SCIE DOI: 10.14744/scie.2023.68542
South. Clin. Ist. Euras. 2023;34(3):283-288

Original Article

Hyperbaric Oxygen Treatment for Post-COVID-19 Sudden Sensorineural Hearing Loss Patients

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Submitted: 06.08.2023
Revised: 07.08.2023
Accepted: 17.08.2023

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Keywords: Acute; COVID-19; hearing loss; hyperbaric oxygen therapy; sensorineural.

ABSTRACT

Objective: Sudden sensorineural hearing loss (SSNHL) has been reported in individuals with a previous medical history of COVID-19. This research was conducted to investigate the outcomes and characteristics of these cases following hyperbaric oxygen treatment (HBO2).

Methods: This retrospective study included patients diagnosed with SSNHL, with a previous history of coronavirus disease, who underwent HBO2. Medical files from four health centers (three tertiary and one state hospital) between March 2020 and September 2021 were reviewed to evaluate the treatment outcomes.

Results: The study found that 25 out of 304 patients who presented with SSNHL had a prior COVID-19 infection. The mean age of the patients was 36.2 ± 12.3 years, with 56% being male. Recovery rates were as follows: complete recovery (20%), partial improvement (20%), and minimal improvement (32%). There was a statistically significant difference between the pre-and post-treatment median values of all frequency levels (**P<0.001).

Conclusion: SSNHL requires immediate management with various treatment modalities. In this study, HBO2 showed improvement in hearing loss specifically in patients with a prior history of coronavirus infection. The varied distribution of recovery rates aligns with existing literature. This is the inaugural study assessing the outcomes of HBO2 in such cases.

INTRODUCTION

Sudden sensorineural hearing loss (SSNHL) is a significant health concern necessitating immediate otolaryngological intervention. It is characterized by a hearing loss of 30 decibels (dB) or higher at at least three consecutive frequencies within 72 hours. Diverse incidence rates are reported, noting 11 cases under 18 years and 77 cases over 65 years per 100,000. Although predominantly observed between ages 43-53, it spans all age groups, affecting both genders equally. Various pathophysiological mechanisms for adult sudden hearing loss are suggested, including in-

fection, vascular or hematological diseases, neoplasm, or trauma. However, 70% are idiopathic, making it challenging to establish definitive causal relationships.[1]

The COVID-19 pandemic, caused by a viral pathogen, has globally escalated morbidity and mortality, characterized mainly by hypoxia, ischemia, and thromboembolism. Concurrent reports detail instances of impaired hearing functions and SSNHL diagnoses, with some indicating sudden hearing loss post-coronavirus infection diagnosis, although rare.[2,3]

Clinical manifestations predominantly include hearing loss, tinnitus, and a sensation of ear fullness. Varied treatment options encompass steroids, hyperbaric oxygen treatment (HBO2), vasodilators, and antiviral drug regimens. HBO2, particularly, is emerging as a beneficial adjunctive therapy by enhancing plasma oxygen dissolution, swiftly resolving hypoxia, reducing edema, bolstering the immune system, and enhancing tissue oxygenation through anti-inflammatory and thrombolytic mechanisms.[4]

The recent pandemic has seen a surge in sudden hearing loss cases, some with prior COVID-19 diagnoses. This study aims to elucidate the characteristics and evaluate the HBO2 treatment effectiveness on SSNHL patients with prior COVID-19 infection by retrospectively examining patient medical records.

MATERIALS AND METHODS

This retrospective study encompassed a group of patients administered HBO2 for SSNHL, having prior treatment for COVID-19. Medical files from four health centers, three tertiary and one state hospital, between March 2020 and September 2021, were scrutinized. The study protocol received approval from the Clinical Research Ethics Committee (Approval No. 21/83, dated 10-12-2021), with all enrolled subjects providing informed consent. Patient files were reviewed for demographic and clinical details, including sex, age, medical history, COVID-19 vaccination status, comorbidities, treatment onset from symptoms' emergence, recovery time, and HBO2 administration details. Data were extracted from the medical database.

Patients

The subjects included patients administered HBO2 for SSNHL within 45 days post-COVID-19 recovery. All reported normal pre-infection hearing levels. Exclusions were those under 18, with a history of middle ear surgery or chronic otitis media, central nervous system disorders, malignancy, or incomplete medical records. Comprehensive data, including SSNHL and COVID-19 details, were recorded, and unavailable COVID-19 data were obtained through patient interviews.

Outcome Assessment

Hearing loss stages and treatment responses were assessed using pure tone audiogram (PTA) results obtained pre and post-HBO2 sessions. Hearing thresholds at 125-8000 Hz were evaluated. Hearing recovery outcomes were categorized per Siegel criteria.

Hyperbaric Oxygen Treatment

Treatment was administered daily for five days weekly in mono or multi-place pressure chambers. Monoplace and multiplace chamber treatments were conducted at 2.2 ATA and 2.4 ATA, respectively, with varying session durations and 100% oxygen inhalation periods interspersed with 5-minute air breaks. Treatment time was 100-minute for monoplace and 120-minute for multiplace chamber and patients inhaled 100% oxygen via face mask. Adverse effects monitoring was continuous.

Statistical Analysis

Data were analyzed with SPSS Inc. V23, IBM, Chicago, IL, USA, presented as mean and percentage. Relationships between independent variables (age, gender, pre and post-HBO2 PTA, comorbid diseases, treatment sessions) and post-HBO2 outcomes were assessed using various tests. Normal distribution was checked by the Shapiro-Wilk test. Pearson chi-square test and Mann-Whitney U test were used as appropriate, with binary logistic regression examining independent variables affecting improvement levels. Results are presented with relevant statistical expressions, considering a p-value under 0.05 as statistically significant.

RESULTS

In the study, we could access the medical records of 304 patients. It was determined that only the medical records of 25 patients complied with the inclusion criteria of the study. The mean age of the patients was 36.2 ± 12.3 years, and 56% of the patients were male. Only 24% of the patients were smokers. Chronic diseases such as hypertension, diabetes mellitus, etc., were present in 16% of patients. The fact that only two (8%) patients had Covid vaccination, and all had received two doses of vaccine before the development of SSNHL.

In terms of treatment management, 4% of the patients were administered intratympanic steroid and HBO2, 32% of patients were administered HBO2 in addition to oral steroid usage, and 36% of the patients were administered both intratympanic and oral steroid with HBO2. Twenty-eight percent of patients did not receive steroid treatment. The frequency distribution of demographic data is summarized in Table 1.

Although most of the patients complained of hearing loss at first, 12% of patients presented to HBO2 centers with other accompanying symptoms such as vertigo, dizziness, and headache. It was demonstrated that 56% of patients had severe or total hearing loss. The mean number of sessions was determined to be 13. However, the minimum and maximum number of HBO2 sessions were 1 and 40 respectively. Descriptive statistics of quantitative data are

Table 1. Frequency distribution of categorical variables

	Frequency (n)	Percent (%)
Gender		
Male	14	56
Woman	11	44
Smoking		
No	19	76
Yes	6	24
Covid 19 Vaccination		
No	23	92
Yes	2	8
Other symptoms (Dizziness, headache etc.)		
No	22	88
Yes	3	12
Steroid used in the treatment of Covid 19		
No	24	96
Yes	1	4
Affected Ear		
Right	11	44
Left	13	52
Bilateral	1	4
Chronic Disease/Comorbid Factors		
No	21	84
Yes	4	16
HBO2 with intratimpanic steroid treatment		
No	15	60
Yes	10	40
HBO2 with oral steroid treatment		
No	8	32
Yes	17	68
Level of hearing loss		
Mild	2	8
Moderate	3	12
Severe	6	24
Very severe	8	32
Total	6	24
Healing degree		
Complete	5	20
Partial	5	20
Minimal	8	32
No	7	28

shown in Table 2. When the levels of improvement were evaluated by grading hearing loss, the recovery rate varied, and the distribution was as follows; complete recovery was found in 5 (20%), partial improvement in 5 (20%), and minimal improvement in 8 (32%) of the cases. Considering the side effects of the HBO2, none of the patients complained of ear barotrauma or other problems.

When the variables of the patients' data were evaluated in terms of age groups (<50 years or >50 years), smoking, presence of chronic disease, time of HBO2 initiation after the onset of symptoms (<15 days or >15 days), no statistically significant differences were found ($P > 0.05$). Moreover, there was also no statistically significant difference between the outcomes of treatment groups who were administered HBO2 with intratympanic or HBO2 group with oral steroids ($P > 0.05$). Besides, it was found that post-HBO2 mean values of all frequency levels were statistically higher (***$P < 0.001$) (Table 3). The effect of variables including time to first symptoms of SSNHL, administration of oral and intratympanic steroid, was evaluated by using univariate and multivariate models in the binary logistic regression analysis, and results were not found to be sta-

Table 2. Descriptive statistics of quantitative data

	Mean (SD)	Median (min. - max.)
Age	36,2 ± 12,32	38 (11 - 54)
The number of HBO2 session	13,28 ± 10,16	10 (1 - 40)
Time to first HBO2 session after the start of SSNHL (days)	16,24 ± 12,3	15 (1 - 45)
Time to start of SSNHL after Covid-19 infection (days)	20,08 ± 12,85	20 (1 - 45)
İmprovement of hearing level (dB)	30,36 ± 28,53	30 (0 - 100)
Level of hearing loss (dB)	81,72 ± 27,77	80 (30 - 120)

Table 3. Comparison of frequency values (dB) before and after HBO2

	Before treatment		After treatment			
Frequency in Hertz	Mean (SD)	Median (min. - max.)	Mean (SD)	Median (min. - max.)	Test statistic	P*
125	76,8 ± 34,46	70 (10 - 120)	55 ± 43,33	50 (0 - 120)	-3,450	0,001
250	77 ± 34,28	70 (10 - 120)	55,2 ± 43,14	50 (0 - 120)	-3,450	0,001
500	80,4 ± 33,94	70 (10 - 120)	57,4 ± 42,36	50 (0 - 120)	-3,526	<0,001
1000	84 ± 29,26	70 (30 - 120)	60,4 ± 40,59	50 (0 - 120)	-3,486	<0,001
2000	87 ± 27,91	90 (40 - 120)	65,2 ± 39,91	60 (0 - 120)	-3,417	0,001
4000	87,4 ± 28,47	90 (40 - 120)	67 ± 40,26	60 (10 - 120)	-3,492	<0,001
8000	87,2 ± 28,03	85 (40 - 120)	65,8 ± 39,41	60 (10 - 120)	-3,530	<0,001

*Wilcoxon sign test.

tistically significant.

DISCUSSION

In this study, we aimed to determine the characteristics of the patients and evaluate the outcomes of HBO2. Our study results showed that HBO2 resulted in an improvement of hearing functions with varying recovery rates as follows: complete recovery in 20%, partial improvement in 20%, and minimal improvement in 32% of the patients. It is important to note that a statistically significant improvement was observed in each frequency at the end of the HBO2 protocol, positively impacting the treatment of hearing impairment in these cases.

In the literature, it was reported that there were several cases who had previously been diagnosed with coronavirus infection and were treated with the diagnosis of SSNHL during the pandemic. The medical history of the patients in these studies and our patients was similar. In this regard, Kılıç et al.'s study is an important source in which the association between COVID-19 infection and sudden hearing loss was mentioned.[5] Considering the criteria recommended by Meng, the onset of hearing loss within two months after COVID-19 infection may be associated with being infected with the coronavirus.[6] Going through the medical records of the participants, we also found that the patients had previous diagnoses of Coronavirus infection. According to the study results and the medical history of our patients, COVID-19 infection might be considered as an etiologic factor which resulted in SSNHL shortly. However, it is not conceivable to make a definite conclusion with the current study results.

Sudden hearing loss is more common between the ages of 43 and 53, while both sexes are affected equally.[1] In our study, considering the gender and age distribution of the cases, 56% of the patients were male, and contrary to the records in the literature, only 28% of the patients were between the ages of 40 and 50. Patients mostly had complaints of acute hearing loss, however, some of them suffered from dizziness, as well as a headache. The symptoms were predominantly unilateral, and the selectivity of the ear varies in the literature whereas most of our patients had left ear involvement. Bilateral involvement can be seen in less than 4% of cases which correlates with the finding we have achieved.[1,7] Studies have revealed that cardiovascular risk factors such as diabetes, atherosclerosis, and hypertension may play a significant role in the etiology.[1,7] Moreover, it has been mentioned that 25.2% of the cases had comorbidities like our findings in sudden hearing loss.[8] Our findings with regard to gender distribution, symptoms and comorbidities have been in accordance with the results of previous studies.

The pathophysiology of SSNHL cannot be clearly defined, and studies emphasize the role of hypoxia. The loss of audiovestibular function may be seen in the disease due to ischemia resulting from thrombotic events. It has been shown that COVID-19 infection could bring about thrombotic events in different tissues.[9] Interestingly, audiome-

try examinations revealed the loss of high frequencies in the hearing threshold of asymptomatic patients diagnosed with COVID-19.[10] Despite not being fully explained, different mechanisms which cause cochlear ischemia such as hypercoagulability, increased blood viscosity, and viral infections are mentioned.[11] Treatments which combat with hypoxia and thrombotic events are considered to have great value.

As is known, another contributing factor related to poor prognosis is widely considered to be the age of the patient. According to the results of some studies, researchers found that patients who are younger than 50 years old had better treatment outcomes with higher hearing gain.[12] On the contrary, our results did not show any difference in hearing gain outcomes in patients younger than 50 years of age, as stated in the study by Çekin et al.[13]

The spectrum of treatments of SSNHL includes steroids (oral, intravenous, intratympanic), HBO2, and vasodilators, etc. Consensus reports were published based on systemic reviews and steroids have been recognized as the gold standard. The conclusion is that HBO2 is as effective as steroids and recommended in clinical practice.[1] It is suggested that the treatment order be as follows: oral steroid, intratympanic steroid, and HBO2.[1,12] Moreover, the high rate of spontaneous recovery, which is 45-65% in the first 2 weeks, creates controversy about the effectiveness of medical treatments and aggressive approach.[14] It is commonly accepted that HBO2 shows significant improvement in indications, and it occupies a big role in sudden hearing loss by accelerating the recovery as well.[1,3] There have been studies which discussed the effectiveness of HBO2 and the outcome of the treatments before the COVID-19 pandemic. Topuz et al. found over 10 dB in hearing gain in the HBO2 group.[15] Hosokawa et al. found the success rate of HBO2 to be 46.1% in cases that did not respond positively after steroid administration.[16] In survey studies, it is stated that hearing gain results vary between 30% to 70%.[7,17,18] In contrast, there are several studies in which the level of hearing gain appears to be lower than expected. After evaluating the results of our patients, we found that the average recovery rate was varied. Most importantly, we also observed a statistically significant improvement in each frequency at the end of HBO2, which is like the findings of the study.[8] Hyperbaric oxygen treatment resulted in improvement in hearing gains in these particular cases.

Conclusion

Sudden sensorineural hearing loss (SSNHL) necessitates immediate intervention utilizing various treatment approaches. This study evaluated the effects of HBO2 on SSNHL patients with a medical history of COVID-19 infection and analyzed the characteristics of patients that may influence treatment outcomes. The distribution of the recovery rate varied, with complete recovery, partial improvement, and minimal improvement observed in 20%, 20%, and 32% of the cases, respectively. This improvement was not correlated with age or the initiation time of HBO2. The diverse recovery rate distribution is consistent with existing literature. This research is pioneering in evaluating the outcomes of HBO2 in such contexts. Nevertheless, further support from more extensive case series is essential for these studies.

Ethics Committee Approval

This study approved by the Hamidiye Medical Faculty Clinical Research Ethics Committee (Date: 10.12.2021, Decision No: 21/38).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: S.G.S., A.A., B.M.; Design: S.G.S., A.A., B.M., Y.A., A.Ç.; Supervision: S.G.S., A.A.; Materials: S.G.S., Y.A., A.Ç.; Data: S.G.S., A.A., B.M., Y.A., A.Ç.; Analysis: S.G.S., A.A., B.M., A.Ç.; Literature search: S.G.S., A.A., A.Ç.; Writing: S.G.S., A.A., B.M., Y.A., ; Critical revision: S.G.S., A.A., B.M., A.Ç.

Conflict of Interest

None declared.

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COVID-19 Pandemisinde Hiperbarik Oksijen Tedavisi Uygulanan İdiopatik Ani İşitme Kaybı Hastalarında Önceden COVID-19 Geçirenlerin Değerlendirilmesi: Retrospektif Bir Çalışma

Amaç: Ani sensörinöral işitme kaybı (SSNHL) tanısı alan bazı hastalarda, özgeçmişlerinde daha önce Coronavirus 2019 (COVID-19) tanısıyla tedavi aldıkları bildirilmiştir. Bu çalışmada, benzer olguların hiperbarik oksijen tedavisi (HBO2) sonuçları ve hastalara ait özelliklerin belirlenmesi amaçlandı.

Gereç ve Yöntem: Retrospektif olarak planlanan bu araştırma, SSNHL tanısı ile HBO2 uygulanan ve daha önce koronavirüs enfeksiyonun hastalığı öyküsü olan hastaları içermektedir. Mart 2020-Eylül 2021 tarihleri arasında dört hastanedeki HBO2 merkezde tedavi uygulanan hastaların tıbbi dosyaları incelendi ve tedaviye yanıtları değerlendirildi.

Bulgular: Bu çalışmada retrospektif olarak hasta kayıtları incelendiğinde, SSNHL tanısı ile başvuran ve HBO2 uygulanan 304 hastanın daha önce COVID-19 enfeksiyonu geçirenlerin sayısı 25 olarak bulundu. Hastaların yaş ortalaması 36.2±12.3 yıl olup, %56'sı erkekti. İyileşme oranlarına bakıldığında olguların %20'sinde tam iyileşme, %20'sinde kısmi iyileşme ve %32'sinde minimal iyileşme saptandı. Saf ses odyometri işitme testi sonuçları değerlendirildiğinde tüm frekans seviyelerinde tedavi öncesi ve sonrası medyan değerler arasında istatistiksel olarak anlamlı bir fark vardı ($p<0.001$).

Sonuç: Ani sensörinöral işitme kaybı, farklı tedavi seçenekleri ile hızlı bir çözüm gerektirir. Bu araştırmada, HBO2 ile daha önce yakın bir zamanda koronovirüs enfeksiyonu tedavisi uygulanmış belli olgularda işitme kaybını iyileştirdiği görüldü. Tedavi sonuçları iyileşme hızının değişkenliği ve literatürle uyumlu olduğunu göstermiştir. Bu çalışma bu gibi olgularda HBO2 tedavisinin sonuçlarını değerlendiren ilk araştırmadır.

Anahtar Sözcükler: Akut; COVID-19; hiperbarik oksijen tedavisi; işitme kaybı; sensorinöral.