, significant differences were explored at each frequency when unilateral HL was present (**Table 6**). This result coincides with [20, 21] that showed significant differences at each frequency in COVID-19 patients with unilateral HL, in addition to revealing more deterioration of hearing at higher frequencies in bilateral HL. Although, the exact cause of this HL is still unknown [20], diversified explanations were suggested. One of those interpretations is the direct viral damage to the inner ear including the organ of corti and/or stria vascularis and spiral ganglia [22]. Hypoxia and its effects on different tissues may be contributing factor. Furthermore, it was stated that the virus may bind to the ACE2 receptors and adverse many organs including cochlea, auditory nerve in addition to the central nervous system [23]. As well, several studies have declared that SARS-CoV-2 could induce an autoimmune response through the production of proinflammatory cytokines [7].

Various degrees of HL were reported in our study, with moderate HL ranked first (44% of our patients) (**Table 7**). This observation is compatible with [24] that clarified that HL due to viral infections may be mild or severe. Moreover, when correlating the degree of HL with the corresponding severity grade of COVID-19 infection, no worthy difference was found among groups (**Table 8**). This result falls in with [25], as they highlighted that even asymptomatic COVID-19 infection is capable of giving rise to SNHL, supporting that viral-related HL is irrelevant to infection intensity.

### Limitations

Being a single center study may be the main limitation of our study. Also the limited data available regarding the previous COVID-19 disease and also HL may not be noted in patients with severe morbidity may be another limitations. So large multi-center studies discussing the issue are recommended.

## CONCLUSIONS

SNHL is one of the extra pulmonary complications of COVID-19 infection. The dgree of hearing affection not related to the severity of COVID-19 disease. The incidence of HL in COVID-19 patients increases with aging. The degree of HL ranged from mild to profound, and bilateral moderate HL is the most common form. It is recommended to assess and follow up hearing functions in patients after COVID-19 for early detection and proper management of such problem.

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**Ethical statement:** The authors stated that the study was approved by the Ethical Committee of Scientific Research (Al-Azhar University, Faculty of Medicine, Cairo, Egypt) on 1 February 2022 (Approval code: Chest-70Med-00000070). Written informed consents were obtained from the participants.

**Declaration of interest:** No conflict of interest is declared by authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

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