Special Article

Hyperbaric Oxygen Therapy: Indications, Benefits and Nursing Management

Yisak Alemayehu, RN, BSc MSc Candidate
Tehran University of Medical Sciences-International Campus
Mekelle University College of health sciences; Ayder comprehensive specialized Hospital

Frank Kiwanuka, MSc Candidate
Tehran University of Medical Sciences-International Campus, Tehran, Iran

Maryam Muhamaddi, BSc, MSc Candidate
Tehran University of Medical Sciences-International Campus, Tehran, Iran

Mesomeeh Imanipour, PhD
Department of Critical Care Nursing and Management, Tehran University of Medical Sciences-School of Nursing, Tehran, Iran

Sanaz Akhavan Rad, BSc MSc
Alameh Ghazivin University, Iran

Correspondence: Frank Kiwanuka, MSc Candidate, Tehran University of Medical Sciences-International Campus, Tehran, Iran E-mail: f.kiwanuka1@gmail.com

Abstract

Background: Hyperbaric Oxygen Therapy (HBOT) is one of the advanced therapeutic modalities for wound management. It has the specific potential to ameliorate tissue hypoxia, diminish pathologic inflammation, and alleviates wound ischemia.
Objectives: To review the evidence concerning indications, benefits and nursing elements associated with the use of HBOT.
Findings: HBOT has various indications which include: air or gas embolism, carbon monoxide poisoning, clostridial myositis, andmyonecrosis, crush injuries, compartment syndrome and other traumatic ischemias, decompression sickness, arterial and venous Insufficiencies, severe anemia, intracranial abscesses, necrotizing infections, osteomyelitis, radiation injury, osteoradionecrosis, compromised grafts and flaps; acute thermal burn injury and idiopathic sudden sensorineural hearing loss. HBOT is promising for conditions which have been highlighted to have few successful alternative treatments, and for which morbidity and mortality correlated to treatment failure are significant such as more advanced Wagner Grades 3 and 4 Diabetic Foot Ulcers.
Nursing elements: the nursing care plan for a patient and family undergoing HBOT includes education, preparation of a patient for an HBOT session, evaluation of wound evolution, follow-up care and management of unpleasant feelings associated with HBOT.

Key words: Hyperbaric Oxygen Therapy: Indications, Benefits, Wounds, Nursing

Introduction

The Undersea and Hyperbaric Medical Society (UHMS) defines Hyperbaric Oxygen therapy (HBOT) as an intervention that involves the intermittent exposure of the body to 100% oxygen at a pressure >1 atmosphere absolute (ATA) (Levett, Bennett, & Millar, 2015; UHMS, 2019). HBOT is administered in two ways; 1) in a multi-place chamber where air within the chamber is pressurized and each patient receives 100% oxygen

through a gas mask; 2) through a mono-place chamber where a single patient is totally surrounded by pressurized oxygen.

HBOT is one of the advanced therapeutic interventions for wounds and it has a specific ability to ameliorate tissue hypoxia, diminish pathologic inflammation, and alleviates wound ischemia(Fife, Eckert, & Carter, 2016). HBOT is a treatment designed to increase oxygen supply to wounds that are not responding to other treatments. In addition, it involves people breathing pure oxygen in a specially designed compression chamber (Kranke, Bennett, Roeckl-Wiedmann, & Debus, 2004).The biochemical mechanism of HBOT has been clearly explained over the past two decades. It involves controlled creation of reactive oxygen and nitrogen species. In so doing, there is potentiation and increased levels of growth factors and activation of various growth factor receptors. This is partly attributed to mobilization of the bone-marrow-derived progenitor cells, altered integrin function, synthesis of hemoxygenase-1, heat shock proteins, hypoxia-inducible factor-1 and chemokine monocytes. Such a mechanism induced by HBOT helps to resolve the pathologic inflammation and ischemia at the wound site (Fife et al., 2016). Although studies highlights indications of HBOT are numerous, evidence on the nursing management associated with HBOT is scanty. We will review data on indications of HBOT, evidence on its benefits and propose a new paradigm for the appropriate nursing management of a patient receiving HBOT.

INDICATIONS OF HBOT

The Hyperbaric Oxygen Therapy Committee has recommended fourteen indications for which *in vitro and in vivo* pre-clinical research finding in addition to profound clinical experience have been convincing (UHMS, 2018). These are as follows; (i) *Air or gas embolism;* where available hyperbaric oxygen therapy is an effective approach to management of air embolism (Brodbeck, Bothma, & Pease, 2018). (ii) *Carbon monoxide poisoning* or Carbon monoxide poisoning complicated by cyanide poisoning. iii) *Clostridial myositis and myonecrosis* (gas gangrene). (iv) *Crush injuries, compartment syndrome and other traumatic ischemias:* The Hyperbaric Oxygen Brain Injury Treatment (HOBIT) trail showed that HBOT is potentially a significant treatment in the acute phase of severe Traumatic Brain Injury (TBI) (Daly et al., 2018). (v) *Decompression sickness*.vi) *Arterial and venous Insufficiencies* for example Central retinal artery occlusions and selected problem wounds including Diabetic Foot Ulcers (DFUs) (microvascular insufficiency). HBOT is beneficial in preventing amputation and promoting total wound healing among patients with Wagner Grade 3 and more severe DFUs which are refractory to more than 30 days of treatment as well as those that have immediately undergone surgical debridement (Huang et al., 2015).Indeed, a randomized double blind study showed that HBOT may improve refractory healing in venous leg ulcers and returning non-healing ulcers to a healing trajectory (Thistlethwaite et al., 2018). vi) *Severe anemia*; (vii) *Intracranial abscesses*. (viii) Necrotizing infections; HBOT is an adjunctive treatment modality for treatment of children and adults with necrotizing fasciitis. Conversely, Levett, Bennet and Millar's (2015) systematic that included all randomized and pseudo-randomized trials highlighted that relevant clinical evidence supporting its used in this patient subpopulation was lacking (Levett et al., 2015). (ix) HBOT has also been indicated in patients with *Osteomyelitis* (refractory).

(x) Delayed radiation injury (soft tissue and bony necrosis) such as radiation-induced gastrointestinal injury (Creutzberg, 2016; Glover et al., 2016; Hampson, Holm, & Feldmeier, 2016). In addition, HBOT has also been used for management of Osteoradionecrosis of the Jaw (ORN). However, controversy exists on the use of HBOT in such cases. There was no consistent evidence in support of HBO for either the prevention or management of ORN (Sultan et al., 2017). Furthermore, a randomized double-blind, sham-controlled phase 3 trial showed that HBOT showed no evidence that patients with radiation-induced chronic gastrointestinal symptoms (Glover et al., 2016)benefit from HBOT despite evidence shown in non-randomized studies. (xi) *Compromised grafts and flaps*; HBOT is one of the current management options to salvage ischemic or necrotizing breast Skin Flap (SF) and Nipple Areolar Complex (NAC) after Nipple-Sparing Mastectomy (NSM). However, current evidence has shown that HBOT does not appear to prevent

the progression of NAC or SF ischemia to necrosis as compared to patients not receiving HBOT following NSM (Sosin et al., 2018). (xii) *Acute thermal burn injury*. (xiii) *Idiopathic sudden sensorineural hearing loss*; HBOT is an emerging therapy for sensorineural hearing loss(Marshall University, Crigger, & Wilson, 2016).

BENEFITS OF HBOT

HBOT is an advanced therapeutic modality for conditions which have been highlighted to have few successful alternative treatments, and for which morbidity and mortality correlated to treatment failure are significant (Barilaro et al., 2017; Fife et al., 2016). It is an advanced management modality that has been shown to be effective in management of more advanced Wagner Grades 3 and 4 DFUs that are refractory to conventional wound management across various studies(Ennis, Huang, & Gordon, 2018). Use of HBOT has been shown to result in significant reduction in major amputations (Eggleton, Bishop, & Smerdon, 2015).

Furthermore, patients with fibromyalgia, HBOT decreases brain activity in the posterior cortex and rises it in the frontal, cingulate, medial temporal and cerebellar cortices, hence, leading to beneficial changes in brain areas that are known to function abnormally. In addition, the amelioration of pain induced by HBOT significantly decreases the consumption of pain-relieving drugs and also has anti-inflammatory and oxygenatory effects for patients with primary or secondary vasculitis (Barilaro et al., 2017).

Various studies have also indicated that HBOT is effective in treatment of chronic wounds that are refractory to other treatment mechanisms(Andrade & Santos, 2016). HBOT is effective in destruction of microorganisms, thus improving the function of leukocytes and macrophages, improves oxygen supply to wounds which facilitates the healing process. In addition, it significantly reduced the risk of major amputation (Andrade & Santos, 2016; André-Lévigne, Modarressi, Pignel, Bochaton-Piallat, & Pittet-Cuénod, 2016).

Where evidence exists, HBOT has also been highlighted to improve the effectiveness of antibiotics which fosters wound healing (Levett et al., 2015) HBOT has also exhibited more efficacy in acute air embolism and decompression illnesses (Fife et al., 2016).

HBOT NURSING MANAGEMENT

The Nursing management plan of a patient admitted to the hyperbaric chamber involves various steps, these include: preparation of the session (both patient and equipment), intra-session monitoring, and evaluation of evolution of the wound ("La revue de l'infirmière, 2019.). While preparing a patient for the HBOT Session, the nurse is responsible for educating the patient and family on HBOT. This reduces the overall anxiety for the patient's experience. The patient and family education should also include indications and explanation on the duration of the session.

Prior to the session, it is also important to assess for claustrophobia and other discomforts of being put in a closed chamber. HBOT involves closing a person in a closed chamber, undoubtedly, claustrophobia will be a concern (Caregiver University, 2019).

Specific Nursing assessment of a patient includes assessment for any medical device attached or implanted on the patient's body, medication history and other materials that the patient might be wearing. Due to the nature of the hyperbaric environment, certain materials are not allowed inside the hyperbaric chamber. These include: all flammable materials, matches and lighters, battery operated materials and electronics (BaroMedical Canada, 2019). Noteworthy, both nicotine and caffeine containing products such as tobacco, caffeine containing beverages should be avoided if possible. These constrict blood vessels thus reducing the effectiveness of HBOT (Neura Performance Brain Center, 2019).

In addition, the nurses should educate the patient on use of products that may produce harmful vapors in the chamber such as body oils, perfumes, lotions, nail polish and deodorants. Other materials that should be avoided during an HBOT session include hearing aids, metal framed eyeglasses, contact lenses, jewelry, watches, dentures and other devices. These should be left home or kept in the patients locker prior to the HBOT session (BaroMedical Canada, 2019).

Other nursing concerns include follow-up care and monitoring for adverse effects of HBOT. Adverse

effects of HBOT are infrequent however, it has associated with fatigue following treatment, myopia, ear barotraumas, and oxygen toxicity (Eggleton et al., 2015).There are minimal unpleasant feelings in the patient's ears caused by the pressure in the chamber. Up to 10% of patients receiving HBOT experience mild to moderate otic barotraumas (Fife et al., 2016). It is important for the nurse to explain to the patient that this is a temporary feeling and this could be minimized by manipulation of the pressure in the middle ear by the patient through yawning and swallowing to equalize the pressure (Hyperbaric Oxygen Therapy Denver, 2019).

Follow-up is need for patients undergoing HBOT. This is attributed to the fact that it is not uncommon for patients to be exhausted after the first few appointments. Moreover, it follow-up is also needed to assess evolution of the wound.

Conclusions

Studies highlighting indications and benefits of HBOT already exist. HBOT has numerous indications, it is also a uniquely beneficial modality for conditions which have been highlighted to have few successful alternative treatments, and for which morbidity and mortality correlated to treatment failure are significant. Studies reporting on nursing care of patients and families receiving HBOT are scanty. Nevertheless, the infrastructure of the hyperbaric chamber environment and sessions requires a nursing management plan that involves preparation of the session, intra-session monitoring, and evaluation of evolution of the wound.

References

Andrade, S. M. de, & Santos, I. C. R. V. (2016). Hyperbaric oxygen therapy for wound care. *Revista Gaucha de Enfermagem / EENFUFRGS*, *37*(2), e59257.

André-Lévigne, D., Modarressi, A., Pignel, R., Bochaton-Piallat, M.-L., & Pittet-Cuénod, B. (2016). Hyperbaric oxygen therapy promotes wound repair in ischemic and hyperglycemic conditions, increasing tissue perfusion and collagen deposition. *Wound Repair and Regeneration*, *24*(6), 954–965.

Barilaro, G., Francesco Masala, I., Parracchini, R., Iesu, C., Caddia, G., Sarzi-Puttini, P., & Atzeni, F. (2017). The role of hyperbaric oxygen therapy in orthopedics and rheumatological diseases. *The Israel Medical Association Journal*, *19*(7), 429–434.

BaroMedical Canada. Preparation for hyperbaric oxygen therapy. Available from: http://baromedical.ca/preparation-for-therapy-adult.php. Accessed on January 2nd 2019.

Brodbeck, A., Bothma, P., & Pease, J. (2018). Venous air embolism: ultrasonographic diagnosis and treatment with hyperbaric oxygen therapy. *British Journal of Anaesthesia*, *121*(6), 1215–1217.

Caregiver University. 8 Ways to Prepare for Your First Hyperbaric Oxygen Therapy Session. Available from: https://www.rehabmart.com/post/8-ways-to-prepare-for-your-first-hyperbaric-oxygen-therapy-session. Accessed on January 2nd 2019

Creutzberg, C. L. (2016). Hyperbaric oxygen therapy for radiation-induced injury: evidence is needed. *The Lancet Oncology*, *17*(2), 132–134.

Daly, S., Thorpe, M., Rockswold, S., Hubbard, M., Bergman, T., Samadani, U., & Rockswold, G. (2018). Hyperbaric oxygen therapy in the treatment of acute severe traumatic brain injury: A systematic review. *Journal of Neurotrauma*, *35*(4), 623–629.

Eggleton, P., Bishop, A., & Smerdon, G. (2015). Safety and efficacy of hyperbaric oxygen therapy in chronic wound management: current evidence. *Chronic Wound Care Management and Research*, 81.

Ennis, W. J., Huang, E. T., & Gordon, H. (2018). Impact of hyperbaric oxygen on more advanced wagner grades 3 and 4 diabetic foot ulcers: matching therapy to specific wound conditions. *Advances in Wound Care*, *7*(12), 397–407.

Fife, C. E., Eckert, K. A., & Carter, M. J. (2016). An update on the appropriate role for hyperbaric oxygen: indications and evidence. *Plastic and Reconstructive Surgery*, *138*(3 Suppl), 107S–16S.

Glover, M., Smerdon, G. R., Andreyev, H. J., Benton, B. E., Bothma, P., Firth, O.,Yarnold, J. (2016). Hyperbaric oxygen for patients with chronic bowel dysfunction after pelvic radiotherapy (HOT2): a randomised, double-blind, sham-controlled phase 3 trial. *The Lancet Oncology*, *17*(2), 224–233.

Hampson, N. B., Holm, J. R., & Feldmeier, J. J. (2016). Hyperbaric oxygen therapy for chronic bowel dysfunction after pelvic radiotherapy. *The Lancet Oncology*, *17*(4), e126–e127.

Huang, E. T., Mansouri, J., Murad, M. H., Joseph, W. S., Strauss, M. B., Tettelbach, W., UHMS CPG Oversight Committee. (2015). A clinical practice guideline for the use of hyperbaric oxygen therapy in the treatment of diabetic foot ulcers. *Undersea & Hyperbaric Medicine : Journal of the Undersea and Hyperbaric Medical Society, Inc*, *42*(3), 205–247.

Hyperbaric Oxygen Therapy Denver: How To Prepare For HBOT. Retrieved January 2, 2019, from https://www.neuraperformance.com/hyperbaric-oxygen-therapy-denver/preparing-for-a-hyperbaric-oxygen-therapy-session/

Kranke, P., Bennett, M., Roeckl-Wiedmann, I., & Debus, S. (2004). Hyperbaric oxygen therapy for chronic wounds. *Cochrane Database of Systematic Reviews*, (2), CD004123.

La revue de l'infirmière - Présentation - EM consulte. (n.d.). Retrieved January 1, 2019, from https://www.em-consulte.com/article/1221241/alertePM

Levett, D., Bennett, M. H., & Millar, I. (2015). Adjunctive hyperbaric oxygen for necrotizing fasciitis. *Cochrane Database of Systematic Reviews*, *1*, CD007937.

Marshall University, Crigger, C. B., & Wilson, S. L. (2016). The use of hyperbaric oxygen therapy in idiopathic sensorineural hearing loss: A case study. *Marshall Journal of Medicine*, *2*(2).

Neura Performance Brain Center. Preparing for your Hyperbaric' ' Oxygen Therapy Session. Available at: https://www.neuraperformance.com/hyperbaric-oxygen-therapy-denver/preparing-for-a-hyperbaric-oxygen-therapy-session/ accessed on January-02-2019.

Sosin, M., Bartholomew, A. J., Kerivan, L., Tousimis, E. A., Willey, S. C., & Pittman, T. A. (2018). Abstract 61. *Plastic and Reconstructive Surgery - Global Open*, *6*, 48–49.

Sultan, A., Hanna, G. J., Margalit, D. N., Chau, N., Goguen, L. A., Marty, F. M., Mawardi, H. (2017). The Use of Hyperbaric Oxygen for the Prevention and Management of Osteoradionecrosis of the Jaw: A Dana-Farber/Brigham and Women's Cancer Center Multidisciplinary Guideline. *The Oncologist*, *22*(3), 343–350.

Undersea & Hyperbaric Medical Society (UHMS). Indications for hyperbaric oxygen therapy. UHMS, 2015. Available at: https://www.uhms.org/resources/hbo-indications.html. Accessed December 17, 2018.

Thistlethwaite, K. R., Finlayson, K. J., Cooper, P. D., Brown, B., Bennett, M. H., Kay, G., Edwards, H. E. (2018). The effectiveness of hyperbaric oxygen therapy for healing chronic venous leg ulcers: A randomized, double-blind, placebo-controlled trial. *Wound Repair and Regeneration*, *26*(4), 324–331.