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Sudden hearing loss and vestibular disorders during and before COVID-19 pandemic: An audiology tertiary referral centre experience

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ABSTRACT

Purpose: During the Coronavirus disease 2019 (COVID-19) pandemic a reduction in the diagnosis of many otorhinolaryngological and audiological disorders has been widely reported. The main aim of this investigation was to evaluate the impact of COVID-19 outbreak on the incidence of acute hearing and vestibular disorders.

Materials and methods: A retrospective analysis was performed of all patients evaluated in an audiology tertiary referral centre for acute cochleo-vestibular impairment between March 1st 2020 and February 28th 2021 (Pandemic Year Period, PYP). Results were compared to patients presenting with the same disorders during two previous periods (March 1st 2019 to February 29th 2020 and March 1st 2018 to February 28th 2019; First Precedent Year Period, FPYP and Second Precedent Year Period, SPYP, respectively).

Results: The annual incidence of total acute audio-vestibular disorders (number of annual diagnoses divided by total number of annual audiological evaluations) was 1.52% during the PYP, 1.31% in FPYP and 1.20% in SPYP. Comparison between the pandemic period and previous periods did not show a significant difference ($p > 0.05$). The overall incidence of SSNHL and combined acute cochlear-vestibular involvement was significantly higher during the PYP compared to the previous periods ($p = 0.022$).

Conclusions: There were no differences in the absolute number of acute audio-vestibular disorders during the pandemic compared to previous periods. Although not significant, the SSNHL during the pandemic appeared worse in terms of pure-tone average with a higher incidence of associated vestibular involvement. Further studies are needed to clarify the role of SARS-CoV-2 on audio-vestibular disorders incidence and pathophysiology.

1. Introduction

Since the beginning of the Coronavirus disease 2019 (COVID-19) pandemic, the healthcare systems have been subjected to increasing pressure and forced to a sudden and never previously occurred series of organizational changes. Most hospitals reduced or suspended elective procedures and examinations in order to face the pandemic burden and avoid viral transmission. In the most critical phases of the pandemic, outpatient visits were limited to urgent and oncological cases [1]. A large decrease in the number of Ear Nose and Throat outpatient urgent consultations was observed during the first phase of the pandemic probably due to national lockdown orders associated with patients' reticence and fear of going to the hospitals [2]. Consequently, a reduction in the diagnosis of many otorhinolaryngological and audiological disorders such as epistaxis, pharyngo-tonsillitis, otitis media,

equilibrium disorders, and sudden sensorineural hearing loss (SSNHL) has been reported [2–4].

On the other hand, reports of SSNHL and vestibular neuritis (VN) COVID-19-related are definitely emerging. A recent meta-analysis of COVID-19-associated audio-vestibular symptoms resulted in a pooled prevalence of 7.6% for hearing loss, 14.8% for tinnitus, and 7.2% for rotatory vertigo [5]. An immune-mediated mechanism has been postulated, since coronaviruses are known to be neurotrophic and may cause peripheral nerves' disorders and/or central nervous system manifestations [6,7]. Secondly, the long-lasting COVID-19 pandemic and related psychological distress might precipitate tinnitus and peripheral vestibular disorders in susceptible patients [8–10]. These aspects may potentially have increased the number of patients seen for acute cochleo-vestibular impairment due to patients' urgency and concern of the diagnosis, in contrast to what was observed in the earliest stages of the

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pandemic.

The main aim of this investigation was to evaluate the impact of the COVID-19 outbreak on the incidence of acute hearing and vestibular disorders in a one-year period of the pandemic. A secondary aim was to identify in our tertiary referral audiological centre possible differences in clinical presentation and outcome of these disorders in the investigated period, eventually related to the direct effect of SARS-CoV-2 on the audio-vestibular system or to behavioural aspects and contingencies of the pandemic.

2. Materials and methods

2.1. Patients

The study was conducted in accordance with the principles of the Helsinki Declaration. Data were examined in compliance with Italian privacy and sensitive data laws, and with the in-house rules of the Audiology Unit at Treviso Hospital, University of Padova. All participants gave their written permission for the publication of their clinical data.

A retrospective analysis was performed of the medical charts of all patients evaluated for acute cochlear-vestibular impairment at our institution between March 1st 2020 and February 28th 2021 (Pandemic Year Period, PYP). Findings were compared to the medical charts of patients evaluated for the same disorders during two previous year periods (from March 1st 2019 to February 29th 2020 and from March 1st 2018 to February 28th 2019; First Precedent Year Period, FPYP and Second Precedent Year Period, SPYP, respectively). A quarterly comparative sub-analysis was also conducted.

Inclusion criteria were: (i) first diagnosis of SSNHL, (ii) acute peripheral vestibular disorder or (iii) combined acute cochlear and vestibular disorders confirmed by clinical evaluation, audiometric test and videonystagmography. SSNHL was defined as a sensorineural decrease in hearing ≥ 30 dB affecting at least 3 consecutive frequencies and occurring within a 72-h period [11]. Acute peripheral vestibular disorders were diagnosed according to current international evidence [12]. The simultaneous presence of criteria for SSNHL plus clinical presentation of acute peripheral vestibular disorder was considered as acute cochlear-vestibular disorder.

Patients with previously known audio-vestibular disorders such as Menière's disease (MD), otosclerosis, chronic otitis media, autoimmune inner ear disorders were excluded as well as those with hearing and/or vestibular loss due to proven traumatic or toxic origin.

Demographic and clinical data were assembled for all considered patients. Clinical data included the side of the cochlear and/or vestibular disorder, auditory measurements and treatment prescribed. The patient auditory measurements were based on the pure-tone average (PTA; hearing thresholds at 500, 1000, 2000 and 4000 Hz) before and after treatment. The hearing recovery was classified according to the modified Siegel's criteria for SSNHL [13]: complete recovery (CR), partial recovery (PR), slight improvement (SI), no improvement (NI), and non-serviceable hearing (NSH).

Any test results related to SARS-CoV-2 infection were also searched and recorded when available.

2.2. Statistical analyses

The one-year period incidence of acute cochlear and/or vestibular impairment was calculated as the number of annual diagnoses divided by the number of annual audiological evaluations. Quantitative variables were reported as mean \pm standard deviation and median values. When appropriate, variables were dichotomized according to median values.

The statistical analyses were performed using Microsoft Office Excel 2013 (Microsoft, Washington, USA) for Windows 10. Comparisons of PYP to FPYP and to SPYP were performed using the Chi square test and

Fisher's exact test when appropriate in the case of categorical variables. Our quantitative data were not normally distributed and the compared cohorts were quite small, so the statistical significance of any differences between medians was ascertained using a non-parametric measure, Mann-Whitney *U* test. A further analysis considered FPYP and SPYP together and compared it with PYP, in order to strengthen the evaluation of incidences between the pandemic year and non-pandemic period.

A *p*-value < 0.05 was considered significant.

3. Results

A total of 42 patients were examined for acute cochlear-vestibular impairment between March 1st 2020 and February 28th 2021 (PYP). The diagnosis of SSNHL, acute peripheral vestibular disorder and combined cochlear and vestibular dysfunction were 19, 8 and 15, respectively. During the two considered pre-pandemic periods, we found 45 patients from March 1st 2019 and February 29th 2020 (FPYP) (17 SSNHL, 18 acute peripheral vestibular disorders and 10 combined cochlear-vestibular damages) and 41 patients from March 1st 2018 to February 28th 2019 (SPYP) (18 SSNHL, 17 peripheral vestibular disorders and 6 combined cochlear-vestibular damages). Number of annual first audiological evaluations was 2761 in the PYP; 3446 in the FPYP and 3407 in the SPYP.

Table 1 summarizes demographics and clinical data of all patients. Statistical analysis ruled out any significant differences between the PYP and other one-year periods. During the PYP, 2 out of 5 tested patients had a positive polymerase chain reaction on nasopharyngeal swab for SARS-CoV-2. They suffered mild and moderate COVID-19 with a course of about 15 days of infection. In one patient SSNHL was present at the onset of COVID-19 infection, in the other case the time elapsed between diagnosis of SARS-CoV-2 infection and our subsequent evaluation for SSNHL was 65 days. The incidence of total acute audio-vestibular disorders diagnosis was 1.52% during the PYP, 1.31% in FPYP and 1.20% in SPYP. The comparison between the pandemic period and previous year periods did not show a significant difference (PYP vs. FPYP, *p* = 0.479; PYP vs. SPYP, *p* = 0.288; PYP vs. FPYP+SPYP, *p* = 0.309; chi-square test).

The incidences and statistical analysis of SSNHL, acute peripheral

Table 1
Demographic and clinical data of included patients.

| | PYP | FPYP | SPYP |
|--|-----------------------|-----------------------|-----------------------|
| Age mean \pm SD; median (years) | 56.2 \pm 18.5; 60.0 | 55.8 \pm 14.2; 54.0 | 58.9 \pm 15.9; 59.0 |
| Gender (No. cases) | | | |
| • Male | 22 | 29 | 22 |
| • Female | 20 | 16 | 19 |
| SSNHL (No. cases) | 19 | 17 | 18 |
| Acute peripheral vestibular disorders (No. cases) | 8 | 18 | 17 |
| Acute combined cochleo-vestibular impairment (No. cases) | 15 | 10 | 6 |
| Pure Tone Average mean \pm SD; median (dB) | | | |
| • Pre-treatment | 61.2 \pm 24.4; 57.5 | 51.9 \pm 28.4; 42.5 | 54.9 \pm 31.4; 52.5 |
| • Final | 50.4 \pm 25.6; 52.5 | 43.1 \pm 26.4; 33.1 | 51.6 \pm 30.2; 48.7 |
| Hearing recovery (No. cases) | | | |
| • Complete recovery | 7 | 8 | 7 |
| • Partial recovery | 5 | 6 | 1 |
| • Slight improvement | 10 | 5 | 6 |
| • No improvement | 10 | 6 | 6 |
| • Non-serviceable hearing | 2 | 2 | 4 |
| Total outpatient visits (No. cases) | 2761 | 3446 | 3407 |

Abbreviations: First Precedent Year Period (March 1st 2019 to February 29th 2020) FPYP; Pandemic Year Period (March 1st 2020 and February 28th 2021) PYP; Second Precedent Year Period (March 1st 2018 to February 28th 2019) SPYP; Sudden Sensorineural Hearing Loss SSNHL.

vestibular disorders and combined cochlear-vestibular disorders, when analysed separately, are reported in Table 2. The incidence of SSNHL plus combined acute cochlear-vestibular involvement was significantly higher during the PYP compared to the previous periods (PYP vs. FPYP, $p = 0.078$, trend toward significance; PYP vs. SPYP, $p = 0.035$; PYP vs. FPYP+SPYP, $p = 0.022$; chi-square test).

Fig. 1 represents the total number of case presentations by quarter in all three periods. The statistical analysis ruled out any significant difference with regard to the total events per month between the three periods (p -values > 0.05, Fisher's exact test). The overall number of SSNHL was significantly higher in the quarter June to August of the PYP in comparison to the same quarter of the FPYP ($p = 0.027$, Fisher's exact test). Conversely, the incidence of acute peripheral vestibular disorders was significantly lower during December, January and February of the PYP (PYP vs. FPYP, $p = 0.031$; PYP vs. SPYP, $p = 0.028$; PYP vs. FPYP+SPYP, $p = 0.018$; Fisher's exact test).

PTA at presentation was 61.2 ± 24.4 dB in the PYP, 51.9 ± 28.4 dB in the FPYP and 54.9 ± 31.4 dB in the SPYP. No significant differences were found.

Among the 42 patients evaluated from March 1st 2020 to February 28th 2021 (PYP), 27 were treated with oral steroids (prednisone 1 mg/kg/day for 10 days with tapering regimen), 10 received oral steroids followed by salvage intravenous methylprednisolone (60 mg/day for 8 days with tapering regimen) and 1 patient received salvage intratympanic dexamethasone after oral steroid therapy. During the 2019 period (FPYP), 7 patients underwent intravenous steroids as first line treatment, 21 patients received oral steroids, 11 patients were treated with oral steroids followed by intravenous methylprednisolone and 3 oral steroids followed by intra-tympanic steroids. In 2018 (SPYP), 8 patients were firstly treated with intravenous methylprednisolone, 22 patients received oral steroids, and 5 oral steroids and subsequent intravenous steroids. None of the patients evaluated during the

Table 2

Incidence of acute audio-vestibular disorders during the COVID-19 pandemic year and in the previous years: values and comparisons.

| | PYP | FPYP | SPYP | PYP vs FPYP p -value | PYP vs SPYP p -value | PYP vs FPYP+ SPYP p -value |
|--|-------|-------|-------|------------------------------|------------------------------|---------------------------------------|
| Incidence of total events | 1.52% | 1.31% | 1.20% | 0.479 ^a | 0.288 ^a | 0.309 ^a |
| Incidence of SSNHL | 0.68% | 0.49% | 0.53% | 0.318 ^a | 0.422 ^a | 0.295 ^a |
| Incidence of acute peripheral vestibular disorders | 0.29% | 0.52% | 0.49% | 0.160 ^a | 0.200 ^a | 0.143 ^a |
| Incidence of combined acute cochleo-vestibular disorders | 0.54% | 0.29% | 0.17% | 0.119 ^a | 0.014^a | 0.016^a |
| Incidence of SSNHL + combined acute cochleo-vestibular disorders | 1.23% | 0.78% | 0.70% | 0.078 ^a | 0.035^a | 0.022^a |

Incidence was defined as the number of events in the target period divided by the number of total outpatient visits to the clinic in the same period (2761 in the PYP; 3446 in the FPYP, and 3407 in the SPYP, respectively).

Abbreviations: First Precedent Year Period (March 1st 2019 to February 29th 2020) FPYP; Pandemic Year Period (March 1st 2020 and February 28th 2021) PYP; Second Precedent Year Period (March 1st 2018 to February 28th 2019) SPYP; Sudden Sensorineural Hearing Loss SSNHL.

The significant p -values are in bold.

^a Chi square test.

pandemic period received intravenous steroids as first line treatment. However, the overall number of intravenous therapies performed did not significantly differ between the three groups (PYP vs. FPYP, $p = 0.116$; PYP vs. SPYP, $p = 0.469$; PYP vs. FPYP+SPYP, $p = 0.226$; Fisher's exact test).

The number of hearing recoveries according to the modified Siegel's criteria for each period is reported in Table 1. Fisher's exact test ruled out any differences in terms of recovery between the pandemic vs non-pandemic periods.

4. Discussion

The restrictive measures adopted during the COVID-19 outbreak determined a large decrease in the number of otolaryngology emergency consultations in Italy. This occurred especially in the first phase of the pandemic [2]. Likewise, the total outpatient audiological visits performed at our institution during 2020 showed a notable reduction [10]. Ueda et al. [3] investigated the impact of the COVID-19 pandemic on vertigo/dizziness outpatient cancellations. They found a 45% reduction in the total number of vertigo-associated visits between March and May 2020 in comparison to the same period of 2019. Interestingly, patients with Ménière's disease (MD) exhibited a lower percentage reduction in clinic attendance with respect to other vestibular conditions [3]. According to this, we discovered a significantly higher incidence of MD-related acute vertigo attacks and MD first diagnosis during 2020, probably due to the pandemic-associated stress and anxiety load [10].

Data about the impact of COVID-19 on audiological emergencies such as SSNHL are currently inconsistent and controversial. Chari et al. [4] reported a decrease in the absolute number of patients who presented with SSNHL during the COVID-19 lockdown period (March to May 2020) in comparison to the similar time frame 1 year before (13 versus 71 patients). However, the ratio of diagnosis over the total patients evaluated was not very different between the two periods (1.91% vs 1.77%). Conversely, Fidan et al. [14], analysing a wider period (April 1st to September 30th 2020 versus 2019), reported an increased incidence of SSNHL during the COVID-19 pandemic. Notably, 57.4% of their patients tested positive for SARS-CoV-2 with nasopharyngeal swabs, strengthening the relationship between SSNHL and SARS-CoV-2 infection [15,16]. Also Mohammed et al. [17] reported an increase in absolute number of SSNHL during 4 months of the pandemic period. Moreover, a change in therapy and management was reported: intratympanic corticosteroids injection was considered a safe, feasible and relatively effective method of SSNHL treatment during the COVID-19 pandemic in their preliminary experience (12 cases).

Our one-year period analysis showed heterogeneous results. The absolute number of acute cochlear-vestibular dysfunction was essentially unchanged during the pandemic period compared to the previous period. However, the incidence at our institution during the pandemic year period was higher in comparison to the previous two years. This was due to a reduction in the overall number of outpatient visits, as previously reported [3,10]. This is consistent with the pandemic restrictions enforced by the Italian government that limited activity to urgent and oncological cases, so patients with acute audiological symptoms were admitted to the clinic while patients with slowly progressive hearing loss, or other mild audiological symptoms were postponed (see Table 1).

According to our retrospective analysis, demographic data were not statistically different comparing the three considered periods. During the PYP, 5 out of 42 included patients were tested for SARS-CoV-2 and 2 of these resulted positive. Hearing loss, in these patients, can be correlated to COVID-19 infection given the modality of diagnosis, temporal relation, clinical presentation and exclusion of other possible causes according to the Satar criteria [18]. The low absolute number of positive molecular scrub tests could indicate no association between COVID-19 and acute cochlear-vestibular dysfunctions in our group, even though we need to focus on the fact that our patients were not routinely

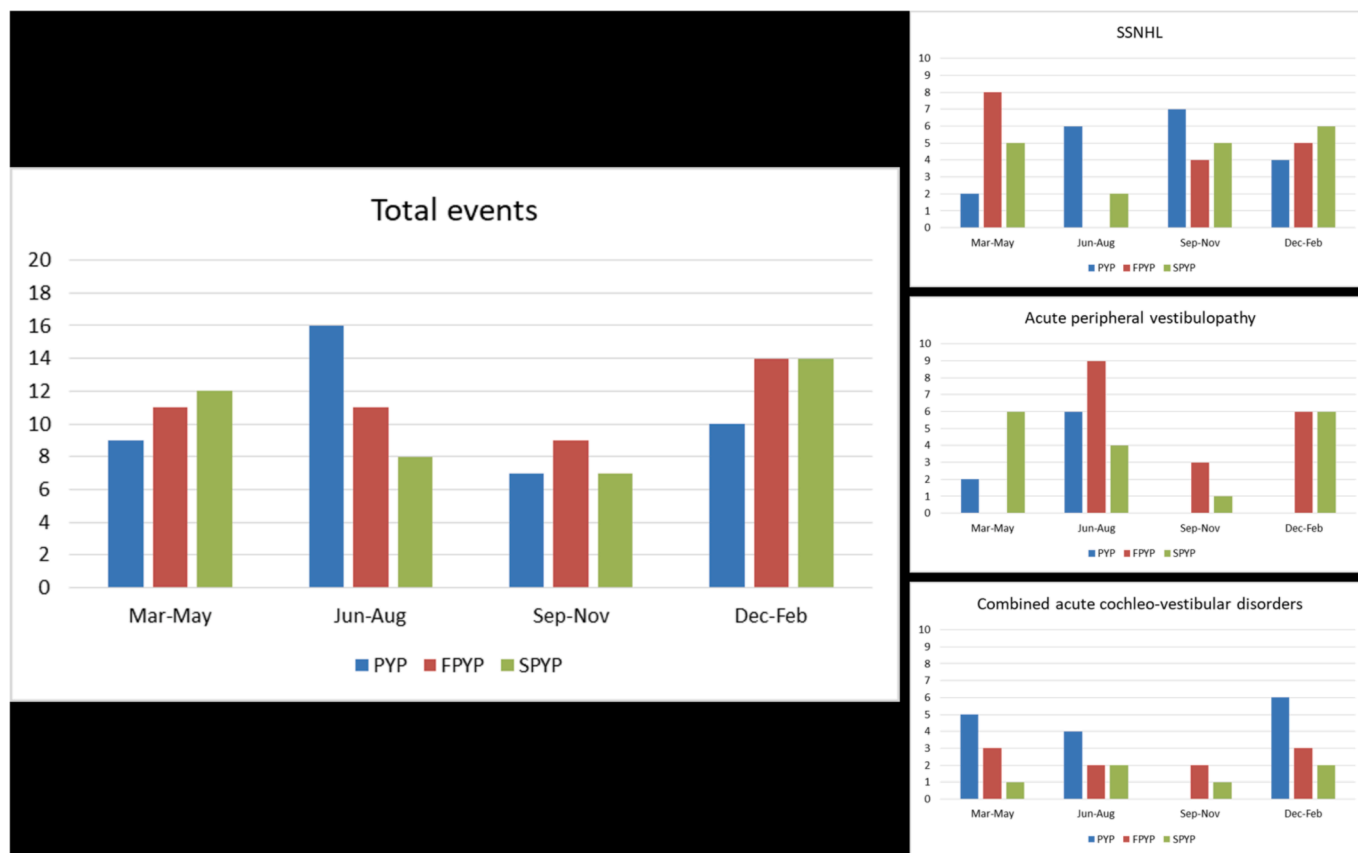


Fig. 1. Number of case presentations represented by quarter in all three periods. SSNHL Sudden sensorineural hearing loss; PYP Pandemic Year Period; FPYP First Precedent Year Period; SPYP Second Precedent Year Period.

screened for SARS-CoV-2 infection. Cases of SSNHL and acute vestibular disorders as the first symptom of COVID-19 have been reported [15,19]. Moreover, considering the cost-effectiveness of nasopharyngeal scrubs and recent studies on the prevalence of audio-vestibular symptoms in COVID-19 [5], we agree with other authors [15,19] who suggested the routine prescription of molecular tests in cases of SSNHL and acute vestibular disorders during the COVID-19 pandemic, in order to facilitate tracking of cases and ameliorate diagnosis and treatment.

When SSNHL and combined cochlear-vestibular disorders were considered together, their overall annual number resulted significantly higher during the PYP compared to previous periods (Table 2). A consequent relative reduction of cases of acute isolated vestibular disorders was observed, as shown in Tables 1 and 2.

Even though the audiometric differences were not statistically relevant, mean PTA in the PYP group was 10 dB worse compared to the previous year period (61.2 ± 24.4 in the PYP versus 51.9 ± 28.4 in the FPYP). This more diffuse and clinically severe damage of the audio-vestibular organ in the PYP group could be explained by a biased selection of cases due to pandemic restrictions, but further studies are needed to rule out an etiopathogenetic hypothesis eventually correlated to SARS-CoV-2 effect on clinical presentation of inner ear diseases [20].

A change in treatment modality of SSNHL during the COVID-19 crisis was reported [17]. This was consistent with what was observed during the PYP at our unit, with preferential use of oral corticosteroids as first line treatment. Nevertheless, our 3 considered cohorts showed no differences in terms of post-treatment recovery according to the modified Siegel classification [13].

Some limitations of the present study have to be taken into account: the retrospective settings, the small study sample and absence of routine SARS-CoV-2 screening in the PYP group.

5. Conclusion

In conclusion, no differences were found at our centre in the absolute number of cases with acute audio-vestibular disorders during the pandemic compared to previous periods. Clinical presentation of patients with SSNHL at our institution during the pandemic was more severe in terms of PTA and presented a significantly higher incidence of associated vestibular involvement. Considering our preliminary data and current evidence, we suggest routine screening for SARS-CoV-2 infection in cases of SSNHL and/or acute vestibular disorders during the ongoing pandemic. Further studies are needed to clarify the role of SARS-CoV-2 on audio-vestibular dysfunction pathophysiology, with particular attention on identifying possible mechanisms of infection and damage of the inner ear.

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CRediT authorship contribution statement

Daniela Parrino: conceptualization; data curation; methodology; investigation; formal analysis; original draft; writing, review & editing.

Andrea Frosolini: data curation; methodology; investigation; writing, review & editing.

Daniele Toninato: data curation; writing, review & editing.

Alessandro Matarazzo: data curation; writing, review & editing.

Gino Marioni: conceptualization; methodology; writing, review & editing; supervision.

Cosimo de Filippis: conceptualization; methodology; supervision.

Declaration of competing interest

None.

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