**Access to emergent hyperbaric oxygen (HBO2) therapy: an urgent problem in health care delivery in the United States**

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**Background**

A number of disorders – including diving-related, embolic, iatrogenic (caused by medical investigation or treatment), traumatic, and infectious conditions – may cause loss of life, permanent neurological damage, loss of an extremity, or permanent loss of vision if not treated promptly with hyperbaric oxygen (HBO2) therapy. Delays in initiating HBO2 reduce or eliminate the possibility of survival or full recovery for patients suffering from these conditions *(Moon 2019, Sadler 2019, Beevor 2016, Vann 2011).*

**Conditions that require emergent HBO2 therapy**

- decompression sickness (DCS)

- diving-related arterial gas embolism (AGE)

- iatrogenic AGE resulting from laparoscopic surgery, central venous catheters, and a wide range of other invasive medical and surgical procedures

- carbon monoxide poisoning

- central retinal artery occlusion (CRAO)

- life-threatening soft tissue infections (e.g., necrotizing fasciitis and clostridial myositis and myonecrosis (gas gangrene) *(Moon 2019, Nicholson 2018, Shaw 2014, Soh 2012)*.

- failing skin flaps *(Moon 2019).*

**Hyperbaric treatment facilities in the United States**

The Undersea and Hyperbaric Medical Society (UHMS) estimates that there are approximately 1,300 hyperbaric treatment facilities (each of which has one or more hyperbaric chambers) in the United States that provide HBO2 therapy *(Personal communication - Mr. John Peters - 3 Feb 20).* These facilities may be located in hospitals, free-standing medical clinics, or may be located with military or commercial diving operations.

**Hyperbaric treatment facility availability to provide HBO2 therapy**

Fewer than 10% of these 1,300 hyperbaric treatment facilities, however, provide emergent HBO2 on a 24/7 basis to patients who need it. The number of hyperbaric treatment facilities in the U.S. that offer emergent HBO2 (on at least an intermittent basis) is 99 according to the list provided by the Divers Alert Network (DAN). The number of hyperbaric treatment facilities in the U.S. that offer full-time access to emergent HBO2 therapy *(provided by Mr. Dick Clarke, President of the National Board of Diving & Hyperbaric Medical Technology)* as of June 2020 is 78, with several treatment facilities having just dropped their 24/7 emergent HBO2 availability in the last several weeks *(Personal communication: Dr. Jim Chimiak – 29 May 2020; personal communication Mr. Dick Clarke – 19 June 2020).* The remaining hyperbaric treatment facilities are used to provide scheduled HBO2 to facilitate wound healing or are intended to support commercial or military diving operations; these latter facilities are typically not available to take emergency patients other than those arising from within their company or unit.

Two decades ago almost all hyperbaric treatment facilities provided emergent HBO2 therapy to patients when needed. The growing prevalence of provision of HBO2 therapy as a venture capital-owned, for-profit enterprise, however, has changed this landscape dramatically *(Clarke 2017).* In addition to the remuneration consideration, there are a number of other considerations that may factor into organizations’ decisions not to make their hyperbaric treatment facilities available to provide emergent HBO2 therapy:

- Providing 24/7 access to emergent HBO2 therapy requires that a hyperbaric-trained physician and chamber operators be available on short recall at all times;

- Maintaining training and certification to treat conditions that require emergent HBO2 imposes an added training and compliance burden on the hyperbaric facility;

- The arrival of an emergent HBO2 patient may interrupt scheduled (and reimbursable) non-emergent HBO2 sessions;

- Emergent HBO2 patients may have no insurance coverage and their treatment may be at the hyperbaric facility’s expense;

- Treating emergent patients who may experience bad outcomes even when HBO2 is provided appropriately increases the liability exposure of the hyperbaric facility;

- Some emergent HBO2 patients may require critical care support during their HBO2 treatment, and many hyperbaric treatment facilities do not have the necessary expertise or equipment to support this level of care *(Clarke 2017).*

**Impact of delays to HBO2 therapy when required**

What happens when patients who require emergent HBO2 do not receive it quickly? That depends on the condition.

- DCS patients may suffer preventable permanent neurologic disability or death (see the two attached publications).

- Diving-related patients with arterial gas embolism (AGE) may suffer preventable permanent neurologic disability or death.

- Iatrogenic AGE patients may suffer preventable permanent neurologic disability or death.

- Carbon monoxide poisoning patients may suffer preventable permanent neurologic disability or death.

- Central retinal artery occlusion patients may suffer preventable and permanent blindness in the affected eye.

- Patients with life-threatening soft tissue infections (e.g., necrotizing fasciitis) or clostridial myositis and myonecrosis (gas gangrene) may require amputation of affected extremities or suffer preventable death from overwhelming sepsis that might not have occurred if prompt HBO2 had been available.

**Burden of death and disability when indicated emergent HBO2 therapy is not available**

As noted above, failure to assure the availability of emergent HBO2 for patients who require it may result in preventable loss of life, cases of preventable permanent neurological impairment, preventable cases of blindness, and preventable instances of limb loss. An approximation of the magnitude of these avoidable bad outcomes and the conditions that will cause them is provided below.

- Serious (neurological or pulmonary) decompression sickness (DCS) and diving-related arterial gas embolism (AGE) – approximately 400 cases per year *(Personal communication – Dr. Jim Chimiak, Medical Director, Divers Alert Network - 21 March 2020).*

- Iatrogenic AGE resulting from laparoscopic surgery, central venous catheters, etc.) complicates 2.65 per 100,000 hospitalizations, with a mortality rate of 21% *(Bessereau 2010).* There were 36,353,946 hospital admissions in the U.S. in 2018 *(AHA website accessed 26 May 2020 https://www.aha.org/statistics/fast-facts-us-hospitals).* This results in an estimated 963 cases of iatrogenic AGE in the U.S. annually.

- Carbon monoxide poisoning – “Every year, at least 430 people die in the U.S. from accidental CO poisoning. Approximately 50,000 people in the U.S. visit the emergency department each year due to accidental CO poisoning.” *(CDC website 10 May 2020)*

- Central retinal artery occlusion (CRAO) – the annual incidence of CRAO is 1.9 cases per 100,000 people in the U.S. *(Leavitt 2011).* With a current U.S. population of 331 million people, this would produce an estimated 6,289 cases of CRAO annually.

- Necrotizing soft tissue infections (also called NSTI or necrotizing fasciitis), including clostridial myonecrosis (gas gangrene) – The incidence of NSTI in the United States is estimated at 13,000 cases per year *(Anaya 2007).*

**Military hyperbaric chambers: a special circumstance**

Hyperbaric chambers that are intended to support military diving or hypobaric operations are a special circumstance. Their primary mission is not to provide routine health care but to be available should active-duty military members require emergent HBO2, typically for diving- or aviation-related DCS or AGE. There is no DoD-wide directive at present that requires these chambers to provide emergent HBO2 to non-military patients, nor is there one that forbids them from doing so. The availability of military hyperbaric chambers for this purpose, then, is at present left to the discretion of the commanding officer of the facility that operates the chamber.

Disincentives for military chambers to provide treatment for non-military patients who require emergent HBO2 include:

- The DoD can be sued by non-military patients (or their families) treated by a military chamber if there is a bad outcome.

- If the chamber is being used to treat a non-military patient, then it is not available to treat injured military divers or aviators for that treatment period (usually five to six hours), possibly delaying military exercises until the chamber is available.

- Providing 24/7 coverage for emergent HBO2 entails a significant demand on the chamber crew and their supervising physician, preventing them from being away from the chamber location for official travel or personal leave. It would also not allow the supervising physician and chamber team to engage in recreational activities that would preclude their emergent recall for an HBO2 treatment.

On the other hand, there are benefits that might be realized by the military should their hyperbaric chambers be made available to treat non-military emergent HBO2 therapy patients:

- The experience gained in conducting emergent HBO2 for non-military patients would increase the skills and expertise of the chamber team in the management of diving-related diseases and make them better able to treat future military diving accident victims.

- Procedures could be established to allow the military to be reimbursed for emergent HBO2 provided to civilians who require it. This is done at present in military treatment facilities that provide trauma care for civilian patients and serves to benefit the local community as well as to enhance the trauma skills of the military providers.

- Just as with sending the USNS ships *Comfort* and *Mercy* to assist in the treatment of non-military COVID-19 patients in New York and Los Angeles, the knowledge that military personnel are providing critically important emergency care generates a significant measure of goodwill toward the military.

Lastly, an important point in considering whether to use military chambers to provide emergent HBO2 is that the chamber availability does not have to be an “all or nothing” decision. As noted by the DAN medical leadership, the availability of a particular chamber to conduct HBO2 therapy is always dependent on chamber staffing and maintenance considerations and whether the chamber is currently engaged in a treatment. Thus, a military chamber may be declared “up” for emergent HBO2 treatments only for designated periods of time, and DAN would direct emergency patients accordingly. The customized tasking function performed by DAN also provides the opportunity to direct patients who are judged likely to require intensive care support to chambers that are capable of providing that level of support *(Personal communication - Dr. Jim Chimiak - 5 May 20).*

**Incentivizing hyperbaric treatment facilities to provide emergent HBO2 therapy**

Optimizing the ability of the U.S. health care system to make emergent HBO2 available to those patients who require it will require the identification and implementation of strategies to incentivize hyperbaric treatment facilities to offer emergent HBO2. Options for accomplishing this include: 10

1) direct federal or state grants to hyperbaric treatment facilities that offer emergent HBO2;

2) indemnification from legal liability for hyperbaric treatment facilities and medical providers who provide emergent HBO2 to divers and other patients who require it;

3) recognition of the public service performed by the hyperbaric treatment facilities that offer HBO2 on an emergent basis when indicated;

4) favorable consideration with respect to Medicare, Medicaid, and private insurance reimbursements to hyperbaric treatment facilities and medical providers that offer HBO2 on an emergent basis when indicated, including carve-outs to inpatient DRG (diagnosis-related group) payments;

5) incentives for military hyperbaric facilities to provide emergent HBO2 to civilian patients through emphasis on the training benefit to military providers that this accomplishes; third-party reimbursement for emergency HBO2 therapy provided to civilian patients by military hyperbaric facilities; and indemnification of the military facility from lawsuits resulting from this public service activity.

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(Free access available at: <https://www.uhms.org/publications/pressure/third-quarter-pressure-2020/viewdocument/4711.html> – Pages 12-16)

**Attachment 1**

Beevor H, Frawley G: Iatrogenic cerebral gas embolism: analysis of the presentation, management and outcomes of patients referred to The Alfred Hospital Hyperbaric Unit**.** Diving Hyperb Med 2016;46:15-21.

**Attachment 2**

Sadler C, Latham E, Hollidge M, Boni B, Brett K: Delayed hyperbaric oxygen therapy for severe arterial gas embolism following scuba diving: a case report. Undersea Hyperb Med 2019;46:197-202.