Med. J. Cairo Univ., Vol. 90, No. 7, December: 2161-2168, 2022
www.medicaljournalofcairouniversity.net

Changes of Audiovestibular Profile During COVID-19 Pandemic in Egyptian Patients

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Abstract

Background: Multiple neurological symptoms, including loss of consciousness, headaches, and vertigo, have been reported by COVID-19 patients. Otologic symptoms associated with COVID-19 include vertigo spells, sudden hearing loss, and facial paralysis. Currently, it is unknown the pathological effects of COVID-19 on hearing and the vestibular systems.

Aim of Study: This study is to perform a comprehensive battery of post-recovery tests to determine if persons infected with COVID-19 had experienced any changes to their auditory and vestibular system.

Patients and Methods: The study comprised 52 participants who finished their treatment with no prior balance or hearing problems. Only patients diagnosed via PCR were included in the study. Pure-tone audiometry used to assess the patients' hearing. Vestibular system was assessed using bedside tests, Ocular (oVEMP) and cervical Evoked Myogenic Potential (cVEMP), and Videonystagmography (VNG).

Results: According to the mean values of the 4000 Hz and 8000 Hz in both ears, there was a statistically significant difference between the COVID-19 positive and control groups. The two groups were found to have statistically significant difference in positioning and head shaking test results. According to the mean value of cVEMP and oVEMP asymmetrical ratio, there was a statistically significant difference between the two groups which was found to be greater in COVID-19 positive patients.

Conclusion: In an audiological assessment, the high frequencies in the COVID-19 positive group were higher in thresholds than those in the control group. Comparatively to the control group, asymmetric findings were discovered in the vestibular system, specifically in the oVEMP and cVEMP. Also significant number of BPPV positive patients in Covid-19 positive group was found. To enable early diagnosis and treatment, we advise COVID-19 patients to proceed with an audio-vestibular evaluation once their illness has stabilized.

Key Words: *COVID-19 – Hearingloss – Videonystagmography – cVEMP – oVEMP.*

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Introduction

IN December 2019, the novel coronavirus disease-2019 (COVID-19), which spreads quickly throughout the world and first surfaced in Wuhan, China's Hubei province, was proclaimed by the WHO to be a worldwide pandemic **[1]**. The severe acute respiratory syndrome-coronavirus-2 (SARSCoV-2) has been identified as the virus that causes this illness **[2]**. By June 2021, 175 million cases and 3.7 million fatalities had been recorded globally **[3]**. This illness can cause symptoms ranging from a minor upper respiratory infection to life-threatening pneumonia. Dry cough, fever, headache, sore throat, shortness of breath, diarrhea, vomiting, and stomach pain are typical clinical signs **[4-6]**. Changes in taste and anosmia are frequent symptoms **[7,8]**. Studies have looked into whether the SARS-CoV-2 virus affects the neurological system directly or indirectly in terms of neurotrophic effects **[9,10]**.

Patients with COVID-19 have reported experiencing a variety of neurological symptoms, including loss of consciousness, headaches, and dizziness **[11-14]**. Otologic symptoms related to COVID-19 have also included episodes of vertigo, sudden hearing loss, and facial paralysis **[15,16]**. It is currently unknown if COVID-19 affects hearing and the vestibular system. Using a comprehensive battery of tests after recovery, we aimed to determine in this study whether there had been any change in the hearing and vestibular system in patients with COVID-19 infection.

Material and Methods

We conducted this prospective study in our department of Audiovestibular Medicine from April 2021 to June 2022. Fifty two patients who had diagnosed as Covid-19 via PCR, finished their treatment and had no prior balance or hearing issues were included in the study. Information was gathered about their disease-related complaints, their hospitalization, and the medical treatment they received.

People hospitalized in intensive care units or with serious illnesses were excluded from the study. The study excluded participants who had previously experienced hearing loss or balance issues, underwent ear surgery, had circulatory or cardiovascular issues, or were taking chloroquine. It was made sure to inquire about the patients' past exposure to noise, and those who had previously worked somewhere noisy were excluded. All study participants gave their agreement, and the study was given the approval from the University Ethics Committee.

All subjects underwent:

1- Basic audiological evaluation: Pure tone audiometry: Air conduction thresholds were tested at frequencies between 250-8000Hz at octave intervals. Speech audiometry: Speech reception threshold (SRT) [17], and word discrimination scores (WDS) [18]. Acoustic immittance testing: This included tympanometry and acoustic reflexes (ipsilateral and contralateral).
2- Vestibular bedside testing: Romberg, tandum Romberg and Fukuda test.
3- Videonystagmography (VNG): VNG was performed using a two-channel. Calibration was mandatory for accurate nystagmus recording. VNG subtests were occulography tests (smooth pursuit, saccade, and optokinetic), spontaneous nystagmus, gaze, positional, positioning, and caloric tests. A software algorithm was used automatically to calculate unilateral weakness, directional preponderance, and total eye velocity using standard formulae.
4- Cervical and ocular vestibular evoked myogenic potential testing: Using Eclipse EP 15 by Interacoustics. The peak latencies of wave P1 and N1, and peak to-peak amplitudes (P1-N1) was recorded for each ear. The peak-to-peak amplitude was rectified for baseline and asymmetric Ratio (AR) was calculated according to this equation: AR = (The larger P 1-N 1 amplitude - The smaller P 1-N 1 amplitude / The Sum of P 1-N1 amplitudes of both ears) x 100.

Equipment:

a- Audiometry: Interacoustics AC40 calibrated according to the ISO standards.
b- Immitancemeter: Interacoustics AT235 calibrated according to the ISO standards.
c- Videonystagmography: Computerized 2-channels VNG Micromedical.
d- Vestibular and ocular evoked myogenic potential testing using Eclipse EP 15 by Interacoustics.

Statistical evaluation:

With the use of the SPSS (Statistical Package for the Social Sciences) 25 programme, the study's data were analysed. For comparison tests, the significance threshold (p) was set at 0.05. S. Wilk Shapiro The data's ability to fit a normal distribution was tested. The case and control groups (COVID (+), COVID (–) were compared using the significance test (t-test) of the difference between the two means because the data were normally distributed. Levene's test was used to determine which test result to look for in the comparison ($p<0.05$) by examining the homogeneity of variances. Frequency, percentage, mean, and standard deviation are used to represent the values of the variables. Cross-tables were made and chi-squared analysis was done for the categorical data analysis.

Results

The study included a total of 106 participants, of whom 52 (49.1%) belonged to the COVID-19 positive group and 54 (50.9%) to the control group. The mean age of the participants was calculated to be 28.98±10.91 years, with 72 (67.9%) of the participants being females and 34 (32.1%) being males. The COVID-19 positive group consisted of 28 (53.8%) female and 24 (46.2%) male individuals, with a mean age of 34.20±12.63. The control group consisted of 44 (81.5%) female and 10 (18.5%) male participants, with a mean age of 23.96 5.92. The COVID-19 positive patients' mean disease duration was discovered to be 66.35±23.51 days. Sixteen patients (30.8%) showed signs of fever, but 36 (69.2%) did not. None of the ten (19.2%) patients who had respiratory distress required oxygen support. Forty two patients (80.8%) were in good respiratory health. Thirty patients (57.7%) did not have joint discomfort or headaches, compared to 22 (42.3%). While forty four (84.6%) patients did not experience taste loss, 8 (15.4%) people did. All patients suffered from dizziness and fatigue.

Audiological findings:

The 250, 500, 1000, 2000, 4000, 8000 frequencies threshold and pure tone average (average of the results for the 500, 1000, 2000 and 4000) was assessed in both ears.

The mean thresholds of the 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, and pure tone average were not statistically different between the COVID-19 positive and control groups in either the right or left ears (p>0.05). According to the mean threshold of the 4000 Hz and 8000 Hz in both the right and left ears, there was a statistically significant difference between the COVID-19 positive and control groups (p<0.05) (Table 1).

Results of vestibular bedside tests:

Regarding the normal or pathological bedside Romberg test results, there was no statistically significant difference between the COVID-19 positive and control group (p>0.05). In the tandem Romberg, Fukuda, and gait tests, there was a statistically significant difference between the two groups (p<0.05) (Table 2).

VNG results:

As per VNG tests findings, Fifteen cases (28.8%) had BPPV (9 cases diagnosed as lateral canal, and 6 cases had posterior canal BPPV) which is statisticallysignificant difference between the COVID-19 positive and control group (p<0.05). six cases (11.5%) had unilateral canal weakness. In terms of their normal or pathological VNG saccade, optokinetic, and spontaneous nystagmus results, there was no statistically significant difference between the COVID-19 positive and control groups (p>0.05). The COVID-19 positive and control groups were shown to have significantly different normal and pathological VNG head shaking results (p<0.05) (Table 3).

cVEMP results:

We compared the mean values of the cVEMP P1 latency, N1 latency, and P1-N1 amplitude. The mean values of the left ear P1 latency and N1 latency measures revealed a statistically significant difference between the COVID-19 positive and control groups (p<0.05) (Table 4), but the right ear P1 latency and N1 latency tests revealed no such difference. In terms of the mean values of the right ear P1N1 amplitude measurement, a statistically significant difference between the COVID positive and control groups was discovered (p<0.05).

No statistically significant difference was discovered between the two groups based on the mean values of the P1N1 amplitude measurement in the left ear (p>0.05). The COVID-19 positive patients had lower mean values for the cVEMP N1 latency, and P1N1 amplitude than the control group (Table 4).

According to the mean value of cVEMP asymmetrical ratio, there was a statistically significant difference between the COVID-19 positive and control groups (p<0.05). The mean cVEMP asymmetry value was found to be greater in COVID-19 positive patients (Table 5).

oVEMP results:

No statistically significant difference was found between the COVID-19 positive and control groups according to the mean values of the P1 latency, N1 latency and P1N1amplitude measurements in both the right and left ears (p>0.05) (Table 4).

The mean oVEMP asymmetric ratio values of the COVID-19 positive group and the control group were observed to differ statistically significantly (p<0.05). In comparison to the control group, it was discovered that the COVID-19 positive group's mean oVEMP asymmetry value was higher (Table 5).

Table (1): Comparison of groups according to audiological values.

Hz	Group	Rt ear		Lt ear	
		Mean ± SD	p-value	Mean ± SD	p-value
250	Covid (+)	9.62±7.34	0.141	10.77±6.59	0.345
	Covid (–)	6.85±6.07		9.07±6.36	
500	Covid (+)	13.27±6.47	0.018	9.81±7.14	0.072
	Covid (–)	8.89±6.55		6.48±6.02	
1000	Covid (+)	6.92±5.67	0.052*	4.81±6.08	0.532
	Covid (–)	6.07±4.17		3.89±4.46	
2000	Covid (+)	11.15±6.68	0.059*	9.04±6.33	0.298
	Covid (–)	8.67±5.19		7.22±6.25	
4000	Covid (+)	13.27±8.6	0.001*	11.54±7.59	0.001*
	Covid (–)	5.37±5.18		4.81±4.7	
8000	Covid (+)	13.65±7.29	0.005*	15.77±10.93	0.047*
	Covid (–)	7.78±7.12		10.56±7.51	
Pure tone average	Covid (+)	11.12±5.78	0.191*	8.58±5.32	0. 144*
	Covid (–)	10.52±4.01		5.85±4.22	

SD: Standard deviation. * p<0,05 there is a statistically significant difference between groups.

Table (2): Comparison of Bedside tests results between the two groups.

Test	Result		Covid (+)	Covid (–)	p-value
Romberg bedside test	Normal	Number %	50 96.2	54 100.0	0.229
	Pathological	Number %	2 3.8	0 0.0	
Tandem Romberg bedside test	Normal	Number %	42 80.8	54 100.0	0.006*
	Pathological	Number %	10 19.2	0 0.00	
Fukudabedside test	Normal	Number %	46 88.5	54 100.0	0.035*
	Pathological	Number %	6 11.5	0 0.0	
Tandem Gaitbedside test	Normal	Number %	42 80.8	54 100.0	0.006*
	Pathological	Number %	10 19.2	0 0.0	

*p<0.05 there is a statistically significant difference between groups.

Table (3): Comparison of VNG results according to groups.

VNG test	Result		Covid (+)	Covid (–)	p-value
Gaze vertical	Normal	Number %	52 100.0	54 100.0	
Gaze horizontal	Normal	Number %	52 100.0	54 100.0	
Saccade	Normal	Number %	48 92.3	54 100.0	0.087
	Pathological	Number %	4 7.7	0 0.0	
Pursuit	Normal	Number %	52 100.0	54 100.0	
Optokinetics	Normal	Number %	46 88.5	54 100.0	0.069
	Pathological	Number %	6 11.5	0 0,0	
Spontaneous nystagmus	Normal	Number %	46 88.5	54 100.0	0.069
	Pathological	Number %	6 11.5	0 0,0	
Head shaking	Normal	Number %	38 73.1	54 100.0	0.001*
	Pathological	Number %	14 26.9	0 0.0	
Positioning tests (Dix Hallpike and head roll)	Normal	Number %	37 71.1	54 100.0	0.001*
	Pathological	Number %	15 28.8	0 0.0	
Caloric test	Normal	Number %	46 88.5	54 100.0	0.069
	Pathological	Number %	6 11.5	0 0.0	

*p<0.05 there is a statistically significant difference between groups.

Table (4): Comparison of groups according to cVEMP and oVEMP latencies and amplitude values.

	Group	Rt ear		Lt ear	
		Mean ± SD	*p*-value	Mean ± SD	*p*-value
P1 LatanciescVEMP	Covid (+) Covid (–)	13.83±1.02 13.58±1.77	0.562	13.43±1.22 14.56±1.66	0.008*
N1 LatanciescVEMP	Covid (+) Covid (–)	20.37±1.53 21.36±1.88	0.050	20.26±1.5 22.55±1.91	0.001*
P1N1 Amplitude cVEMP	Covid (+) Covid (–)	57.5±25.94 82.17±25.79	0.002*	73.23±19.45 86.3±27.78	0.060
P1 LatanciesoVEMP	Covid (+) Covid (–)	10.25±0.91 9.82±0.64	0.053	10.15±0.8 9.92±0.65	0.288
N1 LatanciesoVEMP	Covid (+) Covid (–)	15.24±0.93 15.13±0.94	0.672	15.46±1.05 15.45±1.11	0.982
P1N1 Amplitude oVEMP	Covid (+) Covid (–)	9.98±8.79 8.88±4.49	0.585	10.88±7.65 8.94±3.41	0.281

SD: Standard deviation. *p<0,05 there is a statistically significant difference between groups.

Table (5): Comparison of groups according to cVEMP and oVEMP asymmetrical ratio values.

	Group	Asymmetrical ratio Mean ± SD	*p*-value
cVEMP	Covid (+) Covid (–)	24.35±15.22 11.73±8.31	0.002*
oVEMP	Covid (+) Covid (–)	28.6±20.12 13.77±10	0.004*

SD: Standard deviation.
*p<0,05 there is a statistically significant difference between groups.

Discussion

Over 2 million people have died as a result of the SARS-CoV-2 pandemic, which began in December 2019. The coronavirus family has so far been described as having neurotrophic characteristics **[15]**. Patients with hearing loss, tinnitus, and dizziness have been documented among otoneurologic symptoms. Vasculitis or brain tissue invasion may be directly responsible for this condition **[19]**. The hearing assessment of patients who had COVID-19 and recovered revealed that the average of all frequencies was within the normal ranges, although a significant difference was identified, especially at 4000 Hz and 8000 Hz, in contrast to the control group. The thresholds was higher than the control group even though it was within normal limits (11.12±5.78 dB for the right ear and 8.58 5.32 dB for the left ear). According to the published literature, a 67-year-old COVID-19 patient experienced acute hearing loss, which was treated with steroids [20]. In a different study, participants with asymptomatic COVID-19 underwent audiological assessment, significant findings were attained at 4000 Hz, 6000 Hz, and 8000 Hz when compared to the control group. These studies concurred with the notion that COVID-19 infection may have an impact on cochlear hair cells **[21]**.

Patients with COVID may experience vestibular system abnormalities. As per VNG tests findings in our study, Fifteen cases (28.8%) had BPPV (9 cases diagnosed as lateral canal, and 6 cases had posterior canal BPPV) which is statistically significant difference between the COVID-19 positive and control group (p<0.05). Six cases (11.5%) had unilateral canal weakness and six patients had abnormal findings in the head shaking test of the COVID-19 positive patients.

After assessing 40 cases of recovered Covid-19 patients suffering from vertigo Nada and her colleagues in 2022 had found the following diagnoses: 10 cases (25%) had both BPPV and VN, 17 cases (42.5%) had BPPV and 13 cases (32.5%) had an uncompensated peripheral vestibular lesion **[22]**.

Typically, vestibular neuritis may appear following an upper respiratory illness that leaves patients with severe vertigo **[23]**. Numerous audiovestibular illnesses have a significant role for viral infections in their aetiology **[23,24]**. Additionally, labyrinthitis caused by a virus in particular may impair hearing and balance. Among the possible causes of vestibular neuritis, it is thought to be an inflammatory condition of viral origin that specifically affects the vestibular component of the eighth cranial nerve **[25]**. Vascular aetiology and immunologic aetiology have also been implicated as contributing factors to the development of VN **[26]**. All are relevant to the COVID-19 infection pathway. Coronaviruses have been described as having neuro-trophic and neuro-invasive characteristics

[27]. Therefore, peripheral neuropathies could be brought on by coronaviruses.

Furthermore, the macula's degeneration is the primary cause of BPPV, despite the fact that the majority of cases are idiopathic in origin. Identifiable causes of otoconial dislodgement are referred to be secondary causes of BPPV. These include head trauma, otologic and nonotologic surgery, or any other method that exerts a strong enough mechanical stress on the inner ear [28-30]. When a patient has COVID and is forced to cough for a long time, this could result in stress to the inner ear.

In cVEMP, a statistically significant difference was discovered based on the asymmetry values of the control group. The P1, N1 latencies, as well as P1-N1 amplitudes, a statistically significant difference between the groups, were also discovered. The asymmetry values in oVEMP showed a statistically significant difference, however the amplitude and latency values showed no significant changes.

The patients with COVID had different cVEMP latencies and amplitudes, which indicated that the disease impacts the brainstem and vestibulocollic arc and slows down communication on the arc. In the literature, it has been demonstrated that these effects manifest in retro-labyrinth lesions of the vestibulospinal pathway. The significance of the central vestibular system's compensatory mechanism was demonstrated by the lack of significant changes in the gain asymmetries in VEMPs [31,32]. Additionally, the COVID influence on the vestibulospinal arc and postural balance was highlighted by the difference in the patients with COVID in the bedside tests. If we look at the research on COVID-19 and vestibular system evaluation, we find that 34 patients were found to have balance issues after receiving a COVID-19 diagnosis in a study that evaluated the vestibular system in 185 patients using online questions. 32 of these patients (94.1%) experiencing dizziness, and 2 (5.9%) reported having severe vertigo attacks[19]. A case of vestibular neuritis with vomiting and nausea that may be related to COVID-19 was published in another case study [33]. In a different review publication, 7 individuals with COVID-19 infection reported having vestibular problems, but no reference of a direct vestibular cause was made [34]. Although scientific understanding of COVID-19 is growing, there is still little material available in the audiovestibular literature. The COVID-19's life-threatening symptoms, as well as related hearing and balance issues, have not been addressed by researchers. MERS and SARS, former coronavirus members, have an impact on the hearing and balance system. SARS-CoV-2 may directly affect the nervous system or the inner ear as a result of the recent extensive hypercoagulation observed in COVID-19 patients. One of the clinical indications of COVID-19, including other viral illnesses including hepatitis B and C vasculitis, may entail vascular involvement [35]. Because the inner ear is extremely vulnerable to ischemia, audiovestibular system problems may result from vascular injury [36]. Hearing and vestibular problems may be related to primary and secondary vasculatures [37].

Conclusion:

COVID-related audio-vestibular problems are neither uncommon nor unexpected. In an audiological assessment, the high frequencies in the COVID-19 positive group were higher in threshold than those in the control group. Comparatively to the control group, asymmetric findings were discovered in the vestibular system, specifically in the oVEMP and cVEMP. Also significant number of BPPV in Covid-19 positive group was found. To enable early diagnosis and treatment, we advise COVID-19 patients to proceed with an audio-vestibular evaluation once their illness has stabilized.

Conflicts of interests: None.

Funding: None.

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تغييرات جهاز السمع والاتزان المصاحبة لجائحة كورونا فى المرضى المصريين

العديد من الأعراض العصبية عانى منها مرضى فيروس كورونا كوفيد ١٩ منها فقدان الو عى والصداع والدوار، تشمل أعراض الأذن المرتبطة بمرضى فيروس كورونا كوفيد ١٩ نوبات الدوار وفقدان السمع المفاجئ. حالياً، من غير المعروف تفصيلاً ما هى الآثار المرضية لكوفيد ١٩ على السمع والجهاز الدهليزى. الهدف من هذه الدراسة هو إجراء مجموعة شاملة من اختبارات السمع والاتزان للمرضى بعد التعافى لتحديد ما إذا كان الأشخاص المصابون بفيروس كورونا كوفيد ١٩ قد عانوا من أى تغييرات فى نظامهم السمعى والدهليزى. فى التقييم السمعى، كانت الترددات العالية فى المرضى المتعافين من فيروس كورونا أعلى فى العتبات من تلك الموجودة فى المجموعة الضابطة. بالمقارنة مع المجموعة الضابطة، تم اكتشاف نتائج غير متماثلة فى الجهاز الدهليزى، وتحديداً فى اختبار الجهد العضلى المثار الدهليزى العنقى والبصرى. كما تم تشخيص عدد كبير من المرضى المصابين بالدوار الحركى الحميد بين المرضى المتعافين من فيروس كورونا كوفيد ١٩. لتمكين التشخيص والعلاج المبكر، ننصح المرضى المتعافين من فيروس كورونا كوفيد ١٩ بالمضى قدماً فى التقييم الدهليزى السمعى بمجرد استقرار مرضهم.