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REVIEW ARTICLE

Hyperbaric oxygen as an adjunctive therapy in treatment of malignancies, including brain tumours

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Abstract Hyperbaric oxygen (HBO) therapy is widely used as an adjunctive treatment for various pathological states, predominantly related to hypoxic and/or ischaemic conditions. It also holds promise as an approach to overcoming the problem of oxygen deficiency in the poorly oxygenated regions of the neoplastic tissue. Occurrence of local hypoxia within the central areas of solid tumours is one of the major issues contributing to ineffective medical treatment. However, in anti-cancer therapy, HBO alone gives a limited curative effect and is typically not applied by itself. More often, HBO is used as an adjuvant treatment along with other therapeutic modalities, such as radio- and chemotherapy. This review outlines the existing data regarding the medical use of HBO in cancer treatment, with a particular focus on the use of HBO in the treatment of brain tumours. We conclude that the administration of HBO can provide many clinical benefits in the treatment of tumours, including management of highly malignant gliomas. Applied immediately before irradiation, it is safe and well tolerated by patients, causing rare and limited side effects. The results obtained with a combination of HBO/radiotherapy protocol proved to be especially favourable compared to radiation treatment alone. HBO can also increase the cytostatic effect of certain drugs, which may render standard chemotherapy more effective. The currently available data support the legitimacy of conducting further research on the use of HBO in the treatment of malignancies.

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Introduction

Hyperbaric oxygen (HBO) therapy is the use of oxygen under elevated atmospheric pressure, that is, at a pressure higher than the pressure found on the surface of the earth at sea level, which is defined to be 1 atm [1]. Currently, hyperbaric oxygenation is widely used as an adjunctive treatment for various pathological states, predominantly related to hypoxic and/or ischaemic conditions. The standard protocol for hyperbaric oxygen therapy (HBOT) specifies that patients breathe pure oxygen (*100 %) under pressure between 1.5 and 2.5 atmospheres absolute (ATA), which is defined as the sum of the atmospheric pressure and the gauge pressure inside the hyperbaric chamber.

Oxygen is transported in blood to tissues by two different, well-known mechanisms: in complex with haemoglobin in red blood cells (RBCs) and dissolved in blood plasma. Under normal atmospheric conditions, almost 97 % of the available haemoglobin is saturated with oxygen. In contrast, plasma typically contains only 0.32 % dissolved oxygen [2]. Thus, the administration of HBO does not have a large effect on oxygen delivery *via* red blood cells, but may improve haemoglobin-independent transport. HBO has additional beneficial effects, refining the elasticity of RBCs and reducing platelet aggregation, which are especially important when the underlying cause of the tissue hypoxia is cardiovascular in origin [1]. According to Henry's law, if the partial pressure of oxygen (pO_2) rises, the oxygen content in tissues will also increase [3]. Under higher pO_2, the distance that oxygen diffuses is increased. This phenomenon, along with the property that