CASE REPORT

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Death Due to Inhalation of Ethyl Chloride*

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ABSTRACT: A 30-year-old white male was found dead in a locked apartment with a rag held loosely in his mouth. Four cans (3 empty, 1 partially empty) containing ethyl chloride and labeled as VCR head cleaner were found next to the body. Phenylpropanolamine and low therapeutic levels of diazepam (64 μg/L) and nordiazepam (126 μg/L) were detected during toxicological analysis. An unidentified peak was observed when performing ethanol analysis by headspace gas chromatography. The peak was identified as ethyl chloride and the concentrations in the blood, urine, vitreous, brain, and lungs of the deceased were 423 mg/L, 35 mg/L, 12 mg/L, 858 mg/kg, and 86 mg/kg, respectively. The results were compared with previously reported levels of ethyl chloride in blood and vitreous and, based on a literature search, we believe that this is the first report of ethyl chloride levels in tissue.

KEYWORDS: forensic science, forensic toxicology, ethyl chloride, chloroethane, volatile substance abuse, headspace gas chromatography

Ethyl chloride (chloroethane) is a colorless flammable gas with an ether-like or pungent odor at ambient temperature and pressure. At low temperature or increased pressure it is a very volatile liquid with a boiling point of 12.3°C (54.1°F). Industrial uses of ethyl chloride include its use as a chemical intermediate in the manufacture of tetraethyl lead and ethyl cellulose and as a solvent in the manufacture of perfumes. It has been used as an inhalation anesthetic in the past and is now used as a refrigerant and local anesthetic for freezing tissues for punch biopsies, body piercing, and sports injuries.

Spray canisters of ethyl chloride, some labeled as VCR head cleaner, are sold in "party" or "head" shops with names such as: Head Cleaner, Ethyl Gas, Ethyl Gaz, Ethyl Four Star, Black Jac, and Maximum Impact. Although some are labeled as VCR head cleaner, none of the electronic service stores that we contacted used, or knew of the use of these products for that purpose. Modes of ethyl chloride abuse include inhalation directly from a container ("sniffing"), from a soaked or sprayed cloth ("huffing"), and from a plastic bag ("bagging"). It is used as a source of intoxication or for the enhancement of sexual pleasure.

A complex syndrome of neurological and mental manifestations due to chronic abuse of ethyl chloride has been described in case studies by Hess (1) and Nordin (2). The most common symptom seen with acute exposure is central nervous system depression. Ethyl chloride apparently causes cardiac arrhythmias by decreasing the myocardial threshold for arrhythmias and fibrillation induced by endogenous epinephrine. Death due to ethyl chloride has been reported in the scientific literature (3,4) and popular press (5).

We report here the death of a 30-year-old male apparently due to cardiac arrhythmia secondary to ethyl chloride inhalation.

Case History and Findings

The deceased was a 30-year-old white male (height 5 ft 3 in.; weight 125 lb) who was found unresponsive on the couch in a locked apartment by sheriff's office personnel who had entered through an unlocked window. Four cans (3 empty, 1 partially empty) of Black Jac® VCR tape head cleaner (Western International Distributors, North Hollywood, CA) were found by the body. A rag held loosely in the mouth of the decedent was observed. There were no apparent signs of violence at the scene.

Postmortem examination consisted of external and internal examination and the collection of tissue samples and biological fluids including blood, urine, and vitreous from the decedent. Findings upon completion include cerebral edema and congestion and generalized visceral congestion. Upon receipt of toxicological results the immediate cause of death was determined to be probable cardiac arrhythmia secondary to ethyl chloride inhalation. The manner of death was reported to be accidental.

Toxicological analyses were conducted on the blood, urine, vitreous, brain and lung tissue using a combination of immunoassay (EMIT®), thin-layer chromatography (Toxilab®), and gas chromatography for drugs of abuse, and headspace-capillary gas chromatography for volatiles analysis, including ethanol and ethyl chloride.

Ethyl Chloride Analysis Methods

Ethyl chloride standards in blood were prepared using chilled glassware and maintaining refrigerated temperatures due to the volatility of the compound. A 100 g/L stock standard was prepared

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using ethyl chloride (Sigma-Aldrich, St. Louis, MO) and pooled blood. An intermediate 10 mg/L blood standard was prepared. These standards were used to prepare working standards by addition to 5 mL aliquots of blood. Working standards were stored frozen in capped 16 × 100 mm tubes. Concentrations of the working standards constituting the calibration curve were 20, 50, 100, 200, 1000 mg/L. A stock of the internal standard for urine, blood, and vitreous samples was prepared by dilution of 1 mL 1-propanol (HPLC grade) with 499 mL deionized water. Tissue levels were determined using tissue homogenized in a solution prepared by dilution of 0.5 mL 1-propanol with 499 mL deionized water.

Blood, urine, and vitreous specimens were prepared by addition of 0.2 mL sample and 0.2 mL stock internal standard into 12 × 75 mm test tubes containing approximately 300 mg sodium chloride (NaCl). Frozen tissue, 6.0 to 9.0 g, was homogenized in 10 mL of the internal standard solution prepared for that purpose. Homogenate, 0.4 mL, was added to 12 × 75 mm test tubes containing approximately 300 mg NaCl. Analysis was performed as described below with appropriate dilution factors utilized. The tubes were capped immediately and then equilibrated at 37°C for 5 min prior to injection of 0.7 mL headspace vapor into a Hewlett Packard 5890 gas chromatograph equipped with a flame ionization detector. A capillary column from Hewlett Packard (Palo Alto, CA), Innowax® crosslinked polyethylene glycol (15 m × 0.25 mm inside diameter, 0.5 μm film thickness), was used. The carrier gas was helium at a septum flow (split) of 1.05 mL/min and a linear velocity of 30 cm/s. The oven temperature was 50°C (isothermal), injector temperature was 250°C and detector temperature was 275°C. Samples were injected manually. Quantitation was based on a 5-point calibration curve. The regression curve of area response versus ethyl chloride concentration (mg/L) was $y = 0.003x + 0.049$, $r = 0.9997$, standard error = 0.033. Retention times were: ethyl chloride 1.14 min, 1-propanol (internal standard) 5.12 min, and ethanol 2.82 min. The sensitivity of the assay was 5 mg/L and the within-run ($n = 10$) precision (coefficient of variation) was 6.0% at a mean concentration of 56 mg/L.

Results and Discussion

The results of the analyses are shown in Table 1. Phenylpropanolamine, nicotine and its metabolite were detected in urine using thin-layer chromatography. Immunoassay screening of urine was positive for benzodiazepines. Subsequent gas chromatographic analysis in blood for benzodiazepines detected low therapeutic concentrations of diazepam (64 μg/L; therapeutic 100 to 1000) and nordiazepam (126 μg/L; therapeutic 100 to 500) (6). We have not found any reference to additive effects between ethyl chloride and benzodiazepines, although one might expect such an interaction because of their mutual CNS depressant activities. Headspace gas chromatographic analysis for volatiles in blood was performed using two different systems. One system included a RTX-BAC-1 column and ethyl chloride standards prepared from a 2M stock in t-butyl methyl ether. In this system ethyl chloride and ethanol had identical retention times (1.61 min compared with 2.20 min for 1-propanol, the internal standard). Similar co-elution of ethanol and ethyl chloride using 0.3 and 0.2% carbowax, 60/80 carbopack C columns has been reported by Laferty (7). The co-elution of ethyl chloride and ethanol in this system was deemed unacceptable and the method described here was developed using a second system.

Development of a quantitative assay for ethyl chloride illustrates several aspects about the analysis of volatile compounds in biological samples. Co-elution of compounds with the substance of interest is a consideration for any gas chromatographic procedure. In this instance ethyl chloride co-elutes with ethanol when using a RTX-BAC-1 column, an occurrence previously reported for 0.3 and 2% carbowax, 60/80 carbopack C columns (7). This problem was eliminated by using an Innowax column. Choice of an ethyl chloride standard was another consideration. Standards available in pressurized canisters included pure ethyl chloride or dissolved in t-butyl methyl ether or diethyl ether. Initially the standard in t-butyl methyl ether was chosen based on cost and stability considerations. But t-butyl methyl ether co-elutes with ethyl chloride when the Innowax column and conditions described here are used. Co-elution of ethyl chloride with ethanol in one system and t-butyl methyl ether in another reinforces the conclusion of other investigators (8,9) that a second complementary analytical technique should be used for all forensic toxicological analyses, including volatiles analysis.

Use of pure ethyl chloride to prepare standards for the Innowax column eliminates the co-elution problem but increases the possibility of loss during handling due to its low boiling point (12.3°C). To minimize loss of ethyl chloride all glassware used in preparation of standards was cooled (4) and all blood, urine, and vitreous samples were stored refrigerated or frozen in tightly sealed containers. Because ethyl chloride inhalation was suspected in this case, tissues collected during autopsy were placed in tightly sealed containers and frozen immediately. Accurately weighed samples of frozen tissue were homogenized in a solution of the internal standard similar to the procedure described by Jenkins et al. (8) for the analysis of ethanol in liver. Calculation of the ethyl chloride concentration in tissue included the appropriate dilution factors to account for the tissue density or volume displacement (i.e., when 6.0 to 9.0 g tissue is homogenized in 10 mL of internal standard solution the resultant volume is greater than 10 mL) in the homogenization process.

Concentrations of ethyl chloride in body fluids of the deceased were: 423 mg/L in blood, 35 mg/L in urine, and 12 mg/L in vitreous. The urine and vitreous samples had been previously opened several times for drug analysis which possibly contributed to the loss of the ethyl chloride present. The blood sample had not been previously opened and had been stored frozen. Tissue samples were stored frozen between collection and analysis. Concentrations obtained in tissue were: 858 mg/kg in brain and 86 mg/kg in lung. In 1970 Kuschinsky (3) reported the death of a 14-year-old boy during surgery in which ethyl chloride was the anesthetic but no analyses were performed. Yacoub et al. (4) reported levels of 650, 417, and 200 mg/L in postmortem blood, vitreous fluid, and hospital blood of a college student whose death was attributed to over-

TABLE 1—*Toxicology results.*

Specimen	Drug Screen	Ethanol	Ethyl Chloride
Urine	PPA, Diazepam, Nordiazepam	none detected	35 mg/L
Blood	Diazepam: 64 μg/L; Nordiazepam: 126 μg/L	none detected	423 mg/L
Vitreous		none detected	12 mg/L
Brain			858 mg/kg
Lung			86 mg/kg

* PPA = Phenylpropanolamine.

dose or adverse reaction to ethyl chloride. They also reported a level of 1100 mg/L in a subsequent case involving a traffic fatality. Based on a literature search we believe that this is the first report of ethyl chloride levels in tissue.

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