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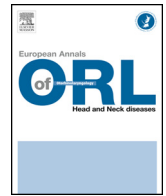
Original article

Incidence and duration of self-reported hearing loss and tinnitus in a cohort of COVID-19 patients with sudden chemosensory loss: A STROBE observational study

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ABSTRACT

Aims. – To investigate the self-reported audiological symptoms in a cohort of coronavirus disease 2019 (COVID-19) patients and monitor improvement or recovery.

Material and methods. – Following the STROBE guidelines for observational studies, a retrospective questionnaire concerning audio-vestibular symptoms was conducted in a cohort of Danish COVID-19 patients with self reported chemosensory loss. Data regarding demographics, symptoms onset, duration and remission was registered in a REDCap database.

Results. – Of the 225 respondents with chemosensory loss, 59 (26.2%) reported concomitant hearing loss (10.7%) or tinnitus (16.4%). In a follow-up questionnaire focused on ear-symptoms, severity, and duration (n = 31), 17 reported hearing loss and 21 reported tinnitus. Debut of hearing loss and tinnitus were on average 10 and 30 days respectively, after onset of initial symptoms. Among the hearing loss patients, only two patients experienced full recovery, whereas 15 had partial or no recovery after on average 266 days from COVID-19 symptom onset. Among the tinnitus patients, 7/21 had full recovery, while 14 had partial or no recovery after on average 259 days from COVID-19 symptom onset.

Conclusion. – In a large Danish cohort of COVID-19 patients, a significant proportion experienced concomitant audiological symptoms which seem long lasting and with negative impact on quality of life. This study warrants further investigation of the association between COVID-19 and audio-vestibular symptoms, and the need for rehabilitation among convalescents.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has caused a worldwide health crisis and affected millions of people. One year into the pandemic, numbers of infected patients and deaths due to COVID-19 are still climbing. Until an efficient vaccine program is completed, COVID-19 will continue to spread, causing vast morbidity and mortality for patients globally.

The course of COVID-19 shows great variety, as known from similar viral infectious diseases, ranging from subclinical or mild symptoms to necessitating intensive care and ultimately death [1]. While fever, body ache, upper and lower respiratory symptoms are common denominators in many viral diseases, a vast amount of publications suggest that anosmia and ageusia are potential specific manifestations of COVID-19 [2–4].

Only a few cases of hearing loss in COVID-19 patients have been presented, the majority of which were sensorineural hearing loss (SNHL) [5–8]. One case of COVID-19 related bilateral cochlear inflammation with acute bilateral hearing loss, requiring treatment with cochlear implant has been reported [9]. Fidan described a single case of hearing loss on the basis of acute otitis media in relation to COVID-19 [10].

Age and comorbidity are found to be the most important risk factors predicting a severe COVID-19 outcome [1]. Young, otherwise healthy COVID-19 patients tend to be pauci- or asymptomatic. However, less severe complications eg. chemosensory and/or hearing loss, could have great impact on quality of life in COVID-19 convalescents.

Ongoing cohort studies suggest partial remission of such symptoms but long term sequelae for patients surviving COVID-19 are not known due to the novelty of the disease [11,12].

As the pandemic continues, the number of COVID-19 convalescents is still growing. Besides developing treatment of acute disease and transmission prevention through vaccines and epidemiological

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measures, focus on post-COVID symptoms and long term sequelae increases. There is a warrant to investigate this growing population and to make a needs assessment and establish structured post-COVID-19 follow-up and treatment accordingly.

The aim of this study was to investigate the extent of hearing loss and tinnitus in a cohort of COVID-19 patients with self-reported chemosensory loss through an observational study following the STROBE guidelines. Furthermore, we wanted to monitor the progress of improvement or recovery and the need for follow-up and rehabilitation in this group of patients.

2. Material and Methods

During the initial months after the COVID-19 pandemic was detected in Denmark on February 28th 2020, an increasing number of patients complained of sudden smell and taste loss to both the only Danish clinic for smell and taste disorders (Flavour Clinic in Holstebro) and to the researchers involved with smell loss at Flavour Institute, Aarhus University. To investigate and evaluate these symptoms, a retrospective questionnaire was created in REDCap and distributed through radio, online on social media, and flyers placed in the waiting rooms of general practitioners and outpatient clinics [13].

Patients were eligible for participating in the study if they were above 18 years of age and had experienced a sudden chemosensory loss after February 28th 2020, where the first confirmed case of COVID-19 in Denmark was registered.

The baseline questionnaire included demographics, information on olfactory, gustatory and trigeminal sensory loss. Furthermore, data was collected about the occurrence and timing of other COVID-19 symptoms, medical history, smoking, alcohol, demographics and previous episodes of chemosensory loss after respiratory infections. Initial data from this questionnaire has previously been published [11].

Data collection for the baseline questionnaire started on April 22nd 2020 and is ongoing. Follow-up questionnaires have been sent to participants every two months to track chemosensory function in participants with prolonged chemosensory deficits. On November 5th 2020, a follow-up questionnaire was sent to all participants from the baseline questionnaire who had voluntarily filled in their email address ($n = 470$). Participants were asked to give additional information on all of their symptoms during COVID-19 and prolonged symptoms after COVID-19, including, but not limited to hearing loss and tinnitus. The questionnaire consisted of specific questions on fatigue, headache, dyspnea, and chemosensory function, hearing loss and tinnitus etc. Example of question: "Which of the following symptoms did you experience during or after, but not before COVID-19 infection?" On December 15th 2020, the ear-symptom-questionnaire was sent to participants with either complaints of newly onset or aggravated hearing loss or tinnitus in relation to presumed COVID-19 infection, in the previous questionnaire. The ear symptom questionnaire included information on audio-vestibular symptoms, time of symptom onset, duration and severeness on a visual analog scale (VAS).

Data was collected following regional approval from the Danish Data Protection Agency (reference number 685149). The questionnaire-based design did not require ethics approval (Danish Committee Act, Section 14, Subsection 2), which was confirmed by the Regional Ethics Committee.

2.1. Statistics

All data was directly registered in the REDCap database and analysed using JMP 14.0. Pearson Chi^2 test was used for evaluating differences in categorical variables between groups. For normally

Table 1
Demographics and symptoms from baseline and follow-up questionnaire ($n = 225$).

	Total ($n = 225$)
Gender (male/female)	50/175
Age (mean, range)	45.5 (19–76)
Chemosensory deficits (n, smell + taste/smell only/taste only)	195/16/14
Fever	151
Cough (dry)	136
Dyspnea	92
Fatigue	189
Blocked nose	87
Runny nose	87
Sore throat	113
Generalized body ache	170
Headache	162
Dizziness	66
Hearing loss	24[a]
Tinnitus	37[a]

[a] Two patients reported both hearing loss and tinnitus.

Table 2
Demographics and symptoms from ear-symptom questionnaire ($n = 31$).

	Total ($n = 31$)	Hearing loss ($n = 17$)	Tinnitus ($n = 21$)
Gender (male/female)	4/27	2/15	2/19
Age (mean, range)	47.1 (25–67)	48.8 (38–76)	46.0 (25–67)
Chemosensory deficits (n, smell + taste/smell only/taste only)	31/0/0	17/0/0	21/0/0
Blocked nose	12	8	9
Runny nose	8	5	6
Headache	23	14	15
Fatigue	27	16	18
Plugged ear sensation	14	8	10
True vertigo	15	7	12
False movement	9	6	6
Hearing loss	17	-	7
Tinnitus	21	7	-

distributed data, mean values were calculated and displayed along with the range of values. For non-parametric data, averages were calculated as median values, and interquartile ranges were added to ensure an adequate representation of the underlying distributions. P-values of 0.05 or lower were considered statistically significant.

3. Results

3.1. Patients

This observational study was completed in accordance with the STROBE guidelines. In total, 225 patients with COVID-related taste and/or smell loss answered the follow-up questionnaire with additional ear symptoms, see Table 1.

As part of a larger cohort of patients with sudden smell and/or taste loss during the COVID-19 pandemic, a follow-up questionnaire included questions regarding hearing loss and tinnitus following COVID-19. An additional ear-symptom questionnaire was sent to patients with complaints of tinnitus or hearing loss ($n = 59$) in the follow-up questionnaire. Of these, 31 patients (53%) replied to the ear-symptom questionnaire, see Table 2.

A comparison of the baseline characteristics of the respondents in each group is shown in Table 3. There was a comparable higher proportion of female respondents in the baseline questionnaire and initial follow-up questionnaire with ear symptoms. Ear symptom complaints were more frequent among female respondents versus male respondents.

Table 3
Gender, age, and BMI distribution among respondents.

	Gender (M, %)	Age (mean, 95% CI)	BMI (mean, 95% CI)
Total cohort ($n = 470$)	23.8%	43.8 (42.6;45.0)	25.4 (25.0;25.8)
Respondents to follow-up questionnaire with ear symptoms ($n = 225$)	22.2%	45.5 (43.8;47.2)	25.5 (24.8;26.2)
Hearing loss ($n = 24$)	8.30%	48.0 (44.1;51.8)	26.0 (22.9; 29.0)
Tinnitus ($n = 37$)	8.10%	46.0 (42.0;50.0)	25.7 (24.1; 27.3)
Respondents to ear-symptoms specific questionnaire ($n = 31$)	12.9%	47.1 (43.6;50.6)	25.5 (23.7; 27.3)
Hearing loss ($n = 17$)	11.70%	48.8 (44.7;52.9)	25.7 (22.8;28.5)
Tinnitus ($n = 21$)	9.50%	46.0 (41.3; 50.7)	26.2 (23.8; 28.7)

3.1.1. COVID-19 testing

As the cohort was based on the symptom sudden smell loss, and not verified COVID-19 diagnosis, 97/225 participants from the follow-up questionnaire did not have a verified PCR-test or antibody test, including 16/59 patients with hearing loss or tinnitus in the follow-up questionnaire, while 7/31 did not have verified COVID-19 in the ear-symptom questionnaire.

3.2. Main objectives: hearing loss and tinnitus

Median time to debut of hearing loss occurred after initial symptom was 10 days (median value, IQR 2.5–35 days). The average time of follow-up was 266.3 days from COVID-19 symptom onset to completing ear-symptom questionnaire (mean, range 209–318 days). Of the 17 patients with hearing loss, two reported normalised hearing, 10 reported improvement but not yet at the same level as before COVID-19, and 5 patients had not experienced improved function at the time of follow-up.

On a scale from 0–100 (ranging from no hearing to best possible subjective hearing), participants rated the pre-COVID-19 hearing as 82.3 (mean, range 62–100), hearing immediately after hearing loss as 51.8 (mean, range 27–75), and current hearing as 64.9 (mean, range 27–86). No patients reported complete deafness. Patients reported how the hearing loss had negative effects on their current quality of life on a scale from 0–100 (ranging from no effect/change to worst possible subjective effect) with an average of 43.8 (mean, range 7–100).

Median time to debut of tinnitus after initial symptom was 30 days (median value, IQR 9–47.5 days). The average time of follow-up was 258.8 days from COVID-19 symptom onset to completing ear-symptom questionnaire (mean, range 72–318 days). Of the 21 patients with tinnitus, 7 reported recovery, 7 patients reported reduction of symptoms, and 7 patients reported no decrease in tinnitus since onset at the time of follow-up.

Patients reported how the tinnitus had negative effects on their current quality of life on a scale from 0-100 (ranging from no effect/change to worst possible subjective effect) with an average of 49.1 (mean, range 6–99).

3.3. Accessory related objectives: relation between ear symptoms and other symptoms

No significant associations were found between hearing loss and blocked nose ($n = 225$; Chi^2 = 1.455, $P = 0.2277$) or hearing loss and runny nose ($n = 225$; Chi^2 = 0.316, $P = 0.5738$).

In the ear-symptom questionnaire, plugged ear sensation occurred in 8/17 patients with hearing loss. However, no significant association was found ($n = 31$; Chi^2 = 0.055, $P = 0.8150$).

Similarly, tinnitus was not found to be associated with blocked nose ($n = 225$; Chi^2 = 1.860, $P = 0.1767$) or runny nose ($n = 225$; Chi^2 = 0.033, $P = 0.8563$).

4. Discussion

In this cohort of COVID-19 patients with sudden chemosensory loss, a surprisingly high proportion of patients reported impaired hearing and/or tinnitus in the aftermath of acute COVID-19 disease. Our data indicate that hearing loss may be a common COVID-19 symptom.

This study holds important limitations by the nature of its design. The end-point measure was self-reported hearing-loss, whereas the gold standard for objectively diagnosing and monitoring such, is a PTA. However, Oosterloo et al. found specificity 69–91% and sensitivity 55–70%, when comparing subjective hearing loss as a dichotomous variable against PTA [14]. Other similar findings support the use of self-reported hearing loss as a valid tool in epidemiological studies and larger cohorts/populations where PTA is not available [15–17].

As smell and taste loss was not officially recognized as a symptom of COVID-19 by the Danish National Board of Health until the 4th of May 2020, many patients with sudden smell and/or taste loss did not meet the criteria to allow for COVID-19 RT-PCR testing. Consequently, 16/59 patients with hearing loss or tinnitus in the initial questionnaire and 7/31 patients in the ear-specific-questionnaire did not have a COVID-19 RT-PCR test. As sudden smell loss has been shown to be the most reliable predictor of COVID-19, these patients were not excluded from the study [2,3].

The present cohort consists of a sub-population of COVID-19 patients with reported chemosensory loss. There may be an over-representation of patients with audio-vestibular symptoms in this sub-group of symptomatic COVID-19 patients with already affected senses. Furthermore, it can be assumed that symptomatic patients were more prone to participating in the questionnaire, thus risking a bias towards overestimation of prevalence of symptoms. However, audio-vestibular symptoms were not specifically mentioned in the invitation of the initial and follow-up questionnaires.

Among asymptomatic COVID-19 patients, Mustafa found significantly worse pure tone audiogram (PTA)-thresholds and transient evoked otoacoustic emissions (TEOAE) in 20 asymptomatic SARS-CoV2 positive patients, when compared to a control group, suggesting a deleterious effect on the intracochlear hair cells [6]. This association between COVID-19 and hearing loss, however, tells nothing about the pathogenesis nor the type of the hearing loss; conductive, sensorineural, or mixed. Several possible mechanisms may be in play.

Upper respiratory tract infections often cause intermittent eustachian tube dysfunction due to swelling of the mucosa, causing ear-symptoms such as a conductive hearing loss, aural fullness/plugged ear sensation, tinnitus and dizziness. Usually, this is a self-limiting medical condition that tends to normalise within days–weeks. Mean follow-up in the present cohort was 258–256 days, and in this period, the majority of affected patients reported no or incomplete recovery of the tinnitus (14/21) and hearing loss (15/17).

Although swelling of nasal mucosa has been suggested as a possible explanation for the sudden smell loss in COVID-19,

COVID-related smell loss is generally not associated with sinonasal symptoms such as blocked or runny nose [4,18]. We found no associations between these sinonasal symptoms and hearing loss or tinnitus.

Congenital or acquired SNHL, caused by viral disease is a well known phenomenon and thoroughly described in the literature [19,20]. It may involve other cranial nerves leading to facial paralysis or anosmia. In a comprehensive review, Cohen et al. described viral causes of hearing loss – typically due to intracochlear damage and multiple other mechanisms of injury – caused by direct viral damage of the organ of Corti, stria vascularis, or spiral ganglion. Furthermore, the patient's immune response and pro-inflammatory agents may damage critical structures in the audio-vestibular system and thereby potentially cause bilateral irreversible SNHL.

Prayuenyong et al. have pointed out that hydroxy-chloroquine has potential ototoxic side-effects [21]. The use of hydroxychloroquine is controversial, but widely used in some geographic areas especially during the early phases of the pandemic, possibly causing iatrogenic attribution to hearing loss among COVID-19 patients. Hydroxy-chloroquine has not been used in the current Danish cohort.

Previously, hearing loss in COVID-19 patients has only been reported in case studies and minor case series [5–10]. This was confirmed in a recent systematic review by Almufarrij et al. [22]. Almufarrij et al. found an association between COVID-19 and audio-vestibular symptoms, well in accordance with the findings of this study. With millions of people affected by COVID-19, some will experience coincidental idiopathic hearing-loss without causal connection, as described on a case-report basis. Nevertheless, our findings suggest a significant association between COVID-19 and hearing symptoms and related audio-vestibular symptoms. This is an important finding, as emphasis shifts in the latter stages of the pandemic to focus on long term sequelae, and as rehabilitation among convalescents therefore become essential issues.

5. Conclusion

In the current cohort of 225 COVID-19 patients with sudden chemosensory loss, more than 10% of patients complained of hearing loss while more than 16% complained of tinnitus. These symptoms seem to be prolonged in many cases and have substantial consequences on the patients' subjective quality of life. In the follow-up of post-COVID patients, attention to potential hearing loss and tinnitus should be included in the diagnostic work up. More research is needed to investigate this association and possible underlying causes.

Disclosure of interest

The authors declare that they have no competing interest.

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