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Case Report

Accidental Formaldehyde Poisoning in an Alcohol-Dependent

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Abstract

Formaldehyde is a colourless, volatile chemical with a strong, pungent odour. In aqueous solution, it is known as formalin and is widely used as a disinfectant, embalming agent, and in industries such as plastics and sericulture. Formalin is a protoplasmic poison with potent caustic and fixative properties, leading to extensive tissue damage upon ingestion or inhalation. Due to its strong odour and unpleasant taste, both suicidal and accidental formalin poisoning are uncommon. We report a case of a 42-year-old male who died following accidental ingestion of formalin while under the influence of alcohol. Clinical history, autopsy findings, and toxicological analysis were consistent with formalin poisoning. This case highlights the medicolegal importance of secure chemical storage & the potential risks of occupational exposure in rural and agricultural settings.

Keywords:formaldehyde; poisoning; accidental ingestion; ethanol; alcohol dependence; forensic toxicology

Introduction

Formaldehyde is a colourless, highly flammable gas that is sold commercially as 30–50% (by weight) aqueous solutions. Formaldehyde (CH2O) is also known as methanal, methylene oxide, oxyethylene, methylaldehyde, oxomethane, and formic aldehyde.[1] Formalin (37% CH2O) is the most common formulation. Methanol or other substances are usually added to the solution as stabilizers to reduce the intrinsic polymerization of formaldehyde.[2]Formaldehyde is frequently found in household decorative materials, typically as a solid polymer. For more than a hundred years, it has also played a significant role as a preservative and tissue fixative in medical diagnostics and scientific research. Moreover, its aqueous solution is commonly utilized as a disinfectant, antiseptic, and fumigant in agriculture, forestry, and livestock management. [3] In medicine, it is used for treatment of uncontrolled intravesical haemorrhage, radiation induced haemorrhagic proctitis and cystitis and to prevent hydatid cysts dissemination.[4]

It is irritating, corrosive, toxic & absorbed from all surfaces of body. Moreover, it is a protoplasmic poison causing tissue fixation, coagulation necrosis, and protein precipitation. [5] Since formaldehyde (also a product of intermediary metabolism) is water soluble, highly reactive with biological macromolecules, and rapidly metabolized, adverse effects resulting from exposure are observed primarily in those tissues or organs with which formaldehyde first comes into contact (that is the respiratory and aerodigestive tract, including oral and gastrointestinal mucosa, following inhalation or ingestion, respectively).[6]

While inhalation and skin absorption are the most common routes, ingestion of formaldehyde, although rare, can have particularly severe consequences for the gastrointestinal (GI) system. Accidental ingestion of solutions containing 10–40% formaldehyde can lead to intense corrosive injury. Mild Inhalation commonly causes irritation of the nose, throat, and lungs (upper respiratory passages) that results in cough, difficulty in breathing, chest tightness, and, in severe cases, asthma or hypersensitivity pneumonitis.[7] Eye contact with formaldehyde vapours leads to lacrimation, redness, and burning. Skin exposure may cause dryness, cracking, discoloration, and allergic contact dermatitis, particularly with repeated or prolonged contact. Formaldehyde is as known skin sensitizer, since it triggers allergic reactions with small amount.

Occupations such as healthcare, textile, printing, and automotive work carry a higher risk of exposure. The strong odour of formaldehyde may not always effectively warn workers, as desensitization can occur over time.[8] About 30 - 50 ml of 100% formalin (liquid); more than 100 ppm (gas). Ingestion of as little as 30 ml of 37% (approximately 2 tablespoons) formaldehyde solution (formalin) has been reported to cause death in an adult. [9]

Chronic exposure to formaldehyde can cause serious health problems. It is a carcinogen linked to lung, nasal passage, nasopharynx, and oropharynx. It also exhibits mutagenic effects and acts as a genotoxic substance in laboratory tests. Prolonged exposure may lead to respiratory problems, nasal tumours, and structural damage to the nasal tissues. Documented cases over the past two decades highlight exposure from polluted air, contaminated water, and adulterated food, all contributing to a wide range of adverse health effects in humans. However, despite its known harmful effects and widespread use, accidental formalin ingestion remains poorly represented in forensic toxicology literature. This lack of detailed documentation presents a significant gap, especially considering the potential for accidental consumption in domestic, clinical, or industrial settings due to improper labelling or storage.[10]

Case details

A 42-year-old male sericulturist, a known chronic alcoholic, began drinking around 12:30 PM on March 21, 2025. While attempting to dilute alcohol, he mixed it with an unidentified liquid stored at the sericulture facility, mistaking it for water. Shortly after ingestion, he experienced a burning sensation in his stomach and severe abdominal pain, following which he collapsed. He was brought to CDSIMER Hospital by ambulance and declared dead on arrival at approximately 2:50 PM. The ingested liquid was later identified as formaldehyde, stored on-site for disinfection.

Autopsy findings

On external examination, the body of the deceased was moderately built and nourished, measuring 172 cm in length. The eyes were closed, the conjunctivae congested, and the pupils dilated and fixed. The nails appeared bluish, suggestive of cyanosis. Rigor mortis was well established throughout the body. Postmortem staining was present and fixed over the dorsal aspect (figure 1). Pinkish-white froth was noted at the angle of the mouth (Figure 2).

No external injuries were observed.On internal examination, the lungs were congested and oedematous; the cut surface exuded froth mixed with blood (figure 3). The heart, including the coronary arteries and major vessels, was patent. The stomach contained approximately 500 ml of partially digested food particles with orange-yellow fluid. The gastric mucosa appeared leathery and haemorrhagic, emitting a peculiar odour (figure 4). All internal organs were intact and congested.

Samples of the stomach and its contents, a portion of the small intestine with its contents, approximately 500 grams of liver, and half of each kidney were collected and preserved in a saturated solution of sodium chloride. In addition, 30 ml of blood preserved with sodium fluoride, along with a control preservative, were labelled, packed, sealed, and sent to the Forensic Science Laboratory, Bengaluru, for chemical analysis.As per the report from the Forensic Science Laboratory, colour tests, headspace gas chromatography, and qualitative analysis indicated the presence of ethyl alcohol and

formaldehyde in the stomach, intestines, liver, blood, and kidneys. The concentration of ethyl alcohol was found to be 187.63 mg/100 ml of blood.

On perusal of FSL report and Autopsy findings, death was due to respiratory failure as a result of consumption of substance containing formaldehyde and ethyl alcohol. Blood Ethyl alcohol level was 187.63 mg/100ml of blood.

Discussion

Formaldehyde plays a critical role in economic development, and millions of people suffer from environmental and occupational exposure to formaldehyde worldwide.[3] Formaldehyde poisoning is an infrequent yet severe condition that can occur through various means and situations. In our case, the deceased individual, employed in silkworm cultivation, consumed formalin thinking it was water while drinking alcohol. This occurred in a setting where formalin was regularly used as a disinfectant for silkworm trays. The victim developed abdominal pain, burning sensation, and distress within minutes and died within approximately two hours. Autopsy findings were consistent with formalin ingestion: leathery mucosa of the stomach, pinkish-white froth at the mouth, systemic organ congestion, and histological signs of caustic damage. Toxicological analysis confirmed the presence of both formaldehyde and ethanol in vital organs, with a notably high blood alcohol concentration of 187.63 mg/100 ml.

Similar instances of accidental ingestion have been documented in the literature. For instance, A case of a 4 -year-old child who ingested formalin stored in a transparent water bottle. The child presented with vomiting and succumbed to refractory shock with severe metabolic acidosis.[11] This case, like ours, emphasizes the critical role of improper labelling and storage, especially in households and workspaces where formalin is commonly present. While the victim in our case was an adult and his judgement possibly impaired by alcohol, both instances demonstrate how familiarity and accessibility of formalin contribute to unintended fatal exposures.

In contrast, suicidal ingestion of formalin has been more commonly documented in medical literature. This was highlighted in a case involving a 26-year-old laboratory technician who consumed formalin with suicidal intent. The victim developed respiratory failure and metabolic acidosis, eventually leading to death.[12] Autopsy findings revealed gastrointestinal corrosion and pulmonary oedema, which closely mirror the forensic presentation in our case. The primary difference lies in the intentionality of ingestion and possibly the volume consumed, but the internal damage caused by the corrosive effects of formalin remained consistent across both scenarios.

These cases consistently show that ingestion of even moderate volumes of formalin leads to corrosive injury, cardiovascular collapse, and systemic organ failure. The similarity in postmortem signs—mucosal hardening, gastrointestinal haemorrhage, and the distinct chemical odour—validates their use as forensic diagnostic markers.

Rarely, homicidal poisoning with formalin has been suggested. One such suspected case is of a child who was covertly administered formalin by a caregiver.[13] Though difficult to prove without eyewitness accounts or surveillance, such cases highlight the need for forensic vigilance when formalin ingestion is not clearly accidental or suicidal. The chemical's pungent odour and irritating nature make homicidal administration difficult without coercion or deceit, but these rare possibilities cannot be entirely excluded in forensic investigation.

Occupational and environmental exposures represent another dimension of formaldehyde toxicity. Unlike acute ingestion cases, such exposures tend to be chronic and lower in concentration, affecting factory workers, laboratory staff, and residents in poorly ventilated homes. A case study reveals a worker survived acute formalin ingestion after early intervention. He exhibited symptoms of nausea and metabolic acidosis but recovered due to prompt gastric lavage and bicarbonate therapy.[14] On the other hand, the NIOSH and WHO recognize formaldehyde as a Group 1 carcinogen. Chronic inhalation has been linked to nasopharyngeal cancer, bronchial asthma, and skin disorders.[15] In these cases, clinical findings differ, often

involving respiratory inflammation, dermatitis, or mucosal changes without the acute corrosive damage seen in ingestion cases.

What makes our case unique is the coexistence of alcohol with formalin. Ethanol can competitively inhibit the metabolism of formaldehyde, theoretically offering partial protective effects.[16] However, in our case, the presence of both substances likely compounded the systemic toxicity. Ethanol may have impaired the victim's judgment, leading to accidental ingestion, while also contributing to central nervous system depression. The combined toxicity and rapid death underscore the complexity of dual-agent exposure.

Moreover, our case sheds light on a neglected occupational domain—sericulture —where hazardous chemicals are used without medical oversight or clear labelling protocols. Unlike laboratory or hospital settings where staff may be trained in chemical handling, informal industries often lack regulatory supervision, making accidental poisonings more likely.

Conclusion

In conclusion, while formaldehyde poisoning through ingestion remains relatively rare, especially accidental ingestion, its clinical and forensic features are strikingly consistent across case types. Corrosive damage to mucosa, organ congestion, and chemical odour are hallmark findings. Our case adds a valuable perspective to the literature by highlighting accidental poisoning in a rural, occupational context involving alcohol co-ingestion. It reinforces the need for safer chemical handling practices, robust labelling standards, and public education on hazardous materials even in non-clinical settings.

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Figures:

Figure 1: Postmortem staining present and fixed over the dorsal aspect.

Figure 2: Pinkish-white froth noted at the angle of the mouth

Figure 3: Cut section of lung exuded froth mixed with blood

Figure 4: Leathery and haemorrhagic gastric mucosa, with a peculiar odour

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