



CRYO-STORAGE AND TECHNOLOGIES (CST)

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SafetyAlert-29

Medical Treatment Protocol for Hydrofluoric Acid Burns

WARNING: Burns with concentrated hydrofluoric acid (HF) are usually very serious, with the potential for significant complications due to fluoride toxicity. Concentrated HF liquid or vapor may cause severe burns, metabolic imbalances, pulmonary edema, and life-threatening cardiac arrhythmias. Even moderate exposures to concentrated HF may rapidly progress to fatality if left untreated. Relief of pain is the only indication of effectiveness of treatment. Therefore, the use of any anesthetic and/or analgesic agent is not advisable.

Properties

Hydrofluoric acid (HF) is an extremely powerful inorganic acid and a vigorous dehydrating agent. Anhydrous hydrofluoric acid and hydrofluoric acid in aqueous solutions range in appearance from colorless to slightly tinted. HF has a pungent odor. It is extremely corrosive.

Health Effects of Exposure

Hydrofluoric acid exposure requires immediate specific and specialized medical treatment. Not only can this strong acid cause burns, but the fluoride ion can be quickly absorbed through the skin. Fluoride ions can then attack underlying tissues and can be absorbed into the bloodstream. HF, liquid or gaseous, may cause severe burns of the skin and deep tissues. If the eyes are exposed to HF, it may penetrate to internal structures. HF inhaled in high concentrations may cause glottitis (obstruction of the airway) and acute pulmonary edema. Absorption of HF may cause hypocalcemia due to HF's fixation of blood calcium. Hyperkalemia may occur if severe hypocalcemia appears.

HF skin burns are usually accompanied by severe, throbbing pain which is thought to be due to irritation of nerve endings by increased levels of potassium ions entering the extracellular space to compensate for the reduced levels of calcium ions, which have been bound to the fluoride.

The effects of exposure to HF may be delayed, depending on the strength of the solution. Solutions containing greater than 50% HF will normally cause an immediate recognizable and painful burn. Solutions containing 20% to 50% HF may cause delayed symptoms that manifest in one (1) to eight (8) hours. Solutions with less than 20% HF may not cause symptoms for up to 24 hours. A similar delay in symptoms may be seen with respiratory and dermal contact.

Safety Precautions

Be prepared! Adequate personal protective equipment must be provided to each employee who may be exposed to HF. **FIRST AID RESPONDERS AND MEDICAL PERSONNEL MUST WEAR RUBBER (NEOPRENE, POLYVINYL CHLORIDE (PVC), NITRILE OR ACID RESISTANT) GLOVES WHEN TREATING HF BURNS TO AVOID HAND BURNS!** Employees must be properly trained in the wearing of personal protective equipment. Safety and handling procedures must be taught to all relevant personnel, and these procedures must be enforced. Personnel who have been trained in the specialized HF first aid procedures must be available immediately. Medical supplies must be readily accessible at all times. (See Medical Supplies List.)

Local emergency medical responders and hospitals must be included in the first aid and medical training for the facility. Effects of HF exposure are unique and must be treated in a specialized medical fashion. An appropriate first response coupled with HF-specific medical treatment is imperative.

Hypocalcemia

Significant fluoride exposure via large burns, inhalation, or ingestion will require observation for hypocalcemia.

An important way to monitor the necessity for and effectiveness of treatment is EKG monitoring (for example, prolongation of the QT interval may indicate hypocalcemia).

Calcium gluconate infusion (using 2 to 3 vials of 10% calcium gluconate in one liter of NSS to pass at the rate of 100 milliliters per hour) may be administered. CAUTION must be taken. Excess calcium can produce ventricular arrhythmias, vagal bradycardia, and ventricular fibrillation. Repeat infusions until EKG abnormalities or symptoms disappear.

Serum calcium, magnesium, and potassium levels must be monitored. Electrolyte monitoring should indicate if and when magnesium should be replaced intravenously.

In cases of extreme fluoride absorption, a potentially therapeutic maneuver is the use of bicarbonate/acetazolamide infusion to control metabolic alkalosis and to enhance fluoride excretion by the kidneys.



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The efficacy of this intervention has not been determined conclusively.

First Aid Treatment

First aid treatment is appropriate in those cases where it is known that:

- The affected area is small (less than four square inches),
- AND the HF solution is less than 20%,
- AND pain is promptly relieved by the application of calcium gluconate gel.

Relief of pain is the only indication of effective treatment. Therefore, the use of any local anesthetic and/or analgesic is NOT advisable.

Medical Treatment

Summon medical professionals and refer to local hospital:

- All cases of eye exposure, ingestion, airway exposure.
- All cases of exposure to genitals, anal area, ear canals, hands or feet, regardless of size of HF concentration.
- Any skin burn with hydrofluoric acid >20% should be regarded as potentially fatal. Patients who have burns and pain within minutes of exposure can be assumed to have been exposed to concentrated acid and are at risk of rapid clinical deterioration and death.
- Any skin burn with hydrofluoric acid <19% that is greater than 4 square inches (dimensions equivalent to 2" x 2").
- Any exposure to gaseous HF where the patient experiences respiratory irritation.

First Aid and Medical Treatment

Table 1 describes additional details on the treatment options. Table 2 lists suppliers for the calcium gluconate gel. Table 3 gives directions for preparing calcium gluconate gel and solutions.

Skin Burns

Skin contacted by HF, vapor, or aqueous solution, rapidly produces any erythematous (reddened) area, often with a white or gray color at the surface caused by coagulation of tissue. Patients who have pain within minutes of exposure can be assumed to have been exposed to concentrated HF acid and are at risk of rapid clinical deterioration and death. Burns due to low concentration HF may cause blistering of the skin. If blisters are present, they should be opened and drained, and necrotic tissue should be debrided by a physician or qualified health care practitioner as soon as possible. Treatment should not be delayed if debridement cannot be accomplished immediately.

1. Immediately go to a safety shower or other available water and flush with copious amounts of water for a minimum of 5 minutes. This will rinse off excess HF. Speed and thoroughness in washing off the acid is of primary importance, since after 5 minutes the HF is being absorbed into the tissue.
2. All clothing must be removed. Continue under water until calcium gluconate gel is available.
3. Summon medical personnel and continue with first aid.
4. Apply calcium gluconate 2.5% gel every 15 minutes and massage continuously until the pain disappears. Remember, rubber gloves must be worn while touching the victim. If pain recurs, apply calcium gluconate gel and massage while transporting the injured worker to an emergency room.

An alternate procedure is to soak the affected areas in an iced 0.13% water solution (1:750) of Zephiran® chloride (benzalkonium chloride solution, NF). Use ice cubes, not shaved ice, in order to prevent frostbite. If soaking is impractical, soaks or compresses may be used. Compresses should be changed every 2-4 minutes. Total immersion for areas such as fingers, hands, and feet is desirable. Do not use Zephiran® solution for burns of the eyes. Zephiran® is an eye irritant.

5. Continue either application of calcium gluconate gel or Zephiran soaks while transporting to a medical facility.

NOTE: Do NOT use local anesthetic or analgesic. Resolution of pain is the means to determine effective medical treatment.

For deep burns, infiltration of aqueous calcium gluconate 2.5% solution with a small-gauge (#25-#30) needle around the affected area and intralesionally may be necessary. Initially use no more than 0.5cc per square centimeter of burned skin. Do not distort skin appearance. Caution must be observed to avoid calcium overdosing. Administration should be performed by a physician only.

In some cases, it may be necessary to surgically remove damaged tissue and then apply calcium gluconate (2.5% aqueous solution) to the affected area.

The person with HF burns covering greater than 4 square inches (dimensions equivalent to 2" x 2") should be admitted immediately to an intensive care unit and monitored carefully for 24 to 48 hours. Burns can be accompanied by absorption of fluoride through the skin with sequestration of circulating calcium leading to hypocalcemia and hyperkalemia from the release of cell contents. Fatal cardiac dysrhythmias may ensue. Serum calcium, potassium, and magnesium levels should be monitored. The QT interval should be followed for signs of hypocalcemia. Hypocalcemia results in prolonged QT intervals. Hemodialysis may be necessary for fluoride removal and correction of hyperkalemia.

Eye Burns

1. Seek medical attention. Transport patient to eye specialist for further treatment.
2. Do not use oils, salves, ointments, or other HF skin burn treatments. Do not use Zephiran for burns of the eye.

3. Hold eyelids apart. Initiate and maintain gentle and continuous irrigation until the patient receives medical care. If medical attention is not promptly available, continue to irrigate for one hour.

If available, apply a few drops of aqueous topical ophthalmic anesthetic solution to the eyes (Proparacaine Hydrochloride 0.5%). Do not delay treatment if ophthalmic anesthetic solution is not readily available.

4. If sterile 1% calcium gluconate solution is available, flushing may be limited to 5 minutes. Place a Morgan's lens or the Eye Irrigator® on patient and irrigate eye intermittently for 20 minutes with an aqueous calcium gluconate 1% solution. Insert and remove a Morgan's Lens while solution is flowing.
5. Install 500-1000cc of aqueous calcium gluconate 1% solution per eye every 2 to 4 hours for the next 2 to 3 days.

Inhalation

1. Seek medical attention. Transport patient to local hospital. Refer to a pulmonologist for further care.
2. Remove victim from source of HF fumes.
3. If not breathing, begin artificial respiration immediately.

NOTE: Mouth-to-mouth resuscitation is not recommended. Use barrier device.

4. Give 100% oxygen by mask.

5. Do not give stimulants. Patient must remain inactive for at least 24 hours.
6. As soon as possible, give 2.5% to 3% calcium gluconate solution by inhalation by Intermittent Positive Pressure Breathing using a nebulizer, or by nebulizer alone. Use mouth/nose mask, NOT a mouthpiece.
7. A patient with a history of recent exposure who is experiencing respiratory irritation should be admitted immediately to an intensive care unit and observed closely for 24 to 48 hours. Administration of nebulized 2.5% to 3% calcium gluconate solution should be considered.
8. Carefully watch the patient for edema of the upper airway with respiratory obstruction. The airway may be maintained by tracheotomy if necessary.

NOTE: Patients with neck, chest, or head burns should be watched for delayed pulmonary edema.

9. Pulmonary edema should be treated by placing the patient on IPPB with Positive End-Expiratory Pressure (PEEP). Close supervision and continued use of 2.5% to 3% calcium gluconate solution by inhalation is necessary.

Hemodialysis must be considered for fluoride removal and to avoid or correct hyperkalemia and recurrent hypocalcemia not responsive to replacement therapy.

Oral Ingestion

1. Seek medical attention. Patient should be admitted to a hospital intensive care unit.
2. Do not induce vomiting. Do not give patient any baking soda or emetics.
3. Give 1 to 3 glasses of milk or water, or administer several vials of 10% aqueous calcium gluconate orally. (Calcium carbonate or an antacid containing calcium

carbonate or magnesium carbonate or hydroxide may also be used.)

4. Gastric lavage with calcium chloride or calcium gluconate or magnesium gluconate may be performed by a physician. Extreme caution must be observed when passing the Levin tube. HF will destroy fiberoptic endoscopes.

Extreme throat swelling may occur, which may require a tracheotomy.

Hemodialysis may be necessary for fluoride removal and to avoid or correct hyperkalemia and recurrent hypocalcemia not responsive to replacement therapy.

Nail Burns

1. Apply calcium gluconate 2.5% gel every 15 minutes and massage continuously until the pain disappears. Remember, rubber gloves must be worn while touching the victim. If pain recurs, apply calcium gluconate gel and massage while transporting the injured worker to an emergency room.
2. Alternate treatment—immediately soak the nail in an iced 0.13% Zephiran solution. Do not use shaved ice. Use ice cubes, not shaved ice, to prevent frostbite.
3. Continue either application of calcium gluconate gel or Zephiran soaks while transporting to a medical facility.
4. If pain does not completely cease, 2 to 3 holes should be drilled in the nail using an 18-gauge needle. Continue calcium gel massage or Zephiran soaks.
5. If pain still does not subside, the nail must be removed by a physician. The nail bed should be massaged with 2.5% calcium gluconate gel. Infiltration of aqueous calcium gluconate 2.5% solution with a small-gauge (#25 - #30) needle, around the burn and intralesionally must be used only in severe cases due to the risk of obstruction of the microcirculation.

Do not use calcium gluconate 2.5% injections without first removing the nail.

The use of 0.5% calcium gluconate given intra-arterially has also been reported.

Medical Supplies for Medical Professionals

It is extremely important that medical supplies be acquired and kept on hand in sufficient quantities at all times. Some of the supplies are difficult to acquire and must be ordered. Others must be prepared by a pharmacist, and a few require a doctor's prescription. Table 2 lists suppliers for the calcium gluconate gel. Table 3 gives directions for preparing calcium gluconate gel and solutions. The immediate application of first aid using HF specific medical supplies is the key to a rapid and successful recovery from HF absorption.

1. Calcium gluconate 2.5% gel.
2. Calcium gluconate 10% aqueous, USP, is available in 10mL vials and requires a doctor's prescription.

3. Proparacaine hydrochloride 0.5% solution for anesthetizing the eyes. This requires a doctor's prescription.
4. Aqueous solution of benzalkonium chloride—0.13% Zephiran. This can be prepared by purchasing Zephiran chloride 15% concentrate and diluting by mixing 1 fluid ounce of concentrate and 127 fluid ounces of water to make 1 gallon of Zephiran solution 0.13%.
5. Syringes—5cc with #25g to #30g gauge needles.
6. Oxygen—99% pure USP medical.
7. Morgan's lens or the Eye Irrigator® to irrigate the eyes.
8. Ice cubes.
9. Towels for use as wet compresses.
10. Basins of assorted sizes for immersion.
11. Gauze, compression dressing, eye patches.
12. Eyewash fountain.
13. Safety showers.
14. Nebulizer.
15. Sterile 0.9% saline: 100cc and 500cc IV bag.
16. Sterile NSS vials: 10cc and 30cc.
17. Rubber (neoprene, PVC, nitrile, acid-resistant) gloves.

Information Sources

- Compressed Gas Association
1725 Jefferson Davis Highway, Suite 1004
Arlington, VA 22202-4102
Phone: 1-703-412-0900
- National Fire Protection Association
1 Batterymarch Park, P.O. Box 9101
Quincy, MA 02269-9101
Phone: 1-800-344-3555

Calcium Gluconate Gel

Calcium gluconate gel, consisting of 2.5% USP calcium gluconate in a surgical water-soluble lubricant, is widely used for first aid and/or primary treatment of HF burns of the skin. The gel is convenient to carry and can be used to initially treat small burns that might occur away from medical care. The gel is not recommended for burns with concentrated HF except as a first aid measure. The gel is used by massaging it promptly and repeatedly into the burned area until pain is relieved. Rubber gloves must be worn during initial application of the gel, so that the person providing the treatment will not receive a secondary burn. This treatment can be started without waiting for medical direction. If used as the only method of treatment, liberal quantities of calcium gluconate gel must be massaged into the burned area continuously for up to several hours. Relief of pain can be used to assess the efficacy of this treatment. If good relief of pain is not obtained after 30-40 minutes, alternate methods of treatment such as calcium gluconate injections or Zephiran soaks should be considered. The gel is especially useful for burns on the face, particularly near the mouth and eyes or on the ears. It may be convenient to use the gel for very small burns where the victim can easily apply and massage the gel into the burned area. Use of the gel may be more convenient to dilute acid burns such as occur with commercial products like rust removers, aluminum cleaners, or etching solutions.

Zephiran® (0.13% Benzalkonium chloride)

The solution should be cooled with ice cubes. Shaved or crushed ice may cause excessive cooling, with danger of frostbite. If immersion in the solution is not practical, soaked compresses of the same iced solution should be applied to the burned area. The immersion or compresses should be used for at least two hours. Compresses should be changed or soaked with additional solution approximately every two to four minutes. If blisters are present, they should be opened and drained, and necrotic tissue should be debrided by a physician or qualified health care practitioner as soon as possible. However, immersion in 0.13% benzalkonium chloride (Zephiran) or use of compresses should not be delayed if debridement cannot be accomplished immediately. Prolonged immersion in the iced Zephiran bath may result in discomfort due to excess chilling; relief may be obtained by removing the part from the bath every 10 to 15 minutes for a few minutes and then re-immersing it. After the initial 30-60 minutes of treatment, less ice can be used so the bath is cool rather than cold. The success of this treatment is indicated by relief of the severe pain in the burned area. If there is no significant relief of pain within 30 to 40 minutes, the use of 2.5% calcium gluconate injections may be necessary. If pain recurs when the treatment is stopped at the end of the first two hours, immersion or compresses should be resumed until pain is relieved. A total of four to six hours immersion or use of compresses of Zephiran is usually required for the treatment of most burns. No further treatment will be required in many instances. The use of iced quaternary ammonium compound solutions offers several advantages: reduction of local pain, possible slowing of the rate of tissue destruction, possible slowing of the passage of the fluoride ion into tissues and into the bloodstream. Large burns, serious burns due to concentrated HF, or burns with delayed treatment will probably require the use of calcium gluconate injections in addition to or instead of Zephiran soaks. Zephiran should not be used for burns on the face, ears, or other sensitive areas due to its irritating nature. It is preferable to use calcium gluconate gel or calcium gluconate injections in these areas.

Calcium Gluconate Injections

After first aid measures have been taken, injection of 2.5% calcium gluconate solution is indicated as the primary medical treatment for large burns (over 4 square inches). For smaller burns, if Zephiran soaks or calcium gluconate gel does not result in significant relief of pain within 30 to 40 minutes, injection of calcium gluconate solution is indicated. Injection of calcium gluconate solution may also be indicated for burns in which treatment has been delayed. The physician should inject sterile 2.5% aqueous calcium gluconate beneath, around, and into the burned area. Calcium gluconate is packaged as 10% solution and must be diluted 50-50 with normal saline. Do not use calcium chloride, which is corrosive and may result in additional damage. If subcutaneous calcium gluconate injections are used, the amount injected initially is small and should not exceed 0.5cc per square centimeter of affected skin. The injections should not distort the appearance of the skin. A small-gauge needle (#25-#30) should be used and the burned area should be injected through multiple sites. With successful treatment, pain relief following injection of 2.5% calcium gluconate is very rapid. The patient can usually advise when the pain stops, which is an indicator of adequate treatment. Multiple injections in the skin that has compromised integrity may increase the risk of infection, and the use of antibiotic creams such as Silvadene or Garamycin should be considered following such treatment. Local anesthetic and/or analgesic should not be used since they mask pain relief, which is an important indication of adequacy of treatment.

Calcium Gluconate Solution

In some instances, a 5% or 10% calcium gluconate solution may be used in compresses or for irrigation. For example, irrigating with a calcium gluconate solution may be the best treatment should HF enter the external ear canal. In this instance, referral to an otolaryngologist may also be needed.

Table 2 Suppliers for Calcium Gluconate Gel

Canada or US:	Pharma Science 8400 Darnly Road Montreal, Quebec H4T 1M4 Tel. 514-340-1114 or 1-800-363-8805 1-800-207-4477 (Buffalo, NY)
Netherlands:	Van der Laan's Handelondememing Nieuwe Maas Apotheek Haantje de Jongstraat 6 3067 AB Rotterdam, Netherlands Tel. 010-4209155
France:	Pharmacie Centrale des Hopitaux de Paris 13, Rue Lavoisier 92033 NANTERRE CEDEX, France Tel. 01-46-69-13-13
Italy:	Stabilimento Ausimont SpA Via della Chimica 5 Porto Marghera (Venezia), Italy Tel. 041-291 2805
Germany:	Krebs Walter Import-Export GmbH & Co. Pharmazeutische Erzeugnisse Dieselstr. 29 D 63071 Offenbach, Germany Tel. (049 69) 80-90-99-3
United Kingdom:	Industrial Pharma. Service Limited Bridgewater Road, Broadheath Altricham, Chesire WA14INA England Tel. 061-928-3672

Calcium gluconate gel retains its efficacy in unopened tubes indefinitely. The shelf life of a tube of calcium gluconate gel extends well beyond the expiration date placed on the tube. Where country regulations allow, using an unopened tube of calcium gluconate gel up to 5 years past expiration date is acceptable.

Table 3 Directions for Preparing Calcium Gluconate Gel and Solutions**Calcium gluconate 2.5% gel (HF gel)**

Mix 10cc of calcium gluconate 10% with 30cc of a water-soluble lubricant gel (K-Y Lubricating Gel—Johnson and Johnson) to yield 40cc of calcium gluconate 2.5% gel by weight. Once mixed, the calcium gluconate 2.5% gel can be repackaged in the K-Y tube and resealed.

Calcium gluconate 1% eye irrigation solution

1. To obtain 100cc of a 1% calcium gluconate solution, mix 90cc of normal saline with 10cc calcium gluconate 10%
2. To obtain 1000cc of a 1% calcium gluconate solution, mix 900cc of normal saline with 100cc calcium gluconate 10%

Calcium gluconate 2.5% solution for nebulizer or for injection

1. To obtain 100cc of a 2.5% calcium gluconate solution, mix 75cc of normal saline with 25cc calcium gluconate 10%
2. To obtain 1000cc of a 2.5% calcium gluconate solution, mix 750cc of normal saline with 250cc calcium gluconate 10%

Shelf life is 6 months from date mixed.

Emergency Response Telephone Numbers

USA

CHEMTRAC

1-800-424-9300 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
703-527-3887 for calls originating elsewhere (Collect calls are accepted)

CHEM-TEL, INC.

1-800-255-3924 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
813-248-0585 for calls originating elsewhere (Collect calls are accepted)

INFOTRAC

1-800-535-5053 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
352-323-3500 for calls originating elsewhere (Collect calls are accepted)

3E COMPANY

1-800-451-8346 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
760-602-8703 for calls originating elsewhere (Collect calls are accepted)

NATIONAL RESPONSE CENTER (NRC)

Call NRC (24 Hours)

1-800-424-8802 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
202-267-2675 in the District of Columbia

MILITARY SHIPMENTS

703-697-0218 Explosives/Ammunition Incidents (Collect calls accepted)
1-800-851-8061 All other dangerous goods incidents

NATIONWIDE POISON CONTROL CENTER (United States Only)

1-800-222-1222 (Toll Free in the U.S.)

CANADA

CANUTECH

613-996-6666 (Collect calls are accepted)
*666 Cellular (In Canada only)

Visit Web Site: www.cstusa.biz for further information

or

Call 410-982-6585

or

Ask your local sales representative