CASE REPORT

María T. Zarrabeitia,[1] M.D., Ph.D.; Clara Ortega,[1] M.D.; Elena Altuzarra,[1] M.D.; María A. Martinez,[2] Ph.D.; Olav Mazarrasa,[3] Ph.D.; and Rosa Calvet,[1] M.D., Ph.D.

Accidental Dichloromethane Fatality: A Case Report

REFERENCE: Zarrabeitia MT, Ortega C, Altuzarra E, Martinez MA, Mazarrasa O, Calvet R. Accidental dichloromethane fatality: a case report. J Forensic Sci 2001;46(3):726–727.

ABSTRACT: A case of accidental dichloromethane poisoning by inhalation is presented. It is of interest that carboxyhemoglobin levels were within the normal range, suggesting that the narcosis and respiratory depression were due to the direct effect of DCM on the central nervous system. The accidental death was attributed to improper ventilation of vapors in the working area.

KEYWORDS: forensic science, dichloromethane, toxicity, carboxyhemoglobin, ventilation

Methylene chloride (dichloromethane or DCM) is a clear, colorless, and volatile solvent. Its high volatility may lead to high concentrations in poorly ventilated areas. It is used as an ingredient in old preparations of paint removers, degreasing agents, aerosol preparations, adhesives, and in a variety of industrial settings (1–3). It is neither flammable nor explosive at room temperature.

Although this chemical has been traditionally considered to be of low toxicity, various toxic manifestations have been observed following its inhalation (4). Toxic effects of DCM have been observed after acute exposures and have resulted from its direct depressant effects on the central nervous system or from its *in vivo* conversion to carbon monoxide. Although the safety limit in air was first set at 500 ppm (5), it was later established at 50 ppm (174 mg/m^3) (6). A case history is reported here in which death resulted from short overexposure to DCM used in an inadequately ventilated atmosphere, with blood carboxyhaemoglobin found to be within the normal range.

Case Report

A 27-year-old male was employed in a company that cleans and then paints and varnishes furniture. The employee was working at the cleaning tank located in a small room (9 × 7 × 8 m) with one door and a window that was shut. There was no mechanical device to provide direct ventilation in the room.

The cleaning tank was made of iron and was 4 m long, 1 m high, and 1 m wide. It could be closed by two doors on the top. The tank had been filled the previous day and contained 700 L of paint stripper to a depth of about 27 cm, and the objects to be cleaned were small enough to be placed into the tank by hand. The paint-stripper used was no. 125 KWICK KLEEN (A.M. Alvarez Hermanos, S.L., Guipuzcoa), which contains 77% DCM, 18% methanol, 1% sodium hydroxide, and 4% others.

The subject was last seen alive 20 to 30 min before being found unconscious. His workmates stated that he was removing the tank bottom looking for a broken glass. He was found slumped over the tank with his head and trunk in the tank and his arms in the solvent. He was wearing one glove; the other glove and the conventional half mask with organic vapor cartridges were later found in the tank.

He was taken to the hospital in cardio-respiratory arrest, but all attempts at resuscitation both in the ambulance en route and in the hospital emergency room proved unsuccessful.

The victim was a healthy man with no history of previous disease.

Postmortem Findings

The main autopsy findings were bilateral pulmonary congestion and oedema. The liver showed slightly increased consistency and size. Microscopic examination confirmed the macroscopic findings. Microhaemorrhagic changes were seen in the lungs and there was a significant increase in pigmented macrophages in the alveoli and around the bronchioles.

The liver showed mild portal inflammation, dilated centrolobular veins, and acute congestion. Autopsy was not conclusive in determining the cause of death but was consistent with acute intoxication.

Samples of body fluids (blood, stomach contents, vitreous humor, and pulmonary exudate) were collected for toxicological analysis, which established the cause of death as asphyxia secondary to inhalation of fumes from a cleaning agent (methylene chloride).

Toxicological Investigation

Air samples—DCM air samples (0.5 to 2.5 L) were collected in activated charcoal tubes (ORBO32, Supelco) by a sampling pump (MSA ESCORT ELF) calibrated with a soap film meter. Methanol was measured in samples collected into silicagel tubes (ORBO 52, Supelco). Flow rates were 0.2 L/min in both cases.

[1] Unit of Legal Medicine and Toxicology, Faculty of Medicine, University of Cantabria, Santander, Spain.
[2] National Institute of Toxicology, Madrid, Spain.
[3] Occupational Health and Security Center, Santander, Spain.
Received 24 May 2000; and in revised form 21 June 2000; accepted 21 June 2000.

Analysis of DCM was performed with the NIOSH 1005 Method (7) in a gas chromatograph (Hewlett-Packard 5890) with a flame ionization detector, equipped with a 50 m × 0.2 mm × 0.33 μ HP-FFAP crosslinked capilar column, and using N_2 as carrier gas under the following conditions: injection port, 150°C; oven, 60–170°C; detector, 250°C; injection vol., 1 μL; and Elution solvent, 1 mL CS_2.

Methanol samples were analyzed under the above mentioned conditions with the NIOSH 2000 method (8). Elution was made with doubled distilled water. Oxygen was measured directly with a MSA Microgard Portable Alarm.

Biological Fluids—Analysis of DCM in biological fluids (blood, vitreous humour, gastric content, and lung exudate obtained by mechanical compression) was performed in 100 μL of each specimen by a HP 5890 chromatograph, with a flame ionization detector and a HP 19375A headspace autoanalyzer equipped with a Supelco 60/80 Carbopack B column with 5% Carbowax 20M, 2 m, 2.0 mm i.d.

The temperatures were set as follows: vial heater, 60°C; transfer line, 65°C; oven 90°C; injection port 200°C; detector 200°C. The times were set as follows: thermostating, 20 min; pressurization, 12 sec; injection, 1 min. The carrier gas was helium flowing at 30 mL/min.

Results

The blood sample contained 3% carboxyhaemoglobin. The biological fluids were also tested for the presence of ethanol and methanol, both of which were present in insignificant concentrations. The DCM concentrations in the biological fluids (blood and pulmonary exudate) were 140 and 540 mg/L, respectively; both represent lethal levels.

The concentrations in air of DCM and methanol and the percentage of oxygen were determined at different levels: 3 levels inside the cleaning tank, and at the level of the upper airways of a worker standing upright and measured with the solvent at rest and on stirring, as the worker would presumably have done. The results obtained from this quantitative analysis are given in Table 1.

Discussion

The death of this worker was accidental and was caused by the acute inhalation of extremely high concentrations of DCM. Analysis of samples taken at the tank bottom some time after the accident gave a DCM concentration of >140 000 mg/m^3, showing that the worker could have been exposed to concentrations up to seventeen times the IDLH (immediately dangerous for life or health concentration) established at 8012 mg/m^3 by the NIOSH and the Occupational Safety and Health Administration (OSHA) (8).

TABLE 1—*Concentrations of solvents in the air.*

Sample	Methanol mg/m^3	DCM. mg/m^3	% Oxygen
Tank bottom (5 to 10 cm from the solvent)	8960	>140000	19.5
Mid-height (25 cm from solvent surface)	6152	89474	…
Brim of tank (75 cm from solvent surface)	461	4789	…
Air (upper airways)	10	243 to 390*	20.9

* The upper limit as measured on stirring solvent.

Consistent with the interpretation of an acute intoxication, the amounts of DCM in the blood and pulmonary tissue were 140 and 540 mg/L, respectively, which are both lethal levels. This suggests that death was the result of the direct narcotic effect of DCM, causing central nervous system depression and respiratory failure (9). In contrast, the levels of carboxyhaemoglobin were found to be within the normal range (<4%); therefore, the blockade of oxygen transport related to the formation of carboxyhaemoglobin induced by DCM metabolites (3,10,11) did not play a significant role in this death.

Fatal DCM poisoning is rare and this is the first reported case in Spain. Nevertheless, this case illustrates that this death could be classified as preventable. When DCM is used in confined spaces, its high volatility poses a serious health hazard as a result of accumulation of the solvent vapor, and precautions should, therefore, be taken. The testing of air prior to entry into the confined space, the installation of a hooded forced-draft ventilation system above the tank or of a down-draft table next to the tank have been suggested as adequate measures (3,11).

In addition, the importance of the need for worker education on the toxicity of the solvent, the proper handling of hazardous chemicals, and the use of appropriate personal protective equipment (air supplied respirators instead of cartridge respirators) should be emphasized. We believe that an awareness of the toxic effects of DCM and knowledge of the proper ventilation techniques would have been enough to prevent the death of this young worker.

Acknowledgment

The authors wish to thank D. Pedro Sainz de la Maza for his technical contribution.

References

1. US Department of Health and Human Services. Methylene chloride toxicity. Agency for toxic substances and disease registry. Am Fam Physician 1993;47:1159–66.
2. Manno M, Rugge M, Cocheo V. Double fatal inhalation of dichloromethane. Hum Exp Toxicol 1992;11:540–5.
3. Leikin JB, Kaufman D, Lipscomb JW, Burda AM, Hryhorczuk DO. Methylene chloride: report of five exposures and two deaths. Am J Emerg Med 1990;8(6):534–7.
4. Rioux JP, Myers RA. Methylene chloride poisoning: A paradigmatic review. J Emerg Med 1988;6:227–38.
5. Baselt RC, Cravey RH. Disposition of toxic drugs and chemicals in man. 4th ed. Foster City, CA: Chemical Toxicology Institute, 1995;231–2.
6. Threshold limit values and biological exposure indices for 1999. American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH.
7. NIOSH. Manual of analytical methods, 4th ed. Methylene chloride: Method 1005; Methanol: Method 2000. National Institute for Occupational Safety and Health. Public Health Service. Cincinnati, OH 1994.
8. NIOSH/OSHA Pocket guide for Chemical Hazards. National Institute for Occupational Safety and Health, 1997;208.
9. Goullé JP, Lacroix C, Vaz E, Rouvier P, Proust B. Fatal case of dichloromethane poisoning. J Anal Toxicol 1999;23:380–3.
10. Novak JJ, Hain JR. Furniture stripping vapour inhalation fatalities: Two case studies. Appl Occup Envirom Hyg 1990;5:843–7.
11. Winek CL, Collom WD, Esposito F. Accidental methylene chloride fatality. Forensic Sci Int 1981;18:165–8.

Additional information and reprint requests:
María T. Zarrabeitia
Unit of Legal Medicine and Toxicology
Faculty of Medicine
University of Cantabria
Santander 39011, Spain
Tel.: (34) 942201984
Fax: (34) 942201903
E-mail: zarrabet@unican.es