

The evolving use of hyperbaric oxygen therapy during the COVID-19 pandemic

Abstract: The Sars-CoV-2 (COVID-19) pandemic has resulted in significant and unprecedented shifts in the delivery of health care services in the United States. Although wound care remains an essential service during the COVID-19 pandemic, the financial consequences and infectious disease ramifications of the pandemic have resulted in closure or limitation of hours in many outpatient wound and hyperbaric oxygen therapy (HBOT) centers. As HBOT patients often require daily treatment sessions for a period of months, it is necessary for facilities providing HBOT services to adjust to the COVID-19 pandemic while still maintaining availability of this important service. Modification of HBOT session timing and chamber decontamination procedures, utilisation of telehealth services for initial

patient evaluations, and acceptance of novel patient populations and diagnoses are mechanisms by which HBOT centers can adapt to the evolving model of health care delivery throughout a pandemic. While COVID-19 is not a currently accepted indication for HBOT, patients may be referred for HBOT consultation due to the post-infectious sequelae of the virus, and thus HBOT facilities must be aware of the potential uses of this treatment for post-viral complications. By redefining paradigms for health care delivery during the COVID-19 pandemic, HBOT and wound centers can continue to provide high-quality and uninterrupted care to vulnerable patient populations.

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Hyperbaric oxygen therapy (HBOT) is a treatment modality in which patients are enclosed in a hyperbaric chamber that enables inhalation of 100% oxygen at 2–3 times atmospheric pressure.¹ HBOT may be performed in a monoplace (single-person occupancy) or multiple (multiple person occupancy) chamber; in the United States, most hyperbaric chambers are located within hospital settings. HBOT is utilised for a variety of medical conditions and can be especially helpful in the treatment of the complex chronic wound patient.¹ Sequential administration of hyperbaric oxygenation can promote neovascularisation of the wounded territory and allow for limb salvage in patients who under other circumstances would face amputation.¹ Interruptions in HBOT may have potentially devastating effects, with progression to amputation leading to significantly increased risk of morbidity and mortality.

In the United States, the Centers for Medicare and Medicaid Services (CMS) has advocated for increased delivery of care through telemedicine or in the home environment during the SARS-CoV-2 (COVID-19) pandemic.² In wound care, these recommendations are difficult to follow as best practices are heavily dependent on in-clinic procedures.² Over the course of the COVID-19 pandemic, wound care centres have temporarily

closed or restricted their hours in response to directions from the CMS and other governing bodies.³ Wound care centres, including HBOT centres, are frequently located within hospitals that have implemented containment strategies including restrictions on visitors and the provision of outpatient services due to the COVID-19 pandemic. Unfortunately, eliminating or significantly reducing the ability to deliver quality care to wounded patients (a large proportion of whom have multiple chronic comorbid conditions such as diabetes) puts this fragile cohort at even greater risk for medical complications during the pandemic. As a result of the COVID-19 pandemic, patients with chronic diseases have experienced adverse health effects including missed routine medical appointments and testing.³ In one survey of healthcare professionals worldwide, 67% of respondents reported that their patients had experienced moderate or severe effects due to COVID-19 related changes in healthcare services; diabetes was the most common condition affected by these changes.⁴

The Alliance of Wound Care Stakeholders (the Alliance) is a not-for-profit organisation that promotes advocacy and outreach regarding wound care in the United States. In March 2020, the Alliance published a position statement in support of the classification of wound care departments as an ‘essential’ service.⁵ In its statement, the Alliance argued that even if clinic visits are limited and transitioned to telehealth, wound care departments should stay open in order to provide urgent wound care that is infection-sparing, limb-salvaging, and life-saving.⁵ Our HBOT centre fully endorses this position statement and is in agreement with the determination made by the Alliance that by providing appropriate and timely wound care, we are

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able to unburden other parts of the hospital system by preventing our patient population from needing to seek emergent care.⁵

The COVID-19 pandemic presents an unprecedented challenge to maintaining patient access to HBOT and has enabled swift yet carefully planned action at our tertiary wound care centre to ensure patient safety and to optimise wound outcomes. The aim of this article is to describe our approach to HBOT over the course of the pandemic and to highlight implications for our patient population.

New approach to HBOT

Patient triage

Considering restrictions placed on our hospital system because of COVID-19, our HBOT team was faced with the difficult task of balancing both continuity of care and the safety of staff and patients. During the earlier months of the pandemic, the American College of Surgeons published COVID-19 guidelines for the triage of patients in departments such as vascular surgery; however, no such guidelines were established specific to HBOT.⁶ We designed an internal system of triage to assist in the decision making process to determine which patients should be encouraged to continue HBOT, pause treatment, or initiate treatment during the pandemic. One of the hurdles we encountered during initial discussions of triage is a core tenet of HBOT: scheduling. Successful treatment with HBOT at our center requires both the ability to deliver care every weekday and the willingness of patients to commit to a daily two-hour treatment session for up to three months. Due to the significant medical comorbidities found in a majority of the HBOT patient population, the risks of travel back and forth to the hospital for daily hyperbaric treatments may be significant. The medical conditions associated with a higher risk of severe disease or death due to COVID-19, including diabetes, hypertension, and coronary artery disease, are also present in many patients who undergo HBOT.⁷

At the start of the pandemic, we were faced with substantial, albeit reasonable, hesitation and apprehension on the part of our patients with regards to coming to the hospital on a daily basis for treatment, including concerns about the availability of personal protective equipment (PPE) and the risks of travel in the context of regional stay-at-home orders. To address these patient concerns, initial hyperbaric patient evaluations were performed via video-assisted telehealth visits whenever possible. While telehealth visits were implemented with relative ease in our practice, we acknowledge the difficulties associated with the transition to virtual patient care. Fortunately, we did not encounter significant obstacles to insurance reimbursement, patient access to telehealth platforms, or other technology-related complications for these initial telehealth visits.

After a stay-at-home order was issued for the District of Columbia at the end of March 2020, a decision was

made to only utilise HBOT for emergent or urgent indications. These patients included those whose conditions were deemed to have the potential to significantly worsen if ongoing treatment was paused or new treatment was not initiated. Prior to the stay-at-home order, our HBOT centre treated from 8–12 patients daily, of both inpatient and outpatient status, with a wide variety of hyperbaric indications. Upon initiation of the stay-at-home order, our patient census was reduced to individuals with urgent or emergent conditions including acute skin graft or flap necrosis and sudden sensorineural hearing loss. As the stay-at-home order included a temporary moratorium on elective surgical procedures, our inpatient HBOT volume (which had previously largely involved the perioperative treatment of limb salvage patients) was essentially eliminated. We established a new core outpatient hyperbaric cohort in which most patients had urgent or emergent indications as delineated above. During this initial time of transition, we also experienced new patient referrals from outside of our local geographic region, since at least one other HBOT centre in our region had closed to outpatient care due to concerns related to infection control in the multiplace hyperbaric environment.

Clinic redesign

Our HBOT suite contains four monoplace hyperbaric chambers and is located within the multidisciplinary wound care center of our institution. Prior to the pandemic, this location served as a hub for all of the members of the multidisciplinary wound care team including the departments of plastic surgery, vascular surgery, podiatry, and rheumatology. This layout enabled centralisation of care for every wounded patient, facilitating rapid collaboration for both evaluation and treatment. Prior to the COVID-19 pandemic, our facility served patients Monday through Friday. With this form of scheduling, our practice served up to 12 patients on any given day, with four hyperbaric chambers running treatments up to three times per day.

As a result of careful planning, our practice was able to maintain its Monday through Friday schedule. A decision was made to decrease the number of daily treatment sessions from 3 to 2 to allow for adequate time between patient cohorts to clean the facility. Around the time of the initiation of the District of Columbia's stay-at-home order, the hyperbaric technicians began to manually disinfect the interior of each hyperbaric chamber following every use. Prior to the COVID-19 pandemic, this process had been performed on a weekly basis as part of a routine chamber maintenance schedule. Each manual disinfection process, which utilised cleaning products and instructions recommended by the chamber manufacturer, lasted approximately 10 minutes in duration. After chamber disinfection, the hyperbaric chamber was pressurised to a standard treatment depth (2.0 atmospheres absolute) for an additional 10 minutes

to fully ventilate the chamber and allow for off-gassing of the disinfectant vapors. All hard surfaces within the HBOT suite, including hyperbaric gurneys, countertops, and vital sign monitors, were disinfected between patient visits. Additionally, the hyperbaric changing room, including lockers and seating surfaces, was disinfected between each patient's use of the area. These enhanced cleaning measures provided an additional margin of safety for reduction of potential virus transmission in the hyperbaric environment; however, the additional time required for the disinfecting process necessitated a change in the daily patient scheduling process to allow for increased time intervals between patients.

New patient population

Despite the logistical challenges encountered by our HBOT practice during COVID-19, the pandemic also enabled us to expand our services to benefit a new patient population. Our approach to patient triage and the redesign of our clinic space allowed us to provide care to patients who had no other HBOT options due to temporary location closure. As a result of these treatment centre closures, our facility remained the only HBOT center in the region capable of treating pediatric patients. We experienced a significant increase in pediatric referrals for HBOT during the initial months of the pandemic, mostly for treatment of acutely compromised skin grafts and flaps. Although the local District of Columbia government had restricted the performance of elective procedures in our region, the pandemic spread throughout the United States at different rates and thus other jurisdictions did not have the same limitations on outpatient surgical procedures during this time. Due to this, we received multiple referrals for the hyperbaric treatment of pediatric patients who lived in our region and who were scheduled to undergo, or who had already undergone, surgical procedures in different areas of the United States. These patients were initially evaluated via telehealth platforms; hyperbaric education and initial chamber orientation were provided to the children's parents via video conference as well. As many of the new paediatric patients experienced daily commutes of an hour or more to reach our facility, we attempted to time the HBOT treatments around the children's naptimes. While the hospital had visitor restrictions in place during the pandemic, paediatric patients could have a single caregiver accompany them into the facility and remain close to them for the duration of each hyperbaric treatment.

Due to concerns for infection control and the lack of overall data regarding the use of HBOT as a treatment for COVID-19, our HBOT facility elected to not treat patients who were diagnosed with acute COVID-19 infection. Recently published case reports and small single-institution studies have proposed that HBOT can be used to improve hypoxemia and prevent transition to mechanical ventilation in COVID-19 patients.^{8,9} A

randomised controlled trial currently underway at the Assaf-Harofeh Medical Center in Israel (ClinicalTrials.gov Identifier: NCT04358926) is investigating the efficacy of HBOT in moderate-severe COVID-19 patients.¹⁰ A similar study is being carried out by the Ochsner Health System in New Orleans, Louisiana (NCT04343183).¹¹ At NYU School of Medicine in New York, HBOT was used to treat 20 patients with respiratory distress due to COVID-19 infection. The results of this study indicated that HBOT can be utilised to safely treat patients with COVID-19 infection, although the results were limited by a small enrollment size and limited inclusion criteria.¹² It is hypothesised that alternate treatment strategies such as HBOT and the delivery of erythropoiesis-stimulating agents may therefore have the potential to increase oxygenation of tissue by means other than standard respiratory and ventilator support.¹³ While these preliminary data are promising, when evaluating these findings it is essential to take into consideration the logistics and possible adverse effects of HBOT, including the risk of oxygen toxicity, the concern for virus aerosolisation in the hyperbaric environment, and practical issue of isolation from other necessary medical interventions during this time.¹⁴ In August 2020, the Undersea & Hyperbaric Medical Society (UHMS) issued a statement concluding that while well-designed clinical trials are necessary to establish a proper clinical foundation for the treatment of COVID-19, the use of HBO on an off-protocol basis may be appropriate in some cases.¹⁵ While we fully endorse the exploration of ways in which HBOT can be used to treat patients during the ongoing pandemic, the use of HBOT for the treatment of acute COVID-19 infection remains experimental at this time.

While our HBOT centre has not treated patients with acute COVID-19 infection during the pandemic, we did experience increased physician-initiated referrals for treatment of patients who experienced chronic sequelae which were temporally related to previous COVID-19 infection. These referrals included patients with acute peripheral lower extremity ischemia, sudden sensorineural hearing loss, acute anaemia with inability to receive transfusion due to religious beliefs, and anosmia/dysgeusia; these patients were diagnosed with these conditions during or soon after their diagnosis of COVID-19 was established. In addition, we received patient-initiated referrals from individuals who were interested in receiving HBOT as a treatment for persistent fatigue and malaise after COVID-19 infection; fatigue, as well as dyspnea, are the most commonly reported long-term health consequences reported after acute COVID-19 infection.¹⁶ As the chronic sequelae of COVID-19 are largely poorly understood at this time, it is unclear whether HBOT is a viable treatment for these COVID-19 related conditions. Additionally, in the United States there are limitations in insurance coverage for the post-COVID-19 conditions which do not align with the traditionally accepted indications for HBOT. In some cases, workers compensation plans may cover the

use of HBOT for patients who contracted COVID-19 due to workplace exposure (e.g., healthcare workers). We continue to explore whether HBOT is a potential effective treatment for the chronic sequelae of COVID-19.

Impact

Despite the challenges associated with the COVID-19 pandemic, our HBOT centre was able to remain open during the duration of the District of Columbia's stay-at-home order in 2020. In doing so, we were able to provide continuing care to multiple patients who would otherwise have not been able to receive this treatment due to temporary closures at other HBOT centres in the region.

Unfortunately, even with the modifications our HBOT team made to adapt to the pandemic, our practice was unable to function at its full capacity throughout this time. There were certain limitations to care during the pandemic: some patients were unable to continue care at our facility due to restrictions in non-emergency medical transport services, and there were occasional difficulties in obtaining insurance prior authorisation for hyperbaric treatments related to communication delays with insurance representatives who were teleworking.

Even as restrictions in the District of Columbia are being lifted, our practice continues to encounter obstacles and redefine our approach in this new era of patient care. Our HBOT center began to schedule our routine patient population in the middle of June 2020. Within the first day of adding patients to an expanded

treatment schedule, it became evident that some patients who had previously received care regularly at our center were unable to continue with the treatment as they were still sheltering in place away from the District of Columbia; other patients voiced concerns regarding their safety when returning to the hospital for care, and many patients required new insurance prior authorizations for HBOT as their previous authorisations' dates of service had expired due to the interruption in treatment. For the most part, these obstacles have been resolved, and as of October 2020 we are experiencing patient volumes which approximate our pre-COVID-19 numbers.

Conclusion

The COVID-19 pandemic resulted in significant shifts to the provision of inpatient and outpatient medical services; given the sustained increases in cases occurring across the United States, the healthcare community will likely be operating under the pandemic model of care for the foreseeable future. As wound care has remained an essential service throughout the pandemic, it is imperative for physicians and healthcare facilities to define paradigms for care for patients who require treatment with HBOT during this time. By understanding the ways in which medical facilities have adapted to provide care to patients during the pandemic, HBOT facilities can continue to optimise our delivery of patient care and provide uninterrupted access to hyperbaric medicine services during this challenging time. **JWC**

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