



CIGNA MEDICAL COVERAGE POLICY

The following Coverage Policy applies to all plans administered by CIGNA Companies including plans administered by Great-West Healthcare, which is now a part of CIGNA.

**Subject Hyperbaric Oxygen Therapy,
Systemic & Topical**

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Coverage Policy

CIGNA covers systemic hyperbaric oxygen therapy (HBO/HBOT/HOT) in single or multiple chambers as medically necessary first-line treatment for ALL of the following conditions:

- acute carbon monoxide poisoning
- air or gas embolism
- decompression sickness
- exceptional blood loss when transfusion is not an option

CIGNA covers systemic hyperbaric oxygen therapy (HBO/HBOT/HOT) in single or multiple chambers as medically necessary adjunctive treatment for ALL of the following conditions:

- acute cyanide poisoning, after antidote administration has been given
- acute traumatic peripheral ischemia/insufficiency (e.g., crush injuries, compartment syndrome, suturing of severed limbs)
- clostridial myositis and myonecrosis (gas gangrene)
- compromised skin grafts and flaps (i.e., preexisting grafts or flaps that are showing signs of failure or necrosis)
- intracranial abscess
- necrotizing soft tissue infections (e.g., necrotizing fasciitis, Meleney's ulcer)
- osteomyelitis that is unresponsive to conventional medical and surgical interventions
- radiation tissue damage (non-neurologic tissue), delayed (osteoradionecrosis and soft tissue radionecrosis)
- radiation-induced cystitis or hemorrhagic cystitis (i.e., resulting from chemolytic response, graft-versus-host disease [GVHD])
- radiation-induced enterocolitis
- thermal burns, acute, requiring inpatient hospitalization
- Wagner grade III or higher diabetic wounds/ulcers of the lower extremities that have failed standard wound therapy

CIGNA does not cover systemic hyperbaric oxygen therapy in single or multiple chambers for the treatment of ANY of the following conditions, because it is considered experimental, investigational or unproven (this list may not be all-inclusive):

- actinomycosis
- acute cerebral edema
- acute coronary syndrome (ACS)/myocardial ischemia/infarction (MI), cardiogenic shock
- acute or chronic cerebral vascular insufficiency
- acute thermal and chemical pulmonary damage (i.e., smoke inhalation with pulmonary insufficiency)
- anorectal disorders (e.g., chronic anal fissure [CAF], internal hemorrhoids, infectious proctitis)
- autism
- brain injury, closed head injury, traumatic brain injury (TBI), anoxic encephalopathy
- brown recluse spider bites
- cancer
- carbon tetrachloride poisoning
- cerebral palsy
- cerebral radionecrosis
- chronic fatigue syndrome
- chronic peripheral vascular insufficiency
- Crohn's disease
- cutaneous, decubitus/pressure ulcers
- dementia
- epilepsy
- fractures, acute, delayed union or nonunion
- headaches (e.g., cluster, migraine)
- hepatic necrosis
- human immunodeficiency virus (HIV)–fatigue
- idiopathic sudden sensorineural hearing loss (ISSHL)
- in vitro fertilization
- Lyme disease
- lymphedema
- malignant otitis externa (e.g., necrotizing external otitis)
- multiple sclerosis

- mycoses
- nonvascular causes of chronic brain syndrome (e.g., Pick's disease, Alzheimer's disease, Korsakoff's disease)
- ophthalmologic conditions (e.g., optic neuropathy, glaucoma, retinal artery occlusion)
- organ storage
- organ transplantation
- pulmonary emphysema
- rheumatoid arthritis
- sepsis
- sickle cell disease
- soft tissue injury (e.g., delayed onset muscle soreness, sprains, strains)
- spinal cord injury
- stroke
- tetanus
- tinnitus
- venous stasis ulcers

CIGNA does not cover topical hyperbaric oxygen (THBO) because it is considered experimental, investigational or unproven.

General Background

Systemic hyperbaric oxygen therapy (HBO/HBOT/HOT) involves the inhalation of 100% oxygen under increased atmospheric pressure. Patients are placed in a hyperbaric chamber in which pressure typically ranges from 1.4 to 2.8 atmospheres absolutes (ATA). 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 the patient's tissues by means of pressurization. Oxygen diffusion levels during systemic HBO inhalation are at least two times the values obtained during normal breathing. Forcing oxygen into the tissues, organs, brain, and fluid of the body is proposed to stimulate cell growth and regeneration, displace toxins and impurities, and stimulate the immune system. Treatment sessions may last for 30–120 minutes and may be given for up to five times per week. Some conditions may only require one or two treatments (e.g., carbon monoxide with cyanide poisoning) while others may require 10–40 treatments (e.g., osteonecrosis) depending upon the severity of the illness and the clinical response of the patient (i.e., complete response occurs or no improvement is being seen).

Complications from systemic HBO can be minimized if pressures within the chamber remain below three times the normal atmospheric pressure and treatment sessions are limited to two hours or less. Mild problems associated with HBO include claustrophobia in single chambers (i.e., monochamber), fatigue and headaches. 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 respiratory failure can also occur. Pregnant women should not be treated with HBO.

Applying these same principles of increased oxygenation, the use of topical oxygen, or topical hyperbaric oxygen (THBO), has been proposed as an adjunctive therapy for the treatment of open acute and chronic wounds (e.g., on the sacrum or an extremity). A chronic wound is defined as a wound that does not heal in the time expected based upon the patient's age, comorbidity, wound location, wound size and wound etiology. Chronic wounds generally do not respond to aggressive clinical management, including dietary therapy, wound care measures and surgical intervention.

With topical oxygen, an airtight chamber or polyethylene bag (e.g., sleeves, boots and pouches) is sealed around a limb by a constriction/tourniquet device or on a part of the body with tape. High flow oxygen (usually 10 liters per minute) is introduced into the bag over the wound. The amount of pressure must be limited to prevent damage from decreased arterial and capillary inflow. These portable units can be used in a physician's office, clinic, or be self-administered in the home setting. Therapy is usually administered 90 minutes per day for four consecutive days, with a three-day break. In total therapy may last for up to 10 weeks. The evidence in the peer-reviewed scientific literature does not support the safety and efficacy of THBO.

U.S. Food and Drug Administration (FDA): Topical hyperbaric oxygen systems are a Class III device approved by the FDA 510(k) process. These devices are indicated for the treatment of open acute or chronic wounds such as decubitus ulcers, amputation/infected stumps, skin grafts, gangrenous lesions, burns, frostbite, and skin ulcerations due to diabetes, venous stasis, and post-surgical infections. Examples of topical systems include the Hyper-Box Topical Wound Oxygen System (Qualtech House, Gateway, Ireland) and the WHS-1000 Wound Treatment System (i.e., Misty™) (IYIA Technologies, Inc., San Marcos, CA) (FDA 2008b, FDA, 2005).

Literature Review – Systemic Hyperbaric Oxygen

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, air or gas embolism, decompression sickness, and exceptional blood loss when transfusion is not an option. Through the forced exchange of oxygen at the plasma levels, tissue function can be sustained (Undersea & Hyperbaric Medical Society [UHMS], 2007; American College of Hyperbaric Medicine [ACHM], 2005; Harwood-Nuss, 2001).

HBO as Adjunctive Therapy: HBO has been shown to be effective as an adjunctive therapy in the treatment of acute cyanide poisoning, acute traumatic peripheral ischemia/insufficiency (e.g., crush injuries, compartment syndrome, suturing of severed limbs), compromised skin grafts and flaps, intracranial abscess, necrotizing soft tissue infections such as necrotizing fasciitis or Meleney's ulcer, non-neurologic radiation tissue damage (e.g., osteoradionecrosis and soft tissue radionecrosis), acute thermal burns requiring hospitalization, and osteomyelitis that is refractory to aggressive medical and surgical management (National Cancer Institute [NCI], 2008; American Cancer Society [ACS], 2007; ACHM, 2005; UHMS, 2003).

There is support in the scientific literature indicating that HBO may be added as an adjunctive therapy for the treatment of clostridal myositis and myonecrosis (i.e., gas gangrene) (Gibbons, 2001; Neumeister, 2005; Agency of Healthcare Research and Quality [AHRQ] evidence reports, 2003; UHMS, 2003; ACHM, 2005).

Studies also support the use of HBO as an adjunctive therapy in the treatment of radiation-induced cystitis or hemorrhagic cystitis resulting from chemolytic response or graft-versus-host disease, for radiation induced enterocolitis, and radiation-induced enterocolitis (Fink, 2006; Chong, 2005; Fine, 2005; Bennett, 2005; El-Zimaity, 2004; Lazzarini, 2004; Hailey, 2003; Lawson, 2003; Wang, 2003; Kalayoglu-Besisik, 2003; Cesaro, 2003).

HBO is also a recognized adjunctive therapy for the treatment of diabetic wounds/ulcers of the lower extremity 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], 2006).

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

Although evidence supporting HBO for the treatment of diabetic wounds/ulcers of the lower extremity is 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 (Kranke, et al., 2005; Roeckl-Wiedmann, et al., 2005).

A 2009 update on the indications for HBO by the Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS) (Quebec) concluded that the recommendations for the indication for HBO as previously published remain "basically unchanged" and the evidence still does not support the effectiveness of HBO for all other conditions. The role of HBA remains experimental treatment for cerebral palsy and autism.

Literature Review - Other Proposed Indications for Systemic 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 (this list may not be all inclusive).

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 (Okulicz and Polenakovic, 2009; Sherwood, et al., 2001).

Acute 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; hypoosmolality; 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, 2005).

Acute Coronary Syndrome (ACS)/Myocardial Ischemia/Infarction (MI), Cardiogenic Shock: 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 a randomized controlled trial 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.

A Cochrane systematic review was conducted by Bennett et al. (2007) of four studies that reviewed the effect of using HBO as an adjunct to standard ACS and cardiogenic shock 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 ACS or cardiogenic shock. 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 or Chronic Cerebral Vascular Insufficiency: Cerebral vascular insufficiency is defined as insufficient blood flow to the brain that can lead to a stroke or transient ischemic attack (TIA). It is most often caused by a blockage of the vessels supplying blood to the brain. Standard treatment depends on the severity of the blockage and can include anticoagulant medications, carotid angioplasty and stenting, surgery to remove the occlusion, or bypass surgery. Although HBO has been proposed as a treatment option for cerebral vascular insufficiency, there is insufficient evidence in the peer-reviewed scientific literature to support its use for this indication.

Acute Thermal and Chemical Pulmonary Damage: The use of HBO for the treatment of acute thermal and chemical pulmonary damage in the absence of acute carbon monoxide poisoning is not supported in the current peer-reviewed literature.

Anorectal Disorders: HBO has been proposed as an option in the treatment of anorectal disorders (e.g., chronic anal fissure, internal hemorrhoids, infectious proctitis). 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 (National Institute of Diabetes and Digestive and Kidney Disease [NIDDK], 2004; Tobin, 2001).

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).

Autism: Autism is the most common condition in the group of developmental disorders known as autism spectrum disorders (ASD). HBO has been proposed as a potential treatment modality for improving cognitive function by increasing tissue oxygenation and improving cerebral blood flow.

In a case series of six children diagnosed with autism, Rossignol and Rossignol (2006) reported that after 40, one-hour sessions of low pressure HBO improvements were noted in the Autism Treatment Evaluation checklist (ATEC) (average overall improvement 22.1%; $p=0.0538$), the Childhood Autism Rating Scale (CARS) (average overall improvement 12.1%; $p=0.0178$), and in the Social Responsiveness Scale (SRS) (average overall improvement 22.1%; $p=0.0518$). More dramatic improvements were noted in children age four and under when compared to those in the older group.

In 2007, Rossignol et al. conducted an open-label pilot study to measure changes in markers of oxidative stress and inflammation and to evaluate the clinical effects and safety of HBO for the treatment of autism. Eighteen children, ages ranging from three to 16 years, with the diagnosis of autism were enrolled in the study. Six were non-randomly assigned to 1.5 atm and 100% oxygen; the remaining 12 were non-randomly assigned to 1.3 atm and 24% oxygen. Both groups underwent 40 treatments of 45 minute duration. After completion of the 40 sessions, neither group demonstrated statistically significant changes in mean GSSG levels ($p=0.583$). CRP profiles declined by 89.5% in the 1.3 atm group ($p=0.123$) and by 61.4% in the 1.5 atm group ($p=0.084$). When all children were pooled, a decline of 88.4% in CRP was noted ($p=0.021$). Statistically significant outcomes were noted in the clinical outcomes of motivation, speech, and cognitive awareness ($p<0.05$). No adverse events were noted.

The AETMIS reviewed the published scientific data and current studies to determine the therapeutic potential of HBO for the treatment of autism. The review included three case series, one randomized controlled trial and five unpublished studies. The studies were limited by small patient populations ($n=10-60$) and variations in the oxygen and pressure parameters. Although the studies seemed to indicate a reduction in autism symptoms, AETMIS concluded that "there is insufficient evidence to build a strong case for the efficacy of hyperbaric oxygen therapy in the management of autistic disorders".

At this time, conclusions cannot be drawn regarding the efficacy of HBO as an adjunctive treatment for autism. Well-designed, randomized, controlled trials are needed before any statement regarding the efficacy of HBO for autism can be made (Rossignol, et al., 2007).

Brain Injury, Closed Head Injury, Traumatic Brain Injury (TBI), Anoxic Encephalopathy: Data from the National Institute of Neurologic Disorders and Stroke (NINDS, 2008) 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. In a Cochrane review, Bennett et al. (2004) reported on the findings of four trials that evaluated the benefits and harms of adjunctive HBO for treating patients with TBI. The authors concluded that the combined results of the four eligible studies, involving 382 patients, suggested that HBO may reduce the risk of death but there was no evidence of improved outcomes or quality of life. Due to the limited number of trials and participants, the authors stated it was impossible to be confident in the findings. The available evidence on adjunctive HBO treatment for severe traumatic brain injury is limited, and patient outcomes after HBO therapy are uncertain (AHRQ, 2003; Rowland, 2005).

An ECRI emerging technology report regarding the use of HBO for traumatic brain injury included three randomized controlled trials ($n=281$). Following a review of the studies, ECRI stated that the strength of the evidence was weak due to "study size, variations in treatment delivery, and omission of some important outcome measures such as duration of hospitalization or intensive care unit stay, duration of rehabilitation, or quality of life". Outcomes regarding coma status, cognitive function, and survival were inconsistent and not

reported by all three trials. ECRI concluded that the “small numbers of patients studied and the inconsistent outcome measures reported among studies make it impossible to determine the effect of HBOT on key outcomes of cognitive function and survival”. Reported adverse events included two incidents of seizure, two incidents of barotrauma otitis, and 15 incidents of pulmonary symptoms (ECRI, 2006).

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, 2008). 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 (2007), “Available scientific evidence does not support claims that HBOT stops the growth of cancer cells”.

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).

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. HBO has been proposed as a treatment for CP.

Cooley et al. (2004), in a clinical report for the American Academy of Pediatrics (AAP) on providing a primary care medical home for children and youth with CP, stated that the use of HBO “has far more cost and risk in the face of no evidence of improvement in function”. In 2007, McDonagh and colleagues conducted a systematic review of the evidence on the benefits and adverse effects of HBO treatment for CP. Two randomized controlled trials (RCTs) and four observational studies were included. According to the data, the improvements in motor function when compared to baseline for both HBO and room air were not significantly different. Adverse events included seizures and ear pressure equalization tube placement. The evidence to support the use of HBO therapy for CP is insufficient at this time.

Following a review of the clinical trials, AETMIS (2007) concluded that the “efficacy of hyperbaric oxygen therapy for the treatment of cerebral palsy has not been scientifically demonstrated to date, and uncertainty persists”. Its use remains experimental. Their review included randomized controlled trials, observational studies and narrative reviews. Although some studies reported improvements in “motor function, some neuropsychological functions, including memory and attention, language and speech, and functional performance”, collectively, outcomes were inconsistent and controversial. AETMIS states that further research is necessary to establish the efficacy of HBO for the treatment of CP.

Cerebral Radionecrosis: Cerebral radionecrosis is a complication of radiation therapy of intracranial and extracranial tumors. Delayed radionecrosis may appear as an intracranial mass and must be surgically removed. 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.

Chronic Fatigue Syndrome: Chronic fatigue syndrome (CFS) is a disorder of unknown etiology, which may have an infectious basis. It is a state of chronic fatigue, which exists without other explanation, for a year or more. CFS can be accompanied by cognitive difficulties. Because most cases of CFS may be based on a viral infection, no effective therapy exists (Cunha, 2008). The literature regarding the use of HBO for the treatment of

chronic fatigue syndrome is limited. Therefore, it is not possible to make a determination regarding the efficacy of HBO for this indication at this time.

Chronic Peripheral Vascular Insufficiency: Peripheral vascular insufficiency is most commonly a disease of the arteries and is caused by atherosclerosis which results in insufficient tissue perfusion. Standard treatment options included medication, angioplasty, atherectomy, or surgical bypass. HBO has been proposed as a treatment option for peripheral vascular insufficiency. There is currently insufficient evidence in the peer-reviewed literature to support the use of HBO for this indication.

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 (NIDDK, 2006). No controlled reports on the use of HBO therapy in perineal Crohn's disease were found. The available evidence is limited and is considered insufficient to determine the effect of HBO treatment on the health outcomes of patients with severe, refractory perineal Crohn's disease.

Cutaneous, Decubitus, and 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) 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) 2005 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).

The use of hyperbaric oxygen, ultrasound, ultraviolet and low-energy radiation for the treatment of decubitus or pressure ulcers has generally been considered either ineffective or not 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.

In a 2008 Health Care Protocol, the Institute for Clinical Systems Improvement (2008) notes that hyperbaric oxygen is one of several therapies considered as an adjunctive therapy to enhance healing of pressure ulcers but there is insufficient evidence to warrant recommendation of its use for this purpose.

Dementia/ Nonvascular Causes of Chronic Brain Syndrome: 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; Korsakoff's disease; Pick disease and frontotemporal dementia; progressive supranuclear palsy; and hereditary ataxia (Rowland, 2005). 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 Eleventh 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 cerebropathy (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.

Fractures (e.g., Acute, Delayed Union 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. In 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 years. 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. In a randomized, double-blind study of the prophylactic effect of HBO therapy on migraines (n=34), Eftedal and colleagues (2004) reported that no significant prophylactic effect on migraine was seen. The HBO therapy did not reduce the amount of attack-averting drugs used and had no measurable influence on endothelin-1 levels in the blood. The role of HBO as a treatment modality for migraine headaches has not been established at this time.

Bennett et al. (2008) conducted a systematic review and meta-analysis to evaluate the safety and efficacy of HBO and normal pressure oxygen (NBOT) used for the prevention and treatment of migraine and cluster headaches. The review included nine randomized controlled trials (n=201) including five trials that compared HBOT to sham for acute migraines, two that compared HBO to sham therapy for cluster headaches and two that evaluated HBO only for cluster headaches. Pooled data suggested that HBO was effective in relieving migraines compared to sham therapy ($p=0.01$), but provided no evidence that HBO could prevent migraines or reduce nausea, vomiting or medication requirements. One trial reported better outcomes using HBO in the treatment of cluster headaches ($p=0.08$). The authors concluded that additional research was necessary to support the use of HBO over NBOT.

Hepatic Necrosis: Hepatic necrosis is a severe and progressive form of hepatitis associated with hepatocellular death and hepatic failure. Although HBO has been proposed as a treatment option for hepatic necrosis, there is insufficient evidence in the peer-reviewed literature to support the use of HBO for this indication.

Idiopathic Sudden Sensorineural hearing loss (ISSHL): Idiopathic sudden sensorineural hearing loss (ISSHL) is an acute hearing impairment defined as a 30 decibel (dB) or greater hearing loss occurring in at least three contiguous audiometric frequencies over 72 hours or less. Treatments are intended to improve circulation and oxygenation of the inner ear and include vasodilators, plasma expanders, steroids, anticoagulants, diuretics, contrast dye, and antivirals. None have been proven effective in large RCTs. The high rate of spontaneous recovery, as high as 65% in some studies, complicates the ability to determine the effectiveness of any of these treatment modalities (Bennett et al., 2005). Hyperbaric oxygen therapy has been proposed as a treatment option for ISSHL. In a Cochrane review, Bennett et al. (2006) evaluated six trials that assessed the effectiveness of HBO for the treatment of ISSHL and found there is limited evidence, from poor quality studies, to suggest that HBO improves hearing in patients who present within two weeks of hearing loss. The routine use of HBO was not justified by the review of the literature. Conlin and Parnes (2007) conducted a systematic review of randomized controlled trials to identify, evaluate and review treatments of SSHL. A total of 21 trials were identified and one study included the use of HBO (n=34) as an adjunctive treatment to pharmacotherapy. A greater rate of improvement was reported with the use of HBO.

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 were 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 (ILADS) (Cameron et al., 2004) 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. In 2006, clinical practice guidelines for Lyme disease were developed by Wormser et al. and stated that due to lack of biologic plausibility, lack of efficacy, absence of supporting data, or the potential for harm to the patient, hyperbaric oxygen is not recommended for treatment of patients with any manifestation of Lyme disease.

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.

Mycosis: Mycosis is an infection or a disease caused by a fungus. Fungi predominantly grow by budding yeasts (e.g., candidiasis) and/or by hyphae mold (e.g., aspergillosis). Candidiasis can cause superficial infections such as oral thrush, esophagitis or vaginitis. Invasive forms of candidiasis can become blood-borne and disseminate to various tissues or organs causing conditions such as renal, myocardial or brain abscesses. *Cryptococcus neoformans* is an encapsulated yeast that causes meningoencephalitis. Molds such as *aspergillus* cause allergies, sinusitis and pneumonia. *Aspergillus* can invade blood vessels and cause hemorrhage and infarction. Zygomycosis (e.g., mucormycosis, phycomycosis) is an infection caused by “bread mold fungi” and can infect immunosuppressed individuals (e.g., HIV). HBO has been proposed as a treatment option for some forms of invasive mycosis (e.g., zygomycosis), but its efficacy remains unproven (McAdam and Sharpe, 2005).

Nonvascular Causes of Chronic Brain Syndrome (e.g., Pick’s Disease, Alzheimer’s Disease, Korsakoff’s Disease): Chronic Brain Syndrome, also called dementia, is a loss of brain function. Alzheimer’s disease and

Pick's disease are forms of dementia. Alzheimer's is a primary degenerative dementia that typically involves diffuse atrophy of the brain, while Pick's disease is a classical frontotemporal dementia. Korsakoff's is a psychosis that results from a thiamine deficiency and is primarily a memory disorder. Intellectual functioning is not as impaired as that seen in the primary degenerative dementias. The efficacy of HBO for these conditions has not been established (Smith and Seirafi, 2006).

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 subsequently reported mixed results. 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 (Bennett and Heard, 2004).

Ophthalmologic Conditions (e.g., Retinal Artery Occlusion, Optic Neuropathy, Glaucoma): 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).

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).

Pulmonary Emphysema: Emphysema is defined as an abnormal permanent enlargement of air spaces in the distal bronchioles that is associated with chronic bronchitis. Treatment generally includes smoking cessation and pharmacologic interventions (Sharma, 2006). HBO has been proposed as a treatment option for emphysema, however, the evidence in the peer-reviewed literature is insufficient to support its use for this condition at the present time.

Rheumatoid Arthritis: Rheumatoid arthritis (RA) is a chronic systemic inflammatory disease of unknown cause that primarily affects the peripheral joints. Symptoms can include fatigue, malaise, and morning stiffness. Involvement of organs such as the skin, heart, lungs, and eyes can be significant. The joint destruction caused by RA leads to considerable morbidity and mortality. The cause of RA is unknown but there may be some genetic, environmental, hormonal, immunologic, and infectious factors involved. Current treatment consists of pharmacological and non-pharmacological (e.g., physical therapy, occupational therapy, surgery) therapies (Smith, 2008).

Sepsis: Sepsis is a group of disorders that result from infection by bacteria, viruses, fungi, or parasites or the toxic products of these microorganisms. Sepsis ranges from early signs of circulatory compromise, including tachycardia, tachypnea, peripheral vasodilation, and fever (or hypothermia), to full-blown circulatory collapse with multiorgan system failure and death. Treatment consists of stabilization and correction of metabolic, circulatory, and respiratory issues and the initiation of appropriate antimicrobial therapy. Surgical intervention (e.g., draining an abscess, venous access, appendectomy) may also be required (Santhanam and Tolan, 2007).

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. 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 (e.g., Delayed Onset Muscle Soreness, Closed Soft Tissue Injury, Sprains, Strains):

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 et al. (2005), in 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.

In a 2006 emerging technology report, ECRI reviewed ten case series (n=176) which used HBOT for the treatment of acute soft tissue injury and concluded that they could not determine if HBOT “speeds wound healing, shortens hospital length of stay, reduces the incidence of infection or number of severity of complications, improves survival rates, or improves quality of life, but overall, no minor complications or instances of harm were reported”. In two randomized controlled trials addressing efficacy, ECRI was unable to compare the results because of the variations in patients, types of injuries, and outcome criteria. Based on two studies, they concluded that the data suggested that HBOT plus standard therapy may result in “a higher incidence of complete or partial limb salvage than patients treated with standard therapies alone”.

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). In a Cochrane review conducted by Bennett et al. (2005), the authors assessed the effectiveness and safety of adjunctive HBO therapy in the treatment of acute ischemic stroke. Three RCTs (106 patients) were included in the review. The authors determined that there is insufficient evidence to make any determinations regarding the safety and efficacy of HBO therapy for stroke patients at this time.

Tetanus: Tetanus is caused by the bacteria clostridium tetani and is characterized by an acute onset of hypertonia and generalized muscle spasms in the absence of other causes. Treatment is directed at managing symptoms, prevention of respiratory and metabolic complications, neutralizing the circulating toxin to prevent the continued spread, and elimination of the source (Dire, 2008). Although HBO has been proposed as a treatment option for tetanus, there is insufficient evidence in the peer-reviewed literature to support the use of HBO for the treatment of tetanus at this time.

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.

In a study to analyze the effectiveness of HBO treatment on tinnitus, Porubsky et al. (2007) randomized 360 patients suffering from tinnitus into two HBO treatment protocols (2.2 bar vs. 2.5 bar). Twelve patients (3.3%) experienced complete remission of tinnitus, in 122 (33.9%) the intensity lessened, and 44 (12.2%) had a subjectively agreeable change of noise characteristics. No change was found in 157 cases (43.6%) and 25 (6.9%) experienced deterioration. There was no statistically significant difference between groups A and B ($p > 0.05$). Out of 68 patients with a positive expectation of HBO effects, 60.3% stated that the tinnitus had improved whereas only 47.2 and 19%, respectively, out of patients who underwent therapy with an indifferent ($n = 271$) or negative expectation ($n = 21$) reported an improvement. The influence of subjective expectation on the outcome was statistically significant ($p < 0.05$).

Venous Stasis Ulcers: Venous stasis ulcers are the result of chronic venous insufficiency (CVI). 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). The authors found only one trial on venous ulcers which suggested significant wound size reduction at the end of treatment, but not at follow up. The authors concluded that there was no statistically significant difference in the chance of healing following HBO treatment of venous ulcers.

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) also 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.

Literature Review – Topical Hyperbaric Oxygen (THBO)

There is a lack of evidence in the peer-reviewed literature to support the safety and efficacy of THBO for the treatment of acute or chronic wounds. The few available studies are limited by small patient populations, short-term follow-ups and lack of a control or a comparison group. Edsberg et al. (2002) conducted a prospective, uncontrolled study to observe the effects of THBO and THBO with electrical stimulation on the healing of chronic wounds. Eight patients with stage III or stage IV chronic wounds received THBO treatments twice daily, seven days a week. THBO sessions lasted for 90 minutes with 2–3 liters of humidified oxygen delivered at 22 millimeters mercury (mm Hg). Three of these patients also received electrical stimulation, once daily for five days. At the end of four weeks, the average wound size had decreased by $34.4\% \pm 22.9\%$ in five of the eight patients. The initial wound size before treatment ranged from 87.75 centimeters squared (cm^2) to 7.04 cm^2 with an average of $30.1 \text{ cm}^2 \pm 28.5 \text{ cm}^2$. No significant differences in healing were observed between patients receiving THBO and patients receiving THBO with electrical stimulation. Limitations of the study include the small patient population, short-term follow-up, and lack of a control group.

Kalliainen et al. (2003) reported on a case series of 58 wounds in 32 patients who received topical oxygen therapy. The authors noted that no specific inclusion and exclusion criteria were used when considering patients for treatment within the study. THBO was administered at one ATA for 90 minutes for four days; then, after a three-day break, therapy was resumed until healing was noted. Treatments were performed in the hospital, clinic and patient home settings. Of the 58 wounds, 38 (65.5%) healed during treatment with THBO. Four additional wounds healed following surgical flaps or grafts. Wounds reoccurred in two patients, with one patient developing a new venous stasis ulcer one month following THBO. The researchers reported that the acute wound group appeared to have the poorest healing rate, with 69% (9/13) of all wounds healed. During this study, treatments were administered in various settings with the assumption that treatment times and applications were administered properly.

In a prospective, unblinded, and nonrandomized observational study (n=374), Landau et al. (2006) measured the effect of using a combination of topical hyperbaric oxygen and low-energy laser therapy in the treatment of chronic ulcers for which conventional treatment had failed. The study included 218 patients with diabetic foot ulcers (DFU) and 156 patients with chronic venous ulcers (CVU). THBO was administered 2-3 times a week in a facility or at home. Oxygen was delivered for 120 minutes into a disposable polyethylene bag placed over the leg and sealed above the knee with an elastic bandage. Low-energy laser treatments were also administered to all patients for 10 to 20 minutes according to the specific device that was used. Conventional wound therapy was continued during the study. The researchers noted that the length of therapy was similar between the groups (3.7 ± 3 months versus 4.1 ± 3 months in DFU and CVU cohorts, respectively). However, the number of treatments required to affect healing was greater in the CVU patients than in the DFU patients (40 ± 25 versus 31.4 ± 20 treatments). Complete ulcer closure was obtained in 78% of the patients (170 DFU versus 127 CVU); treatment failure was noted in 48 patients (22%) with DFU and 29 (22%) with CVU.

Gordillo et al. (2008) conducted a case study of 57 patients with chronic wounds (i.e., wound was present for at least four weeks). Of these 57 patients, 32 qualified for systemic HBO. The remaining 25 patients, who did not qualify for HBO, consented to receive topical oxygen therapy (TO). The primary outcome measure was wound size and the secondary outcome measure was the result of wound edge biopsies to test for O₂-sensitive gene expression following treatment. The difference between the median initial wound volume for the TO group and the median final wound volume was significant (3.3 cm³ vs. 1.4 cm³, respectively; p=0.001). The gene tests found a higher expression of the vascular endothelial growth factor (VEGF) gene in TO-treated healing wounds (p = 0.031). The authors concluded that based on the results of this study, larger, well designed studies are warranted to determine if TO is effective in treating problem wounds in a clinical setting.

Professional Societies/Organizations

In their 2008 guidelines for the management of thromboembolic disorders, the American College of Chest Physicians states "For patients with venous ulcers, we suggest that hyperbaric oxygen not be used" (Hirsh, et al., 2008).

The American College of Foot and Ankle Surgeons (ACFAS, 2006) acknowledges that systemic hyperbaric oxygen therapy (HBO) has shown promise in the treatment of diabetic foot wounds with hypoxia severe enough to interfere with healing. However, most of the HBO studies have been hampered by methodological errors that prevent defining a role for this modality in the routine treatment of diabetic foot ulcers. The benefit of HBO therapy for this indication has not been proven conclusively in large multicenter randomized clinical trials.

The American College of Hyperbaric Medicine (ACHM, 2005) recognizes the use of systemic HBO for the following conditions:

- air or gas embolism
- acute carbon monoxide intoxication (cyanide poisoning)
- acute peripheral arterial insufficiency
- chronic refractory osteomyelitis
- clostridial myonecrosis (gas gangrene)
- compromised skin grafts / tissue flaps
- crush injuries, compartment syndrome and acute traumatic ischemias
- decompression illness
- diabetic foot ulcer
- necrotizing soft tissue infections
- osteoradionecrosis
- soft tissue radionecrosis

ACHM supports the treatment of patients with non-approved indications only in a research setting using approved protocol. Indications that are supported by the ACHM as appropriate for systemic hyperbaric oxygen therapy in a clinical research setting include:

- acute thermal burns
- acute central retinal artery occlusion
- acute frost bite

- actinomycosis (only as an adjunct to conventional therapy when the disease process is refractory to antibiotics and surgical treatment)
- brown recluse spider bite
- intracranial brain abscess

The Undersea and Hyperbaric Medical Society (UHMS, 2003) has approved systemic HBO for use in the following indications:

- air or gas embolism
- carbon monoxide poisoning
- clostridial myositis and myonecrosis (gas gangrene)
- crush injury, compartment syndrome, and other acute traumatic ischemias
- decompression sickness
- enhancement of healing in select problem wounds
- exceptional blood loss (anemia)
- intracranial abscess
- necrotizing soft tissue infections
- osteomyelitis (refractory)
- delayed radiation injury (soft tissue and bony necrosis)
- skin grafts and flaps (compromised)
- thermal burns

Regarding the use of topical oxygen, UHMS states “Topical oxygen should not be termed hyperbaric oxygen since doing so intentionally or unintentionally suggests that topical oxygen treatment is equivalent or even identical to hyperbaric oxygen. Mechanisms of action or clinical study results for hyperbaric oxygen cannot and should not be co-opted to support topical oxygen since hyperbaric oxygen therapy and topical oxygen have different routes and probably efficiencies of entry into the wound and their physiology and biochemistry are necessarily different. The application of topical oxygen cannot be recommended outside of a clinical trial at this time based on the volume and quality of scientific supporting evidence available, nor does the Society recommend third party payer reimbursement. Before topical oxygen can be recommended, as a therapy for non-healing wounds, its application should be subjected to the same intense scientific scrutiny to which systemic hyperbaric oxygen has been held” (Feldmeier, et al., 2005).

Summary

Evidence in the peer-reviewed literature supports the safety and efficacy of systemic hyperbaric oxygen therapy (HBO or HBOT) as a first-line therapy and as an adjunctive therapy for a carefully selected subgroup of conditions.

There is insufficient evidence in the published, peer-reviewed scientific literature to support the use of systemic HBO for all other conditions. There is a lack of evidence in the peer-reviewed literature to support the safety and efficacy of the use of topical oxygen, or topical hyperbaric oxygen, for the treatment of acute and chronic wounds.

Coding/Billing Information

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

Covered when medically necessary:

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

HCPCS Codes	Description
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C1300	Hyperbaric oxygen under pressure, full body chamber, per 30 minute interval
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ICD-9-CM Diagnosis Codes	Description
040.0	Gas gangrene
250.7.0 - 250.73	Diabetes with peripheral circulatory disorders
324.0	Intracranial abscess
446.0	Polyarteritis nodosa
459.81	Unspecified venous (peripheral) insufficiency
526.89	Other specified diseases of the jaws, other
558.1	Gastroenteritis and colitis due to radiation
595.82	Irradiation cystitis
595.9	Unspecified cystitis
673.00 – 673.04	Obstetrical air embolism
686.09	Other pyoderma
728.86	Necrotizing fasciitis
730.00 - 730.09	Acute osteomyelitis
730.10 - 730.19	Chronic osteomyelitis
730.20 - 730.29	Unspecified osteomyelitis
785.4	Gangrene
906.4	Late effect of crushing
909.2	Late effect of radiation
927.00 - 927.9	Crushing injury of upper limb
928.00 - 928.9	Crushing injury of lower limb
929.0 - 929.9	Crushing injury of multiple and unspecified sites
946.3	Full-thickness skin loss due to burn (third degree NOS) of multiple specified sites
946.4	Deep necrosis of underlying tissues due to burn (deep third degree) of multiple specified sites, without mention of loss of a body part
946.5	Deep necrosis of underlying tissues due to burn (deep third degree) of multiple specified sites, with loss of a body part
958.0	Certain early complications of trauma, air embolism
958.90 – 958.99	Traumatic compartment syndrome
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
996.52	Mechanical complication of other specified prosthetic device, implant and graft, due to graft of other tissue, not elsewhere classified
999.1	Complication of medical care, not elsewhere classified, air embolism
	Multiple/Varied

Experimental/Investigational/Unproven/Not Covered:

HCPCS Codes	Description
A4575	Topical hyperbaric oxygen chamber, disposable

ICD-9-CM Diagnosis Codes	Description
037	Tetanus
038.0 - 038.9	Septicemia
039.9	Actinomycotic infection of unspecified site
042	Human immunodeficiency virus [HIV]
088.81	Lyme disease
117.0 - 117.9	Other mycoses
282.60 - 282.69	Sickle-cell disease
290.0 - 290.9	Dementias
291.1	Alcohol-induced persisting amnesic disorder
294.8	Other persistent mental disorders due to conditions classified elsewhere
299.00	Autistic disorder, current or active state
299.01	Autistic disorder, residual state
331.0	Alzheimer's disease
331.11	Pick's disease
340	Multiple sclerosis
343.0 - 343.9	Cerebral palsy
345.00 - 345.91	Epilepsy
346.00 - 346.91	Migraine
348.5	Cerebral edema
362.30	Unspecified retinal vascular occlusion
362.31	Central artery occlusion of retina
362.32	Arterial branch occlusion of retina
362.33	Partial arterial occlusion of retina
362.34	Transient arterial occlusion of retina
365.00-365.9	Glaucoma
377.34	Toxic optic neuropathy
380.14	Malignant otitis externa
388.30 - 388.32	Tinnitus
389.10 - 389.18	Sensorineural hearing loss
410.00 - 410.92	Acute myocardial infarction
411.1	Intermediate coronary syndrome
434.91	Unspecified cerebral artery occlusion with cerebral infarction
437.1	Other generalized ischemic cerebrovascular disease
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
457.0	Postmastectomy lymphedema syndrome
457.1	Other noninfectious lymphedema
492.8	Other emphysema
555.0 - 555.9	Regional enteritis
565.0	Anal fissure
569.49	Other specified disorder of rectum and anus
570	Acute and subacute necrosis of liver
659.30 - 659.33	Generalized infection during labor
707.00 -	Decubitus ulcer

707.09	
714.0 - 714.9	Rheumatoid arthritis
733.82	Nonunion of fracture
768.7	Hypoxic-ischemic encephalopathy [HIE]
780.71	Chronic fatigue syndrome
780.79	Other malaise and fatigue
784.0	Headache
785.51	Cardiogenic shock
854.00 - 854.09	Intracranial injury of other and unspecified nature without mention of open intracranial wound
947.1	Burn of larynx, trachea, and lung
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 (SIRS), sepsis
995.92	Systemic inflammatory response syndrome (SIRS), severe sepsis
998.59	Other postoperative infection
	Multiple/Varied

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References

1. Adamides AA, Winter CD, Lewis PM, Cooper DJ, Kossman T, Rosenfeld JV. Current controversies in the management of patients with severe traumatic brain injury. ANZ J Surg. 2006 Mar;76(3):163-74.
2. Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS). Indications for Hyperbaric Oxygen Therapy: Update. 2009. Accessed Mar 11, 2009. Available at URL address: <http://www.aetmis.gouv.qc.ca/site/250.1093.0.0.1.0.phtml>
3. Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS). The role of hyperbaric oxygen therapy in the management of autism. Nov 2007. Accessed Mar 11, 2009. Available at URL address: <http://www.aetmis.gouv.qc.ca/site/250.1054.0.0.1.0.phtml>
4. Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS). The role of hyperbaric oxygen therapy in the management of cerebral palsy. Nov 2007. Accessed Mar 11, 2009. Available at URL address: <http://www.aetmis.gouv.qc.ca/site/250.975.0.0.1.0.phtml>
5. Agency for Healthcare Research and Quality (AHRQ). Hyperbaric oxygen therapy for brain injury, cerebral palsy, and stroke. Evidence Report/Technology Assessment: 85. Revised Sept 2003. Accessed Mar 10, 2009. Available at URL address: <http://www.ahrq.gov/downloads/pub/evidence/pdf/hypox/hyperox.pdf>
6. Agency for Healthcare Research and Quality (AHRQ). A horizon scan: uses of hyperbaric oxygen therapy. Oct 5, 2006. Accessed Mar 11, 2009. Available at URL address: <http://www.cms.hhs.gov/mcd/viewtechassess.asp?from2=viewtechassess.asp&where=index&tid=42&>
7. American Cancer Society (ACS). Hyperbaric oxygen therapy. May 2007. Accessed Mar 10, 2008. Available at URL address: http://www.cancer.org/docroot/ETO/content/ETO_5_3x_Hyperbaric_oxygen_therapy.asp?s

8. American College of Foot and Ankle Surgeons (ACFAS). Diabetic foot disorders clinical practice guidelines. Updated Sept/Oct 2006. Accessed Mar 10, 2008. Available at URL address: <http://www.acfas.org/pubresearch/cpg/diabetic-cpg.htm>
9. American College of Hyperbaric Medicine (ACHM) Accepted Indications. Revised 2005. Accessed Mar 10, 2009. Available at URL address: <http://www.achm.org/index.php/Resource-Library/Resource-Library/What-are-the-approved-indications-for-Hyperbaric-Oxygen-Therapy.html>
10. Association for the Advancement of Wound Care (AAWC). Summary algorithm for venous ulcer care with annotations of available evidence. Malvern (PA): Association for the Advancement of Wound Care (AAWC);2005. Accessed Mar 10, 2009. Available at URL address: http://www.guideline.gov/summary/summary.aspx?doc_id=7109&nbr=004280&string=summary+AND+a lgorithm+AND+venous+AND+ulcerhttp://www.guideline.gov
11. Barbul A. (author). Chapter 8: Wound healing. In: Brunicki C, editor. Schwartz's Principles of Surgery. 8th ed. Philadelphia, PA: The McGraw-Hill Companies, Inc.;2005.
12. Bennett MH, Best TM, Babul S, Taunton J, Lepawsky M. Hyperbaric oxygen therapy for delayed onset muscle soreness and closed soft tissue injury. The Cochrane Library, Issue 12, 2005. Chichester, UK: John Wiley & Sons, Ltd.; 2005.
13. Bennett M, Fanzca MM, Kertesz T, Yeung P. Hyperbaric oxygen therapy for idiopathic sudden sensorineural hearing loss and tinnitus. The Cochrane Review. In: The Cochrane Library, Issue 12, 2005. Chichester, UK: John Wiley & Sons, Ltd.;2005.
14. Bennett MH, Feldmeier J, Hampson N, Smee R, Milross C. Hyperbaric oxygen therapy for late radiation tissue therapy. The Cochrane Review. In: The Cochrane Library, Issue 12, 2005. Chichester, UK: John Wiley & Sons, Ltd.;2005.
15. Bennett MH, Feldmeier J, Smee R, Milross C. Hyperbaric oxygenation for tumour sensitization to radiotherapy. The Cochrane Database of Systematic Reviews 2005, Issue 4. Art. No.: CD005007.pub2. DOI: 10.1002/14651858.CD005007.pub2.
16. Bennett MH, French C, Schnabel A, Wasiak J, Kranke P. Normobaric and hyperbaric oxygen therapy for migraine and cluster headache. Cochrane Database Syst Rev. 2008 Jul 16;(3):CD005219.
17. Bennett MH, Heard R. Hyperbaric oxygen therapy for multiple sclerosis. Cochrane Database Syst Rev. In: The Cochrane Library, Vol (1). Chichester, UK: John Wiley & Sons, Ltd.; 2004.
18. Bennett MH, Jepson N, Lehm JP. Hyperbaric oxygen therapy for acute coronary syndrome. The Cochrane Review. In: The Cochrane Library, Vol (12). Chichester, UK: John Wiley & Sons, Ltd.; 2007.
19. Bennett MH, Stanford R, Turner R. Hyperbaric oxygen therapy for promoting fracture healing and treating fracture non-unions. The Cochrane Review. In: The Cochrane Library, Vol (12). Chichester, UK: John Wiley & Sons, Ltd.; 2005.
20. Bennett MH, Trytko B, Jonker B. Hyperbaric oxygen therapy for the adjunctive treatment of traumatic brain injury. The Cochrane Review. In: The Cochrane Library, Vol (12). Chichester, UK: John Wiley & Sons, Ltd.; 2004.
21. Bennett MH, Wasiak J, Schnabel A, Kranke P, French C. Hyperbaric oxygen therapy for acute ischaemic stroke. The Cochrane Review. In: The Cochrane Library, Vol (12). Chichester, UK: John Wiley & Sons, Ltd.; 2005.
22. Cameron D, Gaito A, Harris N, Bach G, Bellovin S, Bock K, et al. Evidence-based guidelines for the management of Lyme disease. Expert Rev Anti Infect Ther. 2004;2(1 Suppl):S1-13.

23. Cesaro S, Brugiolo A, Faraci M, Uderzo C, Rondelli R, Favre C, et al. Incidence and treatment of hemorrhagic cystitis in children given hematopoietic stem cell transplantation: a survey from the Italian association of pediatric hematology oncology-bone marrow transplantation group. *Bone Marrow Transplant.* 2003;32:925-31.
24. Chong KT, Hampson NB, Corman JM. Early hyperbaric oxygen therapy improves outcome for radiation-induced hemorrhagic cystitis. *Urology.* 2005;65:649-53.
25. Conlin AE, Parnes LS. Treatment of sudden sensorineural hearing loss: I. A systematic review. *Arch Otolaryngol Head Neck Surg.* 2007 Jun;133(6):573-81.
26. Cooley WC, American Academy of Pediatrics Committee on Children with Disabilities. Providing a primary care medical home for children and youth with cerebral palsy. *Pediatrics.* 2004 Oct;114(4):1106-13.
27. Cunha BA. Chronic Fatigue Syndrome. Jul 2008. Accessed Mar 10, 2009. Available at URL address: <http://www.emedicine.com/med/TOPIC3392.HTM#section~treatment>
28. Dekleva M, Neskovic A, Vlahovic A, Putnikovic B, Beleslin B, Ostojic M. Adjunctive effect of hyperbaric oxygen treatment after thrombolysis on left ventricular function in patients with acute myocardial infarction. *AHJ.* 2004 Oct;148(4).
29. Dire DJ. Tetanus. *EMedicine.* Jul 25, 2008. Accessed Mar 10, 2009. Available at URL address: <http://www.emedicine.com/emerg/TOPIC574.HTM>
30. ECRI Institute. Health Technology Forecast [database online]. Plymouth Meeting (PA): ECRI; Aug 15, 2006. Hyperbaric oxygen therapy (HBOT) for acute soft tissue injury. Accessed Mar 11, 2009.. Available at URL address: <http://www.ecri.org>.
31. ECRI Institute. Health Technology Forecast [database online]. Plymouth Meeting (PA): ECRI; Sep 11, 2006. Hyperbaric oxygen therapy (HBOT) for traumatic brain injury (TBI). Accessed Mar 11, 2009.. Available at URL address: <http://www.ecri.org>.
32. Edsberg LE, Brogan MS, Jaynes CD and Fries K. Topical hyperbaric oxygen and electrical stimulation: exploring potential synergy. *Ostomy/Wound Management.* 2002;48(11):42-50.
33. Eftedal OS, Lydersen S, Helde G, White L, Brubakk AO, Stovner LJ. A randomized, double blind study of the prophylactic effect of hyperbaric oxygen therapy on migraine. *Cephalalgia.* 2004 Aug;24(8):639-44
34. Eisendrath SJ, Lichtmacher JE.(authors). Chapter 25: Psychiatric Disorders. In: Tierney LM, McPhee SJ, Papadakis MA (editors). 2005 *CURRENT Medical Diagnosis & Treatment.* Philadelphia, PA: McGraw-Hill Companies, Inc.; 2005.
35. Eleventh International Congress on Hyperbaric Medicine. Epilepsy. Chapter 9 of the HBOT Manual. Accessed Mar 10, 2009. Available at URL address: <http://miraclemountain.homestead.com/Epilepsy.html>
36. El-Zimaity M, Saliba R, Chan K, Shahjahan M, Carrasco A, Khorshid O, et al. Hemorrhagic cystitis after allogeneic hematopoietic stem cell transplantation: donor type matters. *Blood.* 2004 Jun;103(12):4674-80.
37. Feldmeier JJ, Hopf HW, Warriner RA 3rd, Fife CE, Gesell LB, Bennett M. UHMS position statement: topical oxygen for chronic wounds. 2005;32(3):157-68. Accessed Mar 11, 2009. Available at URL address: <http://www.uhms.org/UHMJournal/Vol32/tabid/258/Default.aspx>

38. Fine HA, Barker II FG, Markert JM, Loeffler JS. (authors). Chapter 39: Neoplasms of the central nervous system. In: DeVita, CANCER Principles & Practice of Oncology. Philadelphia, PA: Lippincott Williams & Wilkins; 2005.
39. Fink D, Chetty N, Lehm JP, Marsden DE, Hacker NF. Hyperbaric oxygen therapy for delayed radiation injuries in gynecological cancers. *Int J Gynecol Cancer*. 2006;16:638-42.
40. Gibbons GW. Chapter 154: The Diabetic Foot. In: Becker, KL. Principles and Practice of Endocrinology and Metabolism. 3rd edition. Philadelphia: PA: Lippincott, Williams & Williams, 2001.
41. Gifford DR, McNicoll L. Decubitus Ulcers. In: Ferri's Clinical Advisor 2007: Instant Diagnosis and Treatment, 9th ed. St. Louis, MO. Mosby; 2007.
42. Gordillo GM, Roy S, Khanna S, Schlanger R, Khandelwal S, Phillips G, et al. Topical oxygen therapy induces vascular endothelial growth factor expression and improves closure of clinically presented chronic wounds. *Clin Exp Pharmacol Physiol*. 2008 Apr 21.
43. Hailey D. Hyperbaric oxygen therapy: recent findings on evidence for its effectiveness. Alberta Heritage Foundation for Medical Research (AHFMR). IP 13: Information paper. 2003 Mar.
44. Harwood-Nuss AL, editor. Smoke inhalation. The five-minute emergency medicine. The clinical practice of emergency medicine. 3rd ed. Philadelphia, PA: Lippincott, Williams & Wilkins; 2001.
45. Hattori K, Yabe M, Matsumoto M, Kudo Y, Yasuda Y, Inoue H, et al. Successful hyperbaric oxygen treatment of life-threatening hemorrhagic cystitis after allogeneic bone marrow transplantation. *Bone Marrow Transplant*. 2001;27:3715-7.
46. Hirsh J, Guyatt G, Albers GW, Harrington R, Schünemann HJ, American College of Chest Physician. Antithrombotic and thrombolytic therapy: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition). *Chest*. 2008 Jun;133(6 Suppl):110S-112S. Erratum in: *Chest*. 2008 Aug;134(2):473.
47. Institute for Clinical Systems Improvement. Health care protocol: pressure ulcer treatment. First edition. Jan 2008. Accessed Mar 11, 2009. Available at URL address:
http://www.icsi.org/guidelines_and_more/protocols_/patient_safety___reliability_protocols/pressure_ulcer_treatment_protocol___review_and_comment_/pressure_ulcer_treatment___protocol_.html
48. Juang J-H, Hsu BR-S, Kuo C-H, Ueng SW-N. Beneficial effects of hyperbaric oxygen therapy on Islet Transplantation. *Cell Transplantation*. 2002;11:95-101.
49. Kalayoglu-Besisik A, Abdul-Rahman IS, Erer B, Yenerel MN, Oguz FS, Tunc M, et al. Outcome after hyperbaric oxygen treatment for cyclophosphamide-induced refractory hemorrhagic cystitis. *J Urol*. 2003 Sep;170:922.
50. Kranke P, Bennett M, Roeckl-Wiedmann I, Debus S. Hyperbaric oxygen therapy for chronic wounds. *The Cochrane Database Syst Rev*. 2005;(12):CD004123. Update in: *Cochrane Database Syst Rev*. 2005;(12).
51. Lawson R. Hyperbaric oxygen therapy for osteomyelitis. *STEER*. 2003 Aug;3(18). Accessed Mar 10, 2009. Available at URL address:
[http://www.wihrd.soton.ac.uk/projx/signpost/steers/STEER_2003\(18\).pdf](http://www.wihrd.soton.ac.uk/projx/signpost/steers/STEER_2003(18).pdf)
52. Lazzarini L, Mader JT, Calhoun JH. Current concepts review: Osteomyelitis in long bones. *JBJS*. 2004;86(10):2305-18.
53. Lodewijk W, van Eps A, de Jong PE. (authors). Chapter 77: Sickle Cell Disease. In: Freedberg E, Wolff A, Goldsmith K. (editors). Schrier: Diseases of the Kidney and Urinary Tract. Philadelphia, PA: Lippincott Williams & Williams; 2007.

54. McAdam AJ, Sharpe, AH. Ch 8: infectious disease. Fungal infections. In: Kumar: Robbins and Cotran: Pathologic Basis of Disease, 7th ed.. St. Louis, MO: W. B. Saunders, 2005.
55. McDonagh MS, Morgan D, Carson S, Russman BS. Systematic review of hyperbaric oxygen therapy for cerebral palsy: the state of the evidence. *Dev Med Child Neurol*. 2007 Dec;49(12):942-7.
56. Mitrovic A, Brkic P, Nikolic B, Dragojevic S, Zaric O, Ljubic A, Jovanovic T. Hyperbaric oxygen and in vitro fertilization. *Aust N Z J Obstet Gynaecol*. 2006 Oct;46(5):456-7.
57. National Cancer Institute. Oral Complications of chemotherapy and Head/Neck Radiation. Nov 5, 2008. Accessed Mar 10, 2009. Available at URL address:
http://www.cancer.gov/cancertopics/pdq/supportivecare/oralcomplications/HealthProfessional/Page12#Section_324
58. National Collaborating Center for Primary Care. Clinical guidelines for type 2 diabetes. Prevention and management of foot problems. London (UK): National Institute for Clinical Excellence (NICE); 2004 Jun. Accessed Mar 10, 2009. Available at URL address:
http://www.guideline.gov/summary/summary.aspx?doc_id=5062&nbr=003546&string=clinical+AND+guidelines+AND+type+AND+diabetes
59. National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). Crohn's Disease. Feb 2006 Accessed Mar 10, 2009. Available at URL address:
<http://digestive.niddk.nih.gov/ddiseases/pubs/crohns/index.htm#treat>
60. National Institute of Mental Health (NIMH). Autism Spectrum Disorders (Pervasive Developmental Disorders). 2009. Accessed Mar 10, 2009. Available at URL address:
<http://www.nimh.nih.gov/health/topics/autism-spectrum-disorders-pervasive-developmental-disorders/index.shtml>
61. National Institute of Neurological Disorders and Stroke (NINDS). Traumatic Brain Injury. Updated Dec 2008. Accessed Mar 10, 2009. Available at URL address:
http://www.ninds.nih.gov/disorders/tbi/detail_tbi.htm
62. National Pressure Ulcer Advisory Panel (NPUAP). NPUAP Staging Report. Updated Jan 2007. Accessed Mar 10, 2009. Available at URL address: <http://www.npuap.org/archive/positn2.htm>
63. Neumeister M, Cram A, Talavera F, Newsome RE, Slenkovich N, Downey SE. Hyperbaric oxygen therapy. Updated Jul 2005. Accessed Mar 10, 2009. Available at URL address:
<http://www.emedicine.com/plastic/topic526.htm>
64. Nilsson Renahl AI, Ansjon R, Lind F, Waldenlind E. Hyperbaric oxygen treatment of active cluster headache: a double-blind placebo-controlled cross-over study. *Cephalalgia*. 2002 Nov;22(9):730-9.
65. Norris RL. Spider bites and scorpion stings. In: Rakel: Conn's Current Therapy. 58th ed. Philadelphia, PA: WB Saunders; 2006.
66. Patterson J. Hyperbaric oxygen therapy for central retinal artery occlusion. *STEER*. 2002 Jun;2(15). Accessed Mar 10, 2009. Available at URL address:
[http://www.wihrd.soton.ac.uk/projx/signpost/steers/STEER_2002\(15\).pdf](http://www.wihrd.soton.ac.uk/projx/signpost/steers/STEER_2002(15).pdf)
67. Patterson J. Hyperbaric oxygen therapy for osteoradionecrosis. *STEER*. 2002 Jun;2(16). Accessed Mar 10, 2009. Available at URL address:
[http://www.wihrd.soton.ac.uk/projx/signpost/steers/STEER_2002\(16\).pdf](http://www.wihrd.soton.ac.uk/projx/signpost/steers/STEER_2002(16).pdf)
68. Phillips JS, Jones SEM. Hyperbaric oxygen as an adjuvant treatment for malignant otitis externa. The Cochrane Review. In: The Cochrane Library, Issue 12, 2005. Chichester, UK: John Wiley & sons, Ltd.; 2005.

69. Porubsky C, Stiegler P, Matzi V, Lipp C, Kontaxis A, Klemen H, Walch C, Smolle-Juttner F. Hyperbaric oxygen in tinnitus: influence of psychological factors on treatment results? *ORL J Otorhinolaryngol Relat Spec.* 2007;69(2):107-12.
70. Rao SSC. Practice Guidelines: Diagnosis and management of fecal incontinence. *Am J Gastro.*2004: 1585-1604.
71. Roeckl-Wiedmann I, Bennett M, Kranke P. Systematic review of hyperbaric oxygen in the management of chronic wounds. *Br J Surg.* 2005 Jan;92(1):24-32.
72. Rossignol DA, Rossignol LW. Hyperbaric oxygen therapy may improve symptoms in autistic children. *Med Hypotheses.* 2006;67(2):216-28.
73. Rossignol DA, Rossignol LW, James SJ, Melnyk S, Mumper E. The effects of hyperbaric oxygen therapy on oxidative stress, inflammation, and symptoms in children with autism: an open-label pilot study. *BMC Pediatr.* 2007 Nov 16;7:36.
74. Rowland LP, editor. *Merritt's neurology.* 11th ed. Philadelphia, PA: Lippincott, Williams & Wilkins; 2005.
75. Santhanam S, Tolan Jr. RW. Sepsis. Dec 2007. Accessed Mar 10, 2009. Available at URL address: <http://www.emedicine.com/ped/TOPIC3033.HTM#section~Treatment>
76. Schwartz DA, Herdman CR. Review article: the medical treatment of Crohn's perianal fistulas. *Aliment Pharmacol Ther.* 2004;19:953-67.
77. Sharma S. Emphysema. *EMedicine.* Jun 14, 2006. Accessed Mar 10, 2009. Available at URL address: <http://www.emedicine.com/med/TOPIC654.HTM>
78. Sherwood, Gorbach M, Falagas M. *The 5-Minute Infectious Disease Consult.* Philadelphia, PA: Lippincott, Williams & Wilkins; 2001.
79. Smith HR. Rheumatoid Arthritis. Nov 2008. Accessed Mar 10, 2009. Available at URL address: <http://www.emedicine.com/med/TOPIC2024.HTM#section~Treatment>
80. Smith J, Seirafi J. Ch 102 – Delirium and dementia. Dementia. In: Marx: *Rosen's Emergency Medicine: Concepts and Clinical Practice*, 6th ed. St. Louis, MO. Elsevier; 2006.
81. Stibich AS, Schwartz RA, Voorhees AV, Butler DF, Miller J, Gelfand JM, Elston DM. Brown Recluse Spider Bite. Revised Aug 8, 2008. Accessed Mar 10, 2009. Available at URL address: <http://www.emedicine.com/derm/topic598.htm>
82. Teas J, Cunningham JE, Cone L, Jansen K, Raghavan SK, Nitcheva DK, et al. Can hyperbaric oxygen therapy reduce breast cancer treatment-related lymphedema? A pilot study. *J Women's Health.* 2004;13(9):1008-18.
83. Tobin RW, Kimmey MB. (authors). Chapter 66: Painful Diseases of the Gastrointestinal Tract. In: Loeser JD. (editor) *Bonica's Management of Pain.* Philadelphia, PA: Lippincott Williams & Wilkins; 2001.
84. Undersea Hyperbaric Medicine Society (UHMS). Indications for hyperbaric oxygen therapy. 2007. Accessed Mar 10, 2009. Available at URL address: <http://www.uhms.org/Default.aspx?tabid=270>
85. United States Food and Drug Administration (FDA). 510(k) summary. HyperOx 1 01, a Multiplace Hyperbaric Oxygen Treatment Chamber. Mar 15, 2006. Accessed Mar 10, 2009. Available at URL address: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm?ID=20278>

86. United States Food and Drug Administration (FDA). 510(k) summary. Monoplace Hyperbaric Chamber. Jul 25, 2008a. Accessed Mar 10, 2009. Available at URL address: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm?ID=27952>
87. United States Food and Drug Administration (FDA). 510(k) summary. Hyper-Box Topical Wound Oxygen System. Aug 6, 2008b. Accessed Mar 10, 2009. Available at URL address: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm?ID=27537>
88. United States Food and Drug Administration (FDA). 510(k) summary. WHS-1000 Wound Treatment System. Jun 17, 2005. Accessed Mar 10, 2009. Available at URL address: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm?ID=17379>
89. Van Voorhis BJ, Greensmith JE, Dokras A, Sparks AET, Simmons ST, Syrop CH. Hyperbaric oxygen and ovarian follicular stimulation for in vitro fertilization: a pilot study. Fertil Steril.2005;83:226-8.
90. Wang C, Schwaitzberg S, Berliner E, Zarin DA, Lau J. Hyperbaric oxygen for treating wounds. Arch Surg. 2003;138:272-9.
91. Wasserman GS. Chapter 348: Brown Recluse Spider Envenomation. In: Harwood-Nuss' Clinical Practice of Emergency Medicine. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2005.
92. Wormser GP, Dattwyler RJ, Shapiro ED, Halperin JJ, Steere AC, Klempner MS, Krause PJ, Bakken JS, Strle F, Stanek G, Bockenstedt L, Fish D, Dumler JS, Nadelman RB. The clinical assessment, treatment, and prevention of lyme disease, human granulocytic anaplasmosis, and babesiosis: clinical practice guidelines by the Infectious Diseases Society of America. Clin Infect Dis 2006 Nov 1;43(9):1089-134.
93. Wound, Ostomy, and Continence Nurses Society (WOCN). Guideline for management of wounds in patients with lower-extremity venous disease. Glenview (IL): Wound, Ostomy, and Continence Nurses Society (WOCN); 2005. Accessed Mar 10, 2009. Available at URL address: http://www.guideline.gov/summary/summary.aspx?doc_id=7485&nbr=004431&string=lower+AND+extremity+AND+venous+AND+ulcers

Policy History

Pre-Merger Organizations	Last Review Date	Policy Number	Title
CIGNA HealthCare	4/15/2008	0053	Hyperbaric Oxygen Therapy
CIGNA HealthCare	7/15/2008	0395	Topical Hyperbaric Oxygen (THBO) Therapy
Great-West Healthcare	7/12/2006	96.226.04	Hyperbaric Oxygen Therapy (HBOT)

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Connecticut General Life Insurance Company has acquired the business of Great-West Healthcare from Great-West Life & Annuity Insurance Company (GWLA). Certain products continue to be provided by GWLA (Life, Accident and Disability, and Excess Loss). GWLA is not licensed to do business in New York. In New York, these products are sold by GWLA's subsidiary, First Great-West Life & Annuity Insurance Company, White Plains, N.Y.