

Subject: Hyperbaric Oxygen Therapy
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INSTRUCTIONS FOR USE

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Hyperbaric oxygen therapy (HBO/HBOT/HOT) in single or multiple chambers is considered medically necessary first-line treatment for the following conditions:

- acute carbon monoxide poisoning
- arterial gas embolism
- decompression sickness

Hyperbaric oxygen therapy (HBO/HBOT/HOT) in single or multiple chambers is considered medically necessary adjunctive treatment for the following conditions:

- acute cyanide poisoning, after antidote administration has been given
- acute traumatic peripheral ischemic wounds (including crush injury), when used in combination with surgical and orthopedic interventions
- clostridial myonecrosis in diabetic wounds complicated by gas gangrene that are unresponsive to aggressive glucose management and wound care
- compromised skin grafts and flaps (i.e., preexisting grafts or flaps that are showing signs of failure or necrosis)
- necrotizing soft tissue infections (e.g., necrotizing fasciitis, Meleny's ulcer)
- osteomyelitis, refractory (i.e., unresponsive to conventional medical and surgical interventions)
- osteoradionecrosis of the jaw
- radiation-induced cystitis or hemorrhagic cystitis (i.e., resulting from chemolytic response, graft-versus-host disease [GVHD])
- radiation-induced enterocolitis
- Wagner grade III or higher diabetic wounds/ulcers of the lower extremities that have failed standard wound therapy

Hyperbaric oxygen therapy in single or multiple chambers for the treatment of ANY of the following conditions is considered experimental, investigational or unproven and thus not medically necessary (this list may not be all-inclusive):

- actinomycosis
- acute coronary syndrome (ACS)/myocardial ischemia/infarction (MI)
- acute traumatic brain injury
- anorectal disorders (i.e., chronic anal fissure [CAF], internal hemorrhoids, infectious proctitis)
- brown recluse spider bites
- cancer

- carbon tetrachloride poisoning
- cerebral edema
- cerebral palsy
- cerebral radionecrosis
- chronic fatigue syndrome
- Crohn's disease
- decubitus/ pressure ulcers
- dementia
- epilepsy
- exceptional blood loss
- fractures (i.e., delayed healing or nonunion)
- headaches (i.e., cluster, migraine)
- human immunodeficiency virus (HIV)–fatigue
- in vitro fertilization
- Lyme disease
- lymphedema
- malignant otitis externa (i.e., necrotizing external otitis)
- multiple sclerosis
- mycoses
- ophthalmologic conditions (i.e., optic neuropathy, glaucoma, retinal artery occlusion)
- organ storage
- organ transplantation
- rheumatoid arthritis
- sepsis
- sickle cell disease
- soft tissue injury (e.g., delayed onset muscle soreness, sprains, strains)
- spinal cord injury
- stroke
- thermal burns
- tinnitus
- venous stasis ulcers

General Background

Hyperbaric oxygen therapy (HBO or HBOT) is a mode of treatment in which a patient breathes 100% oxygen at pressures greater than normal atmospheric (i.e., sea level) pressure. In contrast with attempts to force oxygen into tissues by topical applications at levels only slightly higher than atmospheric pressure, HBO involves the systemic delivery of oxygen at two to three times greater than atmospheric pressure. The Undersea and Hyperbaric Medical Society (UHMS) has approved the use of HBO for several conditions, and studies are underway to expand its usage for other conditions once its efficacy and safety can be determined.

A hyperbaric oxygen chamber (whether single or multiple chamber [i.e., created to hold several people]) is a device intended to increase the environmental oxygen pressure to promote the movement of oxygen from the environment to a patient's tissues by means of pressurization that is greater than atmospheric pressure. Complications from this therapy can be minimized if pressures within the chamber remain below three times the normal atmospheric pressure and sessions last no longer than two hours. Mild problems associated with HBO include claustrophobia (e.g., in monoplace chambers), fatigue and headache. More serious complications include: myopia (i.e., shortsightedness) that can last for weeks or months, sinus damage, ruptured middle ear and lung damage. Oxygen toxicity leading to convulsions, fluid in the lungs, and even respiratory failure can occur. Pregnant women should not be treated with HBO.

U.S. Food and Drug Administration (FDA): The FDA and the Undersea and Hyperbarics Medical Society (UHMS) define HBO therapy as breathing 100% oxygen as pressures higher than atmospheric in

a hyperbaric chamber. According to the National Fire Protection Association (NFPA), hyperbaric chambers are classified into two categories: Class A (multi-occupant) and Class B (single occupant). Chambers that are used for HBO therapy are classified as 510(k) devices by the FDA.

Devices that may be used for the topical application of oxygen to an isolated area or single extremity are not considered hyperbaric oxygen chambers, according to the FDA (2003).

Literature Review

HBO as Primary Therapy: The safety and efficacy of HBO therapy has been demonstrated for numerous conditions in evidence-based, peer-reviewed journals, consensus guidelines and numerous textbooks. HBO therapy is the standard of care in the primary treatment of acute carbon monoxide poisoning, arterial gas embolism, and decompression sickness. Through the forced exchange of oxygen at the plasma levels, tissue function can be sustained (American College of Hyperbaric Medicine [ACHM], 2005; HAYES, 2006; Harwood-Nuss, 2000).

HBO as Adjunctive Therapy: In the case of acute cyanide poisoning, the use of HBO has been proven to be effective as adjunctive therapy after administration of the antidote sodium thiosulfate. In combination with the antidote, HBO provides an alternate pathway to the transport of oxygen to the tissues by increasing the serum dissolved oxygen to levels adequate for life, and thereby bypassing bound hemoglobin.

Through forced oxygenation of tissues, HBO has been shown to be effective in the adjunctive treatment of traumatic or acute peripheral wounds, compromised skin grafts and flaps, necrotizing infections, osteoradionecrosis of the mandible, and osteomyelitis that is refractory to aggressive medical and surgical management (National Cancer Institute [NCI], 2007; American Cancer Society [ACS], 2005; ACHM, 2005).

There is support in the scientific literature indicating that HBO may be added as an adjunctive therapy in diabetic foot wounds when clostridial myonecrosis (i.e., gas gangrene) is present and in deep diabetic ulcerations that are unresponsive to aggressive conventional wound care, glucose management and debridement (Gibbons, 2001; Neumeister, 2004; Agency of Healthcare Research and Quality [AHRQ] evidence reports, 2003).

Studies have also shown that using HBO as an adjunctive therapy in the treatment of hemorrhagic cystitis (HC) resulting from chemolytic response, as a prophylaxis for graft-versus-host disease or when radiation induces HC or enterocolitis (Fink, 2006; Chong, 2005; Fine, 2005; Bennett, 2005; El-Zimaity, 2004; Kalayoglu-Besisik, 2003; Cesaro, 2003).

The Baromedical Research Foundation (2006) is conducting a Phase III, eight-component study that will focus on the degree of benefit that HBO affords in the treatment of late radiation tissue injury focusing on the mandible, larynx, skin, bladder, rectum, colon, and gynecological organs. This study will also focus on the possible use of HBO as a prophylaxis against late radiation tissue injury. The expected completion date is August 2010.

Refractory Osteomyelitis: Refractory osteomyelitis is chronic osteomyelitis (i.e., infection of the bone) which has persisted or recurred despite aggressive medical interventions, including the use of oral and parenteral administration of appropriate antibiotics (i.e., determined by bone culture and sensitivity testing), surgical debridement, nutritional support and reconstructive surgery. The treatment of chronic refractory osteomyelitis with HBO therapy remains controversial. The UHMS recognizes HBO as an adjunctive treatment for this condition.

HBO has been proposed for adjunctive use in patients with osteomyelitis, classified using the Cierny-Mader system as (King, 2006; Lazzarini, 2004; Lawson, 2003):

- stage 3B—localized osteomyelitis (anatomic type)
- stage 4B—systemic, local or systemic and local compromise

Hailey (2003) conducted a literature review concerning the use of HBO for the Alberta Heritage Foundation for Medical Research (AHFMR). In relation to osteomyelitis, no consensus could be reached by the authors on the appropriateness of using HBO, due to the lack of study evidence. Wang (2002) also conducted a literature review and concluded that studies to date have only suggested that HBO used as an adjunct to culture-directed antibiotics, surgical debridement, and nutritional support has decreased bed days and amputations in chronic refractory osteomyelitis.

Published textbook direction on the use of HBO therapy is also conflicting. Although evidence supporting HBO for the treatment of refractory osteomyelitis is very limited, this adjunctive therapy appears to have evolved into accepted practice for a specific subset of patients (King, 2006; Wang, 2003).

Wounds/Ulcers (i.e., Diabetic) of the Lower Extremity: HBO has recently been proposed in the treatment of diabetic wounds that are refractory to aggressive medical management including wound care, glucose control and surgical debridement or surgical revascularization. Peripheral sensory neuropathy in the absence of perceived trauma is the primary factor leading to diabetic foot ulcerations. Other forms of diabetic neuropathy include motor and autonomic. Peripheral vascular disease rarely leads to foot ulcerations directly; however, once an ulceration develops, arterial insufficiency will result in prolonged healing and imparts an elevated risk for amputation. Early recognition and aggressive treatment of lower extremity ischemia is therefore vital to lower limb salvage (American College of Foot and Ankle Surgeons [ACFAS], 2000).

Diabetic ulcers are usually graded using the Wagner Wound Classification system. These classification grades are as follows:

- Grade I: the ulcer is superficial and does not extend into the deeper tissues.
- Grade II: the ulcer is deep and extends to the tendon, bone, or joint capsule.
- Grade III: the ulcer is deep and contains an abscess or osteomyelitis, or both.
- Grade IV: the ulcer has led to gangrene of the toes and/or forefoot.
- Grade V: the ulcer has caused gangrene of the entire foot or enough of the foot that it cannot be salvaged (Daugherty, 2000).

In a Cochrane analysis that was conducted by Kranke and colleagues (2005), the authors concluded that in people with foot ulcers due to diabetes, HBO significantly reduced the risk of major amputation and may improve the chance of healing at one year. In August 2005, the Ontario Health Technology Advisory Committee (OHTAC) issued the following recommendation concerning the use of HBO for nonhealing ulcers in patients with diabetes mellitus: the evidence published to date is uncertain. These treatments may be useful for severe infections or for those that have not adequately responded to therapy, despite correcting for all amenable local and systemic adverse factors (Lipsky, 2004; Kessler, 2003; Fife, 2002; Wunderlich, 2000).

Although evidence supporting HBO for the treatment of diabetic wounds/ulcers of the lower extremity is very limited, this adjunctive therapy appears to have evolved into accepted practice for patients with diabetic wounds Wagner grade III or higher that are refractory to conventional wound care, aggressive diabetic management for glycemic control and surgical interventions.

Other Proposed Indications for HBO

There is insufficient evidence in the published peer-reviewed scientific literature to support the use of HBO for the primary or adjunctive treatment of the conditions outlined below.

Actinomycosis: Actinomycosis is a rare chronic, indolent, suppurative, tissue-destructive infection presenting with lumps and sinus formation, usually involving the head and neck, although it can affect other parts of the body, such as the abdomen and thorax. Standard treatment involves antibiotic therapy for up to 12 months, with surgical intervention as needed (Polenakovik, 2006; Sherwood, et al., 2001). Although some reports are promising, there is insufficient evidence to support the use of HBO therapy in the treatment of actinomycosis.

Acute Coronary Syndrome (ACS)/Myocardial Ischemia/Infarction (MI): ACS includes acute MI and unstable angina. The use of HBO therapy as an adjunct to standard therapy has been proposed to improve oxygen supply to the heart and possibly decrease the amount of ischemic death that could occur. In one randomized study by Dekleva et al. (2004), 74 patients were randomly assigned within the first 24 hours after diagnosis to HBO and streptokinase treatment versus streptokinase treatment alone. This study was small in sample size, showed treatment effectiveness limited to the first three days after HBO and excluded patients with significant electrical complications. Due to these limitations, the effectiveness of HBO for the treatment of acute MI cannot be determined (Dekleva, 2004).

A Cochrane systematic review was conducted by Bennett et al. (2005) of four studies that reviewed the effect of using HBO as an adjunct to standard ACS regimens versus standalone standards of care. The reviewers concluded that there is limited evidence that HBO therapy either reduces the risk of major adverse coronary events (MACE), impacts cardiac dysrhythmia, or decreases the time intervals of ischemic pain during these events. These primary studies were small in number and population size and had methodological and reporting inadequacies. As a result of these findings, the authors cannot recommend the use of HBO as an adjunct to standard ACS therapy regimens within this population.

Acute Traumatic Brain Injury: Data from the National Institute of Neurologic Disorders and Stroke (NINDS, 2007) estimate that there are 1.4 million cases of traumatic brain injury (TBI) in the United States per year, with approximately 230,000 patients requiring hospitalization. In patients with moderate or severe TBI, the goal is to resuscitate the patient adequately to prevent further brain injury. Airway and shock management should be aggressive. The frequent monitoring of hemodynamic and cardiac status, pulse oximetry, and blood and urine analysis is necessary. Symptoms depend on the degree of injury. The duration of symptoms noted after a head injury is related to the patient's age and length of post-traumatic amnesia. The available evidence on adjunctive HBO treatment for severe traumatic brain injury is limited, and patient outcome after HBO therapy is unknown (AHRQ, 2003; McDonough, 2003; Rowland, 2000).

Anorectal Disorders: The safety and efficacy of hyperbaric oxygen therapy as primary or adjunctive treatment for anorectal disorders has not been proven at this time. HBO therapy has not been studied in randomized, controlled clinical trials to compare its efficacy against that of standard care with non-steroidal anti-inflammatory medications, steroid enemas, cauterization or surgical excision (Rao, 2004; Schwartz, 2004; Eisen, 2001).

According to the National Institute of Diabetes and Digestive and Kidney Disease (NIDDK, 2004), proctitis is an inflammation of the lining of the rectum that can be caused by sexually transmitted disease, ulcerative colitis, Crohn's disease, malfunction of the nerves of the rectum or radiation. Standard treatment includes antibiotics, along with the addition of 5-aminosalicylic acid (5ASA) or corticosteroids applied directly to the area (Tobin, 2001).

Brown Recluse Spider Bites: Spiders of the genus *Loxosceles* are distributed around the world. *Loxosceles reclusa*, the most important species in the United States, can be found coast-to-coast, but is most common in the southern Midwestern states. *Loxosceles* venom contains proteins, mostly enzymes that cause both local and systemic toxicity. Dermonecrosis is mainly due to ischemia secondary to inflammation caused by leukocyte infiltration, hemolysis, complement activation and intravascular coagulation. Systemic effects develop within 96 hours after the bite and include fever, chills, malaise, weakness, nausea, vomiting, arthralgia, myalgia and rash. Treatment of necrotic or cutaneous arachnidism consists of supportive and general wound care (Stibich, 2006). There are a few case studies that have been conducted on humans using HBO, but these studies have not shown that HBO therapy produces better patient outcomes than standard aggressive wound care and antibiotic administration (Norris, 2006; Wasserman, 2005).

Cancer: HBO therapy has been proposed for use as both a cure for cancer and as a means of enhancing tumor response to chemotherapeutic treatment. According to the ACS (2005), there is no scientific evidence that supports these proposals. The National Comprehensive Cancer Network (NCCN, 2007) does not indicate that HBO is a primary or adjunctive treatment of cancer.

Carbon Tetrachloride Poisoning: Carbon tetrachloride poisoning causes nausea, vomiting, abdominal pain and diarrhea. High concentrations cause dizziness, confusion, coma, respiratory depression, hypotension and sporadic convulsions. Death may follow from respiratory failure or ventricular fibrillation due to cardiac sensitization to circulating catecholamines. Hepatorenal damage supervenes after a delay of up to two weeks. Gastric emptying is best avoided because of risk of aspiration. Renal and liver failure should be handled with conventional treatment (Harwood-Nuss, 2001). There is insufficient evidence to determine the health outcome of HBO therapy for carbon tetrachloride poisoning.

Cerebral Edema: Brain edema accompanies a wide variety of pathologic processes. It plays a major role in head/brain injury, stroke and brain tumor, as well as in cerebral infections, including brain abscess; encephalitis and meningitis; lead encephalopathy; hypoxia; hyposmolality; the disequilibrium syndrome associated with dialysis and diabetic ketoacidosis; Reye's syndrome; fulminant hepatic encephalopathy; and hydrocephalus. Brain edema occurs in several different forms; clearly, it is not a single pathologic or clinical entity (Adamides, 2006; Rowland, 2000). There is insufficient evidence to support the treatment of brain edema with HBO.

Cerebral Palsy: Cerebral palsy (CP) is an umbrella term covering a group of nonprogressive, but often changing, motor-impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development. A total of 2.0–2.5 of every 1000 (live-born) children in the western world have this condition; incidence is higher in premature infants and in twin births. CP neurodevelopmental conditions are the most common “physical” disabilities in childhood and severely affect a child's development. CP cannot be cured, but a host of interventions can improve functional ability, participation and quality of life. From 1992 to 1999, Harch studied the effect of HBO therapy on 25 children, ages two to four years old. Eighty sessions of HBO therapy were administered to all participants. No blinding or placebo controls were used and, at the end of the trial, 18 of the patients showed minimal or no neurological change. There is insufficient evidence to support the use of HBO therapy for CP.

Cerebral Radionecrosis: The National Center for Complementary and Alternative Medicine (2005) is currently recruiting patients to conduct a Phase II and Phase III study on the effectiveness of using HBO for brain tissue damage that is caused by radiation therapy. Participants in this study will be randomly assigned to receive standard steroid therapy, or steroid therapy plus HBOT for three months.

According to Fine (2005), late radiation of the brain may be due to vascular endothelial injury or to a direct effect on oligodendroglial cells, or white matter changes. Although anticoagulation and HBO have been suggested as treatment when surgery is not feasible, clinical trials demonstrating efficacy are lacking.

Crohn's Disease: Crohn's disease is a chronic inflammatory disease of the gastrointestinal tract, the cause of which remains unknown. It is characterized by a granulomatous inflammation affecting any part of the gastrointestinal tract, frequently in discontinuity and with the tendency to form fistulae. No controlled reports on the use of HBO therapy in perineal Crohn's disease were found. The available evidence consisted of two case reports and two case series totaling 320 patients. The evidence is considered insufficient to determine the effect of HBO treatment on the health outcomes of patients with severe, refractory perineal Crohn's disease (NIDDK, 2004).

Decubitus/Pressure Ulcers: These ulcers are usually localized to an area of tissue necrosis that develops when soft tissue is compressed between a bony prominence and an external surface. This excess pressure causes capillary collapse and obstructs the passage of nutrients to body tissues. Pressure ulcer formation is accelerated in the presence of friction, shear forces, and moisture. Other factors that may contribute to the development of pressure ulcers include immobility, altered activity levels, altered mental status, chronic conditions, and altered nutritional status (Barbul, 2005).

Treatment of these ulcers includes debridement of all necrotic tissue, maintenance of a moist wound environment that will facilitate healing, pressure relief, and aggressively managing nutritional, metabolic, and circulatory status. The wound bed should be kept moist by employing dressings that absorb secretions but do not desiccate the wound. Debridement is most efficiently carried out surgically, but enzymatic proteolytic preparations and hydrotherapy may also be used. Surgical repair, usually involving flap rotation, has been found to be useful in obtaining closure; however, recurrence rates are high (Barbul, 2005).

The National Pressure Ulcer Advisory Panel Statement on Reverse Staging of Pressure Ulcers (NPUAP, 2003) utilizes the following grading system when classifying these wounds:

- Stage I: Pressure ulcer is an observable, pressure-related alteration of intact skin whose indicators compared to the adjacent or opposite area on the body may include changes in one or more of the following: skin temperature (i.e., warmth or coolness), tissue consistency (i.e., firm or boggy feel), and/or sensation (i.e., pain, itching). The ulcer appears as a defined area of persistent redness in lightly pigmented skin, whereas in darker skin tones, the ulcer may appear with persistent red, blue or purple hues.
- Stage II: Partial-thickness skin loss involves epidermis, dermis or both. The ulcer is superficial and presents clinically as an abrasion, blister or shallow crater.
- Stage III: Full-thickness skin loss involves damage to, or necrosis of, subcutaneous tissue that may extend down to, but not through, underlying fascia. The ulcer presents clinically as a deep crater with or without undermining of adjacent tissue.
- Stage IV: Full-thickness skin loss has extensive destruction, tissue necrosis, or damage to muscle, bone, or supporting structures (e.g., tendon, joint capsule). Undermining and sinus tracts may also be associated with Stage IV pressure ulcers.

According to the Wound, Ostomy, and Continence Nurses Society's (WOCN) 2003 guideline for prevention and management of pressure ulcers, the following adjunctive therapies can be considered to enhance the healing of recalcitrant Stage III and IV wounds: growth factors (i.e., platelet-derived growth factor-BB), electrical stimulation, or the possible use of topical negative pressure (NGC, 2003).

Hyperbaric oxygen, ultrasound, ultraviolet and low-energy radiation either are ineffective or have not been extensively evaluated for efficacy (Gifford, 2007). The use of HBO within this population has not been studied in large, randomized clinical trials, according to Kranke, et al. (2005), in a Cochrane Systematic literature review.

Dementia: Dementia is characterized by progressive deterioration that is sufficiently severe to interfere with social or occupational functions, such as: memory, orientation, abstraction, ability to learn, visuospatial perception, language function, and constructional praxis.

In addition, higher executive functions, such as planning, organizing and sequencing, are all impaired in dementia. Alzheimer's disease accounts for more than 50% of cases of dementia in both clinical and autopsy series. Other diseases that are associated with dementia are Parkinson's; Lewy body disease; Huntington's disease; Pick disease and frontotemporal dementia; progressive supranuclear palsy; and hereditary ataxia (Rowland, 2000). There is insufficient evidence to support the treatment of dementia with HBO (Eisendrath, 2005).

Epilepsy: Epilepsy is a disorder characterized by the tendency to have recurring seizures. People with idiopathic seizures usually have their first seizure at age 2–14. Seizures before age two are generally caused by brain defects, chemical imbalances, or high fevers. The 11th International Congress on Hyperbaric Medicine presented the following study and findings: 100 patients (72 males, 28 females; ages four days to 14 years) participated in this study of HBO therapy for the treatment of epileptic seizures in children. Eighty-four percent of the participants were between one month and nine years of age. The cause of the epileptic seizures was unknown in 23 of these children. Known causes included cerebral lesions due to birth injury (55 patients); encephalitis (14 patients); anoxic cerebroopathy (four patients); high fever (two patients); brain tumor (one child); and cerebrovascular malformation (one child). Electroencephalograms, computed tomography (CT) scans and magnetic resonance images (MRIs) were obtained on all children. Seizure activity prior to HBO treatment was stratified based on number of seizures during various time periods: 21 children had seizures every week; 18 children had seizures every month; 23 children had seizures every two months; and 38 children had seizures more than twice a year.

During this study, anticonvulsant medication (neither type[s] nor dosage[s] was recorded) was given systemically to 39 children; 20 children were controlled with diazepam and r-amino butyric acid; and 41 children did not receive medication due to parental choice. HBO therapy was given at 1.7–2.0 atmospheres for 80 minutes every day for 15–30 days, with some children receiving treatment for 35–45 minutes. Only 76 children were able to be followed for a three-year timeframe, with 40 children (52%) being free of anticonvulsants; three children had one or two slight attacks every year. Twenty-five children (32.8%) still required some medication to control their seizure activity, and 11 children (14%) showed no change in seizure activity. Due to inconsistency in treatment duration, unaccounted for loss of participants for follow-up, unknown medication and dosages, and only one study to date, there is insufficient evidence to support the use of HBO for the treatment of epileptic seizures in children.

Exceptional Blood Loss When Transfusion Is Not an Option: There is very little literature regarding exceptional blood loss when religion does not permit transfusion. The mainstay of care in severely anemic patients who refuse transfusions is sedation and artificial ventilation to minimize oxygen requirements. The HBO treatment remains of unproven benefit for this indication (Bell, 2000).

Intermittent HBO exposures have been applied to relieve temporarily physiologic stress from severe, acute anemia. This is a rare practice, but it is sometimes considered when transfusion is not possible due to crossmatching incompatibilities or religious beliefs. Anecdotal reports describe using 2.5 to 3 ATA of oxygen to increase arterial oxygen tension in plasma to meet metabolic needs. Treatments are administered for only brief times when physiologic decompensation occurs because oxygen toxicity can be a problem. Short-term treatments, applied many times over several days, have been used to support life until red blood cells become available or until adequate red blood cell mass is generated endogenously (Huang, 2006).

Fractures (Delayed Healing and/or Nonunion): The primary goal in the treatment of fractures is the realignment and stabilization of the fractured bone and restoration of function. The fracture process may sometimes be impaired by a delay in the healing of the bones due to poor vascularity, malalignment, bone gaps or infection. Nonunions can also occur in the presence or absence of infection. Usually these conditions are treated by the insertion of internal or external fixation devices; bone grafting may need to occur and the administration of antibiotic therapy may be needed. As an adjunct to these therapies, the use of HBO has been proposed to assist in improving the healing outcomes in delayed or nonunion fractures. During a Cochrane systematic review, Bennett et al. (2004) concluded that, although this use of HBO has been proposed for many years, there is insufficient evidence within the literature to support or refute its use for the treatment of fractures, aid in the healing of acute injuries, and/or to assist in the healing process of a nonunion fracture.

Headaches (Cluster): Cluster headaches (CH) are an extremely painful but uncommon type of migraine headache. These headaches primarily affect men over age 30. An attack almost always starts suddenly and ends within an hour. These attacks come in groups, ranging in frequency from two attacks a week to several attacks in a day. Most episodes of cluster headaches last for six to eight weeks and occasionally longer. Treatment includes oral medications (triptans, ergotamine, corticosteroids or methysergide) or injections of Sumatriptan, which may also be used when relief is not obtained from oral therapy. Oxygen may also be administered at normal pressure, via nasal cannula or mask. In 2001, Nilsson conducted a double-blind, placebo-controlled crossover study of hyperbaric oxygen treatment on active cluster headaches. The control group consisted of 10 patients with chronic or episodic CH, with at least six headaches during the week prior to enrollment and an expected remaining CH period of greater than four weeks. The experimental group consisted of 12 noncluster headache sufferers. Patients who were currently receiving prophylactic treatment were excluded. The control group received sham treatment of 10% oxygen for 70 minutes at two sessions that were 24 hours apart. The experimental group received HBO treatment with 100% oxygen per the same protocol. Though the study was small, it found distinct differences between these two groups. Two patients had remission of headaches for greater than one year after sham treatment; five patients reported mild to moderate attacks during sham treatment and none during HBO. Researchers measured a number of serum markers of vasoactivation but reported no significant findings, and the results were poorly reported with apparent post hoc comparisons. There is insufficient evidence to support the use of HBO therapy for the treatment of cluster headaches.

Headaches (Migraines): According to the International Headache Society, a migraine headache is a chronic condition with recurrent, episodic attacks. Its characteristics vary among patients and can even vary among attacks in a single patient. These headaches vary in frequency, duration and disability among sufferers and between attacks. It is appropriate to link the treatment to the severity of the symptoms and the response of the individual to the treatment. Oral medications (e.g., triptans, dihydroergotamine [DHE]) may be used in patients with moderate to severe attacks or who respond poorly to nonsteroidal anti-inflammatory agents (NSAIDs) and caffeine. Antiemetics may also be used for nausea and vomiting control. Alternative treatments that can be used are relaxation and stress-management training or biofeedback. The use of HBO as a preventive or acute therapy for migraine treatment has not been documented in the peer-reviewed literature (Silberstein, 2000). HBO as a treatment modality for migraine headaches remains experimental /investigational and/or unproven.

In Vitro Fertilization (IVF): Infertility may be the result of endometriosis, tubal factors, uterine and endometrial factors, cervical factors, ovulatory factors, or from unexplained factors. Pharmacologic and other medical treatment is typically attempted before more invasive interventions are sought. Ovulatory dysfunction is a frequent cause of female infertility. Ovulation may be absent or occur irregularly due to ovary abnormalities or abnormal secretion of the hormones needed to support ovulation. Mitrovic et al. (2006) reported on a case study of using HBO to improve endometrial preparation prior to IVF. Once the oocytes were obtained, then intracytoplasmic sperm injection (ICSI) occurred, due to male factor infertility. The researchers could not determine if HBO had a direct result on the IVF/ICSI successful pregnancy. In an attempt to stimulate follicular angiogenesis and oxygenation, Van Voorhis et al. (2005) conducted a pilot study to determine the safety, tolerability, and effects of HBO when used during ovarian stimulation for IVF. The researchers determined that although HBO was well tolerated, the study population was too small to prove or disprove their hypothesis, and additional research and studies are needed to: 1) determine methods of accurately and objectively measuring microvasculature of the ovarian follicle in vitro; and 2) the efficacy of using HBO as an adjunct during IVF.

Lyme Disease: Lyme disease is a clinical diagnosis, and currently the early use of antibiotics can prevent persistent, recurrent and refractory conditions. The duration of therapy is determined by each individual's clinical response, but the adjuvant use of HBO therapy is not recommended as part of this treatment. In August 2004, the International Lyme and Associated Diseases Society developed an evidence-based guideline for the management of Lyme disease. It specifically stated that the use of hyperbaric oxygen is not recommended for routine therapeutic use.

Lymphedema: Approximately 10–38% of all women who have breast-conserving surgery (BCS) or modified radical mastectomy have postsurgical irradiation to the lymph nodes, and 10% of those women who have BCS with irradiation to the lymph nodes develop lymphedema. Hyperbaric oxygen therapy has been proposed as an adjunct treatment to assist in reducing lymphedema. A pilot study of 10 patients was conducted in 2004 by Teas and colleagues. Results showed a 38% average reduction in hand lymphedema; however, the total limb volume did not change significantly from baseline measurements after 20 HBO treatments, and vascular endothelial growth factor-C (VEGF-C) levels began to increase. This change may suggest that HBO treatment stimulates the production of this growth factor. The researchers concluded that additional studies with a larger population of patients are needed to document the effects of HBO on lymphedema.

Malignant Otitis Externa: Malignant otitis externa (i.e., necrotizing external otitis) is an uncommon, yet potentially fatal infection of the external auditory canal, possibly including the surrounding tissue and soft bone. This diagnosis is made by clinical exam, and microbiological and radiological evaluations. Traditional treatment has included strict diabetic control, administration of antibiotics, repeat debridement and surgical resection. HBO therapy has been proposed as an adjunct to traditional therapy for this condition.

Phillips et al. (2005) conducted a Cochrane systematic review of the available literature to determine the effectiveness of using HBO as an adjunct to the traditional treatment protocols for malignant otitis externa. The researchers could not locate any randomized controlled trials that have measured the effectiveness of using HBO within this population. A small number of case reports and case series were found, but there was no clear evidence that demonstrated the effectiveness of using HBO therapy for this condition.

Multiple Sclerosis: Multiple sclerosis (MS) is a chronic neurological disease in which there is patchy inflammation, demyelination and gliosis in the central nervous system (CNS). In 1982, James suggested the use of HBO as a treatment of MS based on the demonstrated ability of HBO to produce vasoconstriction with increased oxygen delivery and some anecdotal evidence of efficacy. A number of randomized studies were done as a result, with mixed results reported. In 2001, the UHMS and most neurologists abandoned the concept of listing HBO as a treatment option for MS. An analysis of these studies showed 10 reports with 504 participants in total, yet no consistent evidence confirmed a beneficial effect of HBO for the treatment of MS compared to sham treatment (Huang, 2006; Bennett and Heard, 2004). There is insufficient evidence to support the use of HBO as a treatment for multiple sclerosis.

Organ Transplant/Storage: Researchers have hypothesized that the use of HBO may enhance the performance and growth in pancreatic islet grafts, when they are subjected to high levels of oxygen prior to transplant. At this time, animal studies are being conducted to determine the efficacy of using HBO in preparation of and during islet transplantation (Juang, 2002).

Ophthalmologic Conditions/Retinal Artery Occlusion: Central retinal artery occlusion is unilateral and painless, with acute vision loss occurring over seconds. The critical signs include superficial opacification or whitening of the retina in the posterior pole and a cherry-red spot in the center of the macula. Treatment consists of immediate ocular massage, withdrawal of fluid until the eye shallows slightly, and medications (topical, oral or IV) administered to reduce intraocular pressure. The patient should be referred to an internist for evaluation. There is insufficient evidence to determine the health outcome of HBO therapy for retinal artery occlusion, optic neuropathy or glaucoma (Patterson, 2002).

Sickle-Cell Disease: Sickle-cell disease is a hereditary disorder of hemoglobin structure and function. Hemoglobin S differs from normal hemoglobin in that valine is substituted for glutamic acid in position (6) of the beta globin chain. Both hemoglobins function similarly in the oxygenated state, but deoxygenated hemoglobin tends to polymerize and gelate, leading to red cell sickling. Erythrocytes with less total hemoglobin are more resistant to sickling, as are younger and smaller cells. An estimated 8–10% of African-Americans carry the sickle-cell gene, and about one in 400–600 manifests sickle-cell disease. The anemia of sickle-cell disease is due to both chronic and acute hemolysis. The red cell membranes are damaged by repeated episodes of sickling, leading to increased fluid and electrolyte permeability and fragility. Red blood cells have a life span of about 10–20 days in sickle-cell disease, compared with 120 days in normal subjects. Pain relief and protection from infection are an essential part of therapy. Folic acid should be taken to avoid megaloblastic crisis. Transfusion therapy is indicated in selected sickle syndrome. Several new approaches to treatment of sickle-cell disease are currently under evaluation; however, these approaches do not include HBO. There is no evidence that HBO should be used in the treatment of sickle-cell anemia (Lodewijk, 2007).

Soft Tissue Injury (i.e., Delayed Onset Muscle Soreness, Closed Soft Tissue Injury): Muscle soreness and damage is commonly associated with athletic activity. These soft tissue injuries can range from abrasions and bruising to disruptions of tendons, ligaments and muscles. Traditional treatment includes rest, elevation, anti-inflammatory medications and stretching. If surgical intervention becomes needed, then rehabilitation with physical therapy is used. HBO has been proposed as an adjunct to these therapies to expedite the healing process. According to Bennett, Best et al. (2005) within a Cochrane Systematic review of the literature, there is insufficient evidence to conclude that the use of HBO in the treatment of delayed onset of muscle soreness or closed soft tissue injury is efficacious.

Spinal Cord Injuries: No controlled studies on the adjunctive use of HBO in the treatment of spinal cord injuries have been identified. The evidence consists of three small, uncontrolled case series with a range of spinal cord injuries. Overall, results were not favorable. The use of HBO therapy for the management of spinal cord injury was never widely accepted (Rowland, 2005). The lack of clinical evidence of benefit may have rendered the treatment obsolete.

Stroke: Medical therapies for stroke are designed to minimize or prevent ischemic brain infarction, optimize functional recovery and avert stroke recurrence. Specific therapies depend on the stroke syndrome. Atherothrombotic brain infarction (ABI) and artery-to-artery thromboembolic strokes are the most common stroke syndromes and result from atherosclerosis. ABI represents a continuum from

transient ischemic attacks to complete strokes with fixed neurological deficits. Intermediate manifestations of ABI are progressing strokes or strokes in evolution. Treatment for acute ischemic stroke is thrombolysis within three hours of stroke onset. Anticoagulant is used in embolic stroke of cardiac origin. Supportive therapy is recommended for intracerebral hemorrhage. Surgical, balloon or coagulative extirpation of an aneurysm is the definitive therapy (Rowland, 2005). There is insufficient information to determine the health outcomes of HBO for the treatment of stroke.

Thermal Burns: Researchers disagree whether HBO therapy provides added benefit to a standard thermal-burn protocol. A Cochrane systematic review of the literature conducted by Villanueva et al. (2004) concluded that there was no convincing evidence for a benefit from hyperbaric oxygen in the treatment of burns. At this time, it is not clear whether hyperbaric oxygen confers any benefit when added to standard burn care. There is insufficient evidence to draw an accurate conclusion as to the efficacy of the treatment of thermal burns with HBO therapy (HAYES, 2003; 2006). HBO therapy for the treatment of thermal burns is generally considered experimental/investigational and unproven and not medically necessary.

Tinnitus: Tinnitus, also commonly referred to as “ringing in the ears” or “head noise,” is defined as the perception of sound in the head when no external sound is present. This symptom can occur in one ear or bilaterally as well as internal and external to the auricle. It may accompany hearing loss or exist independently. Normal treatment includes identifying the underlying cause of the symptom, as it can be part of a treatable condition that may require medical or surgical intervention. If the cause cannot be identified, then tinnitus maskers can be used (e.g., drug or vitamin therapy, sound producers, relaxation therapy).

Bennett, Fanzca, et al. (2005) reported on a systemic review of all randomized controlled trials that have been conducted to determine the effectiveness of using HBO to treat tinnitus and sudden sensorineural hearing loss. Of the studies that have been conducted, the authors could not conclude that HBO improves hearing in patients. Although some of the studies indicated there had been improvement noted, the methodology and reporting of these findings was inadequate for a conclusion to be made. Additional randomized controlled studies are needed to verify the use of HBO for this condition.

Venous Stasis Ulcers: Venous stasis ulcers are the result of chronic venous insufficiency (CVI), a condition that affects 2–5% of Americans. CVI can lead to chronic life-threatening infections of the lower extremities. Pain, especially after ambulating, is a hallmark of the disease. Congenital absence of or damage to venous valves in the superficial and communicating systems can cause CVI. Venous incompetence due to thrombi and the formation of thrombi can also cause CVI. Standard treatments for this condition include leg elevation, compression stockings or pressure boots, as well as surgical interventions of vein ligation of superficial veins. For chronic venous insufficiency, venous obstruction must be ruled out through radiographic studies. If surgical interventions are needed to restore normal flow within the vessels, then thrombectomy, saphenous vein crossover grafting, or valvuloplasty may be necessary. Standard aggressive wound care for venous ulcers should also be a part of the treatment plan for these individuals. Although HBO therapy has been proposed for use within this population, its efficacy has not been established within clinical trials (Kranke, 2005).

In 2005, the WOCN published a guideline for the management of lower-extremity venous wounds. Within this guide, the use of HBO therapy is not listed for use within this population. The Association for the Advancement of Wound Care (AAWC) (2005) produced a guide for the treatment of venous ulcers and indicated that HBO may be considered when conservative care does not work within 30 days.

Professional Societies/Organizations

American College of Foot and Ankle Surgeons (ACFAS, 2000): ACFAS acknowledges that there are several reviews and retrospective studies that have reported efficacy of HBO where nonreconstructible, occlusive vascular disease or limb-threatening infection exists. The benefit of HBO therapy has not been proven conclusively in prospective clinical trials.

American College of Hyperbaric Medicine (ACHM, 2004): ACHM recognizes the use of HBO for the following conditions:

- acute carbon monoxide intoxication
- burns
- decompression illness
- gas embolism
- gas gangrene
- acute traumatic peripheral ischemia (loss of limb function or when life is threatened)
- crush injuries and suturing of severed limbs (i.e., as an adjuvant when loss of function occurs or life is threatened)
- Meleney's ulcers
- acute peripheral arterial insufficiency ulcers
- skin grafts (i.e., preparation and preservation of compromised grafts)
- osteoradionecrosis (i.e., as an adjunct to conventional treatment)
- soft tissue radionecrosis (i.e., as an adjunct to conventional treatment)
- cyanide poisoning
- actinomycosis (i.e., as an adjunct to conventional therapy when the process is refractory to antibiotics and surgical treatment)
- diabetic wounds
- venous stasis ulcers (recommended only if venous surgery, local wound care, leg elevation, counter pressure support, and skin grafting fails)
- decubitus ulcers—with underlying osteomyelitis, a compromised skin flap or an infected wound
- arterial insufficiency ulcers (which persist after reconstructive surgery has restored large vessel function)
- necrotic wounds secondary to a brown recluse spider bite

Summary

The safety and efficacy of hyperbaric oxygen therapy (HBO or HBOT) has been demonstrated for numerous conditions in evidence-based, peer-reviewed journals, consensus guidelines and numerous textbooks. HBO therapy is the standard of care in the primary treatment of acute carbon monoxide poisoning, arterial gas embolism, and decompression sickness. Other conditions when HBO may be used as an adjunct to standard care include: acute cyanide poisoning, traumatic or acute peripheral wounds, compromised skin grafts and flaps, necrotizing infections, osteoradionecrosis of the mandible, and osteomyelitis that is refractory to aggressive medical and surgical management. HBO has also been used when clostridial myonecrosis (i.e., gas gangrene) is present in diabetic foot wounds and in deep diabetic ulcers that are unresponsive to aggressive wound care, glucose management and surgical debridement. The addition of HBO has evolved into accepted practice in patients with Wagner III or higher diabetic wounds/ulcers refractory to standard wound care.

There is insufficient evidence in the published, peer-reviewed scientific literature to support the use of HBO for the destruction of disease-causing micro-organisms, actinomycosis, as a cure for cancer, in vitro fertilization, organ transplantation or organ storage, alleviation of chronic fatigue syndrome, or decrease in allergy symptoms. In addition, studies have not proven the efficacy of this therapy for arthritis, autism, stroke, senility, cirrhosis or gastrointestinal ulcers, ulcers due to chronic venous insufficiency (CVI), or fractures.

According to the Alberta Heritage Foundation for Medical Research (AHFMR), studies have not been conducted to prove that HBOT is effective in treating the following conditions, nor is HBOT recommended for these conditions by the Undersea and Hyperbaric Medical Society (UHMS): acute myocardial ischemia; deep fungal infections; Crohn's disease; multiple sclerosis; spinal cord injury; glaucoma; HIV fatigue; optic neuropathy; intracerebral hemorrhage; various cancers; headaches; and tinnitus (AHFMR, 2003).

Coding/Billing Information

Note: This list of codes may not be all-inclusive.

When medically necessary:

CPT®* Codes	Description
99183	Physician attendance and supervision of hyperbaric oxygen therapy, per session

HCPCS Codes	Description
C1300	Hyperbaric oxygen under pressure, full body chamber, per 30 minute interval

ICD-9-CM Diagnosis Codes	Description
040.0	Gas gangrene
250.7.0- 250.73	Diabetes with peripheral circulatory disorders
446.0	Polyarteritis nodosa. Disseminated necrotizing periarteritis, Necrotizing angiitis, Panarteritis (nodosa), Periarteritis (nodosa)
526.89	Osteoradionecrosis of the jaw(s)
558.1	Gastroenteritis and colitis due to radiation
595.82	Irradiation cystitis
595.9	Unspecified cystitis
686.09	Other pyoderma
728.86	Necrotizing fasciitis
730.00- 730.29	Unspecified osteomyelitis
785.4	Gangrene
906.4	Late effect of crushing
927.00- 927.09	Crushing injury of shoulder and upper arm
927.10- 927.11	Crushing injury of elbow and forearm
927.20- 927.10	Crushing injury of wrist and hand(s), except finger(s) alone
927.3	Crushing injury of finger(s)
927.8	Crushing injury of multiple sites of upper limb
927.9	Crushing injury of unspecified site of upper limb
928.00- 928.01	Crushing injury of hip and thigh
928.10- 928.01	Crushing injury of knee and lower leg
928.20- 928.21	Crushing injury of ankle and foot, excluding toe(s) alone
928.3	Crushing injury of toe(s)
928.8	Crushing injury of multiple sites of lower limb
928.9	Crushing injury of unspecified site of lower limb
929.0-929.0	Crushing injury of multiple and unspecified sites
986	Toxic effect of carbon monoxide
987.7	Toxic effect of hydrocyanic acid gas
989.0	Toxic effect of hydrocyanic acid and cyanides
993.3	Caisson disease, bends, compressed-air disease, decompression sickness, diver's palsy or paralysis
996.52	Skin graft failure or rejection
	Multiple varied

Experimental/Investigational/Unproven/Not medically necessary:

ICD-9-CM Diagnosis Codes	Description
038.0	Streptococcal septicemia
038.10- 038.19	Staphylococcal septicemia
038.2	Pneumococcal septicemia
038.3	Septicemia due to anaerobes
038.40- 038.49	Septicemia due to other gram negative organisms
038.8	Other specified septicemia
038.9	Unspecified septicemia
039.9	Actinomycotic infection of unspecified site
042	Human immunodeficiency virus [HIV]
088.81	Lyme disease
117.9	Other and unspecified mycoses
282.60- 282.69	Sickle-cell disease
294.8	Other persistent mental disorders due to conditions classified elsewhere
340	Multiple sclerosis
343.0-343.9	Cerebral palsy
345.00- 345.91	Epilepsy
346.20- 346.21	Variants of migraine
346.90- 346.91	Unspecified migraine
348.5	Cerebral edema
362.30- 362.34	Retinal vascular occlusion
365.00- 365.9	Glaucoma
380.14	Malignant otitis externa
388.30- 388.32	Tinnitus
410.90- 410.92	Acute myocardial infarction, unspecified site
411.1	Intermediate coronary syndrome
434.91	Unspecified cerebral artery occlusion with cerebral infarction
454.0	Varicose veins of lower extremities with ulcer
455.0	Internal hemorrhoids without mention of complication
455.1	Internal thrombosed hemorrhoids
455.2	Internal hemorrhoids with other complication
555.0- 555.9	Regional enteritis
565.0	Anal fissure
569.49	Other specified disorder of rectum and anus
659.30- 659.33	Generalized infection during labor
707.00- 707.09	Decubitus ulcer
714.0	Rheumatoid arthritis
733.82	Nonunion of fracture
780.71	Chronic fatigue syndrome
780.79	Other malaise and fatigue
784.0	Headache

854.00-854.09	Intracranial injury of other and unspecified nature without mention of open intracranial wound
952.00-952.9	Spinal cord injury without evidence of spinal bone injury
982.1	Toxic effect of carbon tetrachloride
987.8	Toxic effect of other specified gases, fumes, or vapors
989.5	Toxic effect of venom
995.91	Systemic inflammatory response syndrome due to infectious process without organ dysfunction
998.59	Other postoperative infection
	Multiple varied

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