

# A COVID-19 infection incidentally detected during hyperbaric oxygen treatment and preventive measures for COVID-19 transmission in a multiplace hyperbaric chamber

Abdurrahman E Demir<sup>1</sup>, Savas Ilbasimis<sup>2</sup>, Akin S Toklu<sup>3</sup>

<sup>1</sup> University of Health Sciences, Turkey, Department of Aerospace Medicine, Ankara, Turkey

<sup>2</sup> Clinic of Hyperbaric Oxygen Therapy, Yunus Emre State Hospital, Eskisehir, Turkey

<sup>3</sup> Department of Underwater and Hyperbaric Medicine, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey

**Corresponding author:** Abdurrahman E Demir, University of Health Sciences, Department of Aerospace Medicine, General Dr.Tevfik Sağlam Cd, Post Code: 06010, Etlik, Ankara, Turkey. [ORCID: 0000-0003-0949-1734](https://orcid.org/0000-0003-0949-1734). [aengindmr@hotmail.com](mailto:aengindmr@hotmail.com)

## Key words

Confined space; Contagion; Infectious diseases; Pressure chambers; SARS-CoV-2

## Abstract

(Demir AE, Ilbasimis S, Toklu AS. A COVID-19 infection incidentally detected during hyperbaric oxygen treatment and preventive measures for COVID-19 transmission in a multiplace hyperbaric chamber. *Diving and Hyperbaric Medicine*. 2022 March 31;52(1):58–62. doi: 10.28920/dhm52.1.58-62. PMID: 35313375.)

**Introduction:** SARS-CoV-2 (COVID-19) was declared a global pandemic on 11 March 2020 and has become a serious threat to public health. As it can easily be transmitted through droplets and aerosols, there is an increased risk of transmission in enclosed environments such as hyperbaric oxygen treatment (HBOT) units if preventive measures are not taken.

**Case report:** A 16-year-old female tested positive for SARS-CoV-2 during HBOT for idiopathic sudden sensorineural hearing loss. The other patients and the inside attendant who attended the sessions with her were regarded as contacts, tested for SARS-CoV-2, and quarantined until the test results were available. Ultimately, none of them tested positive.

**Discussion:** As HBOT in multiplace chambers entails a high risk of SARS-CoV-2 transmission, we strictly adapted our practice to consider that every patient could be a potential asymptomatic carrier. Therefore, the negative results of all contacts in this case and the fact that no confirmed cases of COVID-19 were reported suggests that these measures successfully prevented SARS-CoV-2 transmission in our HBOT clinic. SARS-CoV-2 transmission can be prevented if sufficient protective measures are taken.

---

## Introduction

The spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2, COVID-19) virus, was declared a global pandemic on 11 March 2020, has resulted in a worldwide threat to public health and caused economic and social disruptions that generated global upheaval. Restrictions and precautions were adopted both in routine and emergency health services, as in all areas, to prevent the spread of the virus and to reduce the patient load, especially at the intensive care level. Hyperbaric oxygen treatment (HBOT) units, in which patients inhale 100% O<sub>2</sub> at pressures 2–3 times higher than atmospheric pressure in hyperbaric chambers, are particular at-risk medical facilities.<sup>1</sup> As coronavirus is highly contagious and can easily be transmitted through droplets and aerosols in such closed units, there is a high risk of transmission in hyperbaric chambers.<sup>2</sup> In the early days of the pandemic, the European Committee for Hyperbaric Medicine and Undersea and Hyperbaric Medicine Society published guidelines with the aim of minimising the risk of transmission and preserving continuity of treatments in HBOT clinics<sup>3,4</sup> Following these

guidelines, and recommendations of the Turkish Ministry of Health (TMOH) at that time, we made some necessary adjustments regarding decontamination and patient selection procedures in our HBOT unit. In this report, we present a patient who was incidentally diagnosed with COVID-19 during HBOT and the measures that we have adopted to prevent COVID-19 transmission.

## Case presentation

The patient gave consent for the publication of her case. A 16-year-old female presented to the Ear, Nose and Throat department with a three-day history of left-sided tinnitus and hearing loss in September 2020. She had no history of trauma, ear surgery or ototoxic medications and diseases. Other system examinations were unremarkable. She was diagnosed with idiopathic sudden sensorineural hearing loss (ISSNHL) and referred for HBOT. Treatment was initiated once a day (excluding weekends), at 243 kPa (2.4 atmospheres absolute) pressure for 120 min including compression and decompression time, in a multiplace chamber. Nine days later an urgent HBOT session for a

patient with central retinal artery occlusion (CRAO) was planned. Our ISSNHL patient and three others sharing the same routine sessions with her were also called to the session. That same evening, she presented at the emergency department with a headache, warm forehead, and general feeling of weakness and accordingly, a SARS-CoV-2 RT-PCR (reverse transcriptase-polymerase chain reaction) test was performed. Her remaining sessions were cancelled temporarily until the test result was obtained. She tested positive, HBOT was stopped, and she was quarantined.

When the patient tested positive, we questioned her close contacts, their health status, and medical histories. We were informed that the patient came to other eight sessions with her mother from a neighboring city 80 km away by car except for the fifth session day. On the fifth day, her father drove her to our clinic by car from the same city. They had been in close contact the whole way for about 1.5 hours without wearing masks. Because the patient lived with her mother, this was the first and the last time she had contact with her father throughout her treatment. On the sixth day of her treatment, her father started showing COVID-19 like symptoms. He went to the hospital on the seventh day, gave a sample on that day, and he tested positive on the eighth day. Our patient learned of this medical history of her father when she presented at the emergency department.

Due to preventive measures already in place, there had been only five patients and one inside attendant in each of our routine HBOT sessions. Four patients and the inside attendant had attended the sessions with our patient since the first day of her treatment, all of whom were the same individuals except the patient with CRAO. Upon our patient testing positive, her mother, these four patients, the CRAO patient, and the inside attendant were regarded as contacts, tested for SARS-CoV-2, and quarantined until their test results were available. All of them tested negative. They were also observed in the following days and no symptoms were declared.

## Discussion

Immediately after the first COVID-19 case was recorded in our country, general safety precautions and regulations were implemented according to the recommendations of the ECHM, UHMS and TMOH. It was made compulsory for every person, patient, and healthcare professional in our clinic to wear a surgical mask. All patients and their companions were assessed with temperature monitoring and Quick Recognition code, a screen that indicates whether a person has COVID-19 or has been in contact with a person diagnosed with COVID-19, before entering the clinic. Non-alcohol-based hand sanitisers were placed at the entrance and exit of the clinic and the chamber. Enough time was allowed to maintain passive chamber ventilation between sessions. In addition, indications for HBOT and treatment sessions were restricted. Patients who did not need urgent

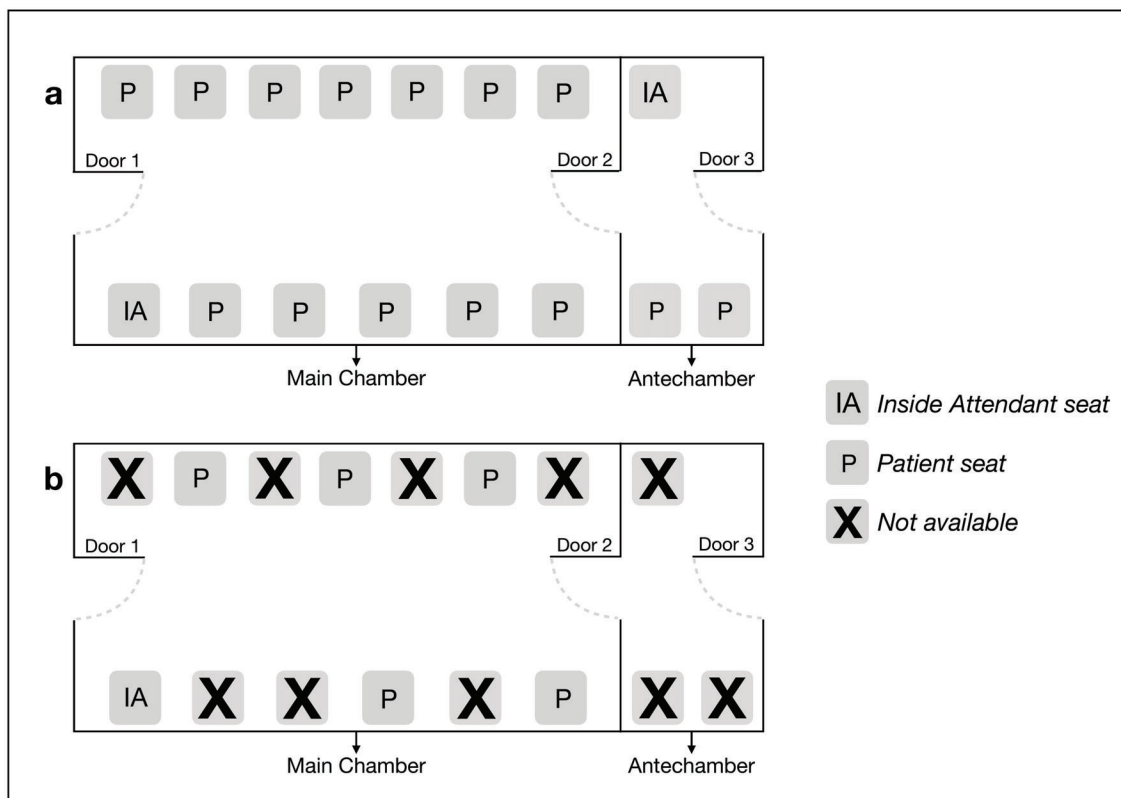
HBOT were added to the waiting list and their treatments were postponed. To execute appropriate disinfection procedures, all personal equipment (masks, hoods, hoses, etc.) and all surfaces of the chamber were disinfected using U.S. Environmental Protection Agency (EPA) approved non-alcohol-based solutions after every session.<sup>5</sup> The EPA List N contains all registered disinfectants suitable for use in inactivating the SARS-CoV-2 virus. Active ingredients which are also approved by TMOH and listed in EPA List N are mostly sodium hypochlorite, hydrogen peroxide and quaternary ammonium.

Our HBOT unit is equipped with a Hypertech® Zyron 12 model multiplace chamber which has a capacity of 12 patients and one inside attendant in the main chamber and two patients and one attendant in the antechamber (Figure 1a). Routine sessions are conducted five days a week (excluding weekends) and the duration of a session is 120 minutes. Normally each patient has one HBOT session per day, but sometimes additional sessions are organised for patients who may have required it. A routine HBOT profile includes a 15-min compression to 243 kPa, a total of period of 90 minutes breathing 100% oxygen at pressure with two five-minute air breaks, and a 15-min decompression time. While an average of 12 patients and one attendant were usually placed in the chamber for each of our routine sessions before the pandemic, the number of occupants was limited to a maximum of six (including the attendant) per session during the pandemic. To maintain recommended social distancing (at least 1 m) inside the chamber,<sup>4</sup> one seat was left unoccupied between each patient (Figure 1b). Before each HBOT session, the patients were questioned if they had any suspicious symptoms (fever, shortness of breath, cough, loss of smell/taste, weakness etc.) of COVID-19. To minimise contact, the dressing room was always supplied with fresh air by passive ventilation and each patient used the room alone.

Our multiplace hyperbaric chamber is compressed with air and built-in breathing system masks are used to provide therapeutic oxygen.<sup>6</sup> Each occupant uses a tight-fitting oronasal mask connected to a demand-type regulator which provides 100% oxygen and vents the exhaust gas outside the chamber and the building. The main purpose of using this system is to prevent air from being drawn into the mask so as to ensure a high oxygen concentration while inhaling, and to prevent oxygen leakage into the chamber while exhaling. Normally, the occupants remove their masks and breathe environmental chamber air during the air breaks to reduce the risk of oxygen toxicity. During the pandemic, those tight-fitting masks, each of which was dedicated to a single patient, were donned as soon as the patients were placed in the chamber and not removed till the end of the session. Air was provided via the masks until the chamber reached 243 kPa. During the air breaks, the mask gas was changed from 100% oxygen to air. This ensured that the environmental chamber air was not contaminated with

**Figure 1**

a. Seating plan in the hyperbaric chamber before the COVID-19 pandemic; b. seating plan during the COVID-19 pandemic



exhaled air and 'respiratory isolation' of individual patients was achieved. Sometimes patients needed to remove their masks to do the Valsalva maneuver effectively, to drink water or for any approved reason. Sufficient spare surgical masks were kept ready in case of temporarily removal of main breathing masks.

Although we prioritised the patients with urgent indications (carbon monoxide poisoning, arterial or venous gas emboli, etc.), we took extra measures for patients with elective indications (diabetic foot ulcer, ischaemic ulcer, etc.) in order not to cause their clinical outcomes to worsen. For example, it has been reported that patients with chronic diseases suffered from the delays and reductions in routine treatments and healthcare services due to the COVID-19 pandemic. In that study, diabetes was found to be the most affected condition.<sup>7</sup> As many patients undergoing HBOT had chronic wound and diabetic foot ulcers, we did additional sessions for these patients each day or over the weekends when needed. Since the beginning of the pandemic, several studies have demonstrated that patients with pre-existing chronic diseases and comorbidities have increased susceptibility to COVID-19, with high severity and mortality rates.<sup>8,9</sup> Most patients who receive HBOT in our clinic are older people with one or more chronic conditions. Therefore, before deciding on HBOT, we made a comprehensive and detailed evaluation of each patient and aimed to maintain the balance between the risk of transmission and the anticipated benefit.

Special attention was also paid to choosing the right mask for inside attendants during the pandemic. In one study, it was shown that wearing a surgical mask reduced the airborne droplet transmission distance to 30 cm from the source, while using an N95 mask reduced it to 15 cm.<sup>10</sup> The attendants are not always in a sitting position throughout the session because of the need to assist the patients (replacing their masks, helping them to do the Valsalva manoeuvre effectively or even performing first aid in case of an emergency). When the patient takes off his or her mask while being assisted, the attendant may come in close contact with the patient. For this reason, attendants always wore N95 masks inside the chamber.

During the pandemic, we also administered HBOT to many intubated patients without knowing if the patient had COVID-19 or not. Although an intubated patient entails a lower risk of aerosol production inside the hyperbaric chamber than a non-intubated patient,<sup>11</sup> the medical staff have worn gowns, double gloves, N95 masks and face shields while providing care to these patients. Normally, these additional items are not routinely used, but they became essential in the pandemic. On the other hand, some of these extra personal protective equipment items could represent an increased fuel load for fire under hyperbaric conditions. Given the protectiveness of these items against COVID-19, we took some measures to minimise the risk of

fire inside the chamber: 100% cotton gowns have been used since the beginning of the pandemic. The oxygen level is maintained at around 21% inside the chamber. The manual fire extinguishers and the deluge system were checked more often than usual.

The incubation period of COVID-19 was found to be approximately 5–6 days.<sup>12,13</sup> In our case, our patient's father developed COVID-19 symptoms one day after they travelled together. He went to the hospital two days after the travel and the positive PCR test was taken on that day. Therefore, he was most probably contagious during the travel and our patient probably became infected during their car ride. In many studies, it was found that confined spaces can easily create a suitable environment for increased virus load and transmission. A car cabin is such a confined space in which respiratory droplets carrying coronavirus can easily accumulate inside and pervade its micro-climate.<sup>14–16</sup> In this case, while the patient tested positive, none of the patients nor the inside attendant who occupied the chamber with this patient tested positive. As HBOT is a long-term therapy in which many of the patients are not required to be hospitalised and therefore are in interaction with different people in daily life, especially during the pandemic, those patients should minimise contact with others, even with their households.

There is evidence that spreading of SARS-CoV-2 may begin 5–6 days before the first symptoms appear, but it may be enough to investigate if there has been a close contact up to 3 days before the symptoms develop.<sup>17</sup> Several published reports also declared that pre-symptomatic transmission was found to be possible 1–3 days before the onset of the symptoms.<sup>18,19</sup> In our case, the patient had most likely been contagious for at least three days before the onset of the symptoms. Despite this, the other patients sharing the same chamber tested negative. In a national environment where only close contacts of known cases or symptomatic individuals are tested, the prevention of cross-infection in the chamber environment in this case demonstrates the value (and successful outcome) of treating every patient as a potential asymptomatic carrier.

This report also highlights the importance of taking strict and solution-focused preventive measures in HBOT clinics and maintaining them without compromising on discipline during the COVID-19 pandemic. These measures seem to be permanent in the coming period as the outbreak lingers.

## References

- Kirby JP, Snyder J, Schuerer DJE, Peters JS, Bochicchio GV. Essentials of hyperbaric oxygen therapy: 2019 Review. *Mo Med*. 2019;116:176–9. PMID: 31527935. PMID: PMC6690283.
- Lo JJ, Wang SC, Lee HY, Lee SS, Lee HC, Hung CT, et al. Proactive COVID-19 infection prevention measures in a hyperbaric oxygen therapy center. *Medicina (Kaunas)*. 2020;56:261. doi: 10.3390/medicina56060261. PMID: 32471203. PMID: PMC7353899.
- ECHM position on hyperbaric oxygen therapy (HBOT) in multiplace hyperbaric chambers during coronavirus disease (COVID-19) outbreak. Updated on 20th March 2020. [cited 2021 Jun 04]. Available from: [https://www.uhms.org/images/Safety-Articles/ECHM-position-on-HBOT-and-COVID-19-16th-March-2020\\_1.pdf](https://www.uhms.org/images/Safety-Articles/ECHM-position-on-HBOT-and-COVID-19-16th-March-2020_1.pdf).
- UHMS guidelines for infection control, patient treatment, and staff safety considerations related to hyperbaric oxygen therapy (HBO<sub>2</sub>) in monoplace and multiplace hyperbaric chambers during the novel coronavirus disease (COVID-19) outbreak. Undersea and Hyperbaric Medical Society. [cited 2021 Jun 11]. Available from: [https://www.uhms.org/images/MiscDocs/UHMS\\_Guidelines\\_-\\_COVID-19\\_V4.pdf](https://www.uhms.org/images/MiscDocs/UHMS_Guidelines_-_COVID-19_V4.pdf).
- United States Environmental Protection Agency [Internet]. List N Tool: COVID-19 Disinfectants. Washington DC: The Agency. [cited: 2021 Oct 22]. Available from: <https://cfpub.epa.gov/wizards/disinfectants/>.
- Jain KK. Hyperbaric chambers: equipment, technique, and safety. In: Jain KK, editor. *Textbook of hyperbaric medicine*. 6th ed. Switzerland: Springer International Publishing AG; 2017. p. 61–78.
- Chudasama YV, Gillies CL, Zaccardi F, Coles B, Davies MJ, Seidu S, et al. Impact of COVID-19 on routine care for chronic diseases: a global survey of views from healthcare professionals. *Diabetes Metab Syndr*. 2020;14:965–7. doi: 10.1016/j.dsx.2020.06.042. PMID: 32604016. PMID: PMC7308780.
- Alyammahi SK, Abdin SM, Alhamad DW, Elgendy SM, Altell AT, Omar HA. The dynamic association between COVID-19 and chronic disorders: an updated insight into prevalence, mechanisms and therapeutic modalities. *Infect Genet Evol*. 2021;87:104647. doi: 10.1016/j.meegid.2020.104647. PMID: 33264669. PMID: PMC7700729.
- Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA*. 2020;323:2052–9. doi: 10.1001/jama.2020.6775. Erratum in: *JAMA*. 2020 May 26;323(20):2098. PMID: 32320003. PMID: PMC7177629.
- Hui DS, Chow BK, Chu L, Ng SS, Lee N, Gin T, et al. Exhaled air dispersion during coughing with and without wearing a surgical or N95 mask. *PloS One*. 2012;7:e50845. doi: 10.1371/journal.pone.0050845. PMID: 23239991. PMID: PMC3516468.
- Lim ML, Kim SJ, Tan MK, Lim KH, See HG. Provision of emergency hyperbaric oxygen treatment for a patient during the COVID-19 pandemic. *Diving Hyperb Med*. 2021;51:78–81. doi: 10.28920/dhm51.1.78-81. PMID: 33761545. PMID: PMC8313772.
- World Health Organization. Coronavirus disease 2019 (COVID-19): situation report, 73. World Health Organization. [cited 2021 Jun 11]. Available from: <https://apps.who.int/iris/handle/10665/331686>.
- Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. *Ann Intern Med*. 2020;172:577–82. doi: 10.7326/M20-0504. PMID: 32150748. PMID: PMC7081172.
- Somsen GA, van Rijn C, Kooij S, Bem RA, Bonn D. Small droplet aerosols in poorly ventilated spaces and SARS-CoV-2 transmission. *Lancet Respir Med*. 2020;8:658–9. doi:

- [10.1016/S2213-2600\(20\)30245-9](https://doi.org/10.1016/S2213-2600(20)30245-9). PMID: 32473123. PMCID: PMC7255254.
- 15 Mathai V. The air we breathe in a car. *Physics Today*. 2021;74(6):66. [cited 2021 Jun 11]. Available from: <https://doi.org/10.1063/PT.3.4779>.
- 16 Mathai V, Das A, Bailey JA, Breuer K. Airflows inside passenger cars and implications for airborne disease transmission. *Sci Adv*. 2021;7:eabe0166. doi: [10.1126/sciadv.abe0166](https://doi.org/10.1126/sciadv.abe0166). PMID: 33277325. PMCID: PMC7775778.
- 17 He X, Lau EHY, Wu P, Deng X, Wang J, Hao X, et al. Author Correction: Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat Med*. 2020;26:1491–3. doi: [10.1038/s41591-020-1016-z](https://doi.org/10.1038/s41591-020-1016-z). Erratum for: *Nat Med*. 2020;26(5):672–5. PMID: 32770170. PMCID: PMC7413015.
- 18 Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, Lee VJ. Presymptomatic transmission of SARS-CoV-2 - Singapore, January 23-March 16, 2020. *Morb Mortal Wkly Rep*. 2020;69(14):411–5. doi: [10.15585/mmwr.mm6914e1](https://doi.org/10.15585/mmwr.mm6914e1). PMID: 32271722. PMCID: PMC7147908.
- 19 If you've been exposed to the coronavirus. Harvard Health Publishing. [cited 2021 Jul 29]. Available from: <https://www.health.harvard.edu/diseases-and-conditions/if-youve-been-exposed-to-the-coronavirus>.

**Conflicts of interest and funding:** nil

**Submitted:** 7 September 2021

**Accepted after revision:** 19 November 2021

**Copyright:** This article is the copyright of the authors who grant *Diving and Hyperbaric Medicine* a non-exclusive licence to publish the article in electronic and other forms.



## HBO Evidence has moved!

**Due to the demise of the Wikispaces platform, the Database of RCTs in Diving and Hyperbaric Medicine (DORCTHIM) has a new address.**

**New url: <http://hboevidence.wikis.unsw.edu.au>**

The conversion to the new platform is still under way, but all the information is there and reformatting work continues.

We still welcome volunteers to contribute CATs to the site.  
Contact Professor Michael Bennett [m.bennett@unsw.edu.au](mailto:m.bennett@unsw.edu.au) if you are interested.