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Case Report

Fatalities Due to Dichloromethane in Paint Strippers: A Continuing Problem

Julia MacIsaac, MD, MPH,[1] Robert Harrison, MD, MPH,[2] Janani Krishnaswami, MD, MPH,[3] Jennifer McNary, IH,[2] Jeffrey Suchard, MD,[4] Megan Boysen-Osborn, MD,[4] Hank Cierpich, BS,[5] Laura Styles, MPH,[5] and Dennis Shusterman, MD, MPH[2]*

Background *Exposure to dichloromethane (DCM or methylene chloride - CH_2Cl_2) in paint strippers continues to be an avoidable source of morbidity and mortality. DCM has been under regulatory scrutiny by occupational and consumer product agencies since the identification of its carcinogenicity in the mid-1980s.*
Methods *We investigated two independent workplace incidents that resulted in three cases of DCM intoxication from paint stripper use.*
Results *Each incident investigated resulted in a fatality. A third worker suffered obtundation requiring hospitalization and intubation.*
Conclusions *The continued occurrence of fatalities and other serious injuries due to DCM-containing paint strippers in the United States calls for a re-evaluation of existing regulatory strategies.* Am. J. Ind. Med. 56:907–910, 2013. *© 2013 Wiley Periodicals, Inc.*

KEY WORDS: dichloromethane; methylene chloride; paint stripper; fatality; chlorinated solvent; asphyxia; confined space

INTRODUCTION

Inhalation of dichloromethane (DCM) at high concentrations can cause central nervous system and respiratory depression [ATSDR, 2000, 2010]. In addition, DCM is metabolized in the liver to carbon monoxide, a phenomenon that was first reported over 40 years ago [Stewart et al., 1972]. Paint strippers may contain high concentrations of DCM and are a regulated occupational hazard. The US Consumer Product Safety Commission (CPSC) requires that consumer-available DCM-containing strippers display a warning to use in a well-ventilated space. However, the following cases illustrate that warnings alone do not ensure safety, and even personal protective equipment (such as respirators) may fail to protect. The continued occurrence of DCM-related fatalities from paint strippers argues for a more aggressive regulatory approach to protect both workers and consumers.

Additional supporting information may be found in the online version of this article.

[1]Division of Occupational and Environmental Medicine, Department of Medicine, San Francisco General Hospital, University of California, San Francisco, San Francisco, California
[2]California Department of Public Health, Occupational Health Branch, Richmond, California
[3]University of California and Kaiser Permanente Combined Preventive Medicine/Internal Medicine Residency Program, San Francisco, California
[4]Department of Emergency Medicine, University of California, Irvine Medical Center, Orange, California
[5]Public Health Institute, Oakland, California

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Work was performed at: The California Department of Public Health, Occupational Health Branch, 850 Marina Bay Parkway, Building P, 3rd Floor, Richmond, CA, 94804; Division of Occupational and Environmental Medicine, San Francisco General Hospital, The University of California, San Francisco, 1001 Potrero Ave, Bldg 30, Suite 3500, San Francisco, CA 94110; and at Irvine Department of Emergency Medicine, University of California, Irvine Medical Center, 101 The City Drive South, Orange, CA 92868.

*Correspondence to: Dennis Shusterman, MD, MPH, California Department of Public Health, Occupational Health Branch, 850 Marina Bay Parkway, Building P, 3rd Floor, Richmond, CA 94804-6403. E-mail: dshuster@cdph.ca.gov

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CASE PRESENTATIONS

Incident #1

In May 2010, a 24-year-old Hispanic male maintenance worker (Case #1) was stripping a waterproof coating off of a baptismal font located within a small enclosed room in a church. Wearing only gloves for protection, he applied one gallon of paint stripper (Klean-Strip Premium Sprayable Stripper) to the floor of the font. The stripper was purchased at a local hardware store and contained 70–85% DCM, with smaller amounts of methanol, isopropyl alcohol, 2-butoxy-ethanol, and ethanol. Six-and-a-half hours after starting the task, he was found unresponsive, on the floor of the baptismal font. Paramedics were called, but despite resuscitation attempts, the patient expired.

The deceased worker had no reported history of chronic health problems. He did not take any medications, did not smoke, and had no known contributory family history. The autopsy revealed cardiomegaly with 4-chamber dilatation and coronary atherosclerosis with 50% occlusion of the left anterior descending artery. Post-mortem studies revealed a carboxyhemoglobin (COHb) of 10% and a blood DCM level of 37.8 mg/dL. Blood methanol, ethanol, and isopropyl alcohol were undetectable. The cause of death was intoxication by DCM, resulting in hypoxia, dysrhythmia, and death.

Incident #2

In November 2011, a 65-year-old Hispanic male at a paint manufacturing facility, entered an empty paint-mixing tank, through a small opening at the top of the tank. He worked alone brushing on a chemical paint stripper (Jasco Premium Paint and Epoxy Remover; 60–100% DCM, 10–30% methanol, 1–5% Stoddard solvent) to the inside walls of the tank to remove dried paint. He wore an organic vapor cartridge respirator, but no other personal protective equipment. A fan and hose assembly exhausted contaminated air out of the tank; however, it was positioned only half way between the tank opening and the floor of the tank. Two-and-a-half hours after entering the tank, he was found unconscious at the bottom of the tank by a 45-year-old Hispanic male coworker (Case #3). Case #3 entered the tank in an attempted rescue, but was also overcome by the vapors.

One hour later, coworkers rescued the two men from the bottom of the tank. Paramedics were called and found Case #2 in asystole. He did not respond to resuscitative efforts and was pronounced dead. Case #2 had a history of diabetes and chronic neuropathic pain; medications were metformin and gabapentin. He had no known allergies and did not smoke. Post-mortem testing revealed a COHb level below the limit of detection (<5%) and a blood DCM level of 220 mg/dL. The lungs and myocardium showed congestion, but no pre-disposing organ system pathology was identified. The cause of death was asphyxia due to inhalation of DCM.

Case #3, also Hispanic, had no past medical history, took no medications, and had no allergies. He had a remote history of tobacco use. Paramedics found Case #3 to have a patent airway, shallow respirations, and a Glasgow Coma Scale (GCS) score of 3. Oxygen saturation was 82% on ambient air, which increased to 100% with bag-valve-mask ventilation and supplemental oxygen. His pulse rate was 100 beats/min, blood pressure 118/68 mm Hg, and he was afebrile. Cardiac monitoring revealed sinus tachycardia.

In the emergency department, Case #3 was combative, GCS 1-4-1 and he was intubated for airway protection. CT scans of the head, cervical spine, abdomen and pelvis, and a chest X-ray revealed no injury. Laboratory tests revealed a respiratory acidosis (pH of 7.32, pCO_2 51 mmHg), a COHb level of 4.0%, and an osmol gap of 17 mOsm/kg (normal < 10 mOsm/kg). The initial serum methanol level was 15.1 mg/dL by gas chromatography analysis (normal < 1.5; Lindinger et al., 1997). Serum ethanol, isopropyl alcohol, acetone, and ethylene glycol were undetectable (a DCM level was not determined). After 4 hr, the patient's mental status improved, he was successfully extubated and admitted to the intensive care unit for observation. His mental status continued to improve; however, his COHb levels continued to rise over the first 24 hr of hospitalization, only returning to normal

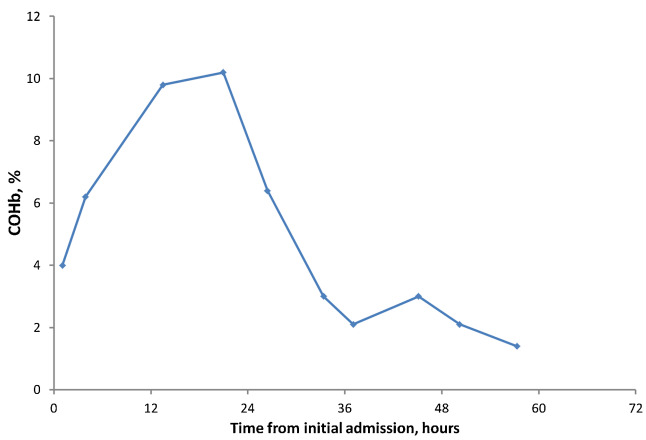

FIGURE 1. Carboxyhemoglobin (COHb) level as a function of time (in hours) from Case #3's initial arrival in the Emergency Department. COHb was 4.0% upon arrival, peaking at 10.2% 24 hr later. The patient was receiving supplemental oxygen throughout this sampling period.

after nearly 60 hr (see Fig. 1). He was discharged home without sequelae on hospital day #4.

DISCUSSION

We report here two occupational incidents: two fatalities and one case of severe obtundation linked to the use of DCM-containing paint strippers. Although the cases presented here involved occupational exposures, both products were consumer-available formulations, one of which was purchased at a local hardware store. DCM-containing paint strippers are sold in U.S. retail stores, placing consumers at risk for similar injury. Consumer deaths due to use of DCM-based strippers have been documented [Stewart and Hake, 1976; Harris County Institute of Forensic Sciences, 2007]. The hazards highlighted herein thus apply to both workers (e.g., painters, furniture or bathtub refinishers) and consumers alike.

Toxicologically, DCM is primarily an inhalational hazard causing CNS and respiratory depression: concentration of 800 ppm can disturb psychomotor performance [Dhillon and Von Burg, 1995], and concentrations of 2,300 ppm are considered to be ''Immediately Dangerous to Life and Health'' [NIOSH, 1994]. The hepatic conversion of DCM to carbon monoxide was discovered serendipitously in the early 1970s [Stewart et al., 1972; Stewart and Hake, 1976]. A rising COHb level in the absence of ongoing chemical exposure is highly suggestive, if not pathognomonic, for DCM toxicity. When methanol is co-present the peak COHb is further delayed [Stewart and Hake, 1976]. This phenomenon was apparent in Case #3. In previously reported DCM intoxications, COHb levels typically rise to 13–16% [Dhillon and Von Burg, 1995], but may reach as high as 50% [Fagin et al., 1980]. DCM-associated COHb elevations (''chemical asphyxia'') may precipitate angina, dysrhythmia and death, especially in patients with underlying cardio-pulmonary disease (as was the case for the deceased worker in Incident #1). In addition, DCM, like other chlorinated solvents, can directly sensitize the myocardium, lowering the threshold for dysrhythmias (National Institute on Drug Abuse, 1977). Each of these mechanisms likely contributed to the morbidity and mortality of the cases presented here. Despite DCM's extreme volatility, simple asphyxia was excluded given that estimated air concentrations of the stripping products were insufficient to create an oxygen deficient atmosphere (see Supplemental Information).

Beyond its acute toxicity, DCM is classified as ''reasonably anticipated to be a human carcinogen'' [NTP, 2011]. Based on carcinogenicity, the Occupational Safety and Health Administration (OSHA, OSHA 1997) set the DCM permissible exposure limit (PEL) to 25 ppm (averaged over 8 hr) and a short-term (15 min) exposure limit to 125 ppm. Even at these levels, there will be an estimated 5–11 excess cases of cancer for every 1,000 people exposed over a working lifetime [OEHHA, 2007]. In the cases presented here, DCM levels were estimated to be as high as 30,000 ppm (see Supplemental Information; Keil, 2009).

DCM-based products used in home settings can also result in high concentrations, exceeding OSHA PELs. For example, in one in-home simulation study of furniture stripping, DCM-concentrations exceeded 2,000 ppm (when used indoors without local exhaust ventilation; Hodgson and Girman, 1987). A separate case report of furniture stripping in a large basement (5,425 cubic feet) with the windows and doors closed led to some of the highest DCM-induced COHb levels ever reported (up to 40%; Langehenning et al., 1976).

Local exhaust ventilation, a supplied air respirator, and protective (e.g., polyvinyl alcohol) gloves should be employed when using DCM. Cartridge respirators are not permitted under OSHA standards since breakthrough times are extremely short, even when DCM concentrations are low. For example, for a DCM concentration of 50 ppm and at high relative humidity (80%), the breakthrough time was as short as 30 min [Moyer and Peterson, 1993]. The fact that Case #2 became obtunded and subsequently died while wearing a cartridge respirator, underscores this point. Only supplied air respirators provide sustained, reliable protection against DCM inhalation.

These incidents suggest that current regulatory standards are insufficient to protect workers and consumers from both acute and chronic DCM toxicity. The CPSC requires that DCM-containing strippers display a warning on the label advising use in a well-ventilated space [CPSC, 1986]. However, a study in which consumers were interviewed regarding their use of DCM-based paint strippers, found that warnings on the label are not adequate to guide safe use or protect against high exposures [Riley et al., 2001]. In 2009, the European Union (EU) concluded that warnings were insufficient, resulting in acute fatalities to workers and consumers. The EU subsequently banned the sale of paint strippers containing DCM to consumers and to professionals working in the field, and restricted sales to fixed commercial/industrial operations with appropriate local exhaust ventilation [European Parliament, 2009].

The EU restrictions are feasible since safe and effective alternatives to DCM-based stripping methods exist. Thermal or mechanical paint-removal methods may obviate the need for a chemical stripper altogether. Less-toxic alternatives such as benzyl alcohol-based paint strippers have been shown to be effective, economical substitutes [Morris and Wolf, 2006]. Successful strategies resulting in either DCM-elimination or reduction have been reported in several industrial settings in the United States [Roelofs and Ellenbecker, 2003].

CONCLUSIONS

We report on two deaths and one serious injury related to the use of DCM-containing paint strippers. Despite more than two decades of regulatory attention, DCM use in paint strippers has evaded effective hazard control, resulting in continued preventable morbidity and mortality. Like our counterparts across the Atlantic, regulatory agencies in the United States should consider approaches to require the use of safer, less-toxic alternatives to DCM in paint strippers.

The cases in this report were investigated under the California Fatality Control and Evaluation Program. This program has an institutional review board exemption from human subjects approval based on public health authority to investigate causes of work-related deaths. Due to this exemption, there is no requirement to obtain written permission from the cases or their next of kin and to report them at the level of detail at which they are described herein.

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