Original Article

Speech in Noise Ability Post COVID-19

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ABSTRACT

Objectives: The aim of this study is to evaluate hearing in noise ability for post COVID-19 patients using the Complete Intelligibility Spatiality Quality (CISQ) questionnaire and Arabic Version of Hearing in Noise Test (HINT).

Patients and Methods: Thirty subjects diagnosed by PCR as covid-19 virus positive were included in this study. Their ages ranged from 20 to 53 years. All participates were subjected to full audiological history, basic audiological evaluation including, complete intelligibility spatiality quality questionnaire (Arabic CISQ) and Hearing in Noise Test (HINT).

Results: HINT results, revealed a strong statistically significant difference when compared to normal in all Noise conditions. As regards Complete Intelligibility Spatiality Quality questionnaire (Arabic CISQ), the results were highly statistically significant in averseness, background noise intelligibility and spatiality subscales.

Conclusion: Post covid-19 infection, many subjects have a difficulty in speech discrimination in noise and also have difficulty in hearing specific loud sound. Further research in central auditory processing abilities post COVID-19 is recommended.

Key Words: Hearing in noise test (HINT), Complete intelligibility spatiality quality questionnaire (CISQ), Covid-19 infection, Speech in noise ability.

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INTRODUCTION

The ability to understand speech in noise depends upon multiple factors such as the characteristics of the speech signal, signal-to- noise ratio (S/N ratio) and the listener's degree of hearing impairment. A routine hearing evaluation usually does not provide simple information about the listener's functional communication abilities[1].

The complete intelligibility spatiality quality (CISQ) questionnaire checks some aspects that are not commonly taken into consideration such as noise intelligibility, spatiality (localization of sound) and quality of sound. The questionnaire is composed of 30 questions divided into six subscales, five questions for each subscale. The answers are demonstrated on a rating scale of 0–10 (0 never and 10 always)[2]. This questionnaire was translated into Arabic language and was tested on Arabic speaking subjects.

Hearing in Noise test (HINT) was developed for the measurement of reception threshold for sentences (RTS) in quiet and in the presence of noisewhich provides a reliable and efficient tool to estimate hearing difficulties in noise[3]. Hearing in Noise Test (HINT) was developed and standardized in Arabic language by Essawy *et al*., 2019.

Several pathophysiological processes have been proposed to explain how COVID-19 causes audio-vestibular disorders. Cochleitis or auditory nerve neuritis can result from viral involvement. Sudden hearing loss may also be caused by cochlear ischemia or hypoxia as a result of COVID-19-related cardiovascular abnormalities. Finally, the virus may cause immune-mediated inflammation that causes hearing loss[4].

COVID-19 is a novel virus with little published researches on its disease process. However, the main cognitive disorders associated with these coronaviruses, as well as in similar disorders, requiring to be investigated. Many of post covid-19 patients, even with normal peripheral hearing, complain of defect in the ability to understand speech in background noise. The aim of this study is to evaluate hearing in noise ability for post COVID-19 patients using the complete intelligibility spatiality quality (CISQ) questionnaire and HINT.

PATIENTS AND METHODS:

This study was conducted in the period from September 2021to March 2022 after approved by the ethical committee with approval code 34856/8/21.

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Subjects in this study included two groups, control group consisted of 30 normal hearing subjects with no history of covid-19 symptoms or speech in noise difficulties whose ages ranged from 22 to 50 years and a study group which consisted of Thirty subjects diagnosed by PCR as covid-19 virus positive were included in this study whose ages ranged from 20 to 53 years.

The inclusion criteria of the study group were age range from 18 to 60 years. These group patients had a history of positive covid-19 infection diagnosed by PCR. All patients had bilateral normal peripheral hearing (with hearing threshold level not exceeding 25 dB at any frequency from the range of 250 to 8000 Hz).

Exclusion criteria of the study group were subjects with history of hearing difficulty in noise previous to the COVID-19 infection. Also, subjects with any hearing complaints, history of audiological diseases or general health problems (e.g. any endocrinal, vascular, renal or neurological and psychiatric diseases) were excluded from this study.

Methods:

All participates in this study were subjected to full audiological history, otological examination and basic audiological evaluation including (pure tone audiometry), speech audiometry by Madsen Astera. This was done to exclude the presence of any peripheral hearing loss. Complete Intelligibility Spatiality Quality (CISQ) questionnaire and Arabic Version of Hearing in Noise Test (HINT) in noise conditions 0°, 90° and 270° were done[6].

The Arabic version of the CISQ questionnaire included 30 questions divided into six subscales (Quality, Reverberation, Background Noise Intelligence, Averseness, Silence, and Spatiality), testing some aspects that are not commonly considered, such as spatiality (sound localization) and sound quality. The questions were divided into six groups, with one item for each subscale in each group. The subscale "quality of signal" looks into the clarity of sounds. The second subscale assesses the subject's ability to hear in a large, empty space with reverberant sounds. The subscale "background noise intelligibility" investigates the subject's ability to communicate verbally in noisy environments. The subscale "spatiality of signal" assesses the subject's ability to determine which direction the sound source is coming from. The former investigates subjects' ability to communicate verbally in silence, while the latter investigates their aversion to loud sounds[2]. Each question received a score ranging from 0 to 10. All patients were asked to give a single number score, with 0 indicating never and 10 indicating always[5].

Arabic Hearing in Noise Test (A-HINT) was conducted in a sound- treated room (Transacoustic Model No RE241) by Madsen Astera which is a Type-1, two channels, and PC-based audiometer with three sound field speakers (MARTIN-AUDIO LONDON) and CD of pre-recorded calibrated test material of HINT sentences list mixed with speech noise. HINT test material was incorporated in Astera software and lists can be selected from software playlist. Thethree loudspeakerswere arranged to be one meter from subject's head. The loudspeakers were separated by a 90° azimuth at the ear level of the tested subject. Sentences speech recognition threshold (sSRT) was measured in noise conditions 0°, 90° and 270°.

The sentence lists were administered from 0° azimuth in all of the three conditions using adaptive testing procedure according to HINT guidelines (House Ear Institute, 1995). The testwas conducted three times,in the 1st condition, both noise and sentences were presented at 0° azimuth, in the 2nd noise presented at 90° azimuth and 3rd noise presented at 270° azimuth. The noise level was fixed at 65 dB (A), whereas the intensity levels of sentences were adjusted according to the participant's response. The sentence was initially presented at –5 dB signal-to-noise (SNR) and the sentence presentation level was increased in 4-dB or lowered by 4 dB according to the patient's response. Thereafter, the adaptive procedure was preceded to the 10th sentence that would have been presented using 2-dB steps. The averaged SNR from the 5^{th} to 10^{th} sentences in a sentence list was regarded as Sentences speech recognition threshold (sSRT) for that list.

Participants were instructed to pay close attention and repeat aloud as much of the sentence as possible. The sentences were presented one at a time. If the listener was unsure of what was said, he/she was encouraged to guess.

Statistical analysis

All data were analyzed by SPSS version 22. Continuous data were tested for normality by Shapiro Wilk test. Normally distributed continuous data were expressed as mean ± standard deviation and Independent Samples Student's T test was used for comparison. while, not normally distributed data were expressed as median and interquartile range (expressed as 25^{th}-75^{th} percentiles), and Mann-Whitney U test was applied for comparison. $P < 0.05$ was considered statistically significant. For correlation, Spearman correlation coefficient was applied to correlate the results of HINT. rs: correlation coefficient was considered significant at $p<0.05$.

Every participant delivered a code number. The outcomes of the research will be applied only in scientific use. The estimate of the research will be explained in details to the participants and also possible complications and side effect. An informed consent was received from all participants in this inquiry. The participation is voluntary and that subject may discontinue participation at any time without penalty or loss of benefits.

RESULTS:

Subjects included in this study included two groups. A control group which consisted of thirty normal hearing subjects with no history of covid-19 symptoms or speech in noise difficulties. They were 17 males and 13 females. Their age ranged from (22 to 50) years with the mean of 36 ±1.15 years. The study group consisted of thirty subjects diagnosed by PCR as COVID-19 virus positive. They were 18 males and 12 females. Their age ranged from (20 to 53) years with the mean of 38 ±1.55 years. These patients had COVID-19 virus infection in a duration ranged from 3 – 12 months. The main symptoms during infection included tinnitus, headache, chest infection symptoms and influenza like symptoms. All this group didn't receive any vaccination.

Results of A-HINT:

The mean of S/N ratio at threshold (sSRT) in the noise 0° condition and in the noise 90° condition was -7.92 ±2.06 and -9.23±1.10 respectively. The mean of S/N ratio at threshold (sSRT) in the noise 270° condition across all subjects was -8.53±1.88. When comparing these results and norms[6], there was a strong statistically significant difference in all noise conditions (*<0.001**) (Table 1).

Results of Arabic CISQ questionnaire:

When we compared the answers of each subscale of the questionnaire between the study group and norms[5] using paired t test, the results were highly statistically significant (*P < 0.001**) in Background noise intelligibility, Averseness and spatiality subscales (Table 2).

We used the Spearman correlation coefficient in finding the correlations between Hearing in Noise Test (HINT) in different noise conditions and the complete intelligibility spatiality quality questionnaire. A significant positive correlation was found between HINT at all noise conditions, averseness, Background noise intelligibility and spatiality. (Table 3).

Table 1: Comparison between Study and control groups as regarding HINT results.

HINT result (sSRT)		Study group N=30	Control group N=30	*P-value*
Noise 0° condition	Mean	-7.92	-10.36	*<0.001**
	SD	2.06	0.58	
Noise 90° condition	Mean	-9.23	-10.45	*<0.001**
	SD	1.10	0.41	
Noise 270° condition	Mean	-8.53	-11.69	*<0.001**
	SD	1.88	1.70	

*Significant at *p<0.05*

Table 2: Comparison between of the study and control group in the Arabic CISQ questionnaire.

		Study group N=30	Control group N=30	*P-value*
Quality	Mean± SD	9.14±.73	8.71±0.92	0.109
Reverberation	Mean± SD	8.03±.86	8.67±1.09	0.253
Background noise intelligibility	Mean± SD	15.92±1.01	8.59±0.99	*<0.001**
Averseness	Mean± SD	6.57±2.05	1.67±0.62	*<0.001**
Intelligibility in silence	Mean± SD	9.46±.55	9.10±1.07	0.188
Spatiality	Mean± SD	14.44±1.00	8.49±0.93	*<0.001**

*Significant at *p<0.05*

Table 3: Correlations between (HINT) in noise conditions and CISQ questionnaire.

	Noise 0		Noise 90		Noise 270	
	r	P-value	R	P-value	r	*P-value*
Quality	-0.033	0.891	-0.209	0.378	-0.013	0.659
Reverberation	-0.054	0.821	-0.089	0.710	-0.129	0.587
Background noise intelligibility	0.723	<0.001*	0.745	<0.001*	0.711	*<0.001**
Averseness	0.743	<0.001*	0.713	<0.001*	0.721	*<0.001**
Intelligibility in silence	0.012	0.961	0.097	0.684	0.148	*0.534*
Spatiality	0.716	0.001*	0.703	0.001*	0.776	*<0.001**

r: correlation coefficient
*Significant at *p<0.05*

DISCUSSION

Many people have struggled with the aftereffects of COVID-19. These symptoms include fatigue, mild cognitive issues, low tolerance to mental activity, speech in noise difficulty or discrimination difficulty and other central processing problems[7, 8].

This research results revealed a highly statistically significant difference in HINT results between norms and study group in all noise conditions. This suggest a difficulty in speech discrimination in noise in patients post COVID-19, whatever the source of noise, that couldn't be detected in conventional audiological testing.

The explanation for these findings may be related to lack of mental clarity, poor concentration, and an inability to stay focused documented in multiple researches about COVID-19. Hidden hearing loss associated with post COVID-19 may be also a contributor to the difficulty to discriminate speech in noise.Moreover, it is suggested that SARS-CoV-2, which has neuro-invasive properties, can cause central nervous system disorders, affecting higher mental functions and leading to memory impairment and neurocognitive problems[9,10, 11].

Abnormality detected in CISQ in averseness, background noise intelligibilityand spatialityare mainly parts of central auditory processing disorders (CAPDs)associated with post COVID-19 effect. Post COVID-19 CAPDs were reported in many researches[12,13,14].

AlJasser *et al*., 2021 created a questionnaire and revised it several times. This revised questionnaire was translated into Arabic in order for each participant's preferred language to be available in both Arabic and English. The main section used a five-point Likert scale to evaluate any self-reported change over time in nine symptoms divided into four categories. Auditory symptoms include hearing abilities (changes assessed for four variables: sense of hearing, ease of conversing over the phone, ability to follow a conversation with background noise, and preferred volume while listening to various media); non-pulsatile tinnitus; and hyperacusis (i.e. stress, irritation, or sensitivity caused by noise and environmental sounds). They concluded that hearing loss and/or tinnitus were reported in 8% of COVID-19 cases (tinnitus resolved in 2% after the acute phase), with no significant difference between severe and mild cases. Hearing loss or tinnitus was not significantly different from controls. However, rotatory vertigo was reported by 5% of the COVID-19 groups and 1.1 percent of the controls, a statistically significant difference[8].

Also, the Hearing in Noise Test (HINT) in different noise conditions and CISQ were highly correlated with averseness, background noise intelligibility and spatiality subscales. These findings strengthen the proposition that CAPDsare related to the consequences of reductions in several brain structures. The researchers analyzed the MRIs of adult subjects who had normal, pre-pandemic MRIs. Their findings identified a greater loss of gray matter in several areas of the COVID-19 brains, with many of the areas related to auditory processing[12].

In fact, hypoxic encephalopathy was found in 20% of the deceased patients in Wuhan (Chen *et al*., 2020). Other neurological effects of COVID-19 may be related to co-occurring increases in coagulation factors (e.g., D-dimer and Fibrinogen levels), which have been linked to poor prognoses[15,16,17,18].

Acute necrotizing encephalopathy is associated with intracranial "cytokine storms" (immune system hyper-inflammatory process) that can result in symmetrical, multifocal lesions of the medial temporal and thalamic cortex. SARS coronavirus 2 was recently discovered in the cerebrospinal fluid of patients with COVID-19-related encephalitis.[19,20]

Spatial signal processing is a way to detect geometry and physical properties of a spatial domain. The defect in this processing indicates difficulty in localization sound source which affects speech discriminative ability mainly in noise. Hypersensitivity and overwhelming fear of sounds (i.e., hyperacusis and phonophobia) were documented in three separate cross-sectional studies. The prevalence of hyperacusis and phonophobia were 35%[21] and 27–30%[22, 23].

CONCLUSION

The ability of hearing in background noise is affected in post COVID-19 patients. This important ability must be taken in consideration even with normal peripheral hearing after COVID-19 infection.SubjectiveArabic CISQ questionnaire revealed difficulty in averseness,background noise intelligibility and spatiality subscales. This finding indicates the presence of difficulty in hearing especially loud sounds and during noise environment by post COVID-19 patients. Also,there was difficulty in localization of sound in this group of patients.

Difficulty in the previous ability may be considered as a complication of COVID-19 and further research in central auditory processing abilities post COVID- 19 is recommended.

CONFLICT OF INTEREST

There are no conflicts of interest.

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