Treatment Protocol for Hydrofluoric Acid Burns

Properties

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

General Health Hazards

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 blood stream. HF, liquid or gaseous, may cause severe burns of 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. A person who has HF burns greater than eight (8) square inches should be admitted immediately to an intensive care unit and carefully monitored for 24 to 48 hours. Anyone who has been exposed to gaseous HF and experiences respiratory irritation should also be admitted to and monitored in an intensive care unit. Blood sampling should be taken to monitor fluoride, potassium, and calcium levels. In some cases, hemodialysis is necessary for fluoride removal and for correction of hyperkalemia.
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 which become 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 OR POLYVINYL CHLORIDE [PVC]) 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.

First Aid and Medical Treatment

Skin Burns

Skin contacted by HF, vapor, or aqueous solution rapidly produces an erythematous (reddened) area, often with a white or gray color at the surface caused by coagulation of tissue.

1. Immediately go to a safety shower or other available water and flush with copious amounts of water for at least five (5) minutes. All clothing must be removed. Calcium gluconate gel can be massaged into skin while flushing with water.
2. Summon medical personnel and continue with first aid.
3. Apply calcium gluconate 2.5% jelly with a massage until the pain disappears. Remember, rubber gloves must be worn while touching the victim. If pain recurs, apply calcium gluconate jelly and massage while transporting the injured worker to an emergency room.
4. 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). If soaking is impractical, soaks or compresses may be used. Total immersion for areas such as fingers, hands, and feet is desirable.
5. Continue procedure in #3 or #4 while transporting to a medical facility.
6. For deep burns, infiltration of 5% aqueous calcium gluconate* 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.

   [*5% solution = 10cc sterile water + 10cc calcium gluconate 10%]
7. Do **NOT** use local anesthetics. Resolution of pain is the means to determine effective medical treatment.
8. In some cases, it may be necessary to surgically remove damaged tissue and then apply calcium gluconate (5% aqueous solution) to the affected area.
9. The person with HF burns covering greater than eight (8) square inches should be admitted immediately to an intensive care unit and monitored carefully for 24 to 48 hours. 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.

Eye Burns

1. Flush immediately with water for one (1) to three (3) minutes, holding eyelids open.
2. Do not use oils, salves, ointments, or HF skin burn treatments.
3. 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 available, place Morgan's lens on patient and irrigate eye for 20 minutes with a 1% aqueous calcium gluconate** solution.

   [**1% solution=10cc calcium gluconate 10% + 100cc normal saline]
5. Transport patient to eye specialist for further treatment. Continue treatment as outlined in Step 4 during transportation.
6. Instill aqueous calcium gluconate 1% solution every two to four hours for the next two to three days.

Inhalation

1. Remove victim from source of HF fumes.
2. If not breathing, begin artificial respiration immediately.

   ***NOTE: Mouth-to-mouth resuscitation is not recommended.**
3. Give 100% oxygen by mask.
4. As soon as possible, give a 2.5% to 3% calcium gluconate solution*** by inhalation by Intermittent Positive Pressure Breathing (IPPB) using a nebulizer, or by nebulizer alone.

   (***2.5% solution=10cc calcium gluconate 10% +20cc sterile water)
5. Refer patient to a pulmonologist for further care.
6. Carefully watch the patient for edema of the upper airway with respiratory obstruction. The airway may be maintained by either endotracheal intubation or tracheotomy if necessary.
7. Pulmonary edema should be treated by placing the patient on IPPB with Positive End-Expiratory Pressure (PEEP). Close supervision and continued use of a 2.5% to 3% calcium gluconate solution*** by inhalation is necessary.
8. Patients with neck, chest or head burns should be watched for delayed pulmonary edema.
9. Hemodialysis must be considered for fluoride removal and to avoid or correct hyperkalemia and recurrent hypocalcemia not responsive to replacement therapy.
10. 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 calcium gluconate should be considered.
11. Do not give stimulants. Patient must remain inactive for at least 24 hours.

Oral Ingestion

1. Do not induce vomiting. Do not give patient any baking soda or emetics.
2. Give one (1) to three (3) glasses of water.
3. Administer several vials of 10% aqueous calcium gluconate orally. (Calcium carbonate, Maalox, Mylanta or Milk of Magnesia may also be used.)
4. Gastric lavage with lime water may be performed by a physician. Extreme caution must be observed when passing the Levin tube.
5. Extreme throat swelling may occur which may require a tracheotomy.
6. Patient should be admitted to a hospital intensive care unit.
7. Hemodialysis may be necessary for fluoride removal and to avoid or correct hyperkalemia and recurrent hypocalcemia not responsive to replacement therapy.

Nail Burns

1. Immediately soak the nail in an iced solution of calcium gluconate. In the past, a 0.13% water solution (1:750) of Zephiran Chloride (benzalkonium chloride solution, NF) was used successfully.
2. If pain does not completely cease, 2 to 3 holes should be drilled in the nail using an 18 gauge needle. Continue soaking.
3. 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 jelly. Infiltration of 5% aqueous calcium gluconate**** 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.

   [****5% solution = 10cc sterile water + 10cc calcium gluconate 10%]
4. Do not use calcium gluconate 5% injections without first removing the nail.
5. The use of 0.5% calcium gluconate given intraarterially has also been reported.

Hypocalcemia

1. Significant fluoride exposure via large burns, inhalation, or ingestion will require observation for hypocalcemia.
2. An important way to monitor the necessity for and effectiveness of treatment is EKG monitoring (for example, prolongation of the Q-T interval may indicate hypocalcemia).
3. Calcium gluconate infusion (using 2 to 3 ampules of 10% calcium gluconate in one liter of 5% dextrose solution or 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.
4. Serum calcium, magnesium, and potassium levels must be monitored. Electrolyte monitoring should indicate if and when magnesium should be replaced intravenously.
5. In cases of extreme fluoride absorption, a potentially therapeutic maneuver is the use of bicarbonate/acetozolamide infusion to control metabolic alkalosis and to enhance fluoride excretion by the kidneys. The efficacy of this intervention has not been determined conclusively.

Medical Supplies

It is extremely important that medical supplies be acquired and kept on hand in sufficient quantities at all times. Some of these supplies are difficult to acquire and must be ordered. Others must be prepared by a pharmacist, and a few require a doctor's prescription. 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% jelly.** Your pharmacist can prepare this jelly by mixing 2.84 grams of USP calcium gluconate powder with a 4 ounce tube of K-Y Lubricating Jelly (Johnson & Johnson). Once mixed, the calcium gluconate 2.5% jelly can be repackaged by the pharmacist in the K-Y tube and resealed.

   NOTE: Calcium gluconate 2.5% jelly can be ordered directly by calling:

   Pharmascience, Inc.
   8400 Darnley Road
   Montreal, Quebec H4T 1M4
   +1 (800) 363-8805
   (headquarters, Marc Beaudet)
   +1 (800) 207-4477
   (Buffalo, NY distributor)
2. **Calcium gluconate 10% aqueous,** USP (standard ampule), is available in 10ml ampules and requires a doctor's prescription. The 5% solution is made by mixing the calcium gluconate 10% with an equal part of sterile saline solution.
3. **One percent calcium gluconate.** The 1% solution is made by mixing 10cc calcium gluconate 10% with 100cc sterile normal saline solution. This requires a doctor's prescription.
4. **Proparacaine hydrochloride 0.5%** solution for anesthetizing the eyes. This requires a doctor's prescription.
5. **Aqueous solution of benzalkonium chloride**–0.13%. (Note: this is less practical and infrequently used). This can be prepared by purchasing "Zephiran" chloride 15% concentrate and diluting by mixing one (1) fluid ounce of concentrate and 127 fluid ounces of water to make a gallon of "Zephiran" solution 0.13%.
6. **Syringes**–5cc #25g to #30g gauge needles.
7. **Oxygen**–99% pure USP medical.
8. **Morgan's lens**–to irrigate the eyes.
9. **Ice cubes.**
10. **Towels** for use as wet compresses.
11. **Basins** of assorted sizes for immersion.
12. **Gauze, compression dressing, eye patches.**
13. **Eye wash fountain.**
14. **Safety showers.**
15. **Nebulizer.**