Review Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2021;11:2:21-28.

Hyperbaric Oxygen: An Overview and its Role in the Management of Periodontal Disease

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ABSTRACT

Background: Hyperbaric medicine is a medical treatment in which an ambient pressure greater than sea level atmospheric pressure is necessary.it was initially use for treating decompression sickness and has shown great effectiveness in treating other conditions such as gas gangrene and carbon monoxide poisoning. Hyperbaric oxygen therapy involves breathing almost pure oxygen in a special room or chamber. Research has examined the possibility of using hyperbaric oxygen therapy (HBOT) treatment in the management of periodontal disease and there have been encouraging results. Patient selection for HBOT should be executed carefully and according to accepted guidelines. If safety guidelines are strictly followed, HBO therapy is a modality with an acceptable rate of complications. Doctors in all fields must familiarize themselves with recent evidence on this mode of therapy, so that their patients are not denied the gains of this modern treatment. As with most areas of medicine, in hyperbaric medicine there is a constant struggle to balance enthusiasm for progress in the field with the need to apply it on the basis of established evidence. Consideration must be given to both the benefits and the risks of a therapy when contemplating its application in any clinical situation. Therefore, this review article gives an overview of the mechanism of hyperbaric oxygen therapy, its indications, contra-indications, advantages, disadvantages and role in the management of periodontal disease.

Keywords: Hyperbaric oxygen, management, periodontal disease.

INTRODUCTION

Periodontitis is an inflammatory disease of the supporting tissues of the teeth caused by specific microorganisms or groups of specific microorganisms, resulting in progressive destruction of the periodontal ligament and alveolar bone with pocket formation, recession, or both. The term periodontitis indicates a variety of clinical manifestations of infectious disorders in which the supporting tissues of the teeth are attacked.[1] It is Basically chronic and destructive disease of the gums and periodontal tissue characterized by the formation of periodontal pocket, the loss of alveolar bone and recession. [2,3]

In general, treatment of progressive periodontitis should be multifaceted and vigorous, including mechanical, antibiotic and antiseptic therapy, and the various treatment approaches should be employed within a short time period. Because of the need, as indicated by the literature, to eliminate/reduce the periodontopathogenic bacteria in order to cure or prevent periodontal disease, novel approaches (both surgical and nonsurgical) deserve attention, in that they may provide useful as alternatives to the conventional approaches, or in combination with them. Now a day various novel therapeutic approaches are tried as an alternative to conventional therapy or in

Received: Oct. 18, 2020**: Accepted**: Dec. 16, 2020
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pISSN 2278-0076
eISSN 2321-9270

combination with conventional therapy to reduce load of periodontopathic pathogens. One of the effective therapeutic measures can be use of hyperbaric oxygen (HBO).

"Hyperbaric oxygen (HBO) therapy has been defined by the Undersea and Hyperbaric Medical Society (UHMS), as an intermittent breath of 100% of oxygen, while the treatment chamber is pressurized to a pressure greater than the atmospheric pressure at sea level (more than 1 ATM)." It is an approved medical application with widely increasing indications to treat various conditions including but not limited to, treatment of carbon monoxide poisoning, smoke inhalation, and enhancement of healing in selected problem wounds, necrotizing soft tissue infections and exceptional blood loss anemia.[4]

HBO therapy has significant physiological improvements for wound healing. Its effect was interpreted by amplifying oxygen gradients along the periphery of ischemic wounds, and promoting oxygen-dependent collagen matrix formation needed for angiogenesis.[5,6]In addition, HBO has antibacterial effects by increasing generation of oxygen free radicals, which oxidize proteins and membrane lipids, damaging DNA of the bacteria and inhibiting the bacterial metabolic functions. It is effective particularly against anaerobes and facilitates the oxygen-dependent peroxidase system by which leukocytes kill bacteria. It also improves the oxygen-dependent transport of certain antibiotics across the bacterial cell walls.[7,8]Besides the medical applications, HBO has shown a good prognosis in various dental conditions.

SOME PHYSIOLOGICAL AND BIOCHEMICAL EFFECTS OF HYPEROXIA

- Suppression of alpha-toxin production by Clostridium perfringens.[9,10]

- Bactericidal for Clostridium perfringens in vitro and in vivo (mice), (Bactericidal for others, but mostly only at pressures and durations of oxygen exposure greater than are safe to be used in clinical practice.) [11,12,13]

- Bacteriostatic for some species of Escherichia and Pseudomonas, and also for a range of enteric bacteria (Salmonella, Shigella and Proteus). [14,15,16,17]

- Improved leucocyte killing activity.[18,6]

- Promotion of fibroblast proliferation, collagen formation and angioneogenesis in problem wounds, flaps and irradiated tissues.[5,19]

- Reduced falls in adenosine triphosphate (ATP) and phosphocreatinine levels in burns and postischaemic tissue.

- Decreased white cell adherence to capillary walls, Vasoconstriction in normal blood vessels and Decreased post-traumatic tissue oedema.

- Reduced half-life of carboxy haemoglobin, improved dissociation of carbon monoxide from cytochrome-c oxidase and prevention of neuronal injury in carbon monoxide poisoning.[20]

- Decreased lipid peroxidation.

THERAPEUTIC EFFECTS OF HBO [21]

1. Immune stimulation by restoring WBC function and enhancing their phagocytic capabilities)

2. Neo-vascularization in hypoxic areas by augmenting fibroblastic activity and capillary growth.

3. It is useful in radiation tissue damage and other problem wounds.

4. Vasoconstriction reduces edema and tissue swelling while ensuring adequate Oxygen delivery and is thus useful in acute trauma wounds and burns.

5. Bactericidal for anaerobic organisms & inhibits growth of aerobic bacteria at pressures > 1.3 ATA. It Inhibits production of alpha-toxin by C Welchii and is synergistic with Aminoglycosides and Quinolones. Thus it is lifesaving in gas gangrene and severe necrotising infections.

6. Reduces half-life of Carboxyhaemoglobin from 4 to 5 hours to 20 minutes or less and is the treatment of choice for Carbon Monoxide poisoning in fire victims.

7.Mechanical effects: Direct benefit of increased pressure helps reduces bubble size in Air Embolism and Decompression Illnesses.

8. Reactivates "sleeping cells " in the penumbra region around central dead neuronal tissue. This is the basis of its use in neurological conditions. It also reduces adherence of WBCs to capillary walls and maybe useful in acute brain and spinal cord injury.[22]

BENEFICIAL EFFECTS OF HBO Following are some of the reasons that HBO is gaining acceptance rapidly the world over.[22]

1. Safe therapy with very few and minor side effects

2. Addition of HBO obviates the need for frequent surgical procedures, promotes healing and early mobilization of the patient.

3. Reduces length of hospitalization and thereby overall treatment and rehabilitation costs.

4. Only treatment available in some indications.

5. Emerging role in indications which have lifetime disabilities.

Indications for hyperbaric oxygen therapy approved by the undersea and hyperbaric medical society

1. Air or gas embolism

2.Carbon monoxide poisoning and smoke inhalation; carbon monoxide poisoning complicated by cyanide poisoning

3. Clostridial myositis and myonecrosis (gas gangrene)

4.Crush injury, compartment syndrome, and other acute traumatic ischaemias

5.Decompression sickness

6.Enhancement of healing in selected problem wounds

7. Exceptional blood loss (anaemia)

8.Intracranial abscess, actinomycosis

9.Necrotising soft tissue infections

10.Osteomyelitis (refractory)

11. Delayed radiation injury (soft tissue and bony necrosis)

12.Skin grafts and flaps (compromised)

13.Thermal burns

14.Arterial insufficiencies

15.Idiopathic sudden sensorineural hearing loss.

Limitations:

Wounds must be evaluated at least every 30 days during administration of HBOT. Continued treatment with HBO therapy is not advised if measurable signs of healing have not been demonstrated within any 30day period of treatment.

Absolute contraindications:

1. Untreated pneumothorax and pneumomediastinum
2. Severe upper respiratory tract infection
3. Pulmonary bulla ,Severe emphysema
4. Active hemorrhage and hemorrhagic disease Bronchiectasis disease
5. The formation of tuberculous cavity and hemoptysis
6. Sinus infection
7. The tension pneumothorax without treatment.
8. Concurrent administration of certain medications like Bleomycin - Causes interstitial pneumonia,Cisplatin - Causes impaired wound healing,Doxorubicin - Causes cardiotoxicity,Disulfiram – Blocks superoxide dismutase, which is protective against oxygen toxicity,Sulfamylon - Causes impaired wound healing.[23]

Relative contraindications:[24,25]

1.Upper respiratory tract infection.
2.Chronic pulmonary obstructive disease.
3.Congenital spherocytosis.
4. Eustachian tube dysfunction.
5.Asthma.
6.Pregnancy.
7. Claustrophobia.
8.Seizure disorder.
9.Hyperthermia.

POSSIBLE ADVERSE EVENTS

Minor Adverse Events

1.Barotrauma to ears and sinuses
2.Myopia
3.Accelerated cataract maturation

Major Adverse Events

1.Seizures
2.Congestive heart failure (CHF) exacerbation
3.Pulmonary edema
4.Retinal changes

TOXIC EFFECTS/COMPLICATIONS

When used in standard protocols of pressures that do not exceed 3 ATA (300 kPa) and the length of treatment is less than 120 minutes, hyperbaric oxygen therapy is safe.

1. Commonest side effect is pain in the ears (aural barotrauma) as a result of inability to equalize pressure on both sides of the tympanic membrane due to a blocked eustachian tube. [26]2.Pneumothorax and air embolism are more dangerous complications due to tear in pulmonary vasculature due pressure changes but are rare.

3. Other rare side effects are pulmonary and neurological oxygen toxicity (Paul Bert effect), retrolental fibroplasia and cataracts.[27]

4.Transient reversible myopia can also rarely occur after prolonged HBO therapy.

5.Fire is a realistic hazard but preventable by strict safety procedures and the patient may be claustrophobic.

6.Rare instances of hypersensitivity to O2 are also documented.[28]

HBO therapy can be of two major types:

- Systemic HBOT where patient breathes HBO in a pressurized chamber and O2 is delivered systemically.

- Topical HBO where O2 is delivered directly to the wound surface.

However, according to U.S. Food and Drug Administration, topical HBOT does not constitute HBOT.

Types of chambers:

Multiplace chambers: These units can accommodate between 2 and 18 or more patients and commonly incorporate a minimum pressure capability of 6.0 ATA.

Advantages

1.Constant patient attendance and evaluation (particularly useful in treating evolving neurological diseases such as decompression sickness and cerebral arterial gas embolism).
2. Multiple patients treated per session.
3.Greater working pressure.

Disadvantages

1. Higher capitalization requirements.
2. Major space requirements; basement and/or ground floor level limitations.
3. Higher operating costs.

Monoplace chambers:

They were designed for single occupancy and usually constructed of acrylic, having a pressure capability of 3.0 ATA, and compressed with 100% oxygen.

The high flow oxygen requirement is ideally supplied via a hospital's existing liquid oxygen system.[29]

Advantages

1.Cost efficient delivery of HBO2.
2.No risk of decompression sickness.
3.Portable, less space, less equipments, no hood or mask.
4.No risk of iatrogenic decompression sickness in patient or staff.

Disadvantages

1.Relative patient isolation.

2. Associated fire hazard.

3.Inability to use certain diagnostic and/or therapeutic equipment.

HBO therapy can be given in a monoplace chamber in which a single patient is placed in a chamber pressurized with 100% oxygen or it can be given in a multiplace chamber where many patients can be treated at the same time. To be effective, hyperbaric

oxygen must be inhaled in the atmosphere or through an endotracheal tube in a monoplace chamber and in multiplace chamber masks, tight-fitting hoods, or endotracheal tubes can be used.

Monoplace chambers are the most common type of chamber used due to their portability, minimal personnel requirements and low cost. Pressure and durationdepend upon the indication. It ranges from 2 to 6 ATA for 2-6 h. Decompression sickness/gas embolism may require prolonged, continuous saturation protocols. PIO2 (partial Procedure & Equipment 39 pressure of inspired) very rarely exceeds 2.8 ATA

In dentistry, HBO is indicated for the following conditions:

- Osteoradionecrosis ¬ Conditions after radiotherapy
- Osteomyelitis of jaws ¬ Mandibular osteomyelitis, chronic refractory osteomyelitis
- Periodontitis ¬ Aggressive periodontitis ,Chronic Periodontitis
- Infected implants ¬ Adjunctive therapy for the placement of the implants in irradiated jaws
- Bone regeneration
- Dry socket
- Fracture reunion

HYPERBARIC OXYGEN THERAPY AND PERIODONTITIS

Mechanism of HBOT in the Treatment of Periodontitis :

HBOT showed to increase oxygen distribution at the base of the pocket which is deleterious to periodontal pathogens, particularly to the anaerobic microorganisms.[30] Cultivation of plaque microorganisms from sites of chronic periodontitis reveals high percentages of anaerobic (90%) bacterial species.[31] HBO2 increases generation of oxygen free radicals, which oxidize proteins and membrane lipids, damaged oxyribonucleic acid and inhibit bacterial metabolic functions. It also facilitates the oxygen-dependent peroxidase system by which leukocytes kill bacteria. HBO2 also improves the oxygen-dependent transport of certain antibiotics across bacterial cell walls.[32] In this way HBOT results in inhibition of bacterial growth. HBOT would also allow the ischemic tissues to receive an adequate intake of oxygen sufficient for a rapid recovery of cell metabolism. Oxygen tension in periodontal pockets is very low (pO2 5-27 mmHg) when compared with atmospheric pO2 (155 mmHg), the arterial blood pO2 (95 mmHg), and the venous blood pO2 (20-40 mmHg).33Fibroblast and leukocyte function are severely compromised when pO2 is less or equal to 30 mmHg. HBO2 increases collagen formation for capillary growth. HBO2 also promotes fibroblast replication and collagen formation while the patient is in the hyperbaric chamber.[34,35] It also increases bactericidal function of leukocytes. HBOT also improve gingival microcirculation and increase gingival blood flow.[36] Thus in periodontal tissues, HBOT showed to have a deleterious effect on periodontal microorganisms as well as beneficial effects on periodontal healing by raising oxygen tension in pocket.

PERIODONTITIS: The effect of hyperbaric oxygen on aggressive periodontitis and subgingival anaerobes in Chinese patients, documented the effect of hyperbaric oxygen therapy. This assessment was done by measuring plaque index, gingival index, probing depth and attachment loss, two years after hyperbaric oxygen therapy was indicated. It was concluded in this study, that HBO could inhibit the growth of subgingival obligate anaerobes, facultative Applied aspect anaerobes and Bacteroides melaninogenicus, thus promoting healing of peridontium, which could help in the treatment of aggressive periodontitis.[37] The use of hyperbaric oxygen as a adjunct to scaling and root planning in patients with generalized chronic periodontitis, is found to improve the clinical parameters like probing depth and attachment level, thus indicating the beneficial effects of hyperbaric oxygen on the periodontium.[38] In a study, hyperbaric oxygen was found to stimulate the proliferation of osteoblastic cells in vitro, in presence of 10% foetal calf serum (FCS) and an inhibitory effect was observed in presence of 2% (FCS). [39]

HYPERBARIC OXYGEN AND FLAPS: The role of the elective hyperbaric oxygen protocol when either muocutaneous or free vascularized soft tissue or bone transfers are employed in radiated tissue is to develop a vascular and cellular tissue bed into which these flaps can heal. If such flaps are required as part of elective construction efforts the patient

undergoes 20 sessions of hyperbaric oxygen first, followed by the planned surgery. The patient returns to the hyperbaric oxygen chamber for the remaining 10 sessions when he or she has sufficiently recovered from the surgery (usually within a week or two). Because the hyperbaric oxygen angiogenic effects are permanent, a delay between the first 20 sessions and the surgery is not critical. In the same manner, should the patient require additional elective surgery later, a second protocol of hyperbaric oxygen is not necessary, However, it is important that the initial hyperbaric oxygen protocol of 20 sessions prior to surgery followed by 10 sessions after surgery be complete with no interruptions of more than 3 days. An interrupted or incomplete oxygen protocol doesn't develop its maximal angiogenic benefit and therefore place the patient at greater risk for wound dehiscence, wound infection and delayed wound healing. Related to wound infections the pattern of results was similar. The hyperbaric oxygen group showed an infection rate of 6% of which only 2.5% required reoperation, while the non-hyperbaric oxygen group showed an infection rate of 24% of which 16% were major infections requiring prolonged treatment and additional surgery. No doubt the use of this elective surgery protocol of hyperbaric oxygen has a proven outcome efficiency in both scientific studies and clinical experience.[40]

CONCLUSION

Hyperbaric oxygen has been successfully used in several medical applications. The therapeutic effect is related to elevated partial oxygen pressure in the tissues. Dental patients too could be benefited with this treatment approach along with the advancement in the medicines and technical equipment's used in the patient care. Although available evidences are few, HBOT was shown to improve gingival blood flow and microcirculation as they inhibit the growth of periodontal pathogens in periodontal pocket when used alone or in combination with conventional periodontal therapy. In future, further research will required to be conducted to prove potential benefits of HBOT.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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