

MEDICAL SCHOOL HOTLINE

Hidden Jewel: The Hyperbaric Treatment Center of the University of Hawai'i

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In 1993, the Medical School Hotline was founded by Satoru Izutsu PhD (former vice-dean UH JABSOM), it is a monthly column from the University of Hawai'i John A. Burns School of Medicine and is edited by Kathleen Kihmm Connolly PhD; HJH&SW Contributing Editor.

Walking past the nondescript building at the southeast corner of the Kuakini Medical Center (KMC) campus, people may not realize that it houses an essential resource for the state of Hawai'i. The Hyperbaric Treatment and Wound Care Center (HTC), Hawai'i's "dive chamber," has been providing life- and limb-saving hyperbaric oxygen therapy (HBOT) for over 37 years, now celebrating its 25th anniversary at its present location at KMC's Hale Pulama Mau building. The unassuming facade belies its importance as the only emergency hyperbaric chamber in the state, serving the most critical patients in need of HBOT, and an essential safety net for military and commercial scuba dive operations. The chamber is owned by the University of Hawai'i John A. Burns School of Medicine (JABSOM), and staffed and supported by University Health Partners, the faculty practice of JABSOM. The HTC has an illustrious history of research under Edward Beckman MD, Frank Farm, Jr., Robert Overlock MD, and Richard Smerz DO, PhD, including development of the novel "Hawaiian Deep Tables."¹ In addition to dive emergencies, the HTC treats a variety of medical conditions including radiation injury and problem wounds. The HTC serves also as a training site for medical students, residents, and fellows both local and international.

HBOT is the primary treatment for decompression illness ("the bends") and arterial gas embolism, and reduces the mortality from acute carbon monoxide poisoning.² Patients with these maladies can be critically ill, paralyzed or require ventilator support. The large multiplace HTC chamber enables care as it allows medical equipment and multiple clinicians to be in the chamber with the patient. It accommodates various patient positions, oral intake, and intravenous therapy. However, the HTC chamber also is very resource-intensive to operate, requiring constant maintenance and a minimum of 4 technicians and clinicians to treat a single patient. Economic pressures have made multiplace chambers an endangered species, less than 16% of hyperbaric facilities have multiplace chambers, and only 12% provide emergency services to high-acuity patients.³

According to the Hawaiian Islands Recreational Scuba Association, an average of 1000 divers per day participated in

recreational scuba diving activities in Hawai'i waters in pre-pandemic times. Military, research, and commercial entities also engage in daily dive operations. Despite technological advances including dive computers and detailed safety protocols, HTC continues to treat approximately 2 dozen patients per year with serious dive-related injuries. Many of these patients that are treated for decompression illness adhered to their dive plan and dive computers, i.e. suffered an "unexplained hit," or without obvious cause. Health care related events such as iatrogenic air embolism, and environmental exposures such as carbon monoxide poisoning, remain omnipresent and unpredictable risks. All of these patients require expedient evaluation and treatment, and the HTC is their lifeline. The next closest emergency chamber is in San Diego; inherent delays in treatment and risks of air transport would significantly increase morbidity in Hawai'i patients.

Over 10% of Hawai'i residents have diabetes, with an even greater prevalence among Native Hawaiians and Pacific Islanders. Diabetics have a roughly 1 in 5 chance of developing a foot ulcer, associated with an 11% annual mortality in Medicare beneficiaries.⁴ The American Diabetes Association consensus statement confirms: "Any ulcer present over four weeks is a cause for concern, as it is associated with worse outcome including amputation." HBOT, in conjunction with comprehensive wound care, improves the odds of healing, achieving a significant improvement in amputation-free survival.⁵ Patients at the HTC receive intensive monitoring with glucose checks, daily wound care, and surgical wound debridement as needed.

Cancer survivors who have received radiation therapy may also benefit from HBOT. The late effects of radiation therapy include radiation cystitis, proctitis, osteoradionecrosis, and other soft tissue necrosis. About half of patients requiring oral surgery after high dose radiation therapy have complications including delayed healing, wound infection, and dehiscence. This risk can be diminished four-fold with the use of adjunct HBOT.⁶ Other approved indications for HBOT include refractory osteomyelitis, acute traumatic peripheral ischemia, crush injuries, necrotizing fasciitis, skin grafts, and actinomycosis.

Providers are encouraged to talk with hyperbaric physicians at the HTC, available 24/7, to discuss potential patients ((808) 587-3425).

The logistics of treating patients living outside Honolulu are considerable but not insurmountable. Over a third of emergency cases are transferred from neighbor islands. Patients with elective conditions for HBOT (e.g. diabetic foot ulcer) have no restrictions on air travel, and typically remain on O‘ahu for their weekday treatments, returning home on the weekends. New patients receive a telehealth consultation, and educational videos orient the patient to the chamber environment and teach techniques of ear pressure equalization.

The SARS-CoV-2 (COVID-19) pandemic has raised valid concerns about the safety of a multiplace chamber environment, as patients and care providers are in a common enclosed space during HBOT. The Undersea & Hyperbaric Medicine Society (UHMS) provided guidelines for infection control, patient treatment, and staff safety in multiplace chambers.⁷ Patients are assessed and counseled regarding their risk for complicated COVID-19 infection and are repeatedly tested for COVID-19. HBOT protocols have been modified to allow for greater distancing in the chamber and all patients have their own personal oxygen and air intake and exhaust for the duration of HBOT, with the exception of the initial 2 minutes of chamber pressurization. Communication with mainland hyperbaric centers has confirmed no signs of increased virus transmission in the multiplace environment following appropriate protocols.

There are intriguing scientific hypotheses and ongoing clinical trials investigating the use of HBOT for patients with COVID-19 infection. HBOT can transiently ameliorate hypoxemia in patients. More durable benefits have been postulated from attenuation of the inflammatory response, repayment of accrued oxygen debt, and possible reduction in hypercoagulation.⁸ UHMS recommends treating COVID-19 patients only in the context of approved clinical trials. The HTC is not currently participating in any of these trials and, given its responsibility as the only emergency chamber in the region with limited resources for staffing, cannot absorb the risk inherent in trial participation. COVID-19 infection is considered a contraindication to elective HBOT at the HTC, and a relative contraindication to emergency treatments, with those patients evaluated on a case-by-case basis. However, the hyperbaric community anxiously awaits the results of national trials, which may inform practice in this realm.

The sustainability of the HTC, for economic viability and maintaining the unique skills of the hyperbaric staff, is dependent upon community referrals for wound care and elective HBOT. However, due to the high cost of maintaining 24/7 availability of a free-standing facility, there remain substantial costs that are not covered by clinical revenue. Philanthropic support of the HTC through the University of Hawai‘i Foundation is encouraged. Members of the dive community remain philosophically supportive, but commercial dive operators have been hard hit financially by the pandemic. Appreciation and funding for Hawai‘i’s multiplace chamber facility and uniquely skilled staff cannot be subject to chance and circumstance. This essential emergency service and public health resource – a jewel of Hawai‘i – deserves substantial and durable support from the government.

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References

1. Smerz RW, Farm F Jr. Medical school hotline: Hyperbaric Treatment Center of the University of Hawai‘i: 2012 update. *Hawaii J Med Public Health*. 2012;71(4):109-111.
2. Moon RE. Hyperbaric oxygen therapy indications. 14th edition. North Palm Beach, FL: Best Pub. Co.; 2019.
3. Chin W, Jacoby L, Simon O, et al. Hyperbaric programs in the United States: Locations and capabilities of treating decompression sickness, arterial gas embolisms, and acute carbon monoxide poisoning: survey results. *Undersea & Hyperbaric Medicine*. 2016;43(1):29-43.
4. Margolis DJ, Malay DS, Hoffstad OJ, et al. Prevalence of diabetes, diabetic foot ulcer, and lower extremity amputation among Medicare beneficiaries, 2006 to 2008: Data Points #1. In: *Data Points Publication Series*. Rockville (MD): Agency for Healthcare Research and Quality (US); February 17, 2011.
5. Liu R, Li L, Yang M, Boden G, Yang G. Systematic review of the effectiveness of hyperbaric oxygenation therapy in the management of chronic diabetic foot ulcers. *Mayo Clin Proc*. 2013;88(2):166-175. doi:10.1016/j.mayocp.2012.10.021
6. Marx RE, Johnson RP, Kline SN. Prevention of osteoradionecrosis: a randomized prospective clinical trial of hyperbaric oxygen versus penicillin. *Journal of the American Dental Association* (1939). 1985;111(1):49-54.
7. UHMS Guidelines for infection control, patient treatment, and staff safety considerations related to Hyperbaric Oxygen Therapy (HBO2) in monoplace and multiplace hyperbaric chambers during the novel coronavirus disease (COVID-19) outbreak. Undersea & Hyperbaric Medical Society website. <https://www.uhms.org/covid-19-information/184-home-page-bulletins/899-uhms-guidelines-for-infection-control-patient-treatment-and-staff-safety-considerations-related-to-hyperbaric-oxygen-therapy-hbo2-in-monoplace-and-multiplace-hyperbaric-chambers-during-the-novel-coronavirus-disease-covid-19-outbreak.html>. Published March 2020. Accessed November 13, 2020.
8. Feldmeier JJ, Kirby JP, Buckley JC. Rationale, study design considerations, and protocol recommendations for treating COVID-19 patients with hyperbaric oxygen. https://www.uhms.org/images/MiscDocs/Rational_and_study_design_for_treating_COVID_patients_with_HBO2.pdf. Published July 2020. Accessed November 13, 2020.