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REVIEW ARTICLE

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Hydrogen Peroxide Poisoning

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Abstract

Hydrogen peroxide is an oxidising agent that is used in a number of household products, including general-purpose disinfectants, chlorine-free bleaches, fabric stain removers, contact lens disinfectants and hair dyes, and it is a component of some tooth whitening products. In industry, the principal use of hydrogen peroxide is as a bleaching agent in the manufacture of paper and pulp. Hydrogen peroxide has been employed medicinally for wound irrigation and for the sterilisation of ophthalmic and endoscopic instruments.

Hydrogen peroxide causes toxicity via three main mechanisms: corrosive damage, oxygen gas formation and lipid peroxidation. Concentrated hydrogen peroxide is caustic and exposure may result in local tissue damage. Ingestion of concentrated (>35%) hydrogen peroxide can also result in the generation of substantial volumes of oxygen. Where the amount of oxygen evolved exceeds its maximum solubility in blood, venous or arterial gas embolism may occur. The mechanism of CNS damage is thought to be arterial gas embolisation with subsequent brain infarction. Rapid generation of oxygen in closed body cavities can also cause mechanical distension and there is potential for the rupture of the hollow viscous secondary to oxygen liberation. In addition, intravascular foaming following absorption can seriously impede right ventricular output and produce complete loss of cardiac output. Hydrogen peroxide can also exert a direct cytotoxic effect via lipid peroxidation.

Ingestion of hydrogen peroxide may cause irritation of the gastrointestinal tract with nausea, vomiting, haematemesis and foaming at the mouth; the foam may obstruct the respiratory tract or result in pulmonary aspiration. Painful gastric distension and belching may be caused by the liberation of large volumes of oxygen in

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Accidental ingestion of a large gulp[®] of 35% hydrogen peroxide by a 64-year-old man resulted in nausea, vomiting of 'white foam', headache, ataxia and confusion.¹¹⁸ The patient was discharged from hospital following 2 hours of observation. Progressive neurological abnormalities occurred subsequently, including increasing difficulty in speaking and walking. Acute cerebral gas embolism was diagnosed and hyperbaric therapy was commenced.

20 hours post-ingestion with complete and rapid resolution of his symptoms with 50 minutes of treatment.

Ingestion of large quantities of relatively dilute hydrogen peroxide has caused significant toxicity in children. Foaming at the mouth, vomiting, haematemesis and multiple gastric ulcers and erosions in the duodenum, bulb were reported after ingestion of some 50–115g 3% hydrogen peroxide by a 3-year-old child.^[24,27] Haematemesis, severe gastritis and venous gas embolism occurred in a 2-year-old child who ingested an unknown amount of 3% hydrogen peroxide.^[25]

5.2 Inhalation

Most inhalational exposures cause little more than coughing and transient dyspnoea. However, inhalation of highly concentrated solutions of hydrogen peroxide can cause severe irritation and inflammation of mucous membranes, with coughing and dyspnoea. Shock, coma and convulsions may ensue and pulmonary oedema may occur up to 24–72 hours post-exposure.^[62,63]

Chronic exposure to an aerosol of hydrogen peroxide was aetologically linked to the development of diffuse interstitial lung disease in a 41-year-old dairy worker who smoked 40 cigarettes daily. Withdrawal from exposure to the aerosol resulted in improvement in his condition.^[64]

5.3 Injection

A 7-month-old child developed an oxygen embolism and died in ventricular fibrillation following accidental intravenous infusion of 100mL 3% hydrogen peroxide.^[31]

Self-administration of 35% hydrogen peroxide intravenously as an attempted therapy for AIDS resulted in nausea, hypotension, tachycardia, intravascular haemolysis with Heinz body formation, progressive renal impairment and subsequent death in a 51-year-old man.^[6] A strikingly similar case was described earlier.^[7]

A 39-year-old man experienced haemolysis after self-administered intravenous injection of hydrogen peroxide, intended as a cancer treatment.^[8]

5.4 Wound Irrigation

Severe toxicity has resulted from the use of hydrogen peroxide solutions to irrigate wounds within closed body cavities or under pressure. Oxygen gas embolism has resulted.^[13,45–53] Venous oxygen embolism has also resulted from the use of surgical packs impregnated with hydrogen peroxide.^[54] Marked ST elevation and a precordial 'mull wheel' murmur have been reported.^[50,51]

One week after a 78-year-old woman had undergone mitral and aortic valve replacements, she developed a massive right haemothorax.^[56] Following sternal incision, blood and clots were found in the right pleural cavity and examination of the wound disclosed a small tear on the anterior surface of the middle lobe. Before chest

closure, the surgeon irrigated the surgical field with 300mL of 1% hydrogen peroxide solution. Immediately, an ST segment increase of 3.2mm was observed in ECG leads II, III and VF, severe bradycardia and hypotension developed prior to asystole. Transoesophageal echocardiography showed air bubbles in left-sided structures and the diagnosis of gas embolism was made. The surgical field was flooded with saline solution. 100% oxygen was administered and a needle was placed into the left ventricle. In a few minutes the ECG abnormalities disappeared and the patient recovered. Follow-up showed no evidence of cardio or neurological deficit.

The syringing of 200mL 3% hydrogen peroxide into a wound and abscess cavity under the fascia lata followed by packing of the wound caused a sudden drop in end-tidal carbon dioxide partial pressure and resulted in cyanosis, tachycardia and hypotension. An oxygen embolus was diagnosed.^[65]

Surgical emphysema was reported in a 6-year-old girl following irrigation of a cheek laceration resulting from a dog bite. This resolved spontaneously over a few hours.^[66] Injection of 10mL 3% hydrogen peroxide under pressure into an anal fistula caused marked subcutaneous emphysema, cyanosis, severe hypotension and bradycardia unresponsive to atropine and epinephrine in an 8-month-old child.^[57] The patient survived following aggressive management including wide excision of the anal fistula.

Fatal posterior pneumocephalus and brain stem compression occurred after irrigation of a lumbar wound with hydrogen peroxide.^[58] The wound was secondary to lumbar disc space infection. Pulmonary oedema and subcutaneous emphysema has resulted following repeated irrigation of a shrapnel wound with 3% hydrogen peroxide administered under pressure.^[55,59]

The use of hydrogen peroxide during root canal treatment has caused subcutaneous emphysema^[60,61] and pneumothorax.^[61]

5.5 Rectal Administration

Nausea, distension, rectal bleeding and slight distal rectal erosion have occurred following rectal exposure to hydrogen peroxide (concentration not stated).^[16] Colonic ulceration has been reported following administration of an enema containing hydrogen peroxide.^[62]

5.6 Dermal Exposure

Dermal contact may cause inflammation, blistering and severe skin damage. A characteristic whitening of the skin may occur.^[14,63] and paraesthesiae have been reported.^[6]

A 34-year-old man who accidentally splashed 35% hydrogen peroxide over his shoulder and back developed erythema, focal epidermal necrosis, purpura and gas-containing 'blisters' following prolonged exposure via wet work clothes. Subcutaneous em-

physema was detected on chest x-ray and was related to the area of skin damage, presumably indicating local penetration of hydrogen peroxide.^[64]

Contact dermatitis has been reported following exposure to hair dye containing hydrogen peroxide and in subsequent patch testing.^[65]

5.7 Ocular Exposure

Hydrogen peroxide has been shown to cause toxicity to human corneal epithelial cells *in vitro* at concentrations as low as 30 ppm.^[17] The effects of ocular exposure in humans have been reviewed.^[66] Exposure to 3% solutions may cause immediate stinging, irritation, lacrimation and blurred vision and subepithelial corneal and conjunctival bubbles may be observed.^[67] Exposure to more concentrated solutions (>10%) may result in ulceration or perforation of the cornea.

Corneal opacity has been reported following the use of hydrogen peroxide-soaked tonometer tips.^[68,69] In one case in which a 3% hydrogen peroxide solution was used, with no subsequent irrigation of the tip, pain and blurred vision were reported following eye examination. The following day an 'O-shaped' opacity was noted in the anterior stroma, which persisted for 4 weeks, and visual acuity was decreased.^[69]

Two women aged 24 and 82 years of age developed 90% and 30% corneal epithelial defects, respectively, following inadvertent administration of Haemocoil developer (4.5% hydrogen peroxide, 75% denatured ethanol) into the eye instead of ophthalmic drops. Immediate and severe pain, tearing and photophobia was experienced by the 82-year-old woman.^[70]

Insertion (without neutralisation) of a soft contact lens that had been stored for 1 week in 3% hydrogen peroxide caused an almost immediate central white corneal opacity. There was no discomfort or reflex tearing and the lesion resolved over several days.^[71]

5.8 Miscellaneous

Three dialysis patients exposed to dialysis fluid inadvertently contaminated with hydrogen peroxide experienced haemolysis and required blood transfusions.^[72]

It has been suggested that a form of colitis, commonly referred to as pseudofolliculitis, is caused by exposure to residual hydrogen peroxide in endoscopic instruments.^[73] An outbreak of enteritis involving seven patients in a gastrointestinal endoscopy unit was linked to the use of endoscopes sterilised with 3% hydrogen peroxide. Instantaneous effervescence and blanching of the mucosal surfaces (the 'snow white' sign) were observed. Non-specific inflammation was noted on biopsy but no subsequent morbidity occurred.^[70]

Oxygen embolisation to the mesenteric and portal veins has been reported in infants following intestinal irrigation with hydro-

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gen peroxide to remove inspissated meconium. In one case, death resulted from gangrene of the bowel.^[74]

6. Management

6.1 Ingestion

6.1.1 Supportive Care

Gut decontamination is not indicated due to the rapid decomposition of hydrogen peroxide. Oral fluids should not be administered if the solution is concentrated as an exothermic reaction will be induced. If gastric distension is painful, a gastric tube should be passed to release gas.

Early aggressive airway management is critical in patients who have ingested concentrated hydrogen peroxide, as respiratory failure and arrest appear to be the proximate cause of death. An ECG, arterial blood gases and a full blood count should be obtained, and venous access should be secured. Cardiorespiratory monitoring is essential in patients with suspected gas embolisation. Metabolic acidosis should be corrected by the administration of sodium bicarbonate.

If clinically significant features develop, or if the patient has ingested either a concentrated hydrogen peroxide solution (>10%) or a substantial amount of a 3% solution, chest and abdominal x-rays should be obtained to detect perforation or gas embolism. A CT or MRI scan should be performed if CNS effects develop.

6.1.2 Upper Gastrointestinal Endoscopy

Endoscopy should be considered if there is persistent vomiting, haematemesis, significant oral burns, abdominal pain, dysphagia or stridor, or if the patient has ingested a substantial amount of >10% hydrogen peroxide. Where there is evidence of gastric mucosal injury, oxygen embolism to the portal venous system is a possibility.^[16] Patients who are asymptomatic after ingestion do not require endoscopy.

6.1.3 Oxygen

In one case report, continuous administration of 100% oxygen for 6 hours through a respiratory mask led to complete resolution of symptoms of cerebral embolism, including neurological deficits.^[26] Hyperbaric oxygen therapy may be of value in treating cerebral gas embolism.^[18,42,53,75,76] although data are limited.

6.2 Inhalation

If respiratory tract irritation is present, a chest x-ray and pulmonary function tests should be performed and be repeated, as necessary. Corticosteroids in high dosage (prednisolone 60–80 mg/day) have been recommended if laryngeal and pulmonary oedema supervene but their value is unproven. Diuretics are of no value. Mechanical ventilation may also be necessary. Endotrache-

at intubation or, rarely, tracheostomy may be required for life-threatening laryngeal oedema.

6.3 Wound Irrigation

Nitrous oxide should not be administered simultaneously as an anaesthetic during wound irrigation with hydrogen peroxide, as use of 60% nitrous oxide may increase the size of an oxygen embolism by up to 300%.¹⁶¹

6.4 Dermal Exposure

The patient should remove soiled clothing and wash him/herself if possible. Contaminated skin should be washed with copious amounts of water. Skin lesions should be treated as thermal burns; surgery may be required for deep burns.

6.5 Ocular Exposure

Irrigate the affected eye(s) immediately and thoroughly with water or 0.9% saline for at least 10–15 minutes. Repeated instillation of a local anaesthetic may reduce discomfort and assist more thorough decontamination. Corneal damage may be detected by instillation of fluorescein; patients with corneal damage and those whose symptoms do not resolve rapidly should be referred for ophthalmological assessment.

7. Conclusions

The deliberate ingestion of household products containing hydrogen peroxide cannot easily be prevented as these formulations are so readily available; ingestion may lead to serious sequelae, particularly if more concentrated solutions are involved. Accidental ingestion of dilute solutions by children is unlikely to lead to serious sequelae, although deaths have been reported from the ingestion of concentrated solutions. Despite serious complications being reported from the use of hydrogen peroxide for wound irrigation, this practice continues, although it should be reconsidered, if not abandoned, in the light of the evidence that substantial morbidity and even death may follow its use. Hydrogen peroxide is a potentially dangerous and unsuitable agent for routine wound irrigation and debridement.³²¹

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