Hyperbaric Oxygen Pressurization (HBO)

Policy Number: MM.02.012
Line(s) of Business: HMO; PPO; QUEST Integration
Section: Medicine
Place(s) of Service: Outpatient; Inpatient

I. Description

Hyperbaric oxygen therapy (HBOT) involves breathing 100% oxygen at pressures between 1.5 and 3.0 atmospheres (atm). It is generally applied systemically with the patient inside a hyperbaric chamber. HBOT can also be applied topically; that is, the body part to be treated is isolated (eg, in an inflatable bag and exposed to pure oxygen). HBOT has been investigated for various conditions that have potential to respond to increased oxygen delivery to the tissues.

The evidence for the use of systemic HBOT in individuals with nonhealing diabetic wounds of the lower extremities, acute traumatic ischemia, soft-tissue radiation necrosis (eg, radiation enteritis, cystitis, proctitis), osteoradionecrosis (ie, pre- and posttreatment), planned dental surgery (non-implant-related) of an irradiated jaw, gas gangrene, and profound anemia with exceptional blood loss when blood transfusion is impossible or must be delayed includes systematic reviews and/or recommendations from the Undersea and Hyperbaric Medical Society’s (UHMS). Relevant outcomes include overall survival, symptoms, change in disease status, and functional outcomes. For all indications in the PICO note, evidence and/or USMS guidelines support use of HBOT. The evidence is sufficient to determine qualitatively that the technology results in a meaningful improvement in health outcomes.

The evidence for the use of systemic HBOT in individuals with any condition other than those specified in the previous paragraph includes systematic reviews, 1 or a few small RCTs, or small uncontrolled studies. Relevant outcomes include overall survival, symptoms, change in disease status, and functional outcomes. The available studies do not demonstrate that HBOT improves relevant outcomes. The evidence is insufficient to determine the effects of the technology on health outcomes.

The evidence for the use of topical HBOT in individuals who might respond to increased oxygen delivery to tissues includes primarily of case series and case reports. Relevant outcomes are symptoms and change in disease status. Only 1 randomized controlled trial (RCT) was published on any indication. This study, in patients with diabetic foot ulcers, had a small sample size and did not find a significant benefit of topical HBOT. The evidence is insufficient to determine the effects of the technology on health outcomes.
II. Criteria/Guidelines

A. Systemic hyperbaric oxygen pressurization is covered (subject to Limitations and Administrative Guidelines) for treatment of the following conditions:

1. Non-healing wounds of the lower extremities in patients with type 1 or type 2 diabetes and who meet all of the following criteria:
   a. Patient has a wound classified as Wagner grade 3 or higher as defined in the table below:

<table>
<thead>
<tr>
<th>Grade Number</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>No open lesion</td>
</tr>
<tr>
<td>1</td>
<td>Superficial ulcer without penetration to deeper layers</td>
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<tr>
<td>2</td>
<td>Ulcer penetrates to tendon, bone, or joint</td>
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<tr>
<td>3</td>
<td>Lesion has penetrated deeper than grade 2 and there is abscess, osteomyelitis, pyarthrosis, plantar space abscess, or infection of the tendon and tendon sheaths</td>
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<tr>
<td>4</td>
<td>Wet or dry gangrene in the toes or forefoot</td>
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<tr>
<td>5</td>
<td>Gangrene involves the whole foot or such a percentage that no local procedures are possible and amputation (at least at below the knee level) is indicated</td>
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b. Patient has no measurable signs of healing after a 30-day course of standard wound therapy which includes the following:
   i. The following standard wound treatment measures have been accomplished for all chronic ulcers and complex wounds:
      a. Evaluation of wound with documentation of measurements (length, width and depth) at baseline and at least weekly by a licensed medical professional.
      b. Debridement of necrotic tissue, if present
      c. Treatment of infection, if present
      d. Management of diabetes mellitus, if applicable
      e. Evaluation and management of peripheral artery disease, if applicable
   ii. The following standard wound treatment measures have been accomplished for chronic ulcers:
      a. For stage III or IV pressure ulcer:
         1. The patient has been appropriately turned and positioned; and
         2. The patient has used a support surface for pressure ulcers on the posterior trunk or pelvis (pressure reducing mattress or pad), (a support surface is not required if the ulcer is not on the trunk or pelvis); and
         3. Moisture and incontinence have been appropriately managed.
b. For neuropathic ulcer
   1. Patient’s diabetes is managed by a physician who is responsible for diagnosing and treating the diabetes through a comprehensive plan of care.
   2. Reduction in pressure on a foot ulcer has been accomplished with appropriate modalities.

c. For venous insufficiency ulcer:
   1. Compression bandages and/or garments have been consistently applied, and
   2. Leg elevation and ambulation have been encouraged.

(Criteria/Guidelines, continued – II.A.)

2. Acute traumatic ischemia e.g. crush injuries, reperfusion injury, compartment syndrome
3. Decompression sickness
4. Gas embolism, acute
5. Cyanide poisoning, acute
6. Acute carbon monoxide poisoning
7. Gas gangrene (i.e., clostridial myonecrosis)
8. Profound anemia with exceptional blood loss: only when blood transfusion is impossible or must be delayed
9. Soft-tissue radiation necrosis (e.g., radiation enteritis, cystitis, proctitis) or osteoradionecrosis
10. Pre- and post-treatment for patients undergoing non-implant related dental surgery (including tooth extraction) of an irradiated jaw
   a. The patient has had prior radiation to the head or neck and has received greater than or equal to a cumulative dose of 60 gray of radiation.
11. Chronic osteomyelitis refractory to conventional medical and surgical management

B. A treatment plan must be submitted for wounds, osteoradionecrosis, soft tissue radiation necrosis and chronic refractory osteomyelitis.

C. Wounds, osteoradionecrosis, and soft tissue radiation necrosis must be evaluated and documented by the treating physician for signs of healing after every 15 treatments or every 14 days of treatment (whichever comes first).

D. Continued treatment with HBO therapy is covered if signs of healing have been demonstrated and documented in the medical record.

III. Limitations

A. The use of HBO is not covered for other indications because it is not known to be effective in improving health outcomes. This includes, but is not limited to:
   1. Compromised skin grafts or flaps
   2. Acute osteomyelitis, refractory to standard medical management
   3. Bisphosphonate-related osteonecrosis of the jaw
   4. Necrotizing soft-tissue infections
   5. Acute thermal burns
6. Acute surgical and traumatic wounds
7. Chronic wounds, other than those in patients with diabetes who meet the criteria specified above in II.A.1
8. Spinal cord injury
9. Traumatic brain injury
10. Inflammatory bowel disease (Crohn disease or ulcerative colitis)
11. Brown recluse spider bites
12. Bone grafts
13. Carbon tetrachloride poisoning, acute
14. Cerebrovascular disease, acute (thrombotic or embolic) or chronic
15. Fracture healing
16. Hydrogen sulfide poisoning
17. Intra-abdominal and intracranial abscesses
18. Lepromatous leprosy
19. Meningitis
20. Pseudomembranous colitis (antimicrobial agent-induced colitis)
21. Radiation myelitis,
22. Sickle cell crisis and/or hematuria
23. Demyelinating diseases, (e.g., multiple sclerosis, amyotrophic lateral sclerosis)
24. Retinal artery insufficiency, acute
25. Retinopathy, adjunct to scleral buckling procedures in patients with sickle cell peripheral retinopathy and retinal detachment
26. Pyoderma gangrenosum
27. Acute arterial peripheral insufficiency
28. Acute coronary syndromes and as an adjunct to coronary interventions, including but not limited to percutaneous coronary interventions and cardiopulmonary bypass
29. Refractory mycoses: mucormycosis, actinomycosis, canidiobolus coronato
30. Cerebral edema, acute
31. Migraine
32. In vitro fertilization
33. Cerebral palsy
34. Tumor sensitization for cancer treatments, including but not limited to, radiotherapy or chemotherapy
35. Delayed onset muscle soreness
36. Idiopathic femoral neck necrosis
37. Chronic arm lymphedema following radiotherapy for cancer
38. Radiation-induced injury in the head and neck excluding radiation-induced soft tissue necrosis or osteoradionecrosis
39. Early treatment (beginning at completion of radiation therapy) to reduce adverse effects of radiation therapy; and
40. Autism spectrum disorders
41. Acute ischemic stroke
42. Bell’s palsy
43. Motor dysfunction associated with stroke;  
44. Herpes zoster; and  
45. Vascular dementia  
46. Fibromyalgia  
47. Mental Illness (i.e., post-traumatic stress disorder, generalized anxiety disorder, depression)

B. Topical hyperbaric oxygen therapy is not a covered benefit.

IV. Administrative Guidelines
A. Precertification is required for wounds, osteoradionecrosis, soft tissue radiation necrosis and chronic refractory osteomyelitis. To precertify, please complete HMSA’s Precertification Request and mail or fax the form as indicated.
B. A treatment plan must be submitted for wounds, osteoradionecrosis, soft tissue radiation necrosis and chronic refractory osteomyelitis.
C. Documentation of previous medical and surgical interventions including outcomes must be submitted.
D. For continuation of therapy, documentation from the medical record showing objective signs of wound healing from wounds, osteoradionecrosis, soft tissue radiation necrosis and chronic refractory osteomyelitis must be submitted.

<table>
<thead>
<tr>
<th>CPT code</th>
<th>Description</th>
<th>Facility code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>99183</td>
<td>Physician attendance and supervision of hyperbaric oxygen therapy, per session</td>
<td>413</td>
<td>Respiratory services – hyperbaric oxygen therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>270</td>
<td>Med/Surg supplies and devices – general classification (for oxygen)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G0277</td>
<td>Hyperbaric oxygen under pressure, full body chamber, per 30 minute interval</td>
</tr>
</tbody>
</table>

Click on link below for ICD-10 codes
See attached code list

V. Scientific Background
Chronic Wounds
Several systematic reviews of RCTs have been published. An updated Cochrane review of RCTs on HBO treatment for chronic wounds was published by Kranke and colleagues in 2012. The authors identified 9 RCTs with a total of 471 participants that compared the effect of HBO on chronic wound healing compared to an alternative treatment approach that did not use HBO. Eight of the 9 trials included in the review evaluated HBO therapy in patients with diabetes. The remaining trial addressed HBO for patients with venous ulcers; that study had only 16 participants and the comparator treatment was not specified. In a pooled analysis of data from 3 trials, a significantly
higher proportion of ulcers had healed at the end of the treatment period (6 weeks) in the group receiving HBO compared to the group not receiving HBO (risk ratio [RR]: 5.20; 95% confidence interval [CI]: 1.25 to 21.7). Pooled analyses, however, did not find significant differences between groups in the proportion of ulcers healed in the HBO versus non-HBO-treated groups at 6 months (2 trials) or 12 months (3 trials). There were insufficient data to conduct pooled analyses of studies evaluating HBO for treating patients with chronic wounds who did not have diabetes.

In 2013, O’Reilly and colleagues published a systematic review of studies on HBO for treatment of diabetic ulcers. The authors identified 6 RCTs and 6 non-randomized controlled studies that compared HBO to standard wound care or sham therapy in patients with diabetes who had non-healing lower limb ulcers. Pooled analyses of observational studies found statistically significant benefits of HBO on rates of major amputation, minor amputation and the proportion of wounds healed at the end of the study period. However, in pooled analyses of RCT data, the stronger study design, there were not statistically significant differences between groups on key outcomes. This included the rate of major amputation (RR: 0.40, 95% CI: 0.07 to 2.23, p=0.29), minor amputation (RR: 0.79, 95% CI: 0.19 to 3.30, p=0.75) and the proportion of unhealed wounds at the end of the study period (RR: 0.54, 95% CI: 0.26 to 1.13, p=0.1).

Systematic reviews have had mixed findings on the impact of HBOT on diabetic ulcers. A Cochrane review found short-term, but not long-term benefit on wound healing, and a 2013 meta-analysis did not find significant benefits of HBOT on outcomes in RCTs, but did find an effect in non-RCTs. There is insufficient evidence on HBOT for treatment of chronic wounds in patients without diabetes.

**Acute surgical and traumatic wounds**

In 2013 an updated Cochrane review of RCTs on HBO therapy for acute wounds (e.g., surgical wounds, lacerations, traumatic wounds, and animal bites) was published by Eskes and colleagues. To be included, studies needed to compare HBO with a different intervention or compare 2 HBO regimens; in addition, studies needed to objectively measure wound healing. A total of 7 potentially relevant studies were identified; 3 of these met the review’s inclusion criteria. The 3 studies ranged in size from 36 to 135 participants. Due to differences among studies in terms of patient population, comparison intervention, outcome measurement, etc., study results could not be pooled. The primary outcome examined by Cochrane reviewers, wound healing, was not reported in either of the 2 trials comparing HBO to usual care and was not reported in the 1 trial comparing HBO to dexamethasone or heparin. Complete wound healing was reported in the 1 RCT comparing active HBO to sham HBO. In this small study (n=36), there was a statistically higher rate of wound healing in the HBO group; the time point for outcome measurement in this study was unclear. In the sham-controlled study there was not a statistically significant difference between groups in the mean time to wound healing.

Another 2014 systematic review of studies on HBO for acute wounds, published by Dauwe and colleagues included randomized and non-randomized controlled studies. The review included 8 studies, with sample sizes ranging from 5 to 125 patients. Four studies were randomized, 3 were prospective non-randomized controlled studies and 1 was a retrospective non-randomized controlled study. As in the Eskes systematic review, data were not pooled. The authors noted that 7 of the 8 studies reported achieving statistical significance in their primary endpoints, but the
endpoints differed among studies e.g. graft survival, length of hospital stay, wound size. Moreover, the studies were heterogeneous in terms of treatment regimens, patient indications (e.g., burns, face lifts), and study designs, making it difficult to draw conclusions about the effect of HBO on acute wound treatment. There is insufficient evidence supporting HBO for treatment of acute wounds; additional evidence from high-quality RCTs is needed.

**Carbon Monoxide Poisoning**

2011 Cochrane review of 7 RCTs concluded that the available evidence is insufficient to determine whether adverse neurologic outcomes in patients with carbon monoxide poisoning are reduced with HBO therapy. In 2008, the American College of Emergency Physicians published a clinical policy on critical issues in carbon monoxide poisoning. Their literature review indicated there was only Level C evidence (preliminary, inconclusive, or conflicting evidence) for treatment of acute carbon monoxide poisoning. The 2008 Undersea and Hyperbaric Medical Society (UHMS), however, lists carbon monoxide poisoning as an indication for HBO therapy.

Two blinded randomized trials were discussed in both the Cochrane and American College of Emergency Physicians reviews. One is a study by Scheinkestel and colleagues, a double-blind, RCT comparing HBO to normobaric oxygen in patients with carbon monoxide poisoning. The authors reported that HBO therapy did not benefit patient outcomes of neuropsychologic performance when HBO therapy was completed and at 1-month follow-up. This study was limited, however, by a high rate (46%) of patients who were lost to follow-up. Moreover, the trial has been criticized for administering 100% normobaric oxygen for at least 72 hours between treatments, which has been called a toxic dose of oxygen. The critiques also mention that there was an unusually high rate of neurologic sequelae after the treatment period, which could be due in part to the high dose of oxygen and/or the high rate of cognitive dysfunction in the study population (69% were poisoned by carbon monoxide through suicide attempts).

The other blinded trial by Weaver and colleagues also compared HBO and normobaric oxygen. Patients received either 3 sessions of HBO or 1 session of normobaric oxygen plus 2 sessions of exposure to normobaric room air. The primary outcome was the rate of cognitive sequelae at 6 weeks. Cognitive function was assessed by a battery of neuropsychological tests. At the 6-week follow-up, the intention-to-treat analysis found that 19 of 76 (25.0%) in the HBO group and 35 of 76 (46.1%) in the control group had cognitive sequelae; the difference was statistically significant, p=0.007. There was a high rate of follow-up at 6 weeks, 147 of 152 (97%) of randomized patients. Enrollment in the study was stopped early because an interim analysis found HBO to be effective. A follow-up study, that included 147 patients from the randomized trial and 75 who had been eligible for the trial but had not enrolled, was published in 2007. Of the group treated with HBO (n=75), cognitive sequelae were identified in 10 of 58 (17%) at 6 months and 9 of 62 (14%) at 12 months. Of the group not treated with HBO (n=163), 44 of 146 (30%) at 6 months and 27 of 149 (18%) at 12 months had cognitive sequelae. (The follow-up rate was higher at 12 months because the investigators received additional funding for data collection).

**Radionecrosis and Osteoradionecrosis**

A 2008 Cochrane review by Esposito et al. reviewed the use of HBO therapy in patients requiring dental implants. The authors identified 1 randomized trial involving 26 patients. The authors concluded that despite the limited amount of clinical research available, it appears that HBO
therapy in irradiated patients requiring dental implants may not offer any appreciable clinical
benefits. They indicate that there is a need for more RCTs to ascertain the effectiveness of HBO in
irradiated patients requiring dental implants.

In 2012, Bennett and colleagues published a Cochrane review on hyperbaric oxygen therapy for
late radiation tissue injury. The authors identified 11 RCTs; there was variability among trials and
study findings were not pooled for the primary outcomes of survival, complete resolution of
necrosis or tissue damage, and improvement in a late effects symptom scale. In a pooled analysis
of 3 studies, a significantly higher proportion of patients with osteoradionecrosis achieved
complete mucosal cover after hyperbaric oxygen treatment compared to control (RR: 1.30, 95%
CI: 1.09 to 1.55). From their review of the literature, the authors concluded that data from small
trials “suggest that for people with LRTI (Late Radiation Tissue Injury) affecting the head, neck,
anus, and rectum, [HBO] is associated with improved outcome. HBO also appears to reduce the
chance of ORN (osteoradionecrosis) following tooth extraction in an irradiated field. There was no
such evidence of any important clinical effect on neurological tissues. The application of HBOT to
selected patients and tissues may be justified.”

HBOT has long been used to treat soft tissue and bone radiation necrosis and for pre- and
posttreatment of dental surgery (non-implant-related) in an irradiated jaw.

Bisphosphonate-related Osteonecrosis of the Jaw
An unblinded RCT was published by Freiberger and colleagues in 2012 on use of HBO as an
adjunct therapy for patients with bisphosphonate-related osteonecrosis of the jaw. (20) Forty-
ine patients were randomly assigned to HBO in addition to standard care (n=22) or standard care
alone (n=27). Five patients in the standard care group received HBO treatment and 1 patient
assigned to the HBO group declined HBO. The investigators decided to do a per protocol analysis
(actual treatment received) because of the relatively large degree of crossover. Participants were
evaluated at 3, 6 12 and 18 months. Data were available on 46 patients, 25 received HBO in
addition to standard care and 21 received standard care alone. The primary outcome measure
was change in oral lesion size or number. When change from baseline to last available follow-up
was examined, 17 of 25 (68%) of HBO-treated patients had improvement in oral lesion size or
number compared to 8 of 21 (38%) in the standard care group, p=0.043. When change from
baseline to 6, 12 or 18 months was examined, there was not a statistically significant difference
between groups in the proportion of patients with improvement. In addition, the proportion of
patients who healed completely did not differ significantly between groups at any time point. This
single trial does not report consistent findings of benefit across outcome measures. It also has a
number of methodologic limitations, e.g., unblinded, cross-over, and analysis performed on a per-
protocol basis rather than intention to treat. A disadvantage of the per-protocol analysis is that
randomization is not preserved, and the two groups may differ on characteristics that affect
outcomes. As a result, this trial is insufficient to conclude that HBO improves health outcomes for
patients with bisphosphonate-related osteonecrosis of the jaw.

Osteomyelitis
No prospective clinical trials on chronic refractory osteomyelitis or acute refractory osteomyelitis
were identified in updated searches. The justification for the use of HBO in chronic osteomyelitis
has been primarily based on case series. Among the larger case series, Maynor and colleagues
reviewed the records of all patients with chronic osteomyelitis of the tibia seen at one institution. Follow-up data were available on 34 patients who had received a mean of 35 adjunctive HBO treatments (range, 6 to 99). Of the 26 patients with at least 2 years of follow-up after treatment, 21 (81%) remained drainage-free. Twelve of 15 (80%) with follow-up data at 60 months had remained drainage-free. A study by Davis and colleagues reviewed outcomes for 38 patients with chronic refractory osteomyelitis treated at another U.S. institution. Patients received HBO treatment until the bone was fully recovered with healthy vascular tissue; this resulted in a mean of 48 daily HBO treatments (range, 8 to 103). After a mean post-treatment follow-up of 34 months, 34 of 38 (89%) patients remained clinically free of infection (i.e., drainage-free and no tenderness, pain, or cellulitis). Success rates from several smaller case series, all conducted in Taiwan, are 12 of 13 (92%) patients, 11 of 14 (79%) patients, and 13 of 15 (86%) patients. Given the high percentage of refractory patients in these series who had successful outcomes.

Fracture Healing
In 2012, Bennett and colleagues published a Cochrane review on HBO to promote fracture healing and treat non-union fractures. The investigators did not identify any published RCTs on this topic that compared HBO to no treatment, sham or another intervention and reported bony union as an outcome.

Compromised Skin Grafts and Flaps
In 2006, Friedman and colleagues published a systematic review of literature on use of HBO for treating skin flaps and grafts. No RCTs were found. The authors identified 2 retrospective case series on use of HBO for clinically compromised skin grafts and flaps. The series had sample sizes of 65 and 26, respectively; both were published in the 1980s based on treatment provided in the 1970s and 1980s. Given the limited published data and lack of recent data, this indication does not meet payment determination criteria.

Necrotizing Soft Tissue Infections
A 2005 systematic review by Jallali and colleagues evaluated the literature on HBO as adjunctive therapy for necrotizing fasciitis. They did not identify any RCTs. There were only a few retrospective studies with small sample sizes and findings were inconsistent. The authors concluded that more robust evidence is needed before widespread use of HBO is recommended. A 2009 retrospective cohort study compared outcomes in 48 patients at 1 center who received adjunctive HBO for necrotizing soft issue infections to those in 30 patients at a different center who did not receive HBO. There was not a significant difference in the mortality rate between the 2 groups; this was 4 of 48 (8%) in the HBO group and 4 of 30 (13%) in the non-HBO group (p=0.48). The median number of days in the intensive care unit and the median number of days in the hospital also did not differ significantly. There was a higher median number of debridement procedures per person in the HBO group, 3.0 compared to 2.0 in the non-HBO group (p=0.03).

Refractory Mycoses
No clinical trials on refractory mycoses (mucormycosis, actinomycosis, canidiobolus coronato) and cerebral edema were found.

Acute Peripheral Arterial Insufficiency
No clinical trial publications were identified that demonstrated benefit in HBO therapy for acute peripheral arterial insufficiency.
**Acute Coronary Syndromes**

A 2012 Cochrane review by Bennett and colleagues identified 6 trials with a total of 665 patients evaluating HBO for acute coronary syndrome. All of the studies included patients with acute myocardial infarction (MI); one study also included individuals presenting with unstable angina. Additionally, all trials used HBO as an adjunct to standard care. Control interventions varied; only 1 trial described using a sham therapy to blind participants to treatment group allocation. In a pooled analysis of data from 5 trials, there was a significantly lower rate of death in patients who received HBO compared to a control intervention (RR: 0.58; 0.36 to 0.92). Due to variability of outcome reporting in the studies, few other pooled analyses could be conducted. A pooled analysis of data from 3 trials on improvements in left ventricular function did not find a statistically significant benefit of HBO treatment (RR: 0.09; 95% CI: 0.01 to 1.4). The authors noted that, although there is some evidence from small trials that HBO treatment is associated with a lower risk of death, larger trials with high methodologic quality are needed in order to determine which patients, if any, can be expected to derive benefit from HBO.

One of the trials was by Sharifi and colleagues and randomly assigned 69 patients with unstable angina or MI to receive or not receive HBO after a percutaneous coronary intervention (PCI). The 24 patients randomly assigned to the HBO group reported on 1 adverse event (death, MI, coronary artery bypass, or revascularization of target lesion), compared to 13 in the 37 control patients. However, this study lacked adequate detail, e.g., on the type of PCI performed, to permit scientific conclusions. In another RCT of 64 patients, Alex and colleagues concluded both neuropsychometric dysfunction and inflammatory response can be reduced postcardiopulmonary bypass when HBO pretreatment is given.

**Acute Ischemic Stroke**

In a 2014 update of a Cochrane systematic review, Bennett et al evaluated HBOT for acute ischemic stroke. The investigators identified 11 RCTs, with a total of 705 participants, that compared HBOT with sham HBOT or no treatment. The authors were only able to pool study findings for 1 outcome (mortality at 3-6 months). A pooled analysis of data from 4 trials with a total of 106 participants did not find a significant benefit of HBOT compared with a control condition for this outcome (RR=0.97; 95% CI, 0.34 to 2.75).

**Motor Dysfunction Associated with Stroke**

In 2013, Efrati and colleagues published an RCT evaluating HBO therapy for treatment of neurologic deficiencies associated with a history of stroke. The study included 74 patients with at least 1 motor dysfunction who had an ischemic or hemorrhagic stroke 6-36 months prior to study participation. Participants were randomly assigned to receive 2 months of HBO treatment (40 daily sessions, 5 days per week, n=30) or delayed treatment (n=32). Patients were evaluated at baseline and 2 months. For patients in the delayed treatment control group, outcomes were evaluated at 4 months after crossing over and receiving HBO treatment. Twenty-nine of 32 patients (91%) in the delayed treatment group crossed over to the active intervention. Outcome measures included the National Institutes of Health Stroke Scale (NIHSS), which was measured by physicians blinded to treatment group, and several patient-reported quality-of-life and functional status measures.
At 2 months’ follow-up, there was statistically significantly greater improvement in function in the HBO group compared to the control group as measured by the NIHSS, quality-of-life scales and the ability to perform activities of daily living (ADLs). These differences in outcome measures were accompanied by improvements in single-photon emission computed tomography (SPECT) imaging in the regions affected by stroke. For the delayed treatment control group, there was a statistically significant improvement in function after HBO treatment compared to before treatment. This RCT raises the possibility that HBO may induce improvements in function and quality of life for post-stroke patients with motor deficits. However, the results are not definitive for a number of reasons. This RCT is small and enrolled a heterogeneous group of post-stroke patients. The study was not double-blind and the majority of outcome measures, except for the NIHSS, were patient reported and thus prone to the placebo effect. Also, there was a high total dropout rate of 20% at the 2-month follow-up point. Therefore, larger, double-blind studies with longer follow-up are needed to corroborate these results.

**Bell’s Palsy**

In 2012, Holland and colleagues published a Cochrane systematic review evaluating HBO treatment in adults with Bell’s palsy. The authors identified one RCT with 79 participants, and this study did not meet the Cochrane review methodologic standards because the outcome assessor was not blinded to treatment allocation.

**Traumatic Brain Injury**

A 2012 Cochrane systematic review addressed HBO as adjunctive treatment for traumatic brain injury. The investigators identified 7 RCTs with a total of 571 participants comparing a standard intensive treatment regimen to the same treatment regimen with the addition of HBO. The review did not include studies in which interventions occurred in a specialized acute care setting. The HBO regimens varied among studies; for example, the total number of individual sessions varied from 3 to 30-40. No trial used sham treatment or blinded the staff members who were treating the patients, and only 1 had blinding of outcome assessment. Allocation concealment was inadequate in all of the studies. The primary outcomes of the review were mortality and functional outcomes. A pooled analysis of data from 4 trials that reported this outcome found a statistically significantly greater reduction in mortality when HBO was added to a standard treatment regimen (RR: 0.69, 95% CI: 0.54 to 0.88). However, when data from the 4 trials were pooled, the difference in the proportion of patients with an unfavorable functional outcome at final follow-up did not quite reach statistical significance (RR: 0.71, 95% CI: 0.50 to 1.01). Unfavorable outcome was commonly defined as a Glasgow Outcome Score (GOS) of 1, 2 or 3, which are described as ‘dead’, ‘vegetative state’ or ‘severely disabled’. Studies were generally small and were judged to have substantial risk of bias.

Several trials on mild traumatic brain injury in military populations have been published and they did not find significant benefits of HBO therapy compared with sham treatment. The first trial, published by Wolf et al in 2012, included 50 military service members, 48 of whom were male, with combat-related mild traumatic brain injury. A sham-controlled double-blind trial evaluating HBO was published by Wolf and colleagues in 2012. The study included 50 military service members, 48 of whom were male, with combat-related mild traumatic brain injury. Participants were randomized to 30 sessions of HBO over 8 weeks (n=25) or a sham intervention (room air at 1.3 ATA) (n=25). The primary outcome measures were scores on the Immediate Post-Concussive
Assessment and Cognitive Testing (ImPACT) and Post-Traumatic Disorder Check List-Military Version (PCL-M) instruments. Patients were evaluated after every 5 treatment sessions and at 6 weeks post-exposure. Forty-eight of 50 participants (96%) completed the study. There were no statistically significant differences on the ImPACT total mean score or the PCL-M composite score at any time point. For example, at the 6 week follow-up, mean composite PCL-M scores were 41.6 in the HBO group and 40.6 in the sham-control group, p=0.28. While the sample size was relatively small, the study was powered to detect clinically significant differences among groups on the cognitive tests.

A 2014 double-blind sham-controlled trial 2014 RCT by Cifu et al included 61 male Marines who had a history of mild traumatic brain injury and post concussive syndrome. To maintain blinding, all patients were pressured inside a hyperbaric chamber to 2.0 ata. They were randomized to breathe 1 of 3 oxygen nitrogen gas mixes equivalent to: (1) 75% oxygen at 1.5 ata (n=21); (2) 100% oxygen at 2.0 ata (n=19); and (3) sham treatment with surface room air (n=21). Patients underwent 40 once-daily 60-minute sessions. Outcomes were assessed 3 months after the last exposure. The primary outcome was a clinically meaningful improvement, defined as a 10% difference between groups in the score on the 16-item Rivermead Post-Concussion Questionnaire (RPQ; (scale range, 50-84; higher values indicate more severe symptoms). At follow-up, there was no statistically significant difference among groups on RPQ-16 score (p=0.41). A variety of secondary outcomes were also assessed. None, including measures of attention, cognition, or depression, differed significantly among groups at follow-up.

In 2015, Miller et al evaluated HBOT in 72 military service members with continuing symptoms at least 4 months after mild traumatic brain injury. Patients were randomized to receive 40 daily HBOT sessions at 1.5 ata, 40 sham sessions consisting of room air at 1.2 ata, or standard care with no hyperbaric chamber sessions. The primary outcome was change in RPQ score. A cutoff of 15% improvement was deemed clinically important, which translates to a change score of at least 2 points on the RPQ-3 subscale. The proportion of patients who met the prespecified change of at least 2 points on the RPQ-3 was 52% in the HBOT group, 33% in the sham group, and 25% in the standard care-only group. The difference between rates in the HBOT and sham groups was not statistically significant (p=0.24). None of the secondary outcomes significantly favored the HBOT group. A criticism of this study, as well as the other military population studies, was that the response in the sham group was not due to a placebo effect but to an intervention effect of slightly increased atmospheric pressure (1.2 ata). Other researchers have noted that room air delivered at 1.2 ata would not be considered an acceptable therapeutic dose for any indication, and especially for a condition with persistent symptoms like post concussive syndrome.

Inflammatory Bowel Disease
A 2014 systematic review by Dulai and colleagues examined the evidence on HBO for treatment of inflammatory bowel disease (Crohn’s disease and ulcerative colitis). The review was not limited by study design. The authors included 17 studies: 1 RCT, 2 case-control studies, 3 case series and 11 case reports. The studies reported on a total of 613 patients, 286 with Crohn’s disease and 327 with ulcerative colitis. The only RCT identified was published in 2013; it was open-label and included 18 patients with ulcerative colitis. Patients were randomized to treatment with standard medical therapy only (n=8) or medical therapy plus HBO (n=10). The HBO intervention consisted of 90 minutes of treatment at 2.4 ATM, 5 days a week for 6 weeks (total of 30 sessions).
The primary outcome was the Mayo score which has a potential range of 0 to 12. 46 Patients with a score of 6 or more are considered to have moderate to severe active disease. At follow-up there was not a significant difference between groups in the Mayo score; the median score at 6 months was 0.5 in the HBO group and 3 in the control group (exact p value not reported). In addition, there were no significant differences in any of the secondary outcomes including laboratory tests and fecal weight. This is a small study that may have been underpowered. Overall, the authors found that the studies had a high risk of bias, particularly in the areas of attrition and reporting bias.

In summary, there is insufficient evidence that HBO therapy is an effective for treating inflammatory bowel disease. Only 1 small RCT has been published and this study did not find a significant improvement in health outcomes with when HBO was added to standard medical therapy.

**Idiopathic Sudden Sensorineural Hearing Loss (ISSNHL)**

In 2011, the Undersea and Hyperbaric Medical Society added idiopathic sudden sensorineural hearing loss (ISSNHL) within the past 14 days as an approved indication for HBO therapy.

A 2012 Cochrane review on HBO for ISSNHL and tinnitus identified 7 trials with a total of 392 participants. [This is an update of a 2007 review; no additional trials were identified]. All trials included patients with ISSNHL with and/or without tinnitus; 2 trials also included patients with tinnitus in the absence of ISSNHL. Randomization procedures were only described in one study, and only one study stated they blinded participants to treatment group assignment using sham therapy. Six of the studies included time-based entry criteria for hearing loss and/or tinnitus; this was 48 hours in 3 studies, 2 weeks in 2 studies (for acute presentation) and 6 months in 1 study. The dose of oxygen per treatment session and the treatment protocols varied among studies e.g., the total number of treatment sessions varied from 10 to 25.

All trials reported on change in hearing following treatment; but specific outcomes varied. Two trials reported the proportion of participants with greater than 50% return of hearing at the end of therapy. A pooled analysis of these studies did not find a statistically significant difference in outcomes between the HBO and control groups (RR: 1.53, 95% CI: 0.86 to 2.78). In contrast, a pooled analysis of 2 trials reporting the proportion of participants with greater than 25% return of hearing at the end of therapy found a significantly higher rate of improvement after HBO compared to a control intervention (RR: 1.39: 95% CI: 1.05 to 1.84). Moreover, a pooled analysis of 4 trials found a significantly greater mean improvement in hearing over all frequencies with HBO compared to control (mean difference: 15.6 decibels (dB); 95% CI: 1.5 to 29.8). The authors stated that, due to methodologic shortcomings of the trials and the modest number of patients, results of the meta-analysis should be interpreted cautiously; they did not recommend use of HBO for treating ISSNHL.

In 2013, Cvorovic and colleagues published an RCT that included 50 patients with ISSHL who had failed primary therapy with intravenous steroids. 49 Patients were randomized to receive HBO (20 treatments, 5 daily treatments per week) or intratympanic steroid injection (4 injections in 13 days). The HBO treatments consisted of 10 minutes of compression on air, 60 minutes of 100% oxygen at 2 ATA and 10 minutes of decompression on air. Outcomes were change in the mean hearing thresholds at each of 5 frequencies (0.25, 0.5, 1, 2 and 4 kHz). After treatment, there were
no statistically significant differences in mean hearing thresholds at 4 of the 5 frequencies. The exception was 2 kHz, and at this frequency, the improvement was significantly greater in the HBO group.

Due to methodologic limitations and variability among published studies, the evidence is insufficient to draw conclusions about the effect of HBO on health outcomes in patients with ISSNHL.

**Cancer Treatment**

In an RCT of 32 patients, Heys and colleagues found no increase in 5-year survival in patients treated with HBO prior to chemotherapy for locally advanced breast carcinoma to increase tumor vascularity. This approach is being studied since studies in animal models have suggested that HBO increases tumor vascularity and thus may make chemotherapy more effective. In a Cochrane review, Bennett and colleagues concluded that HBO given with radiotherapy may be useful in tumor control; however, the authors expressed caution since significant adverse effects were.

**In Vitro Fertilization**

Van Voorhis and colleagues reported that HBO was well-tolerated in women undergoing ovarian follicular stimulation for in vitro fertilization; however, no outcomes were reported, and further study is needed.

**Delayed-onset Muscle Soreness**

In a Cochrane review, Bennett and colleagues concluded that available evidence is insufficient to demonstrate beneficial outcomes with HBO for delayed-onset muscle soreness and closed soft tissue injury. It was noted that HBO possibly even increases pain initially and further studies are needed.

**Autism Spectrum Disorders**

A 2012 systematic review of evidence on hyperbaric oxygen therapy for treatment of children with autism identified 2 RCTs with a total of 89 participants. One of the 2 RCTs found better outcomes after hyperbaric oxygen compared to placebo treatment, and the other did not find significant differences in outcomes. The author concluded that additional sham-controlled trials with rigorous methodology are needed in order to draw conclusions about the efficacy of HBO for treating autism.

A key RCT was by Rossignol and colleagues. This double-blind trial included 62 children, ages 2-7 years, who met Diagnostic and Statistical Manual of mental Disorders (DSM)-IV criteria for autistic disorder. The active treatment was hyperbaric treatment at 1.3 atmospheres (atm) and 24% oxygen in a hyperbaric chamber. (This regimen differs from standard HBO treatment, which uses 100% oxygen and a pressure of at least 1.4 atm.) The other group received a sham treatment consisting of 1.03 atm and ambient air (21% oxygen). Both groups received 40 sessions of active or sham treatment lasting 60 minutes each over a period of 4 weeks. The equipment, procedures, etc. in the 2 groups were as similar as possible to maintain blinding. The investigators, participants, parents, and clinic staff were blinded to treatment group. Only the hyperbaric technician, who had no role in outcome assessment, was aware of group assignment. After completion of the 4-week study, families with children in the control group were offered the
active intervention. When asked at the end of the study, there was no significant difference in the ability of parents to correctly guess the group assignment of their child.

The outcomes were change compared to baseline after 4 weeks on the following scales: Aberrant Behavior Checklist (ABC) total score and 5 subscales: Autism Treatment Evaluation Checklist (ATEC) total score and 4 subscales; and Clinical Global Impression-Improvement (CGI) overall functioning score and 18 subscales. P values of <0.05 were considered statistically significant; there was no adjustment for multiple comparisons. The analysis included all children who completed at least one complete session. Of the 33 children assigned to active treatment, 30 were included in the analysis, and 29 completed all 40 treatments. Of the 29 children assigned to the control treatment, 26 completed all 40 sessions and were included in the analysis.

There was no significant between-group improvement on the ABC total score, any of the ABC subscales, or on the ATEC total score. Compared to the control group, the treatment group had a significant improvement in 1 of 4 subscales of the ATEC, the sensory/cognitive awareness subscale. The change from baseline on this subscale was a mean of 16.5 in the treatment group and a mean of 5.4 in the control group, a difference of 11.1 (p=0.037). (Note: due to an administrative error, baseline ATEC was not collected at one site, and thus data were not available for 23 children in the treatment group and 21 children in the control group). On the physician-rated CGI total score, 9/30 (30%) children in the treatment group had a score of 1 (very much improved) or 2 (much improved) compared to 2/26 (8%) in the control group (p=0.047). On the parental-rated CGI total score, 9/30 (30%) children in the treatment group had a score of 1 or 2 compared to 4/26 (15%) in the control group (p=0.22, not statistically significant). (The exact numbers receiving scores of 1 vs. 2 were not reported.) Change in mean CGI scores were also reported, but this may be a less appropriate way to analyze these data. Among the parental-rated CGI subscales, significantly more children were rated as improved in the treatment group compared to control on 2 out of 18 subscales, receptive language (p=0.017) and eye contact (p=0.032).

A limitation of this study was that the authors reported only outcomes at 4 weeks, directly after completion of the intervention. It is not known whether there are any long-term effects. Additional follow-up data cannot be obtained because members of the control group crossed over to the intervention after 4 weeks. Other limitations include lack of adjustment for multiple comparisons and unclear clinical significance of the statistically significant outcomes. The Undersea and Hyperbaric Medical Society (UHMS) issued a position paper after publication of the Rossignol et al. study stating that they still did not recommend routine treatment of autism with HBO.

An additional 2012 RCT, published after the 2012 systematic review had been completed, was conducted in Thailand and randomly assigned 60 children with autism to receive 20 one-hour sessions with HBO or sham air treatment (n=30 per group). The primary outcome measures were change in the ATEC and CGI, evaluated separately by clinicians and parents. There were no statistically significant differences between groups on any of the primary outcomes. For example, post-treatment clinician-assessed mean scores on the ATEC were 52.4 in the HBO group and 52.9 in the sham air group. In summary, there is insufficient evidence from rigorous RCTs that HBO improves health outcomes for patients with autism spectrum disorder.
**Amyotrophic Lateral Sclerosis**

No randomized trials were found evaluating HBO for treatment of amyotrophic lateral sclerosis. In a small case series, Steele et al. treated 5 patients with HBO and reported some improvements in fatigue but noted that further study is needed with attention to placebo effects.

**Cerebral Palsy**

Two published RCTs were identified. In 2012, Lacey and colleagues published a double-blind RCT that included 49 children age 3-8 years with spastic cerebral palsy. Participants were randomized to receive 40 treatments with either HBO (n=25) or hyperbaric air to simulate 21% oxygen at room air (n=24). The primary efficacy outcome was change in the Gross Motor Function Measure (GMFM-88) global score after the 8-week treatment period. The study was stopped early due to futility, when an interim analysis indicated that there was less than a 2% likelihood that a statistically significant difference between groups would be found. At the time of the interim analysis, the post-treatment GMFM-88 global score was a mean of 40.8 (standard deviation [SD]: 33.4) in the HBO group and 41.2 (SD: 29.6) in the hyperbaric air group. The between-group difference was 0.9 (95% CI: -1.5 to 3.3), p value=0.54.

Previously, in 2001, Collet et al. randomly assigned 111 children with cerebral palsy to 40 treatments over a 2-month period of either HBO (n=57) or slightly pressurized room air (n=54). (56) The authors found HBO produced similar improvements in outcomes such as gross motor function and activities of daily living in both groups as slightly pressurized air. The available evidence does not support HBO as a treatment of cerebral palsy.

**Vascular Dementia**

A 2012 Cochrane review identified 1 RCT evaluating HBO for the treatment of vascular dementia. The 2009 study, conducted in China compared HBO plus donepezil to donepezil-only in 64 patients. The HBO and donepezil group had significantly better cognitive function after 12 weeks of treatment, as assessed by the Mini-Mental State Examination. The Cochrane investigators judged the trial to be of poor methodologic quality because it was not blinded and the methods of randomization and allocation concealment were not discussed. This single trial with limitations provides insufficient evidence on the efficacy of HBO treatment on vascular dementia; thus, HBO does not meet payment determination criteria for this indication.

**Radiotherapy Adverse Effects**

In 2010, Spiegelberg and colleagues conducted a systematic review of studies on HBO therapy to prevent or treat radiotherapy-induced head and neck injuries associated with treatment of malignant tumors. The authors identified 20 studies. Eight of the studies included control groups; their sample sizes ranged from 19 to 78 individuals. Four (50%) of the studies with a control group concluded that HBO was effective, and the other 4 did not conclude that the HBO was effective. The authors noted a paucity of RCTs but did not state the number of RCTs that they identified in their review.

A study by Teguh and colleagues published in 2009 included 17 patients with oropharyngeal or nasopharyngeal cancer who were treated with radiation therapy; the study was conducted in The Netherlands. HBO therapy was used to prevent adverse events following radiotherapy. Eight patients were randomly assigned to receive 30 sessions of HBO, beginning within 2 days of completing radiation therapy, and 9 patients received no additional treatment. All patients were
included in the analysis. Quality-of-life outcomes were assessed, and the primary outcome was specified as xerostomia at 1 year. Quality-of-life measures did not differ significantly between groups in the acute phase (first 3 months). For example, 1 month after treatment, the mean visual analog scale (VAS) score for xerostomia (0-to-10 scale) was 5 in the HBO group and 6 in the control group. However, at 1 year, there was a statistically significant difference between groups; the mean VAS score for xerostomia was 4 in the HBO group and 7 in the control group (p=0.002). Also at 1 year, the mean quality-of-life score for swallowing (0-to-100 scale) was 7 in the HBO group and 40 in the control group (p=0.0001). The study is limited by the small sample size and the wide fluctuation over the follow-up period in quality-of-life ratings.

In 2010, Gothard and colleagues in the U.K. published findings of a RCT using HBO therapy to treat arm lymphedema occurring after radiotherapy for cancer. Fifty-eight patients with arm lymphedema (at least 15% increase in arm volume) following cancer treatment were randomized in a 2:1 ratio to receive HBO (n=38) or usual care without HBO (n=20). Fifty-three patients had baseline assessments and 46/58 (79%) had 12-month assessments. At the 12-month follow-up, there was not a statistically significant difference in the change from baseline in arm volume. The median change from baseline was -2.9% in the treatment group and -0.3% in the control group. The study protocol defined response as at least an 8% reduction in arm volume relative to the contralateral arm. According to this definition, 9 of 30 (30%) of patients in the HBO group were considered responders compared with 3 of 16 (19%) in the control group; the difference between groups was not statistically significant. Other outcomes, e.g., quality-of-life scores on the Short-Form (SF)-36, were similar between groups.

There are limited data on use of HBO to treat arm lymphedema or radiation-induced injury in the head and neck after radiotherapy, as well as early use of HBO after radiation therapy to reduce side effects.

**Idiopathic femoral neck necrosis**

A double-blind RCT that evaluated HBO therapy to treat femoral head necrosis was published in 2010 by Camporesi and colleagues. The study included 20 adult patients with idiopathic unilateral femoral head necrosis. Patients received 30 treatments over 6 weeks with either HBO at 2.5 ATA (n=10) or a sham treatment consisting of hyperbaric air (n=10). The mean severity of pain on a 0-to-10 scale was significantly lower in the HBO group than the control group after 30 sessions (p<0.001) but not after 10 or 20 sessions. (The article did not report exact pain scores.) Several range-of-motion outcomes were also reported; degrees were the unit of measurement. At the end of the initial treatment period, extension, abduction and adduction, but not flexion, were significantly greater in the HBO group compared to the control group. Longer-term comparative data were not available because the control group was offered HBO at the end of the initial 6-week treatment period. This single, small short-term RCT represents insufficient data on which to draw conclusions about the efficacy of HBO for treating femoral head necrosis.

**Migraine**

A 2008 Cochrane review by Bennett and colleagues identified RCTs that evaluated the effectiveness of systemic HBO therapy for preventing or treating migraine headache compared to another treatment or a sham control. In a search of the literature through May 2008, 5 trials with a total of 103 patients were identified that addressed treatment of acute migraine with HBO. A
pooled analysis of 3 trials (total of 43 patients) found a statistically significant increase in the proportion of patients with substantial relief of migraine within 45 minutes of HBO treatment (RR: 5.97, 95% CI: 1.46-24.38, p=0.001). No other pooled analyses were conducted due to variability in the outcomes reported in the trials. The meta-analysis did not report data on treatment effectiveness beyond the immediate post-treatment period, and the methodologic quality of individual trials was moderate to low, e.g., randomization was not well-described in any trial.

**Herpes Zoster**

In 2012, Peng and colleagues in China published an RCT evaluating HBO as a treatment of herpes zoster. Sixty-eight patients with herpes zoster diagnosed within the previous 2 weeks were randomized to 30 sessions of HBO therapy (n=36) or medication treatment (n=32). Pharmacotherapy included antiviral, pain, nerve nutritive and antidepressive medication. Therapeutic efficacy was calculated at the end of the 3-week treatment period and included the proportion of patients who were healed (i.e., complete subsidence of pain and rash) or improved (i.e., significant pain relief and rash subsistence). Rates of therapeutic efficacy were 97.2% in the HBO group and 81.3% in the medication group. The difference between groups was statistically significant, p<0.05. In the HBO group, 22 of 36 patients (61%) were considered to be healed and 13 (36%) were improved. In the medication group, 17 of 32 (53%) patients were healed and 9 (28%) were improved. Limitations of the study include a lack of blinding and lack of long-term follow-up. The evidence from this single RCT is insufficient to draw conclusions about the effect of HBO on health outcomes for patients with herpes zoster.

**Fibromyalgia**

One quasi-randomized trial and 1 delayed-treatment RCT on HBOT for fibromyalgia were identified. In 2004, a study by Yildiz et al included 50 patients with fibromyalgia who had ongoing symptoms despite medical and physical therapy. On an alternating basis, patients were assigned to HBOT or a control group. HBOT consisted of fifteen 90-minute sessions at 2.4 ata (1 session per day, 5 d/wk). The control group breathed room air at 1 ata on the same schedule. Baseline values on the 3 outcomes were similar in the 2 groups. After the course of HBOT treatment, the mean (SD) number of tender points were 6.04 (1.18) in the HBOT group and 12.54 (1.10) in the control group. The mean (SD) pain threshold was 1.33 kg (0.12) and 0.84 kg (0.12), respectively, and the mean VAS was 31.54 (8.34) and 55.42 (6.58), respectively. In the study abstract, the authors stated that there were statistically significant differences between the HBOT and the control groups after 15 therapy sessions, but the table presenting outcomes lacked the notation used to indicate between-group statistical significance. It is not clear whether the control group actually received a sham intervention that would minimize any placebo effect (ie, whether the control intervention was delivered in a hyperbaric chamber). The authors stated that the study was double-blind but did not specify any details of patient blinding.

In 2015, Efrati et al published an RCT that included 60 female patients who had fibromyalgia for at least 2 years and were symptomatic. Patients were randomized to an immediate 2-month course of HBOT or delayed HBOT after 2 months. The HBOT protocol was forty 90-minute sessions of 100% oxygen at 2 ata (1 session per day, 5 d/wk). Forty-eight of 60 patients (80%) completed the study and were included in the analysis. After the initial 2 months, outcomes including number of tender points, pain threshold, and QOL (SF-36) were significantly better in the immediate treatment group than the delayed treatment group (which received no specific intervention.
during this time). After the delayed treatment group had undergone HBOT, outcomes were significantly improved compared with scores prior to HBOT treatment. These findings are consistent with a clinical benefit of HBOT, but also with a placebo effect. A sham control is needed to confirm the efficacy of HBOT in the treatment of fibromyalgia and other conditions where primary end points are pain and other subjective outcomes.

The above studies were few in number with relatively small sample sizes and they have methodological limitations (eg, quasi-randomization and no or uncertain sham control for a condition with subjective outcomes susceptible to a placebo effect). Moreover, the HBOT protocol varied (eg, 15 HBOT sessions vs 40 HBOT sessions). Thus, the evidence is insufficient to draw conclusions about the impact of HBOT on health outcomes for patients with fibromyalgia.

Mental Illness
A Rapid Response Report from the Canadian Agency for Drugs and Technologies in Health searched the literature through July 2014 on the clinical effectiveness of HBOT for treatment of adults with posttraumatic stress disorder, generalized anxiety disorder, and/or depression.69 The review’s inclusion criteria were health technology assessments, systematic reviews, meta-analyses, RCTs, or nonrandomized studies comparing HBOT with any active treatment and reporting clinical outcomes. No eligible studies were identified.

Multiple Sclerosis
A Cochrane review of RCTs on HBOT for multiple sclerosis was published by Bennett et al in 2004.70 The authors identified 9 RCTs, with a total of 504 participants, that compared the effects of HBOT with placebo or no treatment. The primary outcome of the review was score on the Expanded Disability Status Scale (EDSS). A pooled analysis of data from 5 trials (n=271) did not find a significant difference in change in the mean EDSS after 20 HBOT treatments versus control (mean difference [MD], -0.07; 95% CI, -0.23 to 0.09). Moreover, a pooled analysis of data from 3 trials (n=163) comparing HBOT and placebo did not find a significant difference in mean EDSS after 6 months of follow-up (MD = -0.22; 95% CI, -0.54 to 0.09).

Summary of Evidence
The evidence for the use of topical hyperbaric oxygen therapy (HBOT) in individuals who might respond to increased oxygen delivery to tissues includes primarily of case series and case reports. Relevant outcomes are overall survival, symptoms, change in disease status, and functional outcomes. Only 1 randomized controlled trial (RCT) was published on any indication. This study, in patients with diabetic foot ulcers, had a small sample size and did not find a significant benefit of topical hyperbaric oxygen therapy. The evidence is insufficient to determine the effects of the technology on health outcomes.

The evidence for the use of systemic HBOT in individuals with nonhealing diabetic wounds of the lower extremities, acute traumatic ischemia, soft-tissue radiation necrosis (eg, radiation enteritis, cystitis, proctitis), osteoradionecrosis (ie, pre- and posttreatment), planned dental surgery (non-implant-related) of an irradiated jaw, gas gangrene, and profound anemia with exceptional blood loss when blood transfusion is impossible or must be delayed includes systematic reviews and/or recommendations from the Undersea and Hyperbaric Medical Society’s (UHMS). Relevant outcomes include overall survival, symptoms, change in disease status, and functional outcomes. For all of the above indications, evidence and/or USMS guidelines support use of HBOT. The
evidence is sufficient to determine qualitatively that the technology results in a meaningful improvement in health outcomes.

The evidence for the use of systemic HBOT in individuals with any condition other than those specified in the previous paragraph includes systematic reviews, 1 or a few small RCTs or small uncontrolled studies. Relevant outcomes include overall survival, symptoms, change in disease status, and functional outcomes. The available studies do not demonstrate that HBOT improves relevant outcomes. The evidence is insufficient to determine the effects of the technology on health outcomes.

Clinical Input Received through Physician Medical Societies and Academic Medical Centers

While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

In response to requests, input was received through 6 Physician Specialty Societies and 5 Academic Medical Centers while this policy was under review in 2010. While the various Physician Specialty Societies and Academic Medical Centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the Physician Specialty Societies or Academic Medical Centers, unless otherwise noted. The clinical input was variable depending on the condition. There was universal agreement that topical hyperbaric therapy and systemic hyperbaric oxygen therapy for autism spectrum disorders and headache/migraine are investigational. There was also wide support for changing acute carbon monoxide poisoning, compromised skin grafts or flaps, chronic refractory osteomyelitis, and necrotizing soft tissue infections to the list of medically necessary indications for hyperbaric oxygen treatment. Several reviewers acknowledged that there is a paucity of clinical trials on hyperbaric oxygen treatment for compromised skin grafts/flaps, necrotizing soft tissue infections, and chronic refractory osteomyelitis. These reviewers commented on the support from basic science, animal studies, and retrospective case series, as well as lack of effective alternative treatments for these conditions.

Based on the available evidence and clinical input, acute carbon monoxide poisoning and chronic refractory osteomyelitis were changed in 2010 to medically necessary indications for hyperbaric oxygen therapy. However, despite the clinical input and given the limited published evidence, compromised skin grafts and flaps and necrotizing soft tissue infections are still considered investigational.

Practice Guidelines and Position Statements

In 2015, the Undersea and Hyperbaric Medical Society (UHMS) published a guideline on use of HBO for treating foot ulcer. Recommendations are:

- Suggest against using HBOT in patients with “Wagner Grade 2 or lower diabetic foot ulcers....”
- Suggest adding HBOT in patients with “Wagner Grade 3 or higher diabetic foot ulcers that have now shown significant improvement after 30 days of [standard of care] therapy....”
• Suggest “adding acute post-operative hyperbaric oxygen therapy to the standard of care” in patients with “Wagner Grade 3 or higher diabetic foot ulcers” who have just had foot surgery related to their diabetic ulcers.

The UHMS has published indications they consider appropriate for hyperbaric oxygen therapy (2011). These indications are as follows:

• Air or gas embolism
• Carbon monoxide poisoning and carbon monoxide complicated by cyanide poisoning
• Clostridial myositis and myonecrosis (gas gangrene)
• Crush injury, compartment syndrome, and other acute traumatic ischemias
• Decompression sickness
• Arterial insufficiencies
  o Central retinal artery occlusion
  o Enhancement of healing in selected problem wounds
• Severe anemia
• Intracranial abscess
• Necrotizing soft tissue infections
• Osteomyelitis (refractory)
• Delayed radiation injury (soft tissue and bony necrosis)
• Skin grafts and flaps (compromised)
• Acute thermal burn injury
• Idiopathic sudden sensorineural hearing loss (ISSNHL) (patients with moderate to profound ISSNHL who present within 14 days of symptom onset)

In 2012, the American Academy of Otolaryngology-Head and Neck Surgery published a clinical guideline on treatment of sudden hearing loss. The guideline includes a statement that HBO may be considered a treatment option for patients who present within 3 months of a diagnosis of idiopathic sudden sensorineural hearing loss. The document states, “Although HBOT is not widely available in the United States and is not recognized by many U.S. clinicians as an intervention for ISSNHL, the panel felt that the level of evidence for hearing improvement, albeit modest and imprecise, was sufficient to promote greater awareness of HBOT as an intervention for [this condition]”

U.S. Preventive Services Task Force Recommendations – Not applicable

Medicare National Coverage
As of April 1, 2003, the Centers for Medicare and Medicaid Services (CMS) added Medicare coverage of HBO for diabetic wounds of the lower extremities meeting certain criteria. Medicare coverage is provided for HBO administered in a chamber for the following conditions:

• Acute carbon monoxide intoxication (ICD-9-CM diagnosis 986)
• Decompression illness (ICD-9-CM diagnosis 993.2, 993.3)
• Gas embolism (ICD-9-CM diagnosis 958.0, 999.1)
• Gas gangrene (ICD-9-CM diagnosis 0400)
• Acute traumatic peripheral ischemia. HBO therapy is a valuable adjunctive treatment to be used in combination with accepted standard therapeutic measures when loss of function, limb, or life is threatened (ICD-9-CM diagnosis 902.53, 903.01, 903.1, 904.0, 904.41).
Hyperbaric Oxygen Pressurization (HBO)

- Crush injuries and suturing of severed limbs. As in the previous conditions, HBO therapy would be an adjunctive treatment when loss of function, limb, or life is threatened (ICD-9-CM diagnosis 927.00-927.03, 927.09-927.11, 927.20-927.21, 927.8-927.9, 928.00-928.01, 928.10-928.11, 928.20-928.21, 928.3, 928.8-928.9, 929.0, 929.9, 996.90-996.99).
- Progressive necrotizing infections (necrotizing fasciitis) (ICD-9-CM diagnosis 728.86)
- Acute peripheral arterial insufficiency (ICD-9-CM diagnosis 444.21, 444.22, 81)
- Preparation and preservation of compromised skin grafts (not for primary management of wounds) (ICD-9CM diagnosis 996.52; excludes artificial skin graft)
- Chronic refractory osteomyelitis, unresponsive to conventional medical and surgical management (ICD-9-CM diagnosis 730.10-730.19)
- Osteoradionecrosis as an adjunct to conventional treatment (ICD-9-CM diagnosis 526.89)
- Soft tissue radionecrosis as an adjunct to conventional treatment (ICD-9-CM diagnosis 990)
- Cyanide poisoning (ICD-9-CM diagnosis 987.7, 989.0)
- Actinomycosis, only as an adjunct to conventional therapy when the disease process is refractory to antibiotics and surgical treatment (ICD-9-CM diagnosis 039.0-039.4, 039.8, 039.9)
- Diabetic wounds of the lower extremities in patients who meet the following three criteria:
  - Patient has type 1 or type 2 diabetes and has a lower extremity wound that is due to diabetes;
  - Patient has a wound classified as Wagner grade III or higher; and
  - Patient has failed an adequate course of standard wound therapy.

The use of HBO therapy is covered as adjunctive therapy only after there are no measurable signs of healing for at least 30 days of treatment with standard wound therapy and must be used in addition to standard wound care. Standard wound care in patients with diabetic wounds includes: assessment of a patient’s vascular status and correction of any vascular problems in the affected limb, if possible, optimization of nutritional status, optimization of glucose control, debridement by any means to remove devitalized tissue, maintenance of a clean, moist bed of granulation tissue with appropriate moist dressings, appropriate off-loading, and necessary treatment to resolve any infection that might be present. Failure to respond to standard wound care occurs when there are no measurable signs of healing for at least 30 consecutive days. Wounds must be evaluated at least every 30 days during administration of HBO therapy. Continued treatment with HBO therapy is not covered if measurable signs of healing have not been demonstrated within any 30-day period of treatment.

Medicare continues to consider topical HBO therapy ineligible for coverage.

VI. Important Reminder
The purpose of this Medical Policy is to provide a guide to coverage. This Medical Policy is not intended to dictate to providers how to practice medicine. Nothing in this Medical Policy is intended to discourage or prohibit providing other medical advice or treatment deemed appropriate by the treating physician.

Benefit determinations are subject to applicable member contract language. To the extent there are any conflicts between these guidelines and the contract language, the contract language will control.
This Medical Policy has been developed through consideration of the medical necessity criteria under Hawaii’s Patients’ Bill of Rights and Responsibilities Act (Hawaii Revised Statutes §432E-1.4), generally accepted standards of medical practice and review of medical literature and government approval status. HMSA has determined that services not covered under this Medical Policy will not be medically necessary under Hawaii law in most cases. If a treating physician disagrees with HMSA’s determination as to medical necessity in a given case, the physician may request that HMSA reconsider the application of the medical necessity criteria to the case at issue in light of any supporting documentation.

VII. References