Chlorinated Solvent Tox

CASE REPORTS

Trichloroethane Poisoning: Observations on the Pathology and Toxicology in Six Fatal Cases *

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Introduction

1,1,1-Trichloroethane (methyl chloroform) is a widely used industrial solvent with a low toxicity. Fatal poisoning from this compound is rare; only six human deaths have been reported. Four of these deaths resulted from occupational exposure to high concentrations of 1,1,1-trichloroethane in tanks (1, 2). Hall and Hine (3) reported two cases in which the deaths were attributed to abusive inhalation of this compound. It is the purpose of this presentation to describe the circumstances, the pathologic findings, and the results of the toxicologic analyses in six additional cases of trichloroethane poisoning found among over 1.2 million cases on file at the Armed Forces Institute of Pathology, and to stress the danger of working with this chemical in closed spaces.

* Presented at the Twenty-First Annual Meeting of the American Academy of Forensic Sciences, Chicago, Illinois, February 27, 1969. Received for publication March 9, 1969. Accepted for publication March 24, 1969.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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Report of Cases

Case 1. A 20-year-old man who had previously been healthy was found dead, lying on the deck in a closed space aboard ship. He had been working with a "paint remover" and had not been observed for an unknown length of time. There was no evidence of trauma.

The autopsy findings were nonspecific. There was no evidence of either natural disease or injury. The lungs were congested and moderately edematous. The liver, spleen, kidneys, and brain were congested. Microscopic examination confirmed the gross findings. The lungs revealed edema and there were changes suggestive of anoxia in the brain.

The toxicologic analyses excluded the presence of barbiturates, salicylates, and basic compounds in liver tissue, and metals and metalloids in kidney tissue. There were 283 mg lactic acid per 100 gm brain. Gas chromatographic studies revealed the concentrations of 1,1,1-trichloroethane in the brain, kidney, liver, and muscle given in Table I. No other volatile substances were detected.

Case 2. A 17-year-old man was assigned to clean an air vent in a 6 x 8 x 10-foot room, using 1,1,1-trichloroethane. He was observed several times during a four-hour period, and he seemed quite well. Three hours and 45 minutes later the compartment was again checked, and he was found dead on the floor.

At autopsy, his skin was moderately cyanotic. There was no external evidence of trauma, and the autopsy did not reveal internal injuries. The brain, liver, kidneys, and spleen were moderately congested. The lungs were markedly edematous, and there was evidence of aspiration of gastric contents. There were no other significant findings.

Toxicologic analyses did not reveal ethanol or carbon monoxide in the blood, or basic or acid drugs in the liver tissue. The gray matter of the brain contained 226 mg lactic acid per 100 gm. Gas chromatographic analyses showed the concentrations of 1,1,1-trichloroethane given in Table I.

Case 3. Aboard a ship an obese but healthy 24-year-old man had been cleaning electrical gear with 1,1,1-trichloroethane. He apparently went to bed in his compartment and two hours later he was found dead. Two white rags used to clean the electrical gear were found near his head and had the odor of a volatile aliphatic-chlorinated hydrocarbon.

At necropsy, marked cyanosis of head and neck were noted. The body was that of a markedly obese individual. The heart weighed 550 gm, and the coronary arteries showed slight to moderate coronary atherosclerosis. The lungs were congested and edematous. There was a marked degree of fatty metamorphosis of the liver. The brain, spleen, and kidneys were congested. There was no evidence of injury. Histologic sections of liver showed moderate fatty metamorphosis with a centrilobular distribution.

Toxicologic studies did not reveal the presence of ethanol, carbon monoxide, acidic or basic drugs. The lactic acid concentration in the brain tissue was 126 mg per 100 gm. The concentrations of 1,1,1-trichloroethane found are shown in Table I and were determined by gas chromatography.

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Cases 4, 5, and 6. Four crewmen were assigned to clean electrical equipment with 1,1,1-trichloroethane in two closed compartments of a ship. They used a 5-gallon can of 1,1,1-trichloroethane, equipped as a sprayer with 14 feet of ¼-inch copper tubing and connected by a rubber hose to an air-pressure valve. Although the men experienced minor effects of the solvent, particularly giddiness, they continued to work. Early in the evening one of the men, who apparently had been unconscious, awoke to discover the bodies of the other crewmen in a small, unventilated 4 x 5-ft compartment.

Autopsies did not reveal evidence of preexisting disease in the subjects. Bullous lesions and focal denudation of skin of buttocks were noted on all three victims. The lungs were congested and edematous. Microscopic examinations confirmed the gross findings and also revealed focal collections of polymorphonuclear leukocytes in the lungs. The histologic sections of skin showed intra-epithelial bullous changes without evidence of the vital reaction.

Toxicologic analyses excluded the presence of barbiturates and salicylates in the blood, liver, brain, and kidney. Gas chromatographic analyses of liver, brain, and blood in these cases did not provide a differentiation between 1,1,1-trichloroethane and trichloroethylene, but the quantitative analyses were based on calculations using a trichloroethane standard. The results are given in Table I.

TABLE I

Acute 1,1,1-Trichloroethane Intoxication

Results of Toxicologic Examination in Six Fatal Cases

Body Fluid or Tissue	(Concentration (mg per 100 g or 100 ml)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Blood	—	0.15	—	12.0	6.2	6.0
Brain	2.7	0.32	9.3	59.0	56.0	50.0
Kidney	2.4	0.26	7.8	—	—	—
Liver	9.8	0.49	13.2	22.0	11.0	12.0
Muscle	4.9	0.26	—	—	—	—
Lung	—	0.18	2.2	—	—	—
Urine	—	0.1	—	—	—	—

Discussion

1,1,1-Trichloroethane is a colorless, volatile, nonflammable liquid with an odor similar to that of chloroform. It has been promoted as a substitute for carbon tetrachloride because of its low toxicity and is considered to be "one of the safest of the chlorinated aliphatic hydrocarbon solvents" (1). It is used

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widely in various industries for cleaning metals because it removes oils, waxes, and greases easily.

This compound is rapidly absorbed through the lungs and the gastrointestinal tract, but it may also be absorbed in toxic quantities through intact skin. Exposure to low concentrations of its vapor is usually harmless, and repeated exposures to vapor concentrations of less than 500 ppm have not caused any reported injuries in man (1).

In the cases reported by Hall and Hine (3), as well as in the cases presented here, the only significant finding at autopsy was moderate to marked pulmonary edema. The mechanism for the production of the edema in these cases may be the direct action of the inhaled chemical on the lungs, or the edema may be central in origin. The absence of any significant pathologic changes suggests that death may have occurred rapidly. In three of the six cases, ruptured blisters were found in the skin of the buttocks. These bullous lesions are probably a manifestation of anoxia, akin to that seen in cases of prolonged coma.

Data on the distribution of 1,1,1-trichloroethane in fatal human cases are not available. In the two fatal cases described by Hall and Hine, the blood concentrations of 1,1,1-trichloroethane were 13 mg per 100 ml and 72 mg per 100 ml, respectively, and these authors indicate that a range of 35 mg per 100 ml to 100 mg per 100 ml could be expected in fatal cases. On the basis of the concentrations in our cases (Table I), we believe that even lower concentrations may be fatal. In all our cases except Case 2, the concentrations in the organs are considered high enough to be fatal. In Case 2, the concentrations of 1,1,1-trichloroethane are low. It is likely that this man died mainly from oxygen deprivation, and this explanation is supported by the elevated brain lactic acid concentration. In Case 1, the high concentration of lactic acid in the brain also provides evidence of anoxia. According to Stewart, the concentration of 1,1,1-trichloroethane in blood depends on the duration of exposure, the concentration of vapor inhaled, the time elapsed since exposure, the breathing rate of the person during the exposure, and the total concentration of lipid in the blood (1).

1,1,1-Trichloroethane produces the typical effects of an anesthetic agent. The absorption of a toxic quantity results

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in a functional depression of the central nervous system, leading to death from respiratory arrest or shock. It is also capable of sensitizing the heart muscle in a manner similar to chloroform. Sudden death from ventricular fibrillation may occur in persons exposed to anesthetic concentrations.

Most of the reported deaths from exposure to 1,1,1-trichloroethane have been in closed spaces. The dangers of working with this chemical in a closed environment have not been sufficiently publicized. It must be stressed that the knowledge of its low toxicity should not lead to carelessness in dealing with it, and great caution should be exercised while using it in unventilated spaces.

In the practice of forensic pathology, sudden and unexpected death of a young person is a diagnostic challenge. Deaths in closed spaces should arouse the suspicion of the possibility of poisoning by a volatile solvent. A careful circumstantial investigation and appropriate toxicologic study may provide the correct diagnosis in such cases.

Summary

Six cases of fatal 1,1,1-trichloroethane poisoning are presented, with brief descriptions of the circumstances leading to death, the autopsy findings, and the results of toxicologic analyses.

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