

Hyperbaric Oxygen Therapy as an Elective Treatment

by John P. Kirby, MD



HBO₂ can be used electively to transition patients from more acute problems to more elective ones.



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Abstract

Hyperbaric oxygen therapies may have grown out of emergencies such as those for Decompression Sickness (DCS), but more commonly in the U.S., hyperbaric oxygen is used for much more elective problems. Wound healing applications lead this trend. Nationally many more hyperbaric centers exist to treat elective problems adjunctively, and this is a concise review of these indications as well as pointing out where even elective centers might be able to broaden their practices.

Introduction

Table 1 lists the HBO₂ indications for elective problems. As opposed to many of the emergent indications where HBO₂ is often a primary therapy and are highly time dependent in terms of getting HBO₂ underway and repeated; many of these elective indications reflect where HBO₂ is an adjunct to other therapies. Elective uses of HBO₂ can be a way to improve the outcomes of patients who otherwise are not responding to initial therapies. Additionally, some of these elective indications still derive some of their applications from emergent indications and are covered here so that clinicians do not miss these as

opportunities for better care.

For example, both CO and CN poisonings will be offset and more quickly eliminated by HBO₂ if offered as opposed to allowing either or both of these to be off loaded at regular pressures. CO poisoning may present relatively obviously as an emergency as after closed space fire and loss of consciousness or other severe neurological sequelae or with ongoing fetal or cardiac ischemia necessitating HBO₂. But CO poisoning can also be repetitive and low level with harder to define symptoms. A loading dock worker exposed to the exhaust of lifter-loading vehicle with headaches and fatigue may be suffering from CO poisoning and will get missed. HBO₂ may offer better longer term neurologic outcomes than simple 100% oxygen therapy.¹

Clearly delineated classes for emergent HBO₂ include those that offset the effects of poor oxygenating arterial flow perfusing tissue beds, such as in a compromised flap. Many elective indications for of HBO₂ extend these effects to small vessel perfusion defects. For example, medical radiation needed to improve cure rates for cancers, often results in progressive fibrosis and resultant non-healing of those previously irradiated tissues. In fact multimodality cancer care has

Table 1. Elective Indications for HBO₂

- CO and CN Poisonings - while it is assumed that earlier treatments will be better for any patient, there are patients that present in a delayed fashion and may be treated in a time delayed, hence elective fashion for lingering complaints after a CO or CN exposure.
- Decompression Sickness - preferred to be treated as early as possible, like CO/CN poisoning, but often improves even in more elective presentations within the week after the diving incident.
- Chronic Refractory Osteomyelitis
- Radiation Injuries of soft and bony tissue
- Enhanced healing in selected problematic wounds

improved outcomes such that most cancers have better longer term outcomes for more patients than patients needing amputations for diabetic foot ulcerations (DFUs);² however patients are surviving to have other sequelae. Patients who often have had a complete cure of their head and neck tumors from a combination of surgery and radiation can have progressive fibrosis of their soft tissues and gums with loss of teeth, exposure of their jaw and even pathological fracture of their mandible—all of which will have better outcomes when HBO₂ is added to their regimens.³ Patients with ongoing radiation effects after treatment for head and neck cancers should be referred for HBO₂⁴ and this should be coordinated with any planned further operation so that HBO₂ supports optimal tissue healing before and after any procedures.

Therapeutic irradiation is also commonly used in other areas of the body and for other cancers like breast cancer and other soft tissue tumors and for neurologic, gynecologic, colorectal, urologic, and soft tissue cancers. These patients may also have later sequelae from delayed radiation effects such as enteritis, cystitis, bleeding and tissue fibrosis needing surgical resection or revision. All of these have been found to be responsive to HBO₂.^{5,6} Elective hyperbaric when coordinated with other therapies may allow surgical reconstruction of these tissue feasible and protect both the patient and the surgeons from non-healing or other sub-optimal outcomes.

From Radiation Injury to Other More Common Wound Healing Classes

In the U.S., the most common indication to offer elective HBO₂ is now to augment wound healing problems in certain settings. These elective wound

healing indications in addition to radiation effects include necrotizing skin and soft tissue infections and their difficulties in healing, failing grafts or flaps, and thermal burns, but also ulcerations from complications from neuropathy and diabetes. Although varying levels of evidence exist across the broad category of enhancing healing in selected problematic wounds,⁷ this category shares a common theme that the wound and periwound is locally hypoxic as one of the primary reasons for it not to be healing, but response to supplemental oxygen indicating that it is not a large vessel (i.e. vascular) flow problem and not due to poor central cardiopulmonary mechanics either. Hyperbaric centers commonly employ measuring tissue concentration of oxygen to demonstrate this in the wounds or ulcers that are not healing by placing leads on the skin that measure oxygen partial pressure in the tissues of the wound. Tissue concentration of oxygen measurement is painless as the lead stick on, but does take some time, about an hour and sometimes longer if the patient is to be repositioned, to allow for the patient's tissues to react. Should the patient have low oxygen levels that then improve when given supplemental oxygen is given at room pressures, then HBO₂ could be beneficial. This process can also be repeated in the actual HBO₂ chamber as well to document an adequate response at pressure. Each of the specific kind of wounds have varying levels of evidence and various requirements before HBO₂ can be properly used. One of these is the use of HBO₂ in the management of DFUs. As in radiation changes, diabetes mellitus (DM) over time narrows the small and microscopic vessels such that patient's feet become neuropathic, develop characteristic deficiencies in blood flow and bony stability and develop ulcerations that threaten them with higher amputations and mortality.⁸ However, the key to be able to augment a DM patient's healing with HBO₂ is to properly take care of the basics first. Patients should be assisted in giving up smoking, losing weight and having a healthy lifestyle of diet and activity so that their DM is well controlled with an individually acceptable HA1C⁹ and frequent accuchecks. The patient's ulceration should be cleaned and debrided and screened for surgically correctable bony arthropathy and arterial inflow augmentation. Any infection either from local necrotic debris or underlying osteomyelitis should



Figure 1. Combined crush injury with chronic refractory osteomyelitis with non-union threatening amputation before hyperbaric. This patient had already failed initial surgical debridements, antibiotics, and stabilization, and had weeping non-healing ulcerations, and non-union of her bone over her internal fixator.



Figure 2. Same patient after combined surgery, antibiotics, and HBO₂.

be sought or removed. The patient's ulceration should be having regular local wound care with a moist supportive dressing for healing. The patient should be off loaded with a good even custom shoe or total contact casting. Should all this be done and the ulceration be essentially middle grade, not too minor nor not so severe so as to be non-recoverable (Wagner Grade 3)¹⁰ and not be healing at 30 days then HBO₂ can be added based upon the patient's safety profile.¹¹ Much of the data based recommendations both for and against adding HBO₂ have challenges based upon the rigorousness of patients being screened and treated before adding HBO₂ so that only appropriate patients are being included.

Chronic Refractory Osteomyelitis

Similarly, osteomyelitis may also respond very favorably to HBO₂. Recall that some of the most compelling data for osteoradionecrosis began as if high tension oxygen would synergistically attack infection in the bone, but ultimately was found to generate neo-angiogenesis to allow the bone to heal. Although the mainstays for osteomyelitis remain surgical debridement of non-viable or infected bone and any sequestrum, culture driven antibiotics and protective coverage, osteomyelitis responds to HBO₂ both acutely and electively. In the elective setting, HBO₂ has requirements akin to DFUs such that the grossly infected bone needs to be surgically debrided first and that the patient should have failed their first round antibiotics before HBO₂ is offered. Essentially the best data for elective use of HBO₂ is for chronic, refractory osteomyelitis where fundamental care for the osteomyelitis isn't working well. At that point the patient can be re-assessed and HBO₂ added in a coordinated approach

with further bone and soft tissue debridement, re-culturing, off-loading, dressings, nutritional optimization, screening for contractures and control of spasms, and a closure plan for the usually exposed bone.¹²

Severe Anemias not Transfusable

Severe anemia also remains an underutilized opportunity for hyperbaric oxygen to make more of an impact both in acute, if not emergent applications, as well as in subacute or more elective applications. The data behind its rationale is very straightforward and compelling at the basic science level where oxygen delivery goes from being dependent upon hemoglobin concentrations at sea level to near complete replacement of hemoglobin based oxygen delivery mechanisms with HBO₂.¹³ Currently the mainstay of patients with conditions of oxygen debts is blood transfusion, both acutely and sub acutely. However, there are occasions where due to a patient's beliefs, such as observant Jehovah's Witnesses, where a patient may not accept blood transfusions or due to factors inherent in the patient's blood where they cannot be safely transfused. There are also times where logistically blood may not be available for transfusion. In these cases, it can be overlooked that HBO₂ has been shown to support the anemic patient¹⁴ as well as build up hemoglobin in concert with other hematinics.¹⁵ Pulsed HBO₂ in concert with nutritional support and other hematinics will increase the circulating hemoglobin.¹⁶

In conclusion, HBO₂ can be used electively as well as to transition patients from more acute problems—such as when it is added to limit tissue losses and improve resuscitation responses in necrotizing infections or crush injuries—to more elective ones. Often inpatient facilities transition patients from acute indications where patients are given HBO₂ multiple times per day to a tail of treatments where the patient is being transitioned to an outpatient setting and now only needs once a day treatment Monday through Friday to allow better complete healing. Each individual center works with the treating clinicians to work out elective plans to support optimal healing. In this way HBO₂ can improve healing and recovery for a variety of elective problems from radiation injury to the ravages

of diabetes to even chronic presentations of some emergencies such as CO poisoning.

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Disclosure

None reported.

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