Hydrofluoric Acid Burns

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INTRODUCTION

Few nurses are familiar with the pathophysiology and treatment of hydrofluoric (HF) acid burns and given the unique nature of these injuries, RNs working in ER or ICU need to know what HF acid can do and how to care for a HF acid burn. Unlike other chemical burns, HF acid burns can produce serious systemic effects, small amounts and exposure of a small body surface area (BSA) can be dangerous, and the dermal injury caused by HF acid is often disproportionately mild in appearance compared to the severe pain HF acid can cause and its potential systemic effects.

Objectives

When the student has finished this module, he/she will be able to:

1. Identify three household products that contain HF acid.
2. Identify the electrolyte abnormalities caused by HF acid.
3. Identify the most common cause of death due to HF acid exposure.
4. Identify a unique feature of HF acid burns.
5. Identify three potentially serious HF acid exposure scenarios.
6. Identify an important concept about the onset of pain caused by HF acid burns.
7. Identify the immediate treatment for a serious HF acid burn.
8. Identify the proper technique for using topical calcium to treat HF acid burns.
9. Identify the proper technique for using intradermal calcium to treat HF acid burns.
10. Identify the proper technique for using intraarterial calcium to treat HF acid burns.

HYDROFLUORIC ACID: BASIC FACTS AND PATHOPHYSIOLOGY

Hydrofluoric acid is an acid that is in common use in industry, and it is also found in aluminum cleaners, automobile wheel cleaners,

ceramic cleaners, and rust removers that can be purchased for home use. It is a relatively weak acid with a pH of 3.5. Products that can be purchased over-the-counter have low percentage of HF acid, usually 5%-8% or less.

Hydrofluoric acid can cause dermal burns, but unless the concentration of the product is > 50%-70%, the burns caused by HF acid are often mild. The burned area may be red, swollen, and occasionally it will be blistered, but it is very likely that it will not look alarming. However, HF acid burns can be very, very painful – the pain is often far in excess of what would be expected from the *appearance* of the burn – and HF acid can produce serious, life-threatening systemic toxicity.

- **Burns:** As mentioned, the pain caused by many HF acid burns is frequently very disproportionate to the obvious tissue damage. Also, unless the patient has been burned with a strong solution, the onset of the pain is delayed many hours – sometimes as long as 24 hours – after the exposure. These effects happen for several reasons. First, HF acid is a weak acid and most people are exposed to low concentration solutions. Second, most of the pain from a HF acid burn is *not* due to the external tissue damage from the chemical burn. Most acids cause a coagulation necrosis. The acid damages tissues by denaturing proteins, but this process produces a thick, tough scar that stops the acid from penetrating further. However, HF acid does not do this. HF has a very high permeability coefficient so it easily penetrates the skin, and when it does, the fluoride ion dissociates from hydrogen. When this happens, the F ions cause direct tissue damage but they also form complexes with calcium, magnesium, and these complexes directly irritate nerves and also cause mechanical damage. Hydrofluoric acid is also thought to poison the Na^+-K^+ ATPase pump and it cause hyperkalemia, and the high serum potassium can irritate nerves and pain sensors. When the HF acid solution is very dilute, the processes of penetration and dissociation are slow and take a long time, so the onset of the pain is delayed. Also, because HF is a weak acid, the process of dissociation – and the visible damage caused by the H^+ ions – takes a long time unlike strong aids such as muriatic acid, nitric acid, etc.

Learning Break: A HF burn may be "unimpressive" in appearance because the tissue damage is happening below the surface, but the patient can be having excruciating pain. Because of this and because

the onset of pain is often delayed, these cases can be very deceptive to triage and assess.

- **Systemic Effects:** If the solution is very strong, or the duration of contact is long, or the amount of BSA that is burned is high, severe and life-threatening effects are possible. When HF acid penetrates the skin and dissociates, the fluoride ion avidly binds to calcium and magnesium and poisons the Na^+-K^+ ATPase pump. Hypocalcemia, and hypomagnesemia can be profound, and serum potassium can be very elevated. Low serum levels of calcium and magnesium and high serum levels of potassium can seizures, arrhythmias, and death. Ventricular arrhythmias are the primary cause of death from HF acid exposures.

SIGNS AND SYMPTOMS OF HYDROFLUORIC ACID BURNS

Most HF acid burns are not dramatic in appearance. This is because the majority of these injuries involve dilute solutions of HF acid and because the tissue damage and nerve irritation is happening below the epidermis. Fingers and hands are the areas most often affected because patients neglect to wear gloves when using aluminum cleaners, rust removers, etc. The area is swollen, and the skin is erythematous or white and very painful. High concentrations cause erythema, blisters, and necrosis and in severe cases, bone damage.

The onset of pain depends on the HF acid concentration: the weaker the concentration, the longer it takes for the pain to manifest. If the concentration is 0-20%, the onset of pain may be delayed for 24 hours; if the concentration is 20%-50%, the onset of pain may be delayed 1-8 hours; and if the concentration is > 50% pain will happen immediately. As mentioned previously, if the exposure to HF acid was serious, the patient may have signs and symptoms of serious electrolyte disorders.

TRIAGE AND ASSESSMENT OF A HYDROFLUORIC ACID EXPOSURE

When a patient presents with a HF acid exposure, determine the concentration of the acid, the BSA affected, the location of the burn, the duration of contact, and what decontamination procedures were done. There are three situations of HF acid burns that can be very dangerous. If the patient has been exposed to HF acid in one of the following ways, there is potential for serious complications and death.

- **Hydrofluoric acid burns to the face:** *Any* HF acid burn to the face caused by *any* concentration of the product should be considered to be potentially dangerous.

- **BSA burn of > 5% from any concentration of HF acid.**

- **BSA burn of ≥ 1% of a HF acid concentration ≥ 50%**

Learning Break: *Any patient who has been exposed to HF acid in one of these ways should immediately be placed in a monitored bed.* These patients cannot wait to be evaluated and treated. Deaths have been reported from HF acid burns involving 2.5% BSA.

If the patient does *not* a potentially dangerous exposure, perform a physical assessment and determine the circumstances of the exposure. Find out when the patient was exposed, what he/she was exposed to, the concentration of the solution, how the exposure occurred, how long the acid had contact with the skin, and what decontamination, if any was performed. Ask the patient where the pain is, when it started, and how much pain he/she is having. *Don't forget:* The area that was exposed and the burn may not appear badly damaged, but the patient may well be in considerable pain.

Examine the exposed area for signs of tissue damage, swelling, redness, tenderness to touch, etc. Determine if the pulse is regular or irregular. Other things to look for are the presence of tetany, the Chvostek sign, or the Trousseau sign. These are all indicators of hypocalcemia. A prolonged QT interval is an early indicator of hypocalcemia and/or hypomagnesemia.

Learning Break: The Chvostek sign is a spasm of the facial muscles that is elicited by tapping the facial nerve in the area of the parotid gland (anterior to the ear at the level of the bottom of the ear lobe). The Trousseau sign is defined as spasmodic contraction of muscles when the nerves associated with the muscles are stimulated. The Trousseau sign is elicited by inflating a sphygmomanometer above systolic blood pressure for several minutes and watching for spasms of the hand, wrist, or fingers.

TREATMENT OF HYDROFLUORIC ACID BURNS

Remove contaminated clothing if the patient has not done so. If the burn occurred relatively recently, flush the area for 15 minutes with tepid water. If the BSA of the exposure is > 5%, or the concentration of the HF acid solution the patient was exposed to was > 50%, or the

patient's face was exposed, you can flush the exposed area even if the burn has occurred some time ago, but do not delay other treatment to do this.

If the exposure is not considered serious, e.g., involvement of a low BSA, exposure to a low concentration of HF acid, and/or the patient is not having any signs or symptoms of hypocalcemia, there is no need for laboratory studies or an ECG. If the patient is having a lot of pain, consider obtaining an x-ray of the burned area. Proceed to treatment.

If the exposure is considered serious, obtain IV access, place the patient on a cardiac monitor, get a x-ray of the burned area if that would be appropriate, obtain a 12-lead ECG, and obtain serum levels of calcium, magnesium, and potassium.

Systemic and Local Treatment of a Hydrofluoric Acid Burn

If the patient has hypocalcemia or hyperkalemia, give 10% calcium gluconate, 0.2-0.4 mL/kg IV, or 10% calcium chloride, 0.1-0.2 mL/kg, IV. Replace magnesium as needed

Many HF acid burns involve small areas of the body, fingertips, etc. These patients can initially be treated with analgesics such as morphine or dilaudid. These medications will help to relive the pain, but they will not interrupt the pathological process that is causing the pain and they will not prevent further tissue damage. The most effective way to treat pain and prevent tissue damage is to use topical or parenteral calcium preparations. Calcium binds fluoride ions, alleviates pain, and prevents tissue damage.

Learning Break: Do not use parenteral calcium chloride to treat HF acid burns. It is very irritating

- **Topical calcium:** There are commercially produced topical calcium gels that are intended for treating HF acid burns, but these preparations can easily be made by a pharmacy. To make a calcium preparation, dissolve 10% calcium gluconate solution in a sterile, water-soluble lubricant (e.g., K-Y Jelly®) at a 1:3 ratio *or* mix 3.5 grams of calcium gluconate powder in 5 ounces of sterile, water-soluble lubricant. Massage the calcium preparation into the affected area and then cover the area so that body heat can facilitate dermal absorption. If the pain is not relieved or significantly diminished within 30 minutes, the patient should be treated with parenteral calcium.

- **Parenteral calcium:** If the burn is moderate or severe, it is unlikely that topical calcium will be effective and the patient

should be given parenteral calcium, intradermally or intra-arterially. **Intradermal:** Use a 27 or 30 gauge needle and inject 10% calcium gluconate, 0.5 mL into each cm^2 of the affected area. This technique *can* be used for extremities and digits. However, it can actually cause pain, increase tissue pressure in the area (potentially harmful in and of itself) and it must be used cautiously and with no more than 0.5 mL per digit.
Intraarterial: This is reserved for serious or potentially serious cases. Use 10 mL of 10% calcium gluconate, mix with 50 mL of 5% dextrose and infuse over 4 hours through the radial or brachial artery. Repeat if needed.

Learning Break: You may read in the medical literature of other ways of using calcium gel and parenteral calcium that differ from theses approaches. The protocols described here are derived from standard clinical toxicology texts, but at this time *there is no standard, universally accepted protocol for using topical calcium gel and/or parenteral calcium to treat HF acid burns,* the different possible approaches have not been directly compared, and none has been shown to be superior to the others. Researchers have also used milk, antacid liquids, cationic detergents, and other substances to treat HF acid burns, but these are not as effective and/or have side effects.

OCULAR EXPOSURE TO HF ACID

An ocular exposure to HF acid can be devastating. A Morgan lens should be placed and the eye should be irrigated with normal saline until an ophthalmologist has been consulted. Do *not* insert the Morgan lens, remove it, reinsert it, etc: this can cause. It is not clear whether using calcium in the eye will help or be harmful. **Do not use calcium to irrigate the eye unless directed to do so by a physician or an ophthalmologist.**