Pulmonary Oxygen Toxicity

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Why does oxygen cause damage to the lung?

Animal studies have shown that when the lungs are exposed to high levels of oxygen that deterioration occurs progressively by steps that overlap. The first step is an acute outpouring of fluid into the tissues of the lung, filling the spaces usually full of air. Following this there is bleeding between the air sacs that changes into a gummy layer and then into tough membranes and destruction of capillary and type I alveolar epithelial cells. The fluid phase merges into a subacute phase that is characterized by production of tissuesusually seen in attempts at healing, resultin in thickening and scarring. There are type II alveolar epithelial cells produced and partial clearing of earlier acute changes. These changes are influnced by the concentration of inspired O2, duration of exposure and other factors such as species differences.

The lungs of human patients who die after prolonged oxygen therapy have the same damage as is seen in pulmonary oxygen toxicity in experimental animals. The clinical course of these patients, in conjunction with the known susceptibility of humans to oxygen toxicity, leaves no doubt that the observed pathologic changes are caused by pulmonary oxygen toxicity. In monkies and presumably also in humans, recovery from pulmonary oxygen intoxication is accompanied by complete resolution of changes typical of the early fluid phase. However, when exposure to hyperoxia is sufficiently prolonged for the development of prominent scarring , recovery from these pathologic effects is greatly delayed, and chronic changes may be left in the lungs.

Symptoms of pulmonary oxygen poisoning begin slowly as a substernal irritation that becomes progressively more intense and widespread along with with increased coughing. Uncontrollable coughing occurs in severe cases, symptoms originating in the trachea and major bronchi associated with a constant burning

sensation, which is worsened by inspiration. The most severe symptoms are associated with shortness of breath on exertion or even at rest. The onset of symptoms is variable among individuals but usually occurs after about 12 to 16 hours of exposure at 1.0 ata, 8 to 14 hours at 1.5 ata, and 3 to 6 hours at 2.0 ata. (ata= 33 ft sea water)

Pulmonary function changes to hyperoxic O2 exposures include:
1. decreases in inspiratory and expiratory lung volumes
2. decreases in flow rates
3. decreases in carbon monoxide diffusing capacity
4. decrease in lung compliance.

Arterial oxygenation was maintained at rest during early reversible stages of pulmonary intoxication but was detectably impaired during exercise after hyperoxic exposure. The ability to move air in and out is impaired earlier and more severely than is gas exchange function in normal humans exposed continuously to elevated oxygen pressures.

Should I be worried about oxygen treatments in a chamber?

Humans can live normally for seven days with elevated oxygen levels at about half ata, although the level of hyperoxia that can be tolerated indefinitely with no pulmonary effects cannot be identified with certainty. However, exposure for 24 hours at 0.75 ata causes pulmonary symptoms in association with a significant decrease in vital capacity, and the rate of pulmonary intoxication increases progressively at higher oxygen pressures.

Nevertheless, the majority of current applications of hyperoxia in hyperbaric oxygen therapy and diving do not cause pulmonary symptoms or functional deficits.

Hyperbaric oxygenation causes pulmonary symptoms in patients only when used very aggressively for serious conditions, such as severe decompression sickness or arterial gas embolism. Some degree of midchest discomfort is also frequently

experienced by commercial divers who use intermittent hyperoxia to hasten inert gas elimination after unusually long or deep dives. When hyperbaric oxygenation is combined with saturation exposure in the treatment of refractory decompression sickness, it is not uncommon for diving chamber attendants and the patient to experience pulmonary symptoms. In all of these situations, irreversible pulmonary intoxication can be avoided by careful monitoring of symptoms and appropriate alternation of hyperoxic and normoxic exposure periods.

Biochemistry of Oxygen Toxicity

Gerschman and Gilbert were the first to propose that oxygen toxicity is caused by the production of *free radical intermediates* in excessive concentrations during exposure to increased oxygen pressures. The initial involvement of these agents is now well established, and several excellent reviews have summarized the literature on the biochemistry of *oxygen free radicals*. Although exact mechanisms are not yet known, free radical intermediates including superoxide anions, hydrogen peroxide, hydroperoxy and hydroxyl radicals, and singlet oxygen are potentially *toxic to cell membranes, enzymes, nucleic acids, and other cellular constituents*. Along with better understanding of oxygen free radicals has come a greater awareness of the dependence of vital biologic processes on cellular antioxidant defenses such as *superoxide dismutase, catalase, and the glutathione system.* It is now thought that in the absence of these defenses, the same oxygen pressures required to sustain life would cause lethal oxygen poisoning.

References:
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