

Recent advances in hydrogen research as a therapeutic medical gas

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Abstract

Recent basic and clinical research has revealed that hydrogen is an important physiological regulatory factor with antioxidant, anti-inflammatory and anti-apoptotic protective effects on cells and organs. Therapeutic hydrogen has been applied by different delivery methods including straightforward inhalation, drinking hydrogen dissolved in water and injection with hydrogen-saturated saline. This review summarizes currently available data regarding the protective role of hydrogen, provides an outline of recent advances in research on the use of hydrogen as a therapeutic medical gas in diverse models of disease and discusses the feasibility of hydrogen as a therapeutic strategy. It is not an overstatement to say that hydrogen's impact on therapeutic and preventive medicine could be enormous in the future.

Keywords: *Molecular hydrogen, radical oxygen species, antioxidant therapy*

Introduction

Hydrogen is the lightest and most abundant chemical element and provides the source of energy for the sun by nuclear fusion to produce helium. Since Ohsawa et al. [1] discovered that hydrogen gas has antioxidant and anti-apoptotic properties that protect the brain against ischemia-reperfusion (I/R) injury and stroke by selectively neutralizing hydroxyl radicals, hydrogen gas has come to the forefront of therapeutic medical gas research. Accumulated evidence in a variety of biomedical fields using clinical and experimental models for many diseases proves that hydrogen, administered either through gas inhalation or consumption of an aqueous hydrogen-containing solution, can act as a scavenger to selectively alleviate reactive oxygen species (ROS) and exert potent cellular protective effects (Figure 1). This review will focus on the physiological roles of hydrogen in humans, its feasibility as a therapeutic strategy and the possible mechanisms involved in its protective

effects. Additionally, the findings of recent studies of hydrogen in different disease models are summarized.

Chemistry of hydrogen and its industrial use

Hydrogen is a colourless, odourless, non-metallic, tasteless and highly combustible diatomic gas with the molecular formula H₂. Robert Boyle first produced hydrogen gas artificially by dissolving iron in diluted hydrochloric acid in 1671. Henry Cavendish recognized that hydrogen was a discrete gas and referred to it as 'inflammatory air'. Lavoisier named this property 'hydrogen' in 1783 from the Greek words *hydro*, 'water', and *genes*, 'forming'. Free hydrogen is comparatively rare on earth, as Earth's atmosphere contains less than 1 part per million of hydrogen, although hydrogen constitutes nearly 75% of the universe's elemental mass. The majority of hydrogen atoms are found in water and organic compounds. Hydrogen is highly reactive to oxygen

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