

Systematic Review of Conductive Hearing Loss Associated With COVID-19 Infection

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Abstract

Background

Conductive hearing loss is when sounds to the middle ear are affected. The aim of this study is to identify patients with (COVID-19) with a diagnosis of conductive hearing loss (CHL) with an objective to assaying connected mechanisms.

Methods

A systematic review was composed using sites including Google Scholar and PubMed. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were adhered to. Studies that followed the inclusion and exclusion criteria were included in the review. Of the ten papers identified in the starting search, eight met the inclusion criteria. The included eight articles consisted of three case reports, a case series, a prospective study, a retrospective cross-sectional study, a retrospective observational analytical study, and a cross sectional observation study.

Results

All patients were Covid -19 positive and exhibited CHL. In terms of the middle ear effects relating to the hearing loss, abnormalities noted included tympanic membrane dysfunction and abnormal tympanometry. In terms of treatment three studies out of the eight reported hearing loss cleared between 6 weeks and 3 months The other studies reported no treatment information of hearing loss. In terms of associated conditions these included tinnitus, Otitis media, hypertension, and mastoiditis.

Discussion and conclusion

Evidence does point towards a connection between COVID 19 and conductive hearing loss. The current literature describing conductive hearing loss in COVID-19 patients is not enough to elucidate the type of hearing loss or advise about the outcomes. Future research requires a larger sample study with controls.

Keywords: sars-cov-2; Conductive hearing loss; Middle ear; coronavirus; covid-19

Introduction

In December 2019, there were news reports of several patients getting pneumonia from the zoonotic transfer of a new virus related to a market in Beijing. [1] Following identical reports, the World Health Organization declared the new coronavirus 2019 (COVID-19) a pandemic on March 11, 2020.² Frequent symptoms of COVID-19 include fever, cough, and tiredness, but many patients stayed asymptomatic. Some experience unusual symptoms such as anosmia. Recently, a small population with COVID-19 had symptoms of hearing loss, vertigo, and tinnitus.³ Coronaviruses such as COVID-19 target the immune system,⁴ the upper respiratory system,⁵ this relates to the development of ear pathology and hearing loss, hence there is

a need for further research in this area. COVID-19 has also been found in the middle ear system of patients infected with the virus. [6]

Hearing loss is often divided into three types: conductive, sensorineural, and mixed.⁷ mechanics have been described to explain the link with viral infection and sensorineural hearing loss (SNHL), these include viral entrance to the cochlear nerve or fluid area, reactivation of inactive virus within tissues inner ear, or indirect virus antibody triggering.⁸ Conductive hearing loss includes a pathology from the pinna and the external acoustic meatus (EAM) to the foot of the stapes bone which can affect the mechanical transmission of sound from the EAM to the cochlea.⁹ There a limited number of studies on the links of covid nineteen with CHL.

In this systematic review, we identified COVID-19 patients with both a positive diagnosis of the virus and CHL, with an objective of looking at the mechanisms of aetiology between the two.

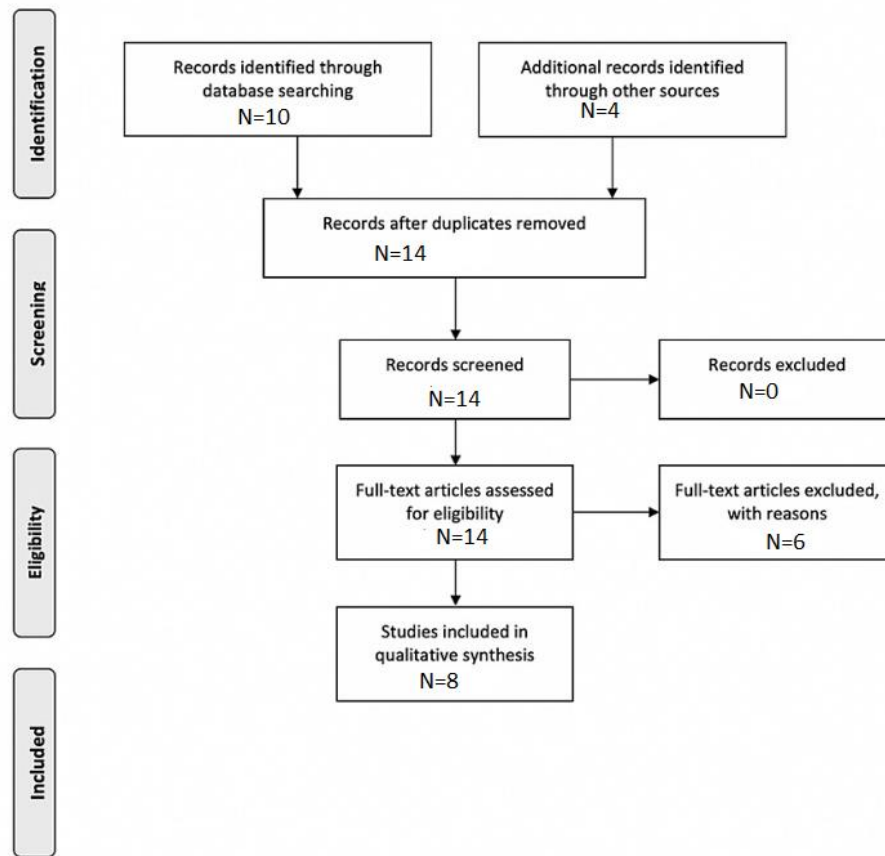


Figure 1: Prisma diagram for study selection

Methods

A systematic review was conducted based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.¹⁰ Ethics committee approval was not required for this literature review. Search Strategy We systematically searched literature databases, including PubMed, Scopus, Web of Science, and Embase, using variations of the descriptors for “COVID-19,” “SARS-CoV-2,” “CHL” with AND/OR. Searches were not restricted to studies by date, publication status, or language.

The inclusion criteria determined in our study included: patients having a positive diagnosis of COVID-19 using polymerase chain reaction (PCR) with a diagnosis of CHL at the time of the study and peer-reviewed articles. The exclusion criteria included: patients who did not have COVID-19 confirmed by PCR or patients without CHL. Eight articles were identified by scanning abstracts of papers. Articles that met the inclusion criteria were fully reviewed by their full text versions. Two independent reviewers assayed the abstracts of articles. The following data was collated: publication year, publication country, study design, age of patient, gender, and CHL diagnosis and which ear and treatment. We also included covid diagnosis method, symptoms, comorbidities, and treatments for covid at the time.

Of the fourteen articles reviewed, ten articles matched the inclusion criteria. Of those, eight papers were included in the study (Figure 1). Six articles were rejected as two were on practicalities of conductive hearing loss testing, two

reported hearing loss in general and did not go into details and two were on pathology. All the patients were between the ages of seventeen and sixty-eight years. All patients exhibited CHL, either unilateral or bilateral. The number of participants ranged from one to six hundred and twenty (Table 1).

Results

Type of study

The eight articles selected consisted of three case reports, a case series, a prospective study, a retrospective cross-sectional study, a retrospective observational analytical study, and a cross sectional observation study (table 1).

Place of study

Two studies came from India, two studies came from Iran. Other countries included Spain, Italy Turkey, and Tanzania (Table 1).

Middle ear pathology

In terms of the middle ear effects relating to the hearing loss, two papers report on tympanic membrane dysfunction, two papers report on abnormal tympanometry with abnormal peaks of type B or C, one paper reports on ossicular chain disruption. Three reported changes in audiological assessments such as middle ear pressure that was negative as well as ear fullness (Table 1).

Treatment of hearing loss

Three studies reported hearing loss cleared between six weeks to three months. The other studies reported no information (Table 1).

Comorbidities

Two papers reported associated conditions of tinnitus. Three papers reported a comorbidity of OM. One reported mastoiditis and one hypertension. There were no comorbidities mentioned with one paper (Table 2).

Covid 19 diagnosis

All diagnosis of COVID 19 was confirmed using PCR. In terms of symptoms four papers reported no symptoms and four noted symptoms including non-productive cough, mild dyspnoea, anosmia, fever, hypertension, asthenia, vomiting, diarrhoea, rhinorrhoea, sore throat, cough, rash, and hyposmia (Table 2).

Covid 19 treatment

Sadiq et al, 2022 reported treatments of (Table 2) oxygen and a multitude of medications over 5 days consisting of intravenous dexamethasone 8mg qd, intravenous ceftriaxone 1 g qd, subcutaneous enoxaparin 40mg qd, oral azithromycin 500mg qd, oral ivermectin 12mg qd, oral colchicine 0.5mg qd, oral vitamin C 1 g qd, oral vitamin D 5000 IU qd, and oral zinc 40mg qd.¹¹ Fidan, 2020 reported antiviral treatment (75 mg of oseltamivir taken orally every 12 h, 7 days). The patient was kept at her home to continue the quarantine protocol for 14 days.¹² Malesci et al, 2022 reported non-ototoxic antibiotics, paracetamol, steroids, immunosuppressants, and heparin for treatment.¹³ Dharmarajan et al, 2021 reported treatment with intravenous steroid.¹⁴ Raad et al, 2019 and Bhatta et al, 2021 reported clearing of symptoms in two to three months.^{15,16} Two studies, Boroujeni et al, 2021 and Enrique et al, 2021 reported no treatments for COVID (Table 2).^{17,18}

Author, year	Country	Type of study	Number of patients	Age range	Sex	Conductive hearing loss symptoms percentage and diagnosis	Description of loss	Treatment of hearing loss
Raad et al, 2019	Iran	Case series	8	20-45	1 m and 7 F	Left sided audiogram. Four out of eight otalgia, ear fullness and hearing loss.	Opacification of the left middle air cavity, indicative of otitis media. central tympanic membrane perforation with purulent otorrhea	Hearing loss resolved from a few days to six weeks.
Sadiq et al, 2022	Tanzania	Case report	1	68	F	A repeat audiological assessment revealed bilateral hearing loss.	Middle ear effusion and negative pressure or tympanic membrane retraction.	Resolution after 2 months.
Boroujeni et al, 2021	Iran	Case report	1	39	F	Tympanometry Earache and fullness.	In the left ear hearing tests, type B tympanometry was still present.	n/a
Bhatta et al, 2021	India and Nepal	Prospective study	331	32 ± 4.3 years	66.7% males and 33.3% females	Audiometry and tympanometry 3.2 % incidence. The aural symptoms were, tinnitus in 6/331 (1.8%), aural fullness in 38/331 (11.4%), hearing loss in 12/331 (3. Nine percent), and earache in 6/331 (1.8%).	The impedance audiometry demonstrated type B and type C curve in 5.1% and 1.15% ears, and out of these 64.7% and 40% bilateral ears	Improved after 3 months
Fidan, 2020	Turkey	Case report	1	35	F	bulging tympanic membrane in her otorhinolaryngologic examination otalgia and tinnitus.	Unilateral Right side	Not noted
Malesci et al, 2022	Italy	retrospective cross-sectional study	37	0-17	N/A	Audiological assessment Normality criteria for tympanometry was a sharp peak with middle ear pressure in the range of -150 to +25 daPa, static compliance between 0.2 and 0.9	CHL was mild in four children (three bilateral and one unilateral) and moderate in two children (one bilateral and one unilateral)	Not noted

						mL and ear canal volume with a normal range (0.4 mL to 1 mL). A reduced or no measurable middle ear pressure with normal ear canal volume suggested a middle ear dysfunction.		
Dharmarajan et al, 2021	India	Cross sectional observational study	100	There were twenty-three patients in the age group of 20–30 years, 31 in 31–40 years and twenty-eight patients in 41–50 years age and eighteen patients between 50 and 60 years	Fifty-eight were male patients and forty-two were female patients.	Six had CHL b audiological examination. Four patients had retracted tympanic membrane and two had dull TM.	30-40 DBHL	n/a
Enrique et al, 2021	Spain	retrospective observational analytical study	620	0-40	Two females with CHL	Case histories	Ossicular dysfunction	n/a

Table 1: Demographics and Clinical Manifestations of Patients with CHL and Confirmed COVID-19 Diagnosis N: Number of patients; F: Female; M=Male; NR: Not reported; CHL: Conductive hearing loss; L: Left; R: Right.

Author, year	Covid symptoms	Diagnosis	Other comorbidities	Treatment of COVID 19
Raad et al, 2019	No symptoms to non-productive cough and mild dyspnoea, anosmia	PCR oropharyngeal or nasopharyngeal swabs.	Otitis media	Cleared after 2 months.
Sadiq et al, 2022	On examination, she had a body temperature of 38.6°C, a blood pressure of 138/89mmHg, a pulse rate of 92 beats per minute, a respiratory rate of 22 breaths	PCR oropharyngeal and nasopharyngeal swabs.	A chest X-ray revealed bilateral peripheral opacifications with cardiomegaly, and a diagnosis of pneumonia was established. Hypertension	she was initiated on oxygen and a multitude of medications over 5 days consisting of intravenous dexamethasone 8mg qd, intravenous ceftriaxone 1 g qd, subcutaneous enoxaparin 40mg qd, oral azithromycin 500mg qd, oral

	per minute, and an oxygen saturation of 91% on room air.			ivermectin 12mg qd, oral colchicine 0.5mg qd, oral vitamin C 1 g qd, oral vitamin D 5000 IU qd, and oral zinc 40mg qd. For five days
Boroujeni et al, 2021	No symptoms	PCR- both oropharyngeal and nasopharyngeal swabs.	Otitis media	n/a
Bhatta et al, 2021	No symptoms	PCR both	Just aural symptoms such as tinnitus.	3 months
Fidan, 2020	No symptoms	PCR both	otalgia and tinnitus.	Antiviral treatment (75 mg of oseltamivir taken orally every 12 h, 7 days) was provided. The patient was kept at her home to continue the quarantine protocol for 14 days.
Malesci et al, 2022	fever, asthenia, vomiting, diarrhoea, rhinorrhoea, sore throat, cough, dyspnoea, rash, and hyposmia.	nasopharyngeal swab PCR	No comorbidities	non-ototoxic antibiotics, paracetamol, steroids, immunosuppressants, and heparin.
Dharmarajan et al, 2021	Ear pain/discharge, hard of hearing, tinnitus, aural fullness, giddiness nine	PCR both	OAE Of the one hundred patients, twenty-seven patients had hypertension, six patients had history of ischemic heart disease. Only one patient had history of using propranolol. Twenty-two patients in total received remdesivir injections for their symptoms	intravenous steroids
Enrique et al, 2021	None	PCR	mastoiditis and deep cervical infections	n/a

Table 2: Covid 19 symptoms, diagnosis measures and treatments N= Number of patients. PCR -polymerase chain reaction.

Discussion

The aim of this study was to determine if there is connection between COVID-19 and CHL with a link to possible mechanics.

COVID-19 is presented in many ways which delays diagnosis. In our study the patients presented with conductive hearing loss as well as other associated conditions including earache and tinnitus. Tinnitus and Otitis media were two conditions presented with conductive hearing loss and no associated symptoms of covid. In terms of tinnitus a recent review found 60.9% patients with covid related hearing loss had tinnitus symptoms.¹⁹

CHL, OM and Covid 19.

Three studies note a link with conductive hearing loss, otitis media and Covid 19.^{15,17,14} Otitis media (OM) refers to infection of the middle ear, swelling, redness and the build-up of fluid in the ear drum/ middle ear space, otitis media with effusion (OME) and has the inclusion of both the adaptive and innate immune systems, eustachian tube dysfunction, and other related factors. Otopathogens, commonly *Streptococcus pneumoniae*, *Haemophilus influenzae* and/or respiratory viruses, colonize and proliferate in the nasopharynx (NP), and eventually infect the middle ear and cause OM.²⁰

Otitis media with effusion (OME) is one of the biggest causes of (CHL).²¹ The angiotensin-converting enzyme-2 (ACE2) receptor, which is an entry point for COVID has a high expression the ciliated cell area of the Eustachian tube and this could promote the passage of infection to the components of the middle ear. This is dependent on the interaction between its spike protein to a cellular receptor named angiotensin-converting enzyme 2 (ACE2) and depends on Furin-mediated spike protein cleavage and spike protein priming by host cell proteases such as transmembrane protease serine 2 (TMPRSS2) for viral entry. An immunohistochemical study showed that Ace2, Tmprss2, and Furin were collectively expressed in the epithelium mucosa lining of the Eustachian tube, middle ear spaces and the organ of Corti, lateral wall, and spiral ganglion cells in the cochlea.²²

CHL, Tympanic membrane dysfunction and Covid 19.

In this review, Dharmarajan et al., 2021 and Fidan et al., 2020 reported on changes in the structure of the tympanic membranes, in COVID-19 patients.^{12,14} Fidan et al. (2020) noted tympanic membrane swelling and increased blood flow,¹² Dharmarajan. et al. (2021), noted patients that presented with tympanic membrane retraction and some with dull membranes.¹⁴ Perforation of the tympanic membrane can also cause a conductive hearing loss.²³ Tympanic membrane shape changes can be a result of long-standing ear conditions that could have been left untreated that are difficult to connect to covid nineteen. Despite this, COVID-19 seems to contribute to middle ear conditions that affect the tympanic membrane especially with an OME association as Dharmarajan et al., 2021.¹⁴ This entails a requirement for hearing professionals to be observant of the chances of structural changes of the tympanic membrane because of middle ear pathologies in patients with COVID 19 that if left could become long lasting, causing speech issues later.²⁴ One study Enrique,2021, reported a patient with ossicular disruption and covid nineteen. A defect in the ossicles will also give a conductive hearing loss. This could be due to head trauma resulting in ossicle discontinuity, or it could be due to a disease process such as otosclerosis.¹⁸ Otosclerosis is an osseous dyscrasia within the temporal bone.²⁵ The ossicular dysfunction may be linked to tympanic membrane damage. More studies are needed to confirm these findings.

CHL, hypertension and Covid 19.

One study (Sadiq et al, 2022) reported on hypertension, with covid nineteen and CHL.¹¹ In terms of covid nineteen and hypertension the link is the renin angiotensin system function and the expression of ACE2, which allows entry of virus. Renin is made in the kidneys by the juxtaglomerular cells and

released into the circulation. Renin catalyses the splitting of the protein angiotensinogen producing Angiotensin I. Angiotensin I is then converted by angiotensin converting enzyme to form angiotensin II, this binds to receptors of angiotensin II triggering aldosterone synthesis which causes increased sodium and water reabsorption and hence pressure of blood.²⁶

A few mechanisms have been proposed linking hypertension with auditory system, increasing blood stickiness leading to increased resistance and deprivation of oxygen to the systems.²⁷ Another way is the high blood pressure in the systemic arteries producing haemorrhage within the cochlea, thus disrupting its integrity, and leading to hearing loss.²⁸ A majority of the studies link hypertension with sensorineural hearing loss. Larger scale studies are needed to review the effect of hypertension on CHL.

CHL, mastoiditis and Covid 19

In this review one study Enrique,2021 reported mastoiditis with one person.¹⁸ The link with covid nineteen is the so called "cytokine storm." This is when there is a pro-inflammatory cytokine surge or a higher concentration of cytokines such as interleukin IL-2R, IL-6, IL-10, and tumour necrosis factor α detected among the group of severe COVID-19 patients. A similar thing could be happening in this patient where exposure to the virus generates a more intense inflammation response and aggravates the infection. Mastoiditis has been linked to CHL and this may be related to the movement of infection as in the case with OME.²⁹ One study Sadiq et al, 2022 reported a link with negative pressure and hearing loss.¹¹ This can be related to tympanic membrane dysfunction and negative pressure changes.³⁰

Abnormal tympanograms and CHL.

Three of the studies assessed (Bhatta et al., 2021; Boroujeni et al., 2021; Fidan, 2020) calculated acoustic immittance to diagnose middle ear disruption if any.^{16,17,12} All these works also reported tympanometry, while Boroujeni et al., 2021 reported on acoustic reflex thresholds, in addition.¹⁷ Type B tympanogram was frequently found in the studies with three studies indicating its presence in connection with COVID-19.^{16,17,12} Bhatta et al. (2021) reported a presence of 5.1% for Type B and 1.15% for type C tympanograms.¹⁶ These studies link middle ear dysfunction with tympanic membrane rigidity. Certain health professionals do not routinely include tympanometry in their testing of patients,³⁰ this review shows that this is an important outcome to measure. This coincides with another study that found in a rat model of diabetes type I, type B tympanograms were present and in the control group type A tympanograms were present. Type A tympanograms are associated with a compliant and fully functional middle ear connection whereas the Type B tympanograms indicate fluid or infection in the region.³² This infection could be the COVID 19. Future studies could also include sensitive instruments of conductive compliance such as the wideband acoustic immittance (WAI).³⁰

CHL and Covid 19 presence.

Eight studies indicated a conductive element to the hearing loss.^{16,17,14,12,13,15,11,18} Bhatta et al. (2021) reported an incidence of CHL with COVID 19 of 3.2%.¹⁶ While the other studies reported the incidence of CHL, two of those studies did not report on the severity of the CHL. Boroujeni et al. (2021) indicated the severity of CHL in a participant infected with COVID-19 was mild to moderately severe.¹⁷ The presence of CHL in these studies is connected to the middle ear disruption. Three of the studies reviewed were case series which involved only one participant. Despite the lack of data from the studies, the evidence presented does present the occurrence of CHL in this group. A much larger study with a group without COVID 19 is needed for a better comparison and to verify these results.

CHL and treatment

Three studies mentioned that hearing loss resolved from a few weeks to three months.^{16,15,11} Five studies did not provide details on the duration of the conductive hearing loss and if it was resolved.^{12,13,14,17,18} There was limited information on treatments given for COVID 19 being used for treating CHL. Although there are studies linking pharmacological treatments of covid nineteen such as hydroxychloroquine with SNHL, tinnitus and vertigo.³³ Steroids,³⁴ Dexomethosone,³⁵ Enoxaparin,³⁶ Ceftriaxone,³⁷ and Colchicine³⁸ have been used in the treatment of sensorineural hearing loss. This is also an avenue to explore in future work. Azithromycin,³⁹ Ivermectin,¹¹ and Oseltamivir,⁴⁰ in combinations with other drugs may lead to ototoxicity as a side effect. Ototoxicity may be manifested by hearing loss, tinnitus, imbalance, and cochlear-mandibular symptoms.⁴¹

This review provided some crucial information about conductive hearing loss in patients infected with COVID-19. The study suggests a need for audiological evaluation and periodic monitoring for patients infected with COVID-19 that is continuous. Hearing professionals in healthcare need to be aware of the risks of COVID-19 on middle ear function to implement effective preventive care, and to provide education and counselling to patients and their families. Larger scale studies are needed to better measure the outcomes of COVID 19 and hearing loss.

Conclusions

This review found a link with CHL and covid 19, However studies are limited. COVID-19 has been noted in the middle ear tissues of patients infected with the virus.⁶ As well as causing infections of the upper respiratory tract,⁵ which will link to middle ear diseases. Results of this study raise expectations for future studies to use correct methodologies, include a control sample, as well as more diagnostic methods and participants.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in authoring this article. Authors' contributions

S.A co-conceptualised the study and the methodology, collected the initial data, screened, and analysed the data with a colleague.

Data availability

Data are available from the first author upon a reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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