BASF Chemical Emergency Medical Guidelines

Hydrofluoric acid (HF) B 1

Information and recommendations for paramedics and doctors at the site

- **Patients whose clothing or skin is contaminated with hydrofluoric acid can secondarily contaminate rescue and medical personnel, by direct contact or through evaporation of hydrofluoric acid.**
- **Hydrofluoric acid is a highly corrosive chemical causing extremely painful burns.**
- **Fluoride ions are very well and rapidly absorbed by all exposure routes which can lead to hypocalcemia and other metabolic changes. Systemic poisoning may result in central nervous system disturbances, cardiovascular, renal, and respiratory failure.**
- **Rapid decontamination by immediate extensive irrigation - even before removing clothing - with copious amount of water is the most critical measure after dermal exposure.**
- **The early administration of calcium and/or magnesium can counteract the systemic effects of hydrofluoric acid. Depending on route and severity of exposure calcium gluconate can be applied locally as a gel, its solution may be used as irrigant, injected (subcutaneously, intravenously, or intraarterially), or inhaled.**

1. Substance information

Hydrogen fluoride (HF), liquid or gas (CAS 7664-39-3), is clear and colorless with a strong and irritating odor.

The boiling point of hydrogen fluoride is 19-20°C, 292-293 K. Hydrogen fluoride is miscible in water and forms a clear and colorless aqueous solution, hydrofluoric acid (boiling point of the azeotrope 112°C, 385 K).

When exposed to air, hydrogen fluoride and its solutions may produce pungent dangerous fumes. Significant vapor concentrations may occur when concentrations of hydrofluoric acid of >40% in water are heated.

The substance is a strong acid and reacts violently with many compounds causing fire and explosion hazard. It attacks metals, glass and stone and dissolves silica, and must be kept in plastic, lead, wax, or paraffin paper bottles. Hydrofluoric acid is used in solutions of various concentrations (concentrated - >50%, e.g. in industrial processes; intermediate - 20-50%, e.g. in the electronics industry; dilute - less than 20%, e.g. in industrial and consumer cleaning compounds). Typical uses are frosting, etching and polishing of glass, removing sand from metal castings, enameling and galvanizing iron, and etching silicon wafers, especially in the semiconductor industry.

2. Routes of exposure

Inhalation

Significant absorption of fluoride ions leading to systemic toxicity may occur by inhalation of hydrofluoric acid fumes or vapors. Hydrofluoric acid's strong irritant properties usually provide an adequate warning of acutely hazardous concentrations.

Skin/eye contact

Skin contact is the major route of toxic hydrofluoric acid exposures. Fluoride ions are absorbed very well and rapidly through the skin and eyes and cause systemic toxicity. If more than 160 cm^2 (25 square inches) of skin are affected, there is risk of serious systemic toxicity. Even dilute solutions (<2%) may cause severe eye or skin burns if contact is prolonged.

Ingestion

Accidental ingestion of hydrofluoric acid may occur and rapidly lead to severe systemic toxicity. Deaths in adults have been described after ingestion of 1.5 g or more.

3. Acute health effects

Local effects

At all sites of oral, gastroesophageal, dermal, or ocular contact hydrofluoric acid can cause severe painful burns.
After skin exposure initially redness, edema, and blistering are usually observed. With concentrated hydrofluoric acid white discoloration of the skin can occur, and, due to liquefaction necrosis a granular exudate may form under blisters.

Clinical signs or symptoms might not be present up to 8 or 24 hours, respectively, after exposure to intermediate or low concentrations of hydrofluoric acid or its vapors/fumes, which may result in the danger of delayed recognition of fluoride ion-related effects. A hallmark of dermal exposure to low concentrations of HF (<20%) is pain that is out of proportion to the physical examination. Severe pain may be reported, while only erythema of the exposed skin is observed.

Eye exposure may result in destruction of the eye or opacification of the cornea.

Inhalation of hydrofluoric acid usually causes sore throat and coughing. Rapid development of respiratory distress with chest pain, dyspnea, laryngospasm may occur. **In symptomatic patients, onset of pulmonary edema may be delayed up to 24 hours.**

Systemic effects

Reaction of fluoride with body calcium may occur by any route of exposure to hydrofluoric acid. This can cause a marked hypocalcemia and other metabolic changes which may result in a fatal outcome. In particular, arrhythmia of the heart leading to cardiovascular failure as well as renal failure may occur. Fluoride ions may also have a direct toxic effect on the central nervous system leading to coma and respiratory failure.

4. Actions

Rescuer self-protection

If the zone which has to be entered by the rescuer is suspected of containing hydrofluoric acid in response situations that involve exposure to hydrofluoric acid vapor or fumes or contact with liquid hydrofluoric acid, pressure-demand, self-contained breathing apparatus and chemical-protective clothing shall be worn; do not use equipment that is contaminated itself.

Patients whose clothing or skin is contaminated with hydrofluoric acid may secondarily contaminate rescue and medical personnel, by direct contact or through evaporation of hydrofluoric acid. Exposure to high concentrations of hydrofluoric acid vapor or fumes may cause absorption of hydrofluoric acid onto clothing; caution should be exercised in decontamination.

Patient recovery

Patients should be removed from the contaminated zone immediately. If patients can walk, they should walk. Patients who are unable to walk may be removed on backboards or stretchers; if these are not available, carefully carry or drag patients to safety.
Immediate priorities must follow the "**A, B, C's**" (Airway, Breathing, Circulation) of resuscitation.

Decontamination and Initial treatment

All patients exposed to hydrofluoric acid require immediate decontamination. Patients who are able and cooperative may assist with their own decontamination. If the exposure involved liquid hydrofluoric acid and if clothing is contaminated, remove and double-bag the clothing.

Eyes

Continue irrigating exposed or irritated eyes with copious amount of water or saline until 1% calcium gluconate solution is available (1:10 dilution of a 10% solution with saline). Remove contact lenses if present and easily removable without additional trauma to the eye.

For extensive eye irrigation consider the use of the Morgan Lens. Continue other basic care during flushing.

If the hydrofluoric acid concentration was intermediate or high, administer 1 or 2 anesthetic eye drops (e.g. 0.5% tetracain hydrochloride). With a syringe, irrigate the eye with the 1% calcium gluconate solution until an ophthalmologist is available, but not longer than 2 hours.

If the hydrofluoric acid concentration was low, with a syringe, irrigate the eye with the 1% calcium gluconate solution until relief of pain occurs or until an ophthalmologist is available, but not longer than 30 minutes.

Skin

Assure that exposed skin and hair have been flushed for at least 5 minutes with copious amounts of plain water, and continue flushing until calcium gluconate is available. Protect eyes during flushing of skin and hair.
If the exposed area is larger than 160 square cm (25 square inches) and the hydrofluoric acid concentration >20%, injection of a sterile 5-10% calcium gluconate solution beneath, around and into the burned area is indicated as primary medical treatment. A small (25-30) gauge needle should be used and the burned area injected through multiple sites. The amount injected initially should not exceed 0.5 ml/cm^2 of affected skin surface. Since pain relief is usually a good indicator of adequate treatment, local anesthesia should be avoided. Calcium gluconate injections may be repeated if pain is not markedly diminished.

Note: DO NOT use calcium chloride instead of calcium gluconate.

If the exposed area is smaller or the hydrofluoric acid concentration low, start massaging the calcium gluconate 2.5% gel into the burn site, wearing protective (e.g. surgical) gloves. Apply new gel every 15 minutes flushing the skin in between with water. If good relief of pain is not obtained within 45 minutes after begin of treatment, inject calcium gluconate subcutaneously as recommended above.

Note: If calcium gluconate gel is not available, iced benzalkonium chloride 0.13% soaks or compresses can be used as an alternative.

In case of burns of fingers and the nails, after a first application of calcium gluconate gel as described above, partially fill an oversize surgical glove with calcium gluconate gel, insert the hand into the glove, and immerse the gloved hand in ice water.

Inhalation

If signs of respiratory irritation (sore throat, cough, dyspnea) are present and exposure to hydrofluoric acid to head, chest, or neck areas has occurred:

Initially, administration of 6 ml of an aqueous solution of 2.5% calcium gluconate by nebulizer with 100% oxygen. 100% humidified oxygen should be administered.

Administration of 8 puffs of beclomethasone (800 µg beclomethasone dipropionate) from a metered dose inhaler.

Establishment of intravenous access.

Intravenous administration of 1.0 g methylprednisolone (or an equivalent steroid dose) is recommended.

Note: Efficacy of corticosteroid administration has not yet been proven in controlled clinical studies.

Intubation of the trachea or an alternative airway management should be considered in cases of respiratory compromise. When the patient's condition precludes this, consider cricothyrotomy if equipped and trained to do so.

Patients with bronchospasm should be treated as follows:

a) Aerolized $ß_2$-selective adrenergic agonist, e.g. 4 puffs of terbutaline, or salbutamol, or fenoterol from a metered dose inhaler (1 puff usually contains 0.25 mg terbutaline sulfate, or 0.1 mg salbutamol, or 0.2 mg fenoterol, respectively); may be repeated once after 10 min.
If inhalation is not possible, terbutaline sulfate (0.25-0.5 mg) subcutaneously or salbutamol (0.2-0.4 mg over 15 min) intravenously.

b) If a) is not effective or insufficient: theophylline (5 mg/kg body weight intravenously over 20-30 min).

c) If a) and b) are not effective or insufficient: 2 puffs of epinephrine (0.4 mg per puff) from a metered dose inhaler; may be repeated after 5 min.

Ingestion

In case of hydrofluoric acid ingestion, do not induce emesis. The vomitus may contain hydrofluoric acid and result in secondary contamination. **If not already done, patients who are conscious and able to swallow should be given immediately 1-2 glasses of milk and/or 12 antacid (magnesium hydroxide, calcium carbonate) tablets/suspensions.**

If possible within 60 minutes after exposure, immediately perform a gastric lavage with calcium chloride solution (20 ml $CaCl_2$ diluted with 1000 ml saline) via a small-bore tube. The benefit usually outweighs the risk of perforation.

Systemic treatment

In cases with a potentially severe exposure administer calcium and magnesium without previous laboratory results. Constant cardiac and vital signs monitoring.
Adults:
1-2 g calcium gluconate IV infused over 5 minutes
2-4 g magnesium sulfate IV infused over 15-20 minutes
Children:
25 mg/kg bodyweight calcium gluconate IV infused over 5 minutes
25-50 mg/kg bodyweight magnesium sulfate IV infused over 15-20 minutes

Further treatment

All exposed patients should be transported to a hospital/emergency department. Establish intravenous access in all patients with serious exposure.

Treat cardiovascular, renal, gastrointestinal, pulmonary and CNS disturbances; provide supportive care.

BASF SE
Corporate Health Management
Carl-Bosch-Straße 38
67056 Ludwigshafen
Germany

BASF Corporation
Medical Department
100 Campus Drive, M/S F 221
Florham Park, NJ 07932
USA