South African General Practitioner. 2021;2(6):228-230
https://doi.org/10.36303/SAGP.2021.2.6.0104

S Afr Gen Pract
ISSN 2706-9613 EISSN 2706-9621

VANTAGE POINT

Hyperbaric oxygen therapy

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Keywords: hyperbaric oxygen therapy, hyperbaric chamber

Definition

The Undersea and Hyperbaric Medicine Society (UHMS) defines hyperbaric oxygen therapy (HBOT) as an intervention in which an individual breathes near 100% oxygen intermittently while inside a hyperbaric chamber that is pressurised to greater than sea level pressure (1 Absolute Atmosphere [1 ATA]). For clinical purposes, the pressure must equal or exceed 1.4 ATA. This must be administered in either a monoplace (one patient) or multiplace (multiple patients) chamber.[1]

History

The first person to propose using air at various pressures for 'medical' purposes was Nathaniel Henshaw, in 1662.[2] He proposed using air at increased pressures for acute conditions, and at decreased pressures for chronic conditions. He had no knowledge of the various components of air.

Joseph Priestly is credited with discovering so-called 'dephlogisticated' air in 1774.[3] Some dispute this! It's a classic example of 'publish or be damned'. It was Anton Lavoisier who first coined the word oxygen. It was the neurological problems experienced by caisson workers in the latter part of the 1800s that fuelled the research into oxygen under pressure, and recompression therapy. In 1878 Paul Bert,[4] and in 1899 J Lorain Smith[5] published their research on the effects of oxygen under pressure on the central nervous system and the pulmonary system respectively.

The modern era of HBOT is said to have begun in 1937 when Benke and Shaw used a hyperbaric chamber to treat decompression sickness (DCS) in divers.[6]

One of the first recognised publications of the use of HBOT was Churchill-Davidson's use to treat radiotherapy-induced tissue damage in cancer patients.[6]

In 1967 the Undersea Medical Society was founded by diving and submarine medical physicians of the US Navy. In 1986, in recognition of the dual interest in diving and the clinical applications of compression therapy, the society was renamed the Undersea and Hyperbaric Medicine Society (UHMS).[6] In South Africa, HBOT falls under the auspices of the South African Undersea and Hyperbaric Medicine Association (SAUHMA).

Medical indications

In certain circumstances, HBOT represents the primary treatment modality, while in others, it is an adjunct to surgical or pharmacological interventions. Based on a thorough review of the best available research and evidence-based medicine, the UHMS recognises certain conditions for which there is strong agreement for the use of HBOT. New indications are considered for acceptance at the meeting of the HBO Committee during the annual meeting of the UHMS.[1] Ongoing research worldwide is regularly adding to the list.

Currently recognised conditions where HBOT is considered beneficial:[1]

1. Air or gas embolism
2. Arterial insufficiencies
   a. Central retinal artery occlusion
   b. Selected problem wounds
3. Carbon monoxide poisoning
4. Clostridial myonecrosis (gas gangrene)
5. Compromised grafts and flaps
6. Acute traumatic ischaemias
7. Decompression sickness
8. Radiation injuries (soft tissue and bone)
9. Sudden sensorineural hearing loss
10. Intracranial abscess
11. Necrotising soft tissue infections
12. Refractory osteomyelitis
13. Severe anaemia
14. Adjunctive treatment of thermal burns

Recent publications have highlighted the use of HBOT for fibromyalgia,[7] delaying onset of dementia,[8] pre-treatment and pre-conditioning prior to surgery,[9] and accelerated healing in sports injuries.[10]

Mechanism of action

During HBOT, the amount of oxygen available to hypoxic tissues can be increased up to fifteen times the normal level found in the body. The therapeutic mechanisms of action are both physical and physiological.

1. Increased hydrostatic pressure reduces the effects suffered from bubble-induced injuries.
2. Elevation of the partial pressure of inspired oxygen increases the production of reactive oxygen and reactive nitrogen species due to hyperoxia. Most studies have verified that the clinical efficacy derives from modulation of intracellular transduction cascades,[11] leading to:
   a. Increased wound growth factor stimulating neovascularisation.
   b. Mobilisation of stem cell progenitor cells from the bone marrow also stimulating neovascularisation.
   c. Lower monocyte chemokine synthesis reducing the inflammatory response and hence improved post ischaemic tissue survival.
   d. Ischaemic pre-conditioning changes in haem oxygenase-1, heat shock proteins, and hypoxia-inducible factor, reducing the inflammatory response and hence improved post ischaemic tissue survival.
   e. Neutrophil B-actin S-nitrosylation causing impaired B_2 integrin function and improving post ischaemia tissue survival.[12]

As with any form of medication, HBOT is not without risk. As exposure to hyperoxia in clinical HBOT protocols is rather brief, studies show that antioxidant defences are adequate so that biochemical stresses related to increases in reactive species are reversible.[13] Treatments often include so-called air breaks, where a patient breathes just air, not oxygen, for five minutes once or twice through the course of a treatment. This intervention has been demonstrated to enhance pulmonary oxygen tolerance[14] and reduce central nervous system oxygen toxicity, which may manifest as a grand mal seizure. This occurs at an incidence of approximately 1 to 4 in 10 000 patient treatments.[15] Pathological changes in association with isolated oxygen-mediated seizures have not been found in studies with guinea pigs, rabbits or humans.[16] Barotrauma to the lungs, ears, and sinuses is avoidable with trained chamber operators. Progressive myopia has been reported in patients who undergo prolonged daily therapy, but this typically reverses within six weeks after termination of treatments.[17] Development of nuclear cataracts has been reported with excessive treatments that exceed a total of 150 to 200 hours, and the change does not spontaneously reverse.[18] Some patients with diabetes experience a drop in blood sugar during hyperbaric treatments. This can be prevented by encouraging them to eat before undergoing treatment.

Contraindications to hyperbaric oxygen therapy

These may include:

1. Untreated pneumothorax
2. Severe cold or fever
3. Recent ear surgery or injury
4. Severe claustrophobia
5. Some oncological medications, and disulfiram, may require modification of the treatment protocol
6. Pregnant women are treated only in cases of life-threatening conditions to the mother herself

The majority of hyperbaric centres in South Africa utilise monoplace chambers. Potential patients are assessed by a qualified hyperbaric-trained doctor to exclude any contraindications to therapy and to establish the correct treatment protocol.

In South Africa, the willingness of medical aids to pay for hyperbaric oxygen therapy varies. While some will pay for the conditions recognised by the UHMS, others flatly refuse to pay for any indications at all.

Treatment times vary between one to one and a half hours depending on the indication and may be performed one to three times daily. Monoplace chambers are usually compressed with pure oxygen. Multiplace chambers are pressurised with air and patients breathe pure oxygen through a hood or tight-fitting face mask.[12] Divers suffering from DCS are treated for more extended periods.

Current status of hyperbaric oxygen therapy in South Africa

In South Africa, there is currently no regulation governing the establishment of centres utilising hyperbaric oxygen – strange state of affairs as 100% oxygen under pressure is regarded as a drug. This has unfortunately led to a proliferation of so-called mild hyperbaric oxygen centres mostly operated by non-medical personnel. Most operate utilising air, not oxygen, under pressures not exceeding 1.4 ATA. This translates into an oxygen partial pressure (PPO2) of 223 mmHg, whereas hyperbaric chambers generate PPO2 of up to 2 280 mmHg.

All medically supervised chambers in South Africa are accredited by SAUHMA, an ongoing process. The location and contact details of accredited hyperbaric chambers can be found on the SAUHMA website: www.sauhma.org.

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