

Hyperbaric oxygen preconditioning improves postoperative cognitive dysfunction by reducing oxidant stress and inflammation

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Abstract

Postoperative cognitive dysfunction is a crucial public health issue that has been increasingly studied in efforts to reduce symptoms or prevent its occurrence. However, effective advances remain lacking. Hyperbaric oxygen preconditioning has proved to protect vital organs, such as the heart, liver, and brain. Recently, it has been introduced and widely studied in the prevention of postoperative cognitive dysfunction, with promising results. However, the neuroprotective mechanisms underlying this phenomenon remain controversial. This review summarizes and highlights the definition and application of hyperbaric oxygen preconditioning, the perniciousness and pathogenetic mechanism underlying postoperative cognitive dysfunction, and the effects that hyperbaric oxygen preconditioning has on postoperative cognitive dysfunction. Finally, we conclude that hyperbaric oxygen preconditioning is an effective and feasible method to prevent, alleviate, and improve postoperative cognitive dysfunction, and that its mechanism of action is very complex, involving the stimulation of endogenous antioxidant and anti-inflammation defense systems.

Key Words: nerve regeneration; brain injury; hyperbaric oxygenation; preconditioning; antioxidants; anti-inflammation; reactive oxygen species; oxidant stress; inflammation; protection; post-operation; cognitive dysfunction; neural regeneration

Introduction

Postoperative cognitive dysfunction (POCD) is a complication of surgery that is widely considered an important clinical problem, particularly in elderly patients (Shoair et al., 2015). However, the pathophysiology underlying POCD is fairly complex, involving numerous mechanisms including oxidant stress, inflammation, and apoptosis (Eckenhoff et al., 2004; Dong et al., 2009; Thom, 2009; Cao et al., 2012; Wilson et al., 2013). Over the past several decades, researchers have explored a wide array of methods for improving POCD, including hyperbaric oxygen preconditioning (HBOPC). HBOPC is one of the most economical, simple, safe, and effective strategies among all the possible choices (Zhu et al. 2016). Indeed, studies have successfully utilized HBOPC to improve cognitive dysfunction (Alex et al., 2005; Peng et al., 2010; Sun et al., 2014). The purpose of this narrative review is to summarize and discuss the literature concerning HBOPC and POCD, with an emphasis on the evidence for a role of HBOPC in treating patients undergoing POCD. The review is organized into the following sections: introduction of HBOPC, mechanisms underlying POCD, and the effect of HBOPC on POCD (Figure 1).

HBOPC

Definition of HBOPC

During HBO treatment, patients usually inhale pure oxygen (100%) at pressures greater than the atmospheric pressure in a steel vessel (Löndahl, 2012), which increases both the dissolved oxygen and the partial pressure of oxygen in blood plasma (Tibbles and Edelsberg, 1996). Consequently, a large amount of oxygen-dependent reactions and signaling pathways are enhanced (Babchin et al., 2011).

Application of HBOPC

Normobaric oxygen and various levels of HBO have been widely utilized therapeutic agents, and Valenzuela pioneered the application of pure oxygen (as high as 2 MPa) in clinical research (Edwards, 2010). The use of HBO as an adjuvant treatment for a number of medical conditions has been widely supported by the experience of experts in hyperbaric medicine and the scientific literature in areas such as traumatic brain injury (Hu et al., 2016; Zhou et al., 2016a, b) complex refractory wounds (Morykwas and Argenta, 1996), cerebral infarction (Tian, 2015), and radiation-tissue injury (Kindwall and Hunt, 1995; Kindwall and Wheland, 1999). Along with the development of medicines, disease prevention has increasingly become recognized as important. Pre-

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