Al-Azhar International Medical Journal

Volume 4 | Issue 2 Article 21

2-2023

“Middle Ear Function of Recovered severe acute respiratory syndrome coronavirus-2 (SARS-COV2) Patients”.

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How to Cite This Article

Medhat, Mariam Magdy; El Fouly, Hedayat El Sayed; and Abdulghffar, Abdulrahman Nabil Fathi (2023) ""Middle Ear Function of Recovered severe acute respiratory syndrome coronavirus-2 (SARS-COV2) Patients”.," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 2, Article 21.
DOI: https://doi.org/10.58675/2682-339X.1676

ORIGINAL ARTICLE

Middle Ear Function of Recovered Severe Acute Respiratory Syndrome Coronavirus-2-Patients

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Abstract

Background: **Several otolaryngology symptoms are reported with coronavirus disease 2019. Ascending infection from the nasopharynx can affect the conductive part of the hearing pathway, which leads to middle ear (ME) effusion. Otitis media may be the first presentation of severe acute respiratory syndrome coronavirus-2 infection.**

Objective: **To evaluate ME function in recovered severe acute respiratory syndrome coronavirus-2-infected patients, and also to compare between the complaint of the patient and the test results.**

Patients and methods: **A case−control study was performed in which the cases and controls groups were age and sex matched, with ages ranging from 18 to 50 years. The ME function of both groups was assessed using tympanometry and the Eustachian tube function test.**

Results: **Tympanometry showed a statistically significant difference in the existence of abnormal tympanometry (type C or As) and Eustachian tube dysfunction in both ears between patients and controls. According to the comparison, there is a statistically significant difference in both ears between the Eustachian tube function and the patient's complaints of ear fullness or a sense of blockage.**

Conclusions: **Coronavirus disease 2019 impairs ME function in both sick and asymptomatic individuals.**

Keywords: Coronavirus disease 2019, Eustachian tube function, Middle ear, Severe acute respiratory syndrome coronavirus-2, Tympanometry

1. Introduction

A number of otolaryngology disorders have been linked to coronavirus disease 2019 (COVID-19). Sore throat, hyposmia or anosmia, hypogeusia or ageusia, dysphagia, tinnitus, dizziness, and hearing loss are a few examples.[1] Ascending infections from the nasopharynx can disrupt the middle ear (ME) function, which may result in a buildup of fluid behind the ME that results in ME effusion. It is possible that otitis media is the initial sign of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection.[2] The Eustachian tube (ET) is a closed tube connecting the nasopharynx to the ME. It consists of a short bony part (12 mm) and a cartilaginous part (24 mm). The junction between both parts is the isthmus, which acts like a valve. The tube closes during rest and when the soft palate muscles contract. It opens during swallowing and yawning. ET allows for ME aeration and equalizes pressure between outside air and inside air pressure for optimal sound transmission. Moreover, it is responsible for ME drainage, preventing secretion buildup.[3] Eustachian tube dysfunction (ETD) usually leads to a buildup of negative pressure in the ME, resulting in a fluid shift into the ME and retraction of the tympanic membrane.[4] ETD is crucial for managing and understanding the pathophysiology of otitis media.[5] People with ETD may complain of ear fullness, hearing loss, clicking sounds, or tinnitus.[6] Eustachian tube function (ETF) tests can detect either passive or active tubal

Accepted 14 December 2022.
Available online 15 May 2023

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https://doi.org/10.58675/2682-339X.1676

opening. In passive tubal opening tests, the tube is frequently opened with high pressure, whereas in active tubal opening tests, the patient is typically asked to swallow or make a 'k' sound. Manometric tests are the most commonly used.[6] The most commonly used manometric test is tympanometry. ME pressure is used as an indirect indicator of ETF. ME effusions and significant negative ME pressure are common symptoms of poor ETF. The tympanogram can objectively determine the degree of negative pressure in the ME.[7] Several tests have been developed to detect an active ET opening. The most basic test uses a basic tympanometry device to examine patient-induced pressure changes in the ME while the patient performs a forcible sniff, a Valsalva, or Toynbee maneuver. Valsalva and Toynbee maneuvers will usually cause a relative increase or decrease in pressure in the ME, which can be measured with tympanometry if the ET opens. The increase or decrease in nasopharyngeal pressures during the sniff, Toynbee, or Valsalva tests has been shown to be highly variable between patients, and the pressure achieved is related to the frequency of detected ET opening.[6]

The aim of this study was to evaluate ME function using both tympanometry and ETF test. In addition, we wanted to compare the findings to the patient's complaints.

2. Patients and methods

This was a case–control study. The study was conducted at the Audio-vestibular Clinic, ENT Department, Kasr Al-Ainy Hospital, Cairo University Hospitals, during the period between July 2021 and June 2022. The study was approved by the Research Ethical Committee and Otolaryngology Department of Faculty of Medicine. An informed consent was signed by all participants for participation in the study.

The study included 116 participants divided into two groups: a study group (cases), which included 58 postrecovery adults who were confirmed positive for SARS-CoV-2 by nasopharyngeal RT-PCR swab. The tests were performed at least 1 month after the symptoms had subsided. Their age ranged from 18 to 50 years, with a mean age of 34.22 ± 9.31 years. There were 28 males and 30 females. The control group included 58 healthy adults, comprising 27 males and 31 females, with no history of auditory symptoms, whose mean age was 32.28 ± 7.84 years, ranging from 18 to 48 years, and whose age and sex were matched with the cases. Controls were either relatives of the patients or colleague of the doctors or nurses. COVID-19 was ruled out due to the absence of COVID-19 symptoms (fever, cough, dyspnea, myalgia, headache, anosmia, ageusia, etc.) and a lack of a prior positive PCR test. Previous history of hearing loss, tinnitus, or other otologic symptoms; previous ear surgery; familial hearing loss; ototoxic drug intake; chronic noise exposure; head trauma; age over 50 years; and any disease or condition affecting hearing, including neurotologic, vascular, autoimmune, or metabolic diseases, were all exclusion criteria.

Each participant was subjected to the following: detailed history taking, including personal history such as age, sex, occupation, and special habits of medical importance; and a complete analysis of symptoms such as hearing loss, tinnitus, a sense of occlusion, and earache. To rule out any other possible causes of hearing loss, a history of local ear diseases, systemic diseases affecting hearing, drug intake, particularly ototoxic drugs, trauma to the ear or head, exposure to acoustic trauma or noise, and other factors that could affect hearing were all considered. Furthermore, COVID-19 infection history was considered, including disease symptoms (fever, cough, dyspnea, myalgia, headache, anosmia, ageusia, etc.), duration of symptoms, duration postrecovery, and period of infection (wave). Otologic examination, including otoscopy and tuning fork tests, was done. Immitancemetry was done using an Immittancemeter Madsen Zodiac 901 ME analyzer (GN Otometrics, Denmark, Ballerup city), calibrated according to ISO standards with a 226-Hz probe tone. It was done in the automatic mode with introduction of pressure of +200 daPa into the external auditory canal, which decreases to −400 daPa to find the peak of maximum admittance. ETF test: first, the patient had a baseline tympanogram. The patient was then instructed to swallow while pinching the nares. Following that, the patient was instructed to stop swallowing and release the nose, and a second tympanogram was obtained. The patient was then asked to swallow or drink water, which causes the ET to open and close, equalizing the pressure if it was working properly. A third tympanogram was performed after swallowing. If there was a shift between the peaks of the second and third tympanogram recordings (15–20 daPa), the ET was considered functioning; otherwise, the results indicated dysfunction.

The Statistical Package for the Social Sciences (SPSS), version 26 was used to code and enter the data (IBM Corp., Armonk, New York, USA). In quantitative data, mean, SD, median, minimum, and maximum were used to summarize the data, whereas frequency (count) and relative frequency (percentage) were used

in categorical data. The nonparametric Kruskal–Wallis and Mann–Whitney tests were used to compare quantitative variables. The χ^2 test was used to compare categorical data. When the expected frequency was less than 5, the exact test was used instead. *P* values less than 0.05 were considered statistically significant.

3. Results

A total of 10 (17.24%) patients reported a bilateral sense of fullness, two (3.44%) reported a left sense of fullness, and one (1.72%) reported a right sense of fullness. Abnormal tympanometry (type B, C, As, and Ad) was found in seven (12%) patients in the right ear and six (10.3%) patients in the left ear. In the right ear, 25 (43.1%) patients had abnormal ETF, whereas 29 (50%) patients had abnormal left ear function. Tympanometry revealed a statistically significant difference between cases and controls regarding abnormal tympanometry (type C or As), and the presence of ETD in both ears (Table 1).

A comparison between patients' complaints of a sense of occlusion or fullness and ETF tests showed that there was a statistically significant difference in both ears. Of 11 patients complaining of a sense of occlusion in the right ear, nine showed ETD, and of 12 patients complaining of a sense of occlusion in the left ear, 11 showed ETD (Tables 2 and 3).

A statistically significant difference was found when the patient's complaint of left ear fullness was compared with the severity of the COVID-19 condition (Table 4).

Table 1. Comparison between cases and controls regarding tympanometry curves and Eustachian tube function.

	Cases [*n* (%)]	Controls [*n* (%)]	*P* value
Right tympanometry			
A	51 (87.90)	58 (100.00)	0.013
As	2 (3.40)	0	
C	5 (8.60)	0	
Right tympanometry			
Normal	51 (87.90)	58 (100.00)	0.013
Affected	7 (12.10)	0	
Right ETF			
Good	33 (56.90)	58 (100.00)	<0.001
Affected	25 (43.10)	0	
Left tympanometry			
A	52 (89.70)	58 (100.00)	0.027
As	2 (3.40)	0	
C	4 (6.90)	0	
Left tympanometry			
Normal	52 (89.70)	58 (100.00)	0.027
Affected	6 (10.30)	0	
Left ETF			
Good	29 (50.00)	58 (100.00)	<0.001
Affected	29 (50.00)	0	

ETF, Eustachian tube function.

Table 2. Comparison between patient's complaint of sense of occlusion or fullness and Eustachian tube function in the right ear.

	Right sense of fullness [*n* (%)]		*P* value
	Yes	No	
Right ETF			
Affected	9 (81.80)	16 (34.00)	0.006
Good	2 (18.20)	31 (66.00)	

ETF, Eustachian tube function.

Table 3. Comparison between patient's complaint of sense of occlusion or fullness and Eustachian tube function in the left ear.

	Left sense of fullness [*n* (%)]		*P* value
	Yes	No	
Left ETF			
Affected	11 (91.70)	18 (39.10)	0.001
Good	1 (8.30)	28 (60.90)	

ETF, Eustachian tube function.

Table 4. Comparison between patient's complaint of sense of fullness and coronavirus disease 2019 disease severity.

	Disease severity (COVID-19) [*n* (%)]			*P* value
	Mild	Moderate	Severe	
Right sense of fullness				
Yes	3 (10.0)	6 (27.3)	2 (33.3)	0.166
No	27 (90.0)	16 (72.7)	4 (66.7)	
Left sense of fullness				
Yes	2 (6.7)	7 (31.8)	3 (50.0)	0.009
No	28 (93.3)	15 (68.2)	3 (50.0)	

COVID-19, coronavirus disease 2019.

4. Discussion

In the current research, 10 (17.24%) patients reported a bilateral sense of fullness, two (3.44%) reported a left sense of fullness, and one (1.72%) reported a right sense of fullness. Earache was reported by two (3.44%) patients. Bhatta et al.[8] noted ear fullness in 1.4% and earache in 1.8% of cases initially presented, and symptoms resolved at 3 months of follow-up, indicating that the virus has temporary effects on the auditory system.

Swain and Pani[9] conducted a prospective study between March 2020 and August 2020 to examine the incidence of hearing loss in COVID-19-infected patients who tested positive for RT-PCR after discharge from the COVID-19 hospital. Of the 472 patients, 28 (5.93%) presented with hearing loss, where 24 (85.71%) of the 28 patients presented with Sensorineural hearing loss (SNHL), whereas four (14.28%) presented with conductive hearing loss. Tympanometry was performed on all participants.

All patients with SNHL had type A tympanograms, whereas patients with conductive hearing loss had type C tympanograms.

To the best of our knowledge, this is the only study that examined ETF. ETF was abnormal in 25 (43.1%) patients in the right ear and in 29 (50%) patients in the left ear (Table 1). The results of the comparison between sense of occlusion and ETF findings revealed a statistically significant difference in both ears. Nine patients with a sense of occlusion in the right ear had ETD, whereas 11 patients with a sense of occlusion in the left ear had ETD (Tables 2 and 3). The SARS-CoV-2 virus was found to be involved in ME infection and ETD.

The infection spreading from the nasopharynx and possibly causing effusion or other alterations in the ME could account for the ME affection seen in the study. It is known that other respiratory viruses can result in otitis media by increasing a person's vulnerability to bacterial otitis media or, less frequently, by directly infecting the ME with a virus.[10,11] Adults who have COVID-19 may also get ME infections.[2,12] As has been demonstrated by other viral upper respiratory tract (URT) infections that result in otitis media, Kurabi et al.[13] propose that ME virus entry occurs through the ET. However, viral invasion via circulation is also a possibility. Both the nasal cavity and the ME epithelium express ACE-2, a receptor that is known to bind with the SARS-CoV-2 spike protein to allow cell entrance. Despite the fact that no Conductive hearing loss (CHL) was detected by Pure tone audiometry (PTA) in the current study, tympanometry revealed abnormal tympanometry in seven (12%) patients in the right ear and six (10.3%) patients in the left ear, whereas ETF was abnormal in 25 (43.1%) patients in the right ear and 29 (50%) patients in the left ear. ETF was significantly more affected than abnormal tympanometry, indicating that SARS-CoV-2 can cause ETD with or without abnormal tympanometry.

A comparison of patients' complaints of occlusion or fullness and their ETF tests revealed a statistically significant difference in both ears. Because COVID-19 is primarily a respiratory tract disease, its potential to spread and affect ETF and ME mucosa could explain this ETD and abnormal tympanometric findings. Furthermore, the ACE-2 receptor, which was recently discovered to be expressed in ME epithelial cells and ETs,[14] explains the virus's involvement in these findings.

A statistically significant connection was found when the patient's complaint of left fullness was compared with the severity of the COVID-19 condition. As the severity of COVID-19 increases, more patients complain of ear fullness. This could be attributed to the variability of viral load in ME in URT viral infections. Higher viral loads are usually associated with worsening URT infection severity.[15–17] ETF was bilaterally impaired in all patients who complained of bilateral or unilateral occlusion. As a result, it is unclear why the patients complain of ear blockage in only the left ear when both ears are affected.

In terms of our study' strengths, we used an equal case–control ratio with an adequate sample size, despite the many omitted cases and controls owing to our commitment to strict inclusion and exclusion criteria to avoid bias. This is the only study to date that has included the ETF in COVID-19-infected patients using an objective test (ETF test). Furthermore, we compared patient complaints to test results. Regarding the current study's limitations, the time between the patient's diagnosis by PCR and the conduct of tests was defined as 1 month with no upper limit, implying that other factors may also have contributed to the patient's findings. In addition, despite having COVID-19 symptoms and hearing problems, many patients were unable to participate in the study because the PCR test was not performed routinely in all cases.

4.1. Conclusions

ME function is negatively affected by COVID-19 in both symptomatic and asymptomatic patients. There is a relationship between the patient's ear fullness complaint and ETF affection.

Author contribution

Mariam M. Medhat: data analysis and interpretation, literature search, and manuscript editing. Hedayat El Sayed El Fouly: design of the study, data analysis, and manuscript review. Abdulrahman N.F. Abdulghffar: literature search, data acquisition, and manuscript preparation.

Conflict of interest

There are no conflicts of interest.

Acknowledgment

To the soul of professor Mohamed Sherif El Minawi who choose with us the idea of this research and shared in the analysis of the the first cases findings.

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