Q6 Describe the pharmacology of oxygen (March 2009, September 2014)

Oxygen is a colourless, odourless, tasteless gas present in the atmosphere at a concentration of approximately 21%. It is used for the treatment of hypoxia, cluster headaches, to assist in the resorption of pneumothoraces, and at high pressures (hyperbaric oxygen therapy) can be used in the treatment of nonhealing ulcers, necrotizing fasciitis and osteonecrosis.

PHARMACEUTICAL

Medical oxygen is produced via fractional distillation of atmospheric air or using an oxygen concentrator, which absorbs nitrogen. It is presented as a liquid or compressed gas. It has a critical temperature of -119 °C.

Oxygen can be delivered via variable intake devices (nasal prongs, Hudson masks), or in fixed amounts via venturi masks or endotracheal tubes.

PHARMACODYNAMICS

Mechanism of action → The main action of oxygen in the body is to participate in oxidative phosphorylation, which produces the ATP required for cellular function. It moves down the oxygen cascade from a partial pressure of 159mmHg in atmospheric gas to approximately 105mmHg in the alveoli (dependent on PACO2 as per the alveolar gas equation), then to the mitochondria, where the PO2 may be as low as 2-3mmHg. Note the Pasteur point (1-2mmHg) is the minimum mitochondrial PO2 required for oxidative phosphorylation to proceed.

Side effects →

CNS – visual changes and seizures may occur at 3 atmospheres

Ocular – retrolental fibroplasia has been seen in premature babies treated with oxygen, possibly due to vasoconstriction of developing retinal vessels

CVS – improvement in haemodynamics if oxygen is being used to correct hypoxaemia. Prolonged administration of 100% FiO2 may cause a reduction in heart rate and cardiac output, and coronary artery vasoconstriction.

Respiratory - Potential decrease in respiratory drive (significant in patients who are CO2 retainers and rely on their hypoxic drive to breathe). Absorption atelectasis. Tracheobronchitis. ALI/ARDS due to the production of oxygen free radicals (superoxide, hydroxide, hydrogen peroxide), which cause parenchymal damage and diffuse lung injury.

PHARMACOKINETICS

Administration → Administered as above. Dose titrated to maintain appropriate PaO2 / SpO2

Distribution → Diffuses across the alveolar membrane as per Fick's Law to enter the blood. Main mode of transportation is bound to haemoglobin, with a small fraction dissolved in blood. Under normal circumstances there is approximately 1.75L of oxygen stored within the body. This may be increased with preoxygenation in anaesthesia or with hyperbaric oxygenation.

Metabolism → Oxygen is consumed in oxidative phosphorylation, producing ATP, CO2 and H2O.