Hydrogen Fluoride (HF)
CAS 7664-39-3; UN 1052 (anhydrous), UN 1790 (solution)

Synonyms include hydrogen fluoride, fluoric acid, hydrofluoride, hydrofluoric acid, and fluorine monohydride.

- **Victims exposed only to hydrogen fluoride vapor do not pose substantial risks of secondary contamination; however, victims whose clothing or skin is contaminated with hydrogen fluoride liquid or solution can secondarily contaminate response personnel by direct contact or through off-gassing vapor.**
- **Hydrofluoric acid is a serious systemic poison. It is highly corrosive. Its severe and sometimes delayed health effects are due to deep tissue penetration by the fluoride ion. The surface area of the burn is not predictive of its effects.**
- **Most hydrogen fluoride exposures occur by inhalation of the gas and dermal contact with hydrofluoric acid.**

Description

Hydrogen fluoride is a colorless, fuming liquid or gas with a strong, irritating odor. It is usually shipped in steel cylinders as a compressed gas. Hydrogen fluoride readily dissolves in water to form colorless hydrofluoric acid solutions; dilute solutions are visibly indistinguishable from water. It is present in a variety of over-the-counter products at concentrations of 6% to 12%.

Although hydrofluoric acid is weak compared with most other mineral acids, it can produce serious health effects by any route of exposure. These effects are due to the fluoride ion's aggressive, destructive penetration of tissues.

Routes of Exposure

Inhalation

Inhalation hazards result not only from exposure to hydrogen fluoride gas, but also from fumes arising from concentrated hydrogen fluoride liquid. Hydrogen fluoride gas is lighter than air. Even fairly low airborne concentrations of hydrogen fluoride produce rapid onset of eye, nose, and throat irritation. Hydrogen fluoride has a strong irritating odor that is discernable at concentrations of about 0.04 ppm, which is considerably less than the OSHA PEL of 3 ppm. Therefore, odor generally provides adequate warning of hazardous concentrations.

Children exposed to the same levels of hydrogen fluoride as adults may receive larger doses because they have greater lung surface area:body weight ratios and increased minute volumes:weight ratios. Children may also be more vulnerable to

corrosive agents than adults because of the relatively smaller diameter of their airways.

Skin/Eye Contact

Most hydrogen fluoride exposures occur by cutaneous contact with the aqueous solution. The fluoride ion, which penetrates tissues deeply, can cause both local cellular destruction and systemic toxicity and is readily absorbed through both intact and damaged skin. Hydrogen fluoride is irritating to the skin, eyes, and mucous membranes.

Children are more vulnerable to toxicants absorbed through the skin because of their relatively larger surface area:body weight ratio.

Ingestion

Ingestion of even a small amount of hydrofluoric acid is likely to produce systemic effects and may be fatal.

Sources/Uses

Hydrogen fluoride is primarily an industrial raw material. It is produced commercially by action of sulfuric acid on the mineral fluorspar. Hydrogen fluoride is used in separating uranium isotopes, as a cracking catalyst in oil refineries, and for etching glass and enamel, removing rust, and cleaning brass and crystal. It also is used in manufacturing silicon semiconductor chips and as a laboratory reagent. Some consumer products that may contain hydrogen fluoride include automotive cleaning products (e.g., for aluminum and chrome), rust inhibitors, rust removers (e.g., for ceramic tubs, sinks, and fabrics), and water-spot removers.

Standards and Guidelines

OSHA PEL (permissible exposure limit) = 3 ppm (averaged over an 8 hour work shift)

NIOSH IDLH (immediately dangerous to life or health) = 30 ppm

AIHA ERPG-2 (emergency response planning guideline) (maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action) = 20 ppm

Physical Properties

Description: Colorless gas or fuming liquid; weak solutions have the appearance of water.

Warning properties: Disagreeable, pungent odor at 0.04 ppm; irritation of eyes and throat at 3 ppm.

Molecular weight: 20.0 daltons

Boiling point (760 mm Hg): 68 ° (20 °C)

Freezing point: -118 ° (-83 °)

Specific gravity: 1 for liquid at 67 °F (20 °C) (water = 1)

Vapor pressure (68 °F): 783 mm Hg

Gas density: 0.7 (air = 1)

Water solubility: Miscible with water with release of heat

Flammability: Nonflammable

Incompatibilities

Hydrogen fluoride reacts with metals and water or steam. It will attack glass and concrete.

Health Effects

- **Hydrogen fluoride is irritating to the skin, eyes, and mucous membranes, and inhalation may cause respiratory irritation or hemorrhage. Systemic effects can occur from all routes of exposure and may include nausea, vomiting, gastric pain, or cardiac arrhythmia. Symptoms may be delayed for several days, especially in the case of exposure to dilute solutions of hydrogen fluoride (less than 20%).**
- **Hydrofluoric acid is corrosive and also causes destruction of deep tissues when fluoride ions penetrate the skin. Absorption of substantial amounts of hydrogen fluoride by any route may be fatal.**
- **The systemic effects of hydrogen fluoride are due to increased fluoride concentrations in the body which can change the levels of calcium, magnesium, and potassium in the blood.**
- **Hypocalcemia can cause tetany, decreased myocardial contractility, and possible cardiovascular collapse while hyperkalemia has been suggested to cause ventricular fibrillation leading to death.**

Acute Exposure

The toxic effects of hydrogen fluoride are due primarily to the fluoride ion, which is able to penetrate tissues and bind intracellular calcium and magnesium. This results in cell destruction and local bone demineralization. Systemic deficiency of calcium and magnesium and excess of potassium can occur. Hypocalcemia can cause tetany, decreased myocardial contractility, and possible cardiovascular collapse, while hyperkalemia has been suggested to cause ventricular fibrillation leading to death. The adverse action of the fluoride ion may progress for several days before symptoms appear.

Children do not always respond to chemicals in the same way that adults do. Different protocols for managing their care may be needed.

Respiratory

Inhaled hydrogen fluoride mist or vapor initially affects the nose, throat, and eyes. Mild clinical effects include mucous-membrane irritation and inflammation, cough, and narrowing of the bronchi. Severe clinical effects include almost immediate narrowing and swelling of the throat, causing upper airway obstruction. Lung injury may evolve rapidly or may be delayed in onset for 12 to 36 hours. Accumulation of fluid in the lungs, constriction of the bronchi, and partial or complete lung collapse can occur. Pulmonary effects can result even from splashes on the skin.

Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways.

Children may be more vulnerable to gas exposure because of relatively increased minute ventilation per kg and failure to evacuate an area promptly when exposed.

Dermal

Depending on the concentration and duration of exposure, skin contact may produce pain, redness of the skin, and deep, slow-healing burns.

Acid concentrations of more than 50% (including anhydrous hydrogen fluoride) cause immediate severe, throbbing pain and a whitish discoloration of the skin, which usually forms blisters. Hydrogen fluoride solutions from 20% to 50% may produce pain and swelling, which may be delayed up to 8 hours. Hydrogen fluoride solutions of less than 20% cause almost no immediate pain on contact but may cause delayed serious injury 12 to 24 hours later.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin.

Ocular

Mild effects of hydrogen fluoride exposure include rapid onset of eye irritation. More severe effects, which may result from even minor hydrofluoric acid splashes, include sloughing of the surface of the eye, swelling of various structures of the eye, and cell death due to lack of blood supply. Potentially permanent clouding of the eye surface may develop immediately or after several days.

Gastrointestinal

Ingestion of hydrofluoric acid may cause corrosive injury to the mouth, throat, and esophagus. Inflammation of the stomach with bleeding occurs commonly. Nausea, vomiting, diarrhea, and abdominal pain may occur. Systemic effects are likely. An acid-base imbalance can occur after acute ingestion. Pulmonary aspiration may lead to respiratory complications.

Electrolyte

Exposure by any route may result in systemic effects, namely, low levels of calcium and magnesium and high levels of potassium in the blood. Low blood pressure, irregular heartbeat, involuntary muscle contractions, seizures, and death may ensue.

Potential Sequelae

Survivors of severe inhalation injury may suffer residual chronic lung disease. Healing of skin burns caused by concentrated hydrogen fluoride may be prolonged, and extensive scarring may result. Fingertip injuries are troublesome with persistent pain, bone loss, and nail-bed injury. After eye exposure, prolonged or permanent visual defects, blindness, or total eye destruction may occur. Hydrogen fluoride ingestion may damage the esophagus and stomach progressively for weeks. Persistent narrowing of the esophagus may result.

Chronic Exposure

Repeated ingestion of more than 6 mg of fluoride per day may result in mottling of the teeth in developing children, accumulation of fluoride in the bone, and hardening of the bone in adults and children. Long-term hydrogen fluoride exposure has been reported to damage the kidneys and liver.

Chronic exposure may be more serious for children because of their potential longer latency period.

Carcinogenicity

Hydrogen fluoride has not been classified for carcinogenic effects.

Reproductive and Developmental Effects

Hydrogen fluoride is not included in *Reproductive and Developmental Toxicants,* a 1991 report published by the U.S. General Accounting Office (GAO) that lists 30 chemicals of concern because of widely acknowledged reproductive and developmental consequences. Fluoride crosses the placenta, and at low doses is thought to be essential for normal fetal development in humans. It is rarely excreted in breast milk. There have been rare cases of mottling of deciduous teeth in infants born to mothers who had high daily intakes of fluoride during pregnancy; skeletal abnormalities are considered unlikely. No reproductive effects due to hydrogen fluoride are known.

Prehospital Management

- **Victims exposed only to hydrogen fluoride gas or vapor do not pose substantial risks of secondary contamination to rescuers. However, victims whose clothing or skin is contaminated with hydrogen fluoride liquid, solution, or condensed vapor can secondarily contaminate response personnel by direct contact or through off-gassing vapor.**
- **Hydrogen fluoride is irritating to the skin, eyes, and mucous membranes. It is a corrosive chemical that can cause immediate or delayed onset of deep, penetrating injury. Systemic effects can occur from all routes of exposure and include pulmonary edema, nausea, vomiting, gastric pain, and cardiac arrhythmia. Absorption of fluoride ions can cause hypocalcemia, hypomagnesemia, and hyperkalemia, which can result in cardiac arrest.**
- **Rapid decontamination is critical. Calcium-containing gels, solutions, and medications are used to neutralize the effects of hydrogen fluoride. Patients may require support of respiratory and cardiovascular functions.**

Hot Zone

Rescuers should be trained and appropriately attired before entering the Hot Zone. If the proper equipment is not available, or if rescuers have not been trained to use it, assistance should be obtained from a local or regional HAZMAT team or other properly equipped response organization.

Rescuer Protection

Hydrogen fluoride is corrosive to the respiratory tract and skin and is a serious systemic poison.

Respiratory Protection: Positive-pressure, self-contained breathing apparatus (SCBA) is recommended in response situations that involve exposure to potentially unsafe levels of hydrogen fluoride.

Skin Protection: Chemical-protective clothing is recommended because skin exposure to either vapor or liquid may cause severe burns and systemic toxicity.

ABC Reminders

Quickly access for a patent airway, ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible.

Victim Removal

If victims can walk, lead them out of the Hot Zone to the Decontamination Zone. Victims who are unable to walk may be

removed on backboards or gurneys; if these are not available, carefully carry or drag victims to safety.

Consider appropriate management of chemically contaminated children, such as measures to reduce separation anxiety if a child is separated from a parent or other adult.

Decontamination Zone

Victims exposed only to hydrogen fluoride gas or vapor who have no skin or eye irritation do not need decontamination. They may be transferred immediately to the Support Zone. Other patients will require decontamination as described below.

Rescuer Protection

If exposure levels are determined to be safe, decontamination may be conducted by personnel wearing a lower level of protection than that worn in the Hot Zone (described above).

ABC Reminders

Quickly access for a patent airway, ensure adequate respiration and pulse. Stabilize the cervical spine with a collar and a backboard if trauma is suspected. Administer supplemental oxygen as required. Assist ventilation with a bag-valve-mask device if necessary.

Basic Decontamination

Rapid decontamination is critical. Victims who are able may assist with their own decontamination. Quickly remove and double-bag contaminated clothing while flushing exposed skin and hair with plain water or saline for at least 30 minutes. Cover exposed skin with a calcium-containing slurry or gel (2.5 g calcium gluconate in 100 mL of water-soluble lubricant, such as K-Y Jelly, or 1 ampule of 10% calcium gluconate per ounce of K-Y Jelly).

Use caution to avoid hypothermia when decontaminating children or the elderly. Use blankets or warmers when appropriate.

Irrigate exposed or irritated eyes with plain water or saline for at least 20 minutes. Remove contact lenses if easily removable without additional trauma to the eye. Continue irrigation during other decontamination procedures. Use of ophthalmic anesthetic eyedrops will increase patient comfort and efficiency of irrigation.

In case of hydrofluoric acid ingestion, **do not induce emesis**. Do not administer activated charcoal. Victims who are conscious and able to swallow should be given 4 to 8 ounces of water or milk. If available, also give 2 to 4 ounces of an antacid

containing magnesium (e.g., Maalox, milk of magnesia) or calcium (e.g., Tums).

Consider appropriate management of chemically contaminated children, such as measures to reduce separation anxiety if a child is separated from a parent or other adult. If possible, seek assistance from a child separation expert.

Transfer to Support Zone

As soon as basic decontamination is complete, move the victim to the Support Zone.

Support Zone

Be certain that victims have been decontaminated properly (see *Decontamination* Zone above). Victims who have undergone decontamination or have been exposed only to vapor generally pose no serious risks of secondary contamination. In such cases, Support Zone personnel require no specialized protective gear.

ABC Reminders

Quickly access for a patent airway. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Ensure adequate respiration and pulse. Administer supplemental oxygen as required and establish intravenous access if necessary. Place on a cardiac monitor. Monitor ECG for prolonged Q-T interval or QRS duration.

Additional Decontamination

Continue flushing exposed skin for 15 minutes. **Do not inject or use calcium chloride** for treating skin burns. It will cause extreme pain and may further injure tissues.

Treat the burned areas with calcium gluconate gel (2.5 g in 100 mL water-soluble lubricant, such as K-Y Jelly, or 1 ampule of 10% calcium gluconate per ounce of K-Y Jelly). Initially, the health care provider should wear rubber or latex gloves to prevent secondary contamination. Continue this procedure until pain is relieved or more definitive care is rendered.

If the eyes are still irritated, continue irrigating with water or saline. Remove contact lenses if present and easily removable without additional trauma. Continue irrigating the eyes with saline during transport. Use of ophthalmic anesthetic eyedrops will increase patient comfort and efficiency of irrigation.

In cases of ingestion, **do not induce emesis**. Do not administer activated charcoal. Victims who are conscious and able to swallow should be given 4 to 8 ounces of water or milk. If available, also give 2 to 4 ounces of an antacid containing

magnesium (e.g., Maalox, milk of magnesia) or calcium (e.g., Tums).

Advanced Treatment

In cases of respiratory compromise secure airway and respiration via endotracheal intubation. If not possible, perform cricothyroidotomy if equipped and trained to do so.

Treat patients who have bronchospasm with aerosolized bronchodilators. The use of bronchial sensitizing agents in situations of multiple chemical exposures may pose additional risks. Consider the health of the myocardium before choosing which type of bronchodilator should be administered. Cardiac sensitizing agents may be appropriate; however, the use of cardiac sensitizing agents after exposure to certain chemicals may pose enhanced risk of cardiac arrhythmias (especially in the elderly). Hydrogen cyanide poisoning is not known to pose additional risk during the use of bronchial or cardiac sensitizing agents.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution in 2.5 cc water, repeat every 20 minutes as needed, cautioning for myocardial variability.

Patients who are comatose, hypotensive, or are having seizures or cardiac arrhythmias should be treated according to advanced life support (ALS) protocols.

Hypocalcemia (manifested by tetany and dysrhythmias) is probable after ingestion of even small amounts of hydrogen fluoride. With medical consultation, treat hypocalcemia with intravenous injections of a 10% solution of calcium gluconate.

For inhalation victims, 2.5% calcium gluconate (2.5 g of calcium gluconate in 100 mL of water or 25 mL of 10% calcium gluconate diluted to 100 mL with water) administered by nebulizer with oxygen has been recommended, but the success of this therapy has not been demonstrated.

Transport to Medical Facility

Only decontaminated patients or patients not requiring decontamination should be transported to a medical facility. “Body bags” are not recommended.

Report to the base station and the receiving medical facility the condition of the patient, treatment given, and estimated time of arrival at the medical facility.

If hydrofluoric acid has been ingested, prepare the ambulance in case the victim vomits toxic material. Have ready several towels and open plastic bags to quickly clean up and isolate vomitus.

Multi-Casualty Triage

Consult with the base station physician or regional poison control center for advice regarding triage of multiple victims.

Persons who have had only minor or brief exposure to hydrogen fluoride gas or vapor and are initially asymptomatic are not likely to develop complications. After their names, addresses, and telephone numbers are recorded, patients may be released from the scene with follow-up instructions (see *Patient Information Sheet* below).

Inhalation Exposure

Immediately transport to a medical facility those patients who have inhaled hydrogen fluoride and have upper respiratory irritation or other acute symptoms.

Skin/Eye Contact

All persons who have eye exposure or serious skin exposure (i.e., fingertip exposure or skin exposure greater than the total surface area of the palm) or any evidence of burns (e.g., erythema, pain, or blisters) should be transported to a hospital as soon as possible. Continue skin and eye irrigation or treatment during transport. Patients who have had even mild skin or eye contact with hydrogen fluoride should be brought to the attention of a physician as soon as possible because they may have delayed pain and systemic complications.

Ingestion Exposure

In cases of ingestion, patients should be transported to a hospital without delay. Watch patients carefully because systemic effects are likely to occur.

Emergency Department Management

- **Patients exposed only to hydrogen fluoride gas or vapor do not pose substantial risks of secondary contamination to personnel outside the Hot Zone. However, patients whose clothing or skin is contaminated with hydrogen fluoride liquid or solution can secondarily contaminate personnel by direct contact or through off-gassing vapor.**
- **Hydrogen fluoride is a corrosive chemical that can cause deep, penetrating injury. Absorption of fluoride ions can result in hypocalcemia and cardiac arrest. Hypocalcemia should be considered a risk in all instances of inhalation or ingestion and whenever skin burns exceed 25 square inches (an area about the size of the palm).**
- **Because of hydrogen fluoride's rapid skin penetration and the serious toxicity of the fluoride ion, rapid decontamination is critical. Calcium-containing gels, solutions, and medications can be used to neutralize the fluoride ion. The intense pain of hydrogen fluoride burns should not be suppressed with local anesthetics because the degree of pain is an indicator of treatment efficacy. Treatment may also include support of respiratory and cardiovascular functions.**

Decontamination Area

Previously decontaminated patients and patients exposed only to hydrogen fluoride gas or vapor who have no skin or eye irritation may be transferred immediately to the Critical Care Area. Other patients will require decontamination as described below.

Because coming in contact with hydrogen fluoride-soaked clothing or skin can cause burns, ED personnel should don chemical resistant jumpsuits (e.g., of Tyvek or Saranex) or butyl rubber aprons, multiple layers of latex gloves, and eye protection.

Be aware that use of protective equipment by the provider may cause fear in children, resulting in decreased compliance with further management efforts.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin. Also, emergency room personnel should examine children's mouths because of the frequency of hand-to-mouth activity among children.

ABC Reminders

Evaluate and support airway, breathing, and circulation. In cases of respiratory compromise secure airway and respiration via

endotracheal intubation. If not possible, surgically create an airway.

Treat patients who have bronchospasm with aerosolized bronchodilators. The use of bronchial sensitizing agents in situations of multiple chemical exposures may pose additional risks. Consider the health of the myocardium before choosing which type of bronchodilator should be administered. Cardiac sensitizing agents may be appropriate; however, the use of cardiac sensitizing agents after exposure to certain chemicals may pose enhanced risk of cardiac arrhythmias (especially in the elderly). Hydrogen cyanide poisoning is not known to pose additional risk during the use of bronchial or cardiac sensitizing agents.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution in 2.5 cc water, repeat every 20 minutes as needed, cautioning for myocardial variability.

Patients who are comatose, hypotensive, or are having seizures or cardiac arrhythmias should be treated in the conventional manner.

Basic Decontamination

Rapid skin decontamination is critical. Patients who are able may assist with their own decontamination. If the patient's clothing is wet with hydrogen fluoride, remove and double-bag the clothing while flushing the skin with water (preferably under a shower). Flush exposed skin for at least 20 minutes. Use caution to avoid hypothermia when decontaminating children or the elderly. Use blankets or warmers when appropriate.

Flush exposed eyes with plain water or saline for at least 20 minutes. Remove contact lenses if present and easily removable without additional trauma to the eye. Continue irrigation while transporting the patient to the Critical Care Area. An ophthalmic anesthetic, such as 0.5% tetracaine, may be necessary to alleviate blepharospasm, and lid retractors may be required to allow adequate irrigation under the eyelids.

In cases of ingestion, **do not induce emesis**. Do not administer activated charcoal. If it has not been given previously and the patient is alert and able to swallow, administer 4 to 8 ounces of water. (More information is provided in *Ingestion Exposure* under *Critical Care Area* below.)

Critical Care Area

Be certain that appropriate decontamination has been carried out (see *Decontamination Area* above).

ABC Reminders

Evaluate and support airway, breathing, and circulation as in *ABC Reminders* above. Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways. Establish intravenous access in seriously ill patients if this has not already been done.

Patients who are comatose, hypotensive, or are having seizures or cardiac arrhythmias should be treated in the conventional manner.

Monitor heart, renal, and liver functions. Hypocalcemia may cause prolonged Q-T interval and cardiac rhythm abnormalities.

Inhalation Exposure

Calcium gluconate (2.5 grams of calcium gluconate in 100 mL of water or 25 mL of 10% calcium gluconate diluted to 100 mL with water) may be administered with oxygen by nebulizer to victims who have severe respiratory distress.

Pulmonary edema or edema of the upper airway may occur. Observe the patient for at least 24 hours and monitor with repeated chest examinations, blood gas determinations, and other appropriate tests. Follow up as clinically indicated.

Skin Contact

A burn specialist or plastic surgeon should be consulted early in the treatment of fluoride burns.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin.

If blisters have formed, they should be opened and drained and debrided of necrotic tissue before treatment; early debridement may facilitate healing.

Do not inject calcium chloride to treat skin burns. It will cause extreme pain and may further injure tissues.

Treat the burned area with calcium gluconate gel (2.5 grams in 100 mL water-soluble lubricant, such as K-Y Jelly) until the pain is relieved. If used as definitive treatment, the gel should be applied 4 to 6 times daily for 3 to 4 days. Initially, health care providers should wear rubber gloves to protect their fingers from secondary contamination. If some relief of pain is not obtained within 30 to 60 minutes, consider calcium gluconate injections.

Subungual (under the nail) burns often do not respond to immersion treatment. The treatments for hand burns require expert assistance; consult a poison center, medical toxicologist, or hand surgeon. Care must be used because multiple injections into the fingers can lead to pressure necrosis. It will be necessary to split or remove the nail.

Large burns or deeply penetrating burns (i.e., from delayed treatment or exposure to hydrogen fluoride concentrations greater than 50%) may require injections of sterile aqueous calcium gluconate into and around the burned area. The recommended dose is to inject up to 0.5 mL of 10% calcium gluconate solution per cm^2 of affected skin surface using a small-gauge needle (#30). No local infiltration of anesthetic should be used, but in the case of severe burns, regional or general anesthesia may be considered. Injection may not be feasible in the case of burns to the fingers; in such cases, intra-arterial infusion should be considered.

Intra-arterial calcium gluconate has been found to be effective for the treatment of burned digits and upper extremities. The radial artery has been preferentially used, with the brachial artery used if there is incomplete anastomotic flow between the radial and ulnar circulations. The initial dosage is 10 mL of 10% calcium gluconate diluted with 40 mL D_5W given intra-arterially over 4 hours. If pain is unrelieved, 20% concentrations have been used. After the first dose, the infusion can be stopped, but the line should be maintained so that further doses can be infused if pain recurs. Once the patient has been pain-free for 4 hours, the catheter can be removed. Although anesthesia can be used, it is not recommended since it invalidates the pain relief which is a titration endpoint for effective treatment.

Eye Contact

Immediate consultation with an ophthalmologist is indicated.

Do not use oils, salves, or ointments for injured eyes. Do not use the gel form of calcium gluconate in eyes, as described for skin treatment.

Irrigate exposed eyes with 1 to 2 L of plain water or saline. Administering drops of a 1% aqueous solution of calcium gluconate (50 mL of 10% solution in 450 mL of sterile saline) has also been suggested as a possible therapy. After irrigation, the pH of the eye should be checked and a complete ophthalmic examination should be carried out.

A topical anesthetic can minimize the tendency for eyelid closure and facilitate irrigation. One or two drops of proparacaine or tetracaine will usually provide rapid-onset ocular anesthesia for 20 minutes to an hour. If exposure was minor, perform visual acuity testing. Examine the eyes for corneal damage and treat appropriately.

Ingestion Exposure

Do not give emetics and do not administer activated charcoal. If the patient is conscious and alert, and treatment has not been administered previously, immediately give 4 to 12 ounces of water to dilute the acid. Orally administer a one-time dose of several ounces of Mylanta, Maalox, or milk of magnesia; the magnesium in these products may act chemically to bind the fluoride in the stomach. Do not give sodium bicarbonate to neutralize acid because it can cause burns.

Consider endoscopy to evaluate the extent of gastrointestinal-tract injury. Extreme throat swelling may require endotracheal intubation or cricothyroidotomy. Gastric lavage is useful in certain circumstances to remove caustic material and prepare for endoscopic examination. Consider gastric lavage with a small nasogastric tube if: (1) a large dose has been ingested; (2) the patient's condition is evaluated within 30 minutes; (3) the patient has oral lesions or persistent esophageal discomfort; and (4) the lavage can be administered within 1 hour of ingestion. Care must be taken when placing the gastric tube because blind gastric-tube placement may further injure the chemically damaged esophagus or stomach.

Because children do not ingest large amounts of corrosive materials, and because of the risk of perforation from NG intubation, lavage is discouraged in children unless performed under endoscopic guidance.

Toxic vomitus or gastric washings should be isolated (e.g., by attaching the lavage tube to isolated wall suction or another closed container).

Systemic Toxicity

Treat hypocalcemia using intravenous 10% calcium gluconate infusions with doses of 0.1 to 0.2 mL/kg up to 10 mL. Infusions can be repeated until serum calcium, ECG, or symptoms improve. Calcium levels should be checked hourly. Treat hypomagnesemia with 2 to 4 mL of 50% of magnesium sulfate intravenously over 40 minutes.

Laboratory Tests

Routine laboratory studies for all exposed patients include CBC, glucose, and electrolyte determinations. Patients exposed to hydrogen fluoride should also have serum calcium, potassium, and magnesium levels monitored. Chest radiography and pulse oximetry (or ABG measurements) may be useful for patients exposed through inhalation.

Disposition and Follow-up

Patients in whom treatment fails to diminish pain and those who have respiratory distress, ingestion exposure, fingertip or eye burns, or substantial skin burns should be admitted to an intensive care unit and watched carefully for 24 hours. (Substantial skin burns are those covering an area greater than the palm of a hand, and causing skin change, or producing pain within 1 hour of exposure.) ECG monitoring may help determine treatment need and effectiveness.

Patient Release

Patients who have eye exposure who have no signs of irritation after treatment do not require hospitalization.

Patients in the ED who have burns covering less than an area equivalent to the palm of the hand and who have normal serum calcium levels who have responded to treatment can be discharged for outpatient follow-up after remaining stable for at least 6 hours. They should be advised to seek medical care promptly if pain recurs (see the *Hydrogen Fluoride—Patient Information Sheet).*

Follow-up

Obtain the name of the patient's primary care physician so that the hospital can send a copy of the ED visit to the patient's doctor.

Survivors of a serious exposure should be evaluated for damage to the lungs and heart. Patients who have serious systemic hydrogen fluoride poisoning may be at risk for respiratory sequelae and should be monitored for several weeks to months. Healing of skin burns may be prolonged and eye exposure can lead to permanent damage. Ingestion may produce progressive damage to the stomach and esophagus for weeks after exposure and may result in persistent narrowing of the esophagus.

Patients who have corneal injuries should be reexamined within 24 hours.

Reporting

If a work-related incident has occurred, you may be legally required to file a report; contact your state or local health department.

Other persons may still be at risk in the setting where this incident occurred. If the incident occurred in the workplace, discussing it with company personnel may prevent future incidents. If a public health risk exists, notify your state or local health department or other responsible public agency. When appropriate, inform patients that they may request an evaluation of their workplace from OSHA or NIOSH. See Appendices III and IV for a list of agencies that may be of assistance.

Hydrogen Fluoride
Patient Information Sheet

This handout provides information and follow-up instructions for persons who have been exposed to hydrogen fluoride gas or hydrofluoric acid solution or vapor.

What is hydrogen fluoride?
Hydrogen fluoride is a colorless, highly irritating gas with a pungent odor. It dissolves easily in water to form hydrofluoric acid. Consumer products that contain hydrogen fluoride include rust removers, water-spot removers, and chrome cleaners.

What immediate health effects can be caused by exposure to hydrogen fluoride?
Most poisonings occur when hydrogen fluoride gets on the skin or in the eyes. Concentrated hydrogen fluoride solutions can cause severe, deep, and disfiguring burns. Absorption of the chemical into the body can cause the heart to beat irregularly, leading to death. Exposure to dilute solutions (less than 20% concentration) may cause few or no symptoms at first, but may cause severe pain later. Drinking hydrofluoric acid can cause severe burns to the throat and stomach and even death. Injury can also occur from breathing hydrogen fluoride gas or the vapor from concentrated hydrogen fluoride solutions. Breathing high concentrations of hydrogen fluoride vapor can cause rapid death from throat swelling or from chemical burns to the lungs.

Can hydrogen fluoride poisoning be treated?
Patients who have experienced serious symptoms, such as severe or persistent coughing or skin or eye burns, may need to be hospitalized. Calcium- or magnesium-containing medicines may be used to treat the skin, and doctors may inject calcium-containing medicines into burned areas or into the blood. If hydrofluoric acid is swallowed, a solution containing calcium or magnesium may be given.

Are any future health effects likely to occur?
A single small exposure from which a person recovers quickly is not likely to cause delayed or long-term effects. After a severe exposure, you may not notice any symptoms for up to 36 hours. Scarring may result from skin contact with hydrogen fluoride.

What tests can be done if a person has been exposed to hydrogen fluoride?
The doctor may order blood tests, urine tests, chest x-ray, and heart monitoring to see whether damage has been done to the heart, lungs, or other organs. Testing is not needed in every case. If hydrogen fluoride contacts the eyes, the doctor may put a special dye into the eyes and examine them with a magnifying device.

Where can more information about hydrogen fluoride be found?
More information about hydrogen fluoride or hydrofluoric acid can be obtained from your regional poison control center; your state, county, or local health department; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in occupational and environmental health. If the exposure happened at work, you may wish to discuss it with your employer, the Occupational Safety and Health Administration (OSHA) or the National Institute for Occupational Safety and Health (NIOSH). Ask the person who gave you this form for help in locating these telephone numbers.

Follow-up Instructions

Keep this page and take it with you to your next appointment. Follow *only* the instructions checked below.

[ ] Call your doctor or the Emergency Department if you develop any unusual signs or symptoms within the next 24 hours, especially:

- difficulty breathing, shortness of breath or wheezing
- hoarseness, high-pitched voice, or difficulty speaking
- chest pain or tightness
- any skin changes, discharge, or increased pain where skin is burned
- stomach pain, vomiting, or diarrhea
- increased pain or a discharge from exposed eyes

[ ] No follow-up appointment is necessary unless you develop any of the symptoms listed above.
[ ] Call for an appointment with Dr. _____ in the practice of _____. When you call for your appointment, please say that you were treated in the Emergency Department at _____ Hospital by _____ and were advised to be seen again in _____ days.
[ ] Return to the Emergency Department/ _____ Clinic on (date) _____at ___ _____ AM/PM for a follow-up examination.
[ ] Do not perform vigorous physical activities for 1 to 2 days.
[ ] You may resume everyday activities including driving and operating machinery.
[ ] Do not return to work for _____ days.
[ ] You may return to work on a limited basis. See instructions below.
[ ] Avoid exposure to cigarette smoke for 72 hours; smoke may worsen the condition of your lungs.
[ ] Avoid drinking alcoholic beverages for at least 24 hours; alcohol may worsen injury to your stomach or have other effects.
[ ] Avoid taking the following medications: _____
[ ] You may continue taking the following medication(s) that your doctor(s) prescribed for you: __
_____
_____
[ ] Other instructions: _____
_____
_____

- Provide the Emergency Department with the name and the number of your primary care physician so that the ED can send him or her a record of your emergency department visit.

- You or your physician can get more information on the chemical by contacting: _____ _____ or _____, or by checking out the following Internet Web sites: _____; _____.

Signature of patient _____ Date _____

Signature of physician _____ Date _____