

Oxygen Toxicity and its Prevention

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Preventing oxygen toxicity from occurring is a major goal in the application of hyperbaric oxygen therapy. However, complete prevention of the direct, intracellular, enzymatic phenomena of oxygen toxicity is not possible in the presence of high cellular oxygen tensions. While overt seizure activity is preventable by the use of anticonvulsant drugs, this does not prevent oxygen toxicity from developing at the cellular level. Most preventive strategies, such as trying to prolong the latent period, only attempt to prevent oxygen seizures, not other toxic effects occurring within the cell.

Superoxide dismutase is the cellular enzyme that degrades superoxide radicals. Catalase and glutathione peroxidase degrade hydrogen peroxide. These antioxidant enzymes are found naturally and convert harmful free radicals into harmless compounds such as water. Other biological defenses against oxygen radicals include Vitamin E, found in lipid membranes; cytoplasmic antioxidant agents, such as ascorbate; and sulfhydryl-containing compounds, such as glutathione, cysteine, and cysteamine. Because hyperoxic environments stimulate an increased production of these protective enzymes, some tolerance to repeated oxygen exposure develops; acute exposures overwhelm these protective systems. Some researchers believe that the prophylactic administration of Vitamin E to patients undergoing HBO treatments will prevent oxygen toxicity from developing at the cellular level (Vitamin E is capable of stimulating glutathione). For theoretical reasons, Vitamin E has been given empirically before HBO at many hyperbaric centers; however, irrefutable evidence to support its clinical efficacy is not available.

The most common and easily performed preventive measure involves the use of intermittent "air breaks." These breaks allow for some respite during which normal enzymatic defenses help detoxify the cellular environment. The process of intermittent "air breaks" has a long history. Soulie initially observed this phenomenon in 1939. During World War II, Donald was the first to observe that a self-contained oxygen diver could reverse early signs of neurologic oxygen poisoning by ascending to lower pressures. Lambertsen first elaborated on the practical applications of "air breaks" during hyperbaric oxygen breathing in 1955. Then during the 1960s, "air breaks" became the standard practice for all U.S. Navy oxygen treatment tables and shortly thereafter became the world standard. The efficacy of "air breaks" has passed the test of time.

An intermittent oxygen exposure delays the onset of oxygen toxic effects in all organs and tissues and has none of the limitations that are associated with pharmacologic protective agents. The basis for the superiority of this procedure as a means for extending oxygen tolerance resides in the periodic, sequential elevation and reduction of oxygen tension, rather than in the passage of a chemical agent across cellular membrane barriers.

Reference List

Clark JM. Oxygen toxicity In: Neuman, TS & Thom SR, Eds. *Physiology and medicine of hyperbaric oxygen therapy*. Philadelphia: Saunders Elsevier. 2008: 527-563.

Clark JM, Fisher AB (1977). Oxygen toxicity and extension of tolerance in oxygen therapy. In: Davis, JC, & Hunt, TK, ed. *Hyperbaric Oxygen Therapy*. (1977). Bethesda: Undersea Medical Society.

Donald, K. (1992). *Oxygen and the diver*. Worcs: The SPA Ltd.

Hammarlund C. (1994). The physiologic effects of hyperbaric oxygen. In: *Hyperbaric Medicine Practice*. EP Kindwall. Ed. Best Publishing Co.: Flagstaff, Arizona, pp. 17-32.

Hart GB, Strauss MB. Central nervous system oxygen toxicity in a clinical setting. In: Bove AA, Bachrach AJ, Greenbaum LJ, Eds. *Undersea and hyperbaric physiology IX. Proceeding of the ninth international symposium on underwater and hyperbaric physiology*. Bethesda, MD: Undersea and Hyperbaric Medical Society, 1987: 695-699.

Lambertsen CJ: Respiratory and circulatory actions of high oxygen pressure. In Goff LG (ed): *Proceedings of the Underwater Physiology Symposium*. Washington, D.C., National Academy of Sciences, National Research Council, Publication 377, 1955, pp 25-38.

Neuman, T. S. & Thom S. R., (Eds.). (2008). *Physiology and medicine of hyperbaric oxygen therapy*. Philadelphia: Saunders Elsevier.

Soulie P: Modifications experimentales de la resistance individuelle de certains animaux a l'action toxique de l'oxgene, CR Seances Soc Biol 130:541-542, 1939

