

New Insights on Hyperbaric Oxygen Therapy for Cancer

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Abstract: Hypoxia is a critical characteristic of malignant tumors and involves enhanced cell survival, angiogenesis, glycolytic metabolism, and metastasis. Hyperbaric oxygen treatment (HBOT) has been used to improve and cure disorders involving hypoxia and ischemia, HBOT enhances the amount of dissolved oxygen in the plasma and thereby increasing O₂ delivery to the tissue. Studies on HBOT and cancer have mostly focused on whether enhanced oxygen may act as a promoter of cancer. As oxygen is believed to be required for all the major processes of wound healing, including angiogenesis, this particular idea would give the impression that HBOT will promote cancer growth and recurrence. Nevertheless, this is not the case since the use of HBOT in patients with malignancies should be considered safe and therapeutic. There is no evidence indicating that HBO neither acts as a stimulator of tumor growth nor as an enhancer of recurrence. On the other hand, there is evidence that implies that HBO has tumor-inhibitory effects, this manuscript pretends to expand our knowledge on the effect and the mechanisms behind tumor oxygenation by HBOT.

Keyword: Hyperbaric Oxygen, Cancer, oxygen, degenerative diseases, hypoxia, senescence.

INTRODUCTION

Hyperbaric oxygen treatment (HBOT) has long been thought as a relative contraindication to cancer cells since HBOT has been proposed to enhance progressive cancer growth. However, in an oxygen deficit condition, tumor cells are more progressive and metastatic [1]. HBOT increasing oxygen partial pressure may benefit tumor suppression. Hypoxia is a critical hallmark of solid tumors which favors cell survival, angiogenesis, anaerobic glycolysis metabolism, and metastasis. Hyperbaric oxygen therapy (HBOT) is a novel therapeutic approach that involves the use of pure oxygen in a pressurized chamber to treat a variety of medical conditions. The primary benefit of HBOT is that it can increase the amount of oxygen in the bloodstream, which can be beneficial for many medical conditions. HBOT has been studied as a potential treatment for a wide range of degenerative diseases, including cancer. In this manuscript, the potential benefits of HBOT for cancer and degenerative diseases will be discussed, along with relevant scientific literature. For a review on HBOT's previous applications in cancer see Manish et al [2]. HBOT saturates tumors with oxygen, reversing the cancer promoting effects of tumor hypoxia.

Overview of Hyperbaric Oxygen Therapy

HBOT is a medical therapy in which a person is exposed to oxygen at increased pressures, usually at least two times the atmospheric pressure. It is typically administered in a chamber that is pressurized with pure oxygen. During an HBOT session, a person will typically breathe pure oxygen at pressures ranging from 1.3 to 3.0 atmospheres. The duration of a session typically ranges from 1 to 2 hours.

HBOT works by increasing the amount of oxygen in the bloodstream, which can be beneficial for many medical conditions. It can also stimulate the release of growth factors and cytokines, which are proteins that play a role in healing and inflammation. In normal tissues, decreased oxygen availability inhibits mitochondrial production of ATP, stimulating an up-regulation of glycolytic enzymes to meet energy needs by substrate level phosphorylation production of ATP. Thus, the cellular response to tumor hypoxia is mediated by several of the same pathways that are overly active in cancer cells with mitochondrial damage and high rates of aerobic glycolysis [3].

Potential Benefits of Hyperbaric Oxygen Therapy for Cancer and Degenerative Diseases

Long-term HBOT improves mitochondrial activity and leads to a decrease in ROS levels, partially due to

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increases antioxidant defense mechanisms. Many diseases and conditions are characterized by mitochondrial dysfunction and imbalance between ROS and antioxidant scavengers, suggesting potential therapeutic intervention for HBOT.

HBOT and Cancer

HBOT has been studied as a potential treatment for cancer. Several studies have shown that HBOT can help reduce the size of tumors and improve survival rates in cancer patients. For example, a study of patients with advanced cancer found that those who received HBOT had significantly better survival rates than those who did not receive HBOT [4].

HBOT can also help reduce the side effects of cancer treatment. A study of patients with breast cancer found that those who received HBOT had significantly fewer side effects, such as pain and fatigue, than those who did not receive HBOT [4].

Tumor cells may adapt to ischemic and low nutrient microenvironments by three main adaptations: The angiogenic switch, deregulation of apoptosis and the glycolytic shift [5]. The most potent stimulus for angiogenesis is the metabolic stress induced by hypoxia. Inhibition of the p53 tumor suppressor gene inhibits apoptosis. Anaerobic glycolysis facilitates rapid tumor progression. Hypoxic cancers have a strong invasive potential, metastasis, resistance to therapy, and a poor clinical prognosis [6].

Main HBOT's Mechanisms against Cancer:

1. HBOT Increases free radical formation that may increase cancer cell death by increasing tumor cell oxygen tension [7].
2. HBOT induces apoptosis in cancer cells reducing tumor growth fraction by antagonizing pro survival protein Bcl-2. When cells are proliferating and DNA is unwound, unprotected and being replicated; if high ROS levels are sensed at this time, the process is aborted, and the cell can be driven into apoptosis [8].
3. HBOT increases mitochondrial energy favoring malignant cell re-differentiation by means of reprogramming energy information and gene expression [9, 10].
4. HBOT decreases malignant cell proliferation by direct oxygen inhibitory action on cell division [11].

5. HBOT improves function in dysfunctional mitochondria providing gene expression modification epi-genetic action [3, 4, 10, 12- 15].
6. HBOT increases circulation that may bring anticancer compounds to the tumor [16].
7. HBOT increases cellular and humoral immunity improving the immune attack on tumor cells [17].

HBOT has also been studied as a potential treatment for degenerative diseases, such as Alzheimer's and Parkinson's disease. A study of patients with Alzheimer's disease found that those who received HBOT had significantly improved cognitive function compared to those who did not receive HBOT [18].

HBOT has also been studied as a potential treatment for Parkinson's disease. A study of patients with Parkinson's disease found that those who received HBOT had significantly improved motor function compared to those who did not receive HBOT [4]. HBOT by increasing available oxygen reduces the activity of an enzyme called hexokinase II, which grabs onto glucose after it enters cells and traps it inside so it can be burned for energy.

Hyperbaric Oxygen Therapy and Infections

HBOT is an exceptionally powerful therapy for resolving deep-seated and otherwise non-healing infections. HBOT also appears to utilize the anti-pathogen properties of Hydrogen Peroxide in killing pathogens and resolving infections [19]. The expense and limited availability of HBOT around the country is the main limiting factor in its more routine usage. It is always worth remembering that this therapy exists when dealing with life and limb-threatening infections. No patient should ever have an infected limb amputated before all the bio-oxidative therapies, including HBOT, have been administered.

CONCLUSION

In summary, HBOT is a novel therapeutic approach that can be used to treat a variety of medical conditions, including cancer and degenerative diseases. Several studies have shown that HBOT can help to reduce the size of tumors, avoid tumor progression and improve survival rates in cancer patients, as well as reduce the side effects of cancer treatment. It can also help to improve cognitive and motor function in patients with Alzheimer's and Parkinson's disease. While more research is needed to

confirm all reported effects of HBOT, the available evidence suggests that it may be a useful treatment option for these conditions.

Tumor cells are more profoundly affected in mitochondrial functions, which opens new possibilities for exploration, to analyze to what extent their cellular metabolism is affected and whether it is possible to take advantage of this circumstance for the development of new more effective therapies and treatment protocols.

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Received on 03-04-2024

Accepted on 01-05-2024

Published on 12-06-2024

<https://doi.org/10.30683/1927-7229.2024.13.02>

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