



A Case Series of Chemical Dermal Injury Requiring Operative Intervention after Prolonged Dermal Methylene Chloride Exposure

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Received: 30 July 2020 / Revised: 29 October 2020 / Accepted: 30 October 2020 / Published online: 5 January 2021
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Abstract

Introduction Methylene chloride, also known as dichloromethane, is a volatile hydrocarbon used in paint strippers and removers. Toxicity from methylene chloride may include narcosis and elevated carbon monoxide (CO) levels. Significant injury to the skin can occur after prolonged exposure to methylene chloride and other hydrocarbon-based solvents causing a chemical dermal injury.

Case Report This case series describes three male patients with prolonged exposure to a methylene chloride-containing paint remover to the bilateral hands with two of the three patients requiring transfer to a tertiary burn center and operative intervention. The clinical significance and impressive resolution of dermal injury from prolonged methylene chloride exposure are highlighted with detailed images and a literature review.

Discussion Chemical dermal injury secondary to methylene chloride exposure likely results from destruction of lipids within the epidermis and dermis and direct chemical injury. Prolonged exposure to skin can result in clinically important injury that requires management by a burn specialist and may necessitate operative intervention. The severity of the dermal injury can range from severe to mild and should be considered by a clinician after skin exposure to hydrocarbons.

Keywords Defatting dermatitis · Hydrocarbon · Methylene chloride · Dichloromethane · Carbon monoxide · Chemical dermal injury

Introduction

Methylene chloride, commonly known as dichloromethane, a halogenated hydrocarbon, is a volatile, colorless, sweet smelling liquid [1]. Methylene chloride is used for a variety of purposes. It is used as a solvent in paint strippers and

removers, propellant in aerosols, metal cleaning and finishing solvent, adhesives and glues [2], electronics manufacturing, processing solvent in the manufacturing of drugs and pharmaceuticals, urethane foam blowing, and, to a lesser extent, as an extraction solvent for spice oleoresins, hops, and caffeine in coffee [1, 3]. Although the most common use for methylene chloride is for paint strippers and removers in the United States (US), the Environmental Protection Agency (EPA), as of November 22, 2019, banned all manufacturing, processing, and retail distribution of methylene chloride in all paint and coat removers [4]. Alternative paint removers contain a mixture of N-methyl-2-pyrrolidone (NMP) and benzyl alcohol, or NMP and dibasic esters such as dimethyl adipate or dimethyl glutarate [5].

Routes of exposure to methylene chloride include oral, inhalation, and dermal. Methylene chloride is rapidly distributed to adipose tissue after an exposure [6]. As methylene chloride is slowly released from the tissue, it undergoes biotransformation via cytochrome P450 (CYP) mixed function oxidase, specifically CYP 2E1, producing a formyl halide intermediate metabolite. The formyl halide either acylates

Prior Publications/Presentation: Data from these cases was presented at the virtual North American Congress of Clinical Toxicology (NACCT) meeting in September 2020.

Supervising Editor: Mark B. Mycyk, MD

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macromolecules or decomposes to carbon monoxide (CO) [7–12]. A minor metabolic pathway utilizes glutathione s-transferase and produces formaldehyde and inorganic halide [10, 11]. Features of acute toxicity from methylene chloride exposure, like other hydrocarbon-based solvents, include central nervous system depression and CO toxicity [13, 14]. A toxicity less commonly considered from this exposure and other hydrocarbon-based solvents is dermal injury. The extent of dermal injury ranges from mild severe and depends upon duration and chronicity of exposure [15–17]. This case series describes the presentation and hospital course of three patients who developed full-thickness dermal injuries requiring operative intervention from prolonged skin exposure to methylene chloride.

Case Report

This is a case series of three Spanish-speaking-only male patients with prolonged dermal methylene chloride exposure. Consent for publication of these cases was obtained and provided to the journal in accordance with JMT policy. Three patients, 20- (patient 1), 21- (patient 2), and 37-year-old (patient 3) males, all presented to the emergency department (ED) with bilateral hand pain, swelling, and erythema. The patients reported a container (946 ml) of Jasco Premium Paint and Epoxy Remover® (60–100% methylene chloride, 10–20% methanol, < 5% petroleum) was accidentally knocked over onto the ground and the contents of the container spilled onto the floor. All three patients cleaned the contents off the floor in

Fig. 1 a Patient 1, b patient 2, c patient 3; image of bilateral palms of patients at initial presentation to the ED



a ventilated spaced with cloth rags and ungloved hands for an approximate duration of 45 min. All three patients applied topical hydrocortisone cream (unknown concentration) to the bilateral palms in an attempt to relieve symptoms prior to ED arrival. Initial vital signs for all three patients were within normal limits. The three patients had physical exams remarkable for bilateral palms that appeared edematous, macerated, and pale and exhibited tenderness to palpation, with the most severe findings noted on patient 3 (Fig. 1). Laboratory evaluation revealed an unremarkable basic metabolic panel (BMP) for all three patients. Carboxyhemoglobin (COhb) percentages (reference range: 0.5–1.5%) for patients 1, 2, and 3 were 3.9% (daily tobacco user), 3.2% (daily tobacco user), and 2.4% (non-tobacco user), respectively. The affected palms of three patients were decontaminated with soap and water in the ED for approximately 30 min. Acetaminophen 1000 milligrams (mg), ibuprofen 600 mg, and oxycodone 5 mg were administered orally, and fentanyl 100 micrograms (mcg) was administered intravenously to each patient for pain relief during their ED course.

After consultation with a burn specialist, transfer to a tertiary burn center for definitive management was arranged to manage the dermal injury; however, only patients 2 and 3 ultimately agreed with transfer to the outside hospital. Patient 1 deferred transfer due to his uninsured status. Repeat COhb levels 12 h after the first level for patients 2 and 3 were 2% and 1%, respectively. Wound care consisted of daily application of an oat beta-glucan occlusive ointment and xeroform. On hospital day two, exam findings for both patients were concerning for full-thickness chemical injury of the bilateral palms (Fig. 2).

On hospital day three, patients 2 and 3 were taken to the operating room (OR) and underwent general anesthesia for



Fig. 2 Patient 3 on hospital day two at burn center; full-thickness injury noted throughout entire palm



Fig. 3 patient 2, intraoperative findings after excision of full thickness injuries

excision of full-thickness injuries of bilateral palms (Fig. 3). The previously excised areas on the palms were dressed in a bioactive tissue allograft composed of dehydrated human amnion/chorion membrane. On postoperative day (POD) five, the dressings were removed (Fig. 4) and bacitracin and xeroform were applied topically with pain control achieved with oral analgesics agents. The patients were discharged from the burn center on POD five with scheduled outpatient follow-up. Patients 1 and 2 were lost to follow-up. Patient 3 returned to the clinic 1 month after discharge with near resolution and complete healing of his dermal injury (Fig. 5).

Discussion

Dermal exposure to methylene chloride was first described in the 1950s. A case report of a 19-year-old male who was given the job of degreasing small copper gaskets by dipping them into an open drum of methylene chloride reported the solvent bath “felt like ice water” on his bare hands [18]. In the 1960s, Stewart and colleagues had healthy volunteers immerse their thumbs in carbon tetrachloride, trichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, and methylene chloride. Methylene chloride produced painful symptoms within 2 minutes of the exposure, and the volunteers described the pain as burning, “numb and cold,” and an “asleep” sensation [19]. Mild erythema and white scaling of the thumb were noted after removal, and physical exam findings and symptoms completely resolved within 1 hour after exposure. Methylene chloride produced more pain than compared to the other

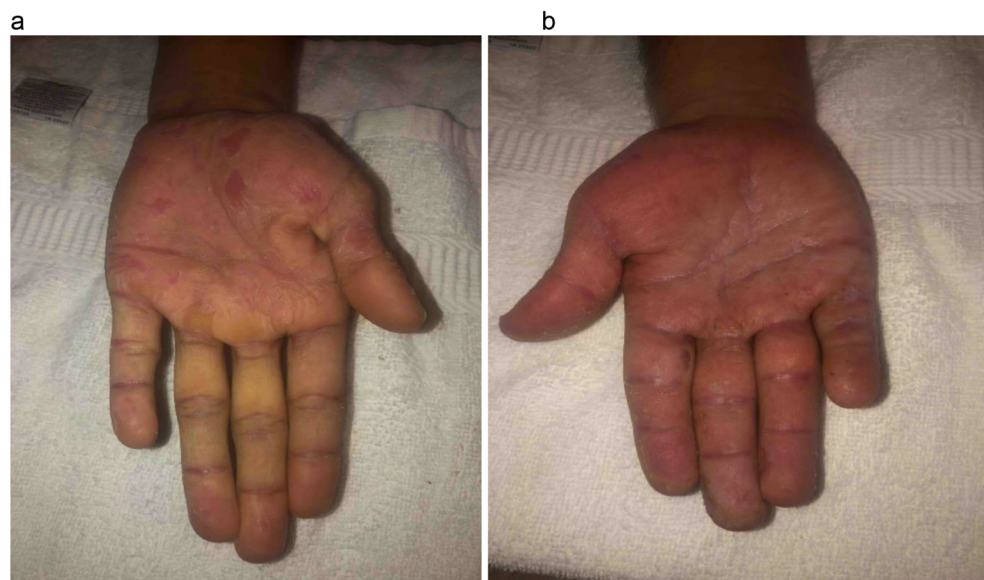
Fig. 4 **a** Patient 2; **b** patient 3; post-operative findings after removal of surgical dressings on postoperative day five



solvents studied [19]. The first case of severe dermal injury from methylene chloride was documented by Wells and Waldron [20]. They detail a case of a male cleaning out a vessel with a methylene chloride solution. The patient became unconscious from the methylene chloride vapors, the bucket of solution spilled onto the patient, and he then sustained 2nd and 3rd degree burns to both legs that required no skin grafting [20]. Another case of a young male cleaning a tank with methylene chloride in a poorly ventilated space noted dermal injury where the solution had been in contact with the skin on post-mortem examination [21]. Hall and Rumack published a case series of four employees in a furniture stripping shop where three of the four subjects sustained first- and second-degree chemical burns from direct skin exposure to methylene chloride [22]. Other hydrocarbon-based solvents can result in

chemical dermal injury with similar severity [16]. Milder cases of dermal injury may arise from chronic occupational exposure to hydrocarbon-based solvents and result in a contact dermatitis [18]. The mechanism for dermal injury in this case series is likely related to the dissolution of lipids in the skin, especially the epidermis and dermis resulting in a defatting dermatitis [16, 23, 24]. In one study examining the effects of jet fuel on pig skin, many morphologic changes were noted, particularly in the epidermal layers. These findings were characterized by epidermal and dermal edema, formation of lipid droplets and disruption of the stratum granulosum-stratum corneum interface [23]. Although this study did not specifically evaluate methylene chloride, a similar mechanism of dermal injury likely exists between methylene chloride and similar hydrocarbons. Although methylene

Fig. 5 Patient 3; image of bilateral palms 1 month after discharge from the burn center



chloride was the major hydrocarbon found in the product described in this case series, it was coformulated with methanol. Methanol is known to cause similar dermal manifestations and was likely contributory to the findings in this case series [15, 25, 26].

Conclusion

Dermal injury from methylene chloride is less commonly described than inhalational injury, and published reports of dermal complications limited. This case series highlights clinically important chemical dermal injury from methylene chloride which may necessitate management by a burn center for complex wound management and operative intervention. Other hydrocarbon-based solvents can result in similar chemical dermal injury, and chronic exposure may result in a contact dermatitis.

Acknowledgments The authors would like to acknowledge Dr. Alexa Camarena Michel for assisting with the production of this manuscript.

Funding None

Compliance with ethical standards

Conflict of Interest None

Consent for Publication Consent for publication of these individual cases and their images were obtained and provided to the journal in accordance with JMT policy.

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