

Case Report

Portal Venous Gas Following Ingestion of Hydrogen Peroxide Successfully Treated with Hyperbaric Oxygen Therapy

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The primary toxicity of hydrogen peroxide results from its interaction with catalase, which liberates water and oxygen. We report the case of a 14-year-old Japanese girl with portal venous gas that was caused by oxygen liberated from intentionally ingested hydrogen peroxide. Although she had a past history of atrial septal defect, recovery without cardiac or neurological sequelae was achieved using hyperbaric oxygen therapy. Emergency physicians must be aware of the danger of liberated oxygen due to hydrogen peroxide ingestion.

Key words: air embolism, ASD, breaching agent, HBO, intoxication

Hydrogen peroxide (H₂O₂) is used for industrial and common household products, including disinfecting products, fabric stain removers, hair dyes, contact lens cleansers, bleaches, and tooth-whitening products. Since hydrogen peroxide is a clear, odorless liquid and relatively easily commercially accessible in low concentrations (3%), accidental ingestions of hydrogen peroxide may occur. The primary toxicity of hydrogen peroxide results from its interaction with catalase, an enzyme present in humans and animals which liberates water and oxygen. The toxic effects of hydrogen peroxide consist mostly of local tissue damage and gas formation [1].

We report the case of a 14-year-old girl with a history of atrial septal defect (ASD) who intentionally ingested hydrogen peroxide and then developed portal venous gas caused by liberated oxygen. We successfully treated the patient using hyperbaric oxygen (HBO). Although 3% hydrogen peroxide is regarded as safe for

household use with minimal toxicity after ingestion, our patient's case suggests that venous or arterial gas embolism may occur after the ingestion of hydrogen peroxide at this low concentration. Our awareness of the signs of this condition, together with the comprehensive medical history that was obtained, facilitated the institution of appropriate treatment. HBO treatment should be considered for gas embolism due to the ingestion of hydrogen peroxide, as it is for all other sources of acute gas embolism.

Case Report

A 14-year-old Japanese girl was transferred to Okayama University, Department of Emergency and Critical Care. She had been undergoing outpatient treatment for depression and was found drowsy at her home with a nearby empty bottle of hydrogen peroxide (200 ml). Following her ingestion of what may have been the entire 200 ml of hydrogen peroxide, she reported

nausea and had several episodes of vomiting that was sometimes associated with bloody secretion. Her mother denied any episode of seizure.

On arrival at a local hospital approx. 2 h after the ingestion, the patient was in stable condition and denied breathing difficulty. She had a history of ASD that had presumably resolved during her childhood. She was alert and oriented. Cardiopulmonary and neurological test results were normal. Her abdomen was slightly distended, but had no rebound tenderness. Her laboratory test results were unremarkable. Non-contrast abdominal computed tomography (CT) showed multiple tiny bubbles in her liver. However, there were no signs of mesenteric ischemia (Fig. 1).

Due to the large amount of suicidal ingestion of hydrogen peroxide and the patient's history of ASD, the local hospital decided to transfer the patient to our department for HBO chamber treatment. She underwent a single HBO therapy of 2 ATM for 2 h. The repeated CT scan the next morning revealed resolution of the portal venous gas. In light of the patient's complete recovery from her symptoms and the ear pain that

she reported during the HBO therapy, no further HBO was performed. She was released after 3 days in the hospital with no major sequelae and with plans for outpatient mental healthcare support.

Discussion

The toxicity of hydrogen peroxide is caused via 3 main mechanisms: lipid peroxidation, oxygen gas formation, and corrosive damage. Direct contact between hydrogen peroxide and mucosa can lead to hemorrhagic gastritis and gastrointestinal bleeding. In addition, as hydrogen peroxide is immediately converted into water and oxygen by means of catalase in the red blood cells, the perils of the accidental ingestion of hydrogen peroxide include a broad embolism of oxygen bubbles in the portal vasculature associated with arterial and venous gas embolic conditions, potentially resulting in shock and death. Rackoff and Merton first reported hematemesis and transient radiologic evidence of portal venous gas embolism without other abnormalities after the ingestion of 3% hydrogen peroxide [2].

One ml of 3% hydrogen peroxide will liberate approx. 10 ml of oxygen. However, a 30% concentration rapidly generates an extreme amount of oxygen gas accumulated in closed body cavities, which can lead to mechanical stress on hollow organs and as a consequence, perforations [3]. Although 3% hydrogen peroxide is regarded as safe with minimal toxicity after ingestion and most serious cases are associated with exposure to mixtures greater than 30%, hemorrhagic gastritis, portal venous emboli, and death have all been reported even with the consumption of 3% solutions [4,5].

Two major inducements of hepatic portal venous gas are mesenteric necrosis and ischemia. Hepatic portal venous gas has also been reported in nonfatal conditions such as Crohn disease, ulcerative colitis, bowel obstruction, bacterial abscesses, paralytic ileus, and gastrointestinal dilation [6,7]. Hepatic portal venous gas due to the ingestion of hydrogen peroxide is a rare event. Alone, hepatic portal venous gas cannot be an indication for aggressive procedures; the treatment depends mainly on the underlying disease [8].

In our patient's case, 200 ml of 3% hydrogen peroxide was ingested and this was enough to produce 2,000 ml of oxygen gas into the gastric mucosa. This could have resulted in massive venous gas emboli from



Fig. 1 Abdominal CT demonstrates widespread air densities in portal venous branches of the patient, a 14-year-old girl.

gastrointestinal absorption into the mesenteric and portal venous system prior to the decomposition of the gas in the stomach or intestine. Additionally, the patient might have been at a higher risk of arterial gas embolism since she had a history of ASD, the spontaneous closure of which is uncertain.

Arterial or venous gas embolism can occur when the amount of oxygen involved exceeds its maximum solubility in blood. Arterial emboli may be caused by a right-to-left shunt across the heart through an ASD, directly through pulmonary aspiration, or by the absorption of hydrogen peroxide across the alimentary tract and catabolism within the arterial vasculature. In addition to brain ischemia due to cerebral artery embolization, intravascular foaming after absorption can significantly hinder the right ventricular output and result in a complete loss of cardiac output.

Aside from the ingestion of hydrogen peroxide, oxygen embolization may occur after hydrogen peroxide use for tissue irrigation during surgery. It was reported that complications after the irrigation of wounds or colonic irrigation with hydrogen peroxide during surgery may occur [9]. Wound irrigation with hydrogen peroxide is currently discouraged because of the potential hazards, including cardiovascular collapse.

No consensus on a standard treatment for acute oxygen embolism after hydrogen peroxide ingestion has been reached. Because of the rapid decomposition of hydrogen peroxide by catalase to oxygen and water, gut decontamination is not indicated following ingestion. A gastric tube should be passed to release gas when gastric distension is painful. When patients ingest a concentrated hydrogen peroxide solution, early aggressive airway management is critical; respiratory arrest and failure appear to be the cause of death in these cases. Trendelenburg positioning may trap the air in the apex of the right ventricle and avoid obstruction of the blood flow.

In 1998, HBO was demonstrated to be beneficial for the treatment of gas embolism caused by an ingestion of hydrogen peroxide [4]. HBO is strongly recommended for an air embolism with the presence of neurological deficits [10]. Other clinical indications for HBO include: a patient in critical illness; intubation precluding detailed neurological examination; gas passing from the portal venous system into the right side of the heart, increasing the risk for potential arterial gas embolism; clinical

suspicion and signs of arterial gas embolism; and significant discomfort due to gastric or portal venous gas [11]. HBO therapy can decrease the volume of gas emboli and the solubility of gas into the tissue or plasma due to the high atmospheric pressure HBO provides. However, since some facilities are not equipped with HBO chambers, such treatment might not be available, even in HBO-indicated cases of hydrogen peroxide ingestion.

In conclusion, our 14-year-old patient, liberated oxygen ascended through the gastric veins to the portal venous system and into the liver. Fortunately, she recovered with HBO without complications. Her case illustrates that the ingestion of hydrogen peroxide may lead to gas embolism. Emergency physicians must be aware of the hazards of hydrogen peroxide ingestion resulting in a broad embolism of oxygen bubbles, which may lead to heart or brain embolization as well as gangrenous or perforated bowel.

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