Hyperbaric oxygen therapy and promoting neurological recovery following nerve trauma

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ABSTRACT

There is a constant search for new techniques that induce more extensive and rapid wound healing. Hyperbaric oxygen therapy (HBO_2T) involves placing a patient in a sealed chamber and elevating its pressure several-fold above ambient air pressure while the patient breathes 100% oxygen. HBO_2T induces a number of physiological actions, and which wounds are selected for HBO_2T depends on the specific actions of HBO_2T relative to the wound's healing requirements. Although nerve traumas are not yet indicated for HBO_2T, there are many animal and clinical examples showing the benefits of HBO_2T in inducing neurological recovery following nerve trauma. This review examines the general mechanisms required to induce wound healing and the actions of HBO_2T which meet these requirements. It then examines the requirements for inducing axon regeneration and how many are met by HBO_2T. Finally, we discuss anecdotal evidence that HBO_2T enhances the rate and extent of axon regeneration in both animal models and clinically. We conclude that HBO_2T triggers most of the mechanisms required to induce axon regeneration.

WOUNDS AND WOUND HEALING

Certain characteristics of wounds (ischemic appearance, a history of a lack of healing, physical examination yielding no pulse or a transcutaneous oxygen evaluation suggesting tissue hypoxia), identify a wound as hypoxic, or related to arterial disease. What factors allow one to identify and classify patients with arterial wounds? How does one manage those primarily caused by peripheral arterial occlusion or damage? When and how does one use transcutaneous oximetry to evaluate this subgroup of patients and the use of endovascular interventions such as arteriography, angioplasty and arterial stenting? When is the use of hyperbaric oxygen therapy (HBO_2T) appropriate, and when should it be used to provide arterial revascularization to manage wounds?

Collagen production is maximal at 250mm Hg and falls to almost zero in severe clinical hypoxia (Km=25 mm Hg pO_2) [1-4] due to the failure of collagen fibril cross-linking, which requires the hydroxylation of proline and lysine to synthesize mature collagen [5]. Cell motility decreases as available cell energy production via oxygen decreases to or below 10mm Hg pO_2 [6-8]. Re-epithelization, essential to wound healing, is oxygen-dependent [9-11]. Similarly, elimination of bacteria within a wound is oxygen-dependent due to oxidative killing of bacteria [12-14], and reaches its maximal effect at several hundred mm Hg pO_2, and drops to almost zero in hypoxic patients [15,16]. Thus, since enhanced oxygen presentation induces events required for wound healing, HBO_2T, which provides enhanced oxygen to tissues, is a reasonable place to start wound healing therapy [8,17,18]. However, before discussing HBO_2T itself, it is important to consider the potential influences of oxygen on wound healing.

Bacterial infection

Although many factors contribute to poor wound healing, the most common is wound infection caused by foreign debris and necrotic tissue [19,20]. Therefore, debridement of all necrotic tissue and debris, whether performed by surgical means, the use of enzymatic agents or wound dressings, is critical for achieving wound healing [21].

However, wound hypoxia predisposes tissue to bacterial infection and inhibited wound healing by hypoxia by blocking fibroblast proliferation, collagen production and capillary angiogenesis [22], and also because leukocytes' oxidative phosphorylation bactericidal activities are severely impeded without normal