CLINICAL VIGNETTE

Hydrofluoric and Phosphoric Acid Burn

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Case Description

A 45-year-old male presented to the Emergency Department for chemical burns to his right hand. A day prior to presentation, he was cleaning metal with a product called, "Foaming Aluminum Brightener". He was using a leaky plastic spray bottle to disperse the product. His right hand was in direct contact with its droplets continuously for three hours. He did not note any pain or discomfort initially, but at the end of the three-hour usage, he noted 10/10 pain, burning and redness of his right hand. He immediately washed the hand heavily with soap and water, and spent the night drinking alcohol and using marijuana to ease the pain. He also applied CBD oil topically and used an infrared light therapy device, both of which alleviated some pain. He noted that there had been some swelling around his fingers which initially limited flexion of his digits. He also complained of mild blistering and discomfort at the ends of his fingers and around the nails on the ring finger and middle finger. He denied fever, chills, weakness, and numbness. On arrival to the Emergency Room, his temperature was 97.5 F, pulse 79 beats per minute, respiratory rate 18 breaths per minute, blood pressure 168/95 mmHg, and his oxygen saturation was 100%.

His physical exam, including head, ears, nose and throat, pulmonary, cardiac, and abdominal, were normal. The skin of his right hand and fingers showed redness with blanching and swelling from the second through fourth fingers, and mild blistering on medial aspect of the middle finger (Figures 1, 2). Range of motion of the fingers were intact with mild tenderness to palpation. Strength of the hands and fingers were 5/5 bilaterally, and sensation was intact bilaterally. There were intact radial pulses bilaterally and capillary refill was less than two seconds.

Poison Control was contacted. Poison control team called the manufacturer of Foaming Aluminum Brightener and reported potential for phosphoric acid and hydrofluoric acid exposure, with high concentration up to 30% for phosphoric acid and up to 10% for hydrofluoric acid. Poison control advised EKG for evidence of electrolyte abnormality. He was treated topically with calcium gluconate, which significantly improved symptoms. Poison control center also recommended admission to the hospital or transfer to a burn center for evaluation. Patient declined admission and preferred outpatient follow up with the burn center. A referral was made to a local burn center where the patient was scheduled for follow up next morning.

Discussion

Chemical (caustic) burns comprise a minority of burn injuries, accounting for 3.5% of burn patients admitted to participating hospitals between 2009 and 2018, according to the National Burn Repository Report of the American Burn Association. These burns in the United States occur in both work-related (43.0%) and non-work-related (47.6%) accidents, with most occurring in the home (45.1%), followed by industrial settings (30.6%).[1] Immediate availability and poor labelling of occupational or domestic products with the potential to cause chemical burns contribute significantly to such accidents.[2] Exposure to occupational chemicals involves acids, bases, oxidants, and other agents that commonly come from manufacturing reagents, disinfectants, pesticides, and fertilizers.[3] Domestic chemicals usually come from cleaners, rust removers, fireworks, and fertilizers.[3] The top five chemicals associated with injury were carbon monoxide (4.1%), ammonia (2.0%), chlorine (1.3%), hydrochloric acid (0.56%), and sulfuric acid (0.55%) according to a review of the Agency for Toxic Substances and Disease Registry from 1991 to 2009.[4] Of chemical incidents, an overwhelming majority (95%) involved the release of only one chemical.[4]

Inorganic acids such as nitric, sulfuric, phosphoric, and hydrofluoric acids are generally more irritating than organic acids such as acetic, glycolic, formic, and salicylic acids.[5] Acids damage the epidermis due to cytotoxicity and protein denaturation, leading to clinical features such as erythema, blistering, and necrosis.[5,6] Usually, the symptoms develop immediately or in close proximity to the exposure, allowing for relatively easy diagnosis of chemical skin burns.[7] Nevertheless, certain chemicals such as weak hydrofluoric acid, phenols, and sulfur mustard gas can have delayed reactions which can first appear hours to up to a day post-exposure.[7] Initial management to most dermal corrosive chemical exposure is immediate decontamination.[3,8] The first step of decontamination is removal of agent by dusting off dry agents and removing soiled clothing.[3] The second step is dilution with ample irrigation of all wounds and areas of exposure with water, which has been studied extensively as the best decontaminating solution for most corrosive chemicals.[3,8] The exceptions to this are elemental metals due to their exothermicity when combined with water and phenols due to their potential deeper infiltration when in aqueous solutions.[6] After the initial management, secondary treatment may differ depending on the chemical involved.[3] Some acids such as hydrofluoric acid have unique

characteristics and management strategies beyond supportive, wound-specific care.

Hydrofluoric acid is found in consumer products including rust removal agents, marble, brick and stone cleaners, automobile wheel cleaners, toilet bowl cleaners, air conditioner cleaners, and insecticides.[9] These consumer products usually have diluted hydrofluoric acid, which can cause delayed onset of symptoms.[7,9] One of the hallmark symptoms is strong pain disproportionate to physical examination findings due to the highly lipophilic hydrofluoric acid molecules releasing fluoride ions which bind to calcium in tissues, affecting the nervous system.[7,10] This is in addition to fatty acids scavenging the free hydrogen ions, resulting in fat saponification and liquefactive necrosis as in the case of most strong acid burns.[6] Another unique sequala of a hydrofluoric acid burn is electrolyte disturbance—most commonly hypocalcemia, but hypomagnesemia, acidosis, fluorosis and hyperkalemia may also occur.[10] This is due to the fluoride anions binding to calcium and magnesium cations, leading to decreased serum concentrations and their associated systemic effects.[3,7,9,10] Therefore, monitoring electrolytes for systemic toxicity is especially important in managing a hydrofluoric acid burn as seemingly innocuous burns may cause severe electrolyte imbalance.[3]

Hydrofluoric acid burns also have unique treatment strategies. To ease the pain caused by the fluoride ions that have penetrated into tissues, calcium gluconate gel can be applied to the wound, which promotes the formation of an insoluble calcium salt that can be washed from the skin surface.[6,10] Calcium gluconate gel can be created by using calcium gluconate solution or powder dissolved in a water-soluble lubricant, such as K-Y Jelly (Johnson & Johnson, USA).[10] The standard practice is to topically re-apply the gel every 15 to 30 minutes initially, then every four hours until the absence of pain, which is a clinically reliable indicator of effectiveness.[9,10] Calcium gluconate can also be administered by intravenous or intraarterial injections for more severe and deeper burns caused by >20% hydrofluoric acid.[6,10] Lastly, hydrofluoric acid readily damages subungual tissues beneath the nail plate, and could cause severe pain. Because calcium gluconate gel is not effective in treating burns of the nails, drilling, splitting, or removing the fingernail is often required to allow the topical calcium gluconate to be effective.[9,10]

Conclusion

This case highlights the presentation and management of a patient with acid burn without systemic toxicity. This patient presented with a history of hydrofluoric and phosphoric acid exposure to his right hand and fingers. Poison control team recommended admission and transfer to a local burn center for evaluation; however, the patient opted for outpatient management. The patient did follow up with a burn specialist the next day. By that time, he had resolution of pain and no sign of deep dermal injury. He was released and was doing well at four days post exposure. In conclusion, hydrofluoric acid burn is a unique chemical burn that requires a prompt and accurate diagnosis for optimal management and relief.

Figures

Figure 1

Figure 2

REFERENCES

1. Committee ABANA. National Burn Repository 2019 Report. American Burn Association, 2019.
2. **Gnaneswaran N, Perera E, Perera M, Sawhney R**. Cutaneous chemical burns: assessment and early

management. *Aust Fam Physician*. 2015 Mar;44(3):135-9. PMID: 25770579.

3. **Robinson EP, Chhabra AB**. Hand chemical burns. *J Hand Surg Am*. 2015 Mar;40(3):605-12; quiz 613. doi: 10.1016/j.jhsa.2014.07.056. Epub 2015 Feb 1. PMID: 25653184.
4. **Anderson AR; Centers for Disease Control and Prevention (CDC).** Top five chemicals resulting in injuries from acute chemical incidents—Hazardous Substances Emergency Events Surveillance, nine states, 1999-2008. *MMWR Suppl*. 2015 Apr 10;64(2):39-46. PMID: 25856537.
5. **Allnutt K, Nixon R**. Dermal effects of chemical exposures. In: Cohrssen B, ed. *Patty's Industrial Hygiene*, 7th ed. John Wiley & Sons; 2020. p. 361-81.
6. **Friedstat J, Brown DA, Levi B**. Chemical, Electrical, and Radiation Injuries. *Clin Plast Surg.* 2017 Jul;44(3):657-669. doi: 10.1016/j.cps.2017.02.021. Epub 2017 Apr 21. PMID: 28576255; PMCID: PMC5488710.
7. **Chiang A, Bruze M, Fregert S, Gruvberger B**. Chemical Skin Burns. In: John S., Johansen J., Rustemeyer T., Elsner P., Maibach H. (eds) *Kanerva's Occupational Dermatology*. Springer, Cham. 2018. https://doi.org/10.1007/978-3-319-40221-5_13-2.
8. **Brent J**. Water-based solutions are the best decontaminating fluids for dermal corrosive exposures: a mini review. *Clin Toxicol (Phila).* 2013 Sep-Oct;51(8):731-6. doi: 10.3109/15563650.2013.838628. Epub 2013 Sep 5. PMID: 24003912.
9. **Bajraktarova-Valjakova E, Korunoska-Stevkovska V, Georgieva S, Ivanovski K, Bajraktarova-Misevska C, Mijoska A, Grozdanov A**. Hydrofluoric Acid: Burns and Systemic Toxicity, Protective Measures, Immediate and Hospital Medical Treatment. *Open Access Maced J Med Sci*. 2018 Nov 20;6(11):2257-2269. doi: 10.3889/oamjms.2018.429. PMID: 30559898; PMCID: PMC6290397.
10. **McKee D, Thoma A, Bailey K, Fish J.** A review of hydrofluoric acid burn management. *Plast Surg (Oakv).* 2014 Summer;22(2):95-8. PMID: 25114621; PMCID: PMC4116323.